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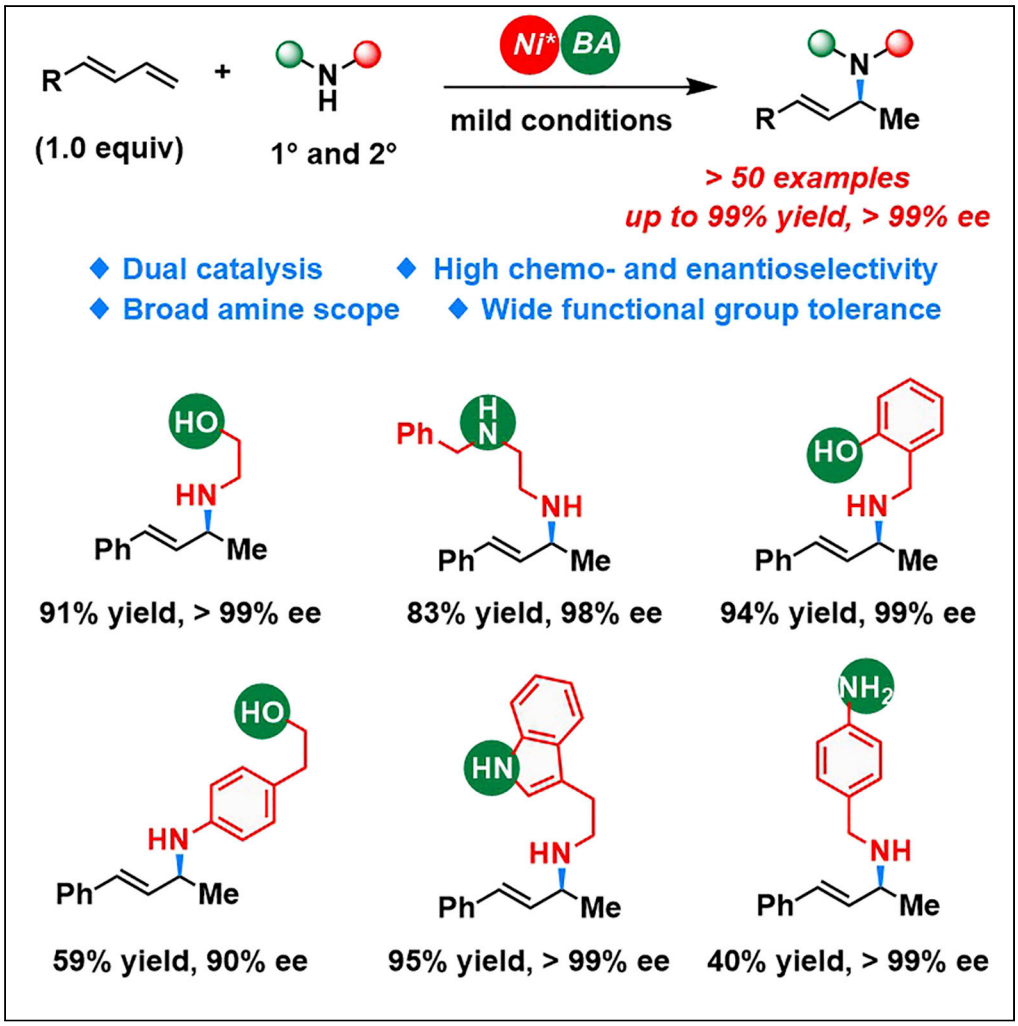

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HIGHLIGHTS

Nickel/Brønsted acid-catalyzed asymmetric hydroamination of conjugated dienes

High regio-, chemo-, and enantioselectivity

Broad range of substrate scope

Wide functional group tolerance

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Nickel/Brønsted Acid-Catalyzed Chemo- and Enantioselective Intermolecular Hydroamination of Conjugated Dienes

Jiao Long,[1] Peng Wang,[1] Wang Wang,[1] Yuqiang Li,[1] and Guoyin Yin[1,2,*]

SUMMARY

A novel nickel/Brønsted acid-catalyzed asymmetric hydroamination of acyclic 1,3-dienes has been established. A wide array of primary and secondary amines can be transformed into allylic amines with high yields and high enantioselectivities under very mild conditions. Moreover, our method is compatible with various functional groups and heterocycles, allowing for late-stage functionalization of biologically active complex molecules. Remarkably, this protocol exhibits good chemoselectivity with respect to amines bearing two different nucleophilic sites. Mechanistic studies reveal that the enantioselective carbon-nitrogen bond-forming step is reversible.

INTRODUCTION

Chiral amines represent a privileged pharmacophore and are present in a myriad of natural products and drugs (Figure 1A) (Francotte and Lindner, 2006; Lough and Wainer, 2002; Nugent, 2010). Therefore, organic chemists have made considerable efforts toward their synthesis during the last decade (Grogan, 2018; Li and Zhang, 2014; Nugent and El-Shazly, 2010; Patil et al., 2018; Robak et al., 2010). Among them, asymmetric hydroamination of unsaturated C-C bonds serves as an efficient and powerful tool in organic synthesis, particularly hydroamination using free amines (Aillaud et al., 2007; Clement and Jerome, 2017; Dondoni, 2015; Hannedouche and Schulz, 2013, 2018; Hii, 2006; Huang et al., 2015; Huo et al., 2019; Jerome, 2018; Müller et al., 2008; Patel et al., 2017; Pirnot et al., 2016; Reznichenko and Hultzsch, 2016; Zi, 2009, 2011). In this context, transition-metal-catalyzed intermolecular asymmetric hydroamination of allenes (Berthold and Breit, 2018, 2019; Cooke et al., 2012; Dion and Beauchemin, 2011; Lin et al., 2019; Parveen et al., 2017; Xu et al., 2016), alkynes (Athira et al., 2018; Liu et al., 2011; Lutete et al., 2004; Patil et al., 2006; Xu et al., 2019), and conjugated dienes (Adamson et al., 2017; Dion and Beauchemin, 2011; Lin et al., 2019; Löber et al., 2001; Park and Malcolmson, 2018; Xiong et al., 2018; Yang and Dong, 2017; Zhou and Hartwig, 2008) has been extensively studied (Figure 1B). Nevertheless, the use of noble transition metals such as rhodium and palladium are often mandatory (Adamson et al., 2017; Aillaud et al., 2007; Athira et al., 2018; Berthold et al., 2019; Berthold and Breit, 2018; Clement and Jerome, 2017; Cooke et al., 2012; Dion and Beauchemin, 2011; Dondoni, 2015; Hannedouche and Schulz, 2013, 2018; Hii, 2006; Huang et al., 2015; Huo et al., 2019; Jerome, 2018; Lin et al., 2019; Liu et al., 2011; Löber et al., 2001; Lutete et al., 2004; Müller et al., 2008; Park and Malcolmson, 2018; Parveen et al., 2017; Patel et al., 2017; Patil et al., 2006; Pirnot et al., 2016; Reznichenko and Hultzsch, 2016; Xiong et al., 2018; Xu et al., 2016, 2019; Yang and Dong, 2017; Zhou and Hartwig, 2008; Zi, 2009, 2011); in addition, these methods suffer from limited amine scope (Adamson et al., 2017; Dion and Beauchemin, 2011; Lin et al., 2019; Löber et al., 2001; Park and Malcolmson, 2018; Xiong et al., 2018; Yang and Dong, 2017; Zhou and Hartwig, 2008), as well as excessive quantities of the unsaturated substrate are always required to achieve a high level of efficiency (Adamson et al., 2017; Dion and Beauchemin, 2011; Lin et al., 2019; Löber et al., 2001; Park and Malcolmson, 2018; Yang and Dong, 2017; Zhou and Hartwig, 2008).

In recent years, research toward nickel-catalyzed oxidative addition with X-H (X = C, O …) bonds has become a hot theme owing to earth-abundance of nickel and its great potential in oxidative addition (Ananikov, 2015; Tasker et al., 2014; Wang, 2016; Figure 1C). Significant progress has been made in the asymmetric hydrofunctionalization of alkenes through nickel-catalyzed reactions (Bezzenine-Lafollee et al., 2017; Cai et al., 2019; Chen and Lu, 2018; Cheng et al., 2018, 2019, Diesel et al., 2018, 2019; Donets and Cramer, 2013; Li et al., 2018, 2019a; Lv et al., 2018; Richmond and Moran, 2018; Woźniak and Cramer,

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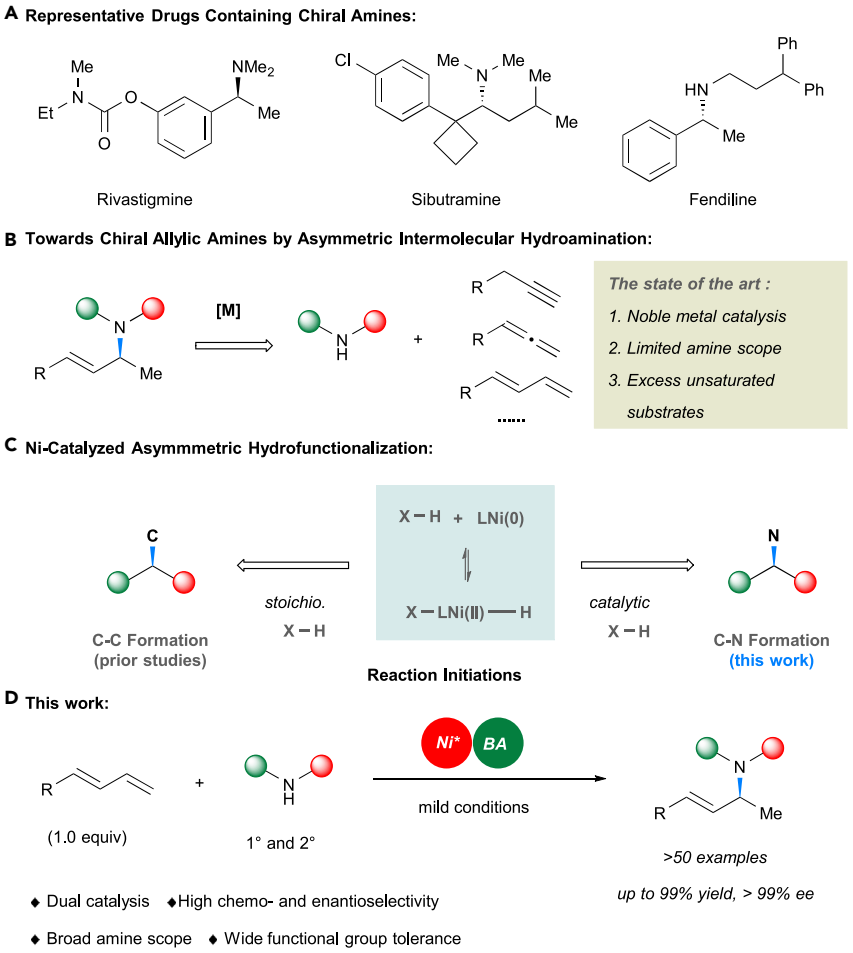


Figure 1. Reaction Design

(A) Representative drugs containing chiral amines.

(B) Toward chiral allylic amines by asymmetric intermolecular hydroamination.

(C) Ni-catalyzed asymmetric hydrofunctionalization.

(D) Nickel/Brønsted acid-catalyzed chemo- and enantioselective intermolecular hydroamination of conjugated dienes.

2019; Xiao et al., 2016, 2018; Zhang et al., 2019). Chiral centers are generally induced via a carbon-carbon bond-forming process, involving the direct oxidative addition of C-H bonds (Cai et al., 2019; Cheng et al., 2018, 2019, Diesel et al., 2018, 2019; Donets and Cramer, 2013; Li et al., 2019a; Lv et al., 2018; Woźniak and Cramer, 2019; Zhang et al., 2019) or an external stoichiometric reductant, such as alcohol (Chen et al., 2019) or hydrosiloxane (Ahlin and Cramer, 2016). However, nickel-catalyzed asymmetric hydrofunctionalization of unsaturated compounds involving a carbon-heteroatom bond formation has not been studied much (Tran et al., 2019). As an extension of our studies with nickel-catalyzed carbon-carbon bond formations (Li et al., 2019b; Wang et al., 2019), we turned our attention to carbon-heteroatom bonds. Inspired by the recent reports on metal/Brønsted acid dual catalysis (Adamson et al., 2017; Dion and Beauchemin, 2011; Han et al., 2018; Kathe and Fleischer, 2019; Lin et al., 2019; Liu and Feng, 2018; Löber et al., 2001; Park and Malcolmson, 2018; Yang and Dong, 2017; Zhou and Hartwig, 2008), we have developed a novel, room temperature nickel/Brønsted acid-catalyzed asymmetric hydroamination using conjugated dienes as a limiting reagent (Figure 1D). This protocol can transform a wide array of primary and secondary amines into allylic amines in high yields with excellent enantioselectivities. Significantly, good regio-, chemo-, and enantioselectivity have been achieved using amines bearing potentially competitive nucleophilic sites. It is noteworthy that the nickel-catalyzed racemic hydroamination of cyclic dienes has only been reported by the Hartwig group before, wherein they also demonstrated the challenge for the development of an enantioselective variant (Pawlas et al., 2002).

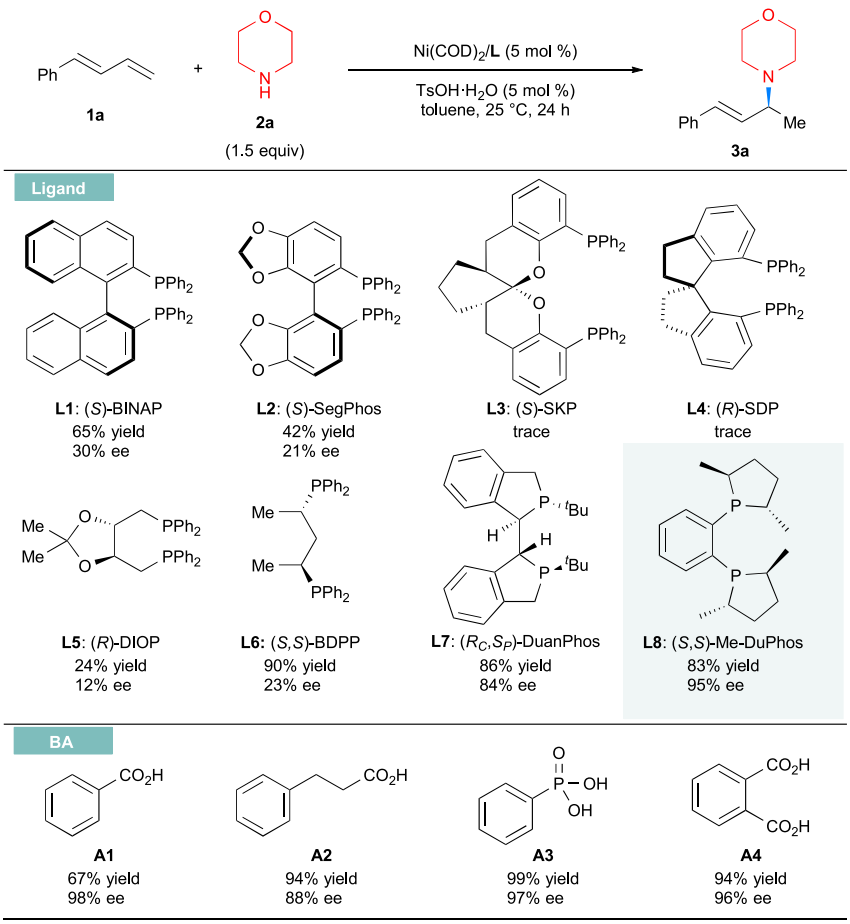


Figure 2. Reaction Optimization

Reactions were conducted at 0.2 mmol scale, see Supplemental Information for reaction details. See also Tables S1–S3.

RESULTS

Optimization Reaction Conditions

We initiated this study by choosing phenyl-1,3-diene (**1a**) and morpholine (**2a**) as model substrates. Ligand evaluations were conducted using Ni(COD)2 as the precatalyst and TsOH•H2O as a cocatalyst. As shown in Figure 2, a series of bisphosphine ligands were examined; the 1,2-hydroamination product **3a** (Wang et al., 2014) was obtained in a moderate yield with a low enantiomeric excess (ee) when chiral BINAP (**L1**) or SEGPHOS (**L2**) was used, which demonstrated the feasibility of this hydroamination reaction. Unfortunately, (*S*)-SKP (**L3**), (R)-SDP (**L4**), and (R)-DIOP (**L5**) as ligand were not effective for this transformation, although (*S,S*)-BDPP (**L6**), a flexible bisphosphine ligand, yielded **3a** in an excellent yield, but with low enantioselectivity (23% ee). However, both high yields and enantioselectivities were achieved by (R_C,S_P)-DuanPhos (**L7**). To our delight, excellent ee (95% ee) was obtained when (*S,S*)-Me-DuPhos (**L8**), as a more rigid ligand, was used. In addition, the Brønsted acid cocatalyst can also affect the efficiency and enantioselectivity of this hydroamination reaction. Further studies demonstrated that the desired product can also be obtained in high yields without a decrease in enantioselectivity when switching the acid cocatalyst to phenylphosphonic acid (**A3**) or phthalic acid (**A4**). To easily weighout, we selected **A4** as cocatalyst. Moreover, control experiments indicated that both nickel catalysts and the Brønsted acids were crucial to the success of this reaction. Notably, no other regioisomers were detected in these reactions.

Substrate Scope Study

With the optimal conditions in hand, we shifted our attention to investigate the generality of this Ni-catalyzed asymmetric hydroamination reaction. Utilizing **1a**, we examined the scope of the amines. As illustrated in Figure 3, a series of primary amines bearing various functional groups produced the

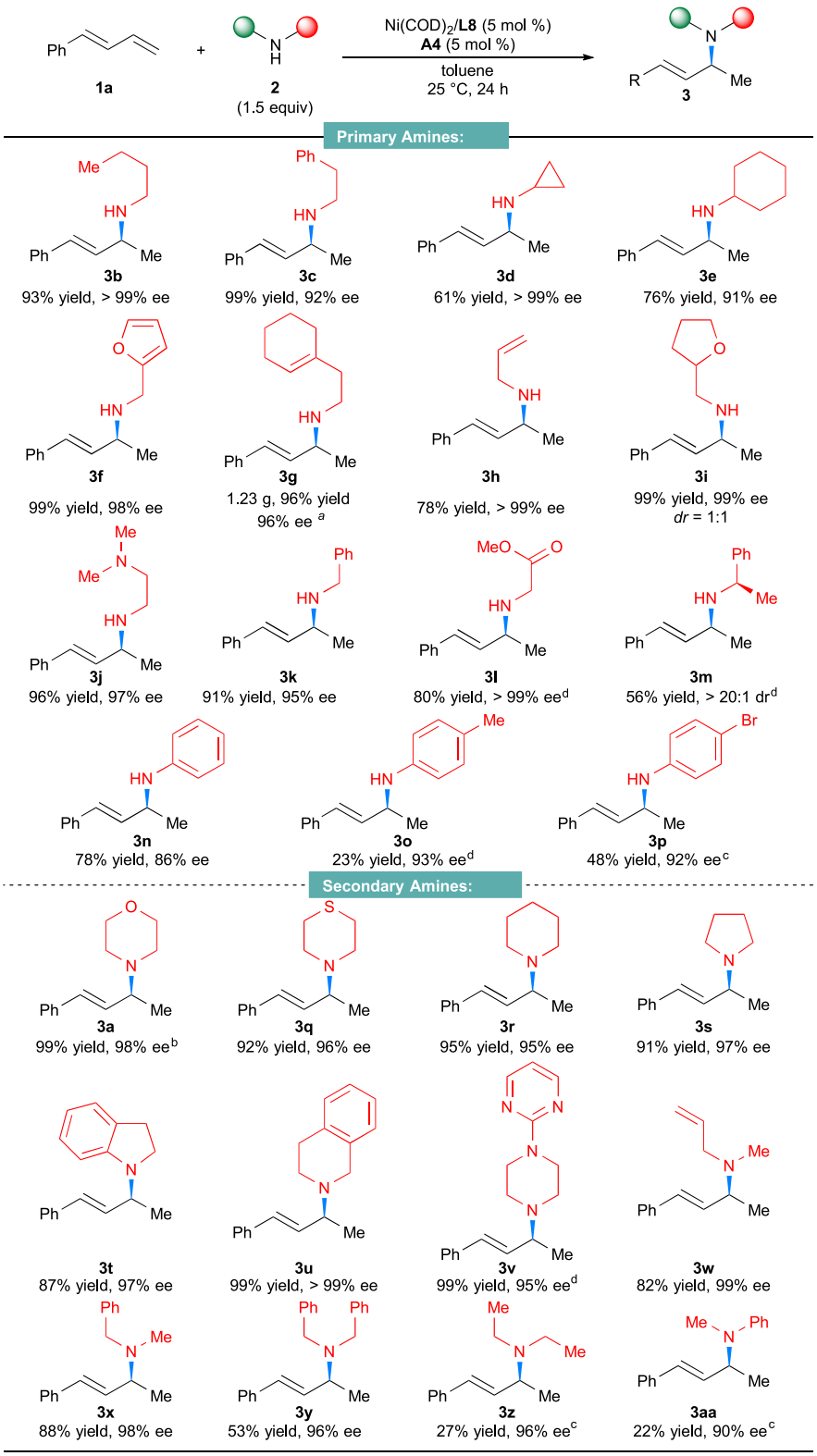


Figure 3. Scope of Primary and Secondary Amines

Reactions were conducted at 0.2 mmol scale, see Supplemental Information for reaction condition details. [a]Reactions were conducted at 5 mmol scale. [b]12 h; [c]36 h; [d]48 h. See also Scheme S3.

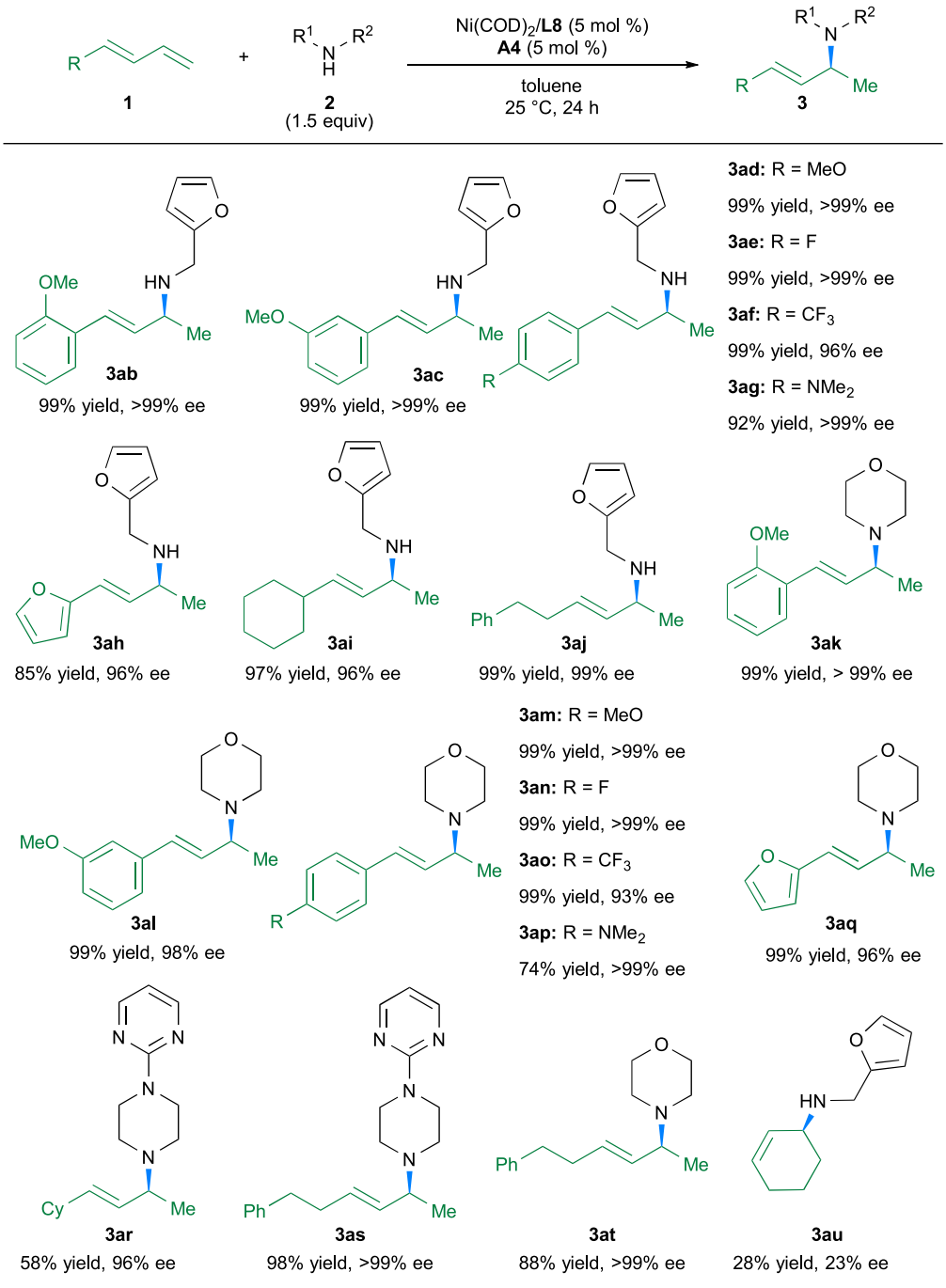


Figure 4. Scope of Conjugated Dienes

Reactions were conducted at 0.2 mmol scale, see Supplemental Information for reaction condition details. See also Scheme S3.

corresponding hydroamination products **3b**-**3l** with good to excellent yields with excellent enantioselectivities. Notably, (*R*)-(+)-1-Phenylethylamine, a chiral amine, also gave the hydroamination product in a moderate yield with an excellent diastereomeric ratio (dr > 20:1, **3m**). In addition to the aliphatic amines, primary arylamines were also suitable for the reaction to generate the chiral amine products with excellent enantioselectivities, albeit in lower yields under the current reaction conditions. It is noteworthy that the aryl bromide is compatible with this nickel-catalyzed reaction (**3p**). To assess the practicality of this

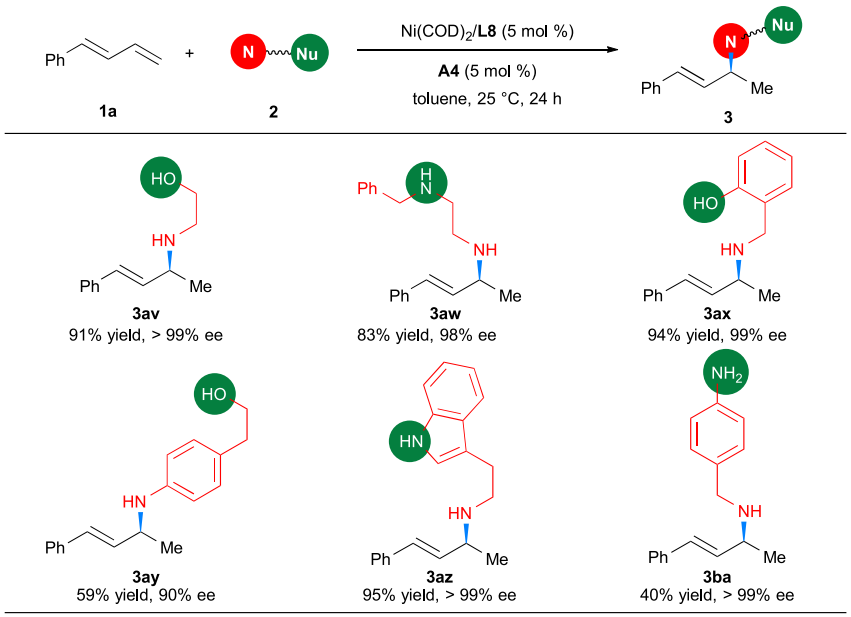


Figure 5. Substrates Containing Two Nucleophilic Sites

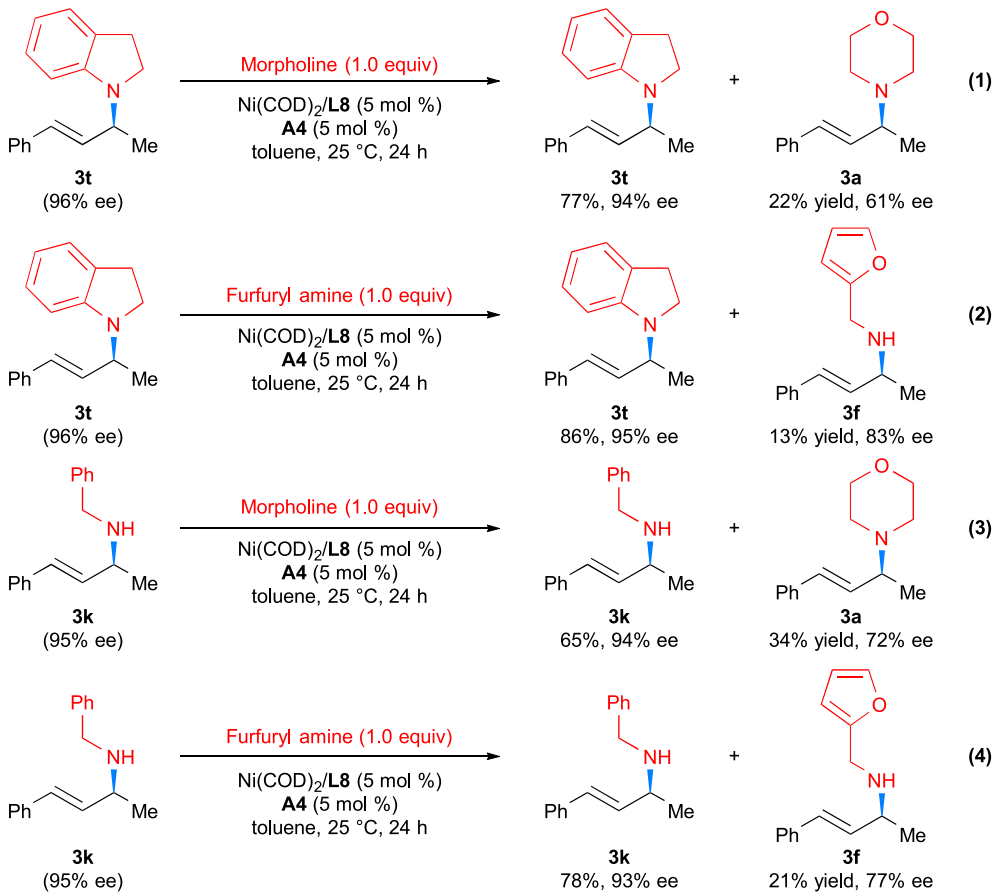
Reactions were conducted at 0.2 mmol scale, see Supplemental Information for reaction condition details. See also Scheme S3.

asymmetric hydroamination reaction, a gram-scale experiment was conducted. When the reaction of **1a** with **2g** was performed on a 5 mmol scale, it still was able to furnish **3g** without loss of reaction efficiency and optical enantioselectivities, even in the presence of 1 mol % catalysts.

Next, the scope of secondary amines was tested. Various secondary cyclic amines afforded the chiral allylic amines in both remarkable yields and enantioselectivities (**3a**-**3v**). Moreover, acyclic secondary amines were also able to produce the desired hydroamination products with excellent enantioselectivities under the same reaction conditions (**3w**-**3aa**). Interestingly, although catalytic amount of Brønsted acid was used as a cocatalyst, amines containing other nitrogen atoms did not affect this asymmetric transformation (**3j** and **3v**). Additionally, a series of functional groups, including ethers (**3i** and **3a**), esters (**3l**), thioethers (**3q**), terminal alkenes (**3h** and **3w**), and heterocycles such as furan (**3f**) and pyrimidines (**3v**), all were well tolerated in this reaction.

Subsequently, the scope of 1,3-dienes was studied. A set of aryl-substituted linear 1,3-butadienes were examined with both primary and secondary amines under the optimal conditions. As shown in Figure 4, both electron-rich and deficient substituents did not affect the efficiency or enantioselectivity. Alkyl-substituted butadienes were also capable of producing the Markovnikov hydroamination products (**3ai**, **3aj**, **3ar**, **3as**, and **3at**) in excellent yields with an excellent ee value. Notably, no other regioisomers were detected in these reactions. Furthermore, the hydroamination product (**3au**) could also be synthesized from 1,3-cyclohexadiene, albeit in low yields and enantioselectivity under the current conditions.

As we have highlighted earlier, both primary and secondary alkyl and aryl amines can produce satisfactory results in this nickel/Brønsted acid-catalyzed reaction. We were curious about the chemoselectivity when using one substrate containing two different nucleophilic sites. Guided by this idea, a set of more complex amines were tested under the optimal conditions and the results have been displayed in Figure 5. With aminoethanol, only the 1,2-hydroamination product (**3av**) was isolated with an excellent yield and ee value. Notably, the less sterically encumbered primary amine was found to be more reactive than the secondary amine when N-benzylethylediamine was used (**3aw**). Interestingly, the acidic phenol did not affect the amination (**3ax**), and the hydroamination reaction of the aryl amine (**3ay**) was not affected by the presence of an alcohol. Moreover, a single isomer with both excellent ee and yield could be obtained from tryptamine (**3az**). Finally, high chemoselectivity was shown at the aliphatic amine part when 4-aminobenzylamine was used (**3ba**). Collectively, these results suggest that this nickel-catalyzed reaction exhibits



Scheme 1. Amine Exchange Experiment

(1) Exchange experiment of secondary amine-based product (3t) with secondary amine (morpholine).
(2) Exchange experiment of secondary amine-based product (3t) with primary amine (furfuryl amine).
(3) Exchange experiment of primary amine-based product (3k) with secondary amine (morpholine).
(4) Exchange experiment of primary amine-based product (3k) with primary amine (furfuryl amine).
Data are represented as mean value of three times; see also Scheme S5.

good chemoselectivity toward hydroamination and also demonstrates the potential of this method in the late-stage diversification of biomolecules.

DISCUSSION

Mechanism Study

To get more details of this transformation, a preliminary mechanistic investigation was conducted. In Hartwig's reaction, a reversible carbon-nitrogen bond formation was observed. To determine if this phenomenon also exists in our reaction, amine exchange experiments were performed first. When the enantioenriched **3t** and stoichiometric morpholine were subjected to the optimal conditions, both **3t** and **3a** were detected (Scheme 1-1). A similar phenomenon was also observed in the reaction of **3t** with a primary amine (Scheme 1-2). This reversible effect was also found when a primary amine-based product was used (Schemes 1-3 and 1-4). These findings strongly suggested that a reversibility of carbon-nitrogen bond formation was involved in this reaction. These results are in consistence with Hartwig's results (Pawlas et al., 2002) but inconsistent with the results of Mazet's conditions (Tran et al., 2019).

Furthermore, a decrease in enantioselectivity over time has been observed in the palladium-catalyzed hydroamination reactions (Löber et al., 2001; Pawlas et al., 2002). To determine if this phenomenon also exists in our reaction, time course experiments were conducted for both primary and secondary amines (Figure 6). To our surprise, significant racemization was observed for the reaction with a secondary amine

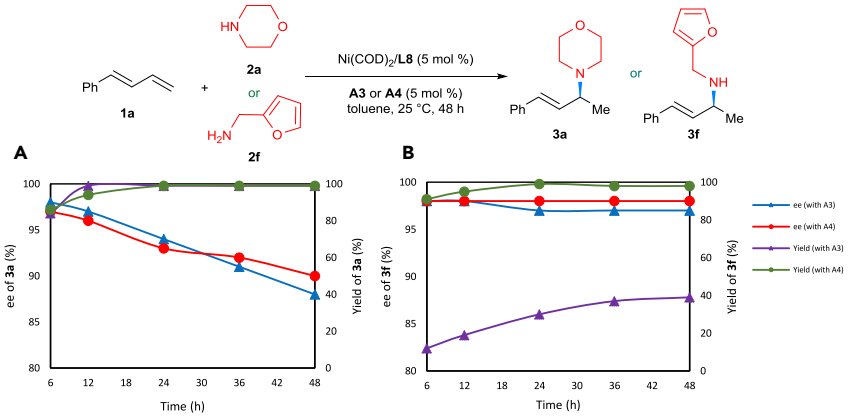


Figure 6. Reaction Profiles

(A) Time course experiments of secondary amine.

(B) Time course experiments of primary amine.

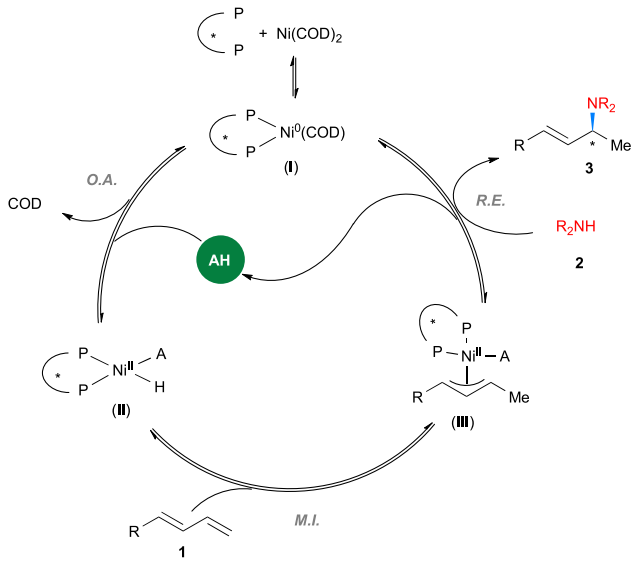
Data are represented as mean value of three times; see also Scheme S6 and Figure S246.

(Figure 6A), whereas there was nearly no alteration of enantioselectivity in a reaction with a primary amine (Figure 6B). Moreover, similar results were also obtained switching **A4** to **A3**.

Finally, based on precedent studies (Adamson et al., 2017; Dion and Beauchemin, 2011; Lin et al., 2019; Löber et al., 2001; Park and Malcolmson, 2018; Xiong et al., 2018; Yang and Dong, 2017; Zhou and Hartwig, 2008) and the above-mentioned findings (see Supplemental Information for more results), a mechanistic profile is proposed for this transformation. As illustrated in Scheme 2, the reaction is initiated by a Ni(0) species (**I**), which undergoes oxidative addition to form a Ni(II)-H species (**II**). Subsequently, a 1,3-diene migratory insertion leads to the formation of a π-allylNi(II) intermediate (**III**). The hydroamination product **3** is ultimately generated from the π-allylNi(II) complex by an amine nucleophilic attack (McDonald et al., 2011), accompanied by releasing of a Ni(0) species and regeneration of the acid cocatalyst.

Conclusion

In summary, we have developed a novel nickel and Brønsted acid-cocatalyzed asymmetric hydroamination reaction. The choice of chiral bisphosphine ligand and the use of a suitable Brønsted acid in catalytic amount are crucial to the success of this transformation. This protocol allows access to a series of



Scheme 2. Proposed Mechanism

enantiopure secondary and tertiary allylic amines from linear conjugated dienes and free amines. This method provides high enantioselectivity and a broad substrate scope for the synthesis of various chiral amines. Importantly, a set of complex amines have been accomplished with excellent chemo- and enantioselectivity in this system. The good functional group tolerance and the scalability demonstrates the potential of this method in the synthesis of enantiopure amines. Mechanistic studies indicate that the C-N bond formation is a reversible step. Moreover, racemization over time exists in the reaction with secondary amines but not for primary amines. We believe this chemistry will greatly benefit medicinal chemistry and further reaction development.

Limitations of the Study

The disubstituted diene was not suitable in this methodology.

METHODS

All methods can be found in the accompanying Transparent Methods supplemental file.

DATA AND CODE AVAILABILITY

All data and methods can be found in the Supplemental Information.

SUPPLEMENTAL INFORMATION

Supplemental Information can be found online at https://doi.org/10.1016/j.isci.2019.11.008.

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AUTHOR CONTRIBUTIONS

G.Y. conceived the project and designed the experiments. J.L. discovered the reported process and designed and carried out almost all the experiments. P.W. participated in synthesizing partial substrates. W.W. helped in executing isotopic labeling studies, and Y.L. helped in analyzing the data. G.Y. wrote the manuscript. J.L. wrote Supplemental Information. All the authors discussed the results and commented on the manuscript.

DECLARATION OF INTERESTS

The authors declare no competing interests.

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Supplemental Information

Nickel/Brønsted Acid-Catalyzed Chemo- and Enantioselective Intermolecular Hydroamination of Conjugated Dienes

Jiao Long, Peng Wang, Wang Wang, Yuqiang Li, and Guoyin Yin

Supplemental figures for ^{1}H, ^{13}C and ^{19}F-NMR spectra of substrate 1a-1j.

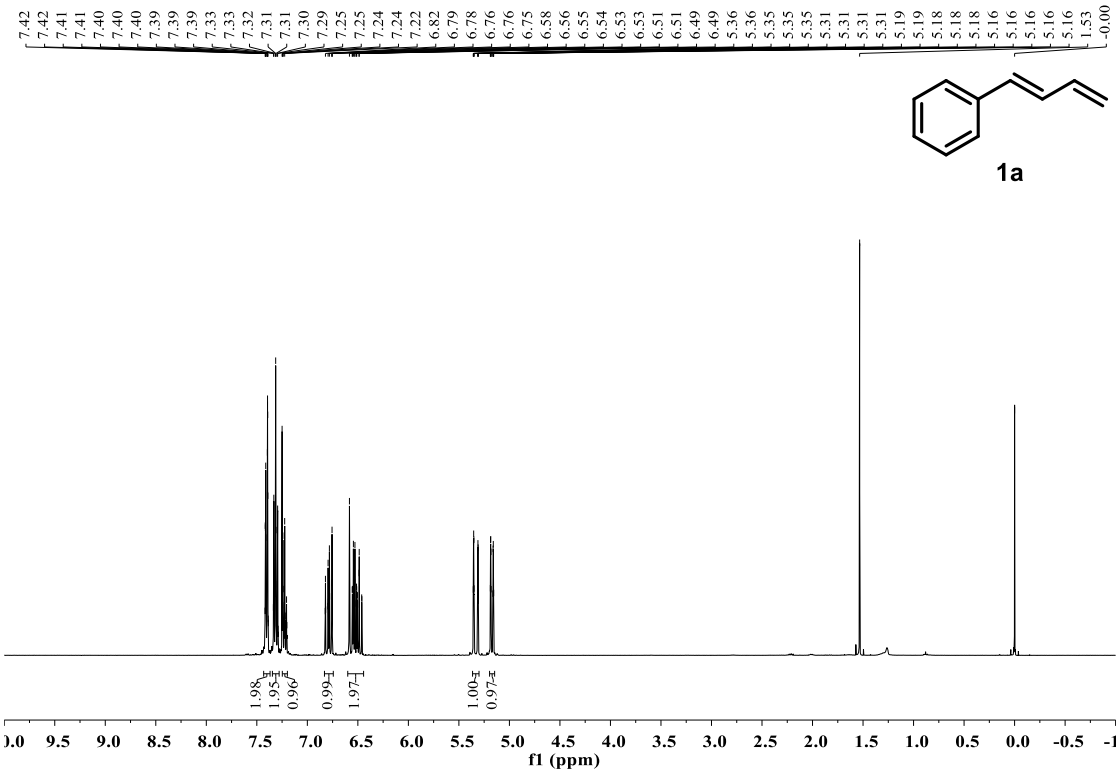


Figure S1. ^{1}H NMR spectra of substrate **1a**, related to **Figure 2**.

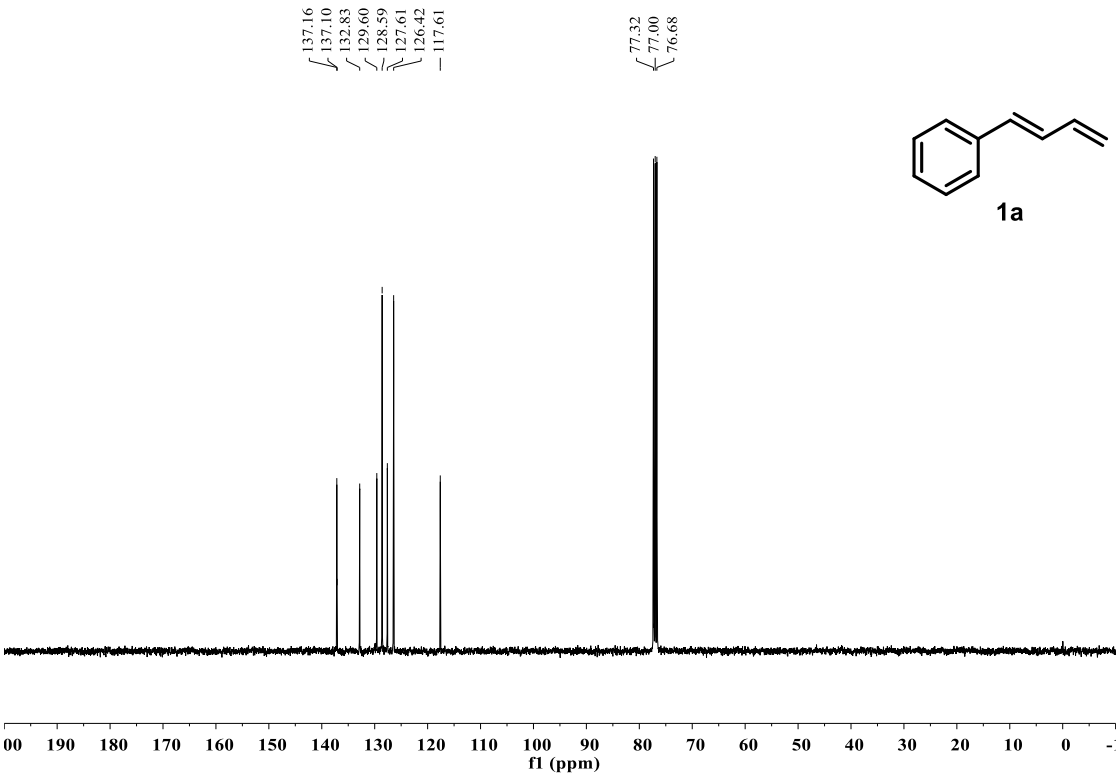


Figure S2. ^{13}C NMR spectra of substrate **1a**, related to **Figure 2**.

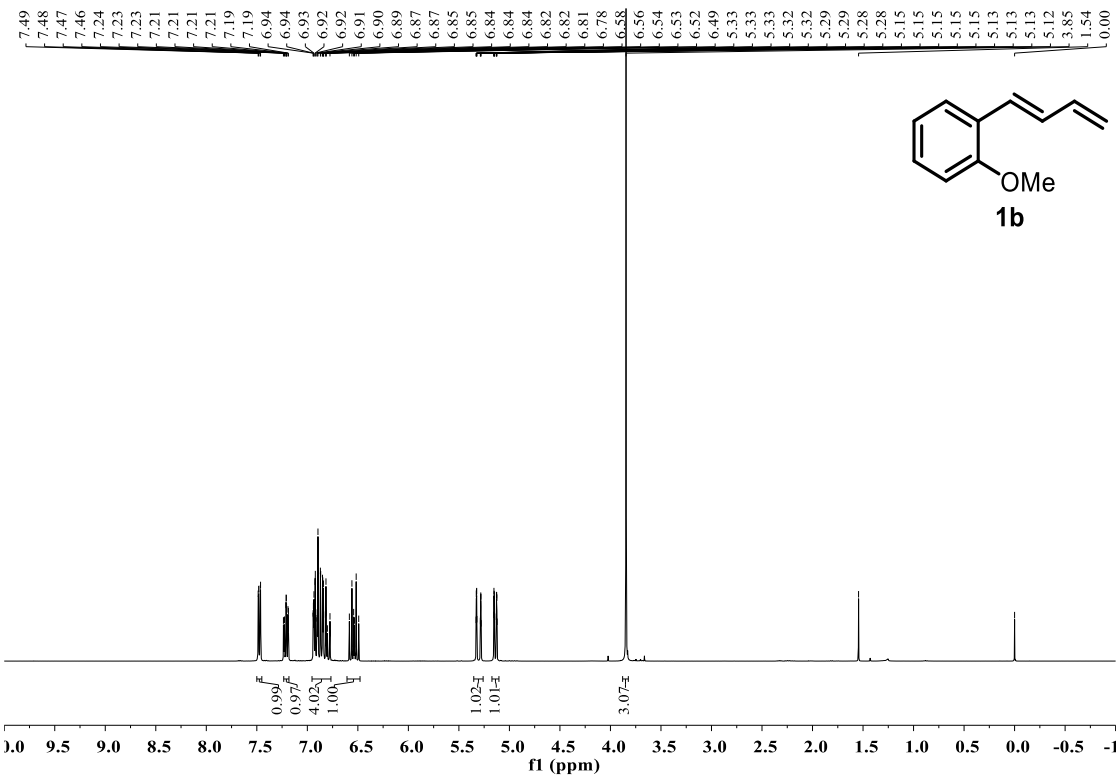


Figure S3. ^{1}H NMR spectra of substrate **1b**, related to **Figure 4**.

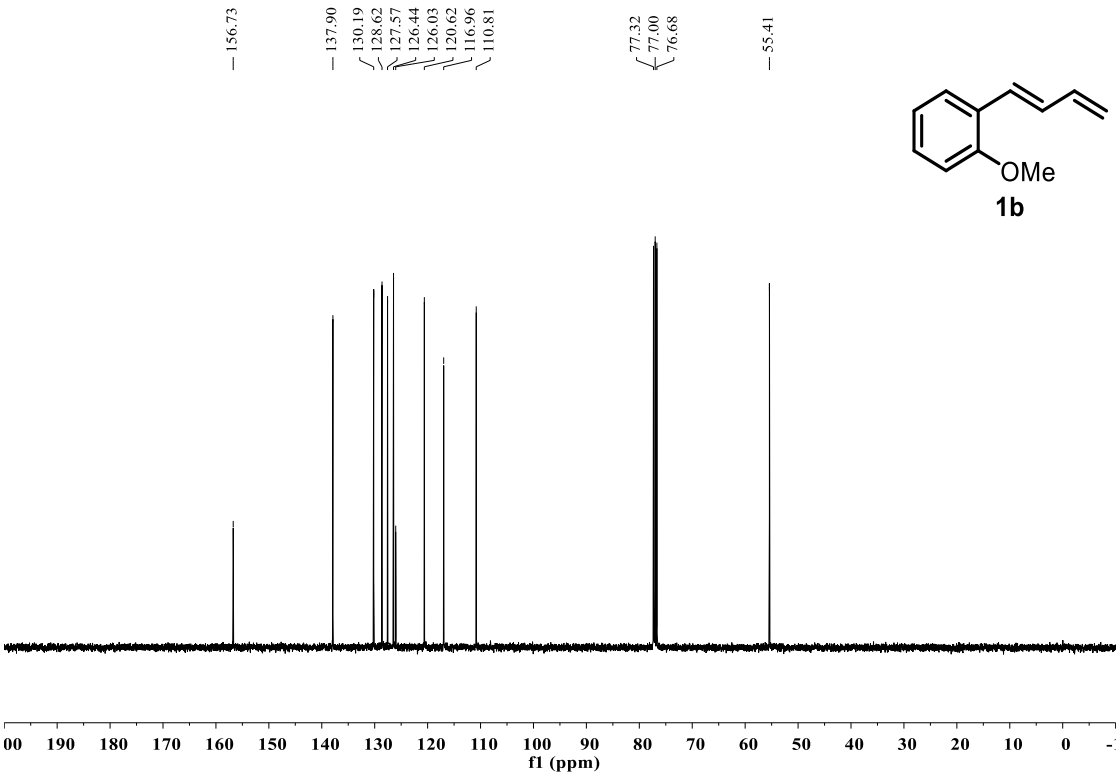


Figure S4. ^{13}C NMR spectra of substrate **1b**, related to **Figure 4**.

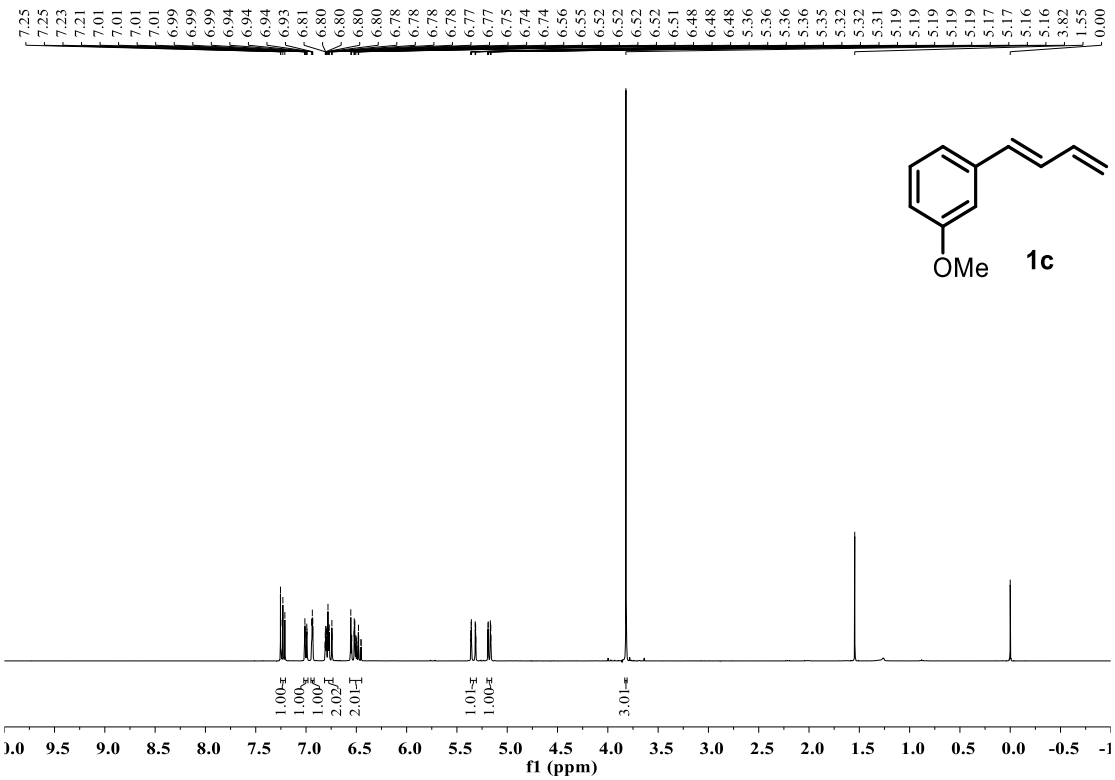


Figure S5. ^{1}H NMR spectra of substrate **1c**, related to **Figure 4**.

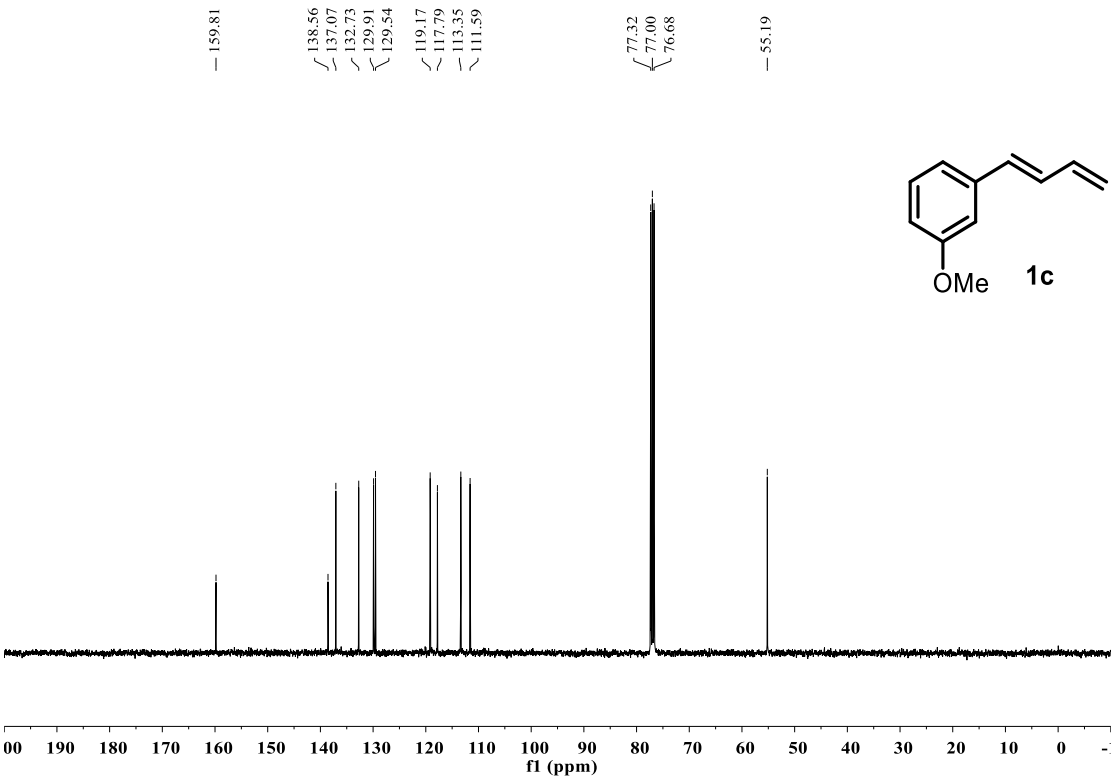


Figure S6. ^{13}C NMR spectra of substrate **1c**, related to **Figure 4**.

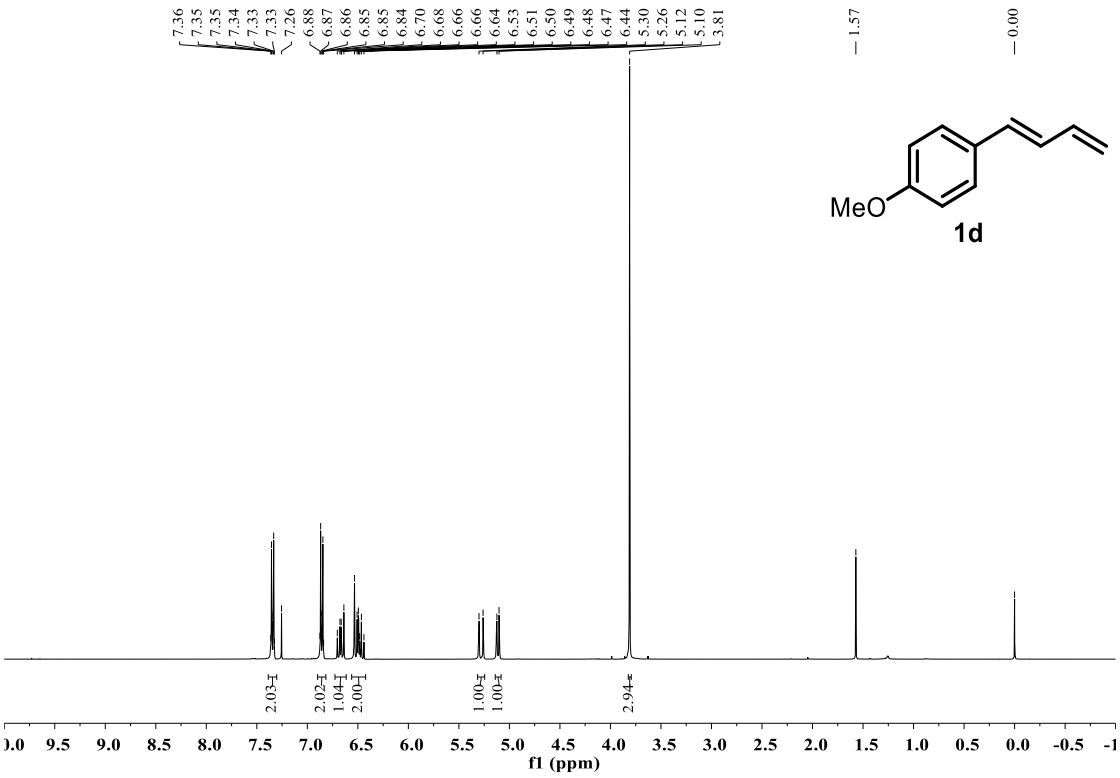


Figure S7. [1]H NMR spectra of substrate **1d**, related to **Figure 4**.

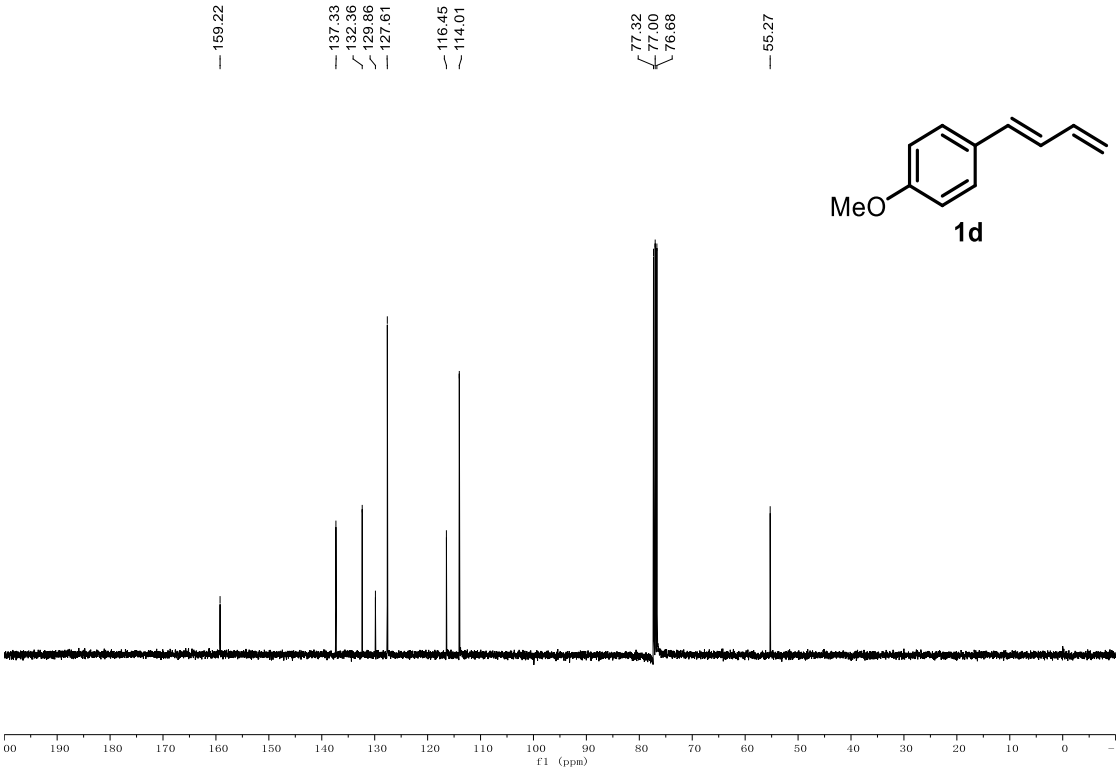


Figure S8. [13]C NMR spectra of substrate **1d**, related to **Figure 4**.

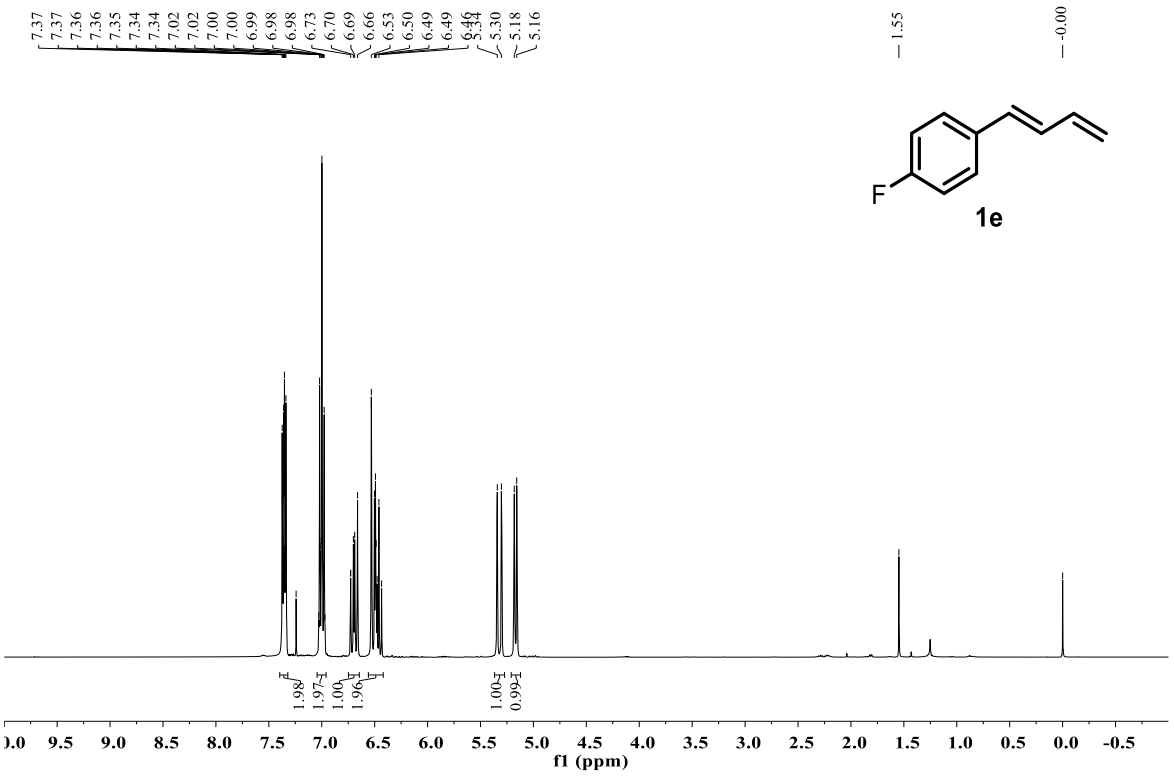


Figure S9. [1]H NMR spectra of substrate **1e**, related to **Figure 4**.

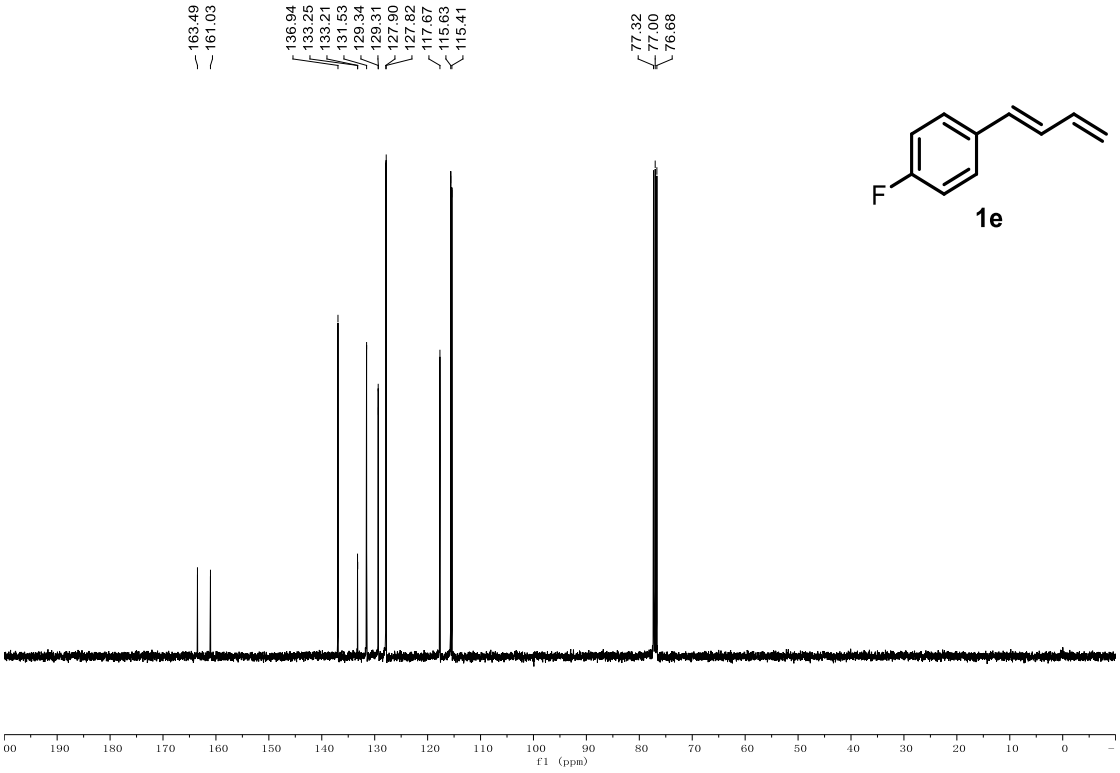


Figure S10. [13]C NMR spectra of substrate **1e**, related to **Figure 4**.

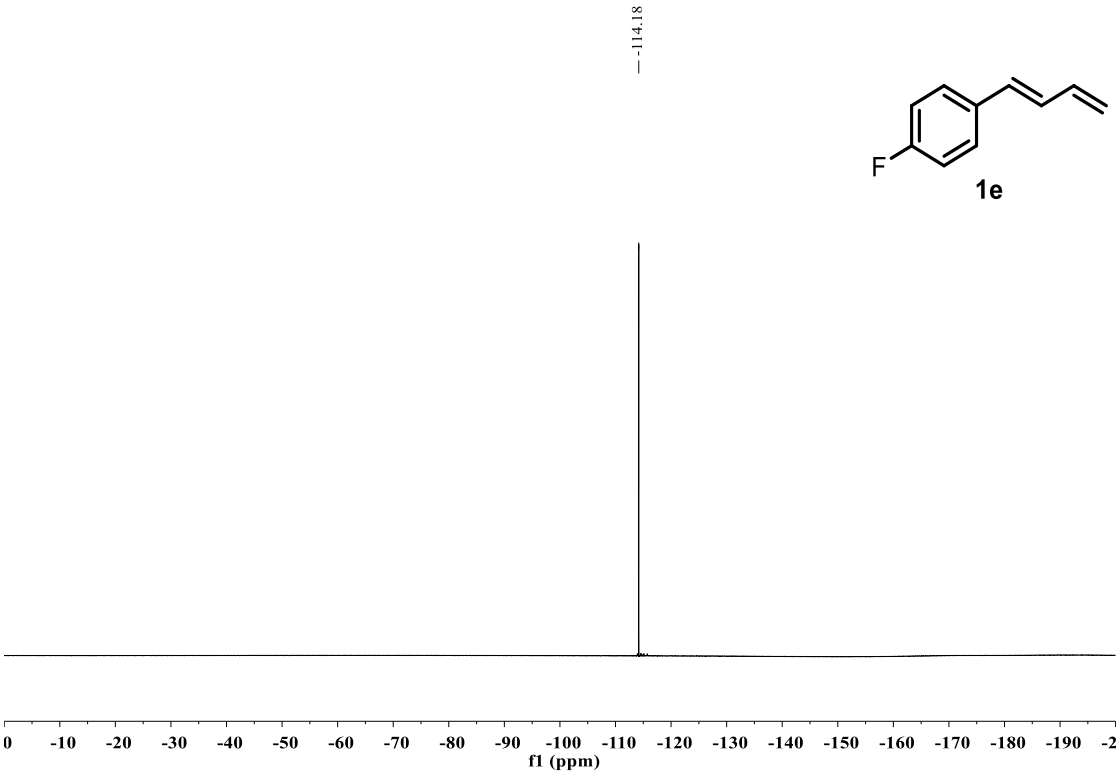


Figure S11. ^{19}F NMR spectra of substrate **1e**, related to **Figure 4**.

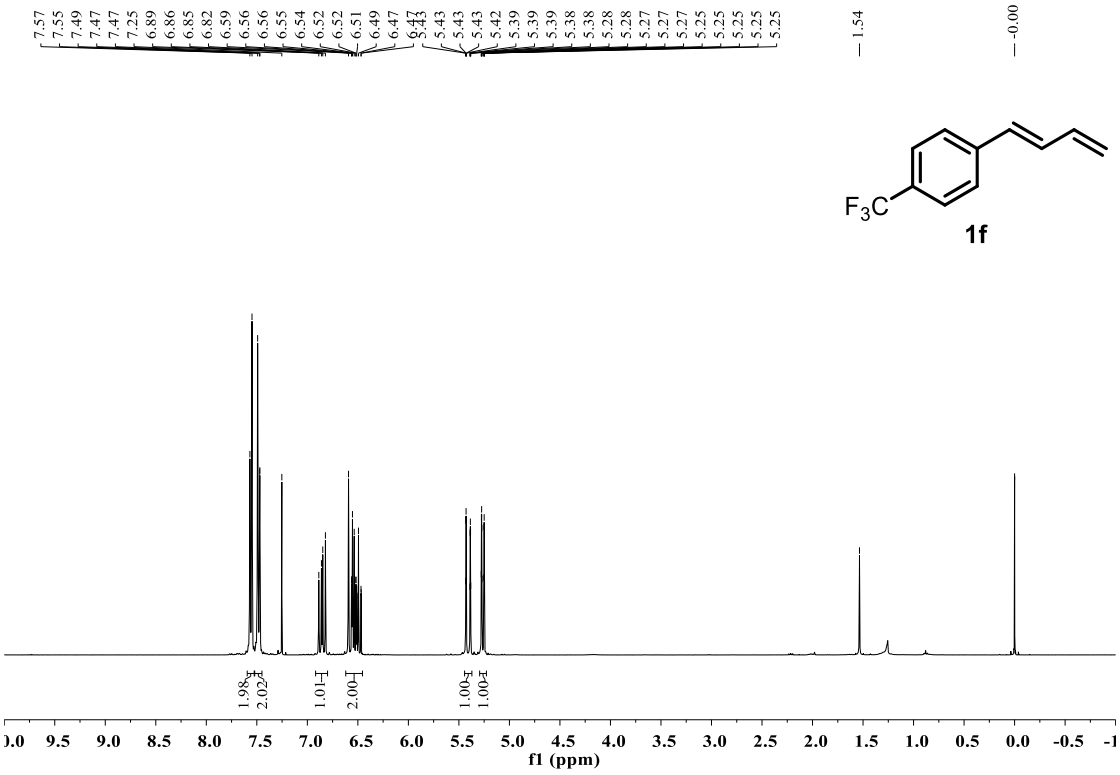


Figure S12. ^{1}H NMR spectra of substrate **1f**, related to **Figure 4**.

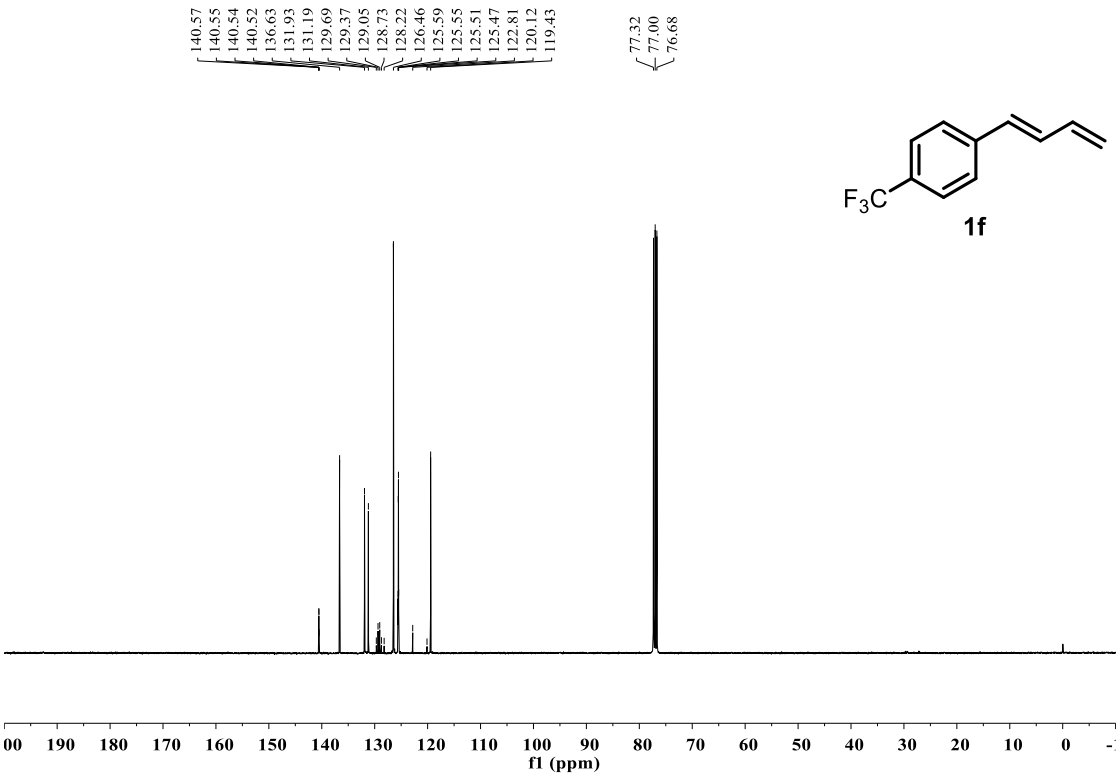


Figure S13. ^{13}C NMR spectra of substrate **1f**, related to **Figure 4**.

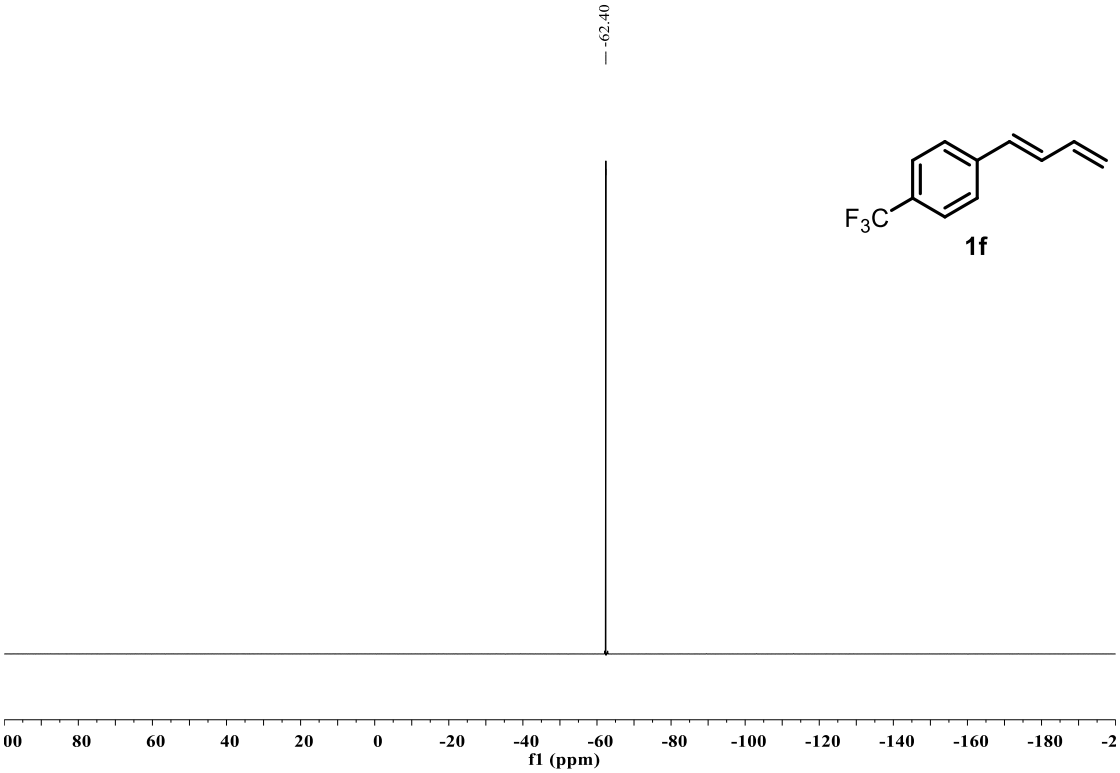


Figure S14. ^{19}F NMR spectra of substrate **1f**, related to **Figure 4**.

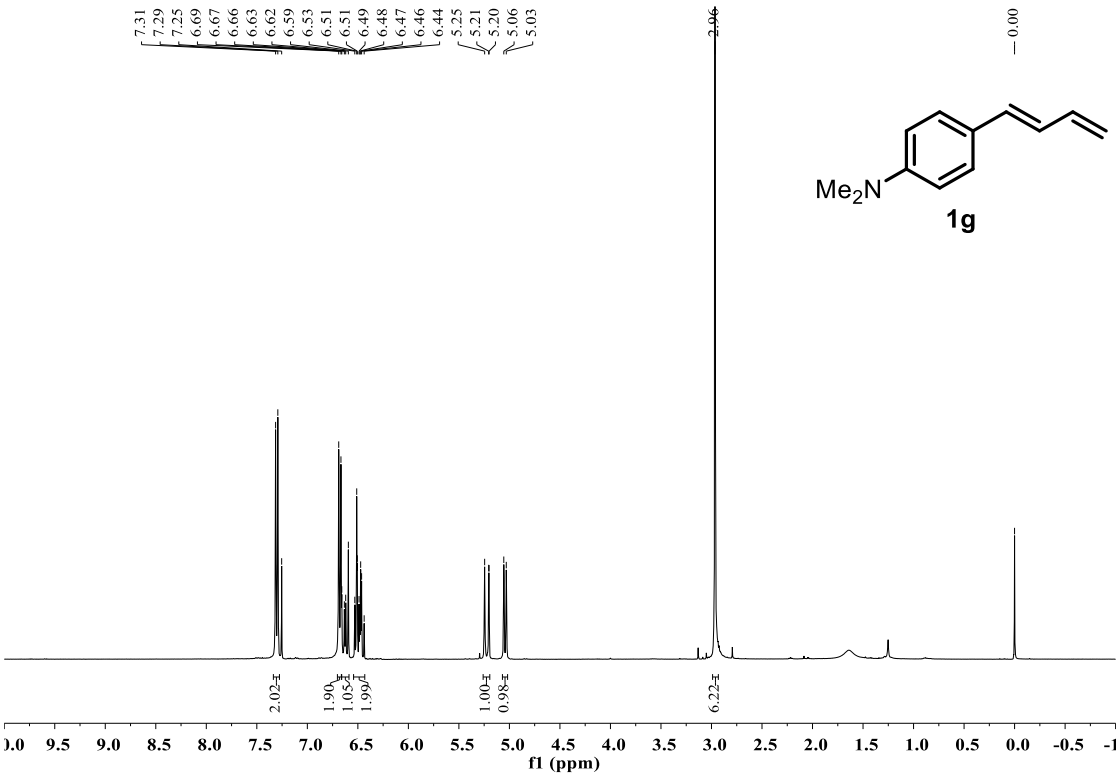


Figure S15. ^{1}H NMR spectra of substrate **1g**, related to **Figure 4**.

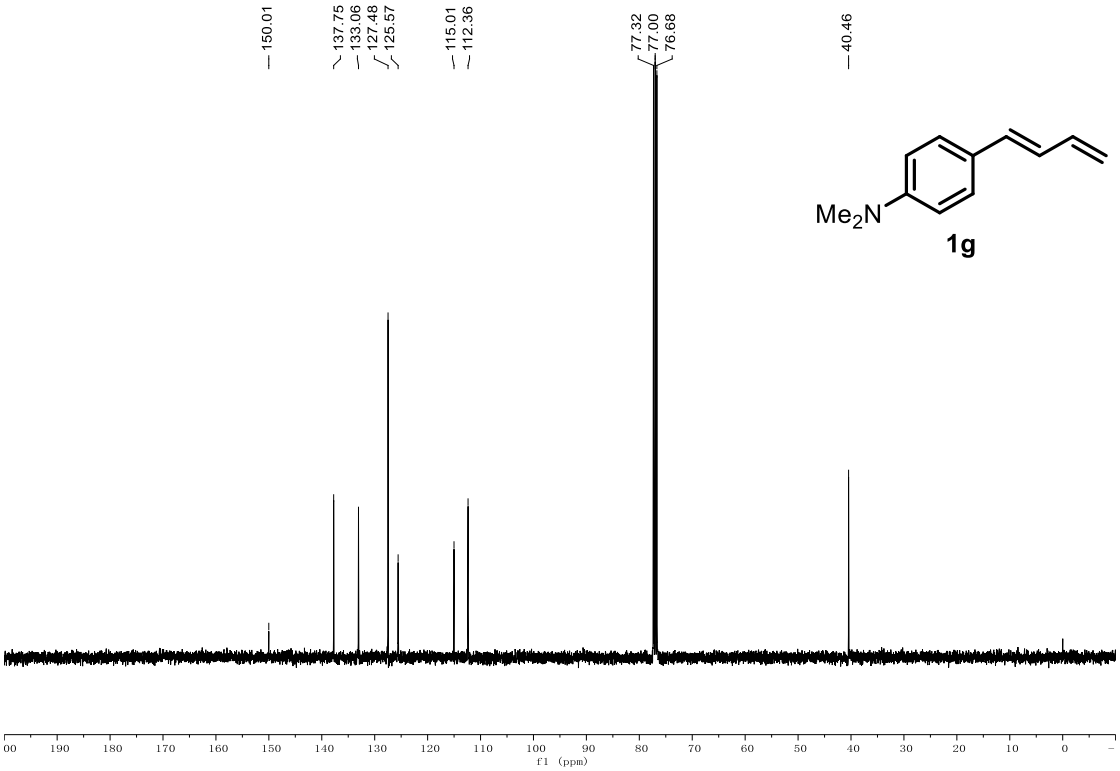


Figure S16. ^{13}C NMR spectra of substrate **1g**, related to **Figure 4**.

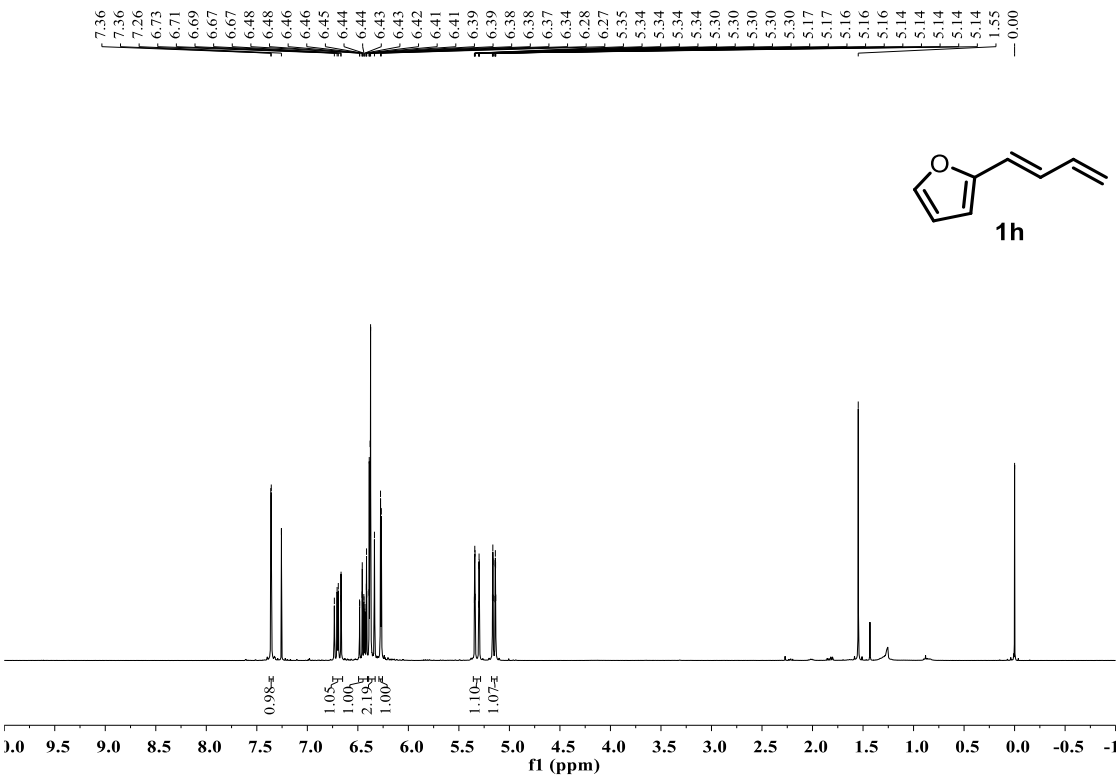


Figure S17. ^{1}H NMR spectra of substrate **1h**, related to **Figure 4**.

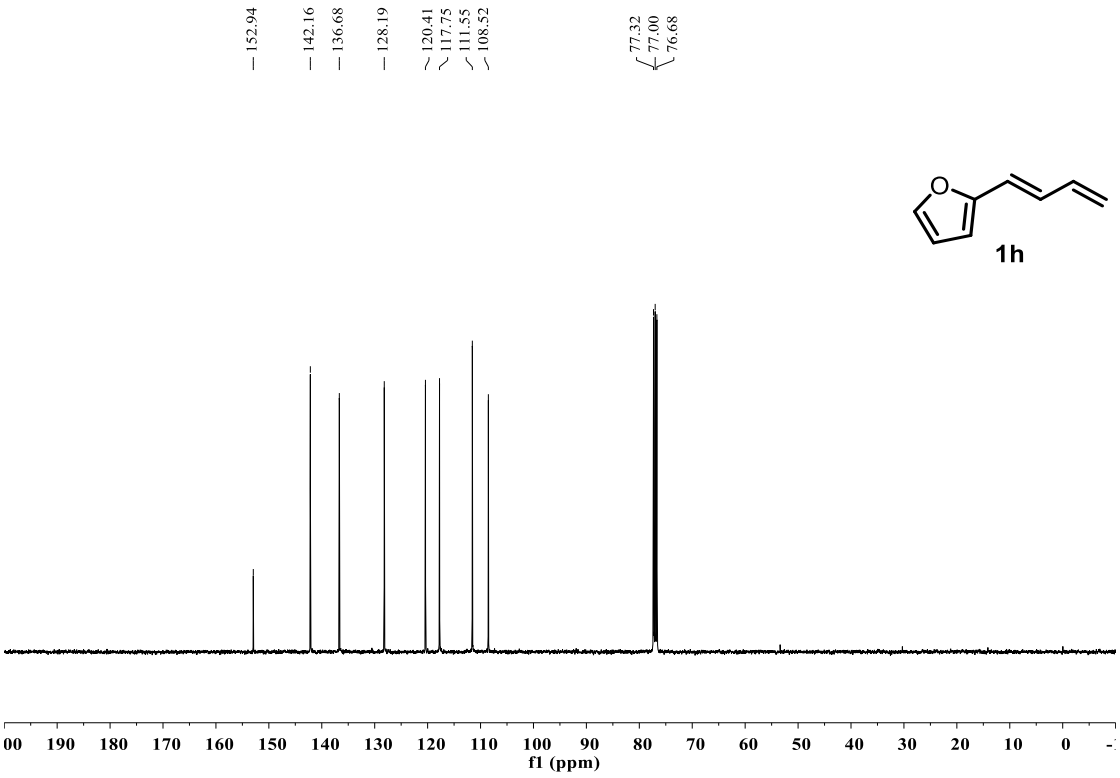


Figure S18. ^{13}C NMR spectra of substrate **1h**, related to **Figure 4**.

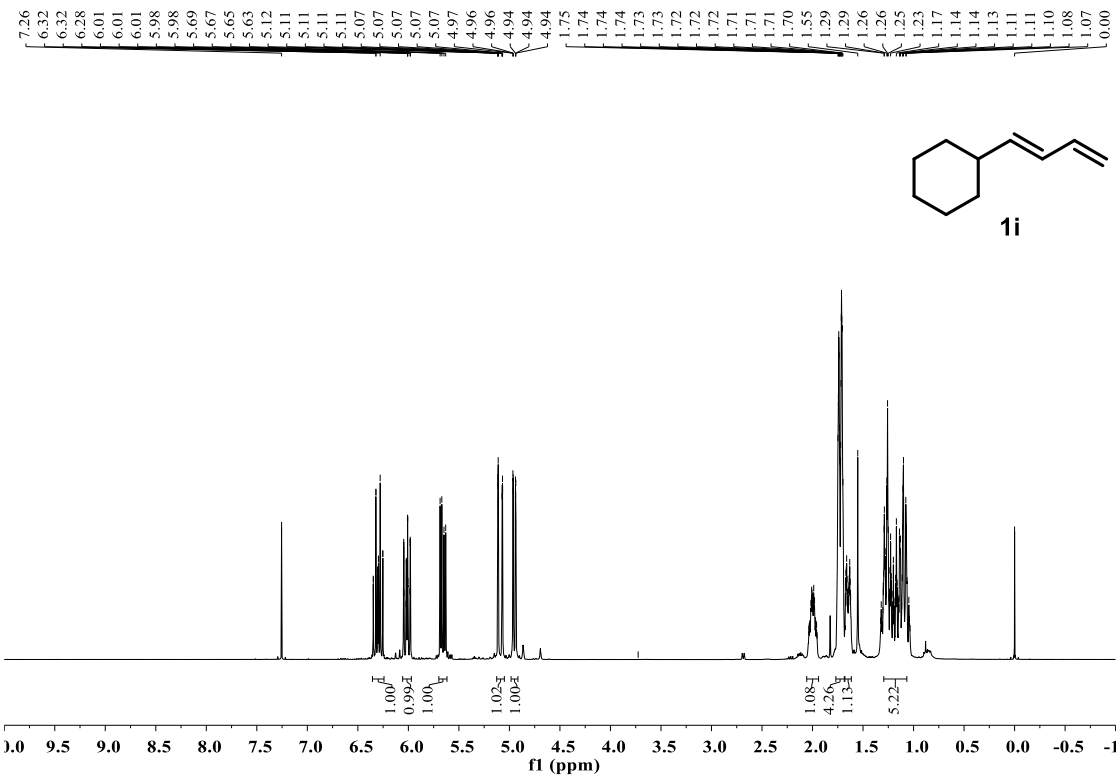


Figure S19. ^{1}H NMR spectra of substrate **1i**, related to **Figure 4**.

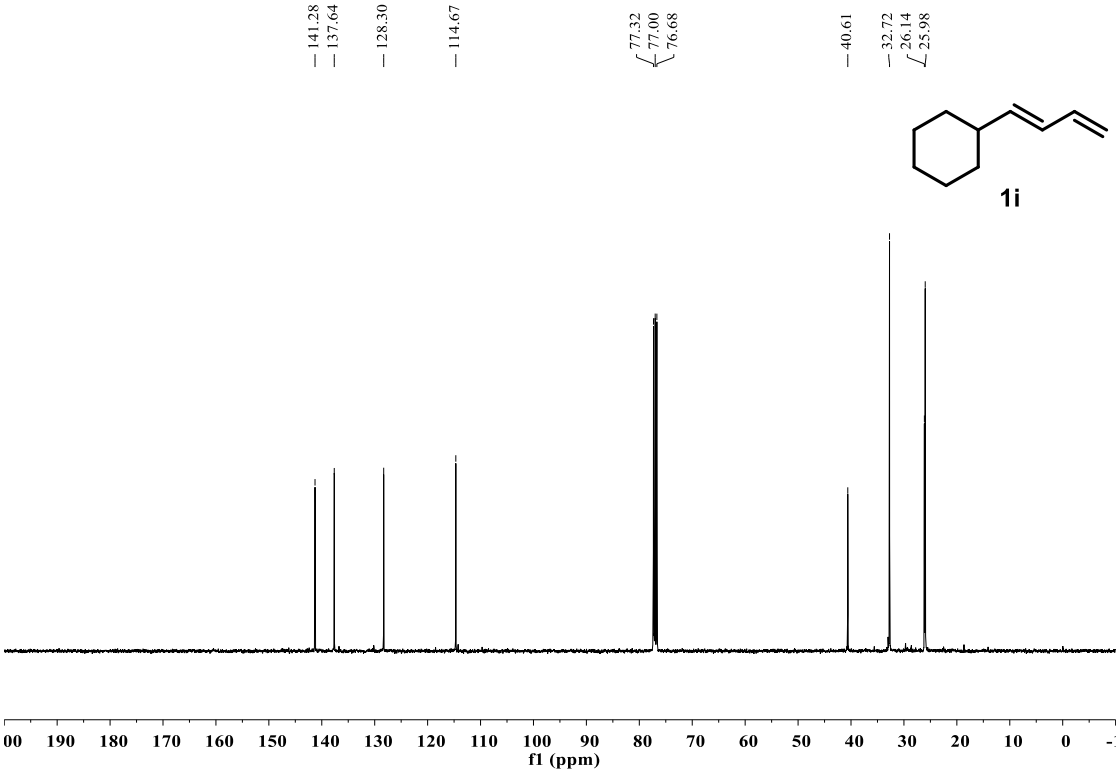


Figure S20. ^{13}C NMR spectra of substrate **1i**, related to **Figure 4**.

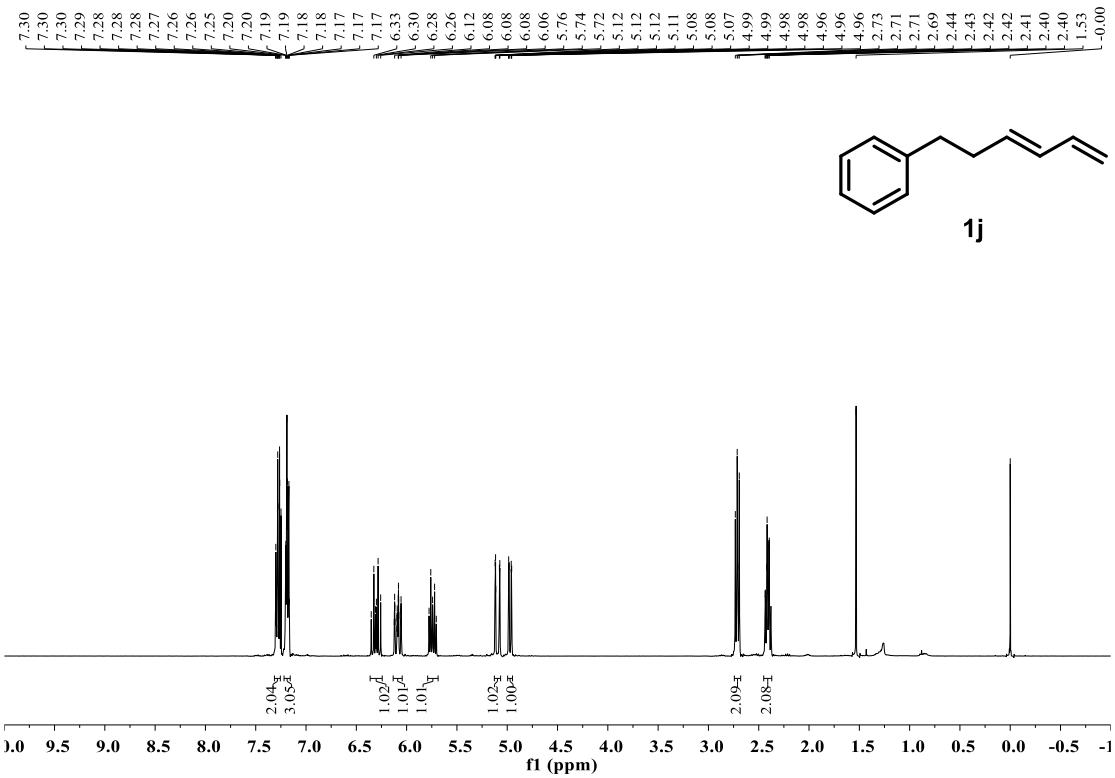


Figure S21. ^{1}H NMR spectra of substrate **1j**, related to **Figure 4**.

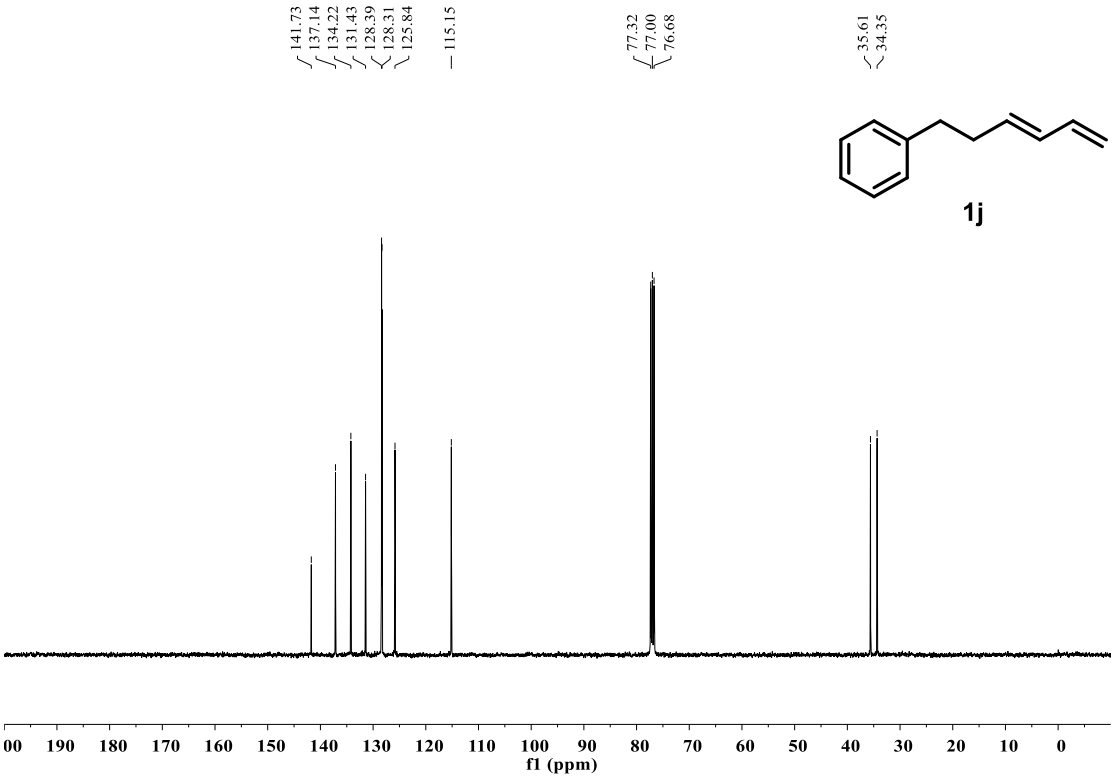


Figure S22. ^{13}C NMR spectra of substrate **1j**, related to **Figure 4**.

Supplemental figures for ^{1}H, ^{13}C and ^{19}F-NMR spectra of products 3a-3bd.

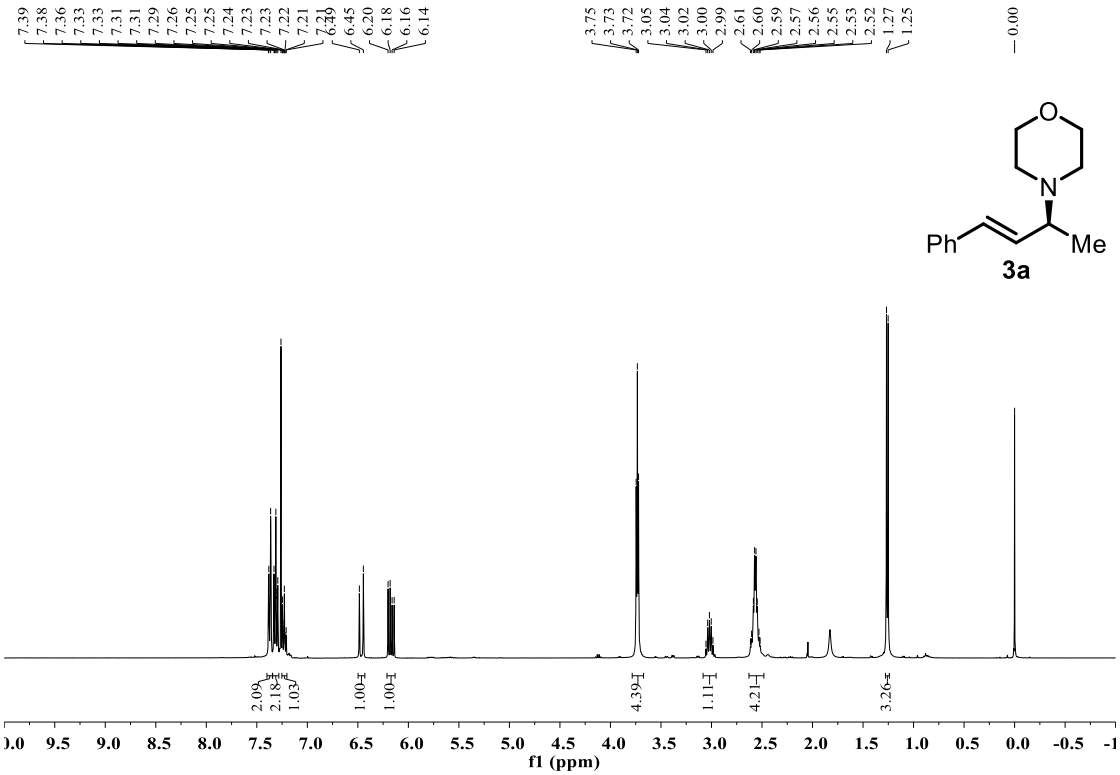


Figure S23. ^{1}H NMR spectra of **3a**, related to **Figure 3**.

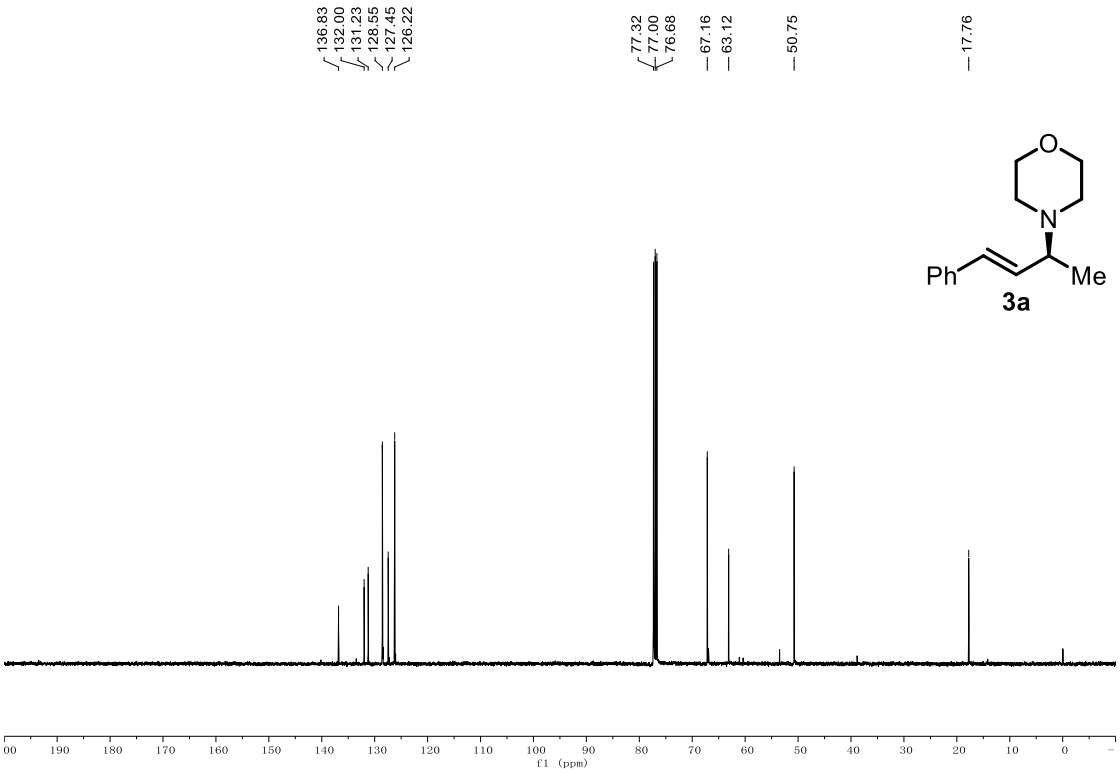


Figure S24. ^{13}C NMR spectra of **3a**, related to **Figure 3**.

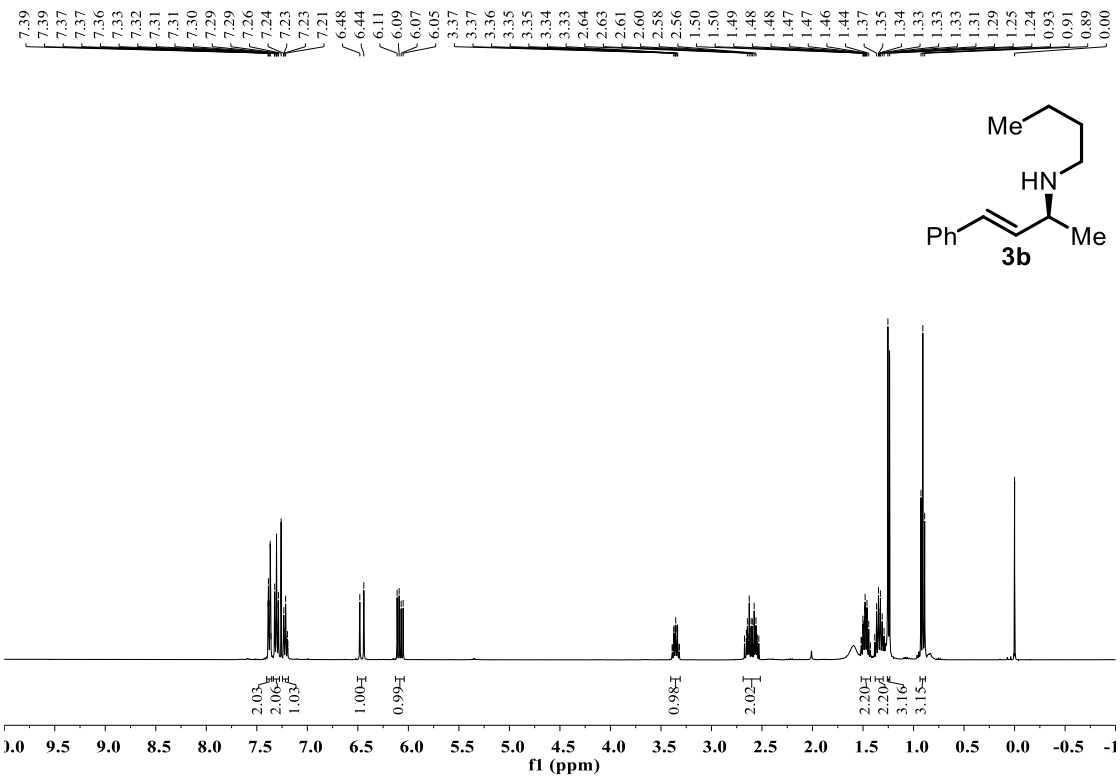


Figure S25. ^{1}H NMR spectra of **3b**, related to **Figure 3**.

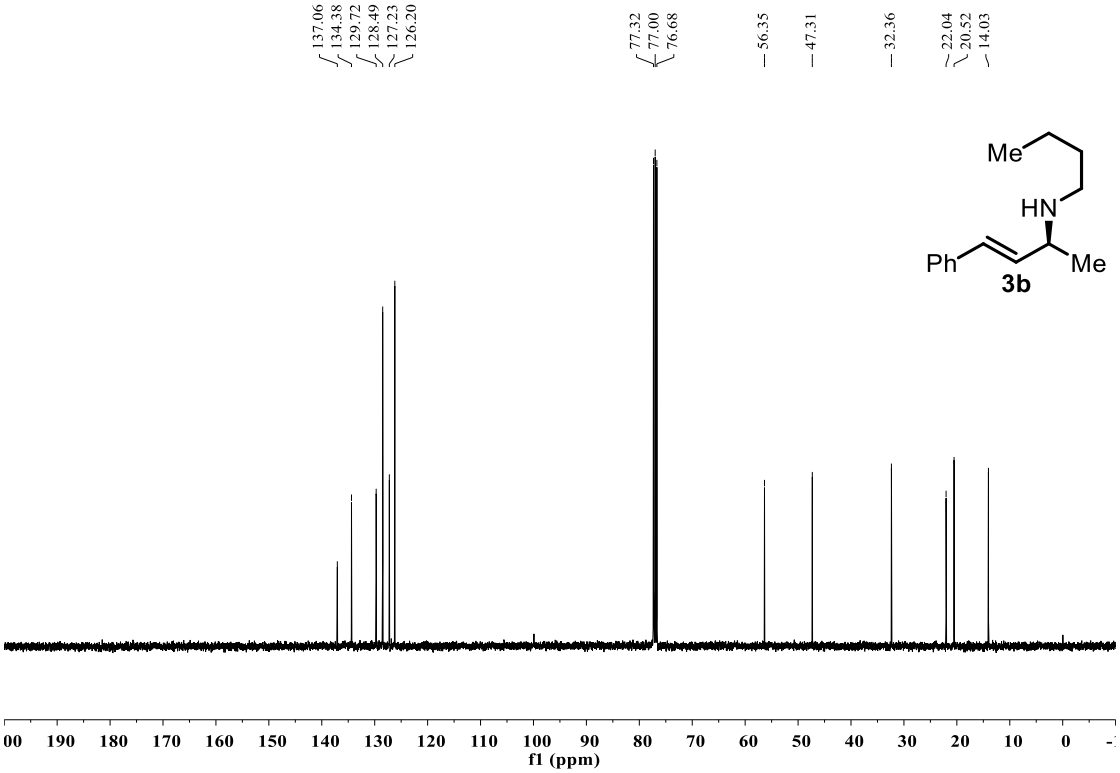


Figure S26. ^{13}C NMR spectra of **3b**, related to **Figure 3**.

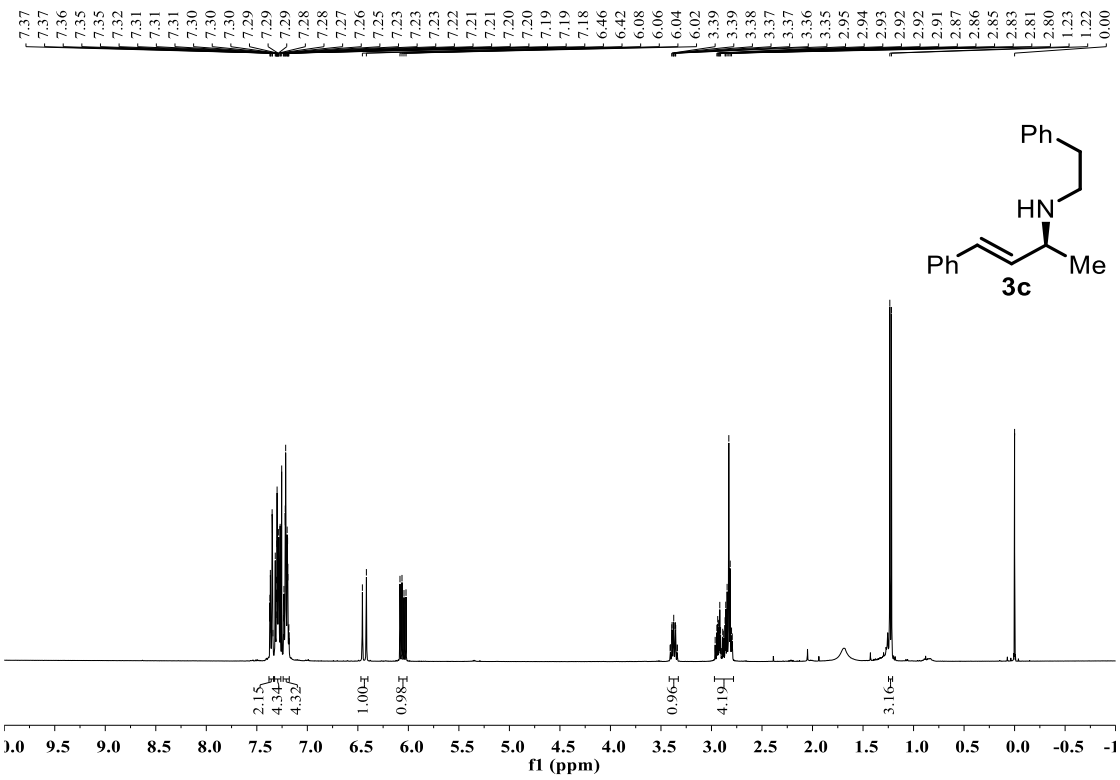


Figure S27. ^{1}H NMR spectra of **3c**, related to **Figure 3**.

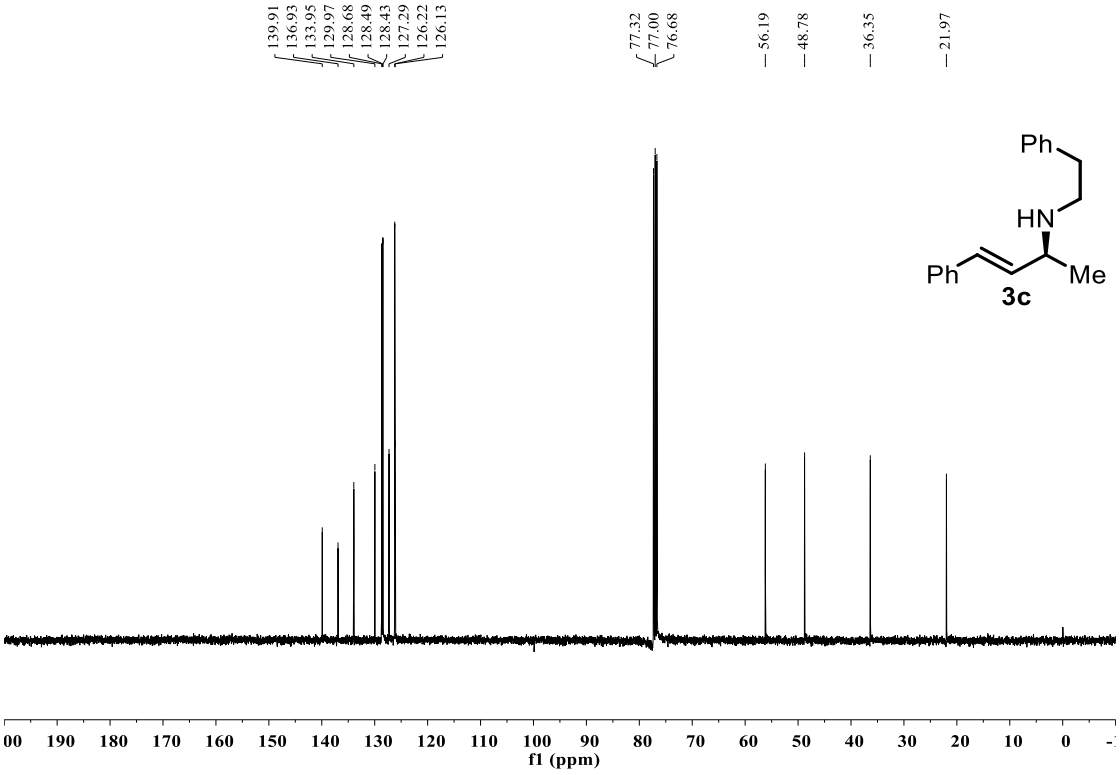


Figure S28. ^{13}C NMR spectra of **3c**, related to **Figure 3**.

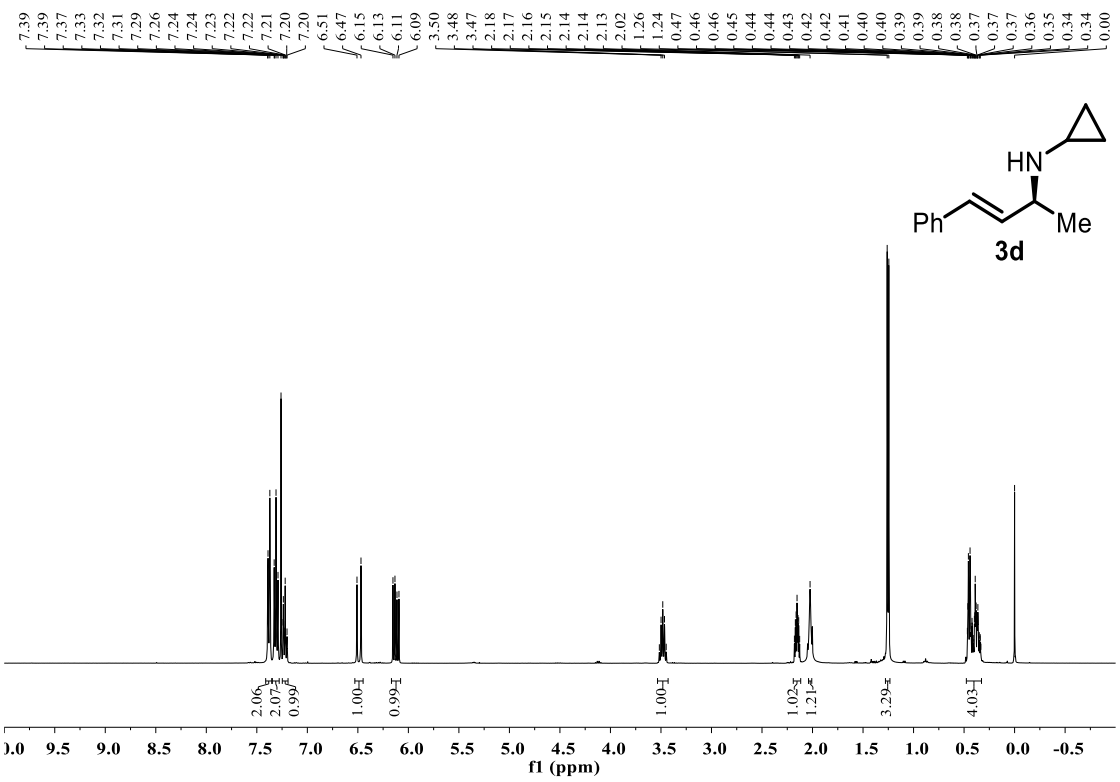


Figure S29. ^{1}H NMR spectra of **3d**, related to **Figure 3**.

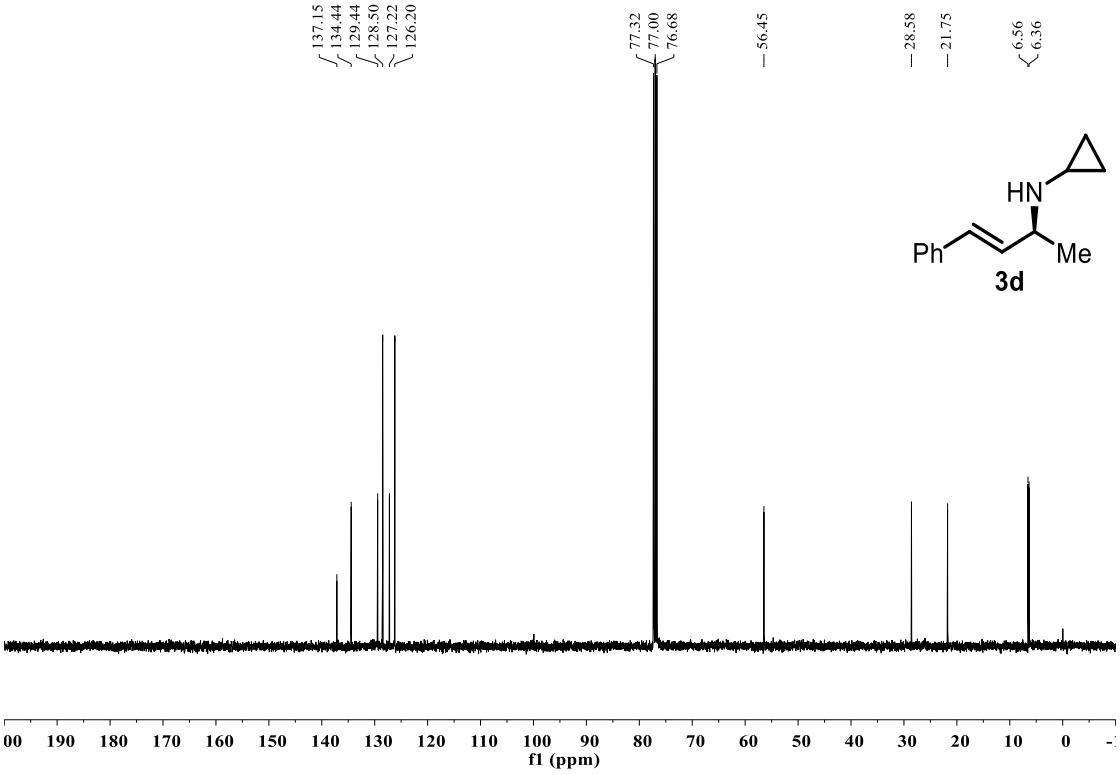


Figure S30. ^{13}C NMR spectra of **3d**, related to **Figure 3**.

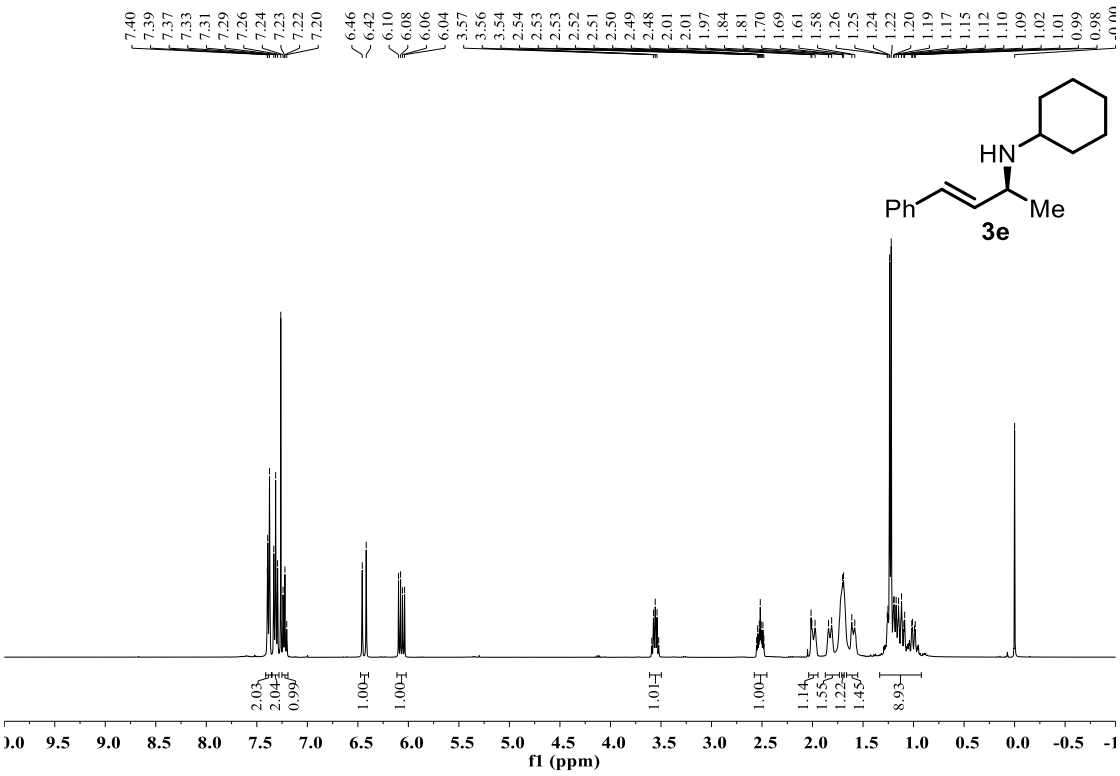


Figure S31. ^{1}H NMR spectra of **3e**, related to **Figure 3**.

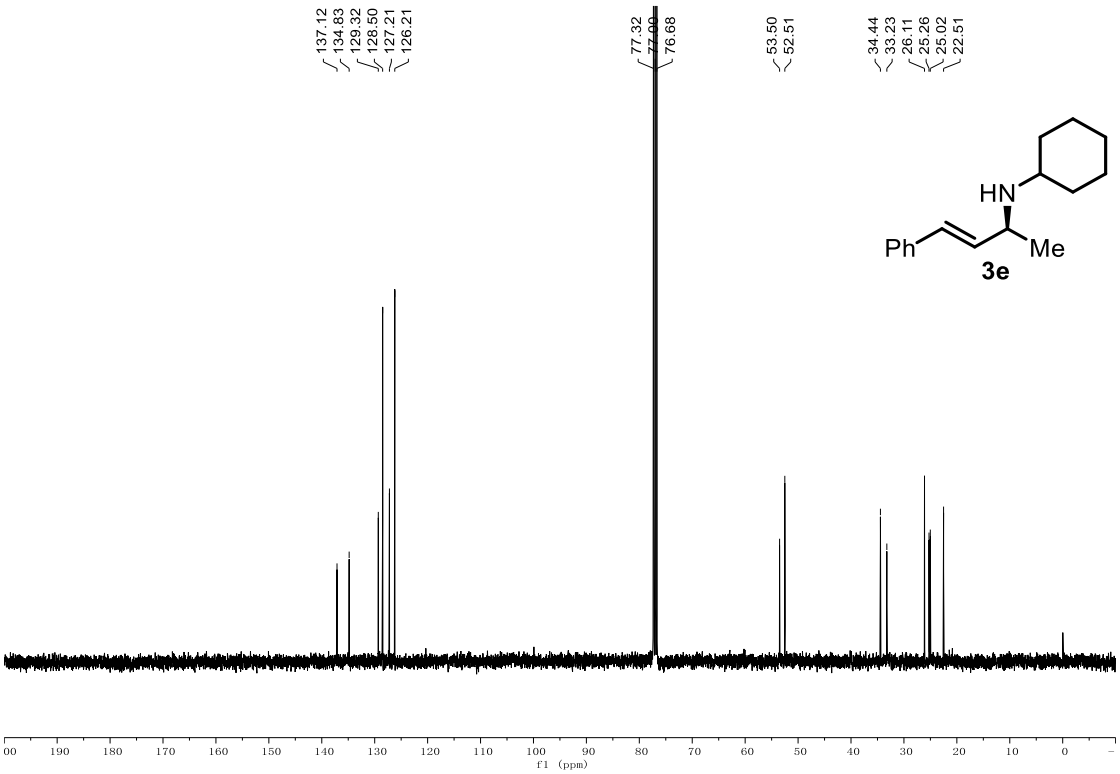


Figure S32. ^{13}C NMR spectra of **3e**, related to **Figure 3**.

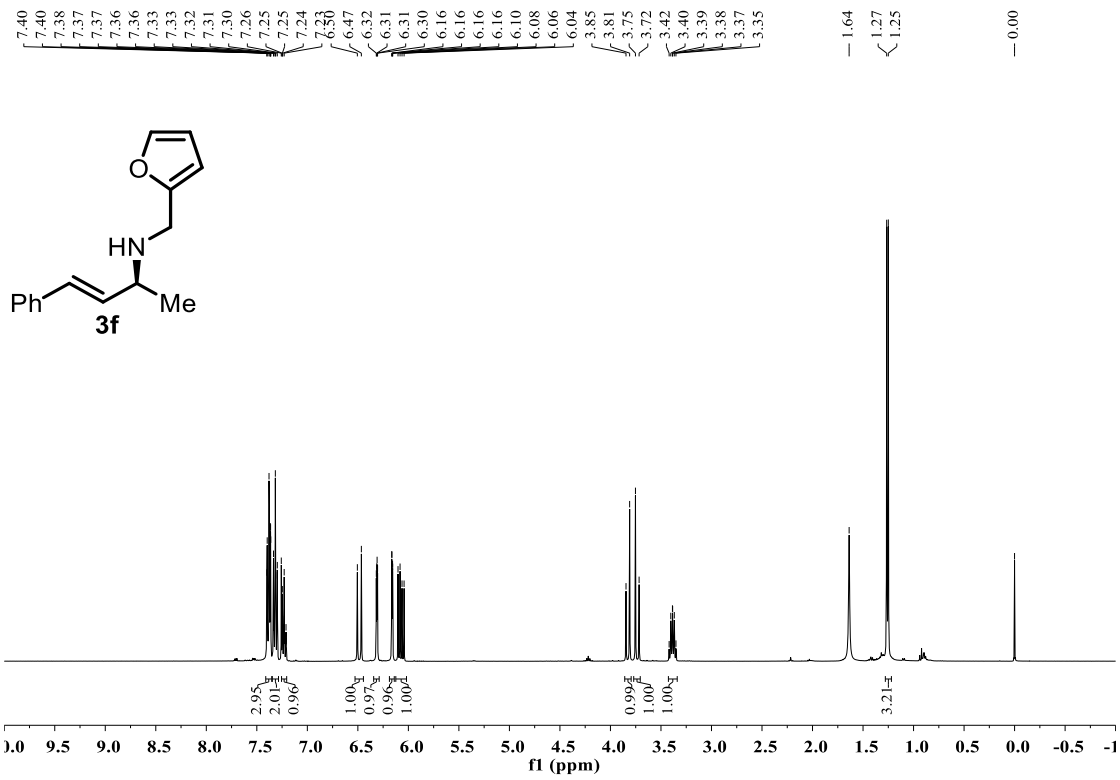


Figure S33. ^{1}H NMR spectra of **3f**, related to **Figure 3**.

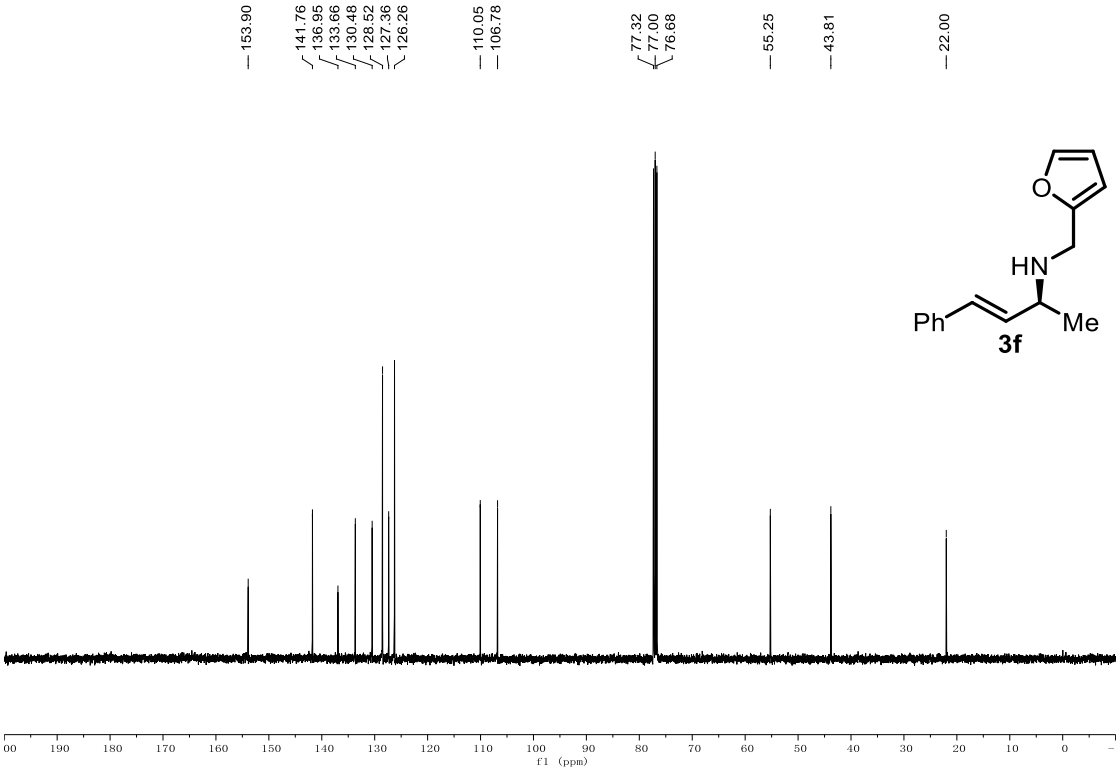


Figure S34. ^{13}C NMR spectra of **3f**, related to **Figure 3**.

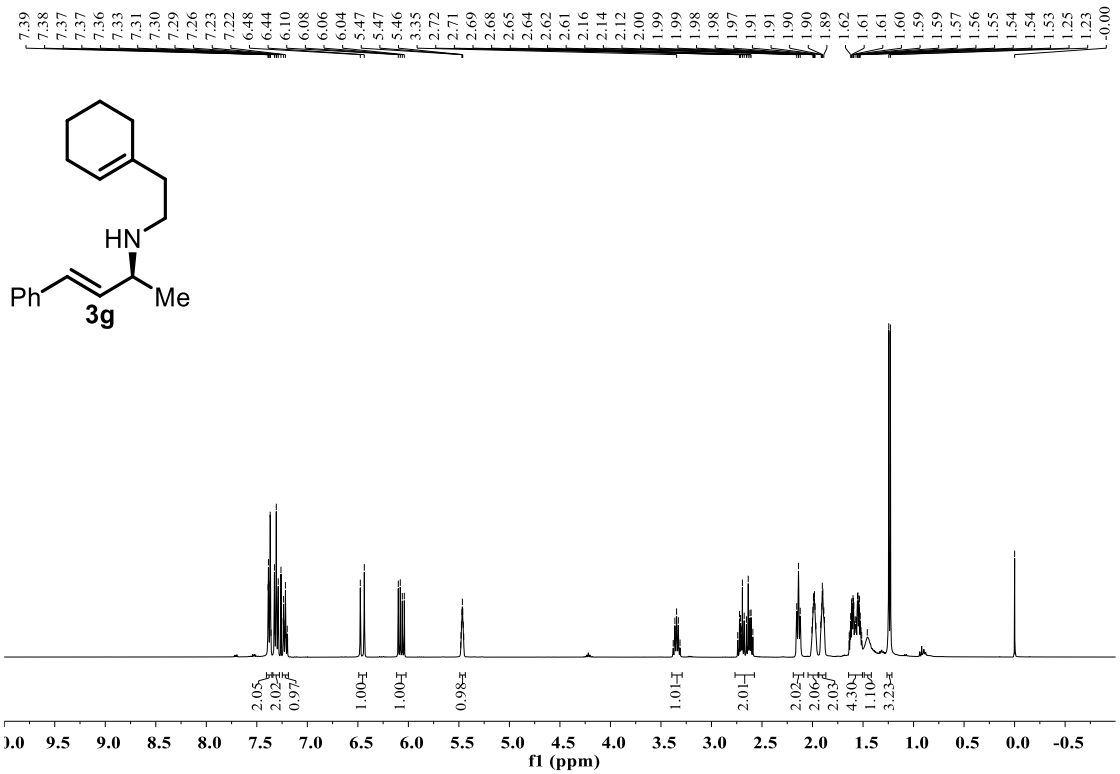


Figure S35. ^{1}H NMR spectra of **3g**, related to **Figure 3**.

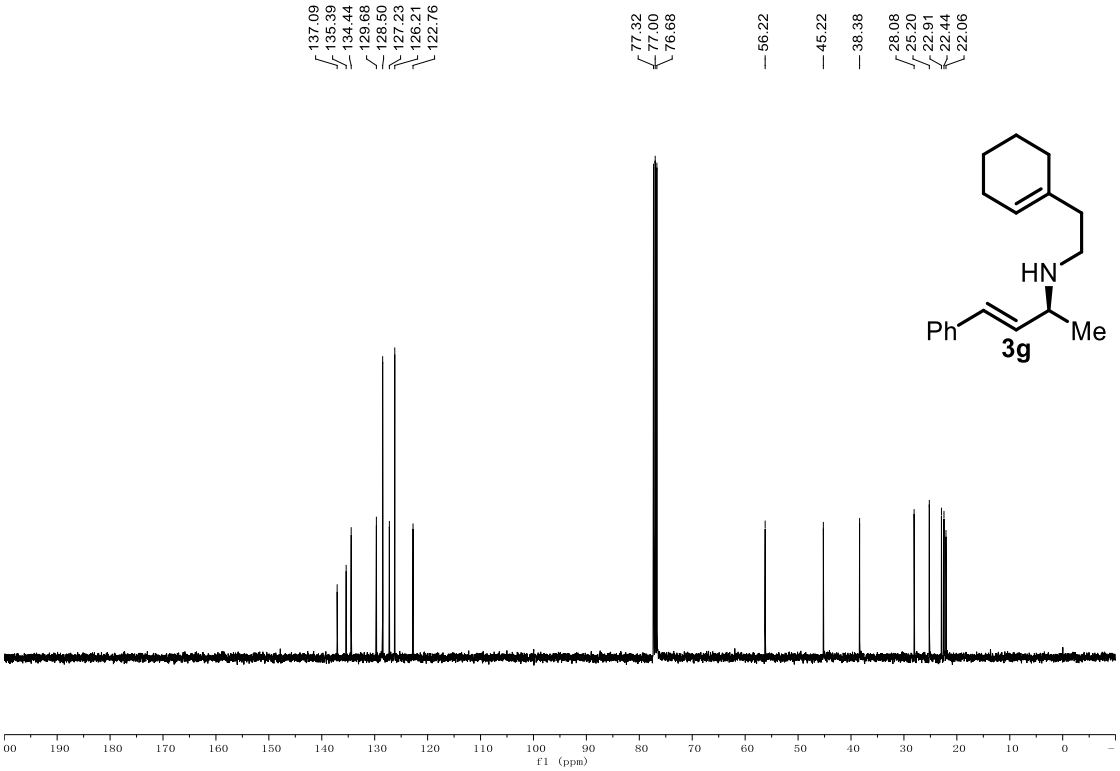


Figure S36. ^{13}C NMR spectra of **3g**, related to **Figure 3**.

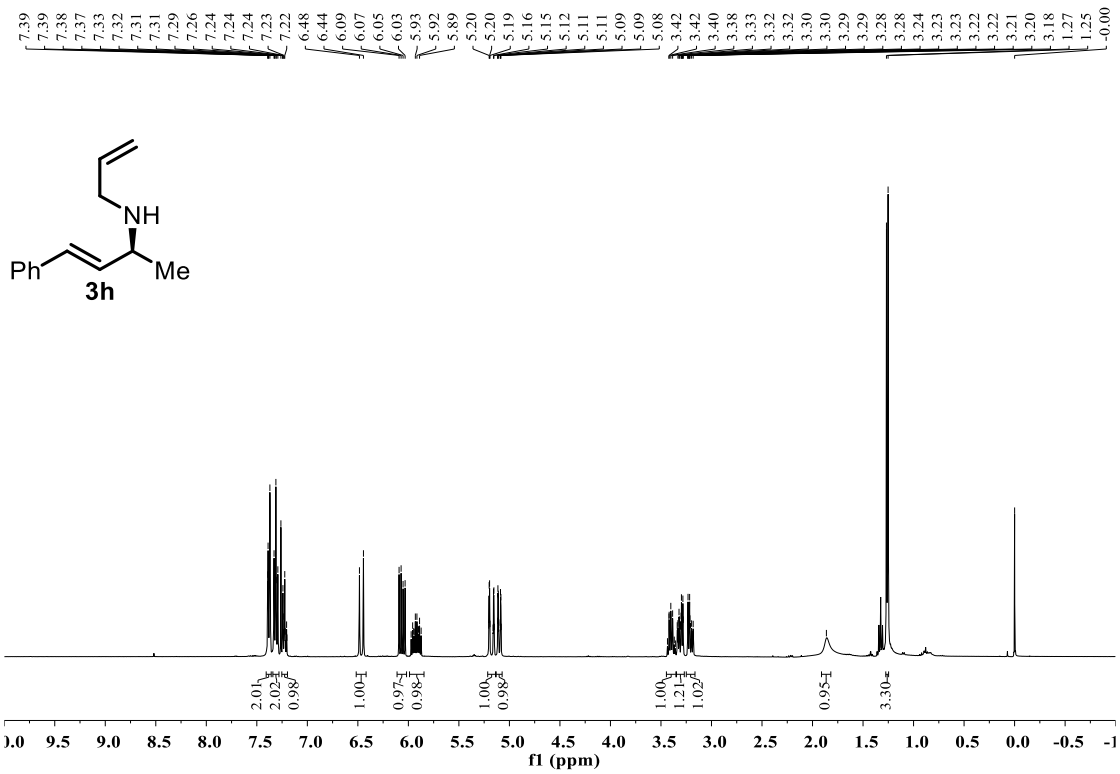


Figure S37. ^{1}H NMR spectra of **3h**, related to **Figure 3**.

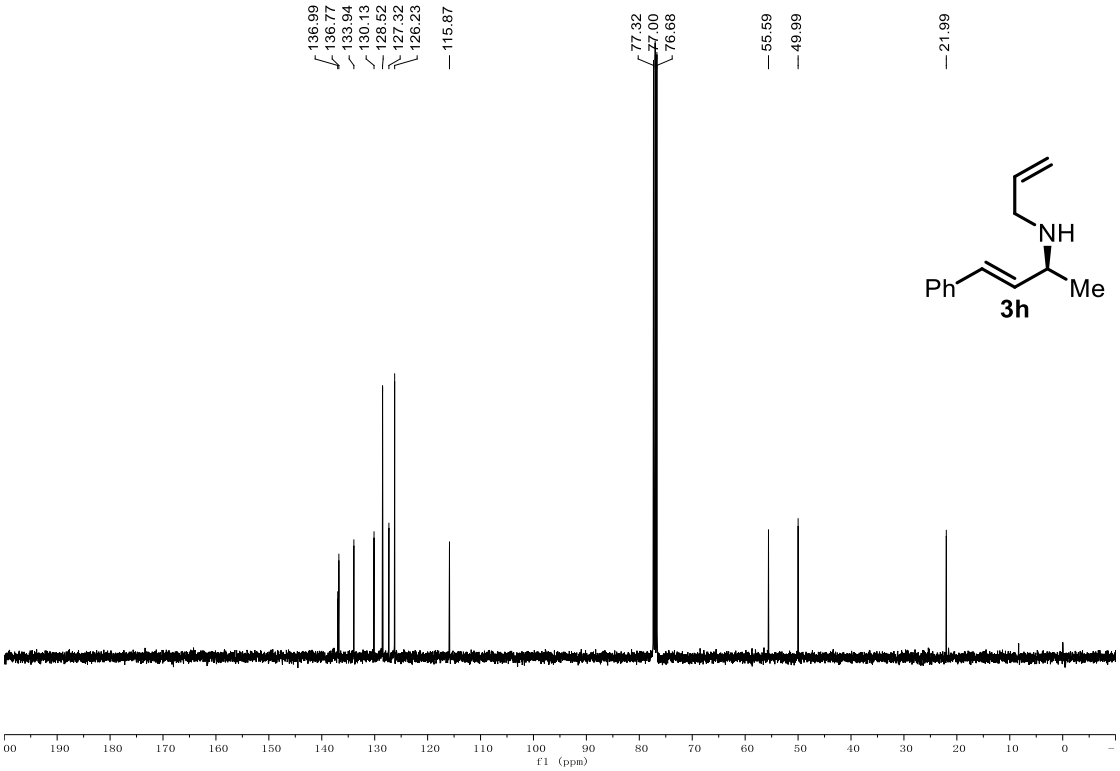


Figure S38. ^{13}C NMR spectra of **3h**, related to **Figure 3**.

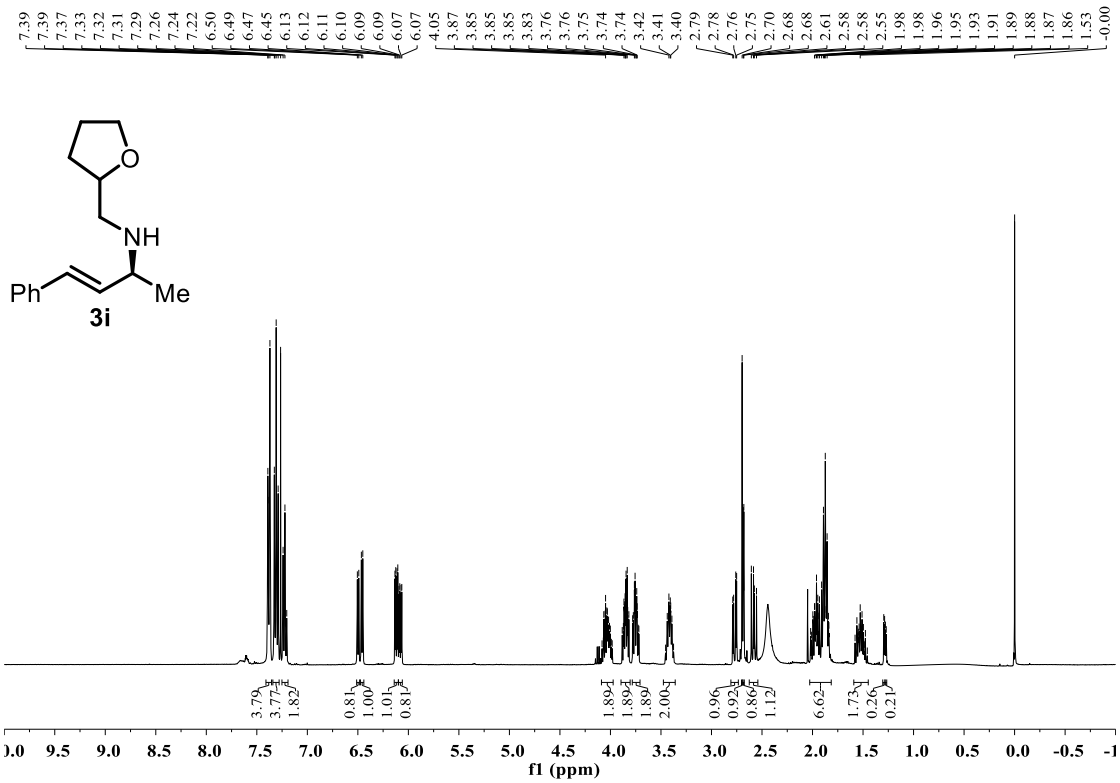


Figure S39. [1]H NMR spectra of **3i**, related to **Figure 3**.

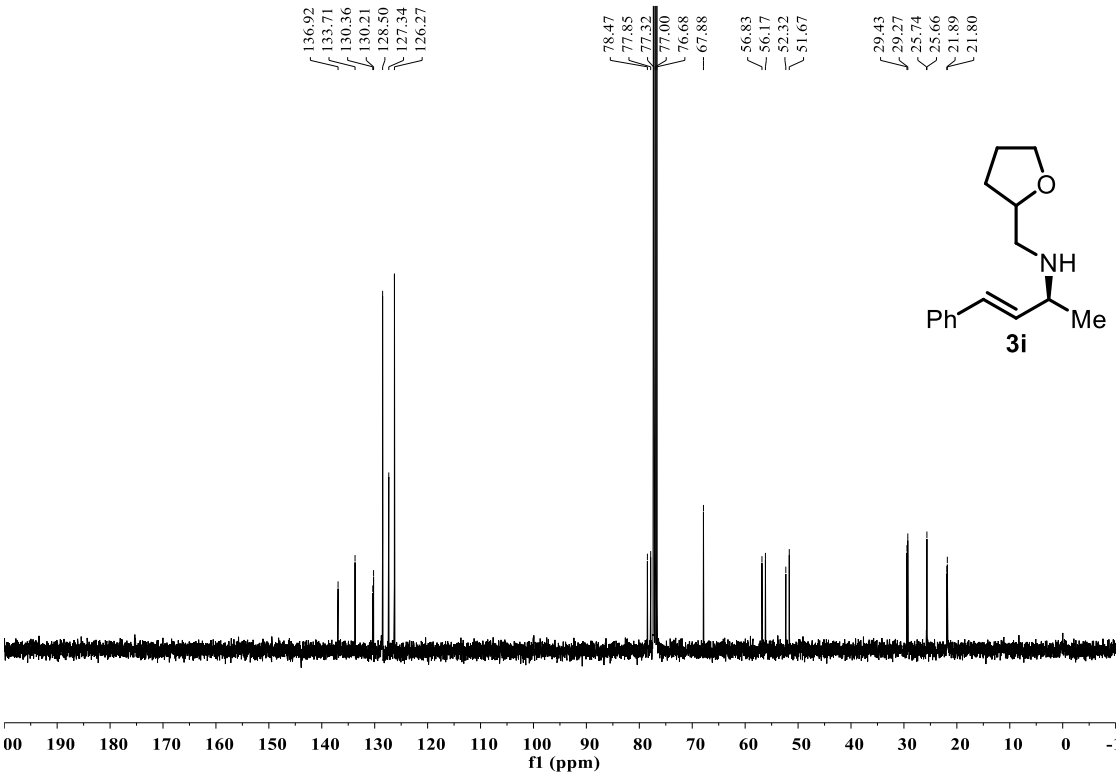


Figure S40. [13]C NMR spectra of **3i**, related to **Figure 3**.

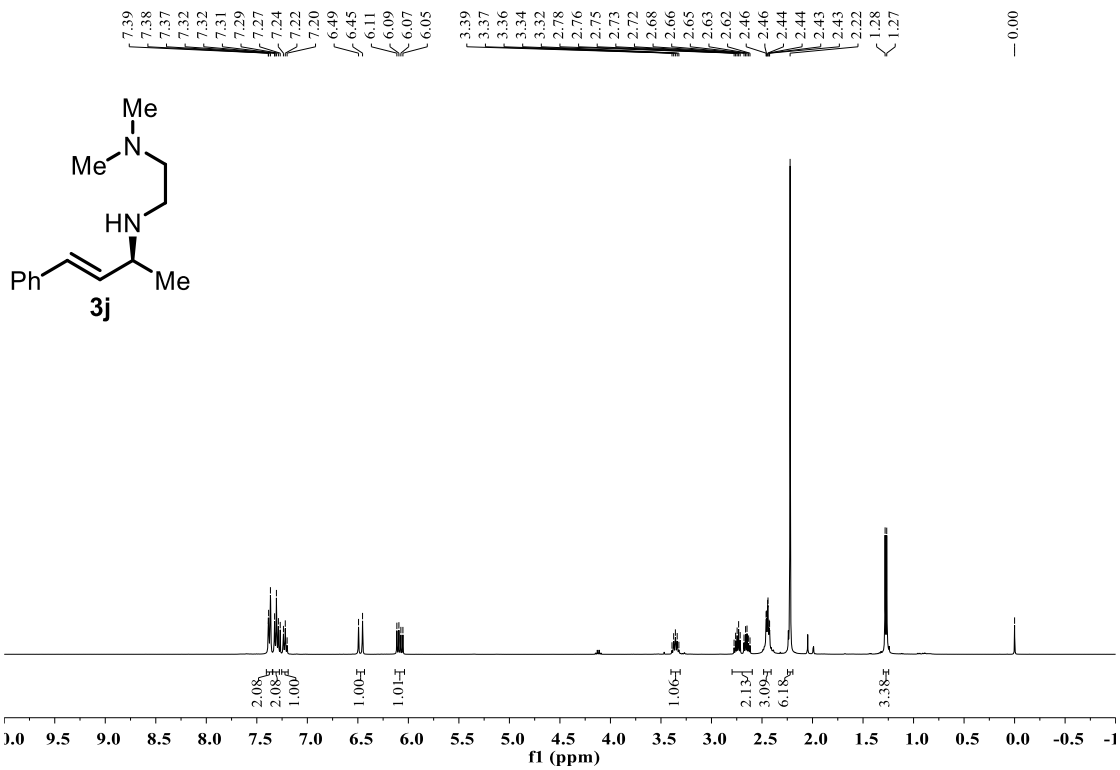


Figure S41. [1]H NMR spectra of **3j**, related to **Figure 3**.

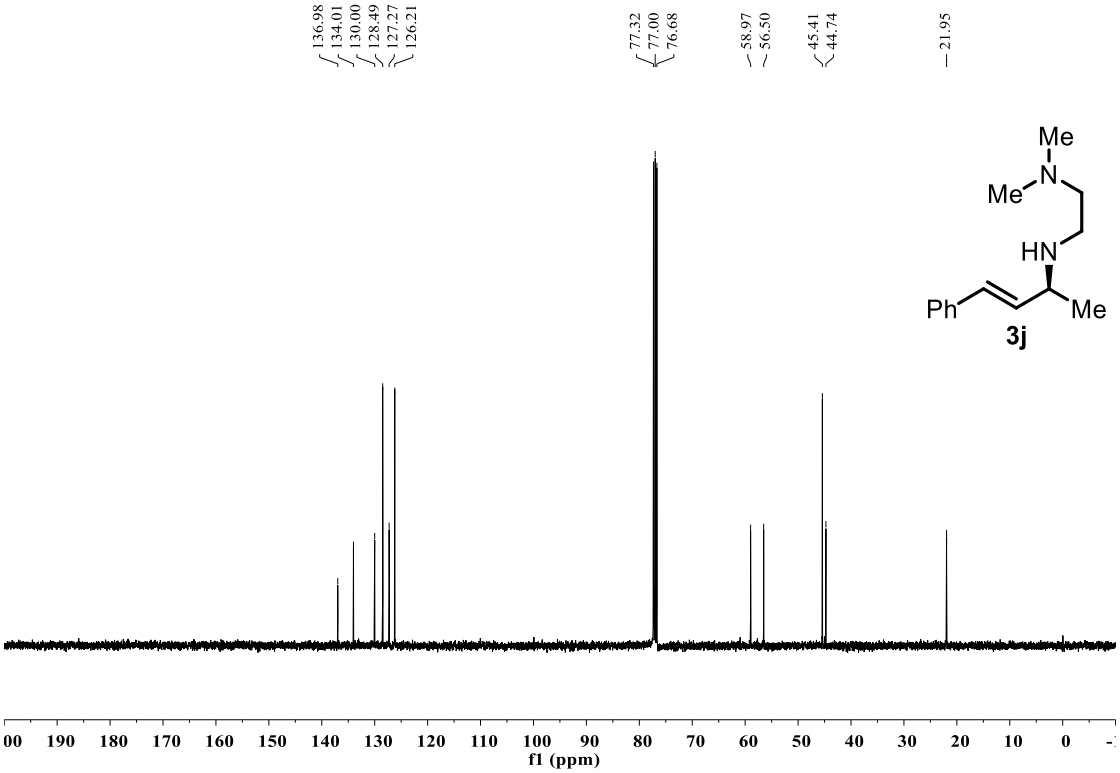


Figure S42. [13]C NMR spectra of **3j**, related to **Figure 3**.

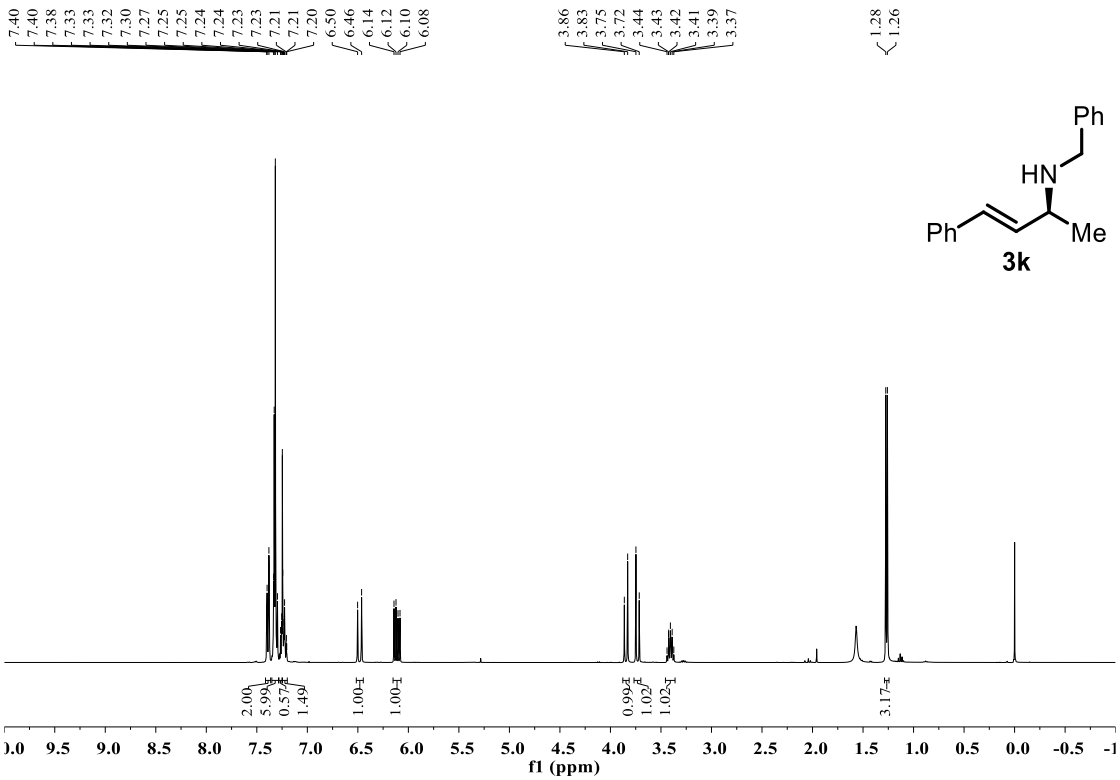


Figure S43. ^{1}H NMR spectra of **3k**, related to **Figure 3**.

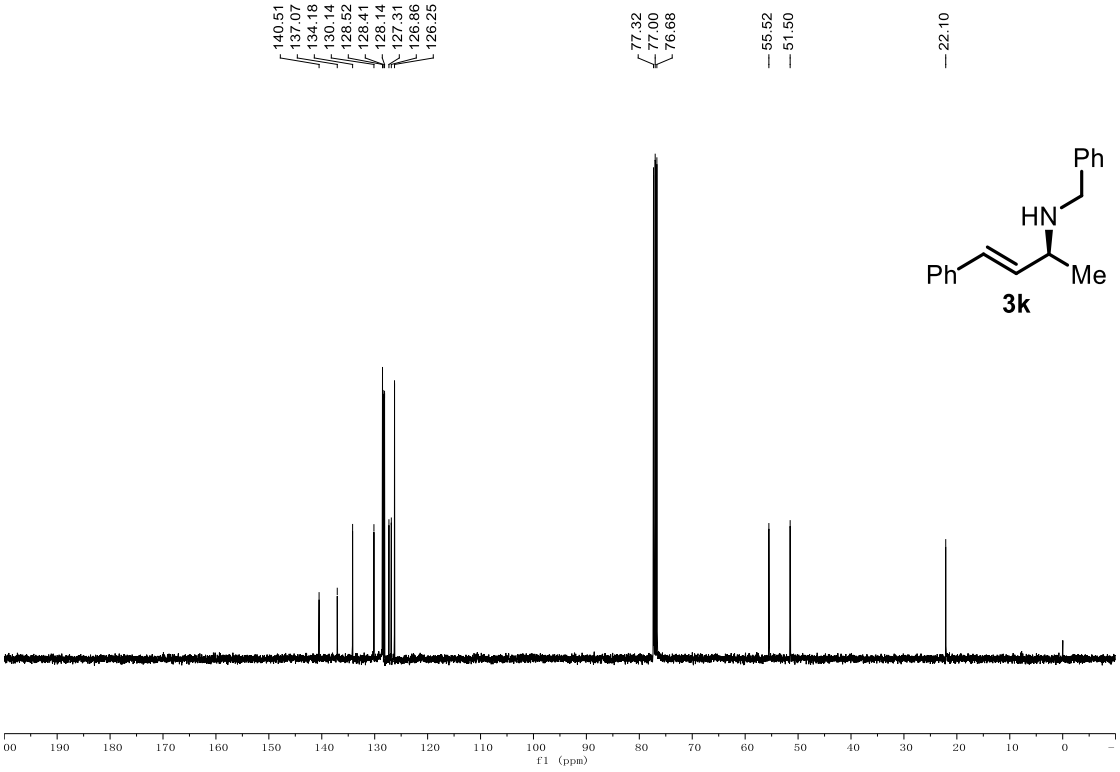


Figure S44. ^{13}C NMR spectra of **3k**, related to **Figure 3**.

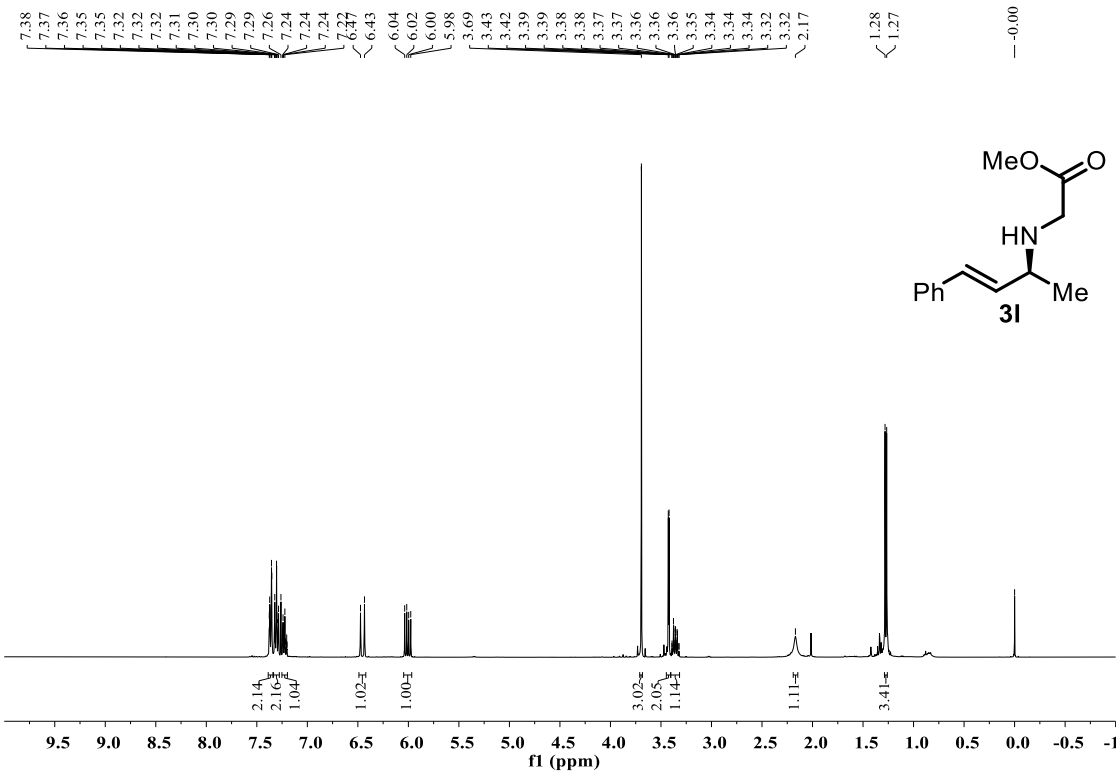


Figure S45. ^{1}H NMR spectra of **3l**, related to **Figure 3**.

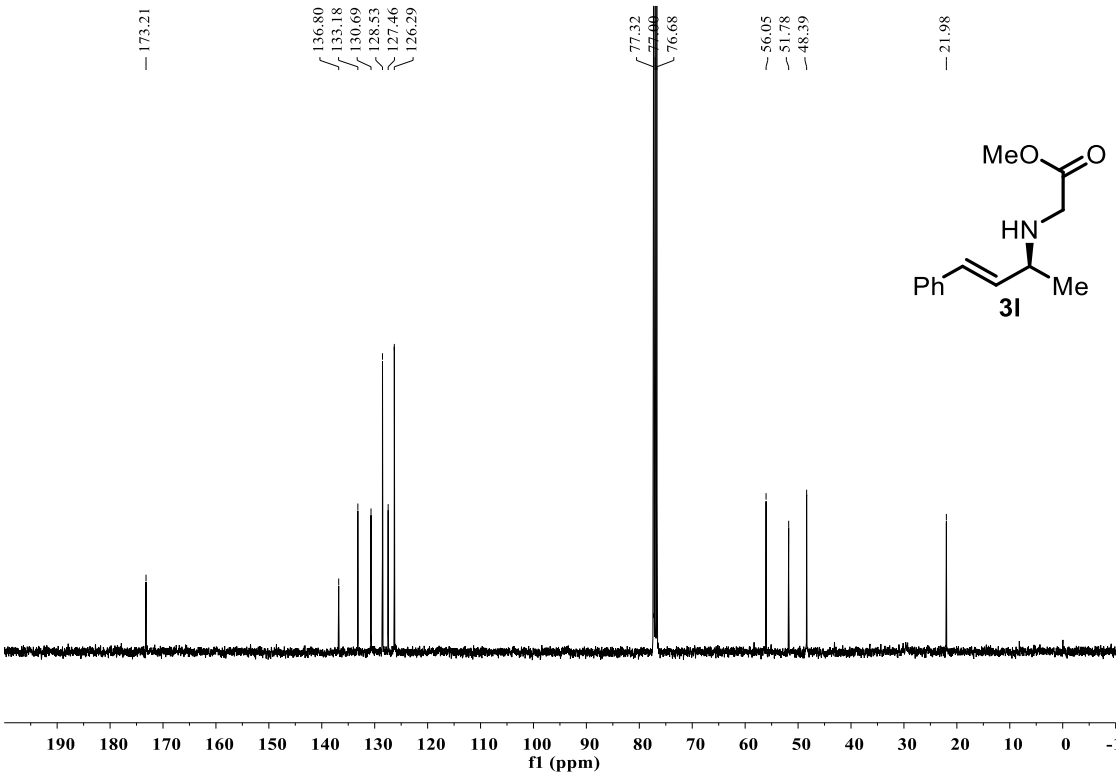


Figure S46. ^{13}C NMR spectra of **3l**, related to **Figure 3**.

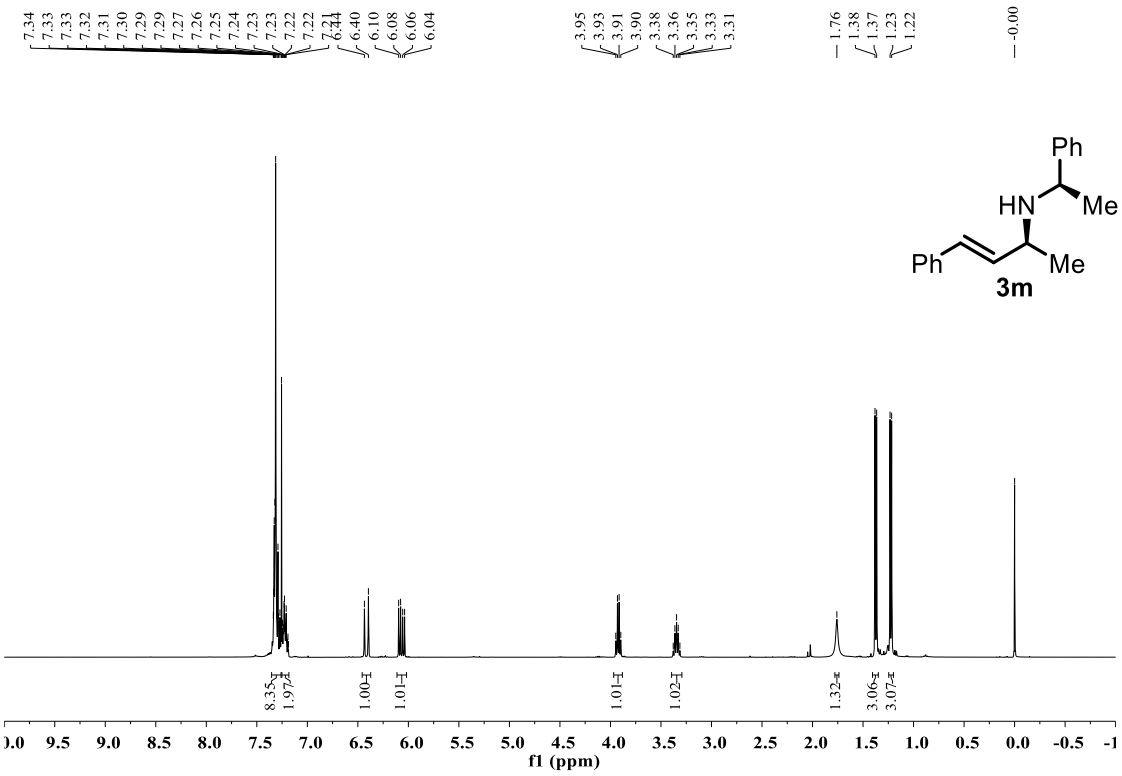


Figure S47. ^{1}H NMR spectra of **3m**, related to **Figure 3**.

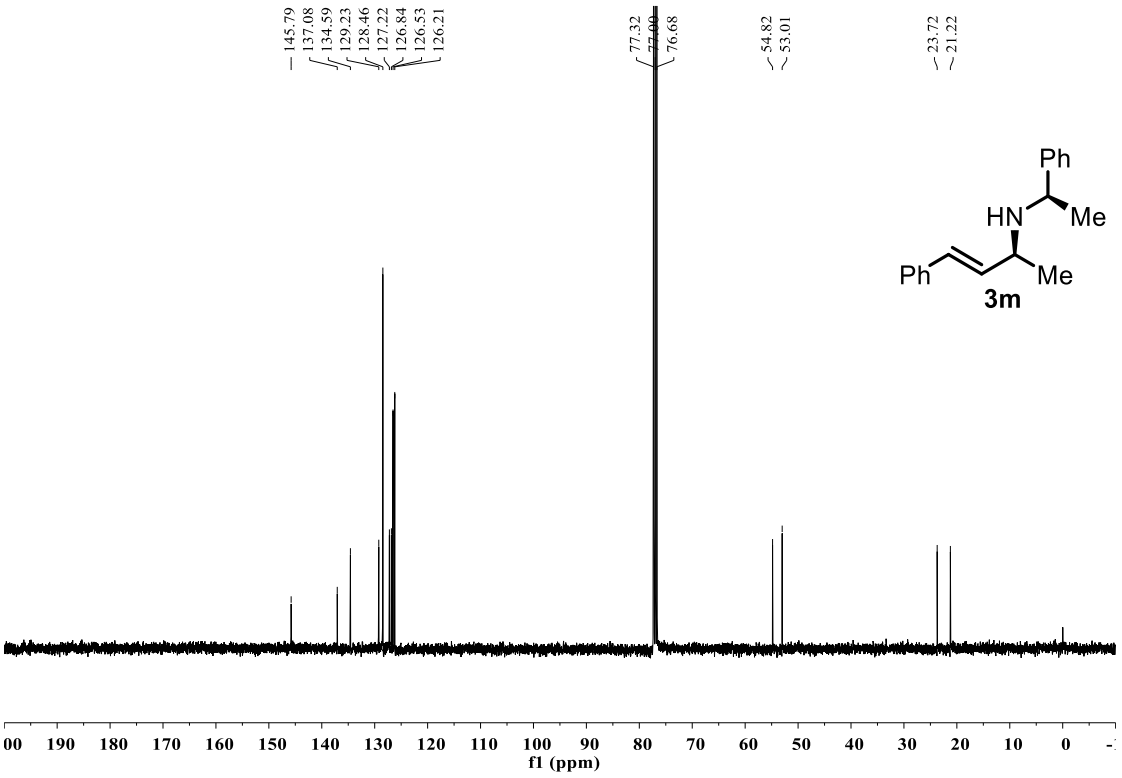


Figure S48. ^{13}C NMR spectra of **3m**, related to **Figure 3**.

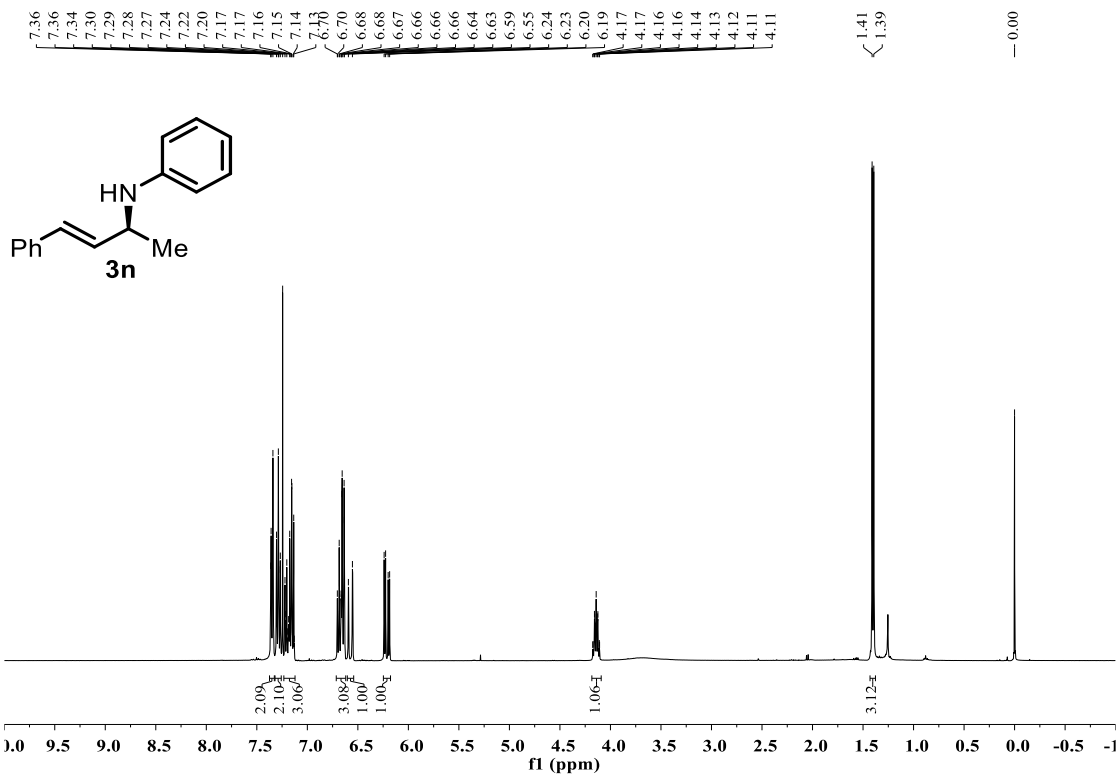


Figure S49. ^{1}H NMR spectra of **3n**, related to **Figure 3**.

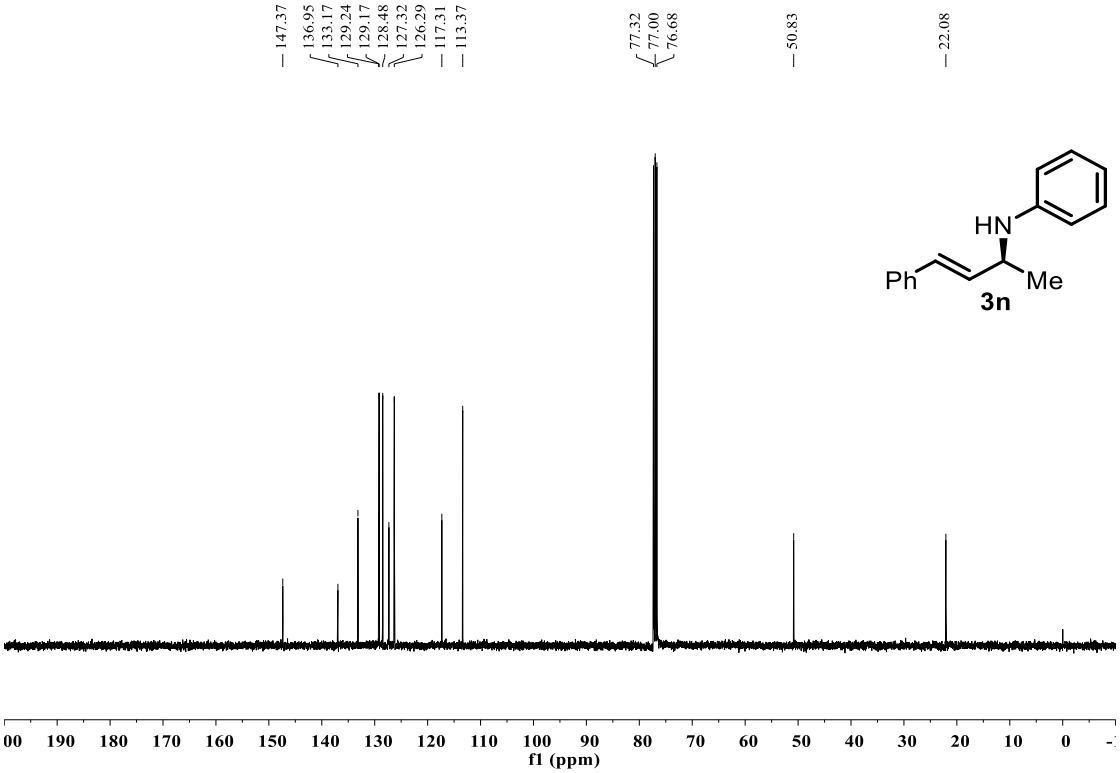


Figure S50. ^{13}C NMR spectra of **3n**, related to **Figure 3**.

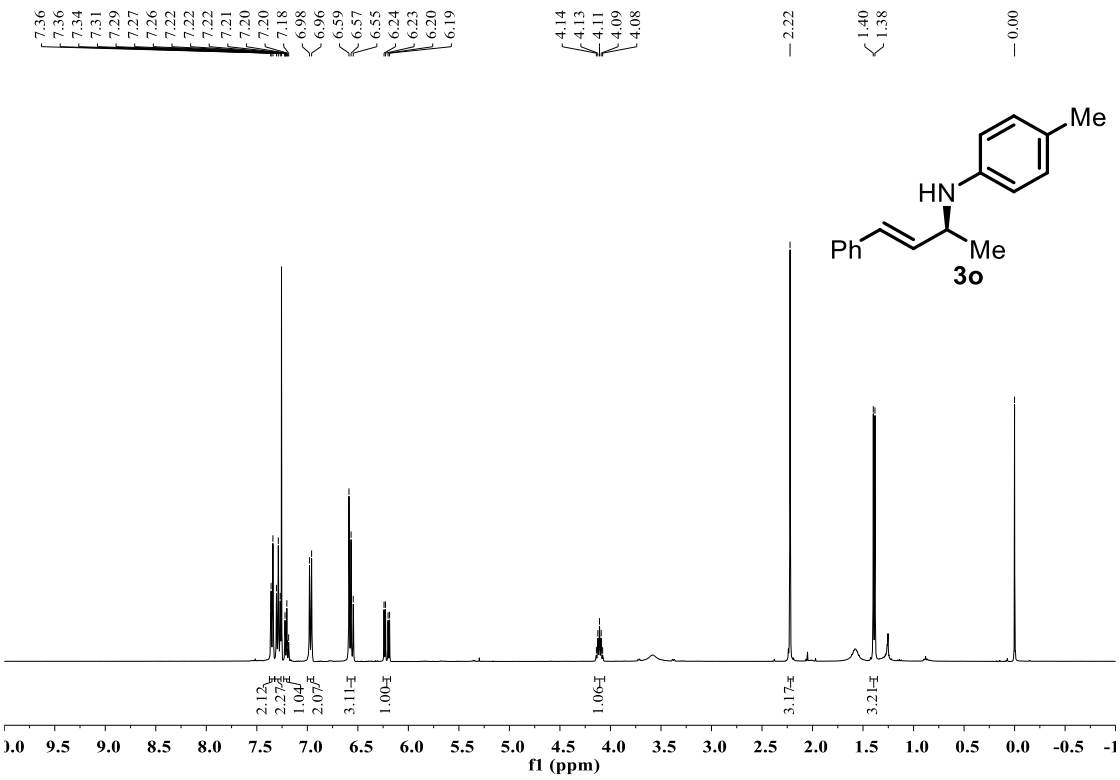


Figure S51. ^{1}H NMR spectra of **3o**, related to **Figure 3**.

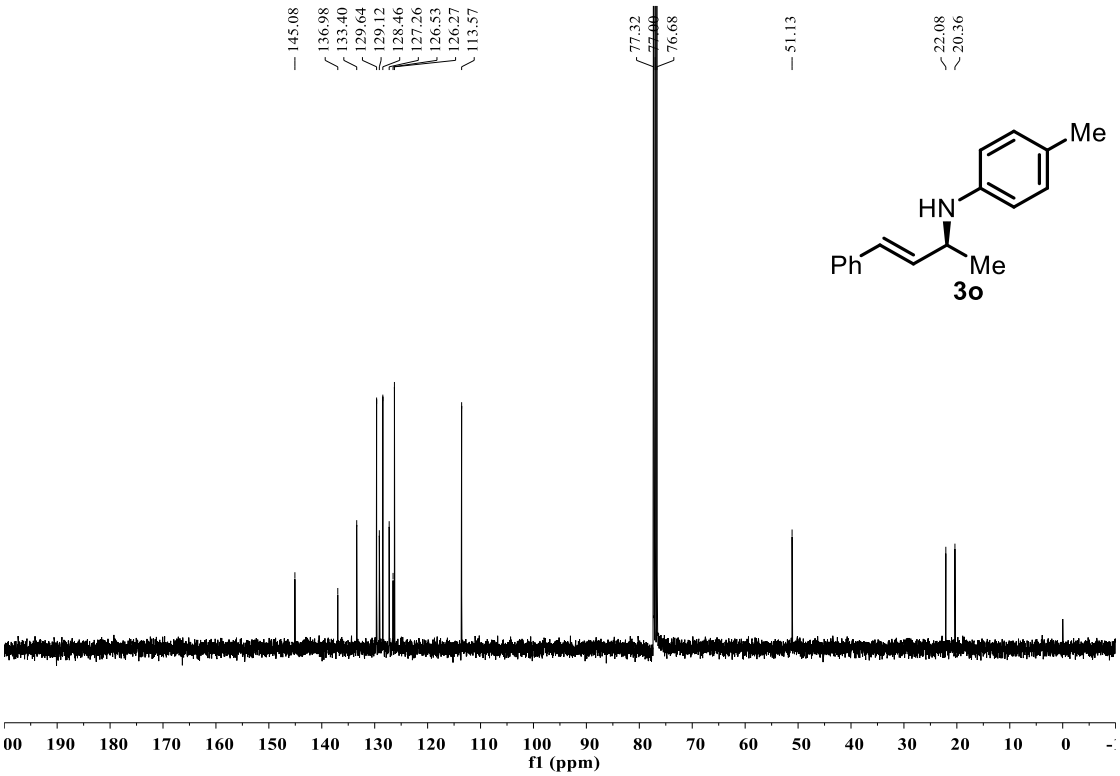


Figure S52. ^{13}C NMR spectra of **3o**, related to **Figure 3**.

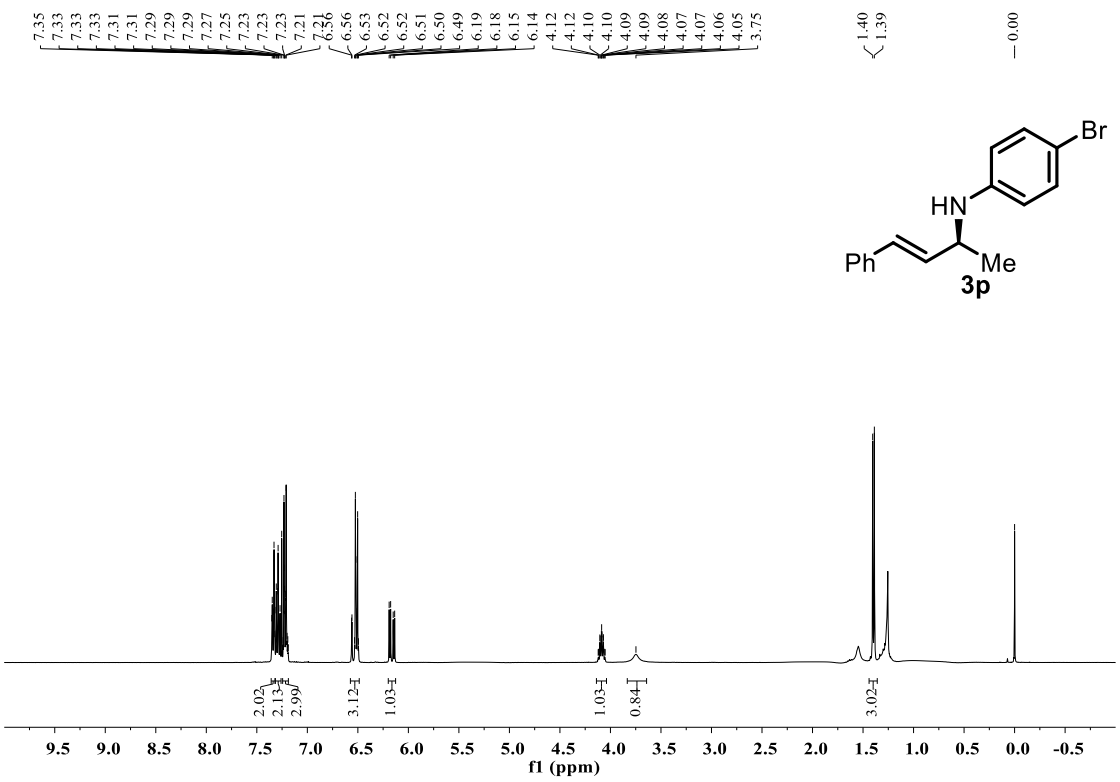


Figure S53. ^{1}H NMR spectra of **3p**, related to **Figure 3**.

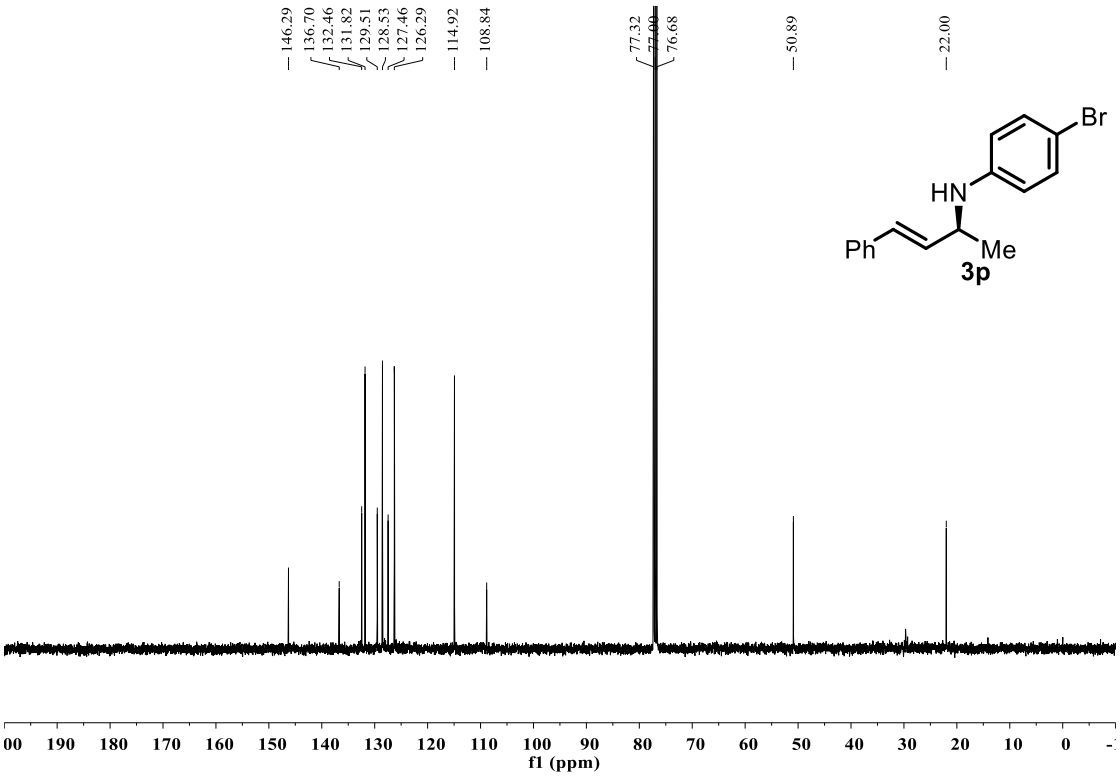


Figure S54. ^{13}C NMR spectra of **3p**, related to **Figure 3**.

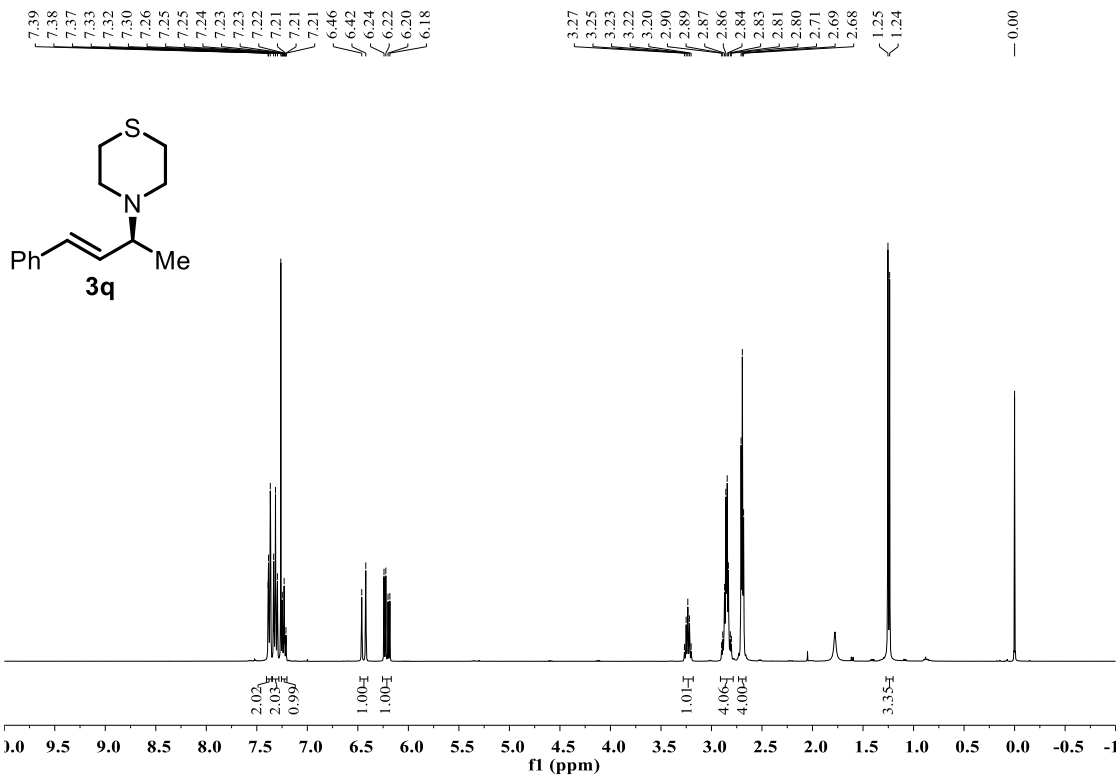


Figure S55. ^{1}H NMR spectra of **3q**, related to **Figure 3**.

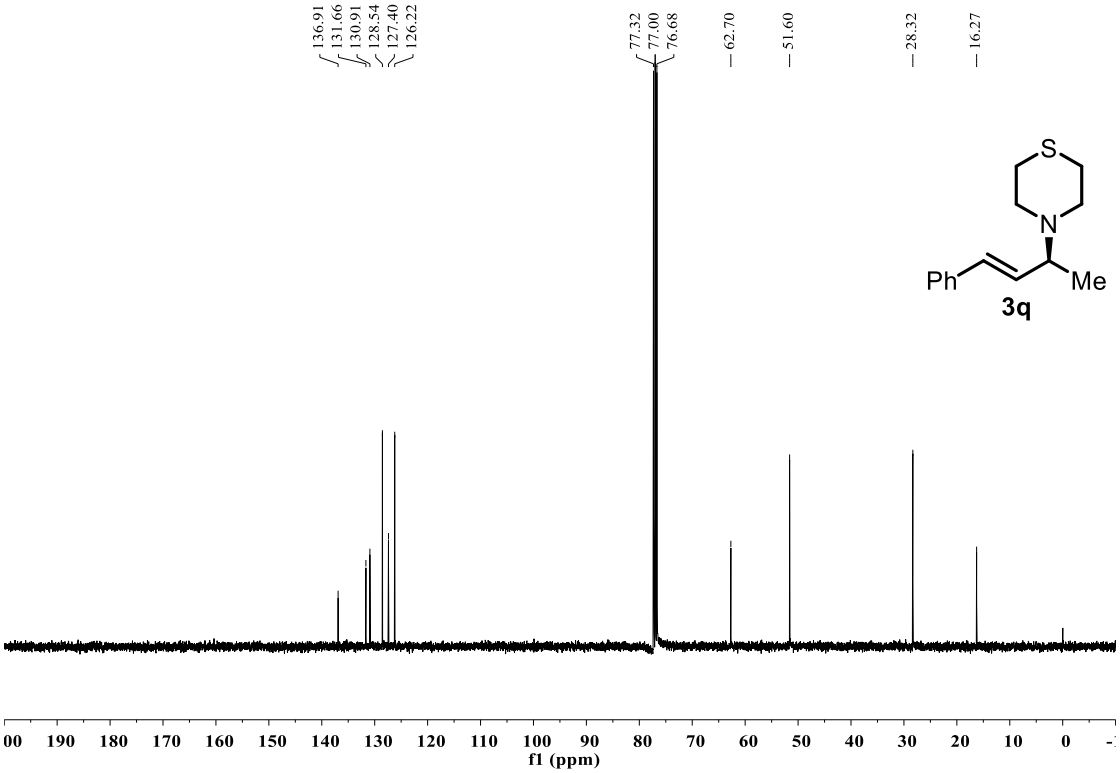


Figure S56. ^{13}C NMR spectra of **3q**, related to **Figure 3**.

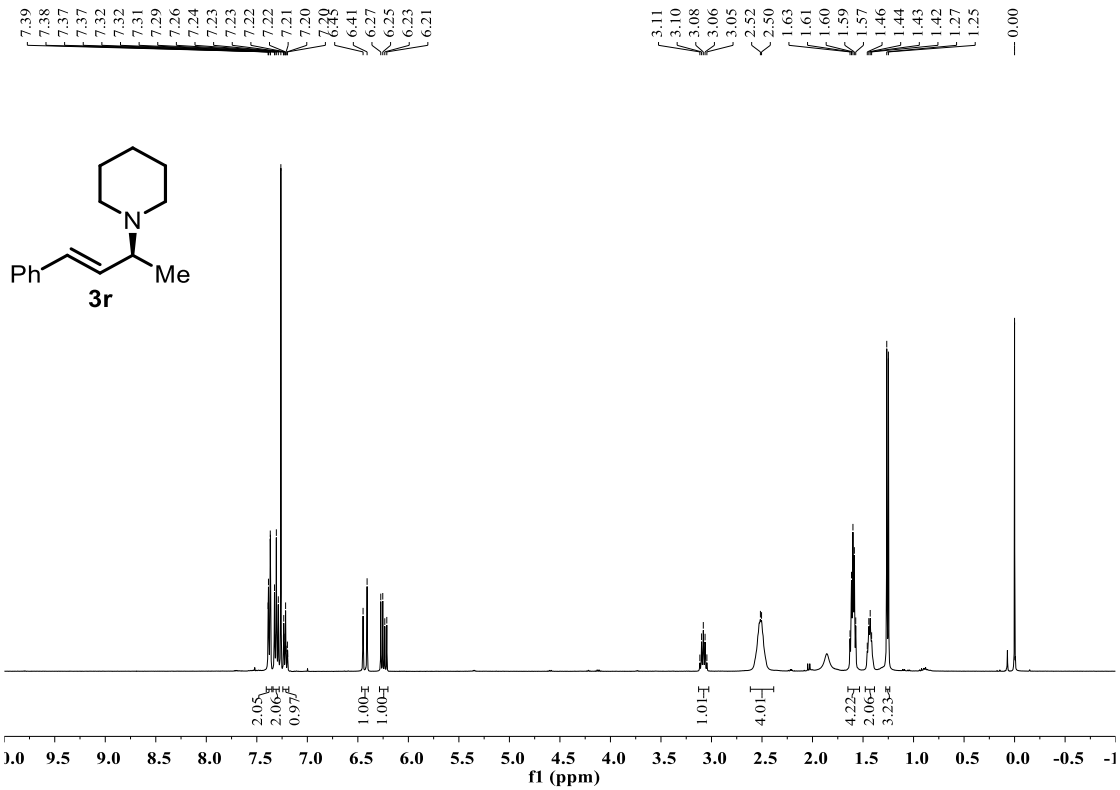


Figure S57. ^{1}H NMR spectra of **3r**, related to **Figure 3**.

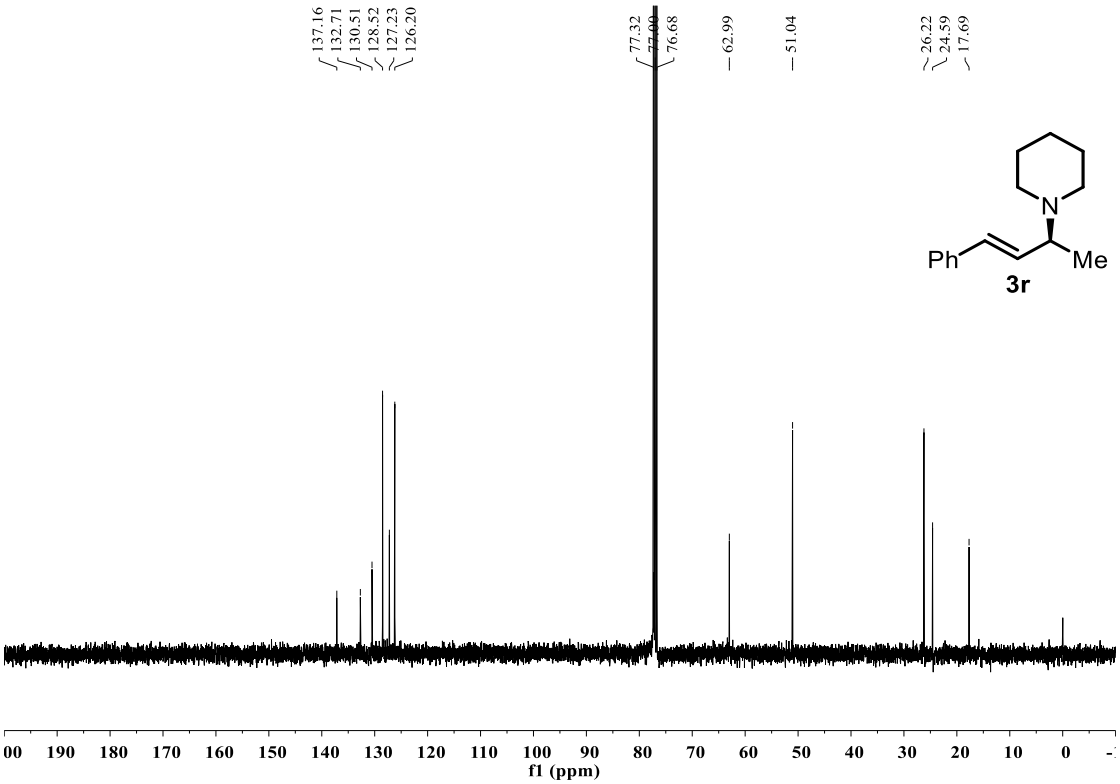


Figure S58. ^{13}C NMR spectra of **3r**, related to **Figure 3**.

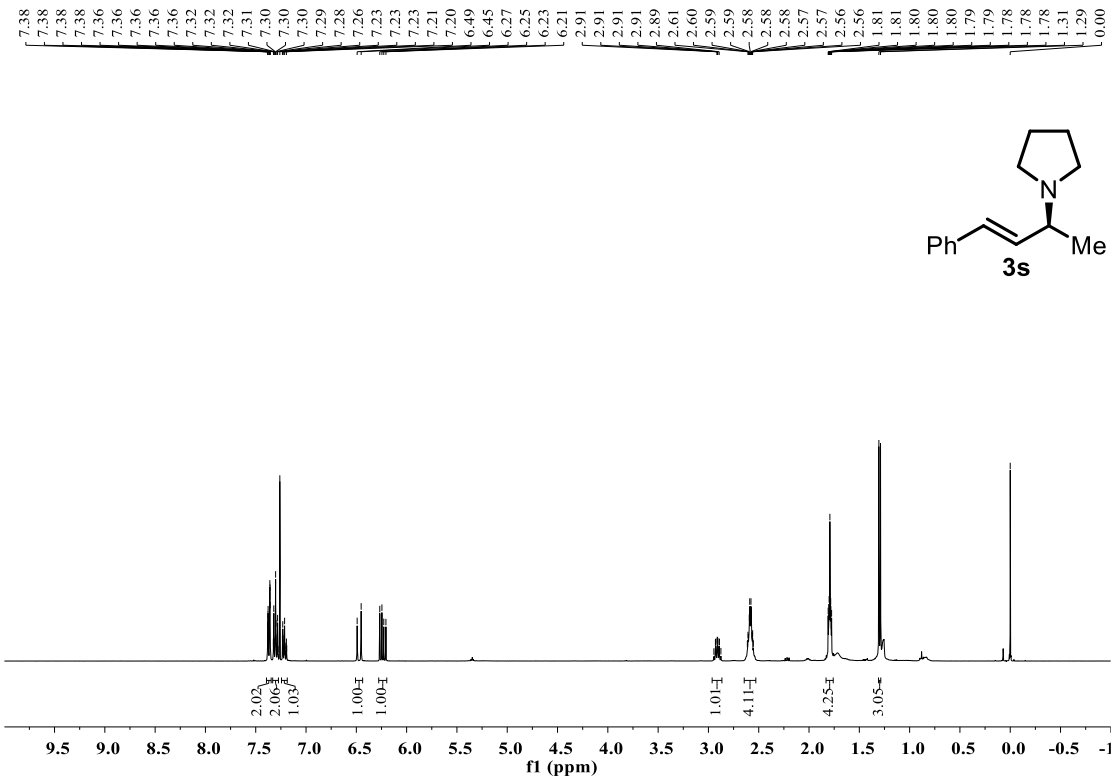


Figure S59. ^{1}H NMR spectra of **3s**, related to **Figure 3**.

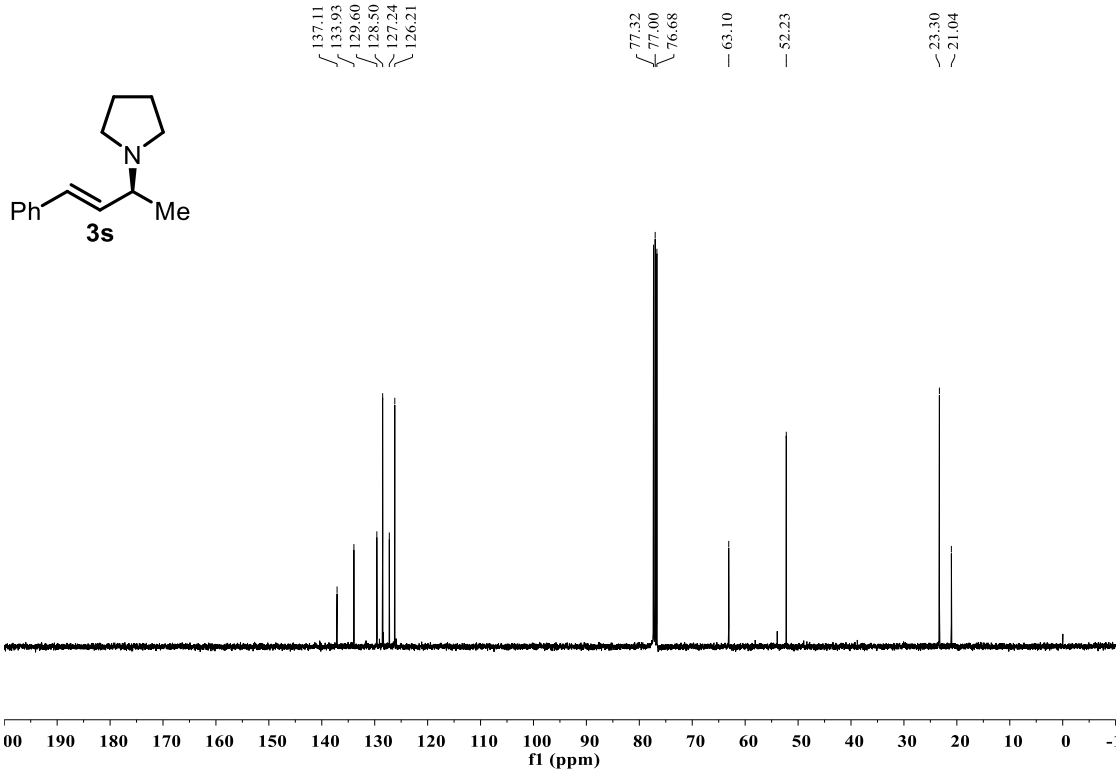


Figure S60. ^{13}C NMR spectra of **3s**, related to **Figure 3**.

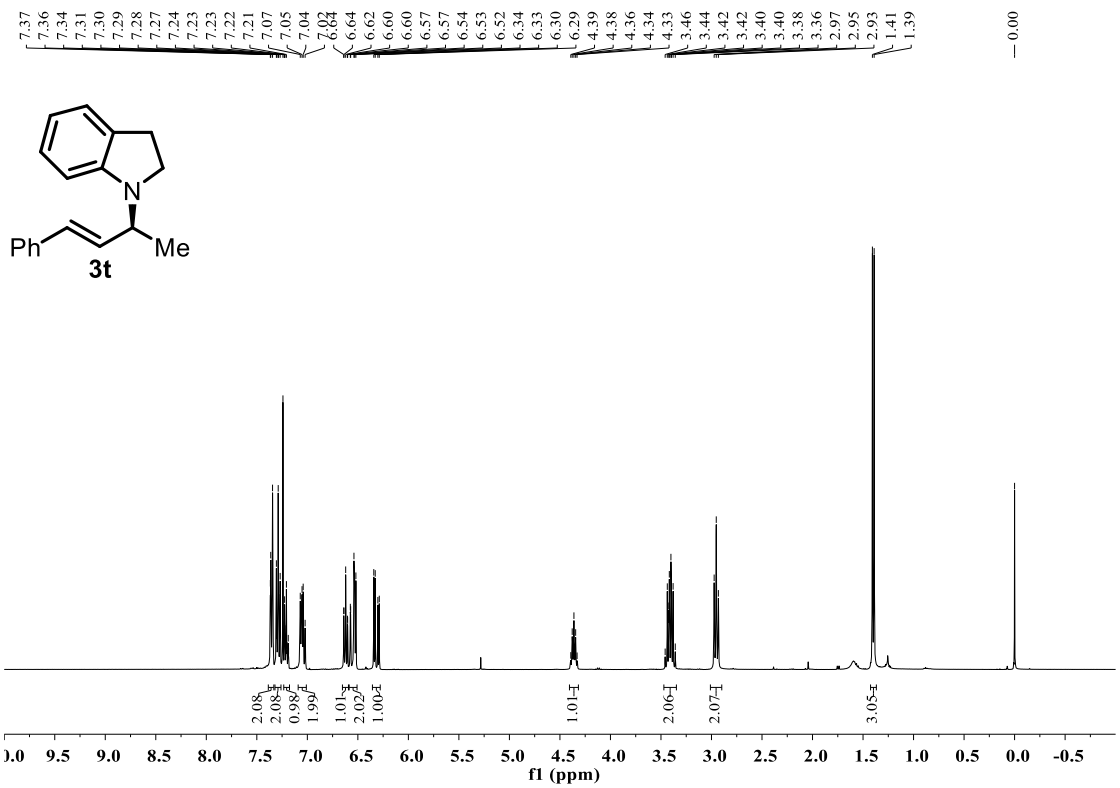


Figure S61. ^{1}H NMR spectra of **3t**, related to **Figure 3**.

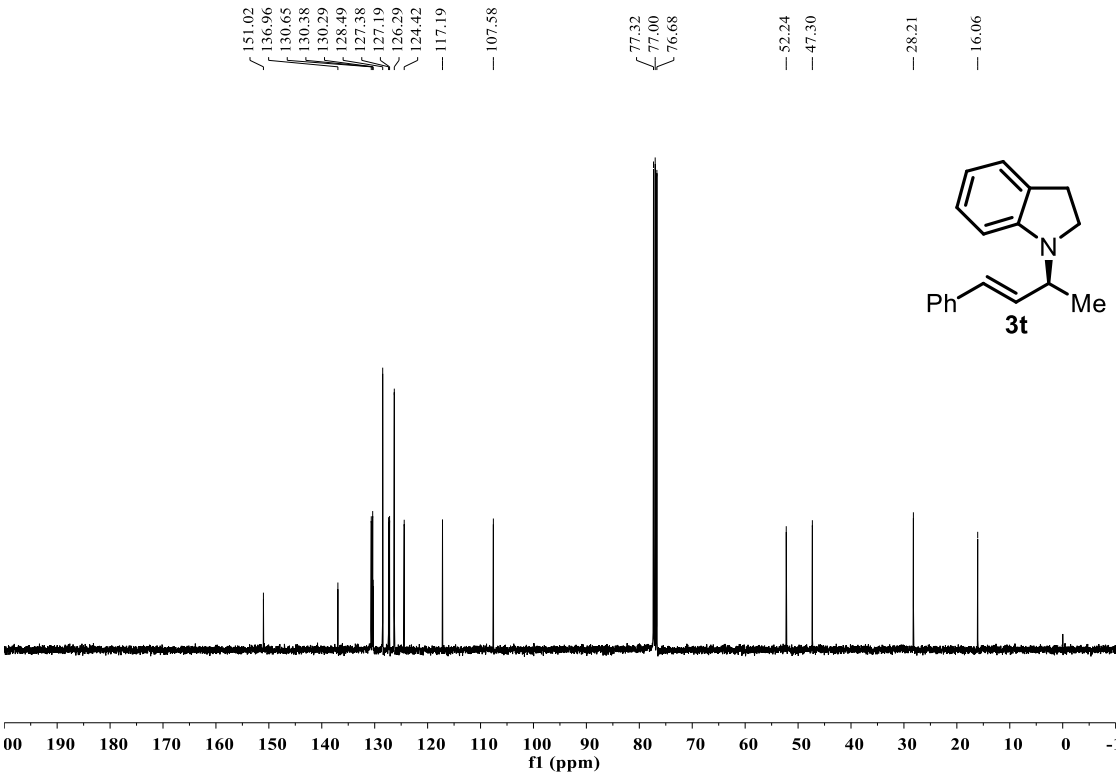


Figure S62. ^{13}C NMR spectra of **3t**, related to **Figure 3**.

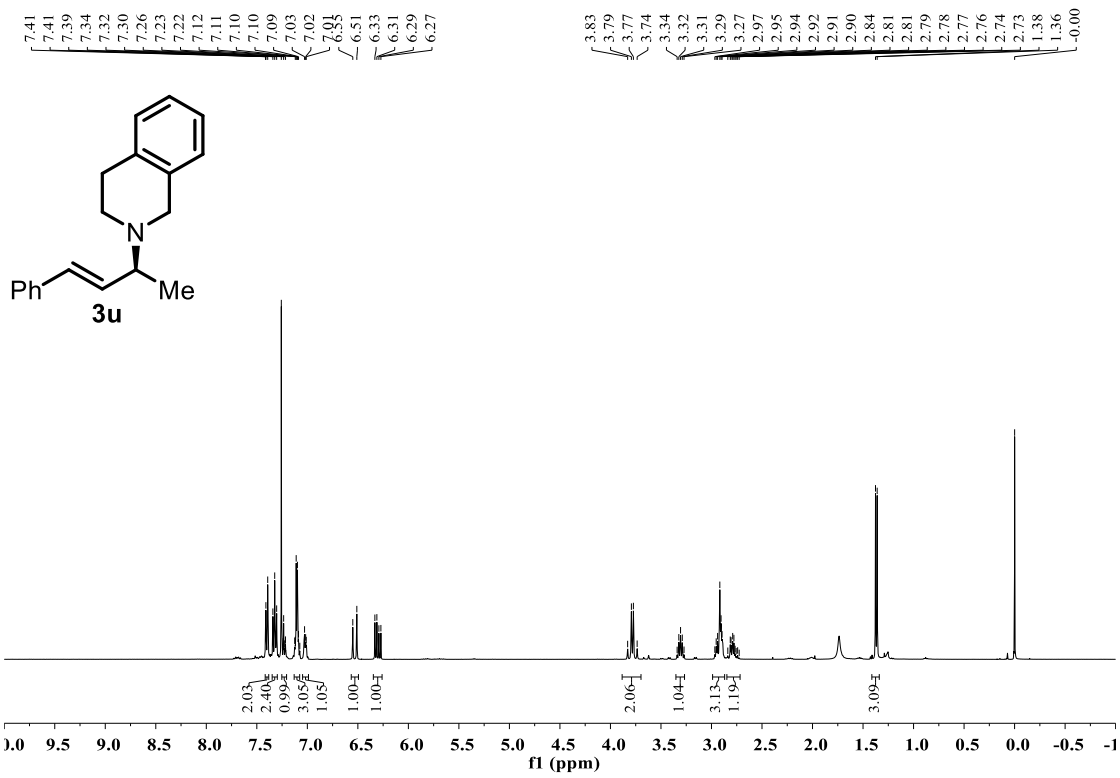


Figure S63. [1]H NMR spectra of **3u**, related to **Figure 3**.

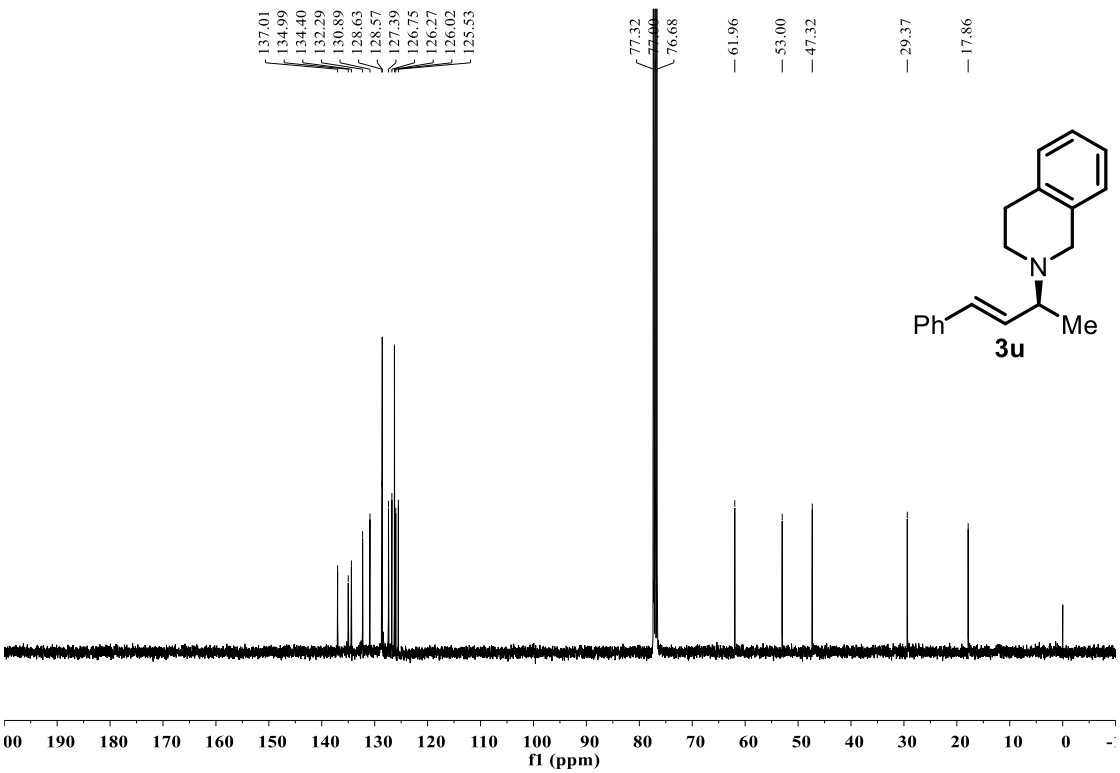


Figure S64. [13]C NMR spectra of **3u**, related to **Figure 3**.

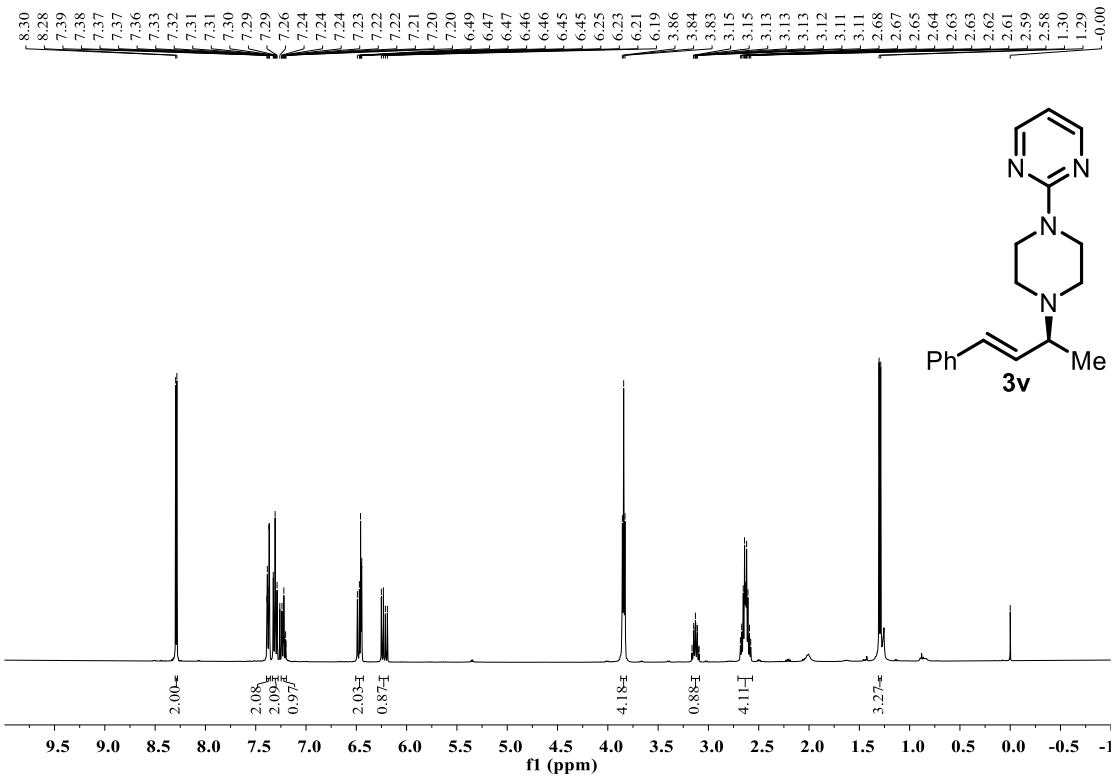


Figure S65. ^{1}H NMR spectra of **3v**, related to **Figure 3**.

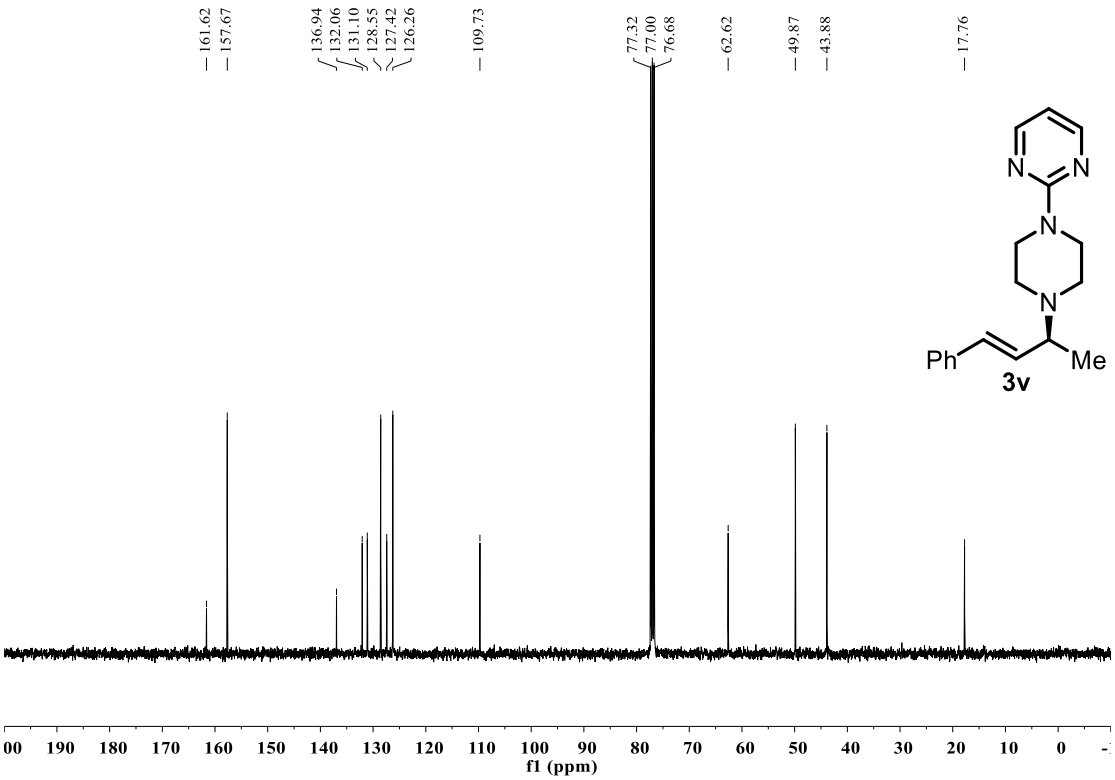


Figure S66. ^{13}C NMR spectra of **3v**, related to **Figure 3**.

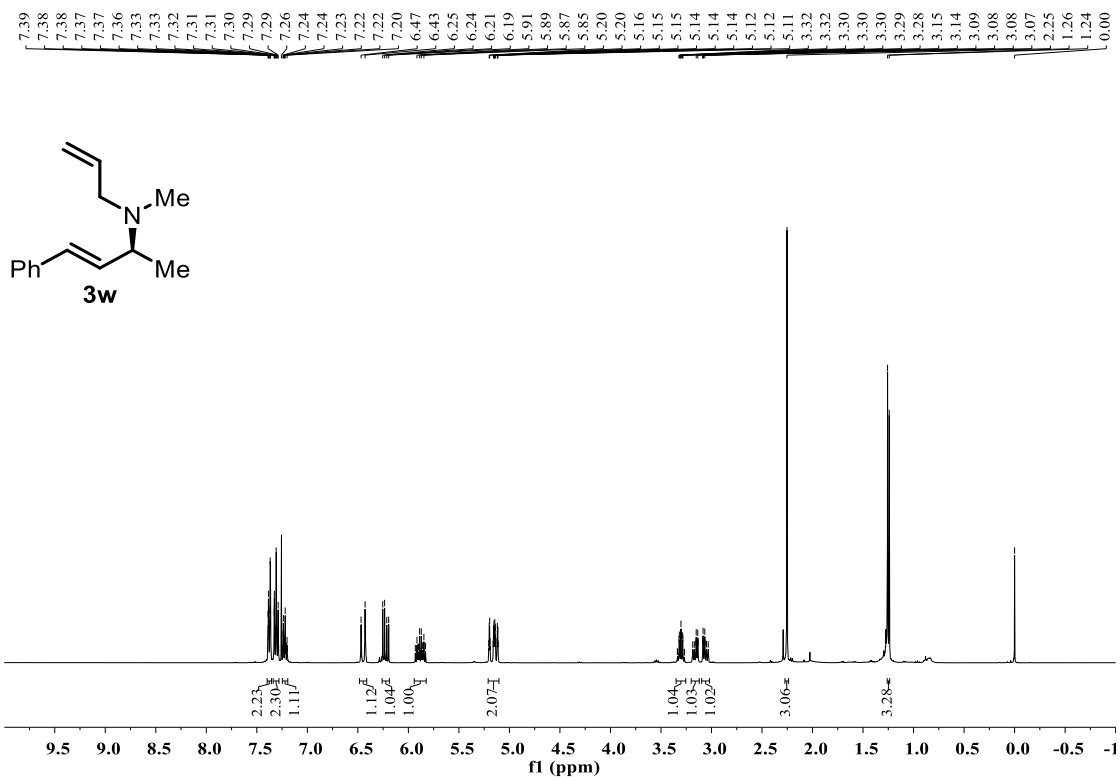


Figure S67. ^{1}H NMR spectra of **3w**, related to **Figure 3**.

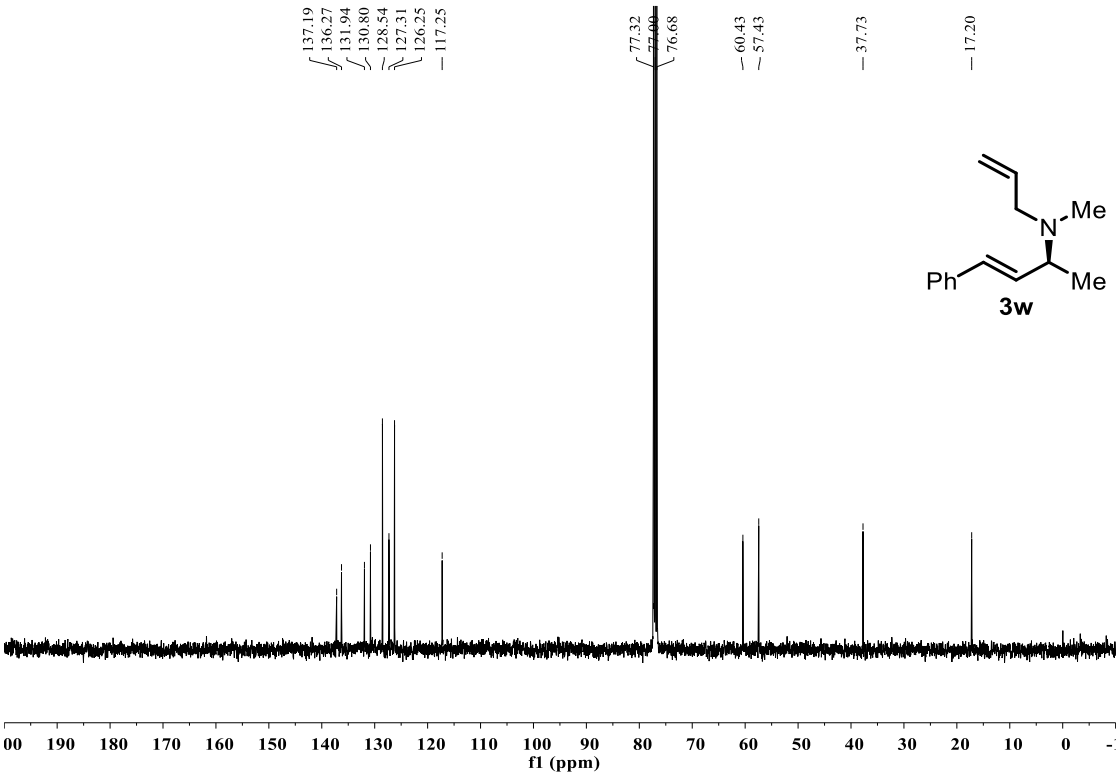


Figure S68. ^{13}C NMR spectra of **3w**, related to **Figure 3**.

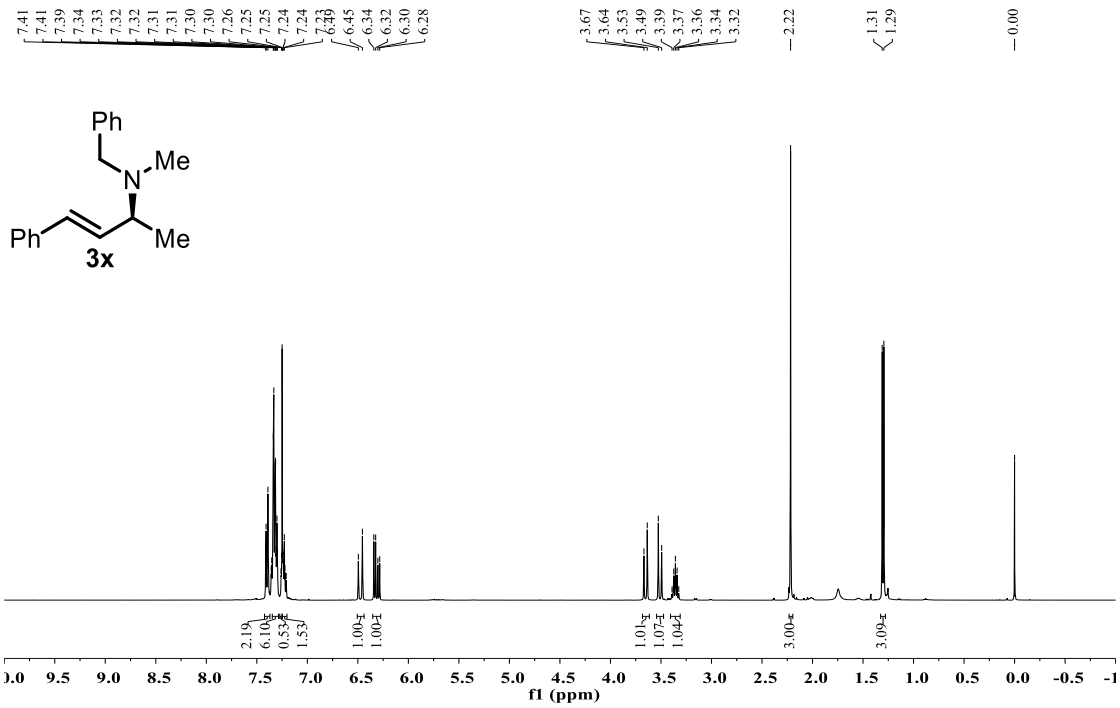


Figure S69. ^{1}H NMR spectra of **3x**, related to **Figure 3**.

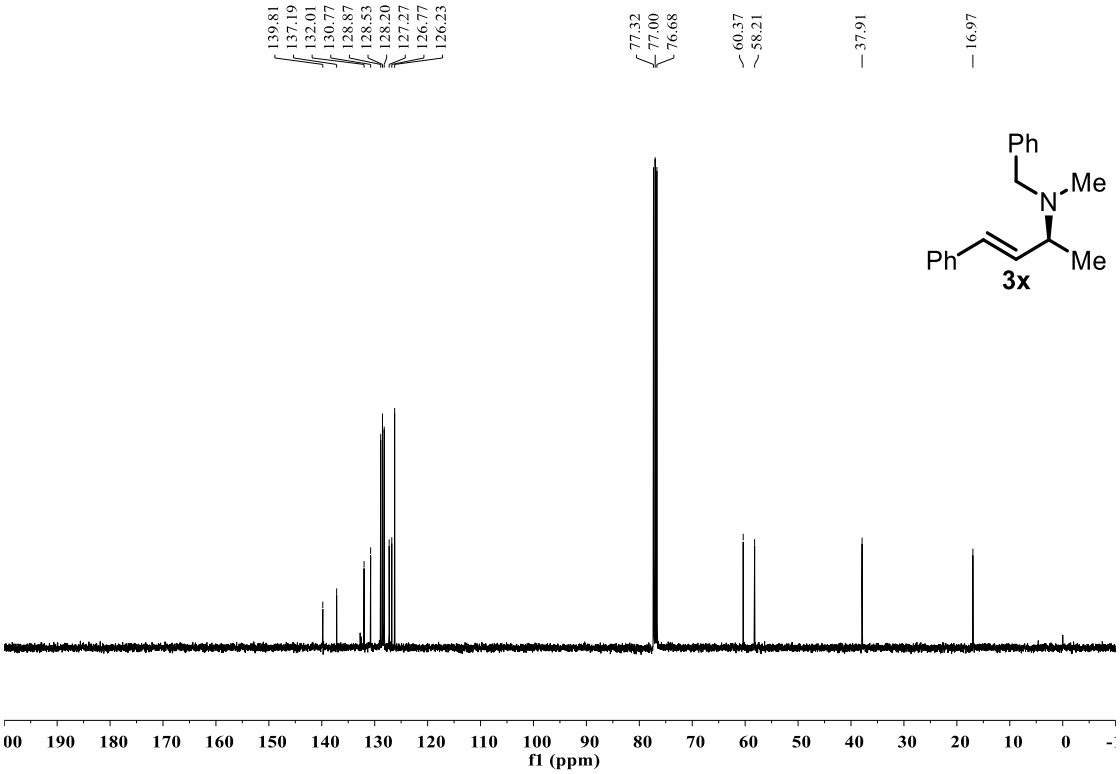


Figure S70. ^{13}C NMR spectra of **3x**, related to **Figure 3**.

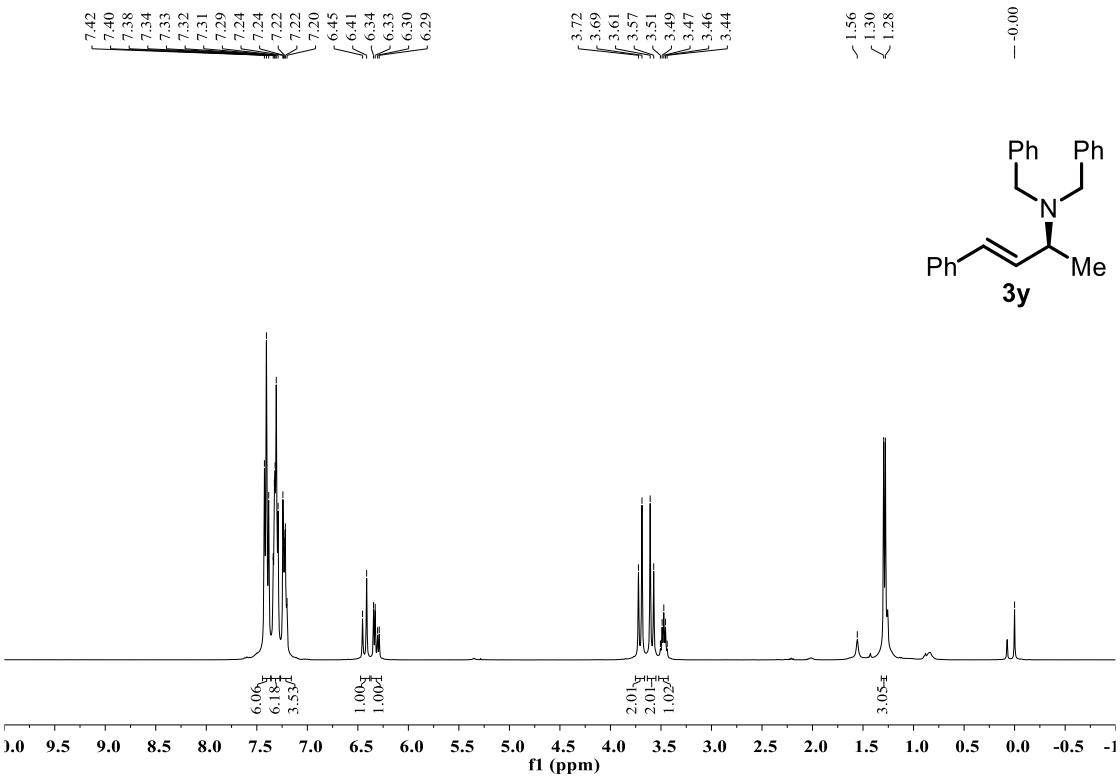


Figure S71. ^{1}H NMR spectra of **3y**, related to **Figure 3**.

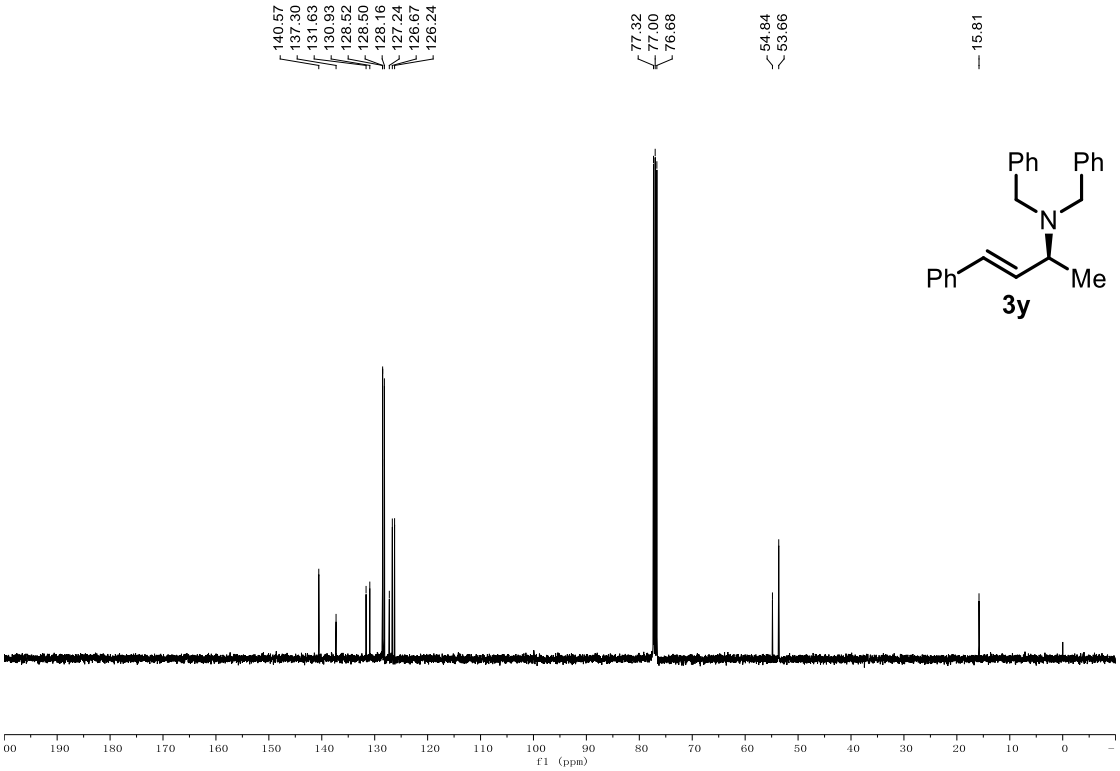


Figure S72. ^{13}C NMR spectra of **3y**, related to **Figure 3**.

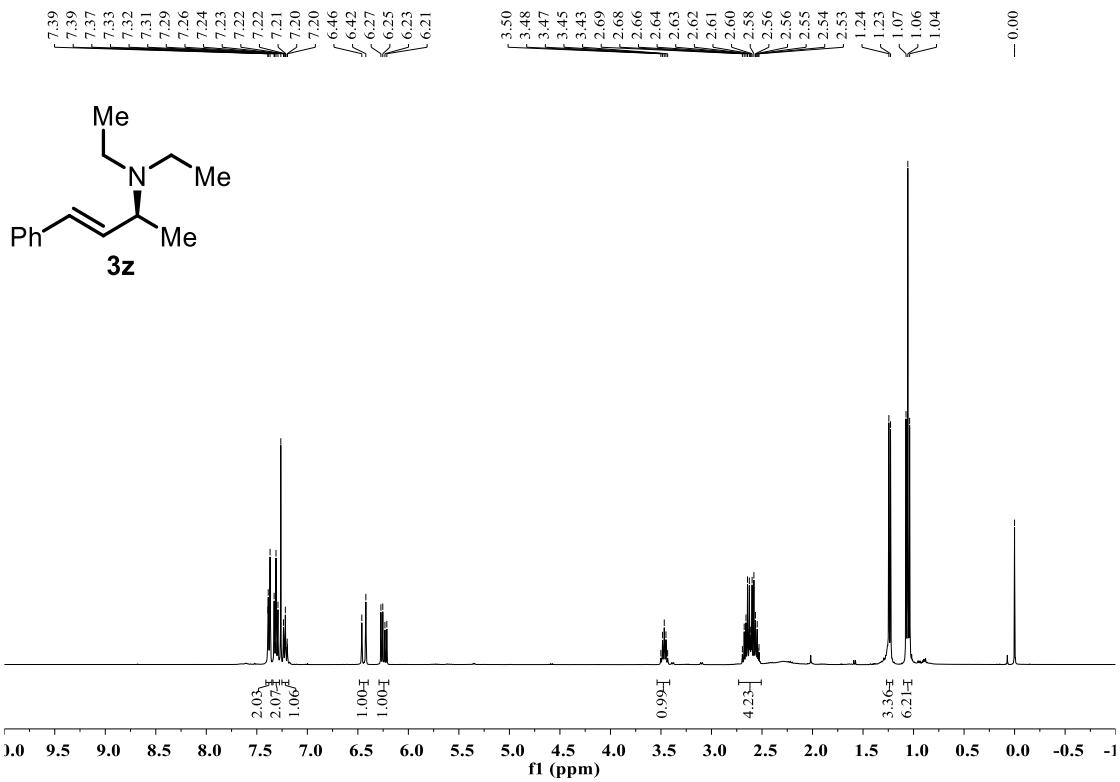


Figure S73. ^{1}H NMR spectra of **3z**, related to **Figure 3**.

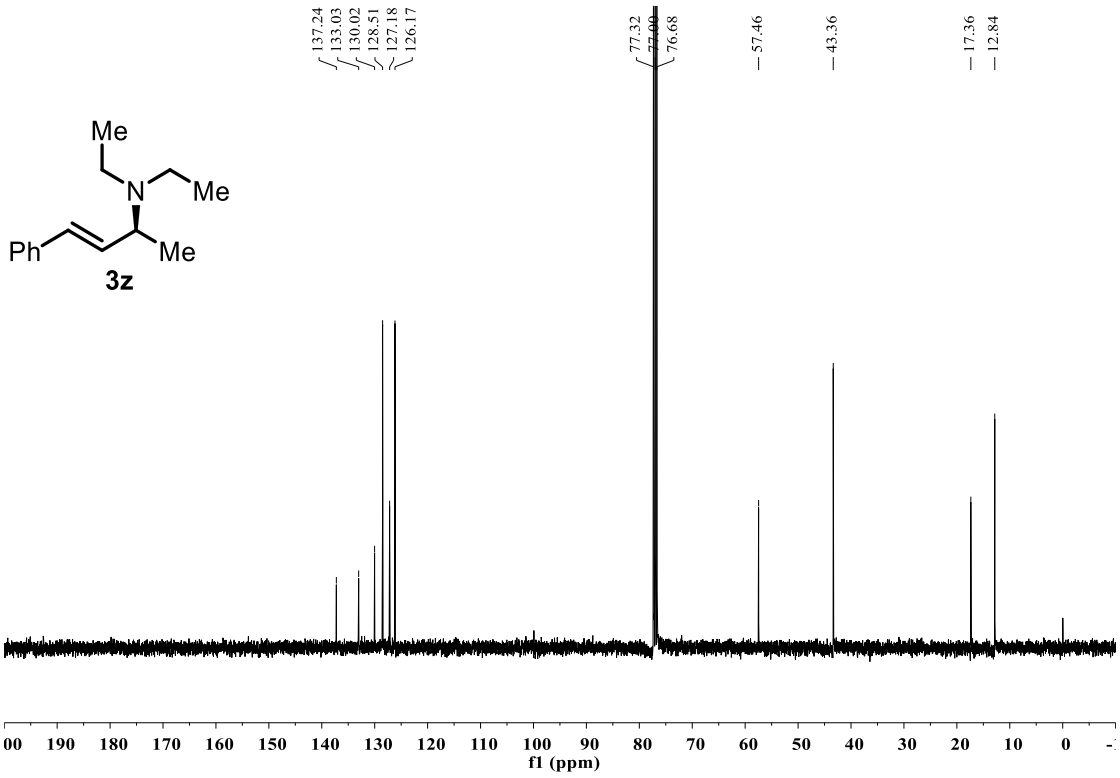


Figure S74. ^{13}C NMR spectra of **3z**, related to **Figure 3**.

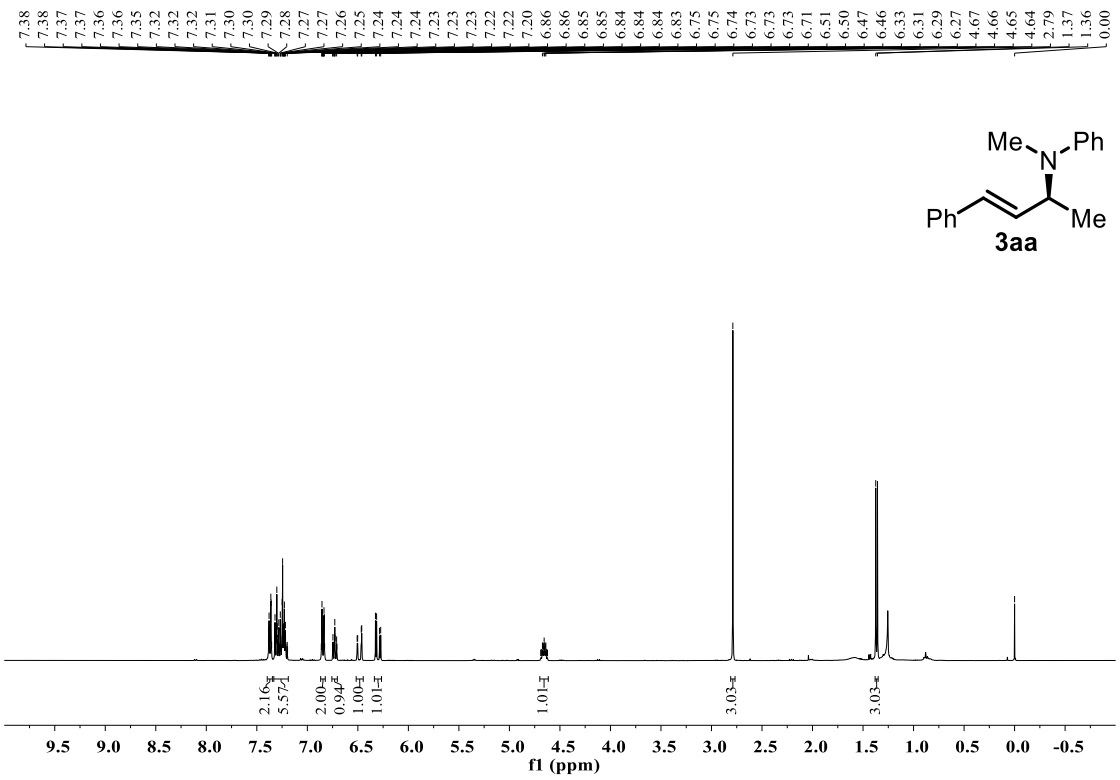


Figure S75. ^{1}H NMR spectra of **3aa**, related to **Figure 3**.

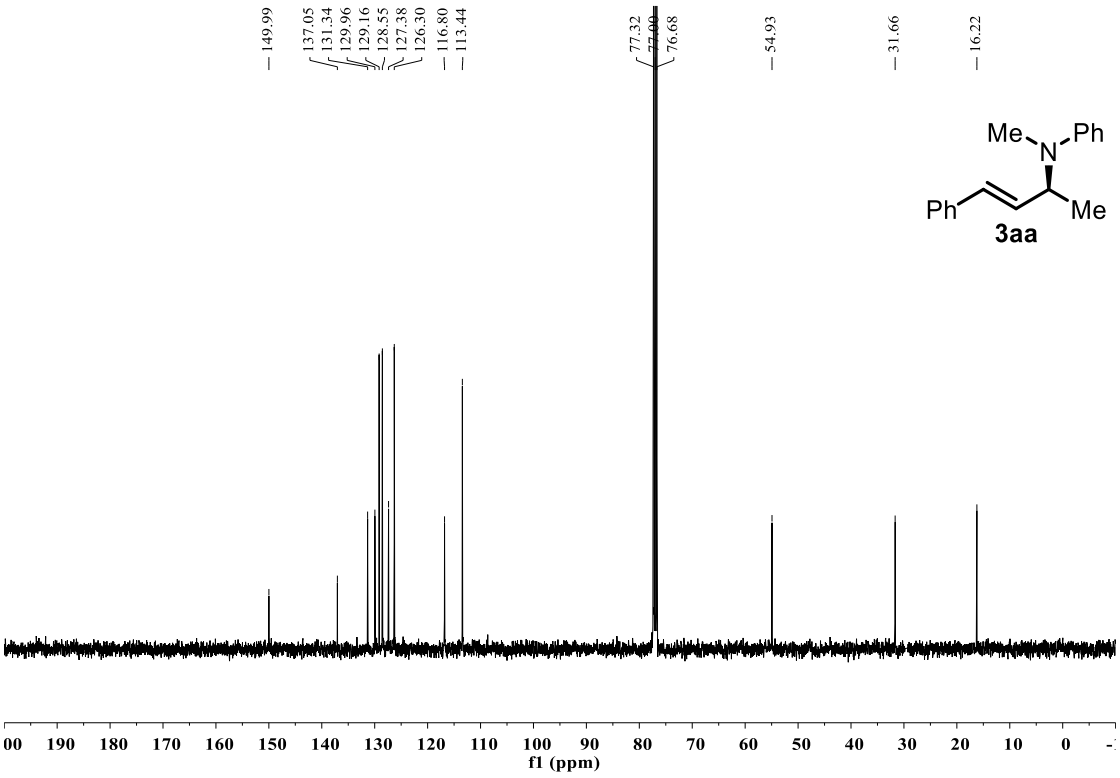


Figure S76. ^{1}H NMR spectra of **3aa**, related to **Figure 3**.

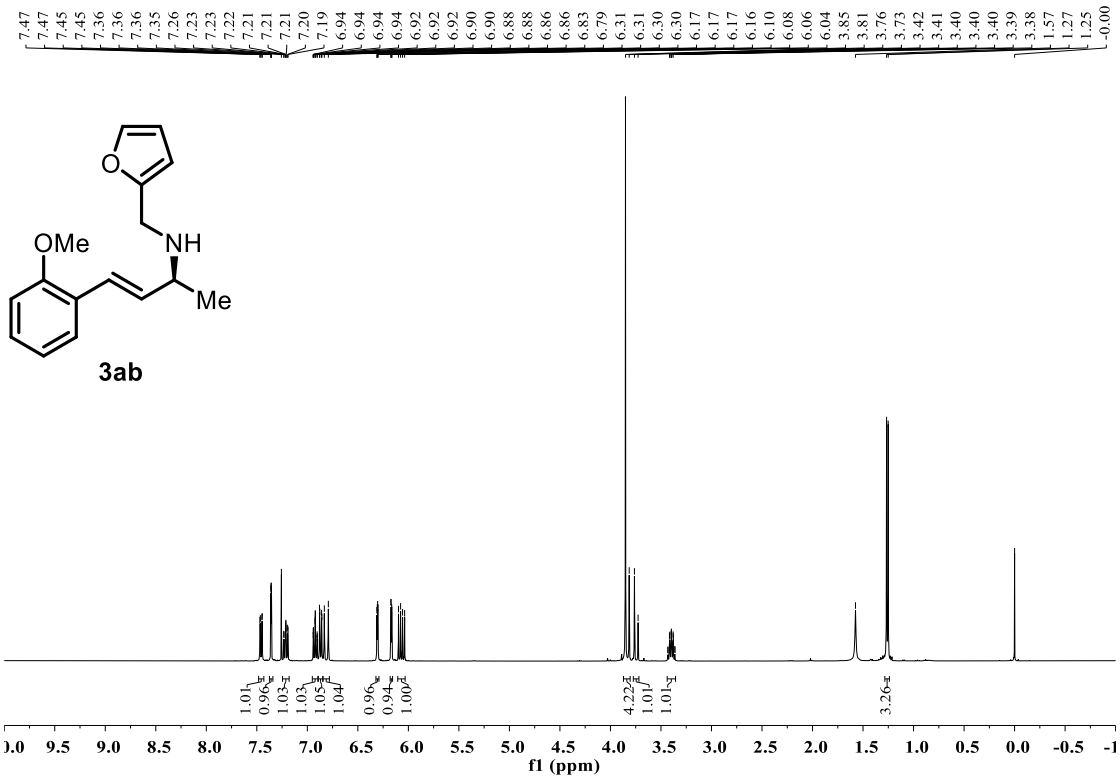


Figure S77. ^{1}H NMR spectra of **3ab**, related to **Figure 4**.

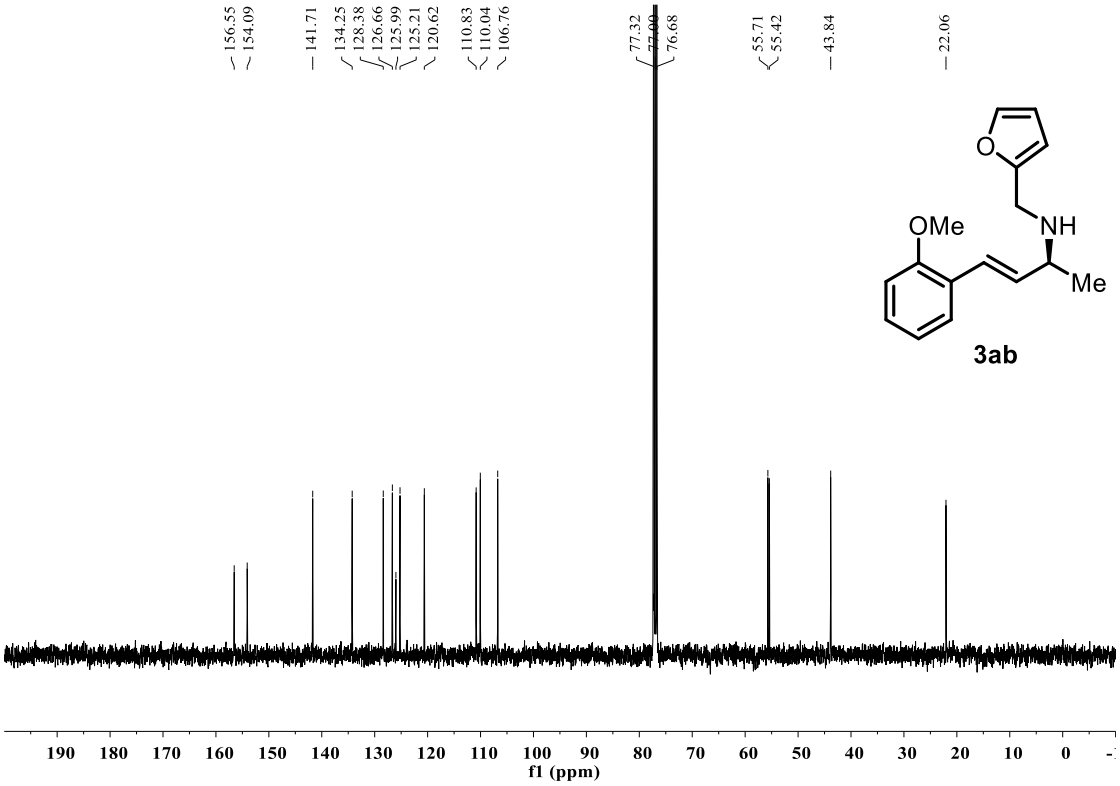


Figure S78. ^{13}C NMR spectra of **3ab**, related to **Figure 4**.

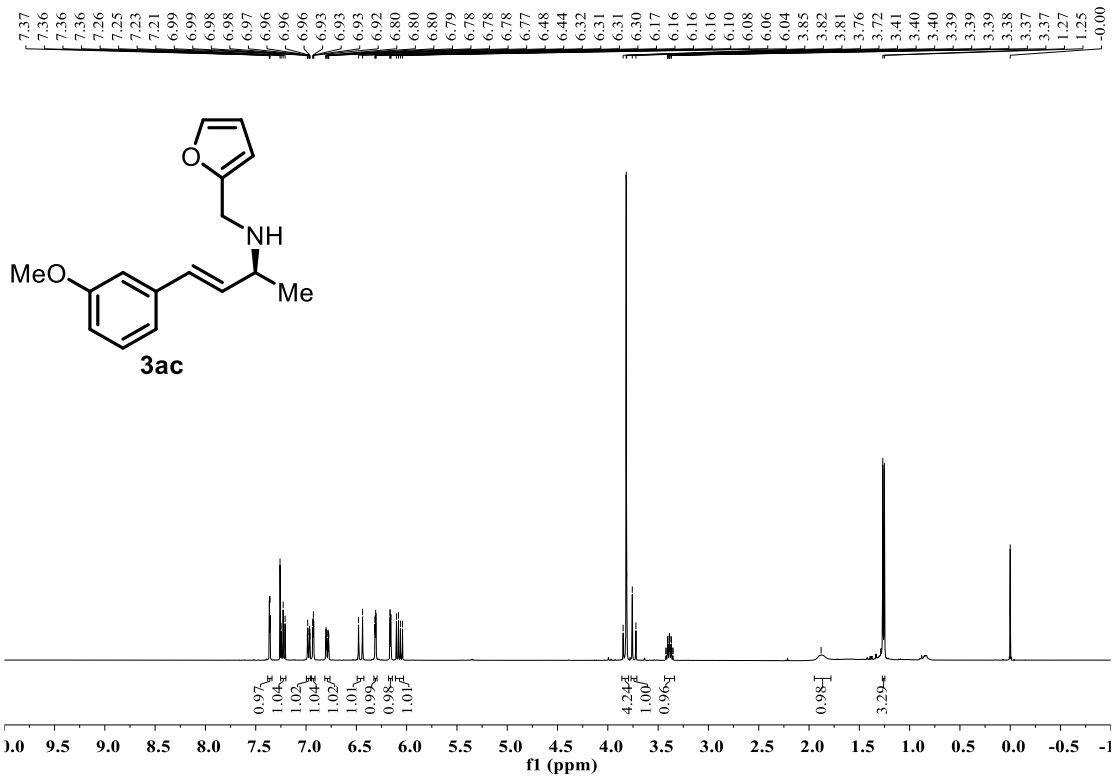


Figure S79. ^{1}H NMR spectra of **3ac**, related to **Figure 4**.

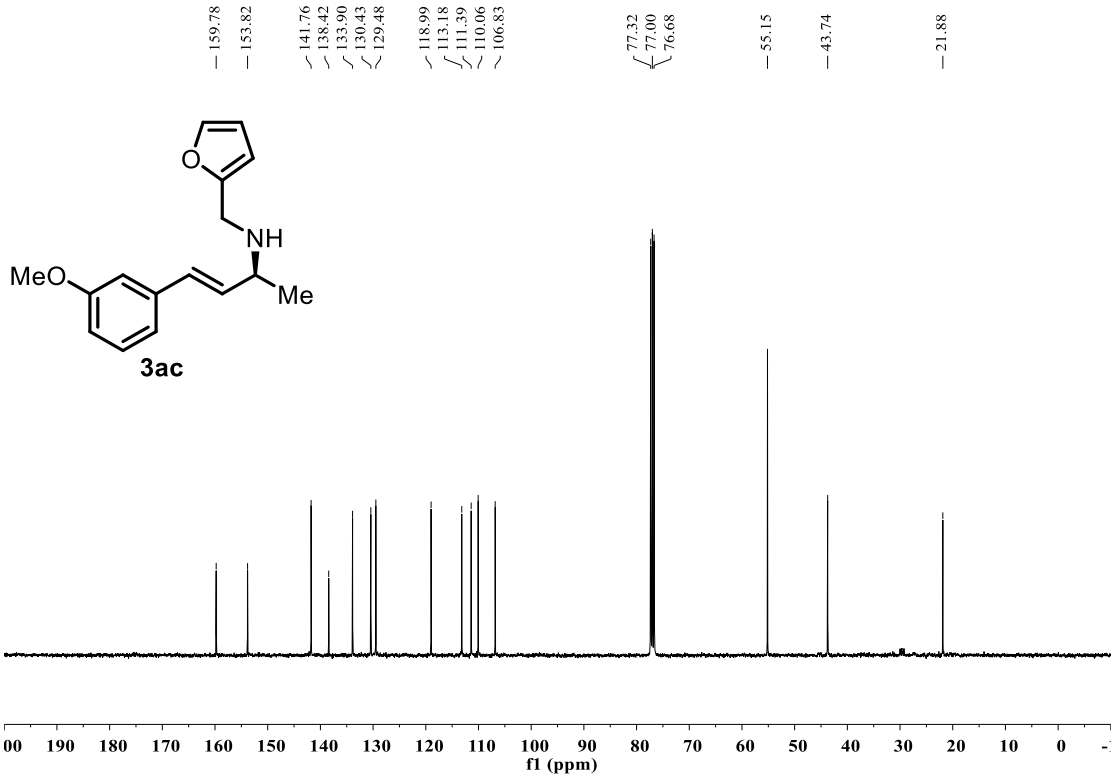


Figure S80. ^{13}C NMR spectra of **3ac**, related to **Figure 4**.

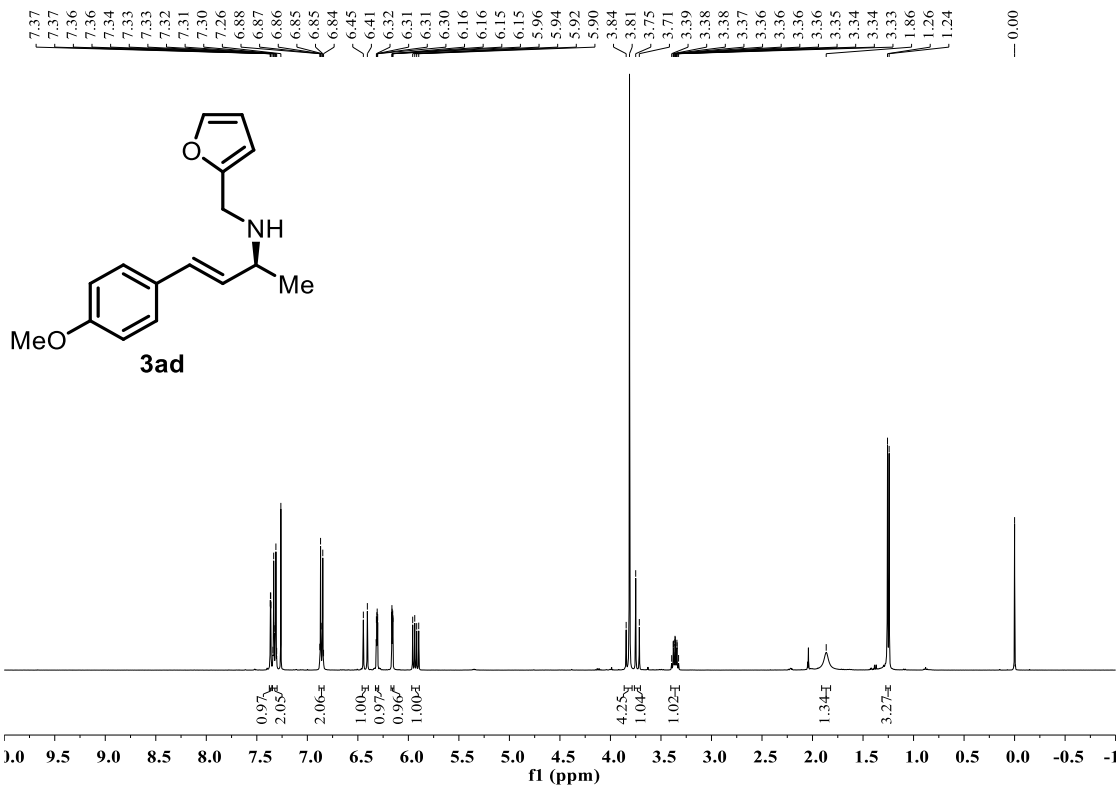


Figure S81. ^{1}H NMR spectra of **3ad**, related to **Figure 4**.

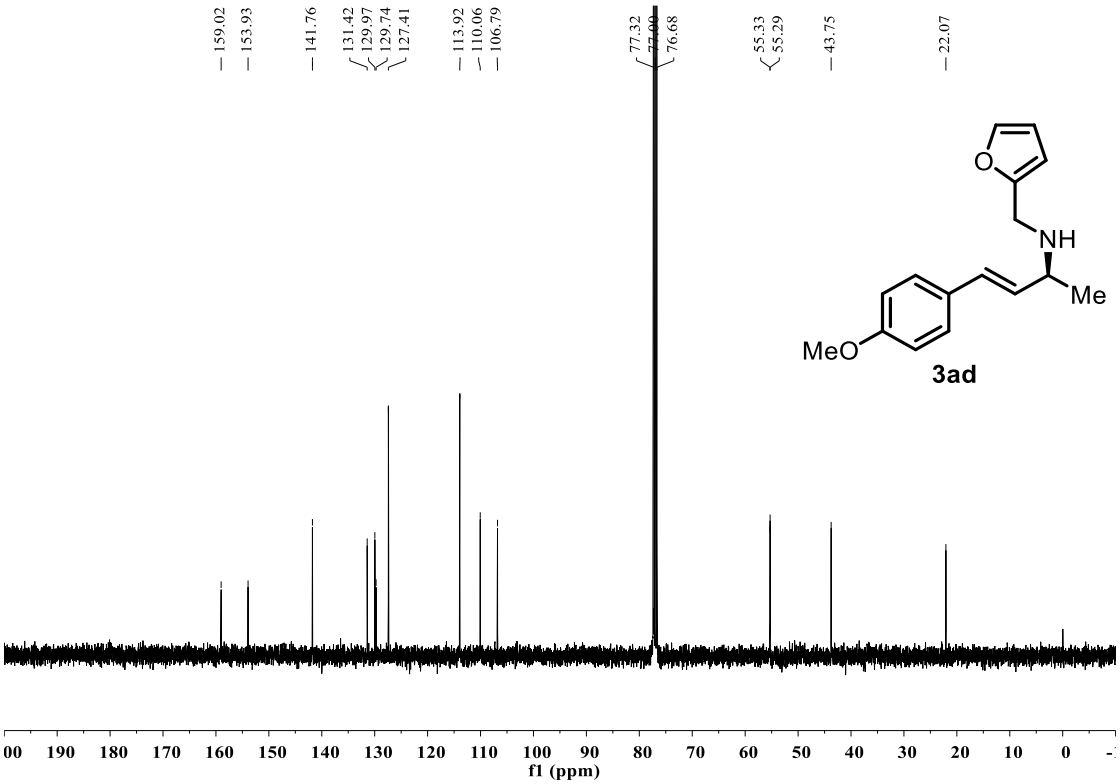


Figure S82. ^{13}C NMR spectra of **3ad**, related to **Figure 4**.

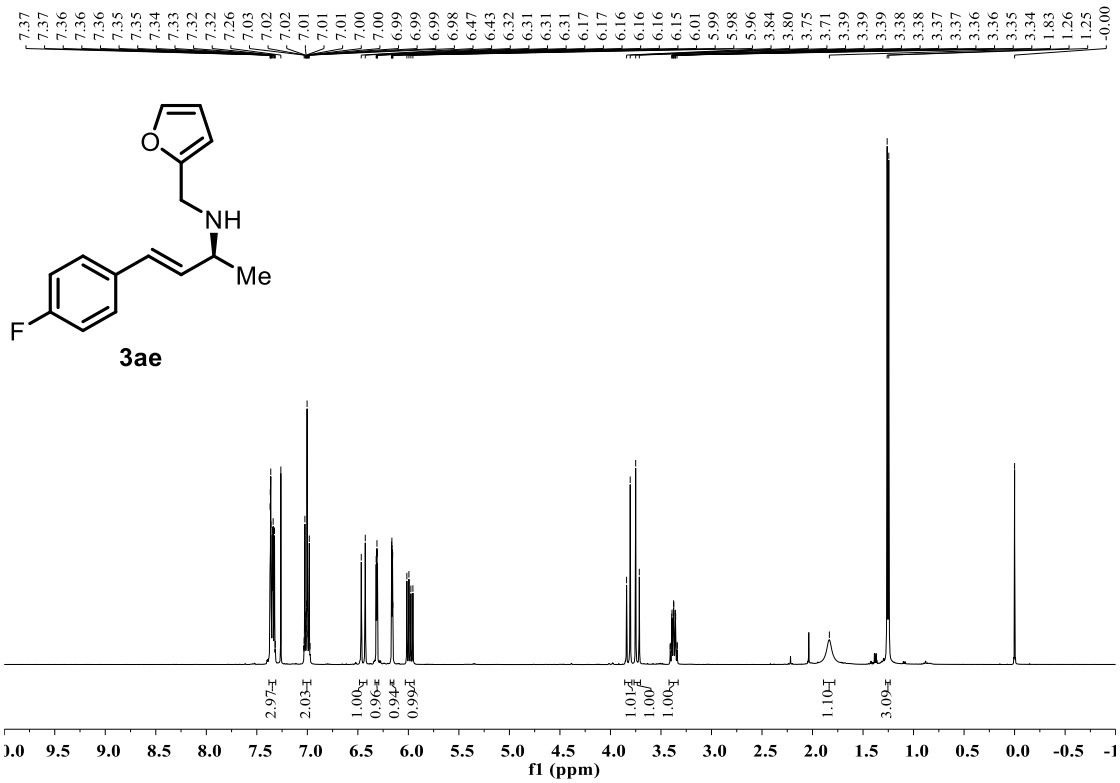


Figure S83. [1]H NMR spectra of **3ae**, related to **Figure 4**.

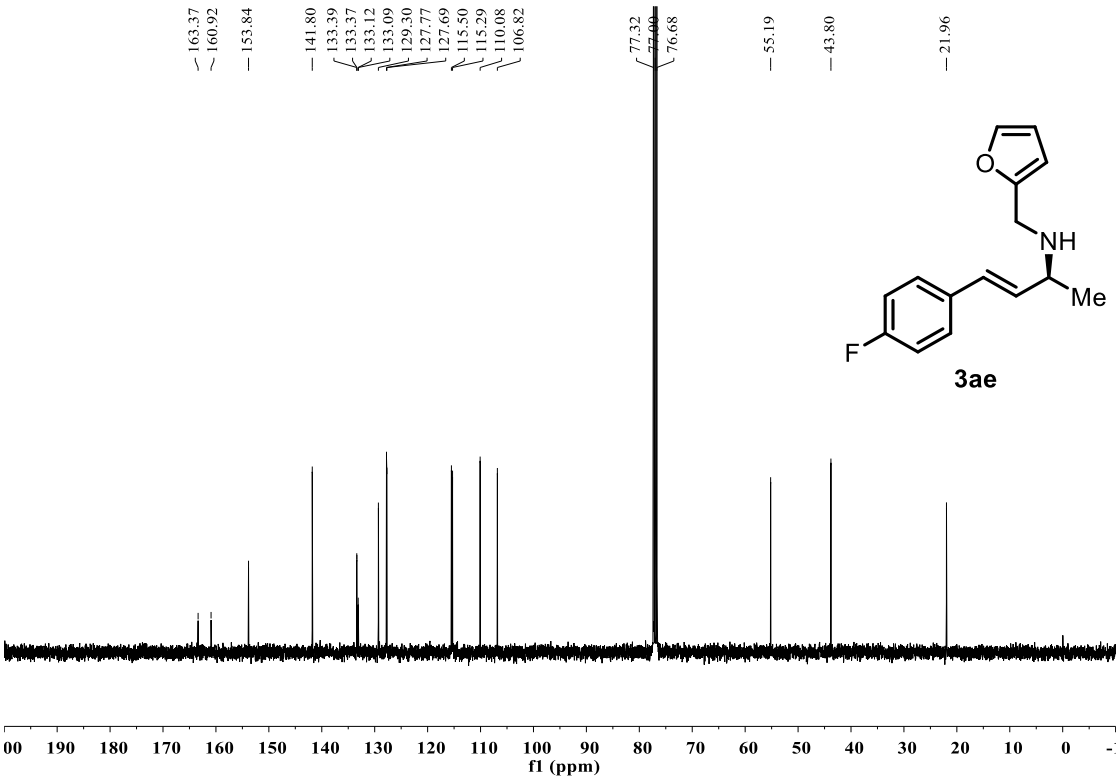


Figure S84. [13]C NMR spectra of **3ae**, related to **Figure 4**.

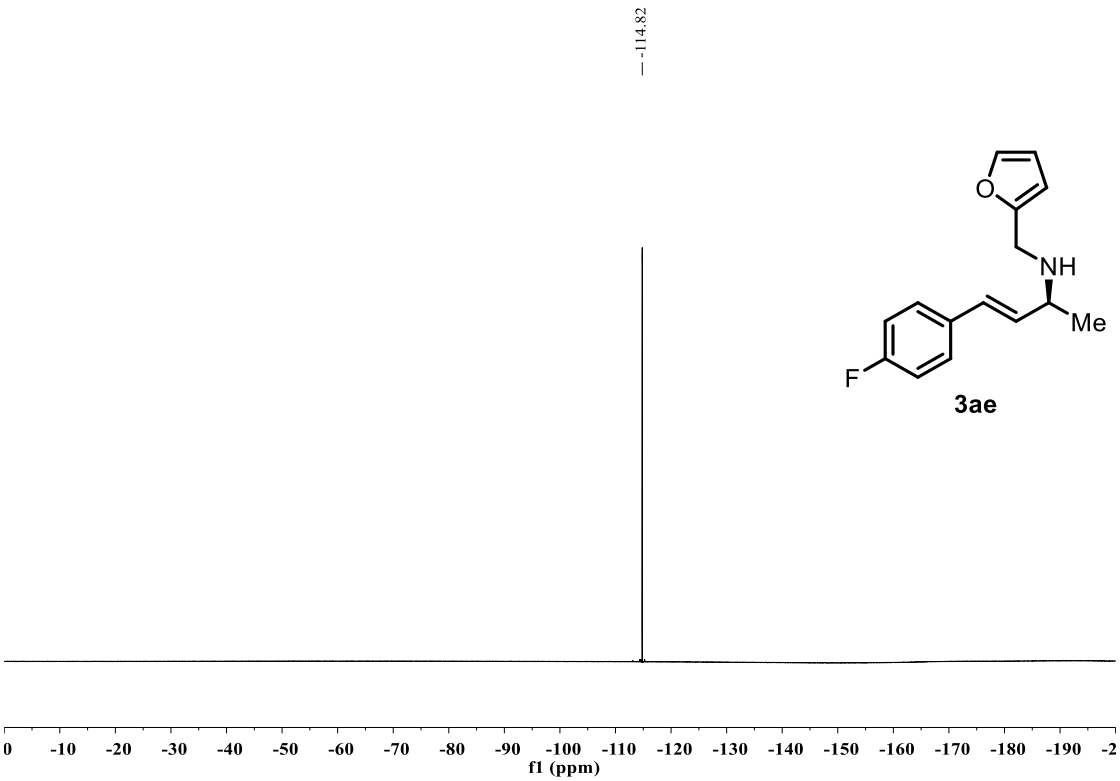


Figure S85. ^{19}F NMR spectra of **3ae**, related to **Figure 4**.

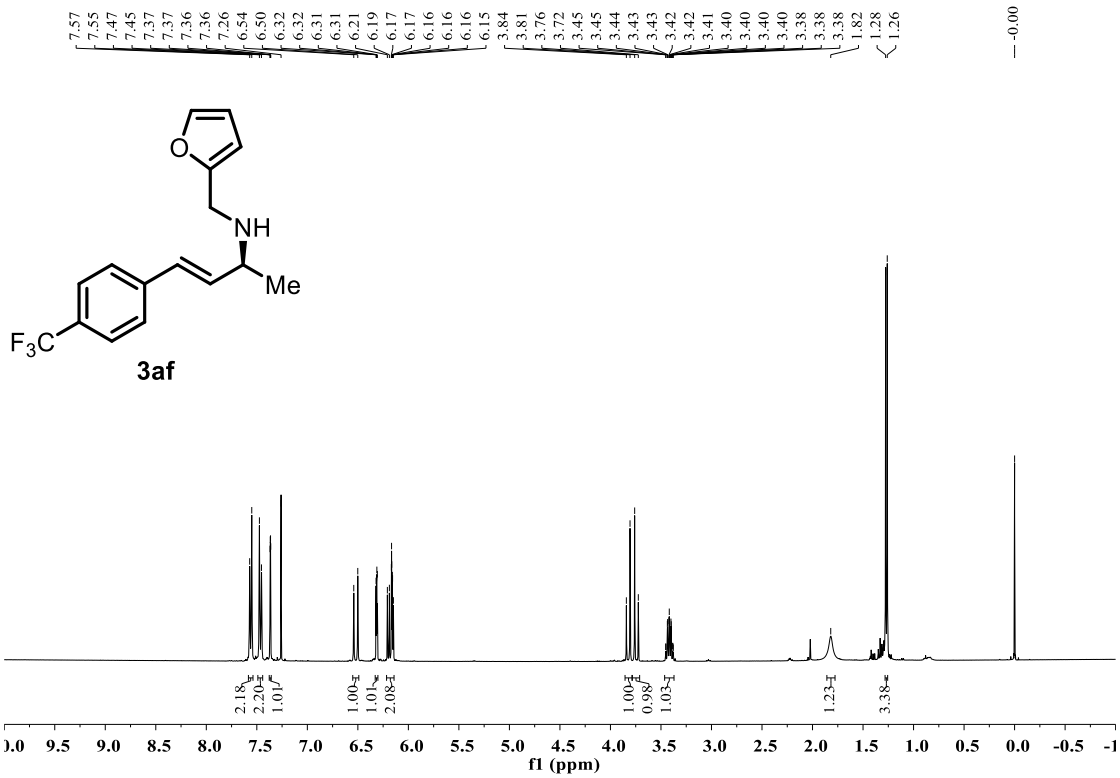


Figure S86. ^{1}H NMR spectra of **3af**, related to **Figure 4**.

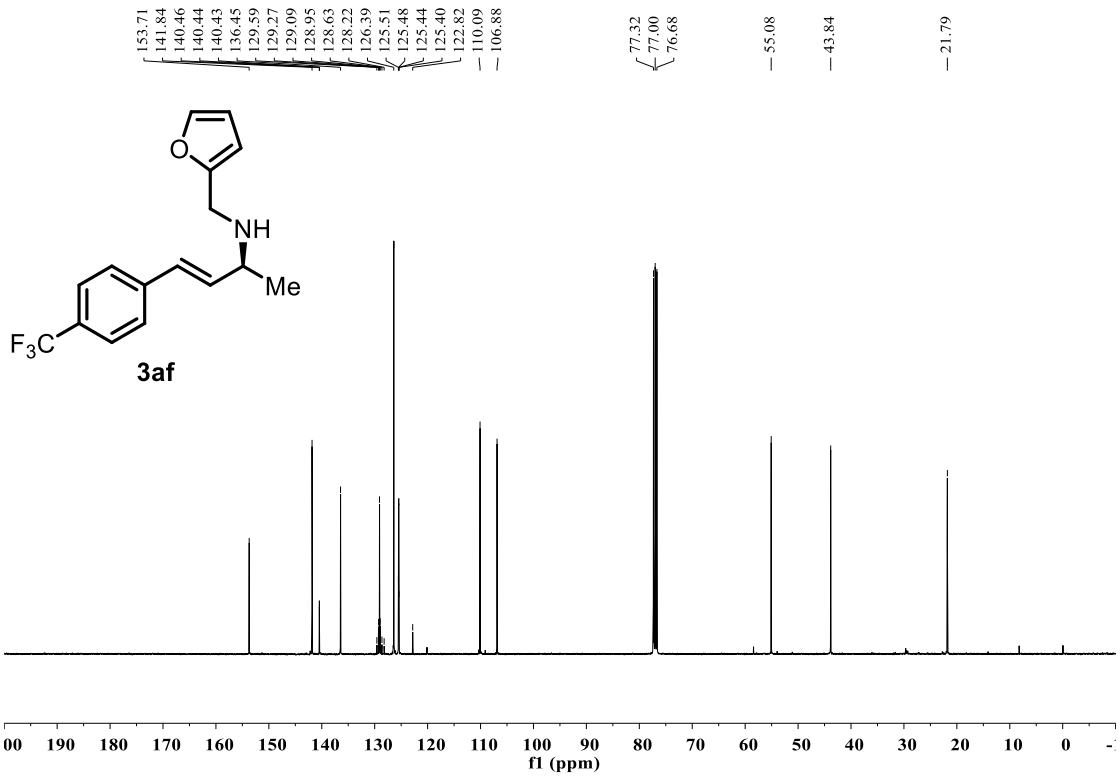


Figure S87. ^{13}C NMR spectra of **3af**, related to **Figure 4**.

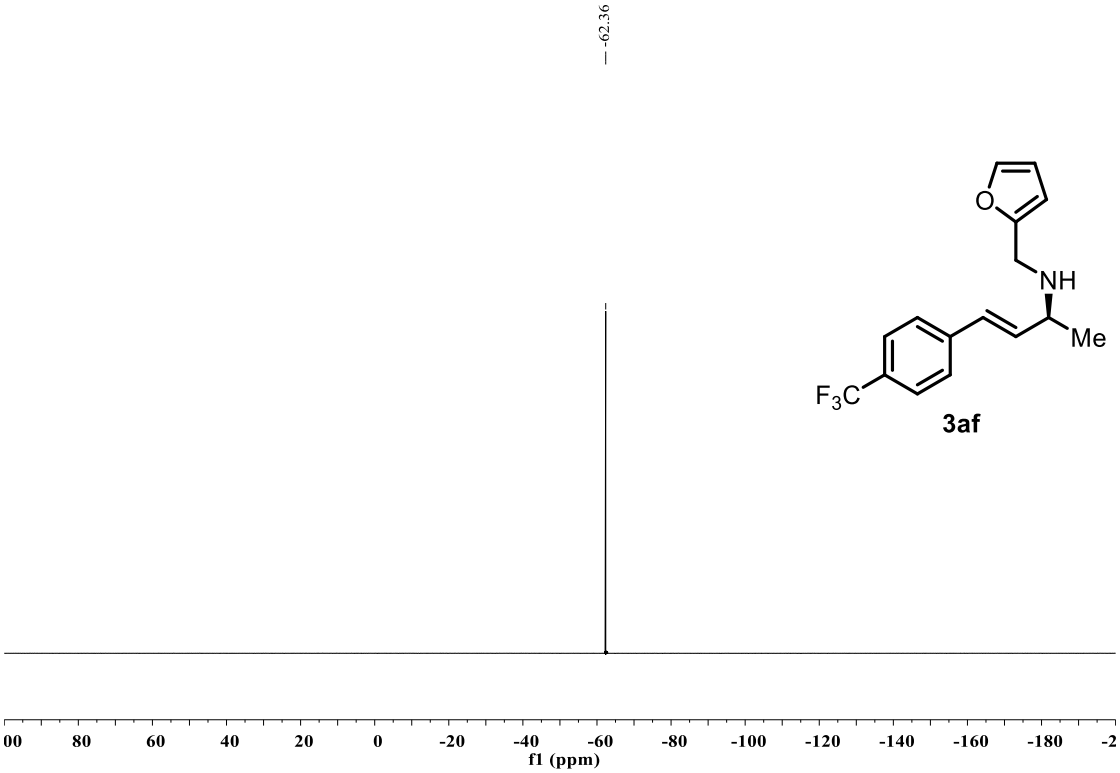


Figure S88. ^{19}F NMR spectra of **3af**, related to **Figure 4**.

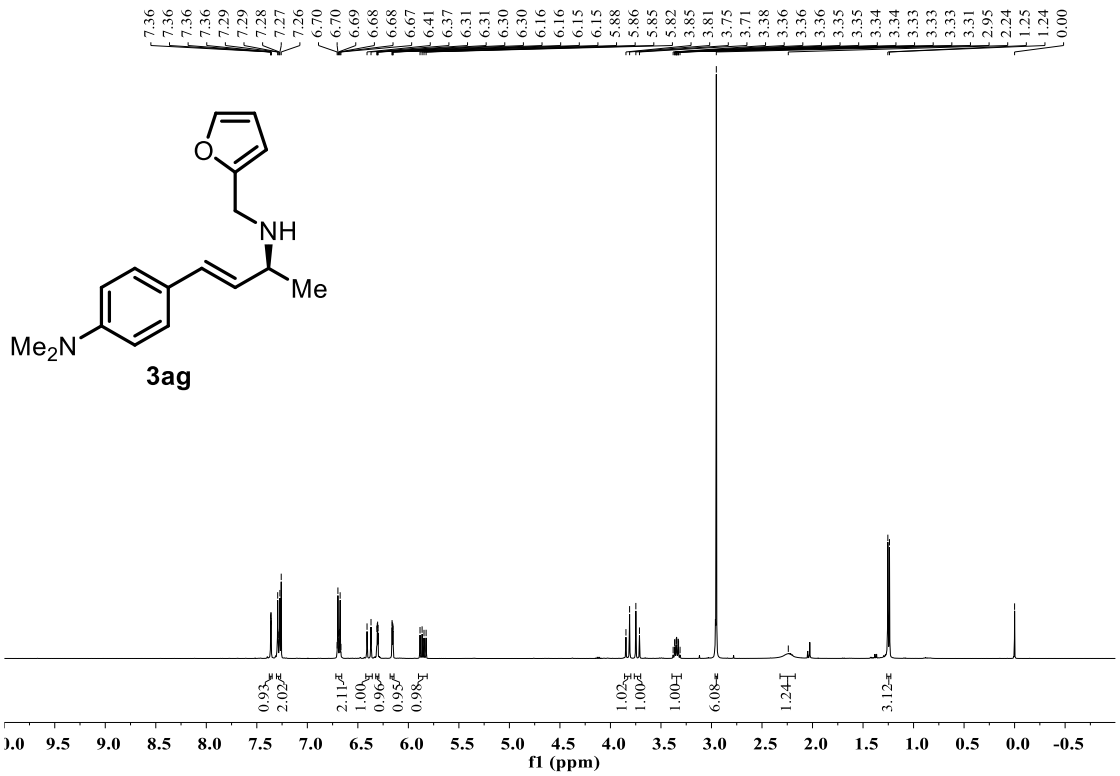


Figure S89. ^{1}H NMR spectra of **3ag**, related to **Figure 4**.

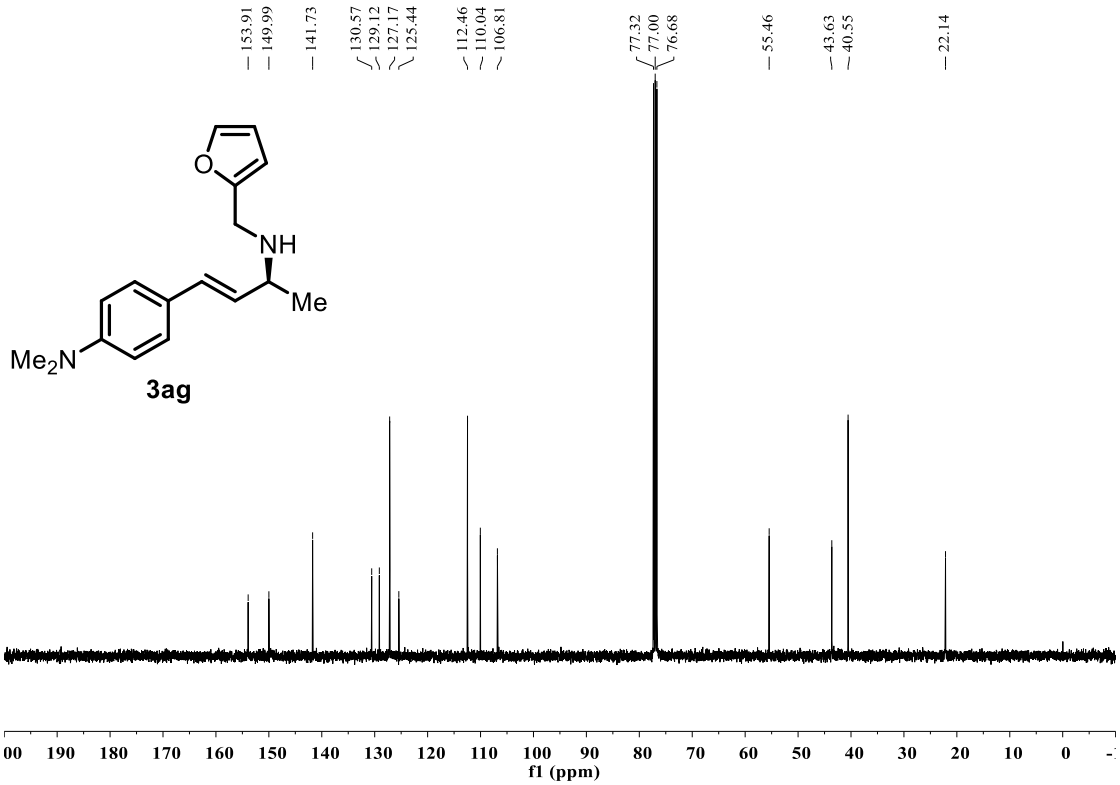


Figure S90. ^{13}C NMR spectra of **3ag**, related to **Figure 4**.

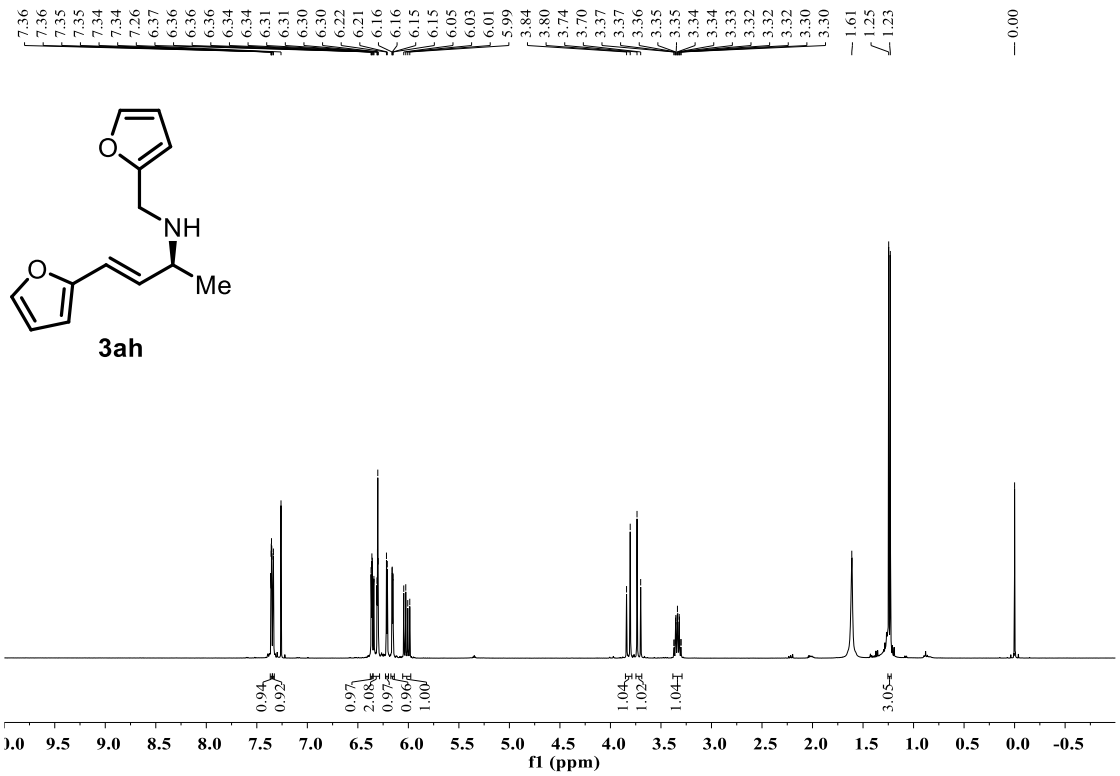


Figure S91. [1]H NMR spectra of **3ah**, related to **Figure 4**.

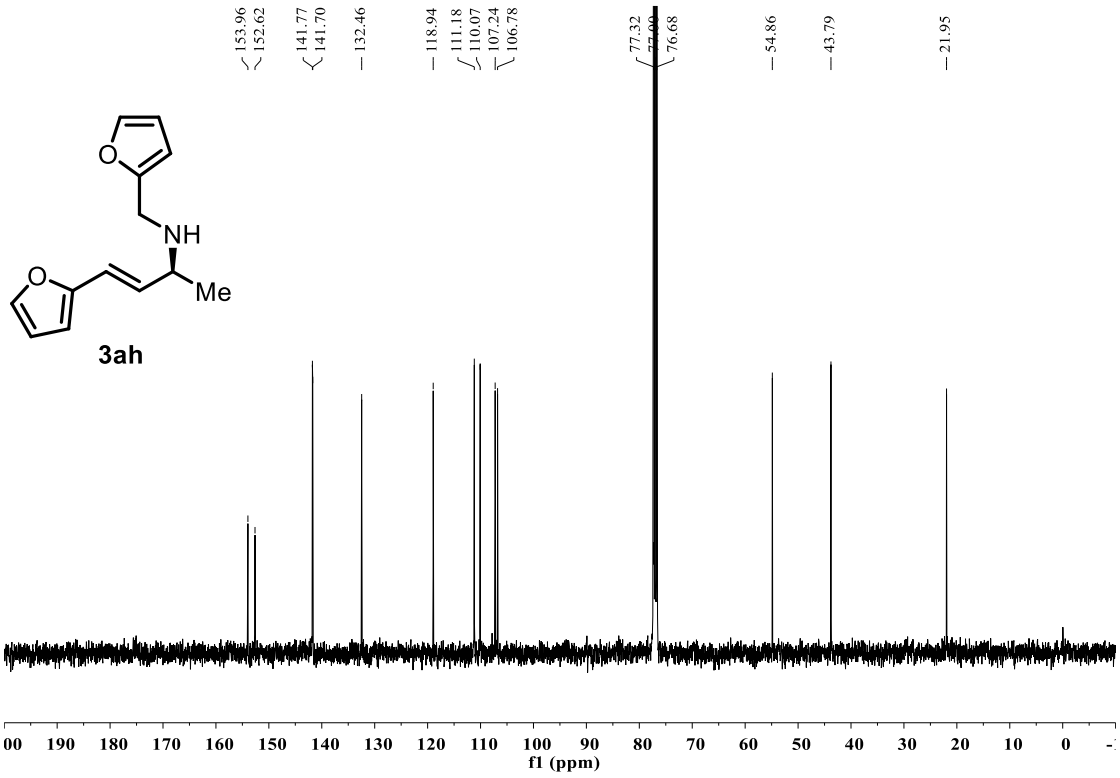


Figure S92. [13]C NMR spectra of **3ah**, related to **Figure 4**.

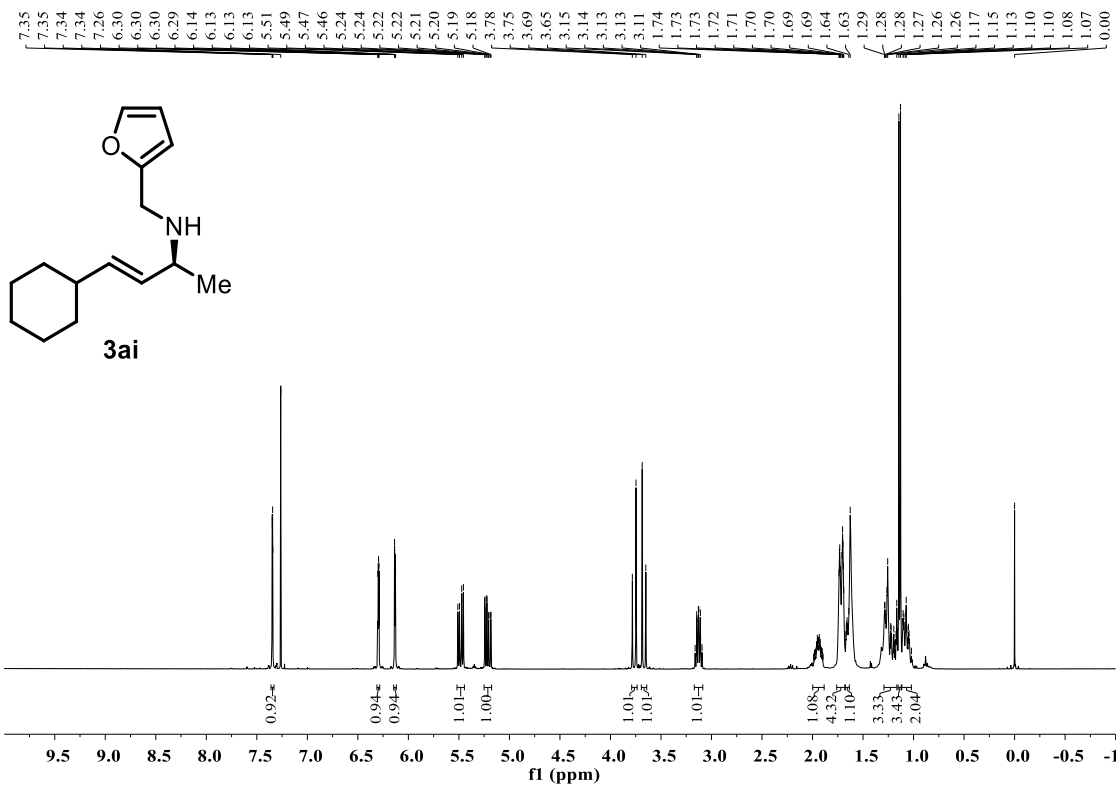


Figure S93. ^{1}H NMR spectra of **3ai**, related to **Figure 4**.

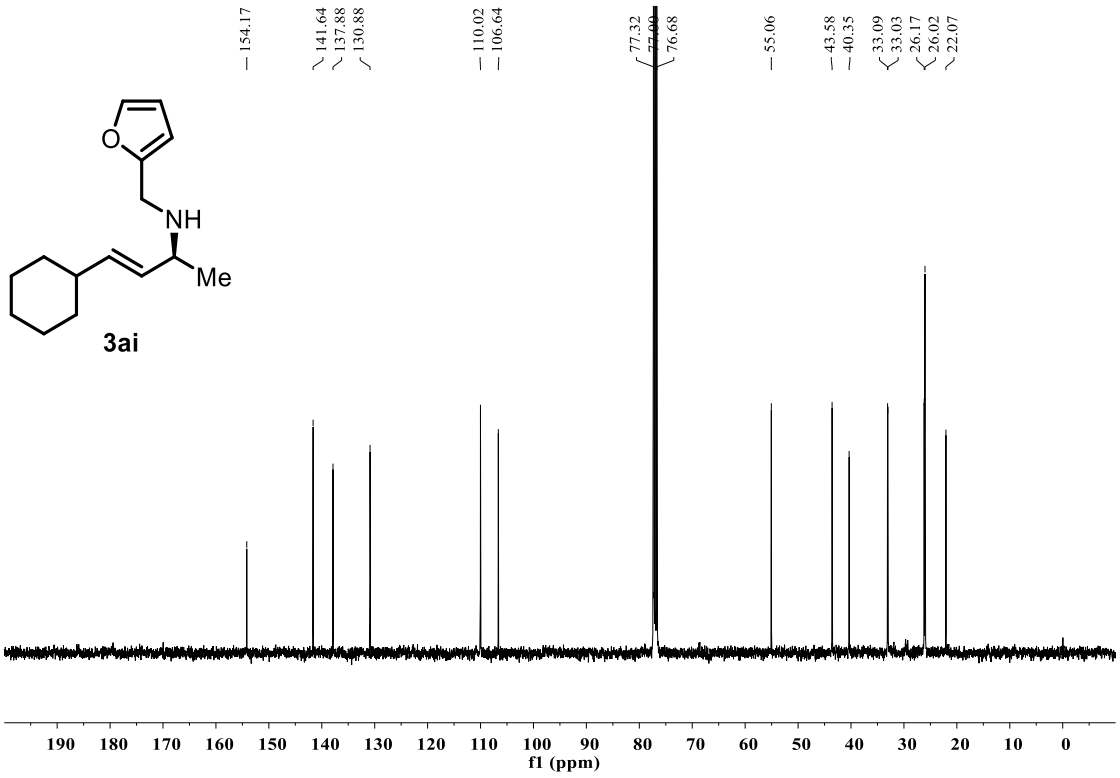


Figure S94. ^{13}C NMR spectra of **3ai**, related to **Figure 4**.

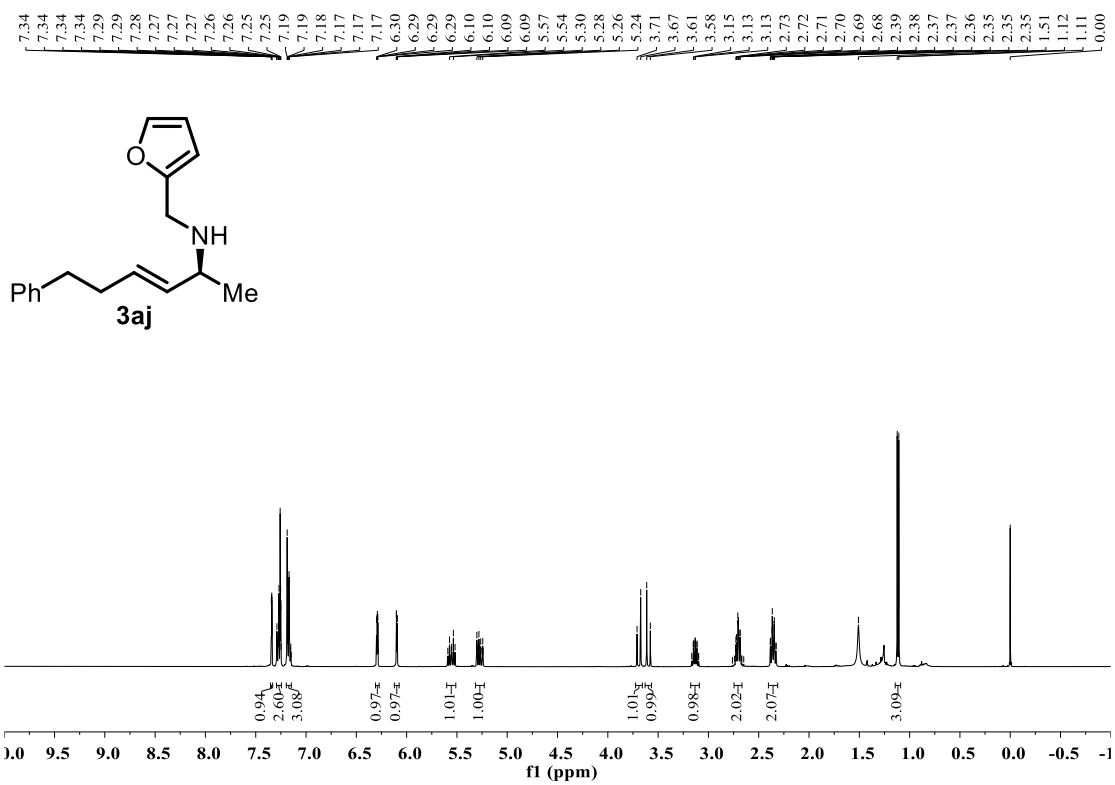


Figure S95. [1]H NMR spectra of **3aj**, related to **Figure 4**.

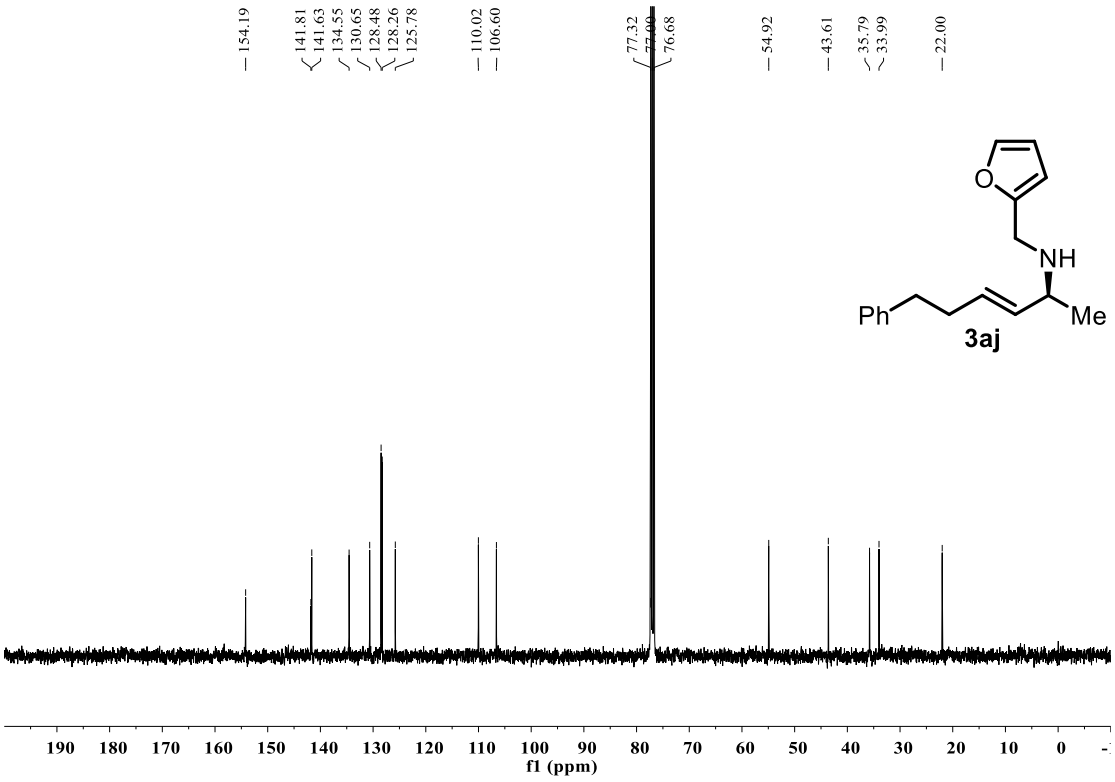


Figure S96. [13]C NMR spectra of **3aj**, related to **Figure 4**.

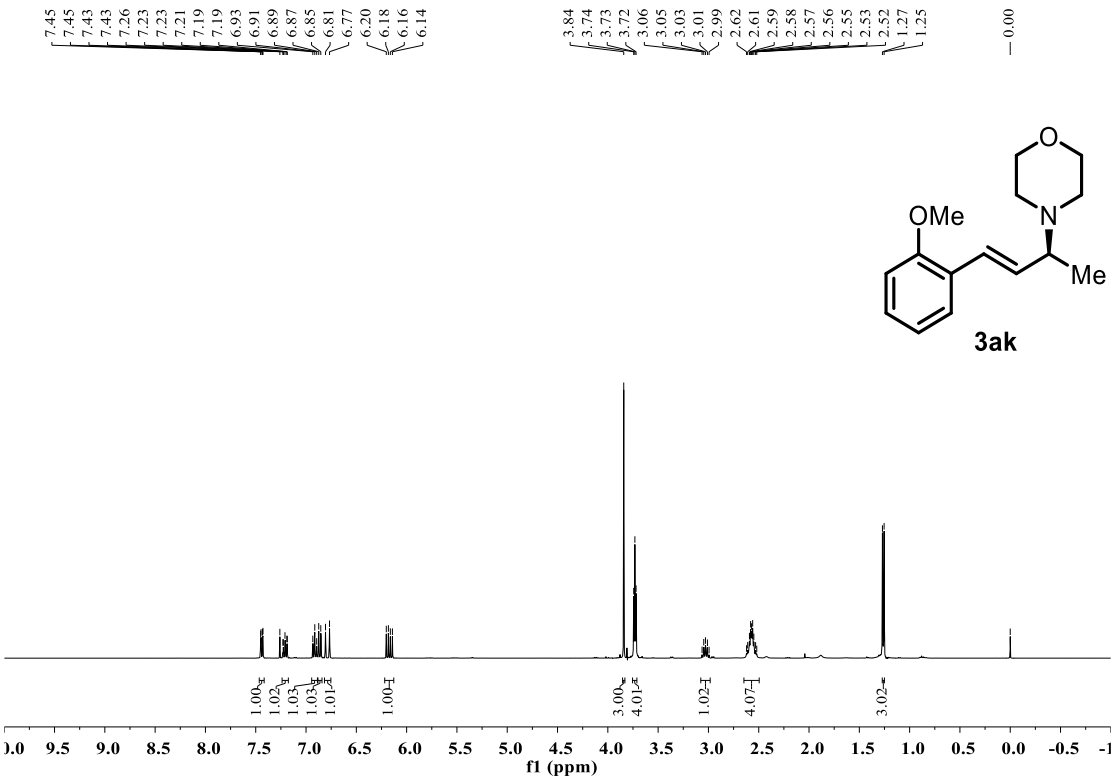


Figure S97. ^{1}H NMR spectra of **3ak**, related to **Figure 4**.

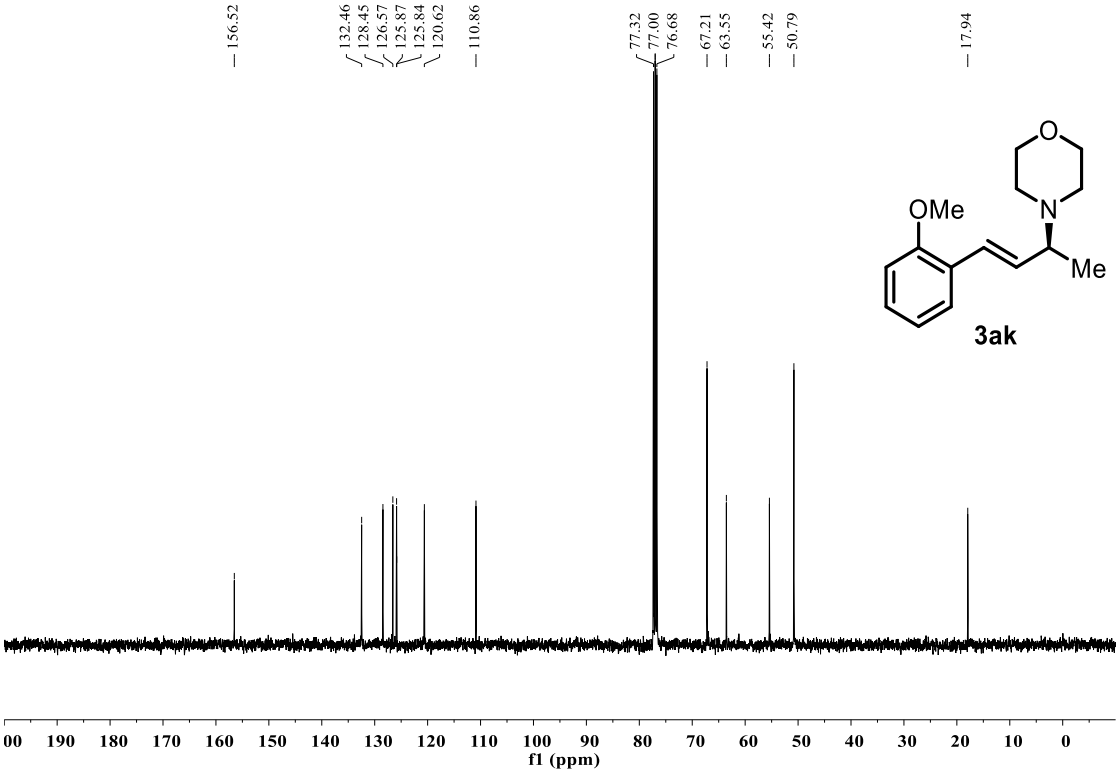


Figure S98. ^{13}C NMR spectra of **3ak**, related to **Figure 4**.

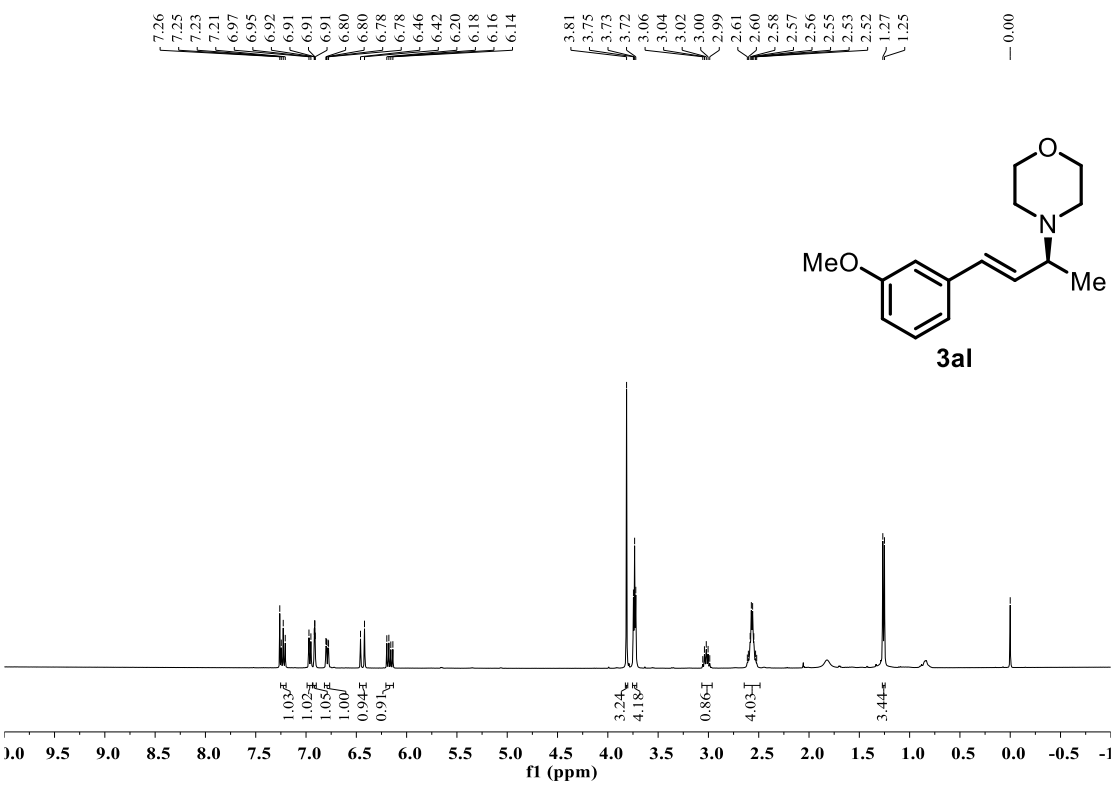


Figure S99. [1]H NMR spectra of **3al**, related to **Figure 4**.

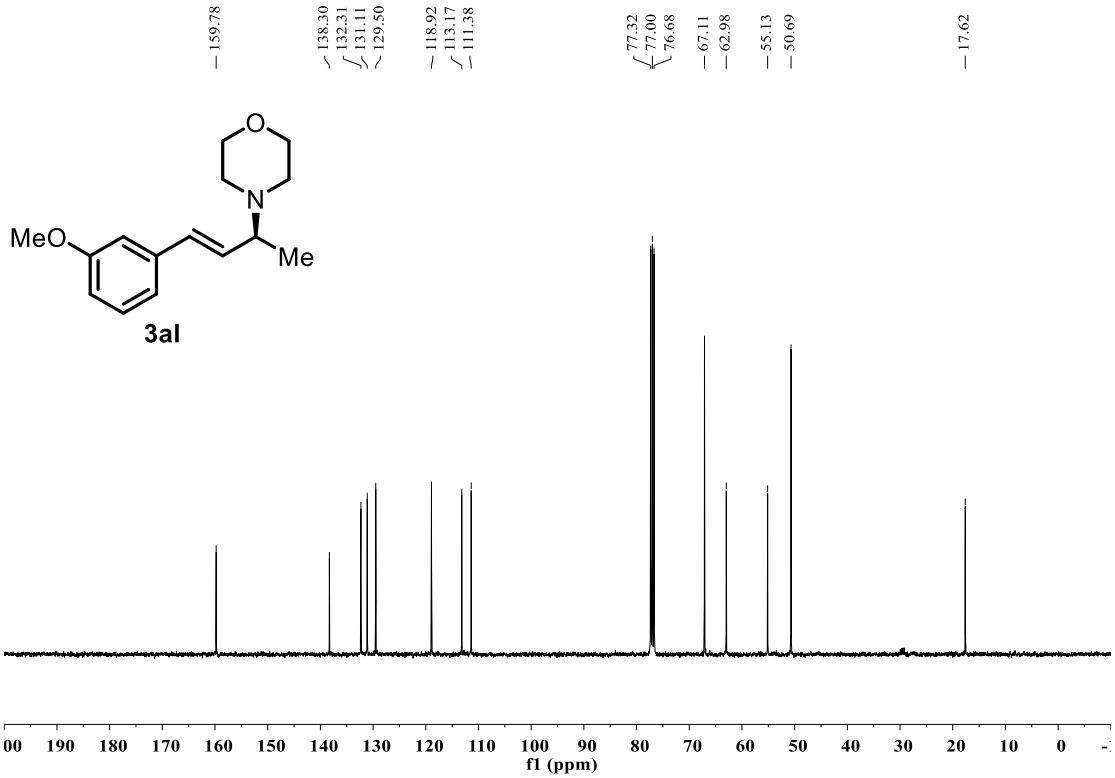


Figure S100. [13]C NMR spectra of **3al**, related to **Figure 4**.

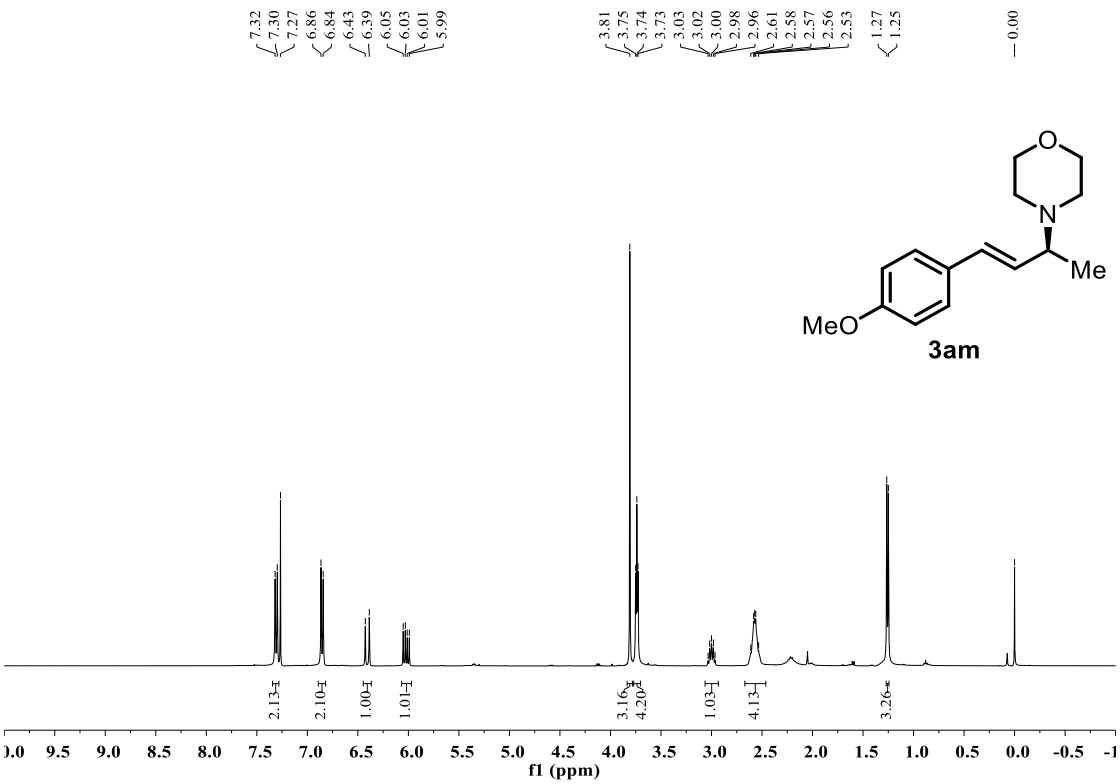


Figure S101. [1]H NMR spectra of **3am**, related to **Figure 4**.

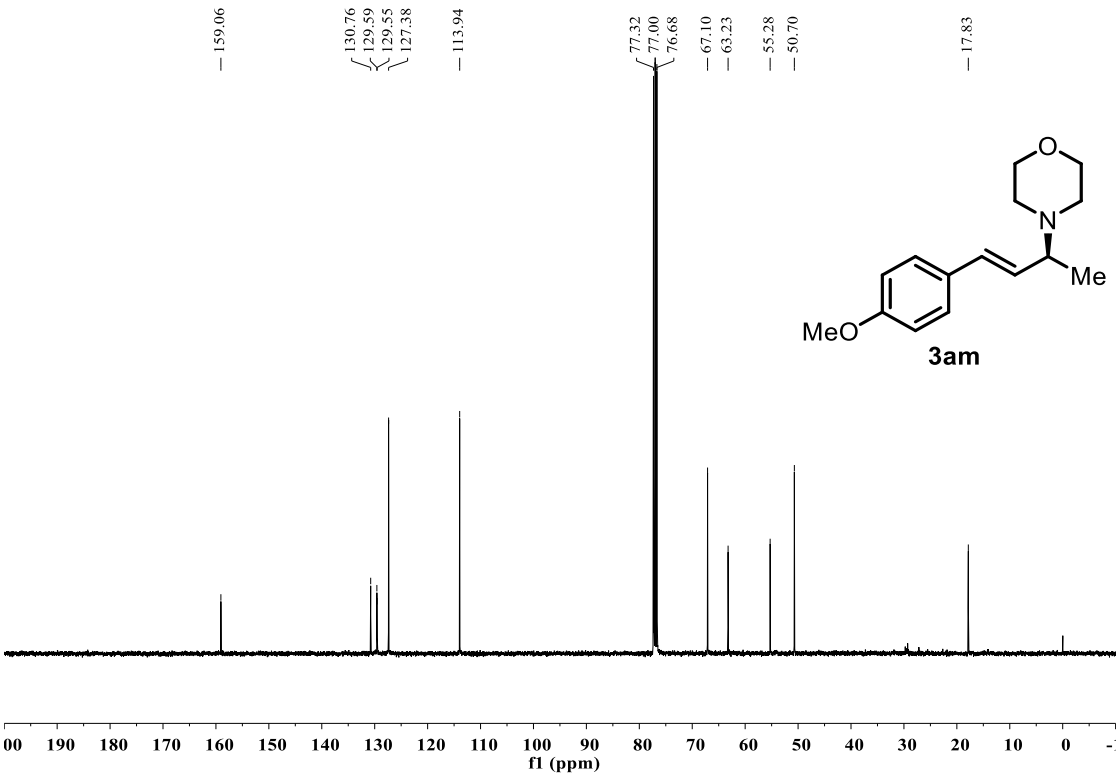


Figure S102. [13]C NMR spectra of **3am**, related to **Figure 4**.

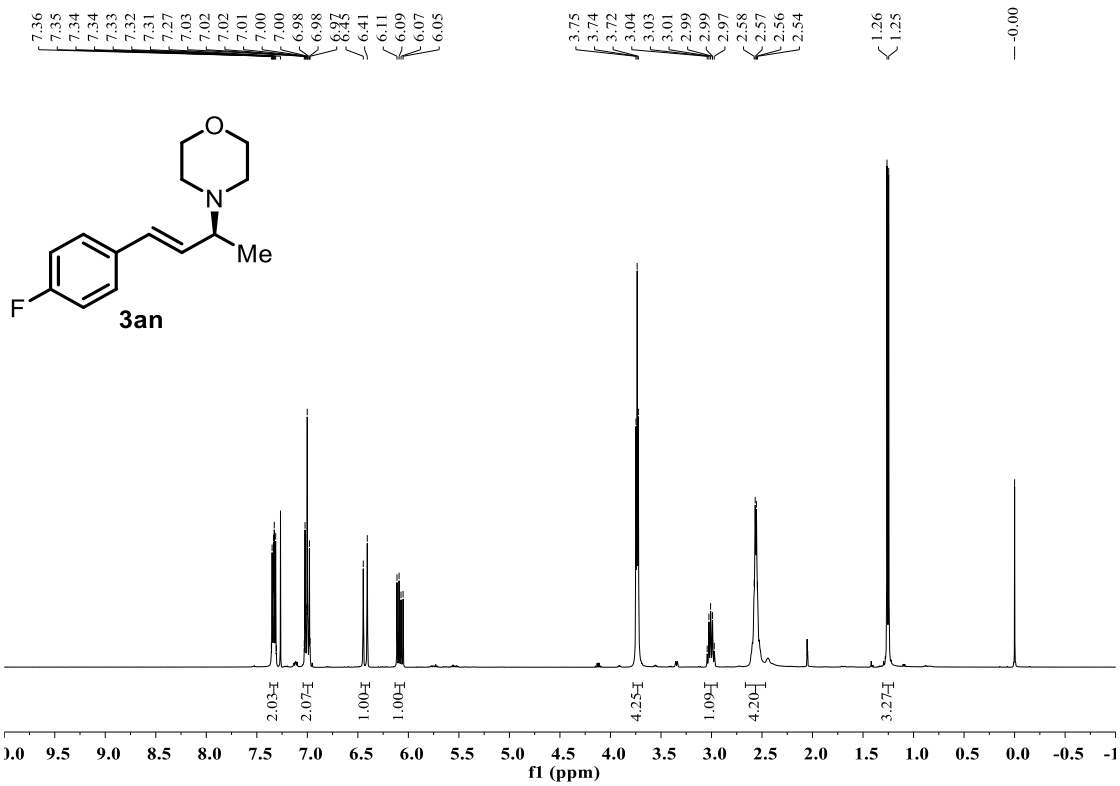


Figure S103. ^{1}H NMR spectra of **3an**, related to **Figure 4**.

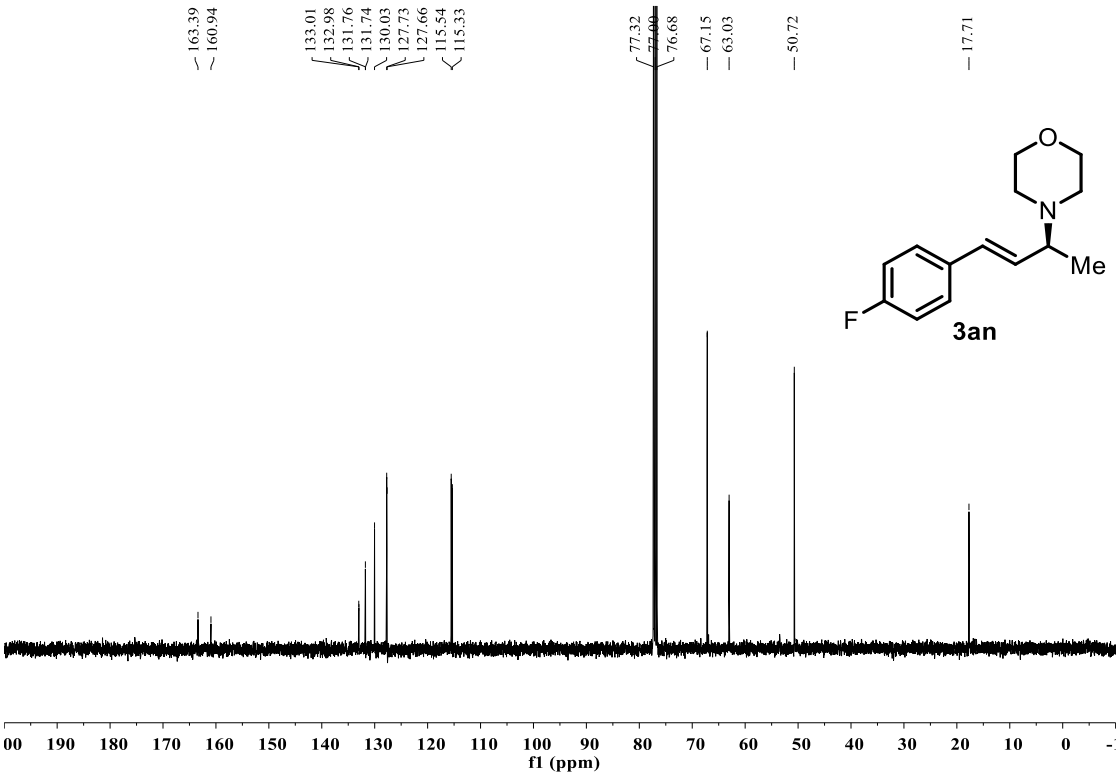


Figure S104. ^{13}C NMR spectra of **3an**, related to **Figure 4**.

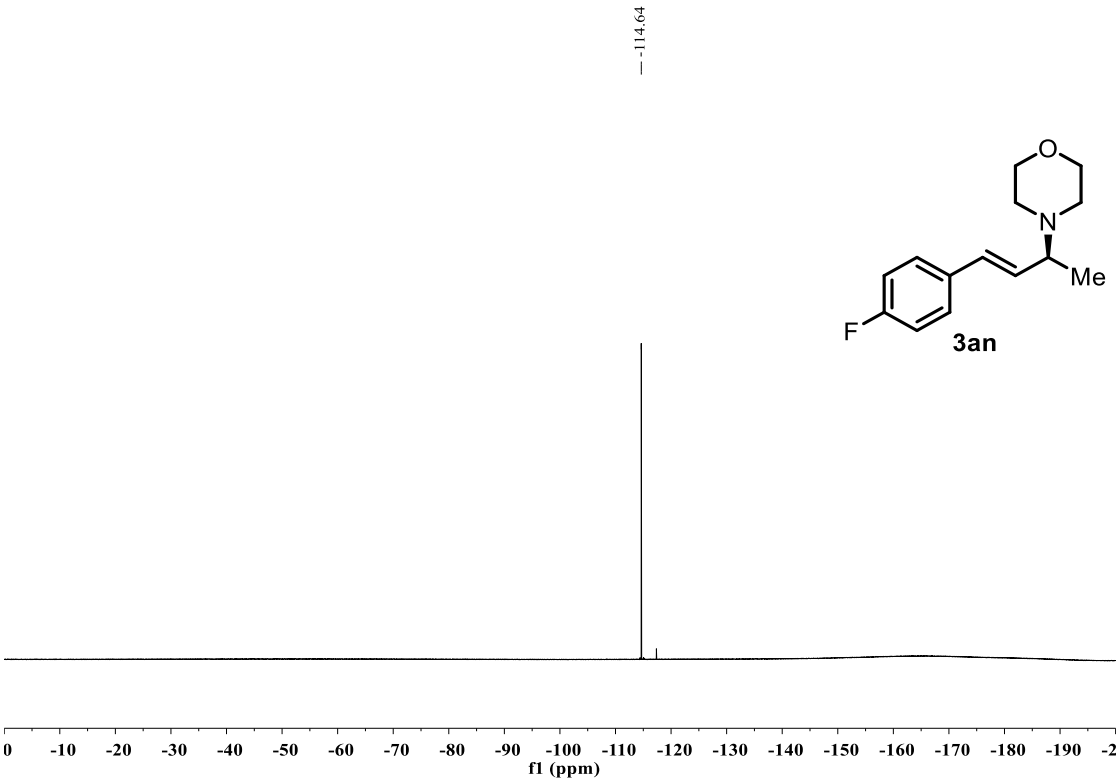


Figure S105. ^{19}F NMR spectra of **3an**, related to **Figure 4**.

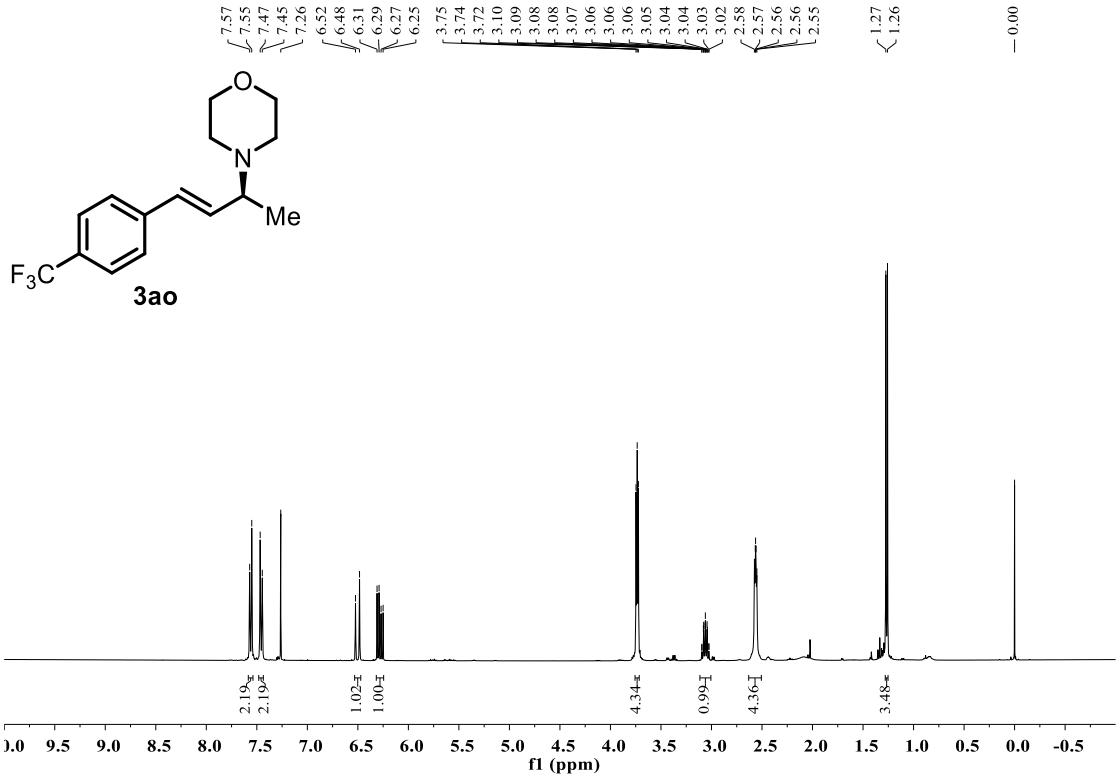


Figure S106. ^{1}H NMR spectra of **3ao**, related to **Figure 4**.

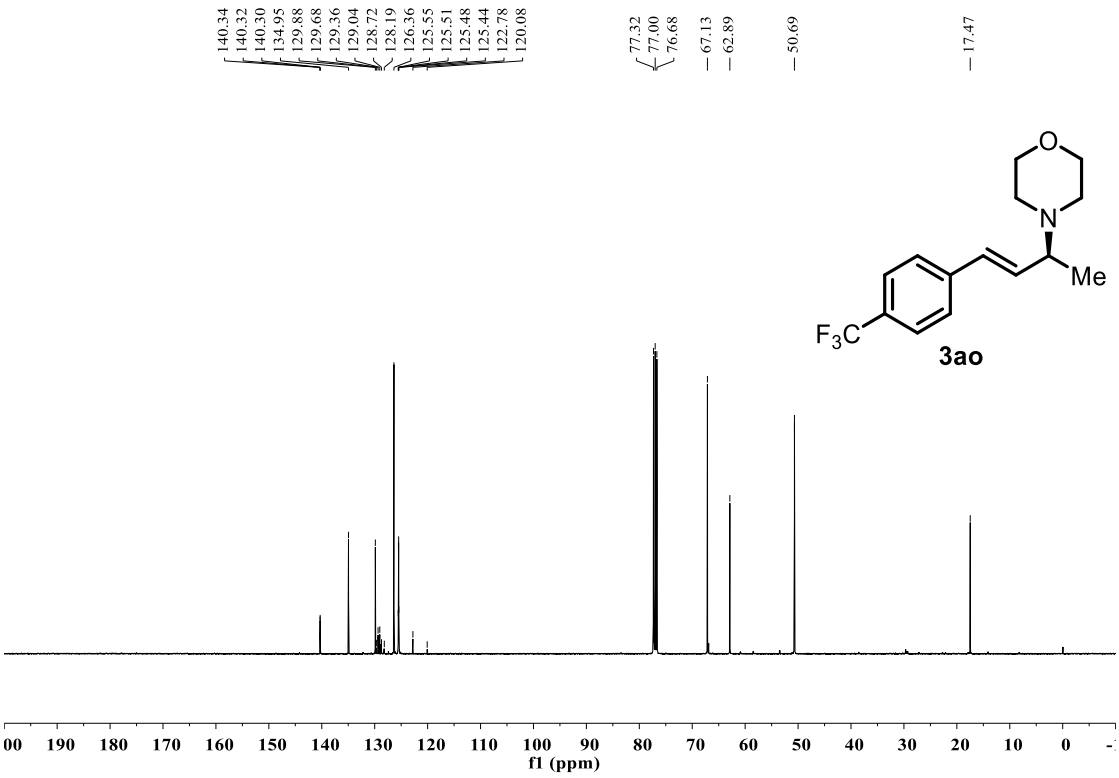


Figure S107. ^{13}C NMR spectra of **3ao**, related to **Figure 4**.

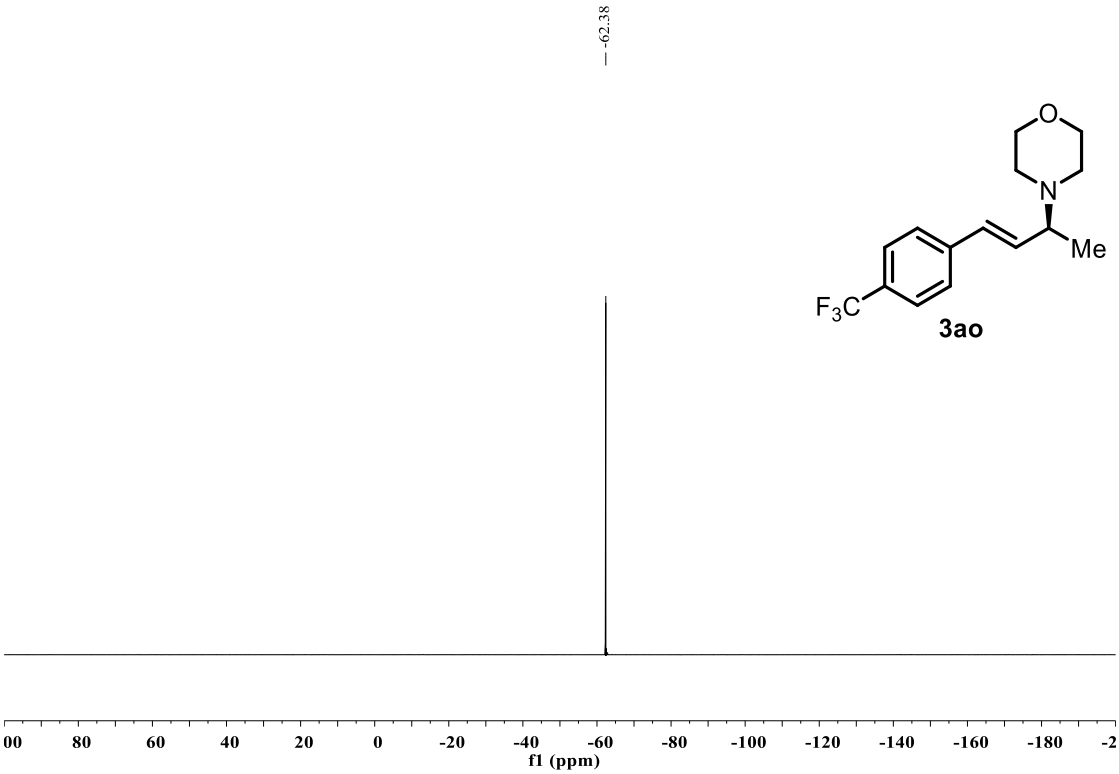


Figure S108. ^{19}F NMR spectra of **3ao**, related to **Figure 4**.

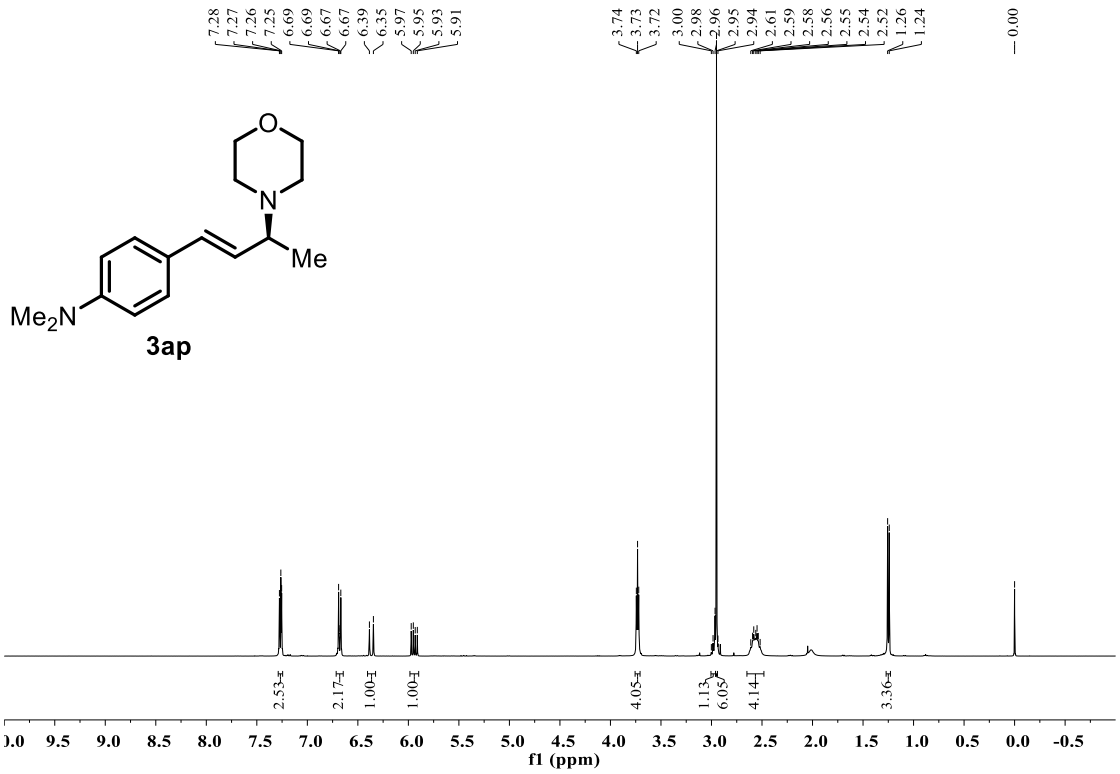


Figure S109. ^{1}H NMR spectra of **3ap**, related to **Figure 4**.

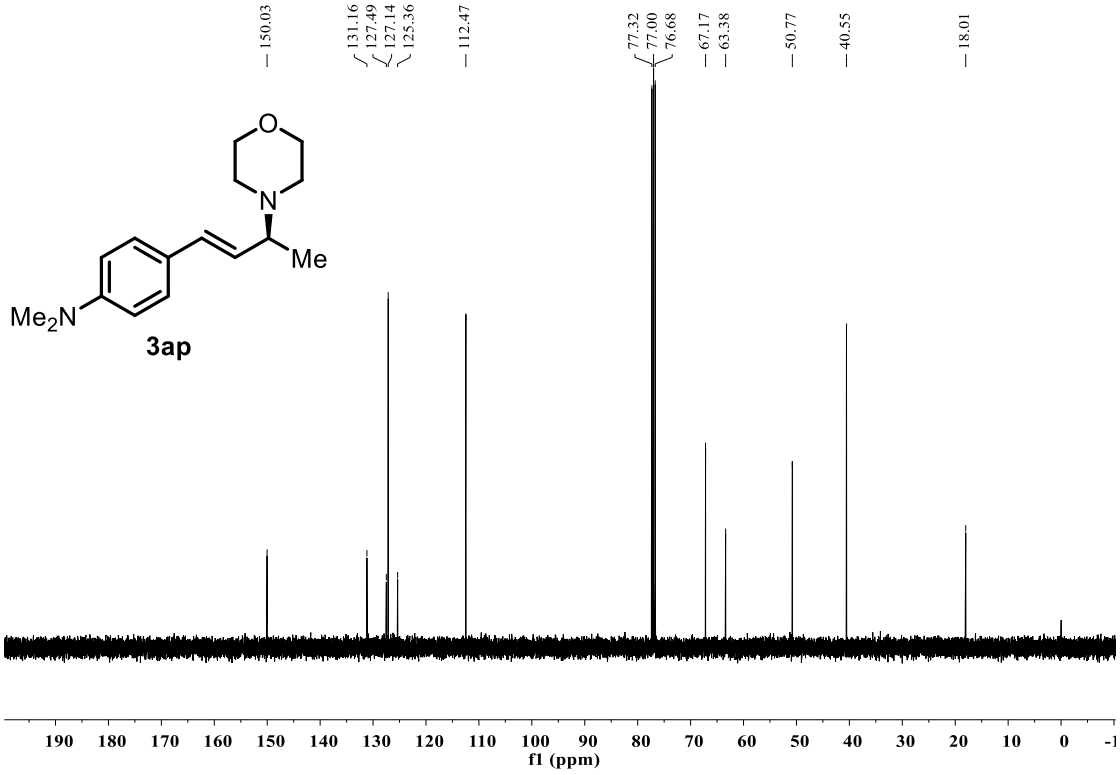


Figure S110. ^{13}C NMR spectra of **3ap**, related to **Figure 4**.

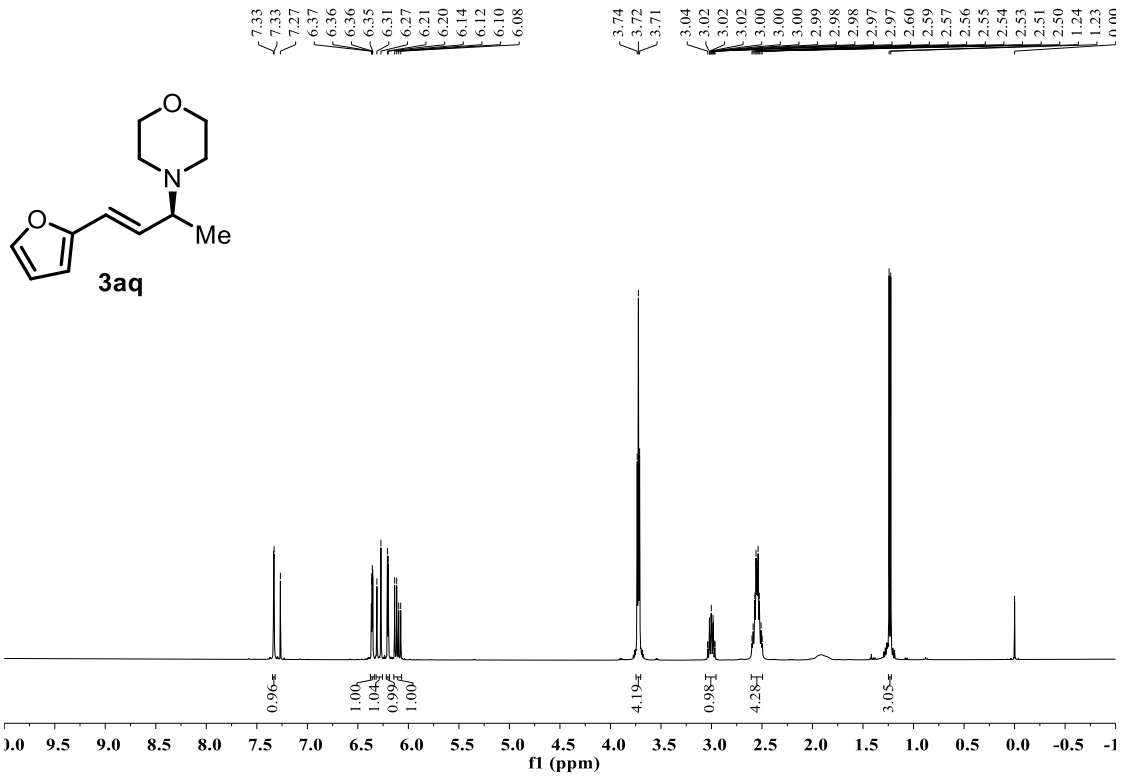


Figure S111. [1]H NMR spectra of **3aq**, related to **Figure 4**.

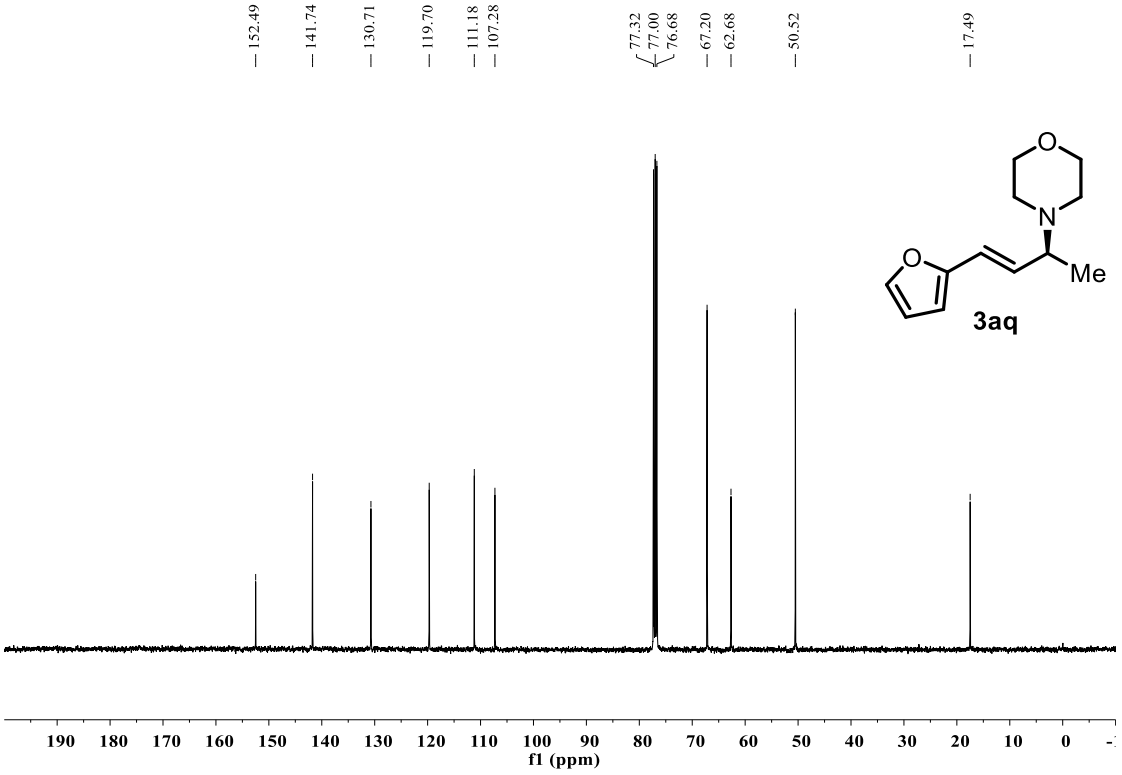


Figure S112. [13]C NMR spectra of **3aq**, related to **Figure 4**.

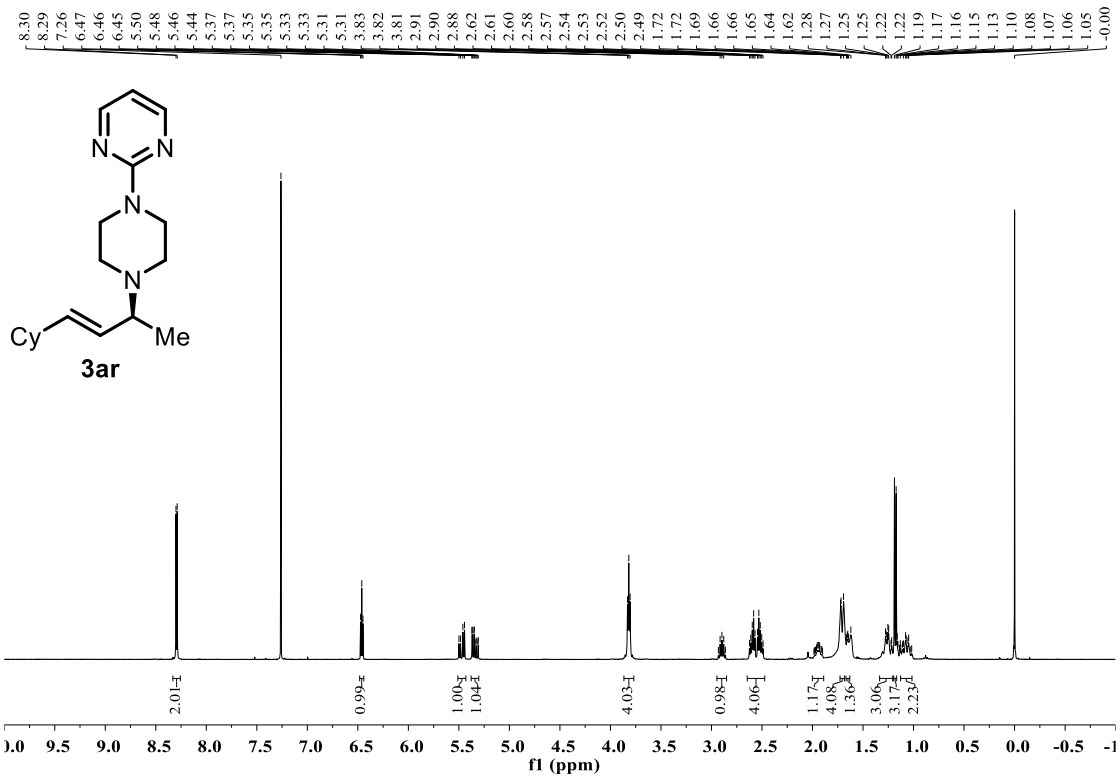


Figure S113. ^{1}H NMR spectra of **3ar**, related to **Figure 4**.

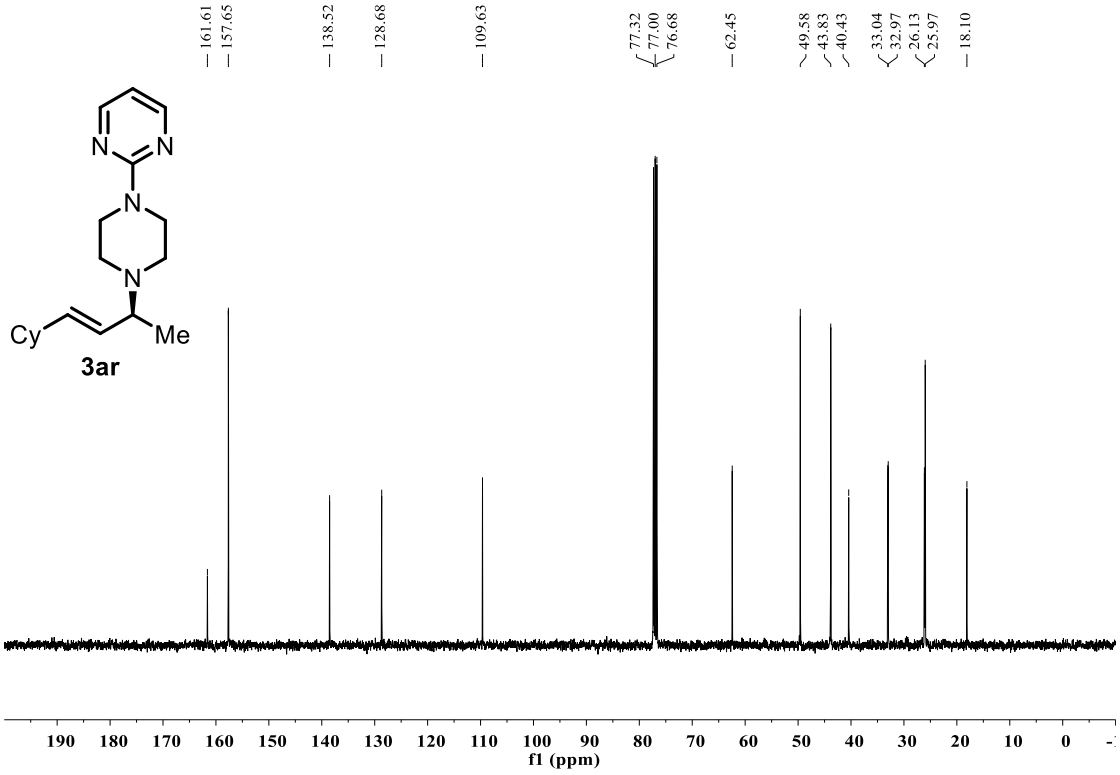


Figure S114. ^{13}C NMR spectra of **3ar**, related to **Figure 4**.

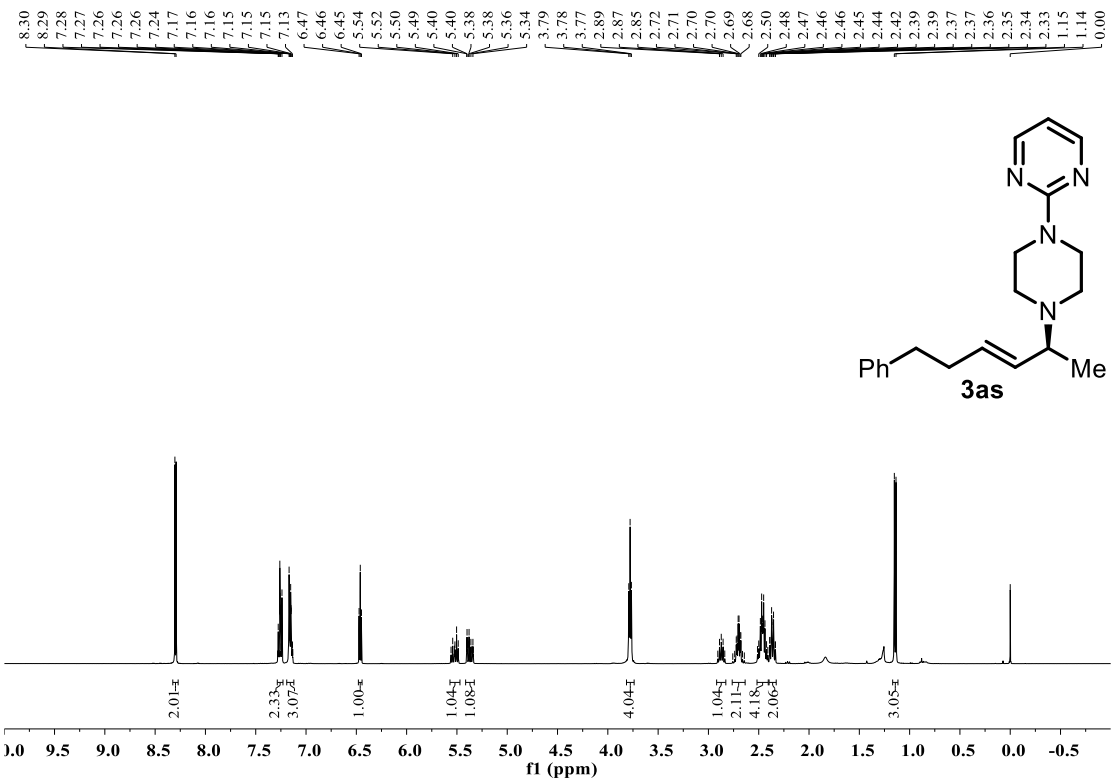


Figure S115. [1]H NMR spectra of **3as**, related to **Figure 4**.

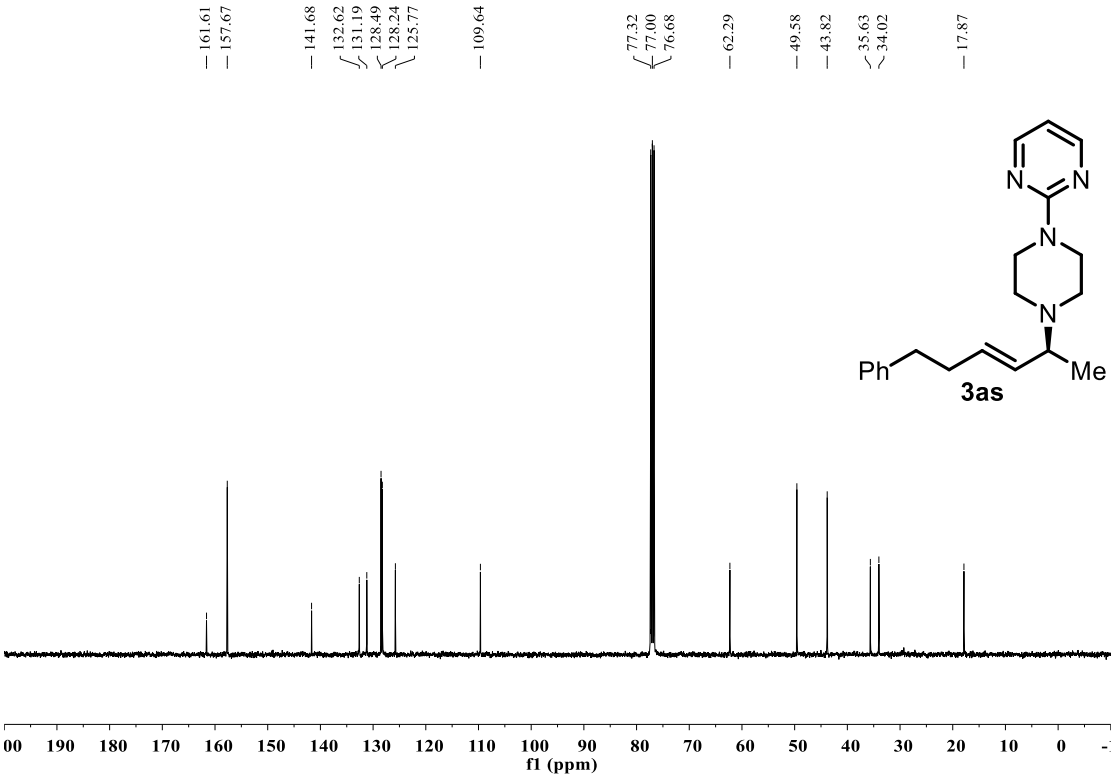


Figure S116. [13]C NMR spectra of **3as**, related to **Figure 4**.

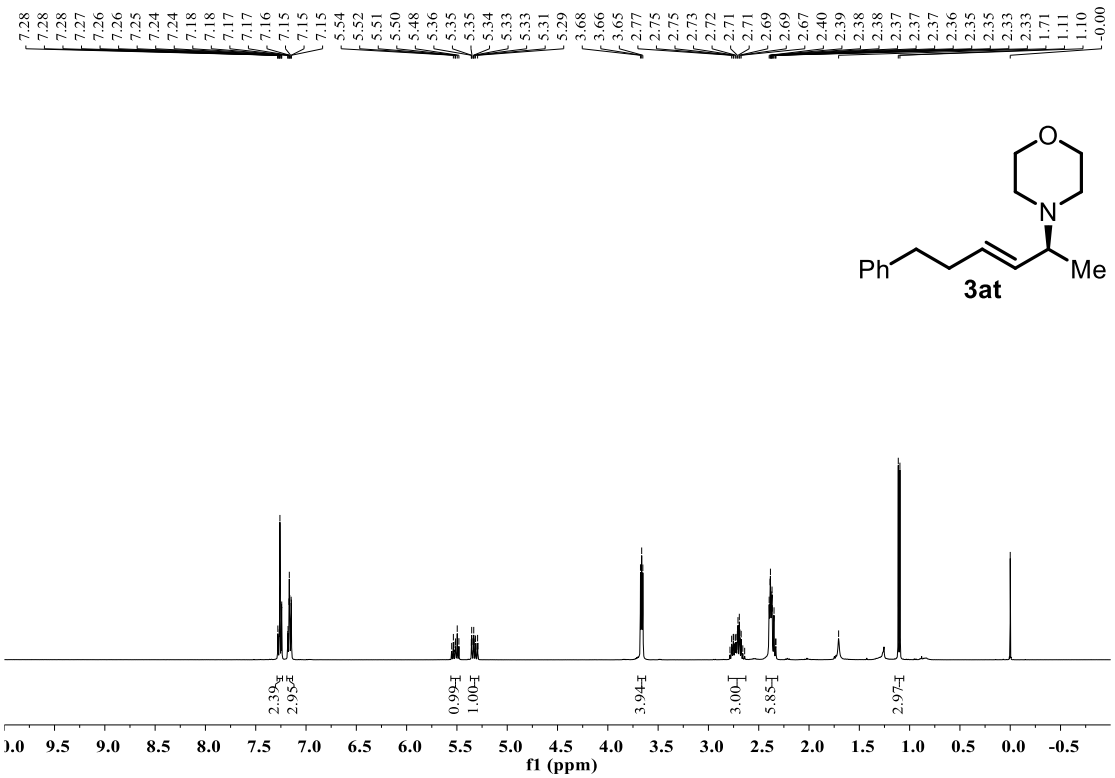


Figure S117. [1]H NMR spectra of **3at**, related to **Figure 4**.

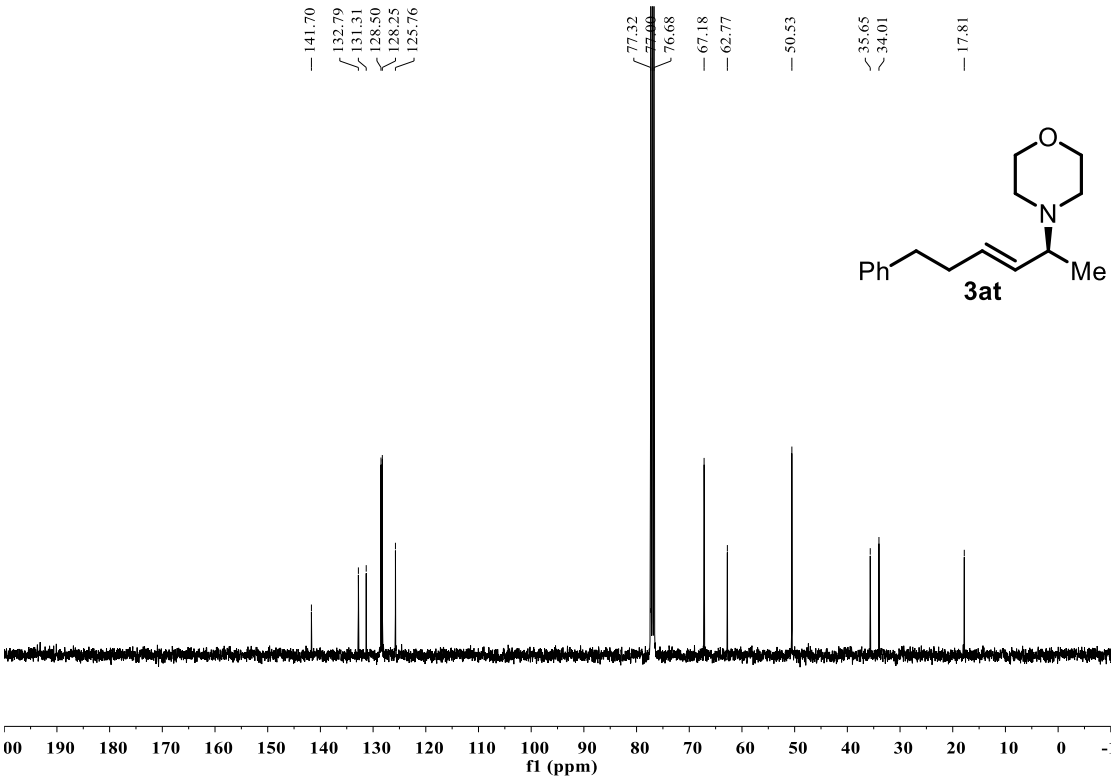


Figure S118. [13]C NMR spectra of **3at**, related to **Figure 4**.

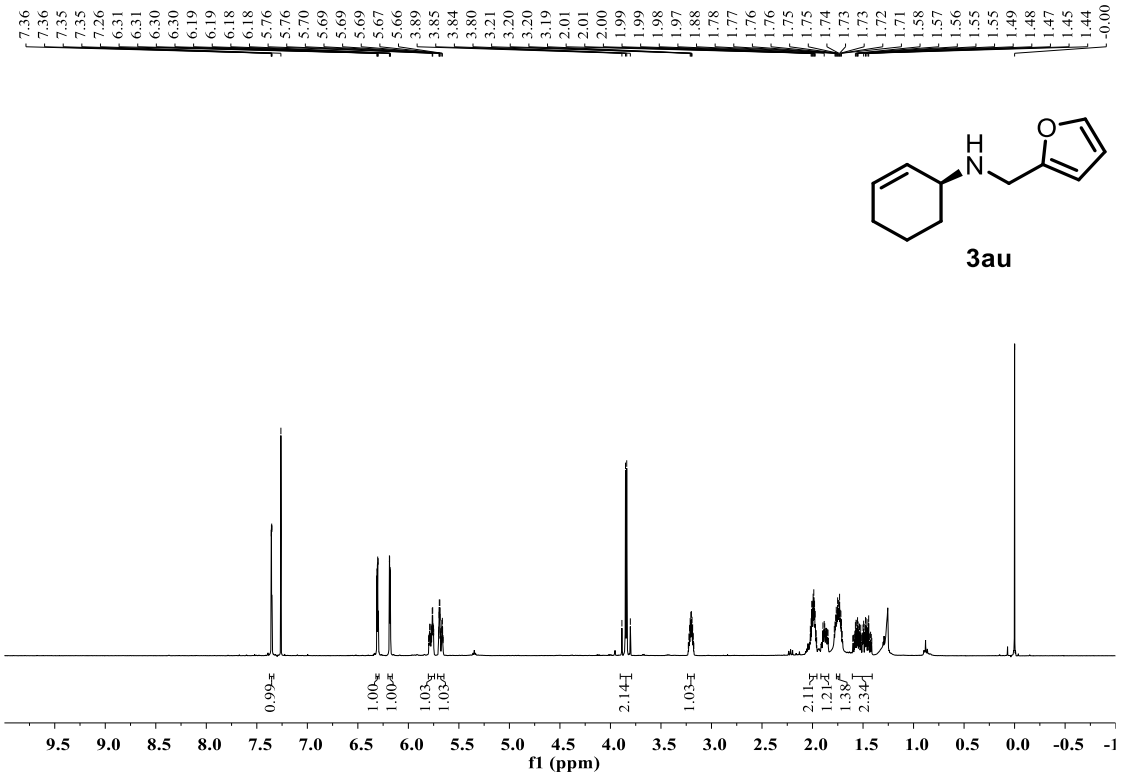


Figure S119. [1]H NMR spectra of **3au**, related to **Figure 4**.

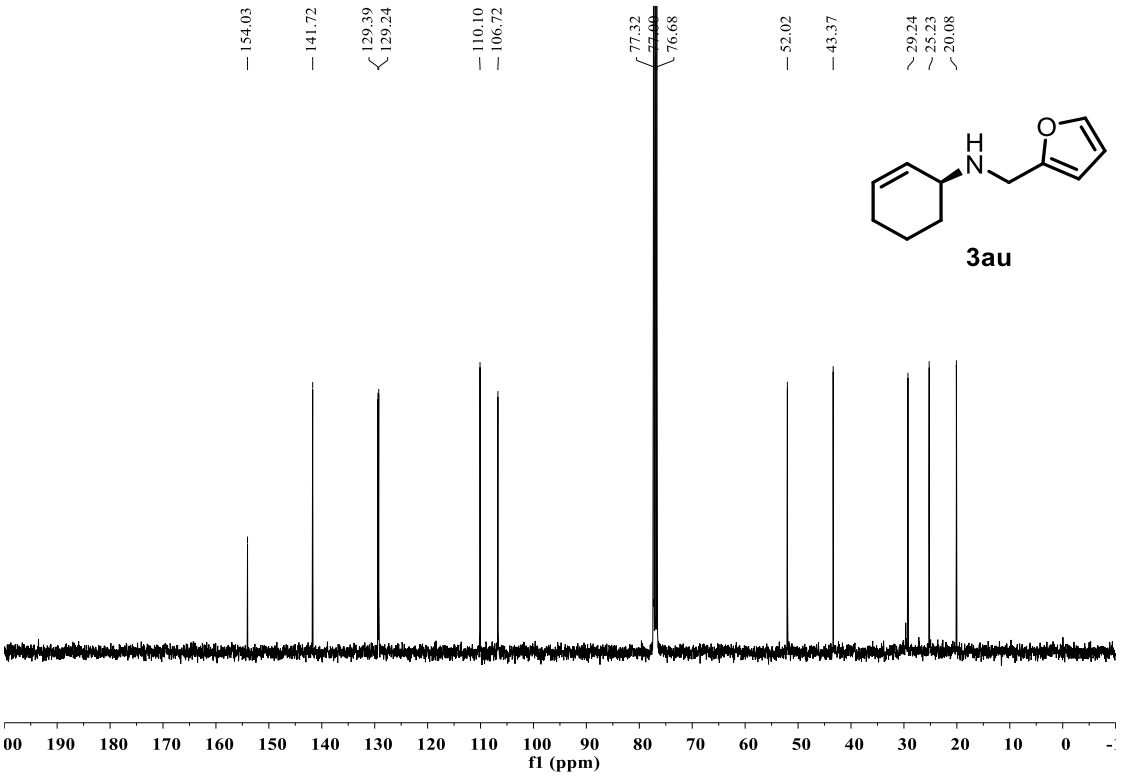


Figure S120. [13]C NMR spectra of **3au**, related to **Figure 4**.

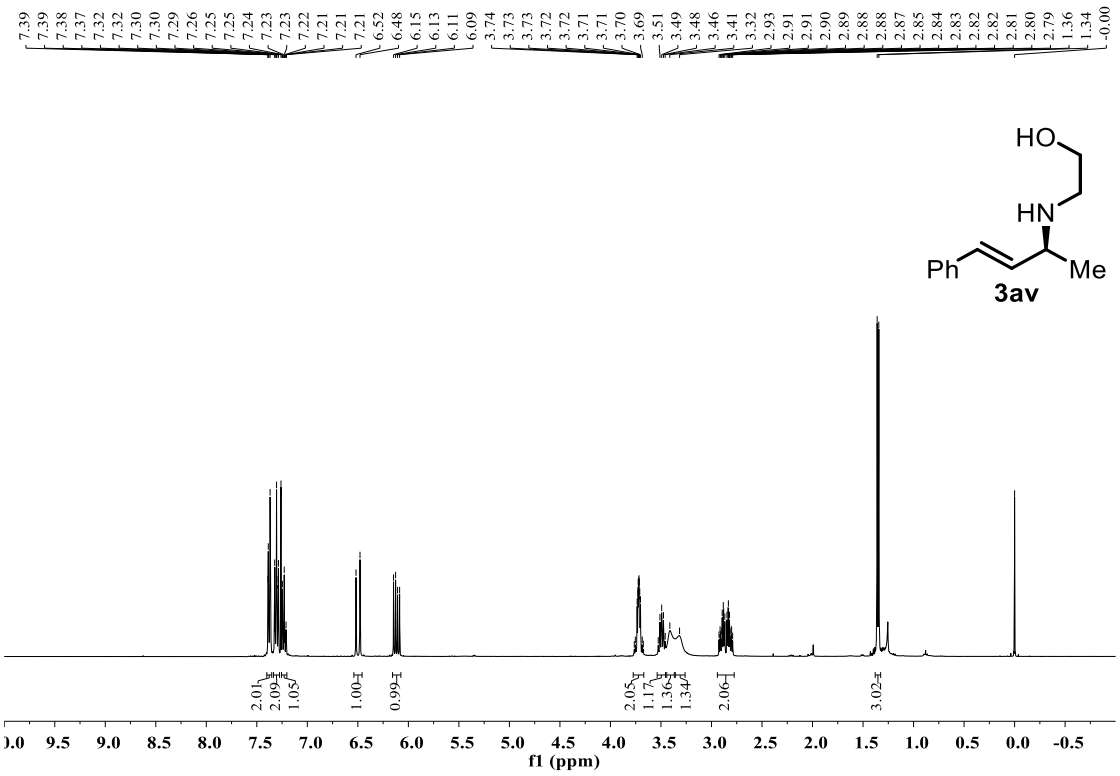


Figure S121. ^{1}H NMR spectra of **3av**, related to **Figure 5**.

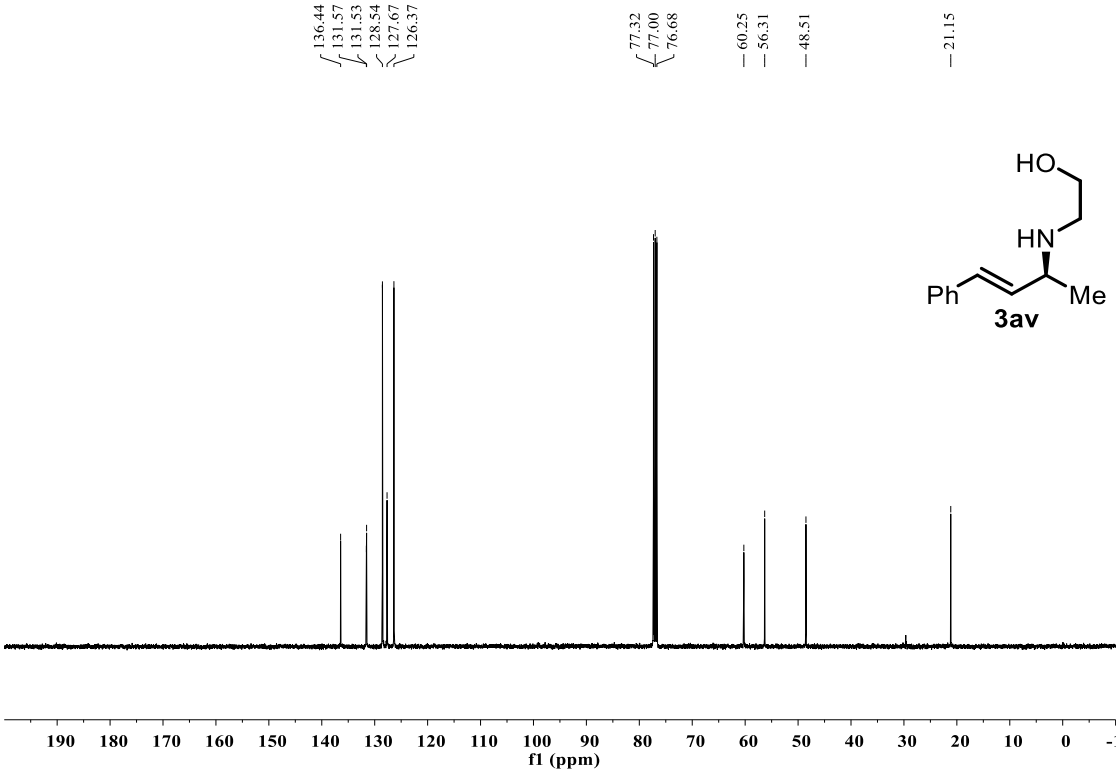


Figure S122. ^{13}C NMR spectra of **3av**, related to **Figure 5**.

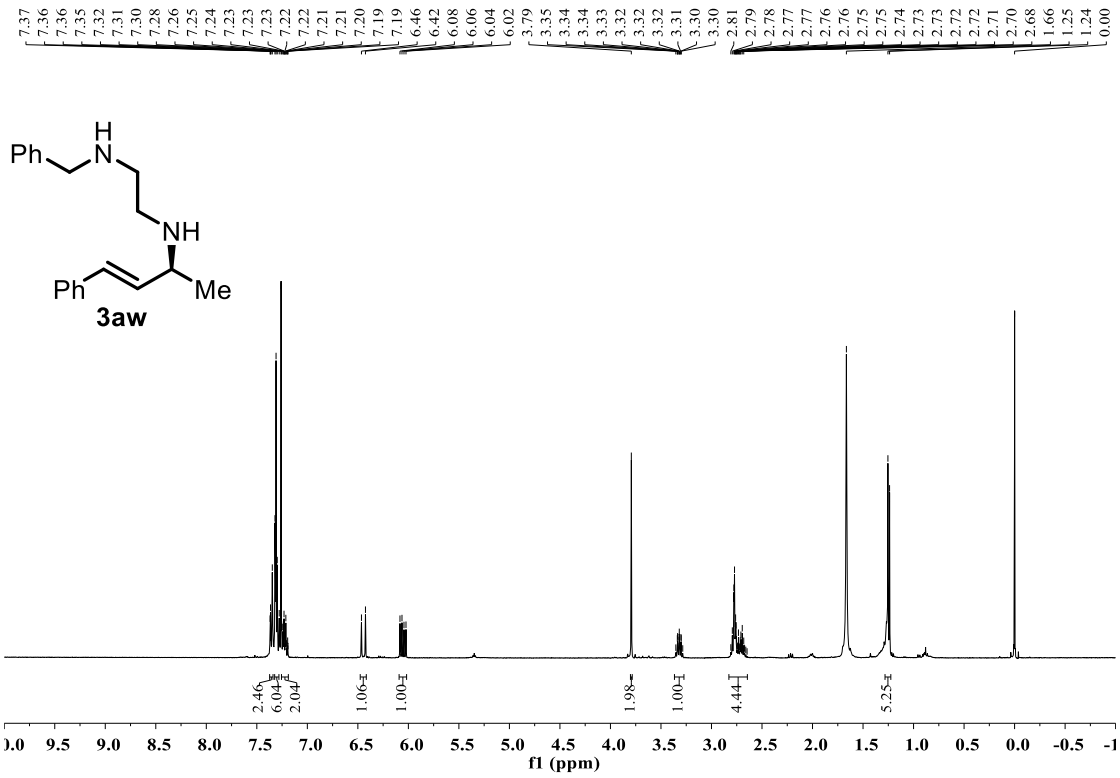


Figure S123. ^{1}H NMR spectra of **3aw**, related to **Figure 5**.

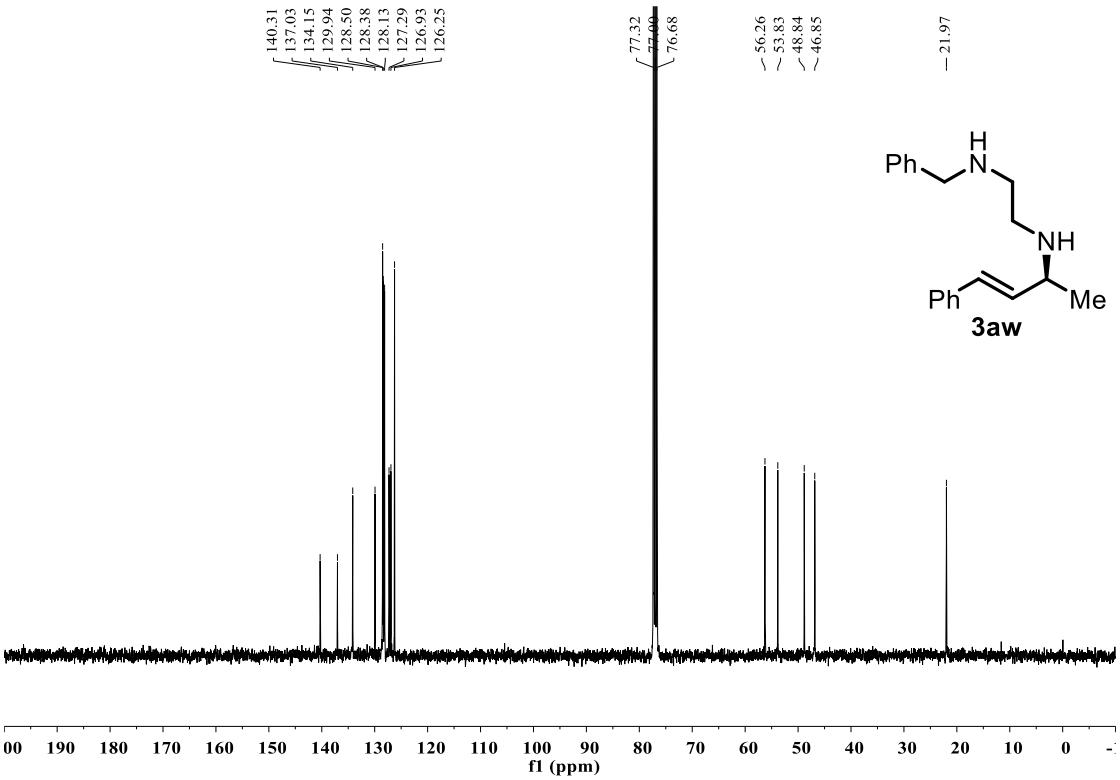


Figure S124. ^{13}C NMR spectra of **3aw**, related to **Figure 5**.

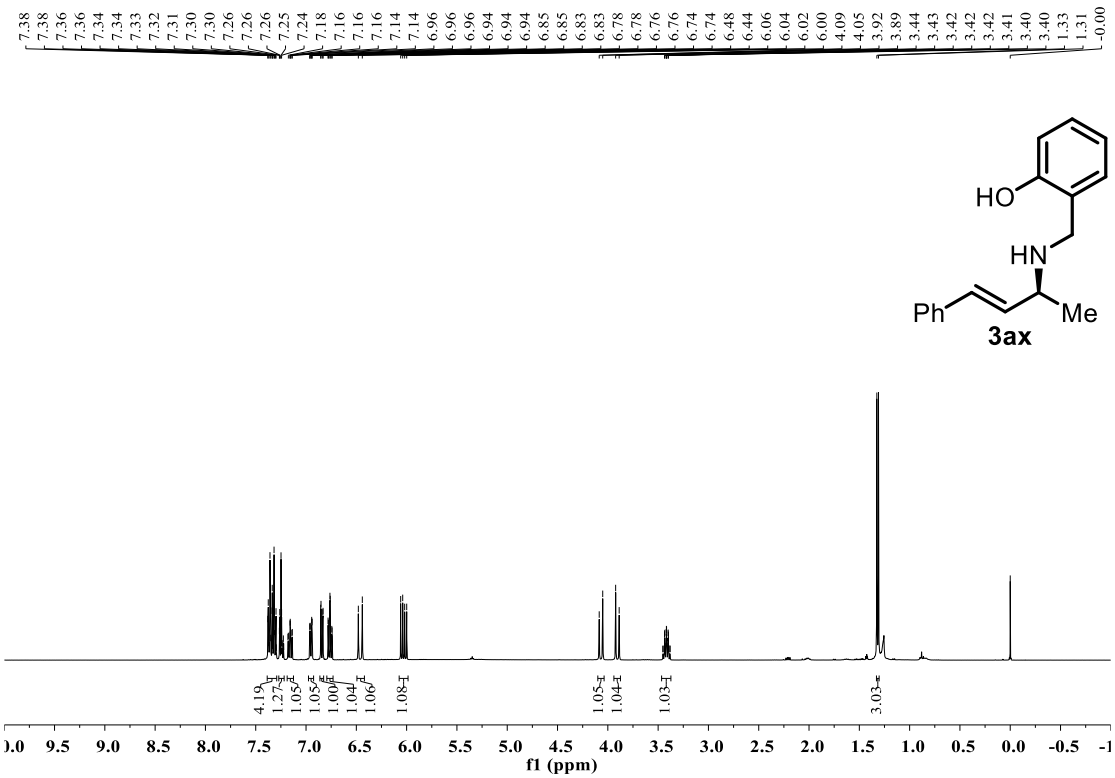


Figure S125. ^{1}H NMR spectra of **3ax**, related to **Figure 5**.

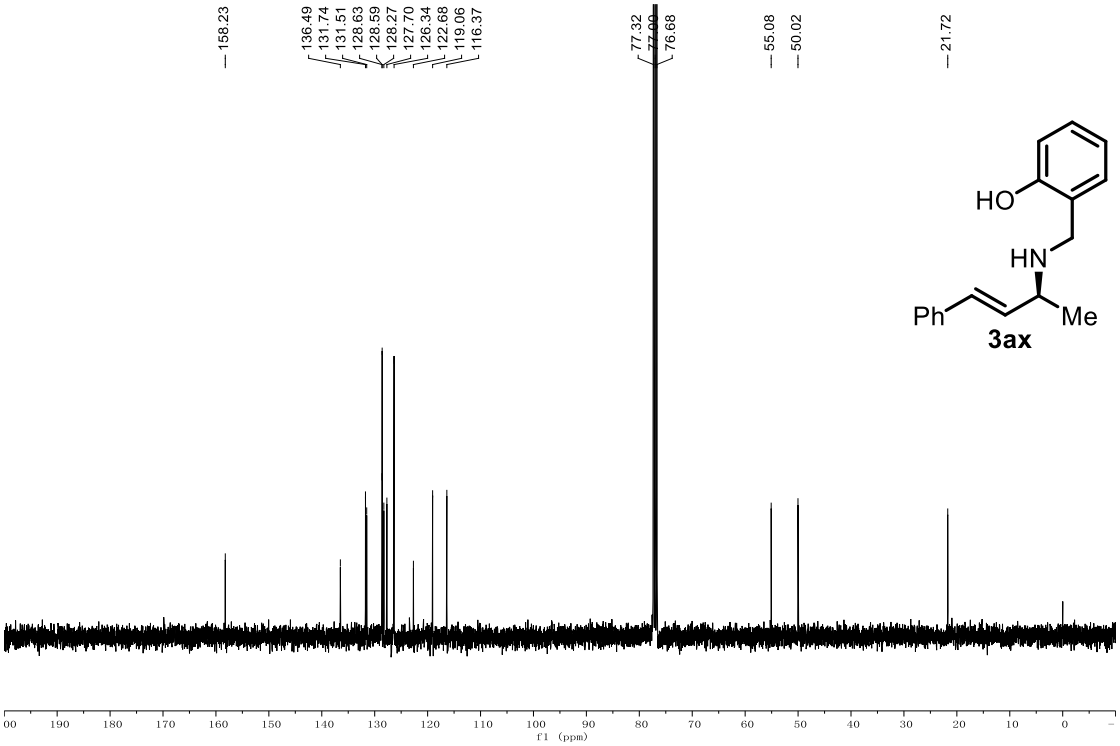


Figure S126. ^{13}C NMR spectra of **3ax**, related to **Figure 5**.

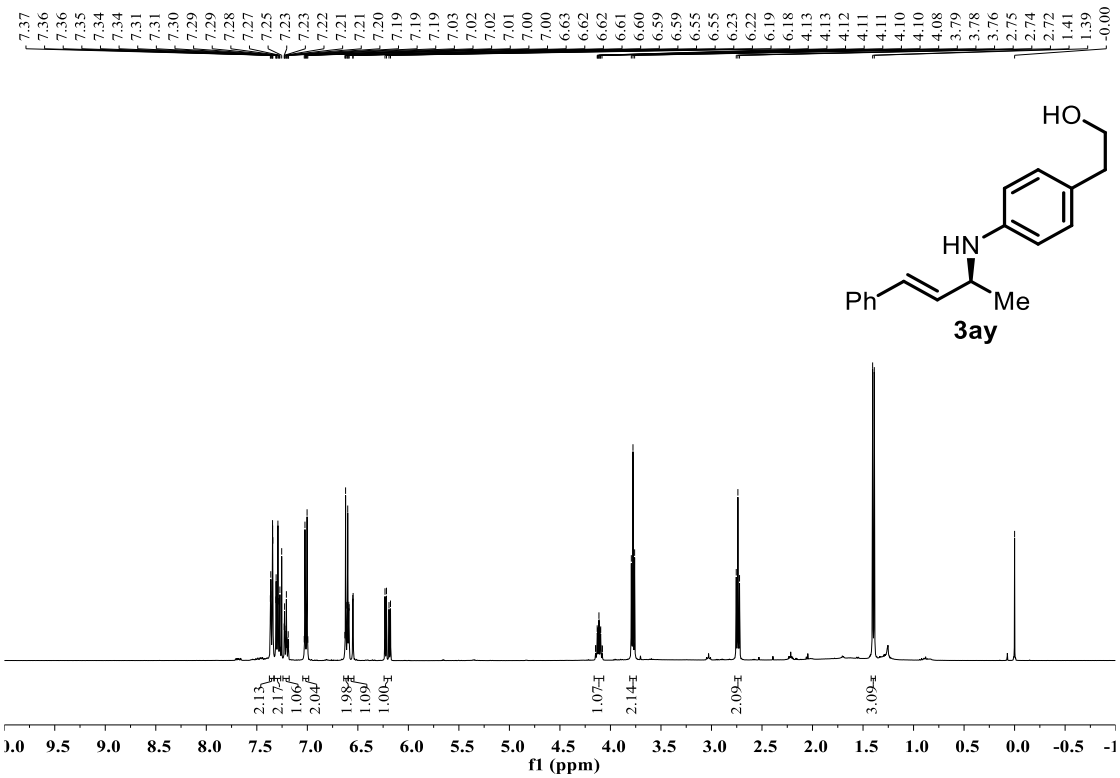


Figure S127. ^{1}H NMR spectra of **3ay**, related to **Figure 5**.

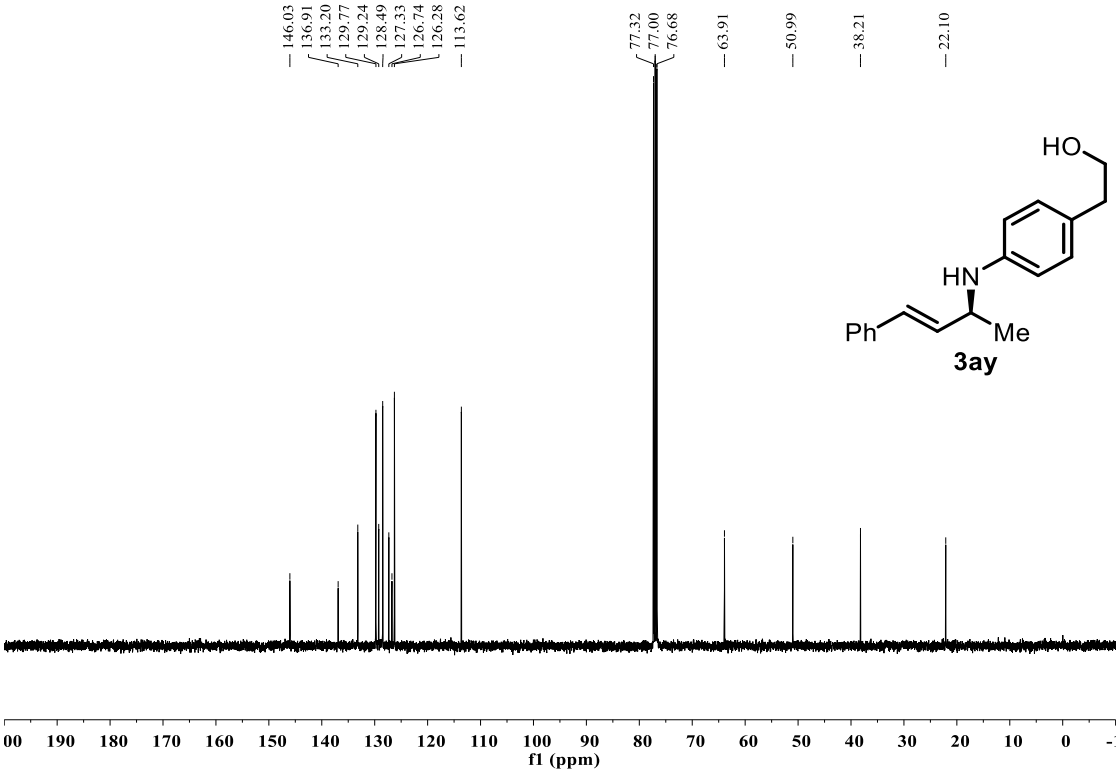


Figure S128. ^{13}C NMR spectra of **3ay**, related to **Figure 5**.

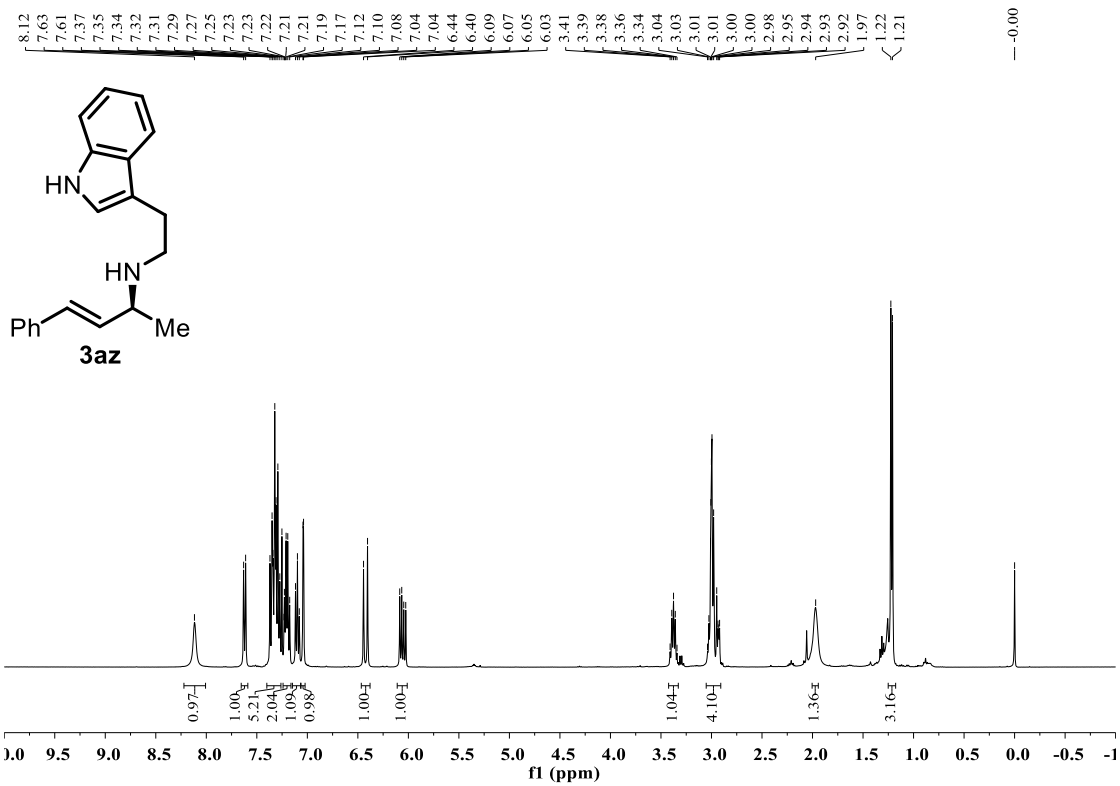


Figure S129. ^{1}H NMR spectra of **3az**, related to **Figure 5**.

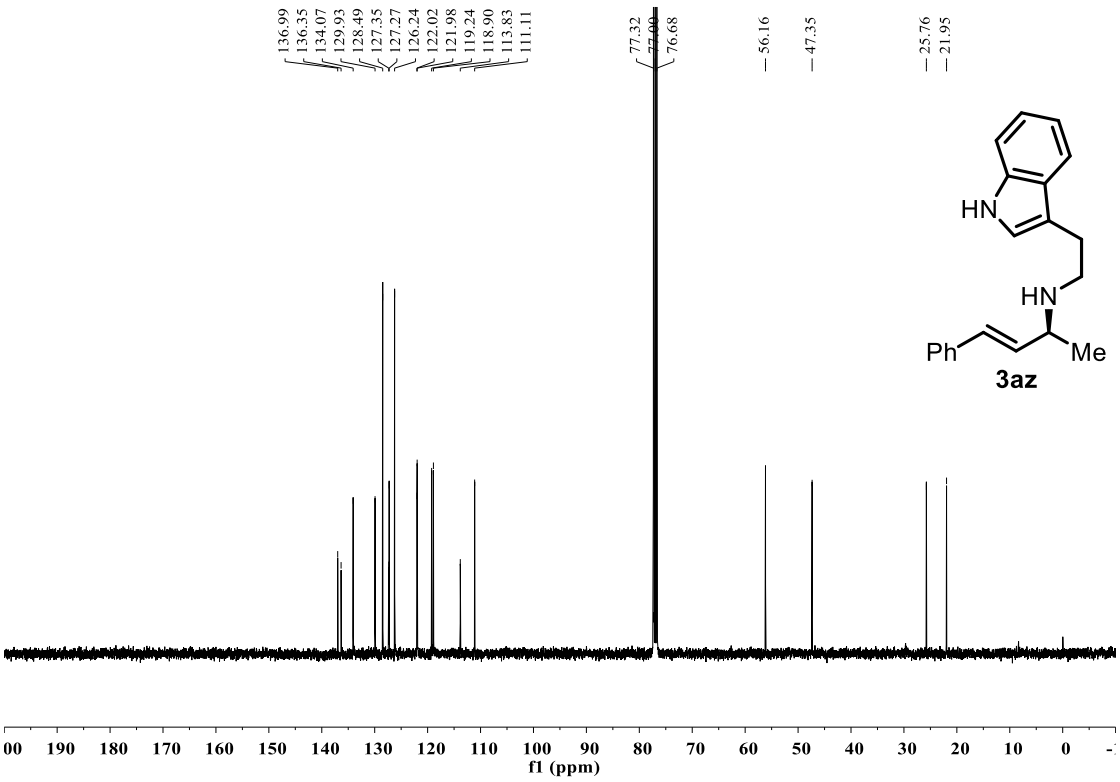


Figure S130. ^{13}C NMR spectra of **3az**, related to **Figure 5**.

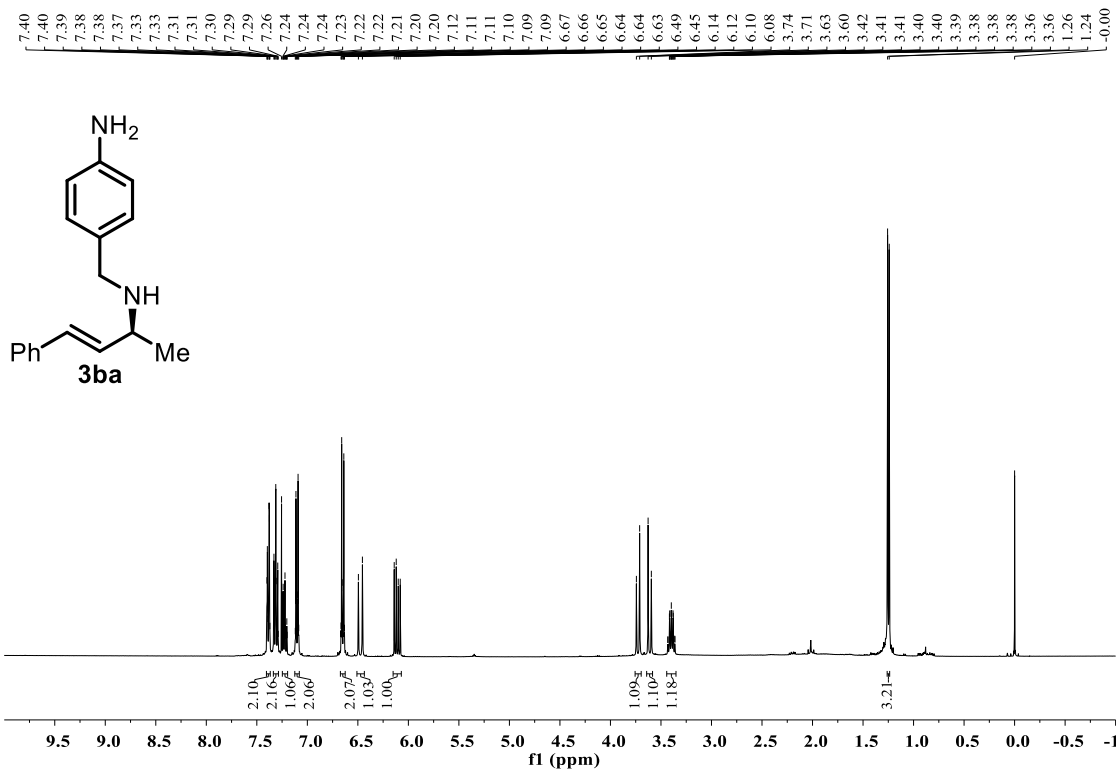


Figure S131. ^{1}H NMR spectra of **3ba**, related to **Figure 5**.

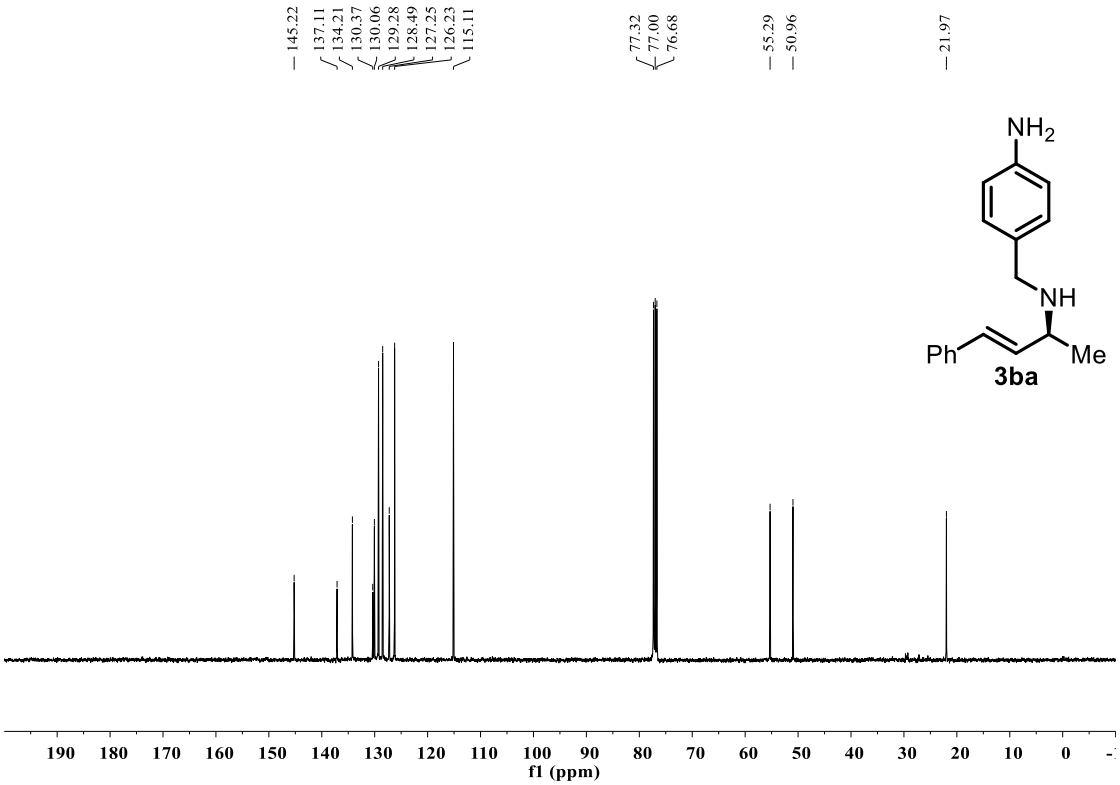


Figure S132. ^{13}C NMR spectra of **3ba**, related to **Figure 5**.

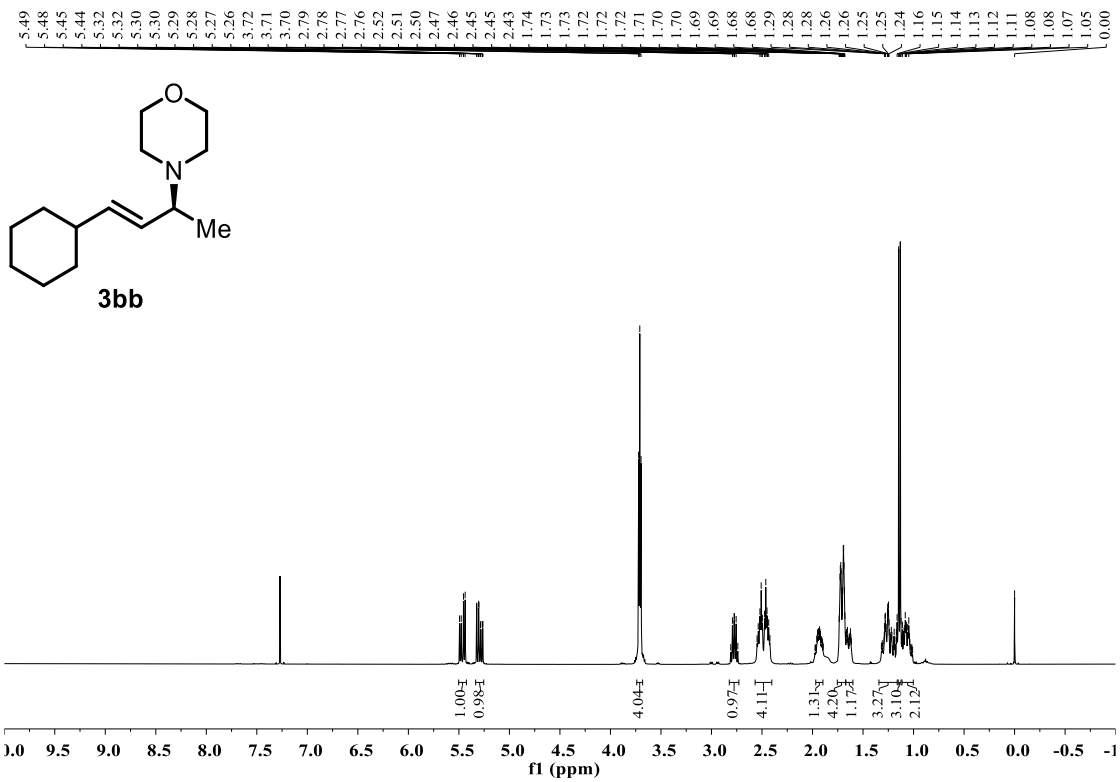


Figure S133. ^{1}H NMR spectra of **3ba**.

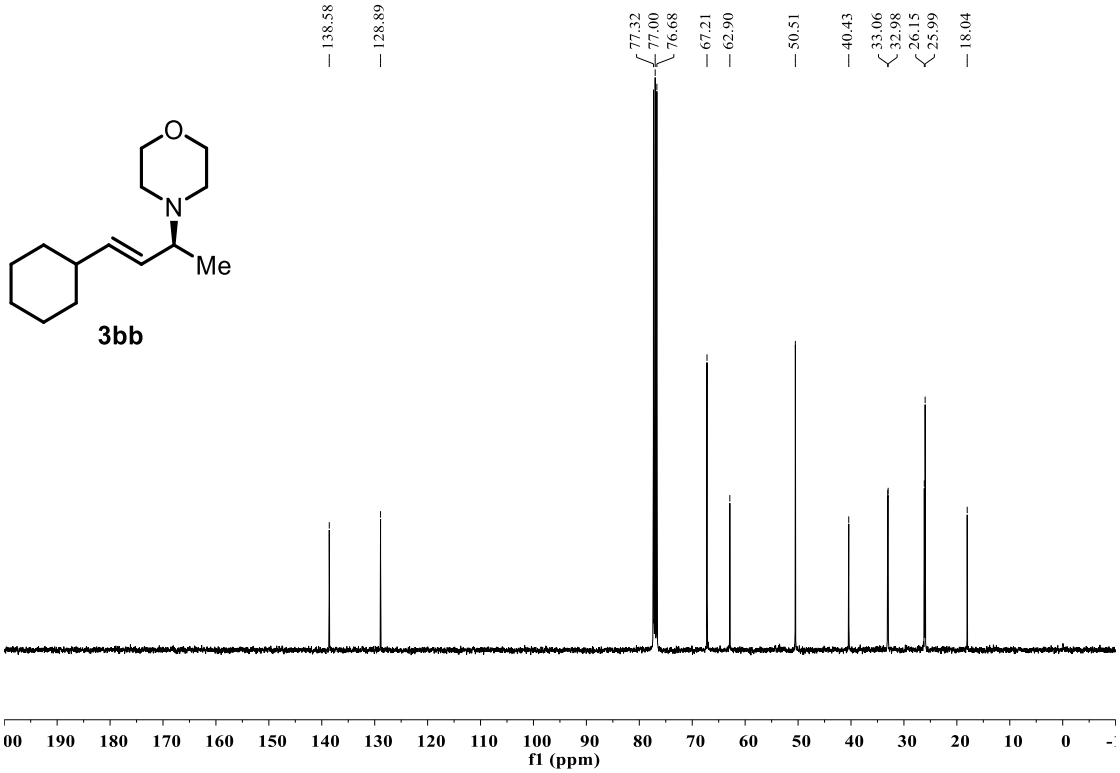


Figure S134. ^{13}C NMR spectra of **3ba**.

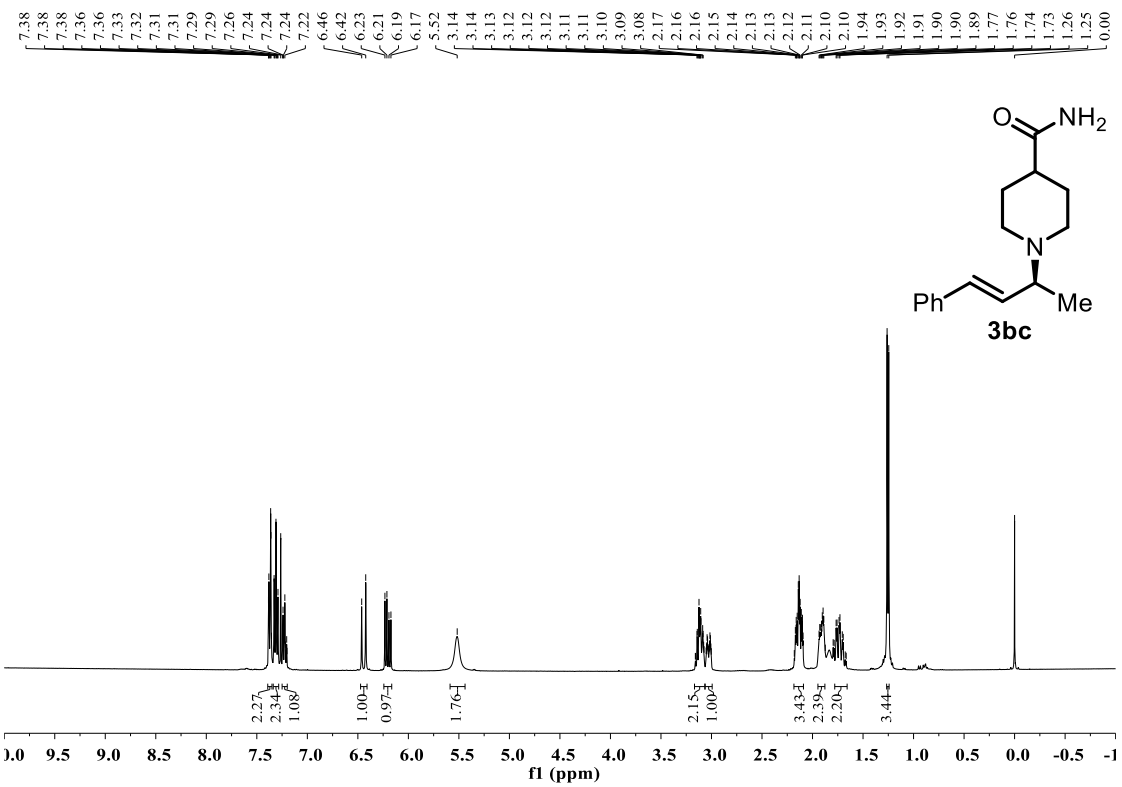


Figure S135. [1]H NMR spectra of **3bc**.

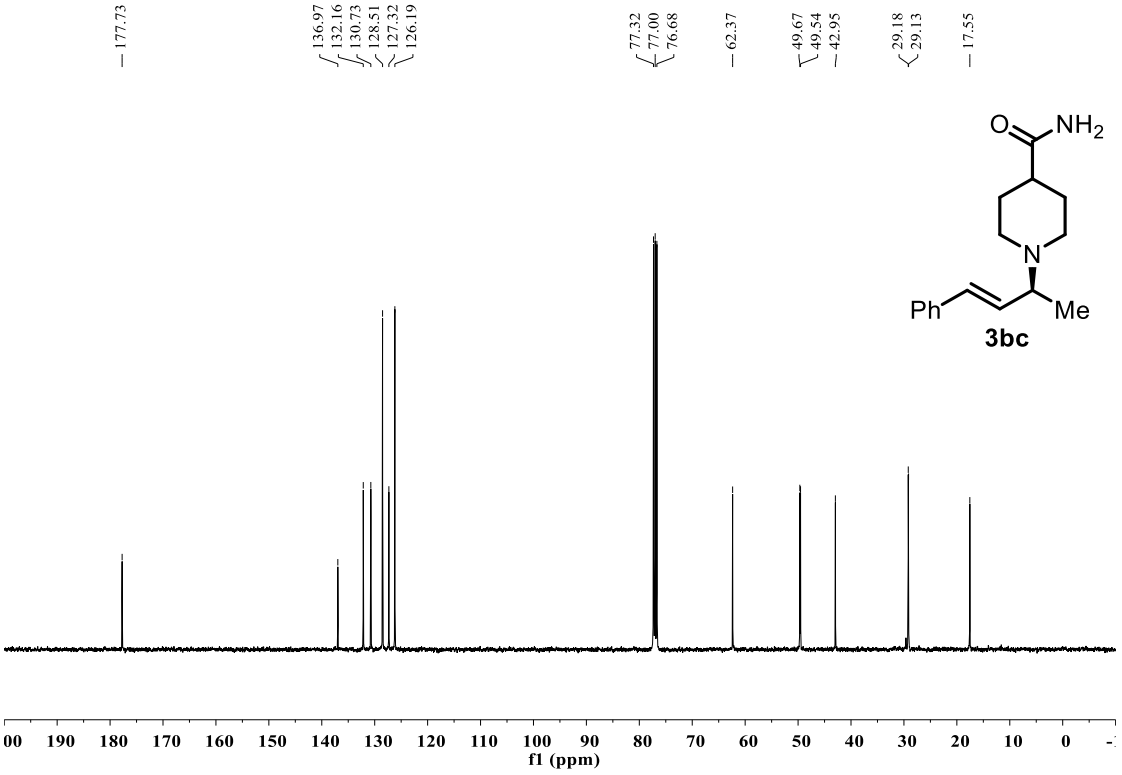


Figure S136. [13]C NMR spectra of **3bc**.

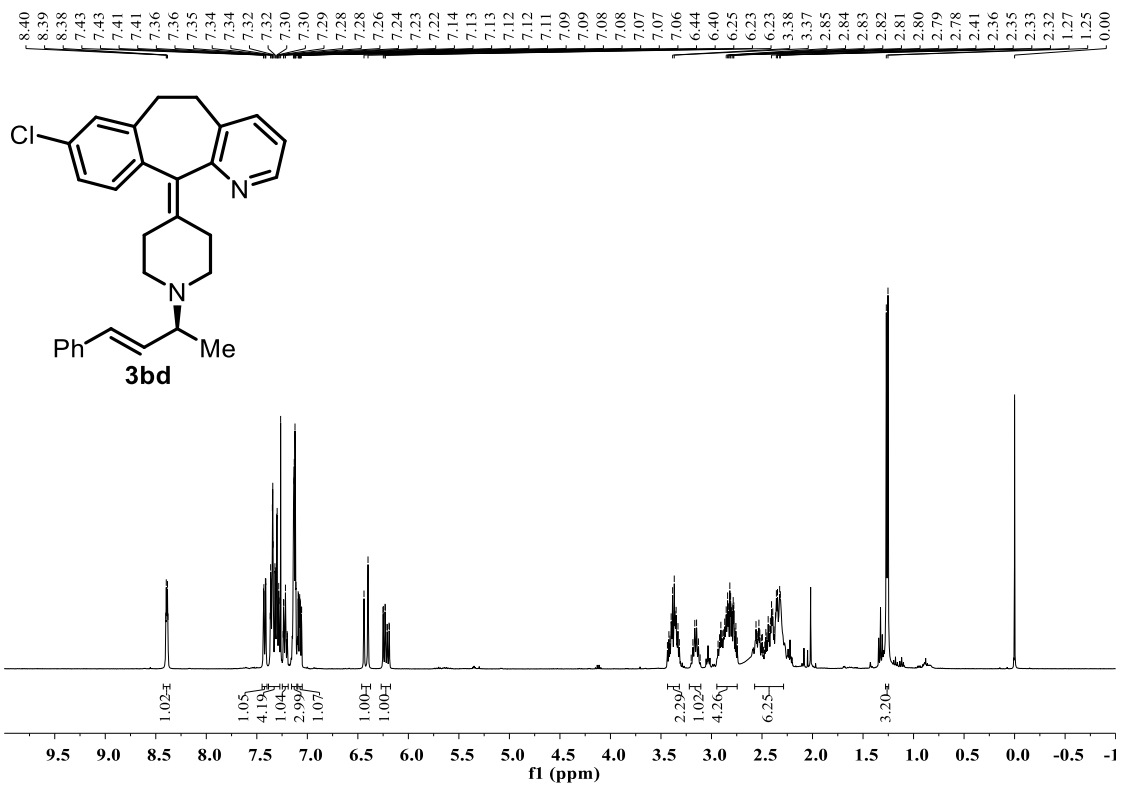


Figure S137. ^{1}H NMR spectra of **3bd**.

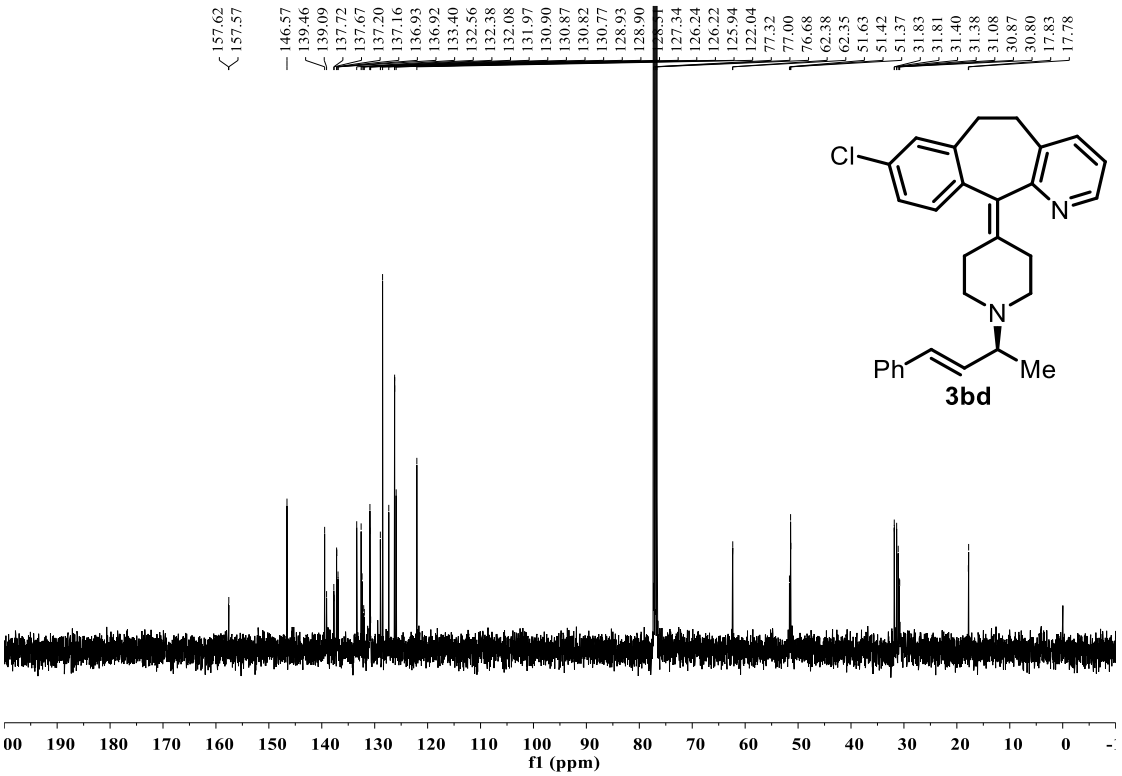


Figure S138. ^{13}C NMR spectra of **3bd**.

Supplemental figures for ^{1}H and ^{2}H-NMR spectra of deuterium labeling studies

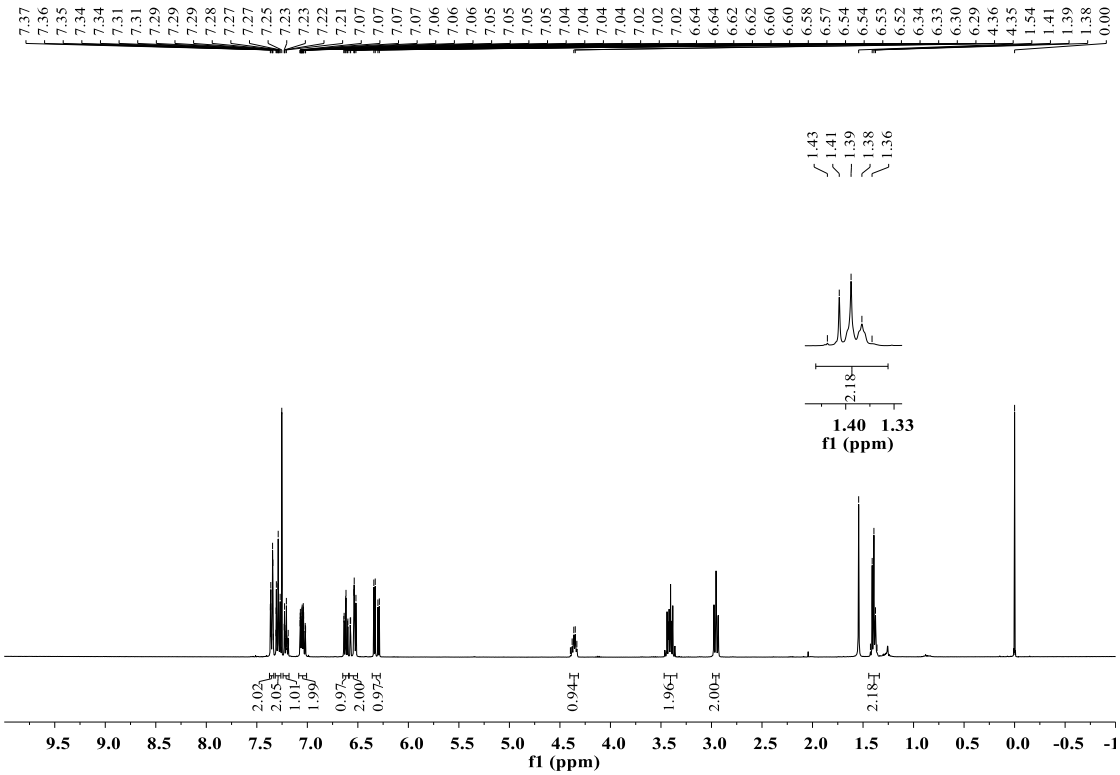


Figure S139. ^{1}H NMR spectra of *d*-**3t**, related to **Scheme S7**.

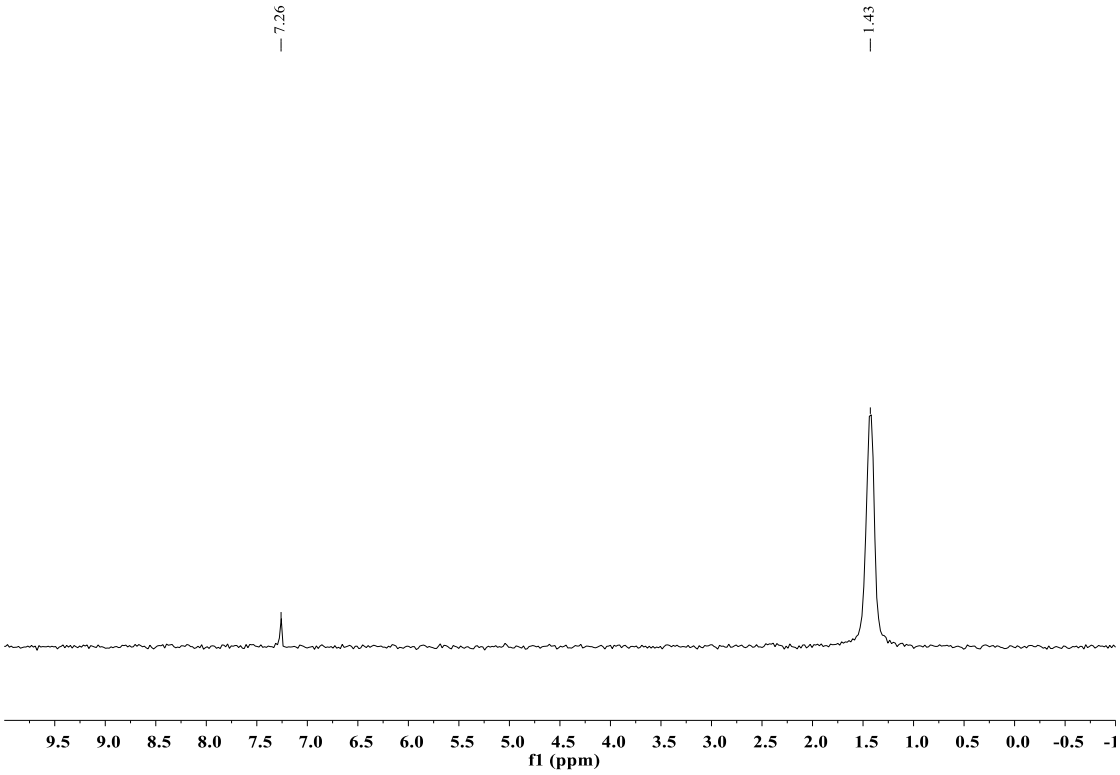
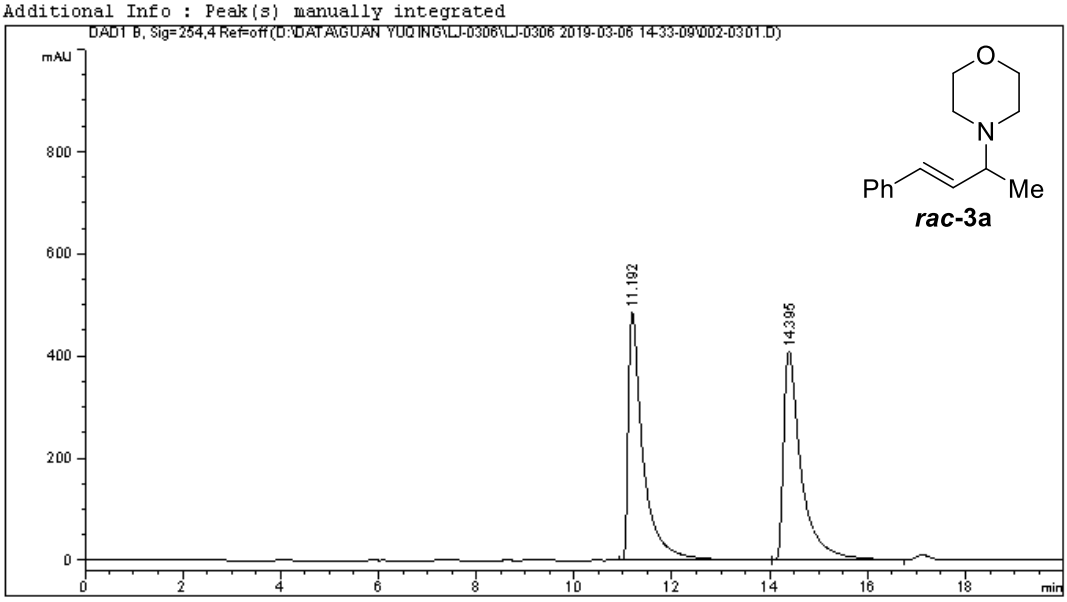


Figure S140. ^{2}H NMR spectra of *d*-**3t**, related to **Scheme S7**.

Supplemental Figures for HPLC spectra

Data File D:\DATA\GUAN YUQING\LJ-0306\LJ-0306 2019-03-06 14-33-09\002-0301.D
Sample Name: LJ-100-7-RAC

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :   3
    Acq. Instrument : Instrument 2                    Location : Vial 2
    Injection Date  : 3/6/2019 3:06:17 PM                 Inj :   1
                                                    Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-0306\LJ-0306 2019-03-06 14-33-09\DAD-OD(1-2)-90-10-0
                      .5ML-5UL-ALL-20MIN.M
    Last changed    : 1/20/2019 9:58:06 PM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\DAD-OD(1-2)-95-5-1ML-5UL-ALL-20MIN.M
    Last changed    : 3/6/2019 3:50:27 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

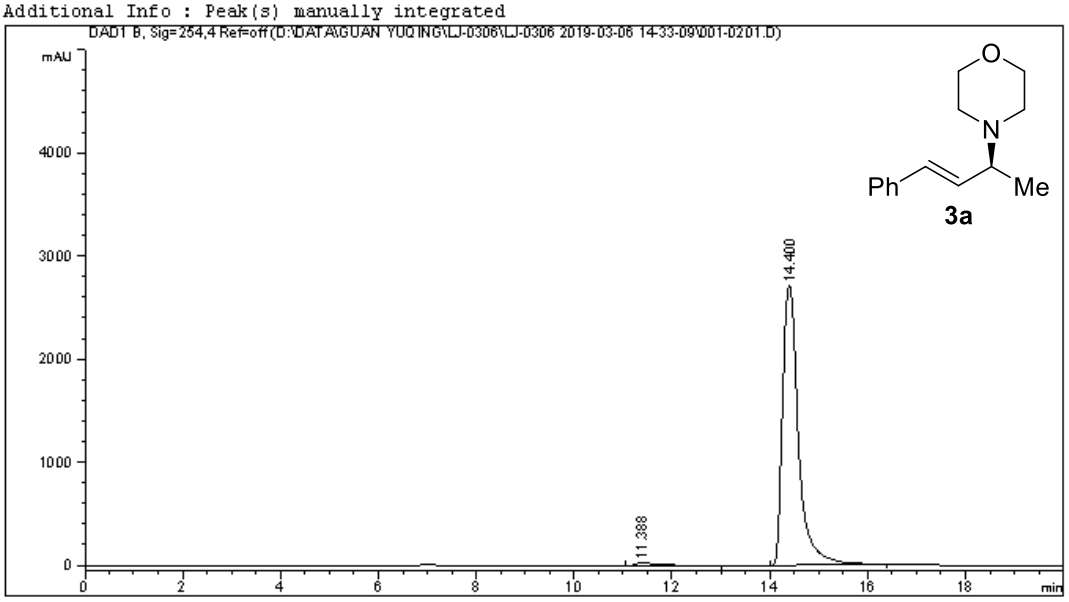



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 B, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  11.192 BB    0.3028 1.02861e4   486.24136  50.2351
       2  14.395 BB    0.3613 1.01898e4   408.17218  49.7649

    Totals :                  2.04759e4   894.41354
```


Figure S141. HPLC spectra of ***rac*-3a**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-0306\LJ-0306 2019-03-06 14-33-09\001-0201.D
Sample Name: LJ-100-7

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   2
    Acq. Instrument : Instrument 2                  Location : Vial 1
    Injection Date  : 3/6/2019 2:45:19 PM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-0306\LJ-0306 2019-03-06 14-33-09\DAD-OD(1-2)-90-10-0
                      .5ML-5UL-ALL-20MIN.M
    Last changed    : 1/20/2019 9:58:06 PM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\DAD-OD(1-2)-95-5-1ML-5UL-ALL-20MIN.M
    Last changed    : 3/6/2019 3:56:51 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

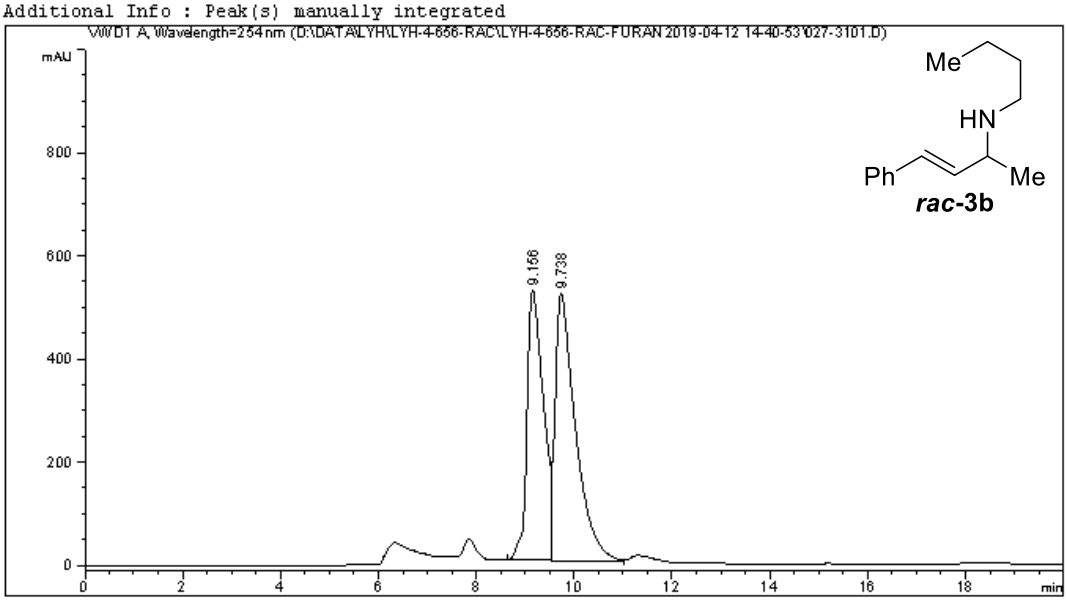



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 B, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1  11.388 BB    0.4032  650.96808   23.07139   1.0541
       2  14.400 BB    0.3453 6.11045e4  2707.21484  98.9459

    Totals :                  6.17554e4  2730.28624
```


Figure S142. HPLC spectra of **3a**, related to **Figure 3**.

Data File D:\DATA\LYH\LYH-4-656-RAC\LYH-4-656-RAC-FURAN 2019-04-12 14-40-53\027-3101.D
Sample Name: LJ-130-2

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :  31
    Acq. Instrument : Instrument 1                  Location : Vial 27
    Injection Date  : 4/13/2019 8:42:22 AM               Inj :  1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LYH\LYH-4-656-RAC\LYH-4-656-RAC-FURAN 2019-04-12 14-40-53\VWD-AD(1-
                      2)-99-1-0.6ML-5UL-254NM-40MIN.M
    Last changed    : 3/5/2019 3:34:42 PM
    Analysis Method : D:\METHOD\LG\DAD-OD(1-2)-95-5-1ML-2UL-ALL-50MIN.M
    Last changed    : 4/15/2019 11:27:15 AM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

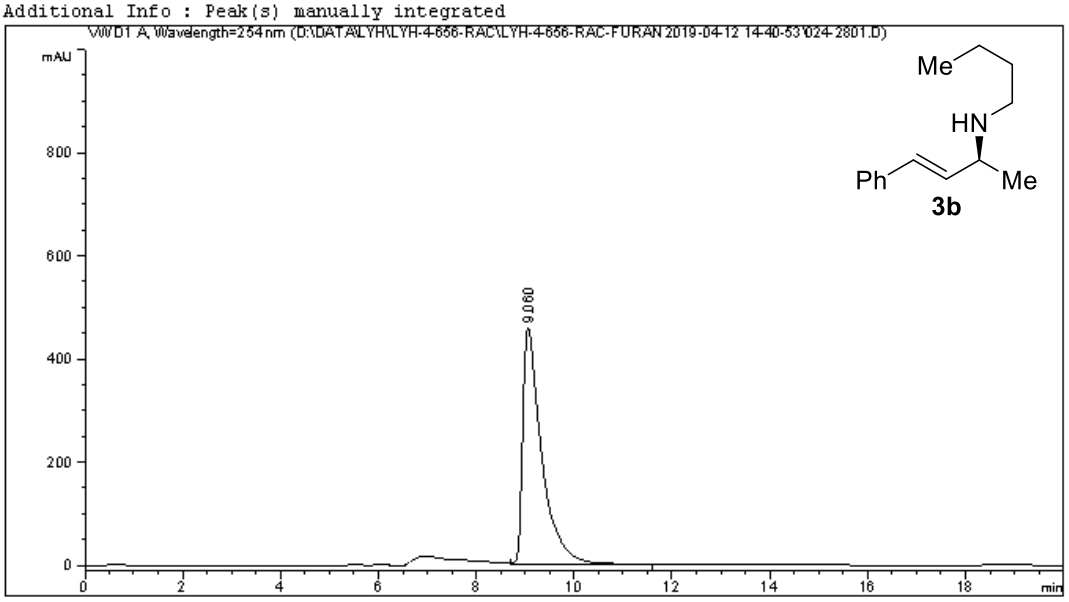



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1   9.156 BV    0.3458 1.21645e4   524.16223  44.6965
       2   9.738 VV    0.4121 1.50512e4   519.38824  55.3035

    Totals :                   2.72157e4  1043.55048
```


Figure S143. HPLC spectra of ***rac*-3b**, related to **Figure 3**.

Data File D:\DATA\LYH\LYH-4-656-RAC\LYH-4-656-RAC-FURAN 2019-04-12 14-40-53\024-2801.D
Sample Name: LJ-108-7

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :  28
    Acq. Instrument : Instrument 1                    Location : Vial 24
    Injection Date  : 4/13/2019 6:39:44 AM                 Inj :  1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LYH\LYH-4-656-RAC\LYH-4-656-RAC-FURAN 2019-04-12 14-40-53\VWD-AD(1-
                      2)-99-1-0.6ML-5UL-254NM-40MIN.M
    Last changed    : 3/5/2019 3:34:42 PM
    Analysis Method : D:\METHOD\LG\DAD-0J(1-6)-80-20-1ML-5UL-ALL-60MIN.M
    Last changed    : 4/14/2019 8:49:14 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```



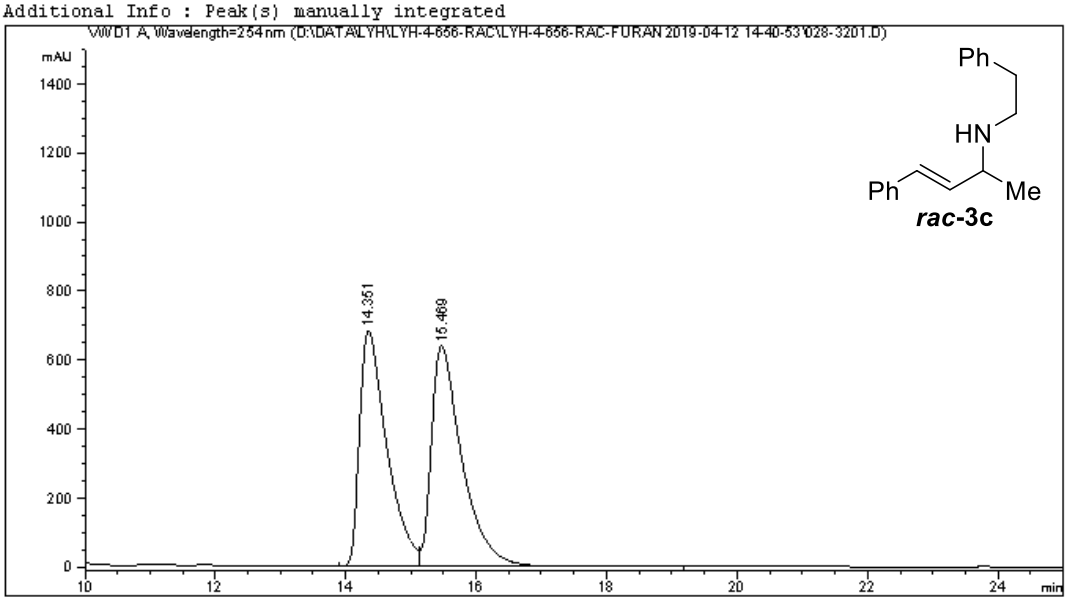

```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1   9.060 VB    0.3911 1.24684e4   460.12094 100.0000

    Totals :                  1.24684e4   460.12094


    ======================================================================
```

Instrument 2 4/14/2019 8:51:04 PM Page 1 of 1

Figure S144. HPLC spectra of **3b**, related to **Figure 3**.

Data File D:\DATA\LYH\LYH-4-656-RAC\LYH-4-656-RAC-FURAN 2019-04-12 14-40-53\028-3201.D
Sample Name: LJ-130-3

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :  32
    Acq. Instrument : Instrument 1                    Location : Vial 28
    Injection Date  : 4/13/2019 9:23:12 AM                 Inj :  1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LYH\LYH-4-656-RAC\LYH-4-656-RAC-FURAN 2019-04-12 14-40-53\VWD-AD(1-
                      2)-99-1-0.6ML-5UL-254NM-40MIN.M
    Last changed    : 3/5/2019 3:34:42 PM
    Analysis Method : D:\METHOD\LG\DAD-OD(1-2)-95-5-1ML-2UL-ALL-50MIN.M
    Last changed    : 4/15/2019 11:29:25 AM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

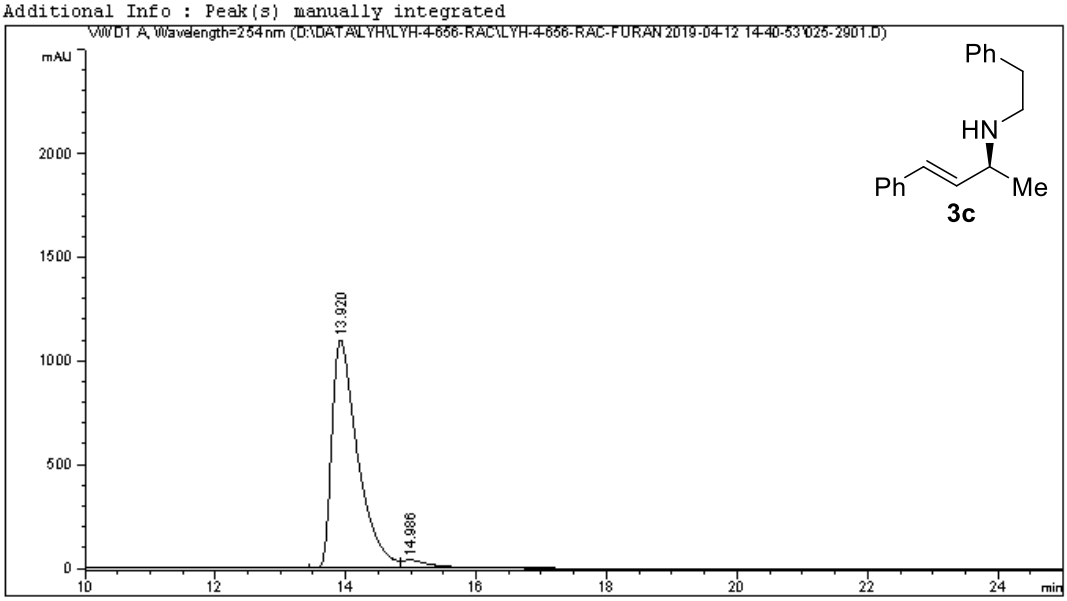



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  14.351 BV    0.4302 1.98917e4   684.26312  48.7101
       2  15.469 VB    0.4812 2.09452e4   639.34631  51.2899

    Totals :                  4.08368e4  1323.60944
```


Figure S145. HPLC spectra of ***rac*-3c**, related to **Figure 3**.

Data File D:\DATA\LYH\LYH-4-656-RAC\LYH-4-656-RAC-FURAN 2019-04-12 14-40-53\025-2901.D
Sample Name: LJ-108-9

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :  29
    Acq. Instrument : Instrument 1                    Location : Vial 25
    Injection Date  : 4/13/2019 7:20:36 AM                 Inj :  1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LYH\LYH-4-656-RAC\LYH-4-656-RAC-FURAN 2019-04-12 14-40-53\VWD-AD(1-
                      2)-99-1-0.6ML-5UL-254NM-40MIN.M
    Last changed    : 3/5/2019 3:34:42 PM
    Analysis Method : D:\METHOD\LG\DAD-OD(1-2)-95-5-1ML-2UL-ALL-50MIN.M
    Last changed    : 4/15/2019 11:31:56 AM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

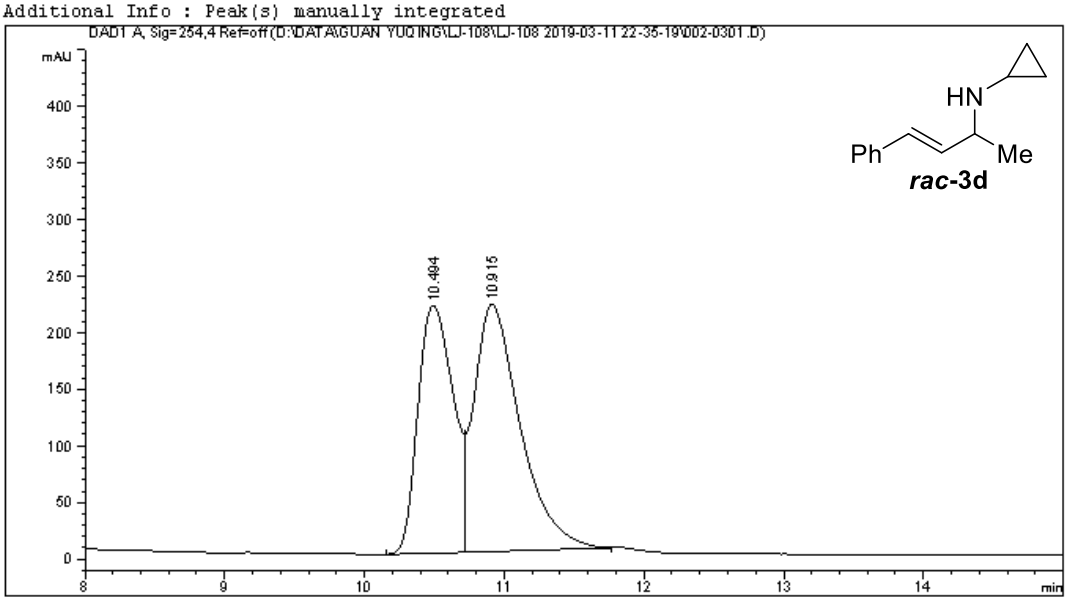



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  13.920 VV    0.4096 3.02696e4  1097.99194  96.0947
       2  14.986 VB    0.4442 1230.14990   38.24589   3.9053

    Totals :                  3.14997e4  1136.23783
```


Figure S146. HPLC spectra of **3c**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-108\LJ-108 2019-03-11 22-35-19\002-0301.D
Sample Name: LJ-108-5-RAC

```
    ======================================================================
    Acq. Operator   :                               Seq. Line :   3
    Acq. Instrument : Instrument 2                   Location : Vial 2
    Injection Date  : 3/11/2019 11:48:25 PM              Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-108\LJ-108 2019-03-11 22-35-19\DAD-0J(1-6)-95-5-0.
                      5ML-5UL-ALL-60MIN.M
    Last changed    : 3/7/2019 10:25:35 PM
    Analysis Method : D:\METHOD\YANG JIAXIN\VWD-IA-(1-2)-85-15-1.0ML-5UL-210NM-60MIN.M
    Last changed    : 5/31/2019 8:36:13 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

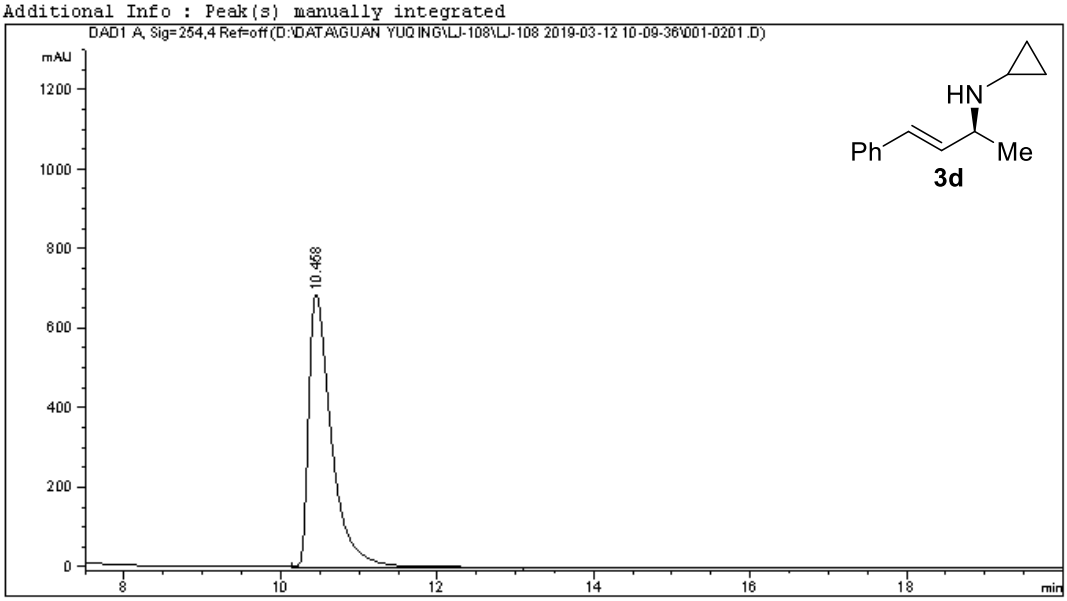



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1  10.494 BV    0.2743 3832.56519  218.90829  43.3094
       2  10.915 VB    0.3402 5016.70459  218.20282  56.6906

    Totals :                  8849.26978  437.11111


Instrument 1 5/31/2019 8:36:20 PM                              Page 1 of 2
```

Figure S147. HPLC spectra of ***rac*-3d**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-108\LJ-108 2019-03-12 10-09-36\001-0201.D
Sample Name: LJ-108-5

```
    ======================================================================
    Acq. Operator   :                               Seq. Line :   2
    Acq. Instrument : Instrument 2                   Location : Vial 1
    Injection Date  : 3/12/2019 10:23:31 AM               Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-108\LJ-108 2019-03-12 10-09-36\DAD-0J(1-6)-95-5-0.
                      5ML-5UL-ALL-60MIN.M
    Last changed    : 3/12/2019 10:32:53 AM
                      (modified after loading)
    Analysis Method : D:\METHOD\LWD\VWD-AD(1-2)-95-5-1ML-3UL-210NM-10MIN.M
    Last changed    : 3/21/2019 8:42:39 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

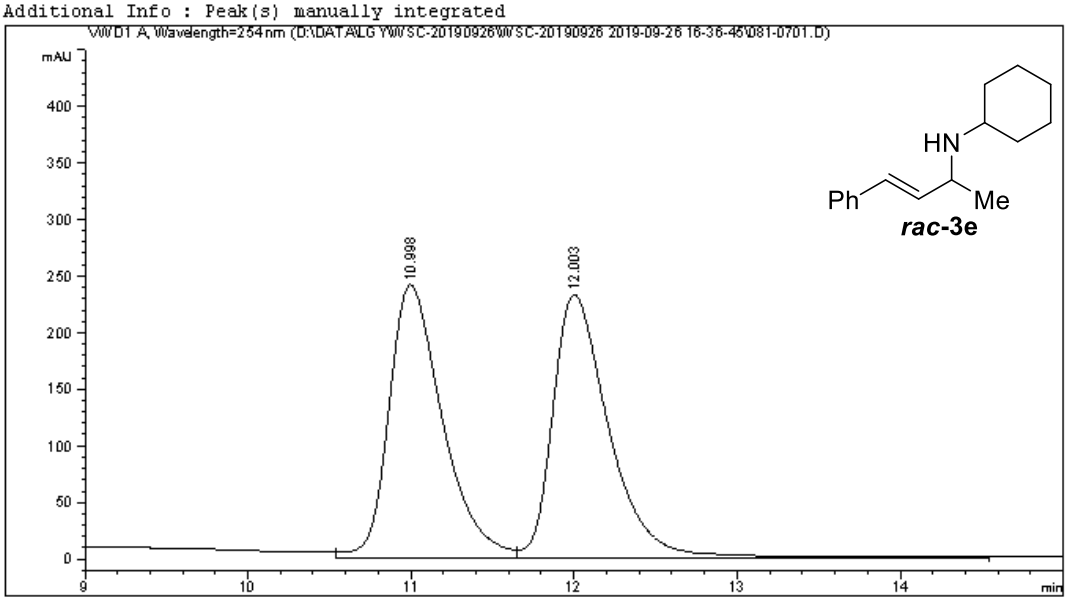



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  10.458 VB    0.3057 1.38817e4   687.03412 100.0000

    Totals :                  1.38817e4   687.03412


Instrument 2 3/21/2019 8:42:46 PM                          Page 1 of 2
```

Figure S148. HPLC spectra of **3d**, related to **Figure 3**.

Data File D:\DATA\LGY\WSC-20190926\WSC-20190926 2019-09-26 16-36-45\081-0701.D
Sample Name: LJ-108-3-RAC

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   7
    Acq. Instrument : Instrument 1                  Location : Vial 81
    Injection Date  : 9/26/2019 7:23:06 PM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LGY\WSC-20190926\WSC-20190926 2019-09-26 16-36-45\VWD-AD(1-2)-99-1-
                      0.5ML-5UL-254NM-25MIN.M
    Last changed    : 9/26/2019 6:06:23 PM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\VWD-AD(1-2)-99-1-0.5ML-5UL-254NM-25MIN.M
    Last changed    : 9/26/2019 8:26:00 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

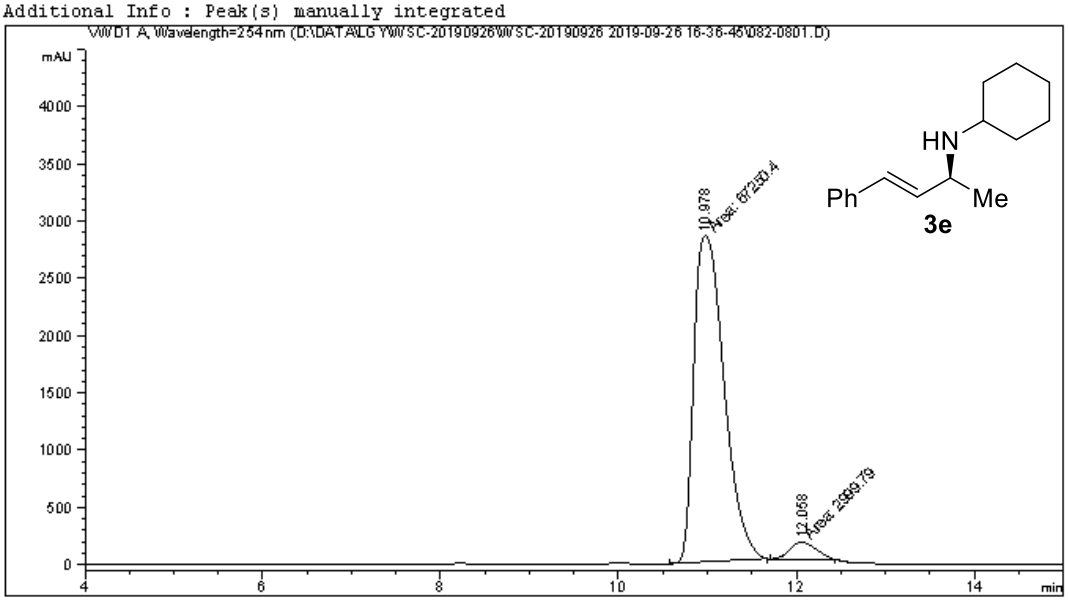



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  10.998 VV    0.3455 5517.50684  241.51408  49.7795
       2  12.003 VB    0.3631 5566.38281  232.71924  50.2205

    Totals :                  1.10839e4   474.23332
```


Figure S149. HPLC spectra of ***rac*-3e**, related to **Figure 3**.

Data File D:\DATA\LGY\WSC-20190926\WSC-20190926 2019-09-26 16-36-45\082-0801.D
Sample Name: LJ-108-3

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   8
    Acq. Instrument : Instrument 1                  Location : Vial 82
    Injection Date  : 9/26/2019 7:48:55 PM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LGY\WSC-20190926\WSC-20190926 2019-09-26 16-36-45\VWD-AD(1-2)-99-1-
                      0.5ML-5UL-254NM-25MIN.M
    Last changed    : 9/26/2019 6:06:23 PM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\VWD-AD(1-2)-99-1-0.5ML-5UL-254NM-25MIN.M
    Last changed    : 9/26/2019 8:22:26 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

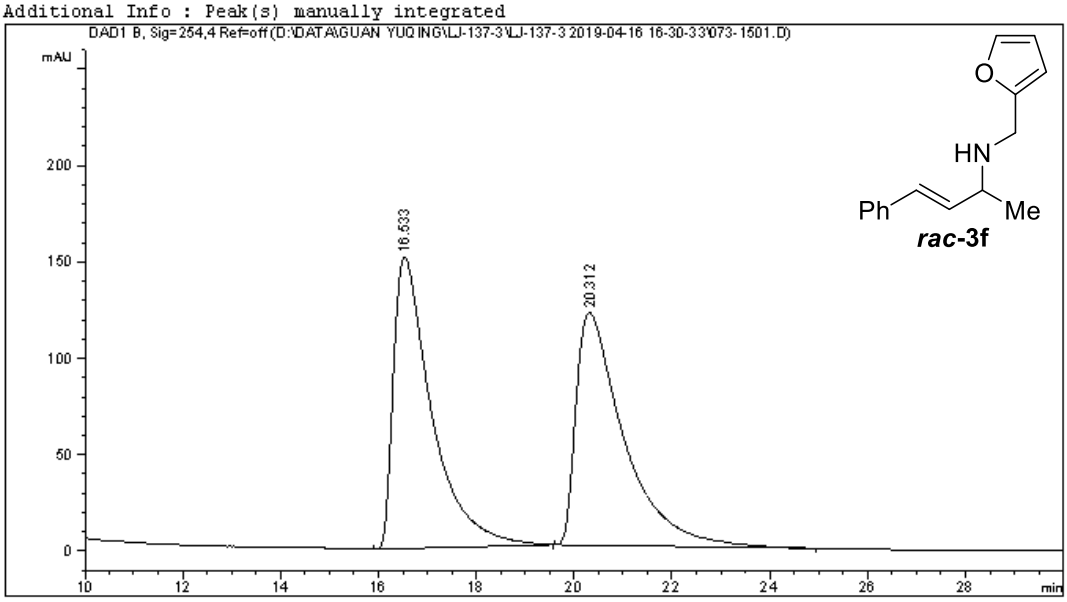



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1  10.978 MM    0.3938 6.72504e4  2846.45654  95.7299
       2  12.058 MM    0.3352 2999.78540  149.16602   4.2701

    Totals :                  7.02502e4  2995.62256
```


Figure S150. HPLC spectra of **3e**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-137-3\LJ-137-3 2019-04-16 16-30-33\073-1501.D
Sample Name: LJ-137-5-RAC

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :  15
    Acq. Instrument : Instrument 2                  Location : Vial 73
    Injection Date  : 4/16/2019 8:30:00 PM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-137-3\LJ-137-3 2019-04-16 16-30-33\DAD-OD(1-2)-99-1-
                      0.5ML-5UL-ALL-60MIN.M
    Last changed    : 4/16/2019 8:04:43 PM
    Analysis Method : D:\DATA\GUAN YUQING\LJ-137-3\LJ-137-3 2019-04-16 16-30-33\DAD-OD(1-2)-99-1-
                      0.5ML-5UL-ALL-60MIN.M (Sequence Method)
    Last changed    : 4/17/2019 8:22:42 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

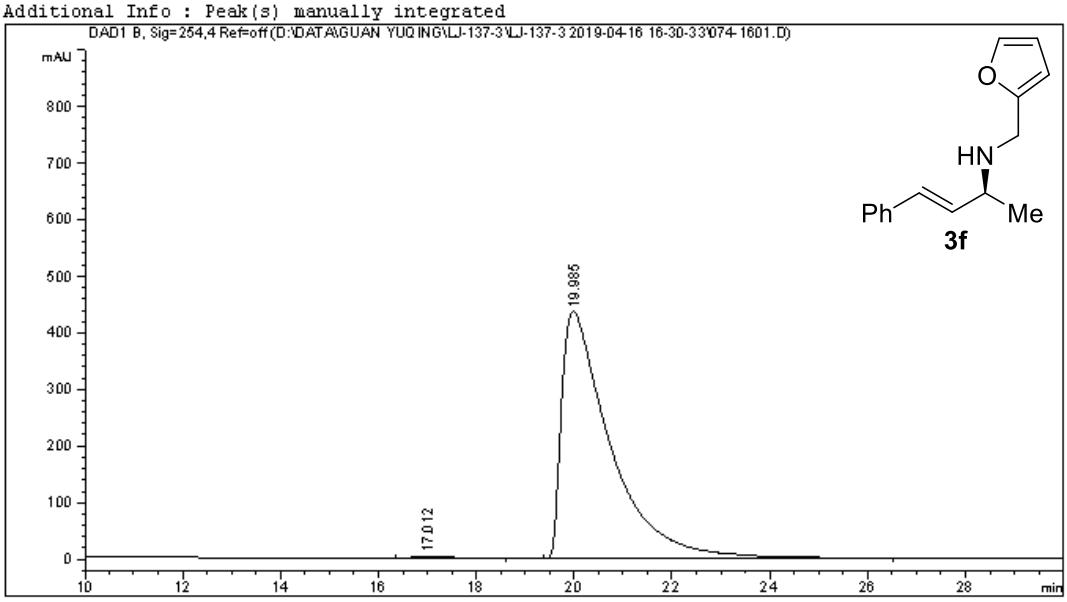



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 B, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  16.533 BB    0.7913 8224.38672  151.04292  49.9715
       2  20.312 BB    0.9384 8233.77539  120.61980  50.0285

    Totals :                  1.64582e4   271.66273
```


Figure S151. HPLC spectra of ***rac*-3f**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-137-3\LJ-137-3 2019-04-16 16-30-33\074-1601.D
Sample Name: LJ-137-5

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :  16
    Acq. Instrument : Instrument 2                    Location : Vial 74
    Injection Date  : 4/16/2019 9:31:03 PM                 Inj :  1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-137-3\LJ-137-3 2019-04-16 16-30-33\DAD-OD(1-2)-99-1-
                      0.5ML-5UL-ALL-60MIN.M
    Last changed    : 4/16/2019 8:04:43 PM
    Analysis Method : D:\DATA\GUAN YUQING\LJ-137-3\LJ-137-3 2019-04-16 16-30-33\DAD-OD(1-2)-99-1-
                      0.5ML-5UL-ALL-60MIN.M (Sequence Method)
    Last changed    : 4/17/2019 8:24:00 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

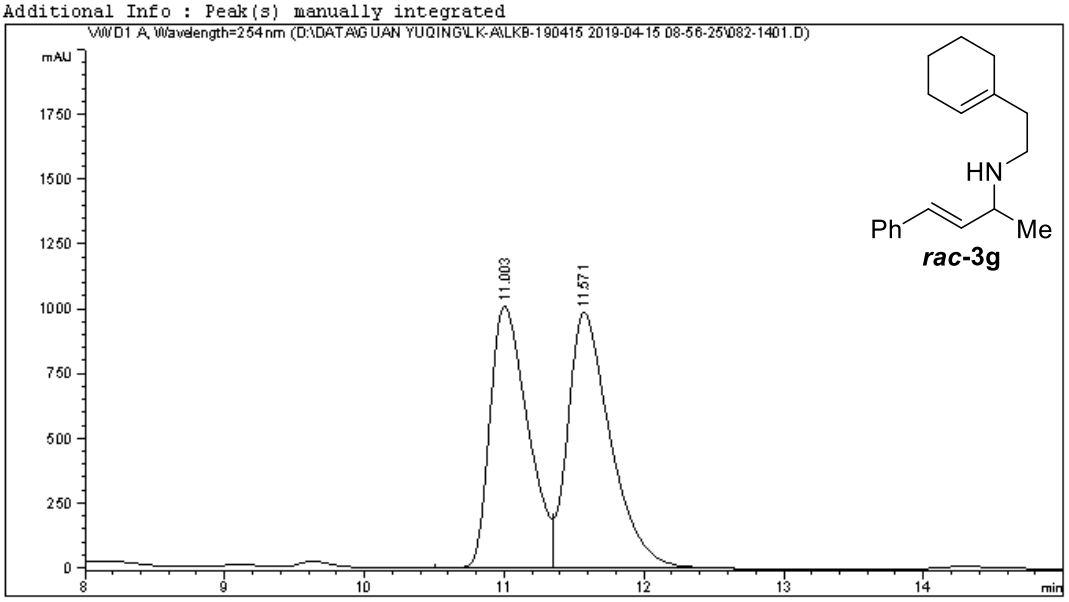



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 B, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  17.012 BB    0.6427  203.91769    3.79637   0.6686
       2  19.985 BB    0.9646 3.02947e4   436.01385  99.3314

    Totals :                  3.04986e4   439.81022
```


Figure S152. HPLC spectra of **3f**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LK-A\LKB-190415 2019-04-15 08-56-25\082-1401.D
Sample Name: LJ-137-2-RAC

```
    ======================================================================
    Acq. Operator   :                               Seq. Line :  14
    Acq. Instrument : Instrument 1                   Location : Vial 82
    Injection Date  : 4/15/2019 4:32:13 PM                Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LK-A\LKB-190415 2019-04-15 08-56-25\VWD-AD(1-2)-95-5-0.
                      5ML-5UL-254NM-20MIN.M
    Last changed    : 3/6/2019 6:07:05 PM
    Analysis Method : D:\DATA\GUAN YUQING\LJ-137-3\LJ-137-3 2019-04-16 16-30-33\DAD-0J(1-6)-99-1-
                      1ML-5UL-ALL-40MIN.M
    Last changed    : 4/16/2019 5:10:13 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

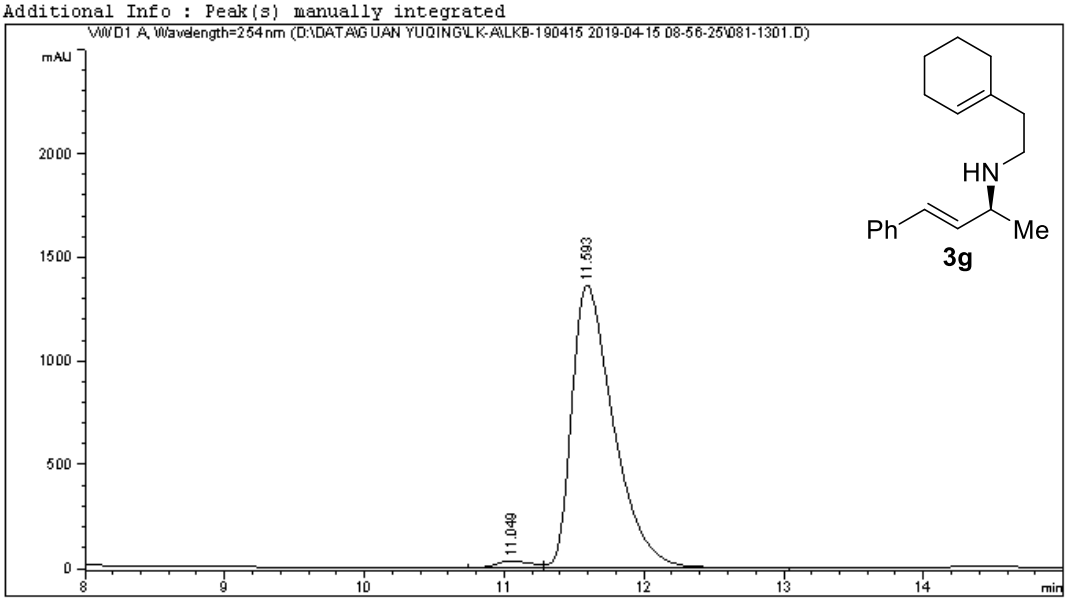



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  11.003 BV    0.2840 1.88847e4  1010.75867  47.4026
       2  11.571 VB    0.3170 2.09543e4   985.94733  52.5974

    Totals :                  3.98390e4  1996.70599
```


Figure S153. HPLC spectra of ***rac*-3g**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LK-A\LKB-190415 2019-04-15 08-56-25\081-1301.D
Sample Name: LJ-137-2

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :  13
    Acq. Instrument : Instrument 1                    Location : Vial 81
    Injection Date  : 4/15/2019 4:11:23 PM                 Inj :  1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LK-A\LKB-190415 2019-04-15 08-56-25\VWD-AD(1-2)-95-5-0.
                      5ML-5UL-254NM-20MIN.M
    Last changed    : 3/6/2019 6:07:05 PM
    Analysis Method : D:\DATA\GUAN YUQING\LJ-137-3\LJ-137-3 2019-04-16 16-30-33\DAD-0J(1-6)-99-1-
                      1ML-5UL-ALL-40MIN.M
    Last changed    : 4/16/2019 5:13:01 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

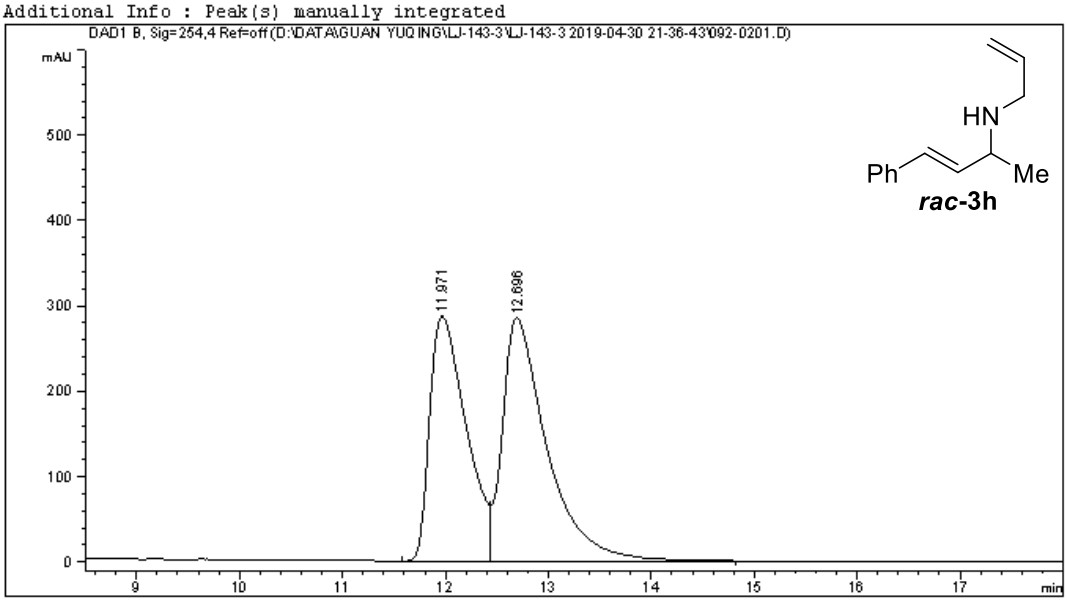



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  11.049 BV    0.2695  572.29053   32.96646   1.9854
       2  11.593 VB    0.3129 2.82527e4  1362.80029  98.0146

    Totals :                  2.88250e4  1395.76675
```


Figure S154. HPLC spectra of **3g**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-143-3\LJ-143-3 2019-04-30 21-36-43\092-0201.D
Sample Name: LJ-143-3

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :   2
    Acq. Instrument : Instrument 2                    Location : Vial 92
    Injection Date  : 4/30/2019 9:48:50 PM                 Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-143-3\LJ-143-3 2019-04-30 21-36-43\DAD-0J(1-6)-99-1-
                      0.5ML-5UL-ALL-60MIN.M
    Last changed    : 4/30/2019 10:09:25 PM
                      (modified after loading)
    Analysis Method : D:\DATA\GUAN YUQING\LJ-143-3\LJ-143-3 2019-04-30 21-36-43\DAD-0J(1-6)-99-1-
                      0.5ML-5UL-ALL-60MIN.M (Sequence Method)
    Last changed    : 5/15/2019 6:54:22 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

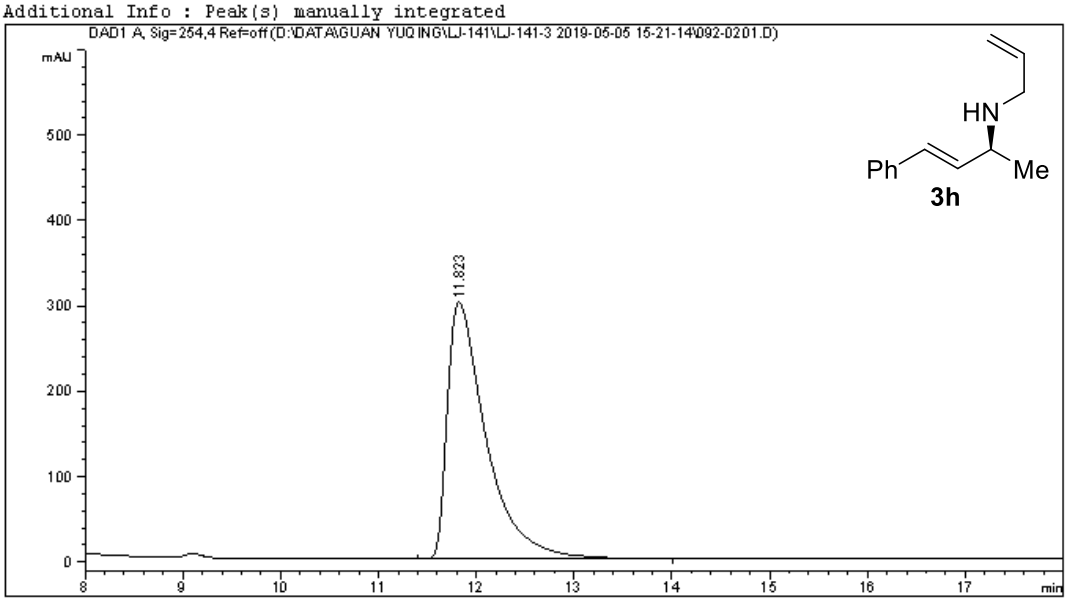



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 B, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  11.971 BV    0.3726 7039.42920  286.54825  45.4016
       2  12.696 VB    0.4370 8465.38184  284.63971  54.5984

    Totals :                  1.55048e4   571.18796
```


Figure S155. HPLC spectra of ***rac*-3h**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-141\LJ-141-3 2019-05-05 15-21-14\092-0201.D
Sample Name: LJ-141-3

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   2
    Acq. Instrument : Instrument 2                  Location : Vial 92
    Injection Date  : 5/5/2019 3:33:20 PM                Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-141\LJ-141-3 2019-05-05 15-21-14\DAD-OJ(1-6)-99-1-0.
                      5ML-5UL-ALL-40MIN.M
    Last changed    : 5/5/2019 3:47:20 PM
                      (modified after loading)
    Analysis Method : D:\DATA\GUAN YUQING\LJ-141\LJ-141-3 2019-05-05 15-21-14\DAD-OJ(1-6)-99-1-0.
                      5ML-5UL-ALL-40MIN.M (Sequence Method)
    Last changed    : 5/15/2019 6:58:10 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

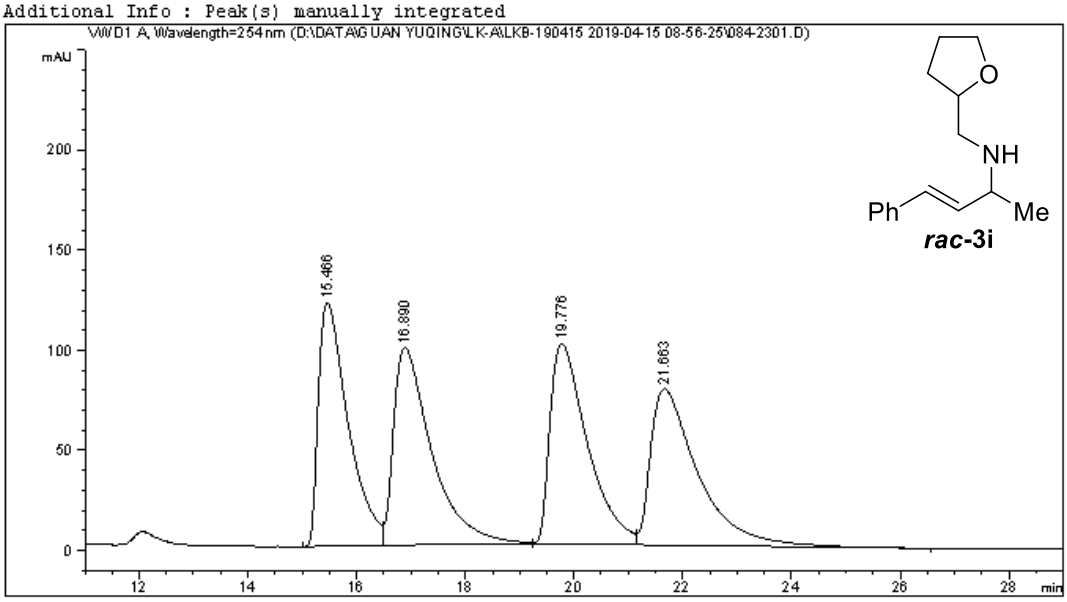



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  11.823 BB    0.4130 8336.08691  301.08655 100.0000

    Totals :                  8336.08691  301.08655
```


Figure S156. HPLC spectra of **3h**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LK-A\LKB-190415 2019-04-15 08-56-25\084-2301.D
Sample Name: LJ-137-4-RAC

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :  23
    Acq. Instrument : Instrument 1                  Location : Vial 84
    Injection Date  : 4/15/2019 8:20:08 PM               Inj :  1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LK-A\LKB-190415 2019-04-15 08-56-25\VWD-AD(1-2)-99-1-0.
                      6ML-5UL-254NM-40MIN.M
    Last changed    : 3/5/2019 3:34:42 PM
    Analysis Method : D:\DATA\GUAN YUQING\LJ-137-3\LJ-137-3 2019-04-16 16-30-33\DAD-0J(1-6)-99-1-
                      1ML-5UL-ALL-40MIN.M
    Last changed    : 4/16/2019 5:15:44 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

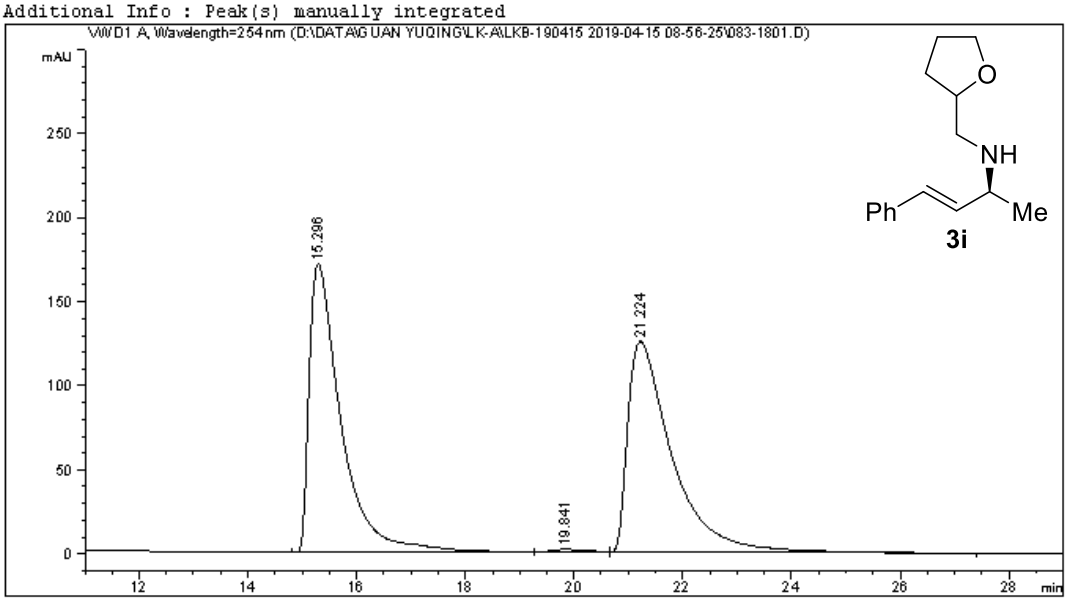



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  15.466 BV    0.5692 4599.29883  121.60919  24.3744
       2  16.890 VB    0.7248 4798.18164   98.42130  25.4284
       3  19.776 BV    0.7116 4753.76123  100.00168  25.1929
       4  21.663 VB    0.8876 4718.16992   77.89811  25.0043
```


Figure S157. HPLC spectra of ***rac*-3i**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LK-A\LKB-190415 2019-04-15 08-56-25\083-1801.D
Sample Name: LJ-137-4

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :  18
    Acq. Instrument : Instrument 1                    Location : Vial 83
    Injection Date  : 4/15/2019 6:25:42 PM                 Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LK-A\LKB-190415 2019-04-15 08-56-25\VWD-AD(1-2)-99-1-0.
                      6ML-5UL-254NM-40MIN.M
    Last changed    : 3/5/2019 3:34:42 PM
    Analysis Method : D:\DATA\GUAN YUQING\LJ-137-3\LJ-137-3 2019-04-16 16-30-33\DAD-0J(1-6)-99-1-
                      1ML-5UL-ALL-40MIN.M
    Last changed    : 4/16/2019 5:17:35 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

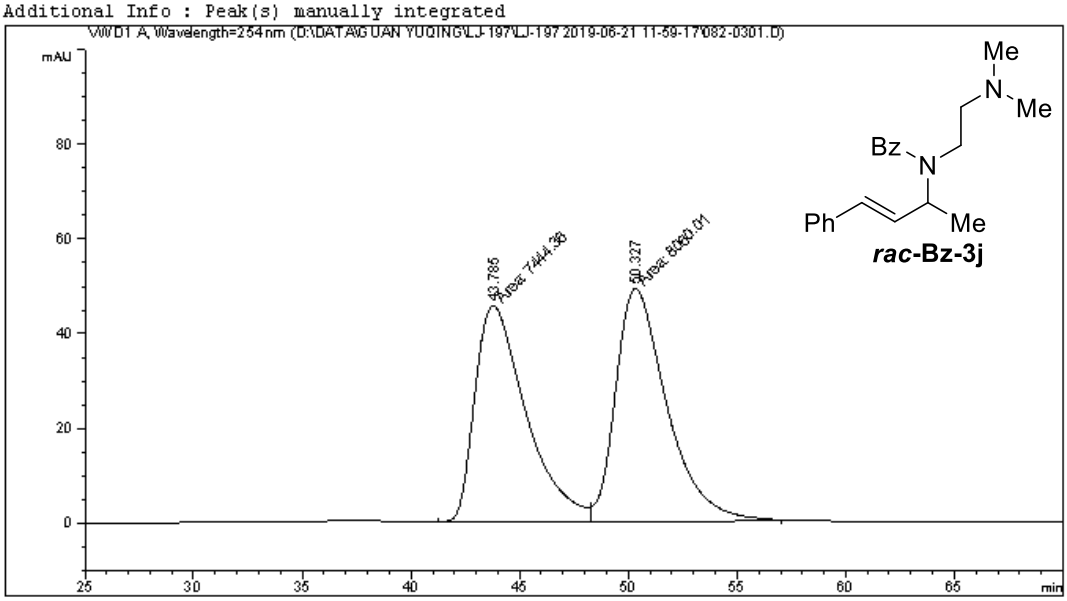



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1  15.296 BB    0.6059 7013.24561  171.57776  49.3191
       2  19.841 BV    0.5918   75.46820    1.71367   0.5307
       3  21.224 VB    0.8378 7131.41895  125.51943  50.1502

    Totals :                  1.42201e4   298.81086
```


Figure S158. HPLC spectra of **3i**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-197\LJ-197 2019-06-21 11-59-17\082-0301.D
Sample Name: LJ-197-1

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   3
    Acq. Instrument : Instrument 1                  Location : Vial 82
    Injection Date  : 6/21/2019 1:33:44 PM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-197\LJ-197 2019-06-21 11-59-17\VWD-AS(1-6)-90-10-0.
                      5ML-5UL-254NM-80MIN.M
    Last changed    : 6/21/2019 11:56:20 AM
    Analysis Method : D:\METHOD\LG\VWD-AS(1-6)-85-15-1ML-2UL-210NM-30MIN.M
    Last changed    : 6/26/2019 3:41:31 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

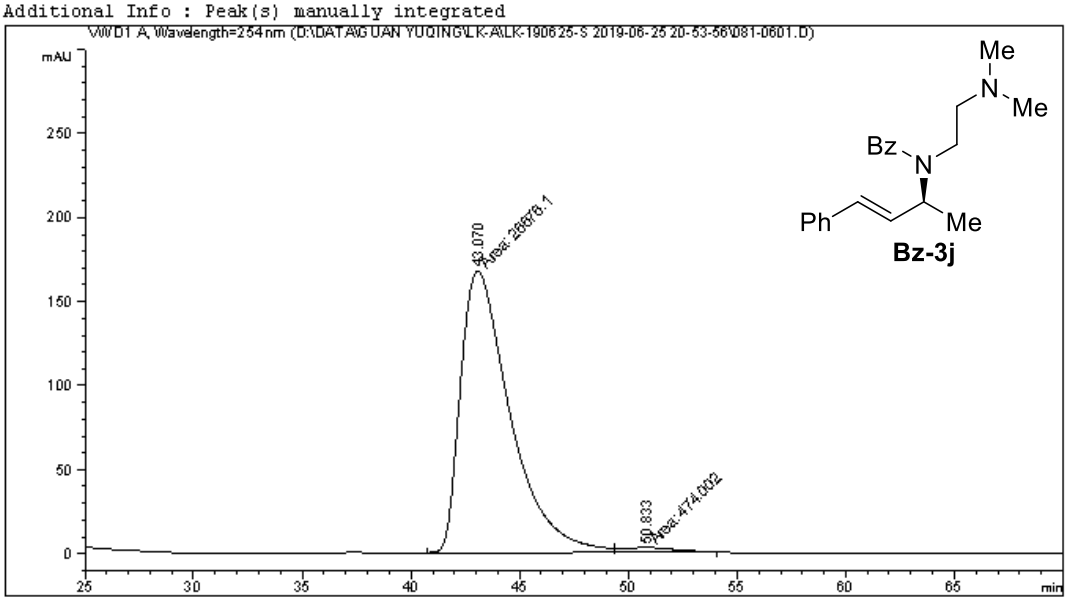



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1  43.785 MF    2.7221 7444.35938   45.58009  48.0146
       2  50.327 FM    2.7315 8060.00781   49.17983  51.9854

    Totals :                  1.55044e4    94.75991
```


Figure S159. HPLC spectra of ***rac*-Bz-3j**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LK-A\LK-190625-S 2019-06-25 20-53-56\081-0601.D
Sample Name: LJ-201-2

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   6
    Acq. Instrument : Instrument 1                  Location : Vial 81
    Injection Date  : 6/26/2019 1:24:20 AM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LK-A\LK-190625-S 2019-06-25 20-53-56\VWD-AS(1-6)-90-10-
                      0.5ML-5UL-254NM-80MIN.M
    Last changed    : 6/21/2019 11:56:20 AM
    Analysis Method : D:\METHOD\LG\VWD-AS(1-6)-85-15-1ML-2UL-210NM-30MIN.M
    Last changed    : 6/26/2019 3:39:40 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

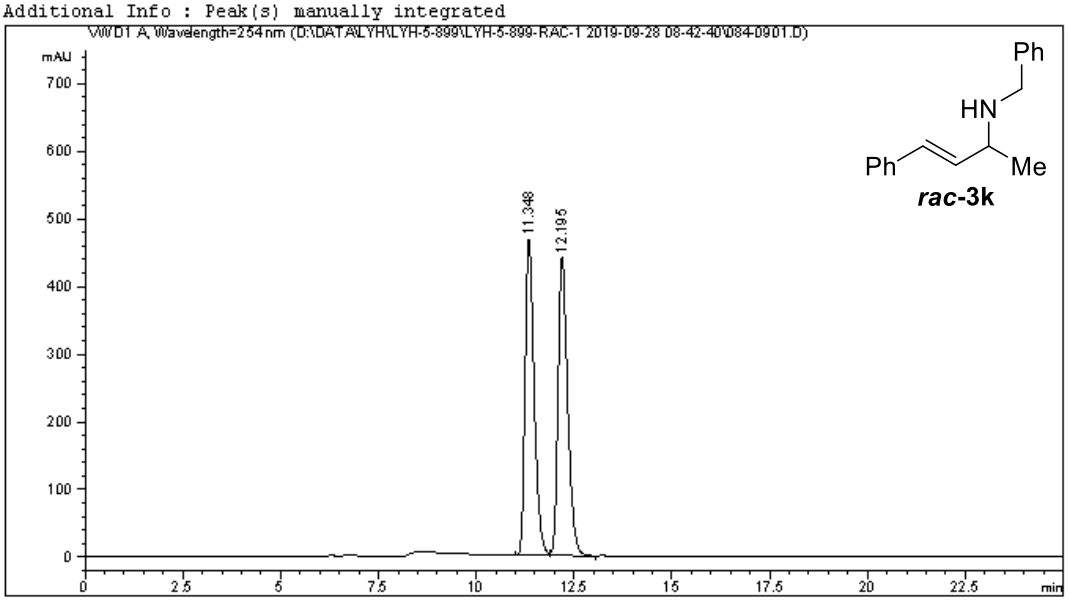



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  43.070 MF    2.6495 2.66761e4   167.80351  98.2541
       2  50.833 FM    2.8864  474.00171    2.73700   1.7459

    Totals :                  2.71501e4   170.54051
```


Figure S160. HPLC spectra of **Bz-3j**, related to **Figure 3**.

Data File D:\DATA\LYH\LYH-5-899\LYH-5-899-RAC-1 2019-09-28 08-42-40\084-0901.D
Sample Name: LJ-2-48-RAC

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   9
    Acq. Instrument : Instrument 1                  Location : Vial 84
    Injection Date  : 9/28/2019 12:30:11 PM              Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LYH\LYH-5-899\LYH-5-899-RAC-1 2019-09-28 08-42-40\VWD-AD(1-2)-95-5-
                      0.5ML-5UL-254NM-30MIN.M
    Last changed    : 4/9/2019 4:22:03 PM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\VWD-AD(1-2)-99-1-0.5ML-5UL-254NM-25MIN.M
    Last changed    : 9/28/2019 10:40:08 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

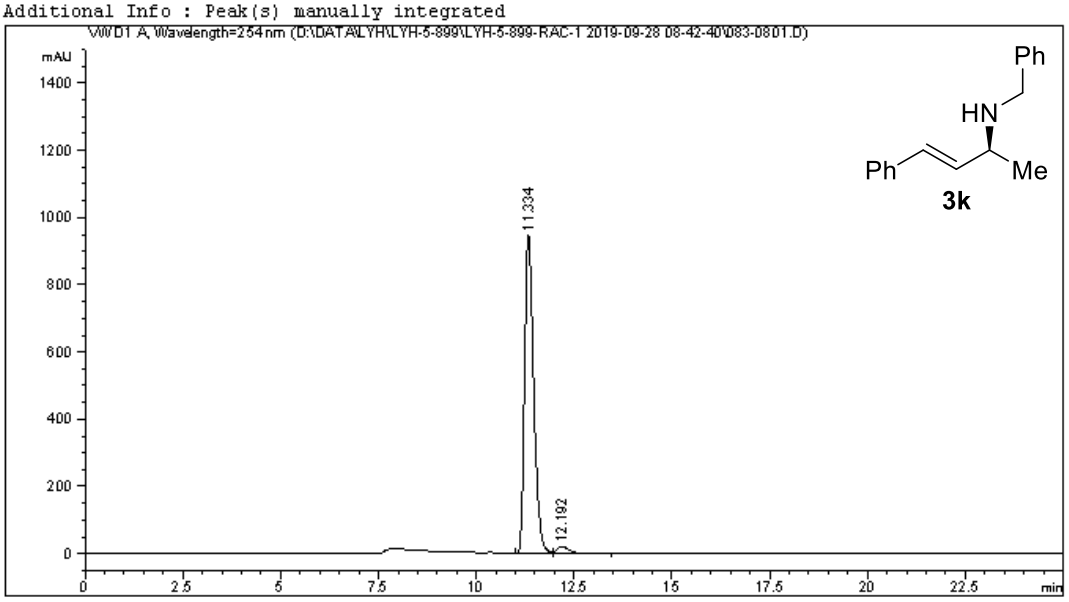



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1  11.348 BV    0.2453 7554.13770  468.01944  49.9302
       2  12.195 VB    0.2624 7575.27100  441.02200  50.0698

    Totals :                  1.51294e4   909.04144
```


Figure S161. HPLC spectra of ***rac*-3k**, related to **Figure 3**.

Data File D:\DATA\LYH\LYH-5-899\LYH-5-899-RAC-1 2019-09-28 08-42-40\083-0801.D
Sample Name: LJ-2-48

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :   8
    Acq. Instrument : Instrument 1                    Location : Vial 83
    Injection Date  : 9/28/2019 11:59:20 AM              Inj :   1
                                                    Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LYH\LYH-5-899\LYH-5-899-RAC-1 2019-09-28 08-42-40\VWD-AD(1-2)-95-5-
                      0.5ML-5UL-254NM-30MIN.M
    Last changed    : 4/9/2019 4:22:03 PM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\VWD-AD(1-2)-99-1-0.5ML-5UL-254NM-25MIN.M
    Last changed    : 9/28/2019 10:43:16 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

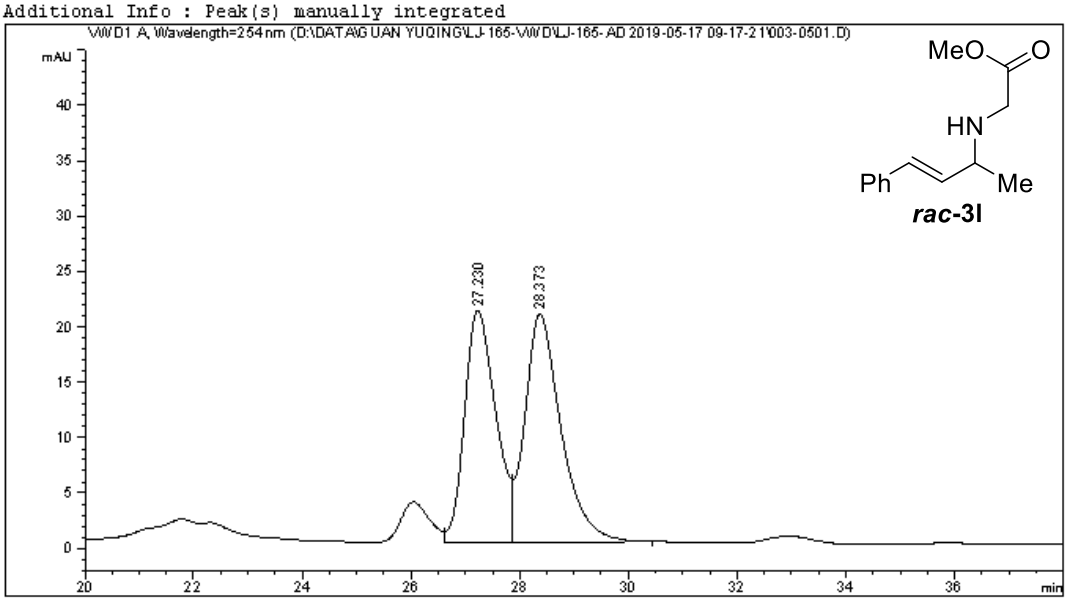



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  11.334 BV    0.2461 1.52293e4   944.59326  97.5071
       2  12.192 VB    0.2853  389.35504   20.52347   2.4929

    Totals :                  1.56187e4   965.11673
```


Figure S162. HPLC spectra of **3k**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-165-VWD\LJ-165-AD 2019-05-17 09-17-21\003-0501.D
Sample Name: LJ-165-RAC

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   5
    Acq. Instrument : Instrument 1                  Location : Vial 3
    Injection Date  : 5/17/2019 11:13:20 AM              Inj :   1
                                                  Inj Volume : 8.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-165-VWD\LJ-165-AD 2019-05-17 09-17-21\VWD-AD(1-2)-99
                      -1-0.5ML-5UL-254NM-60MIN.M
    Last changed    : 5/17/2019 9:43:47 AM
                      (modified after loading)
    Analysis Method : D:\METHOD\LWD\DAD-OD(1-2)-95-5-0.5ML-3UL-ALL-60MIN-517.M
    Last changed    : 5/18/2019 9:15:28 AM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

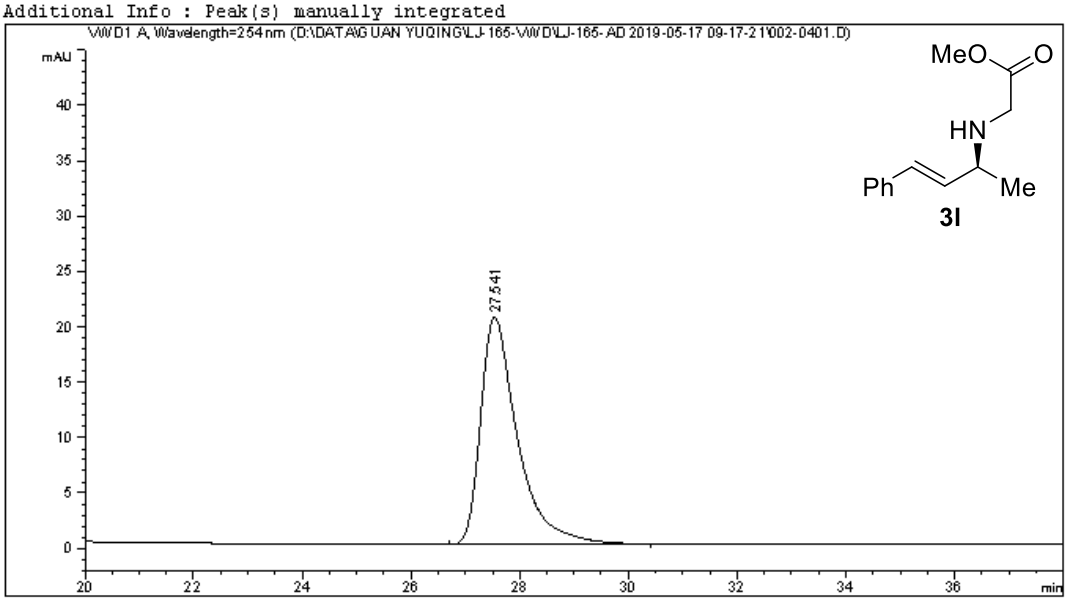



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  27.230 VV    0.5995  832.64209   20.91406  46.7610
       2  28.373 VB    0.6807  947.98993   20.56817  53.2390

    Totals :                  1780.63202   41.48223
```


Figure S163. HPLC spectra of ***rac*-3l**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-165-VWD\LJ-165-AD 2019-05-17 09-17-21\002-0401.D
Sample Name: LJ-165-2

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   4
    Acq. Instrument : Instrument 1                  Location : Vial 2
    Injection Date  : 5/17/2019 10:27:26 AM              Inj :   1
                                                  Inj Volume : 8.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-165-VWD\LJ-165-AD 2019-05-17 09-17-21\VWD-AD(1-2)-99
                      -1-0.5ML-5UL-254NM-60MIN.M
    Last changed    : 5/17/2019 9:43:47 AM
                      (modified after loading)
    Analysis Method : D:\METHOD\LWD\DAD-OD(1-2)-95-5-0.5ML-3UL-ALL-60MIN-517.M
    Last changed    : 5/18/2019 9:15:28 AM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

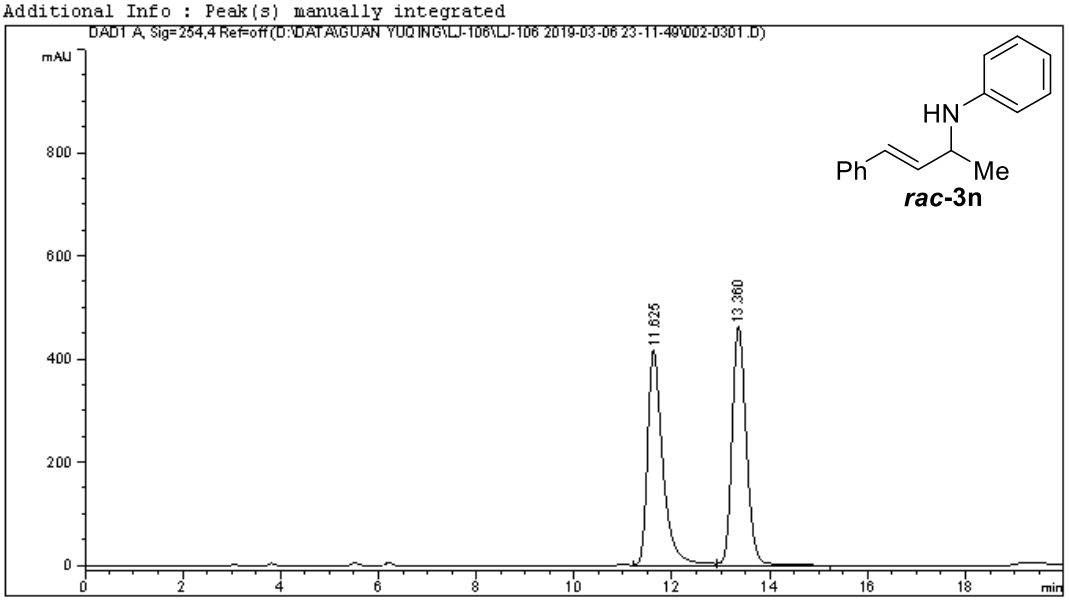



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  27.541 BB    0.6917  967.04639   20.52325 100.0000

    Totals :                   967.04639   20.52325
```


Figure S164. HPLC spectra of **3l**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-106\LJ-106 2019-03-06 23-11-49\002-0301.D
Sample Name: LJ-103-1-RAC

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   3
    Acq. Instrument : Instrument 2                  Location : Vial 2
    Injection Date  : 3/6/2019 11:49:55 PM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-106\LJ-106 2019-03-06 23-11-49\DAD-OD(1-2)-95-5-1ML-
                      5UL-ALL-20MIN.M
    Last changed    : 3/5/2019 8:56:43 PM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\DAD-IA(1-6)-95-5-0.5ML-5UL-ALL-40MIN.M
    Last changed    : 3/19/2019 9:55:54 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

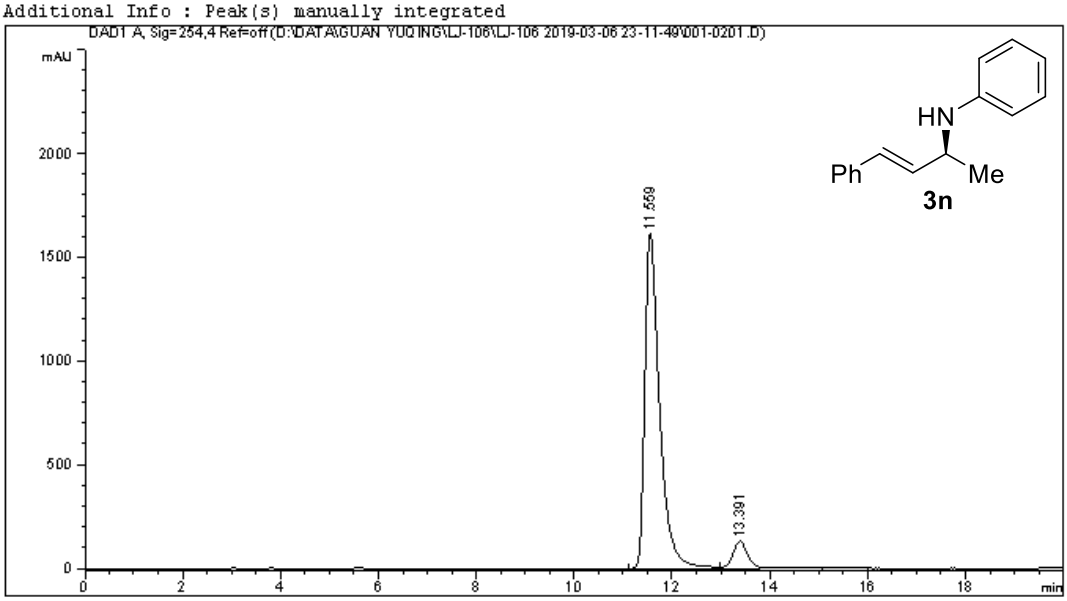



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1  11.625 VV    0.3233 9037.16797  416.16431  49.3755
       2  13.360 VB    0.3097 9265.78516  462.59473  50.6245

    Totals :                  1.83030e4   878.75903
```


Figure S165. HPLC spectra of ***rac*-3n**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-106\LJ-106 2019-03-06 23-11-49\001-0201.D
Sample Name: LJ-103-1

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   2
    Acq. Instrument : Instrument 2                  Location : Vial 1
    Injection Date  : 3/6/2019 11:28:57 PM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-106\LJ-106 2019-03-06 23-11-49\DAD-OD(1-2)-95-5-1ML-
                      5UL-ALL-20MIN.M
    Last changed    : 3/5/2019 8:56:43 PM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\DAD-IA(1-6)-95-5-0.5ML-5UL-ALL-40MIN.M
    Last changed    : 3/19/2019 9:58:51 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

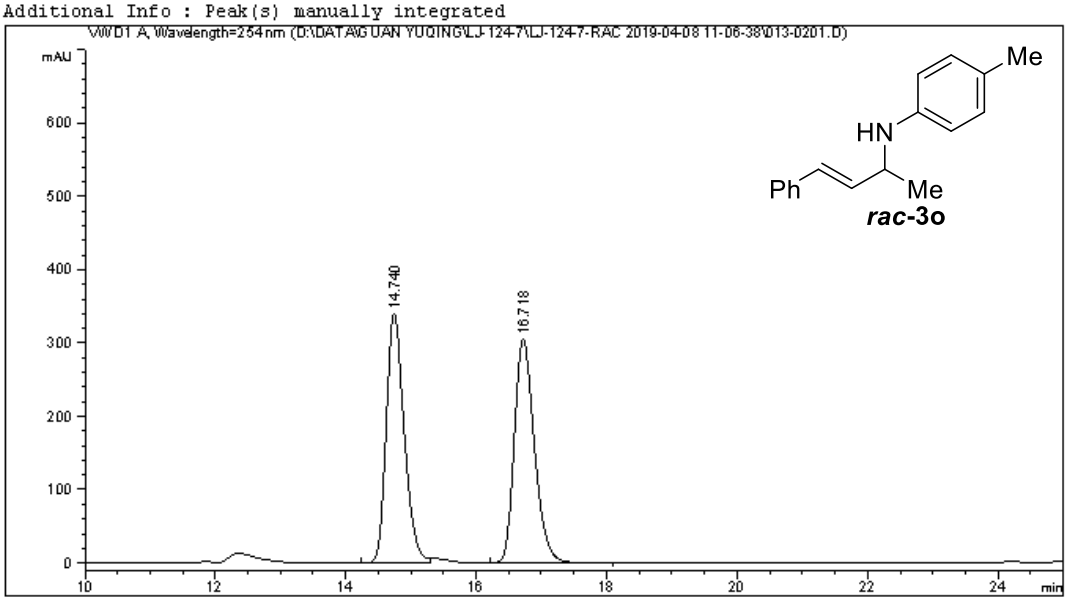



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1  11.559 BV    0.3120 3.36730e4  1609.93042  92.6141
       2  13.391 VB    0.3181 2685.40967  129.39296   7.3859

    Totals :                  3.63584e4  1739.32338
```


Figure S166. HPLC spectra of **3n**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-124-7\LJ-124-7-RAC 2019-04-08 11-06-38\013-0201.D
Sample Name: LJ-124-7-RAC

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   2
    Acq. Instrument : Instrument 1                  Location : Vial 13
    Injection Date  : 4/8/2019 11:20:11 AM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-124-7\LJ-124-7-RAC 2019-04-08 11-06-38\VWD-AD(1-2)-
                      95-5-0.5ML-5UL-254NM-60MIN.M
    Last changed    : 3/11/2019 10:31:45 PM
    Analysis Method : D:\METHOD\LG\DAD-0J(1-6)-80-20-1ML-5UL-ALL-60MIN.M
    Last changed    : 4/14/2019 9:50:19 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

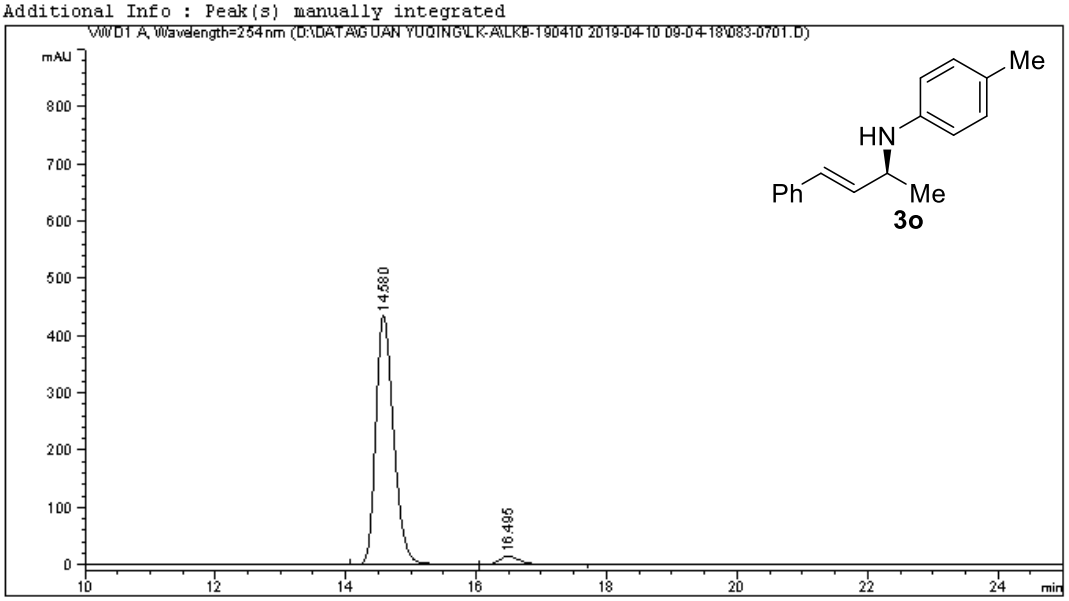



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  14.740 BV    0.2928 6485.12012  339.57712  50.0335
       2  16.718 BB    0.3248 6476.43945  304.93433  49.9665

    Totals :                  1.29616e4   644.51144
```


Figure S167. HPLC spectra of ***rac*-3o**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LK-A\LKB-190410 2019-04-10 09-04-18\083-0701.D
Sample Name: LJ-124-7

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   7
    Acq. Instrument : Instrument 1                  Location : Vial 83
    Injection Date  : 4/10/2019 11:42:55 AM              Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LK-A\LKB-190410 2019-04-10 09-04-18\VWD-AD(1-2)-95-5-0.
                      5ML-5UL-254NM-30MIN.M
    Last changed    : 4/9/2019 4:22:03 PM
    Analysis Method : D:\METHOD\LG\DAD-0J(1-6)-80-20-1ML-5UL-ALL-60MIN.M
    Last changed    : 4/14/2019 9:48:13 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

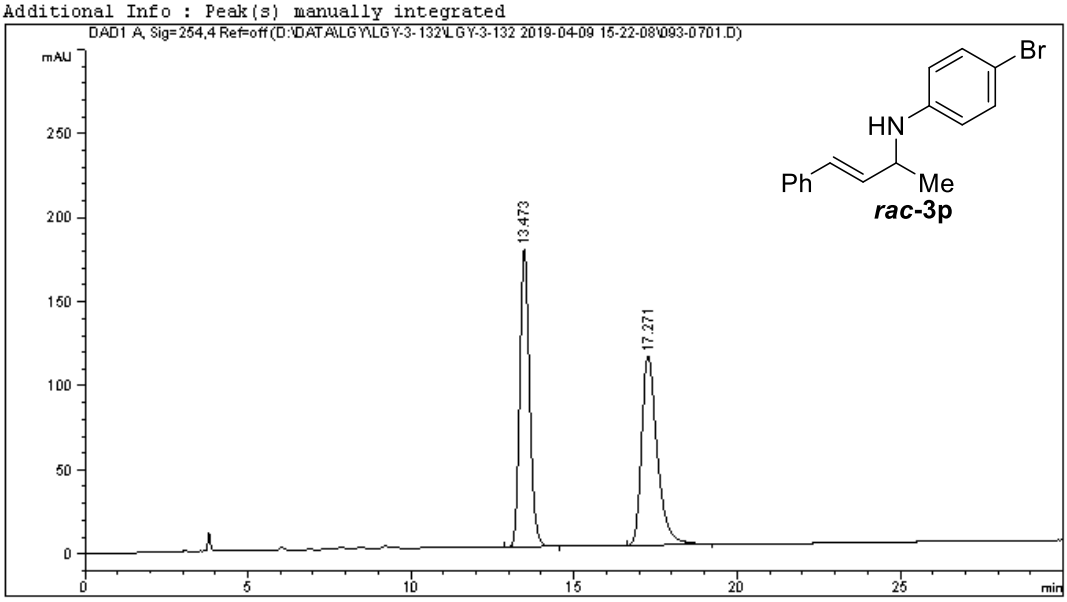



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  14.580 BB    0.2905 8222.70313  435.13837  96.3629
       2  16.495 BB    0.3246  310.35309   14.56537   3.6371

    Totals :                  8533.05621  449.70374


Instrument 2 4/14/2019 9:48:21 PM                          Page 1 of 2
```

Figure S168. HPLC spectra of **3o**, related to **Figure 3**.

Data File D:\DATA\LGY\LGY-3-132\LGY-3-132 2019-04-09 15-22-08\093-0701.D
Sample Name: LJ-129-10-RAC

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   7
    Acq. Instrument : Instrument 2                  Location : Vial 93
    Injection Date  : 4/9/2019 6:24:24 PM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LGY\LGY-3-132\LGY-3-132 2019-04-09 15-22-08\DAD-0D(1-2)-95-5-1ML-
                      5UL-ALL-60MIN.M
    Last changed    : 4/9/2019 6:21:57 PM
                      (modified after loading)
    Analysis Method : D:\METHOD\LG\DAD-0J(1-6)-80-20-1ML-5UL-ALL-60MIN.M
    Last changed    : 4/14/2019 9:53:27 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

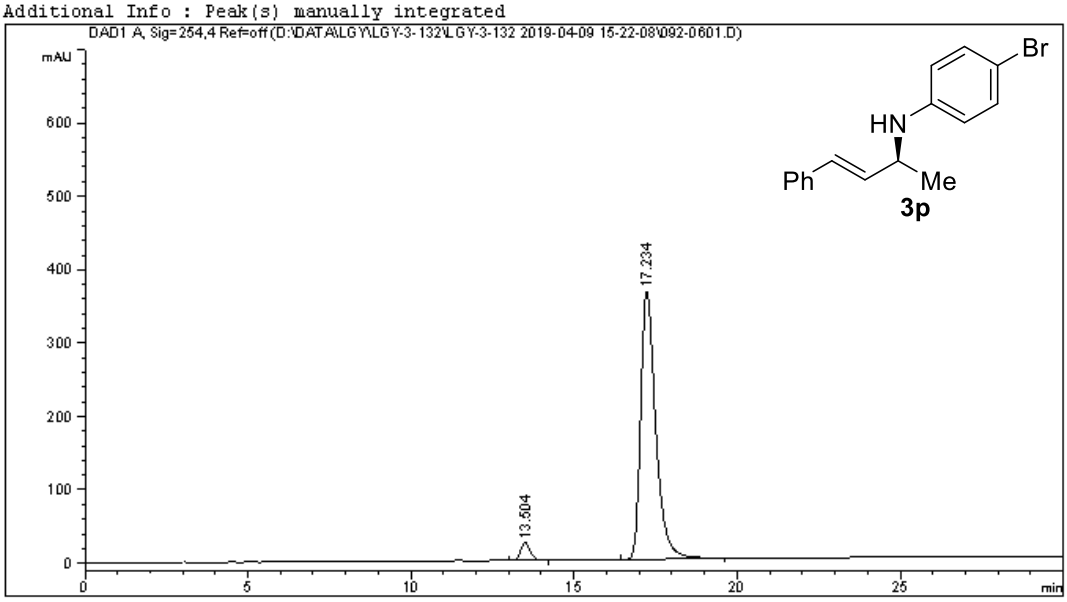



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  13.473 BB    0.3213 3693.51050  177.09816  49.7634
       2  17.271 BB    0.4958 3728.63354  112.74161  50.2366

    Totals :                  7422.14404  289.83977
```


Figure S169. HPLC spectra of ***rac*-3p**, related to **Figure 3**.

Data File D:\DATA\LGY\LGY-3-132\LGY-3-132 2019-04-09 15-22-08\092-0601.D
Sample Name: LJ-129-10

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :   6
    Acq. Instrument : Instrument 2                    Location : Vial 92
    Injection Date  : 4/9/2019 5:43:24 PM                 Inj :   1
                                                    Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LGY\LGY-3-132\LGY-3-132 2019-04-09 15-22-08\DAD-0D(1-2)-95-5-1ML-
                      5UL-ALL-60MIN.M
    Last changed    : 4/9/2019 6:21:57 PM
                      (modified after loading)
    Analysis Method : D:\METHOD\LG\DAD-0J(1-6)-80-20-1ML-5UL-ALL-60MIN.M
    Last changed    : 4/14/2019 9:54:40 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

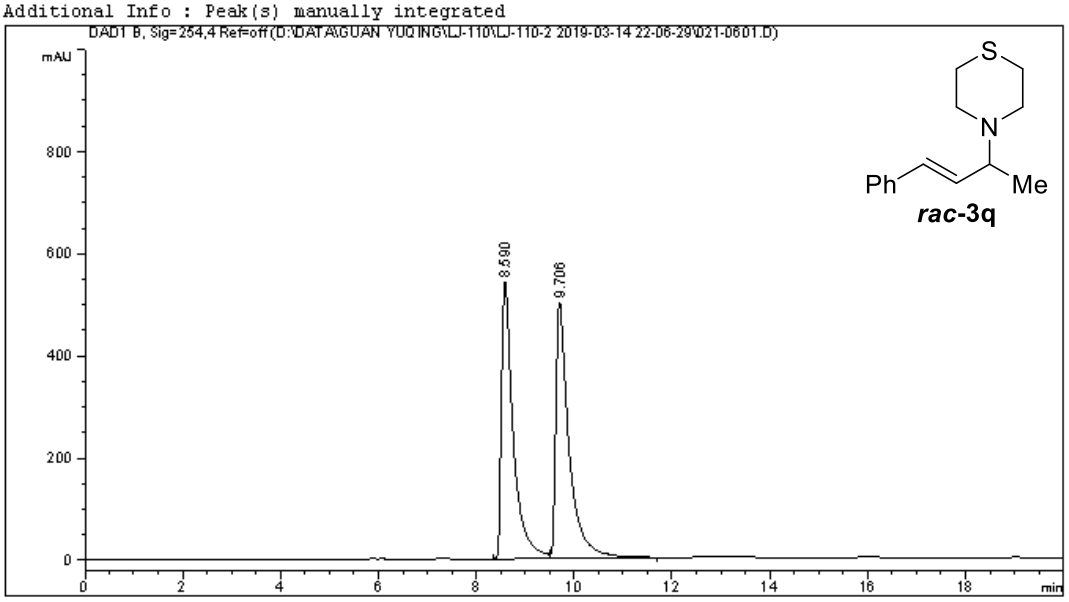



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  13.504 BB    0.3190  496.94272   23.86341   4.0801
       2  17.234 BB    0.4827 1.16826e4   365.71744  95.9199

    Totals :                  1.21796e4   389.58085
```


Figure S170. HPLC spectra of **3p**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-110\LJ-110-2 2019-03-14 22-06-29\021-0601.D
Sample Name: LJ-109-5

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   6
    Acq. Instrument : Instrument 2                  Location : Vial 21
    Injection Date  : 3/14/2019 11:32:48 PM              Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-110\LJ-110-2 2019-03-14 22-06-29\DAD-OD(1-2)-90-10-0
                      .5ML-5UL-ALL-30MIN.M
    Last changed    : 10/30/2018 11:03:07 PM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\DAD-IA(1-6)-95-5-0.5ML-5UL-ALL-40MIN.M
    Last changed    : 3/19/2019 10:31:02 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

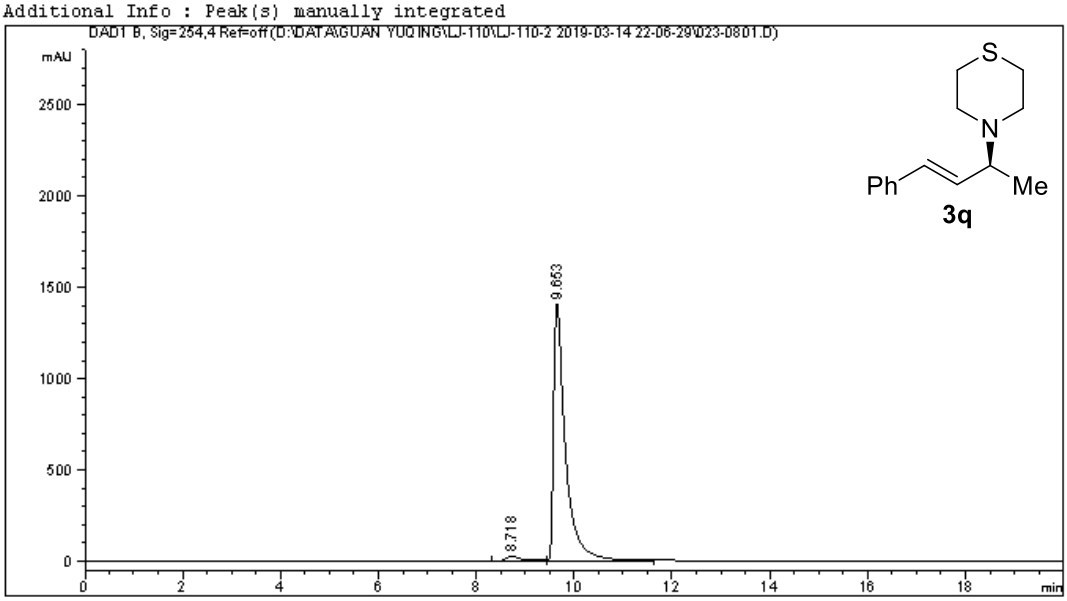



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 B, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1   8.590 BV    0.2446 9138.08984  542.15143  49.1392
       2   9.706 VB    0.2699 9458.22656  501.71347  50.8608

    Totals :                  1.85963e4  1043.86490
```


Figure S171. HPLC spectra of ***rac*-3q**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-110\LJ-110-2 2019-03-14 22-06-29\023-0801.D
Sample Name: LJ-110-5

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   8
    Acq. Instrument : Instrument 2                  Location : Vial 23
    Injection Date  : 3/15/2019 12:34:45 AM              Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-110\LJ-110-2 2019-03-14 22-06-29\DAD-OD(1-2)-90-10-0
                      .5ML-5UL-ALL-30MIN.M
    Last changed    : 10/30/2018 11:03:07 PM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\DAD-IA(1-6)-95-5-0.5ML-5UL-ALL-40MIN.M
    Last changed    : 3/19/2019 10:29:50 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

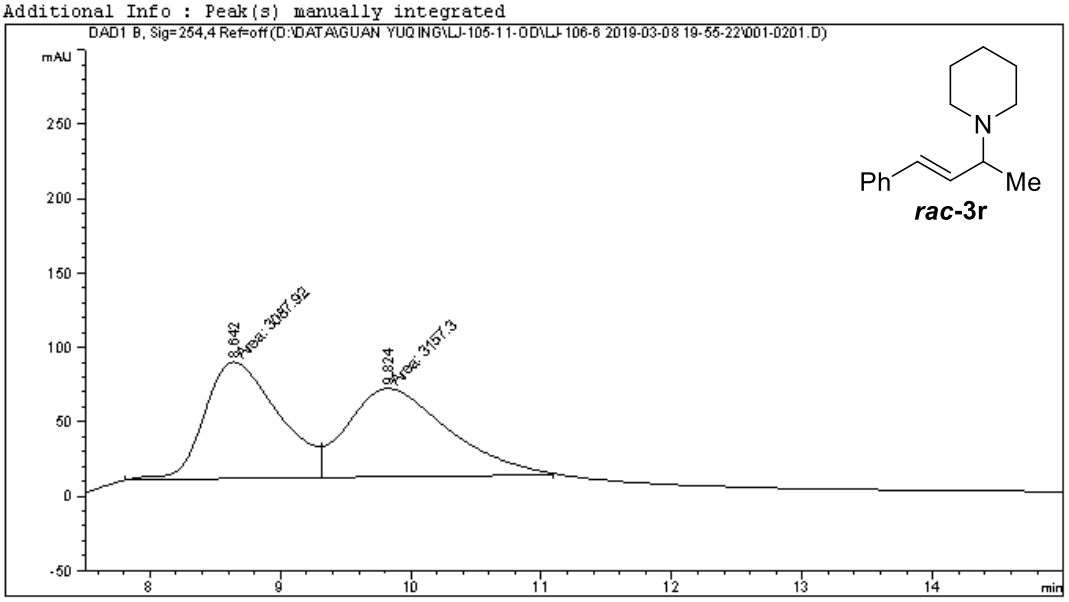



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 B, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1   8.718 BV    0.3143  527.30475   24.37941   2.1601
       2   9.653 VB    0.2483 2.38843e4  1404.88000  97.8399

    Totals :                  2.44116e4  1429.25941
```


Figure S172. HPLC spectra of **3q**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-105-11-OD\LJ-106-6 2019-03-08 19-55-22\001-0201.D
Sample Name: LJ-106-6-RAC

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   2
    Acq. Instrument : Instrument 2                  Location : Vial 1
    Injection Date  : 3/8/2019 8:07:24 PM               Inj :   1
                                                  Inj Volume : 2.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-105-11-OD\LJ-106-6 2019-03-08 19-55-22\DAD-OD(1-2)-
                      99-1-0.5ML-2UL-ALL-40MIN.M
    Last changed    : 3/8/2019 8:20:08 PM
                      (modified after loading)
    Analysis Method : D:\METHOD\YANG JIAXIN\DAD-OJ(1-6)-90-10-1ML-3UL-ALL-40MIN.M
    Last changed    : 3/8/2019 9:25:14 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

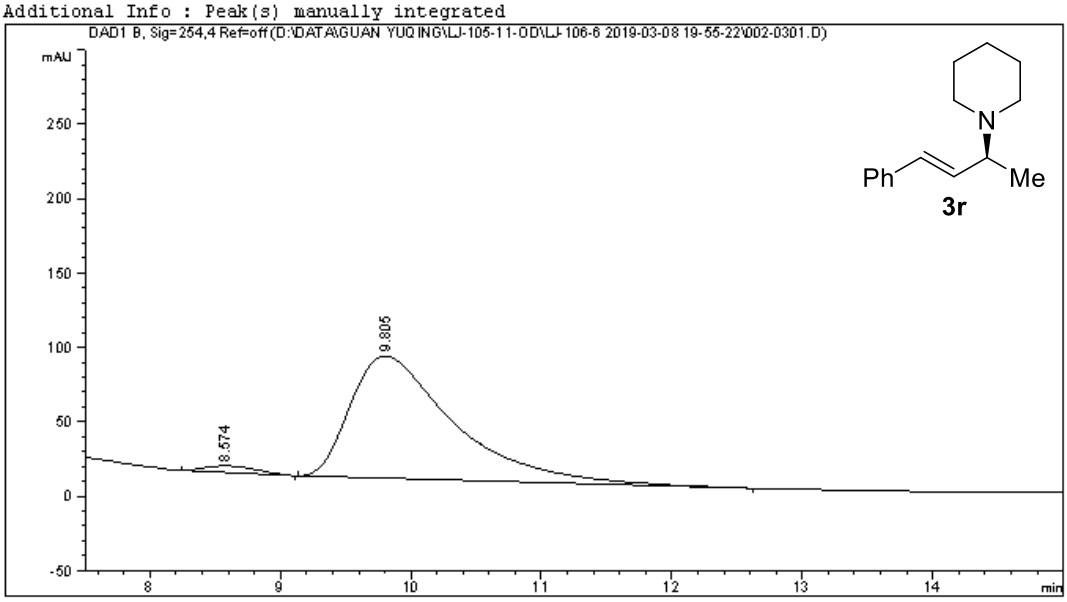



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 B, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1   8.642 MF    0.6583 3087.92310   78.17834  49.4446
       2   9.824 FM    0.8897 3157.29639   59.14474  50.5554

    Totals :                   6245.21948  137.32309
```


Figure S173. HPLC spectra of ***rac*-3r**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-105-11-OD\LJ-106-6 2019-03-08 19-55-22\002-0301.D
Sample Name: LJ-106-6

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   3
    Acq. Instrument : Instrument 2                  Location : Vial 2
    Injection Date  : 3/8/2019 8:28:20 PM               Inj :   1
                                                  Inj Volume : 2.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-105-11-OD\LJ-106-6 2019-03-08 19-55-22\DAD-OD(1-2)-
                      99-1-0.5ML-2UL-ALL-40MIN.M
    Last changed    : 3/8/2019 8:20:08 PM
                      (modified after loading)
    Analysis Method : D:\METHOD\YANG JIAXIN\DAD-OJ(1-6)-90-10-1ML-3UL-ALL-40MIN.M
    Last changed    : 3/8/2019 9:25:14 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

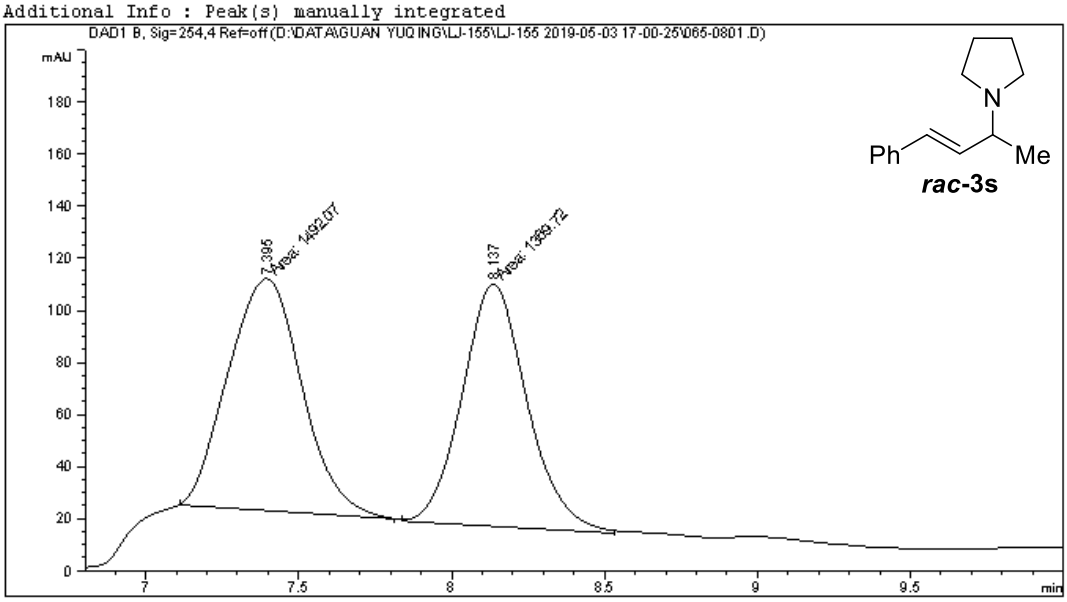



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 B, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1   8.574 BB    0.3580  118.74886    4.30188   2.5651
       2   9.805 BB    0.7912 4510.67627   82.06714  97.4349

    Totals :                   4629.42513   86.36902
```


Figure S174. HPLC spectra of **3r**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-155\LJ-155 2019-05-03 17-00-25\065-0801.D
Sample Name: LJ-108-4-RAC

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   8
    Acq. Instrument : Instrument 2                  Location : Vial 65
    Injection Date  : 5/3/2019 9:52:17 PM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-155\LJ-155 2019-05-03 17-00-25\DAD-0D(1-2)-95-5-0.
                      5ML-5UL-ALL-40MIN.M
    Last changed    : 5/3/2019 10:02:26 PM
                      (modified after loading)
    Analysis Method : D:\DATA\GUAN YUQING\LJ-155\LJ-155 2019-05-03 17-00-25\DAD-0D(1-2)-95-5-0.
                      5ML-5UL-ALL-40MIN.M (Sequence Method)
    Last changed    : 5/4/2019 9:40:19 AM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

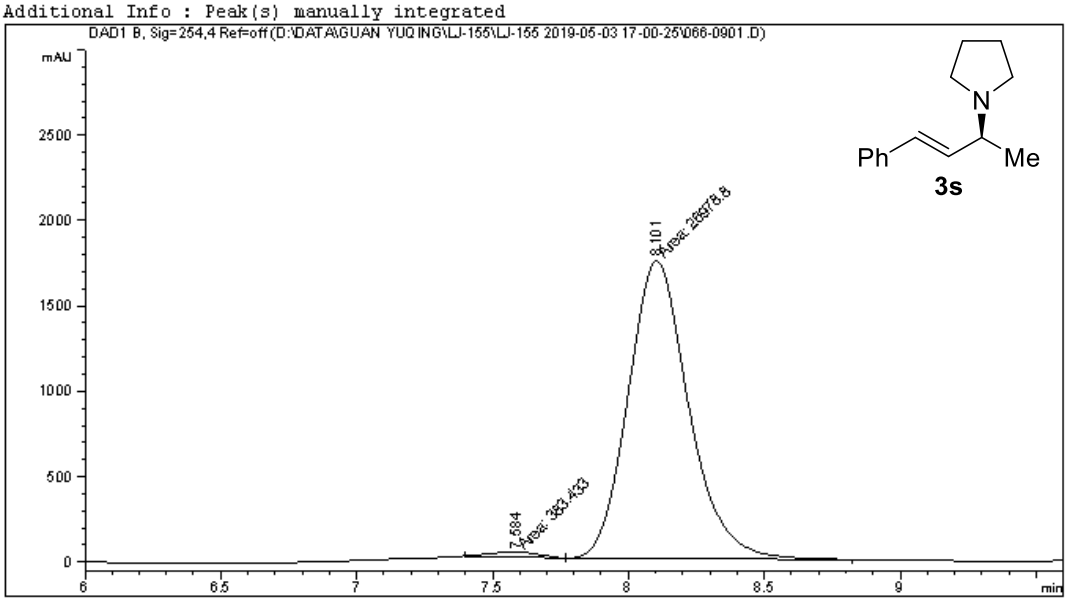



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 B, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1   7.395 MM    0.2795 1492.07043   88.97803  52.1377
       2   8.137 MM    0.2450 1369.72009   93.17516  47.8623

    Totals :                  2861.79053  182.15319
```


Figure S175. HPLC spectra of ***rac*-3s**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-155\LJ-155 2019-05-03 17-00-25\066-0901.D
Sample Name: LJ-108-4

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :   9
    Acq. Instrument : Instrument 2                    Location : Vial 66
    Injection Date  : 5/3/2019 10:13:18 PM                 Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-155\LJ-155 2019-05-03 17-00-25\DAD-OD(1-2)-95-5-0.
                      5ML-5UL-ALL-40MIN.M
    Last changed    : 5/3/2019 10:02:26 PM
                      (modified after loading)
    Analysis Method : D:\DATA\GUAN YUQING\LJ-155\LJ-155 2019-05-03 17-00-25\DAD-OD(1-2)-95-5-0.
                      5ML-5UL-ALL-40MIN.M (Sequence Method)
    Last changed    : 5/4/2019 9:54:17 AM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

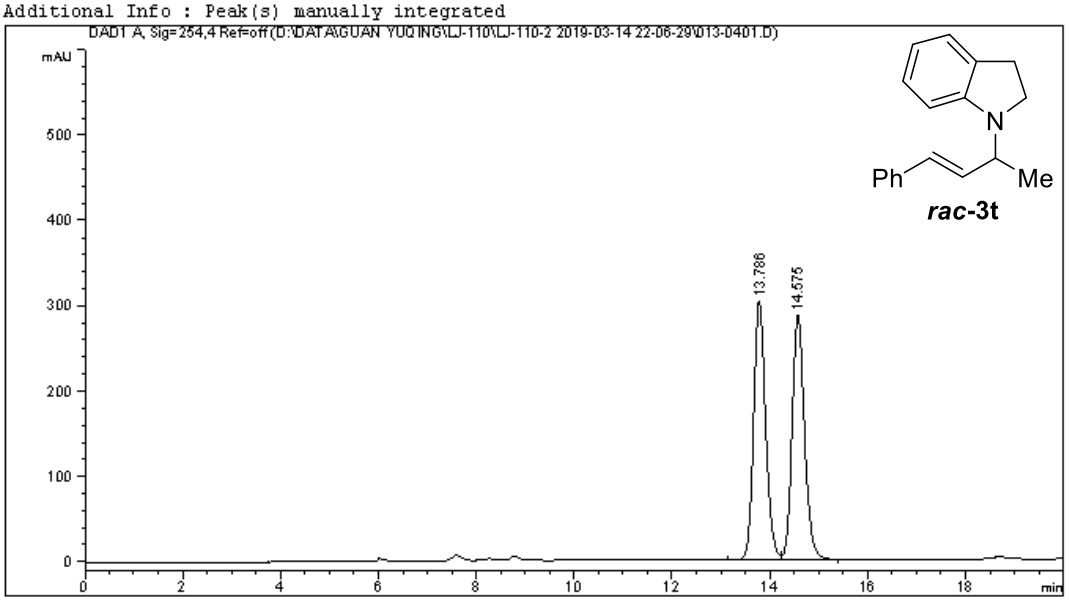



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 B, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1   7.584 MF    0.2171  383.43253   29.43110   1.4013
       2   8.101 FM    0.2581 2.69788e4  1742.11572  98.5987

    Totals :                  2.73622e4  1771.54683
```


Figure S176. HPLC spectra of **3s**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-110\LJ-110-2 2019-03-14 22-06-29\013-0401.D
Sample Name: LJ-110-2-RAC

```
    ======================================================================
    Acq. Operator   :                               Seq. Line :   4
    Acq. Instrument : Instrument 2                   Location : Vial 13
    Injection Date  : 3/14/2019 11:00:40 PM               Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-110\LJ-110-2 2019-03-14 22-06-29\DAD-OD(1-2)-95-5-0.
                      5ML-5UL-ALL-20MIN.M
    Last changed    : 3/4/2019 3:12:24 PM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\DAD-IA(1-6)-95-5-0.5ML-5UL-ALL-40MIN.M
    Last changed    : 3/19/2019 10:24:44 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

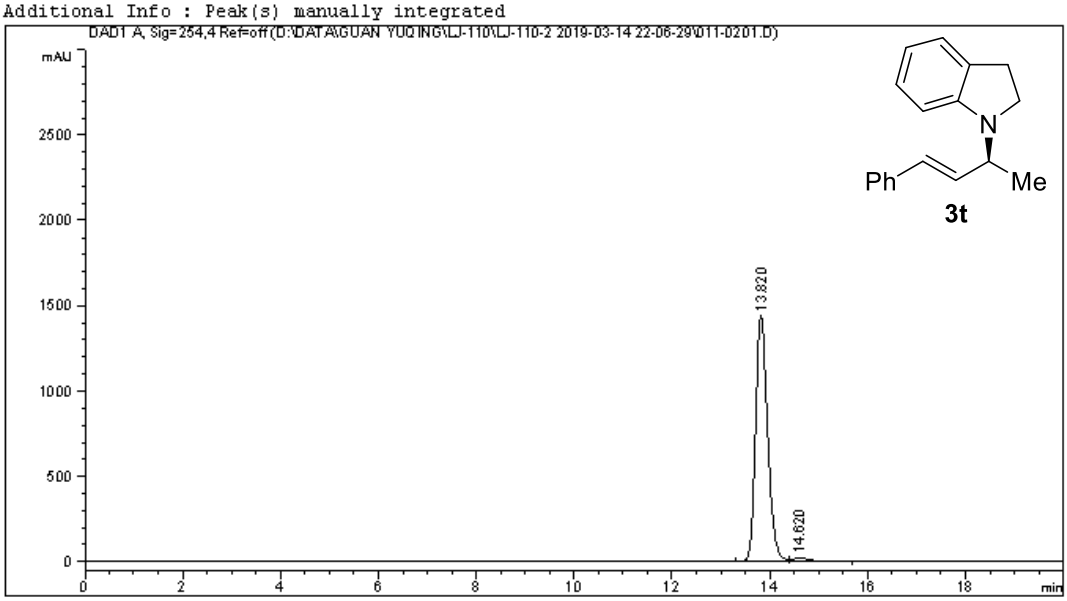



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1  13.786 BV    0.2600 5142.11768  303.06146  50.4431
       2  14.575 VB    0.2721 5051.77002  285.98007  49.5569

    Totals :                  1.01939e4   589.04153
```


Figure S177. HPLC spectra of ***rac*-3t**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-110\LJ-110-2 2019-03-14 22-06-29\011-0201.D
Sample Name: LJ-110-2

```
    ======================================================================
    Acq. Operator   :                               Seq. Line :   2
    Acq. Instrument : Instrument 2                   Location : Vial 11
    Injection Date  : 3/14/2019 10:18:39 PM              Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-110\LJ-110-2 2019-03-14 22-06-29\DAD-OD(1-2)-95-5-0.
                      5ML-5UL-ALL-20MIN.M
    Last changed    : 3/4/2019 3:12:24 PM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\DAD-IA(1-6)-95-5-0.5ML-5UL-ALL-40MIN.M
    Last changed    : 3/19/2019 10:26:50 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

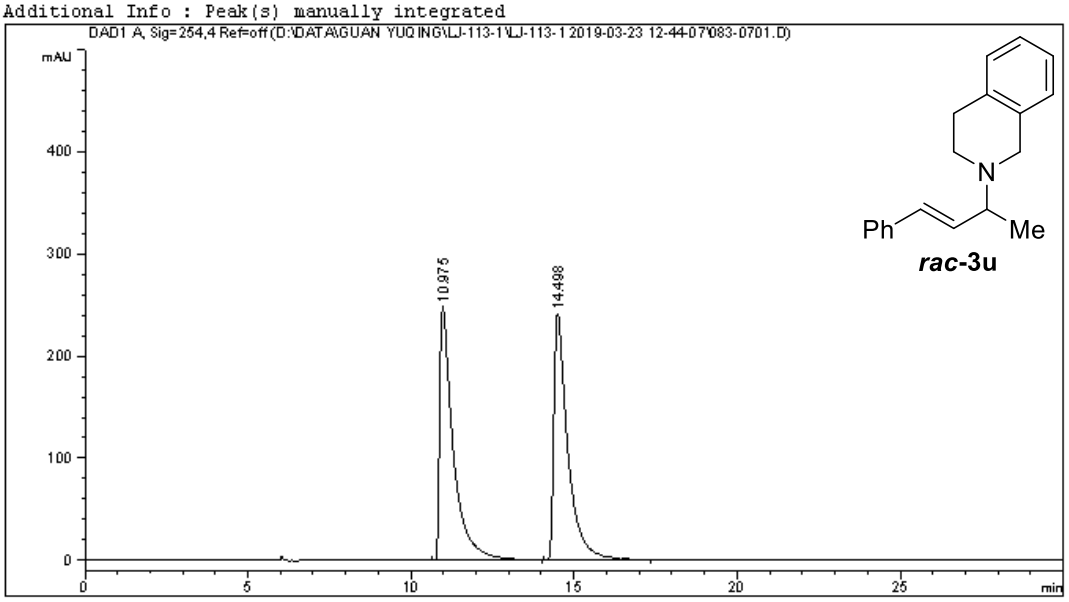



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1  13.820 BV    0.2600 2.43711e4  1436.18689  98.4123
       2  14.620 VB    0.2869  393.19205   20.21956   1.5877

    Totals :                  2.47643e4  1456.40645
```


Figure S178. HPLC spectra of **3t**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-113-1\LJ-113-1 2019-03-23 12-44-07\083-0701.D
Sample Name: LJ-113-2-RAC

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   7
    Acq. Instrument : Instrument 2                  Location : Vial 83
    Injection Date  : 3/23/2019 2:54:08 PM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-113-1\LJ-113-1 2019-03-23 12-44-07\DAD-OD(1-2)-95-5-
                      0.5ML-5UL-ALL-60MIN.M
    Last changed    : 3/23/2019 3:10:35 PM
                      (modified after loading)
    Analysis Method : D:\METHOD\XZC\DAD-OD(1-2)-95-5-1ML-5UL-ALL-50MIN.M
    Last changed    : 3/23/2019 4:04:01 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

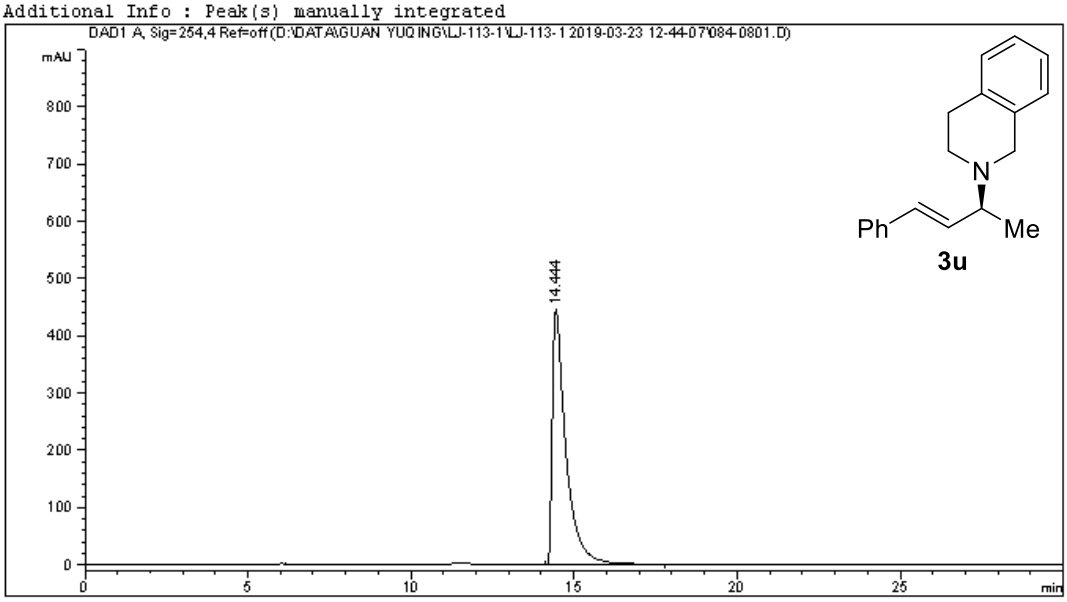



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  10.975 BB    0.4104 7225.67285  249.14714  50.1755
       2  14.498 BB    0.4295 7175.11523  240.88791  49.8245

    Totals :                  1.44008e4   490.03505
```


Figure S179. HPLC spectra of ***rac*-3u**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-113-1\LJ-113-1 2019-03-23 12-44-07\084-0801.D
Sample Name: LJ-113-2

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :   8
    Acq. Instrument : Instrument 2                    Location : Vial 84
    Injection Date  : 3/23/2019 3:25:10 PM                 Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-113-1\LJ-113-1 2019-03-23 12-44-07\DAD-OD(1-2)-95-5-
                      0.5ML-5UL-ALL-60MIN.M
    Last changed    : 3/23/2019 3:10:35 PM
                      (modified after loading)
    Analysis Method : D:\METHOD\XZC\DAD-OD(1-2)-95-5-1ML-5UL-ALL-50MIN.M
    Last changed    : 3/23/2019 4:06:28 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

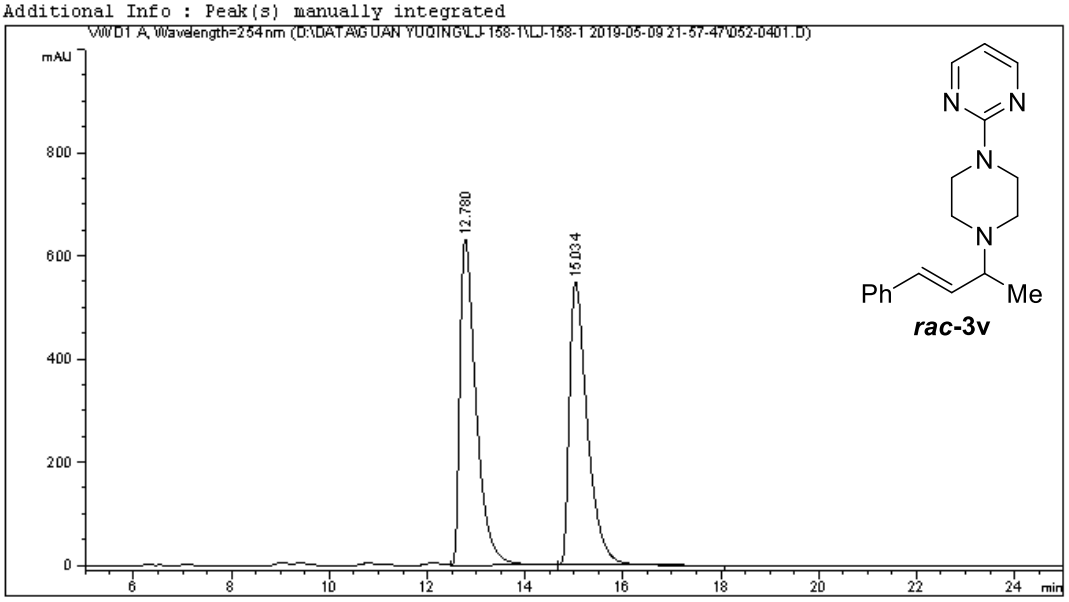



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  14.444 BB    0.4151 1.30190e4   447.92014 100.0000

    Totals :                  1.30190e4   447.92014
```


Figure S180. HPLC spectra of ***rac*-3u**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-158-1\LJ-158-1 2019-05-09 21-57-47\052-0401.D
Sample Name: LJ-158-1-RAC

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :   4
    Acq. Instrument : Instrument 1                    Location : Vial 52
    Injection Date  : 5/9/2019 11:02:38 PM                 Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-158-1\LJ-158-1 2019-05-09 21-57-47\VWD-AD(1-2)-95-5-
                      0.5ML-5UL-254NM-30MIN.M
    Last changed    : 4/9/2019 4:22:03 PM
    Analysis Method : D:\METHOD\LG\VWD-AD(1-2)-100-0-0.2ML-1UL-220NM-100MIN.M
    Last changed    : 5/10/2019 2:56:18 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

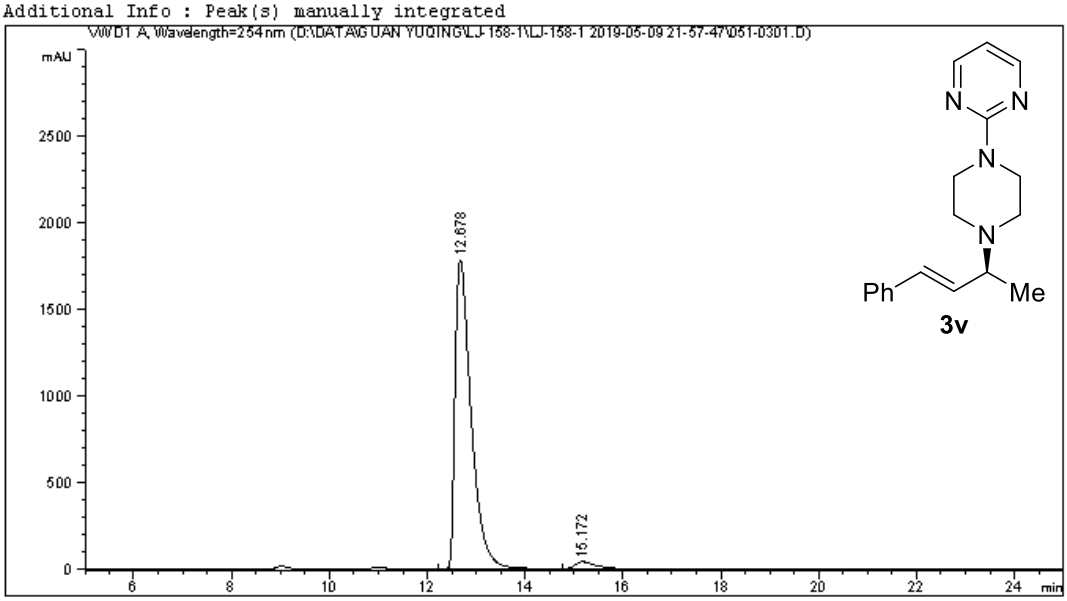



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1  12.780 VB    0.3437 1.44385e4   631.57111  50.8506
       2  15.034 BB    0.3822 1.39554e4   547.74023  49.1494

    Totals :                  2.83939e4  1179.31134
```


Figure S181. HPLC spectra of ***rac*-3v**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-158-1\LJ-158-1 2019-05-09 21-57-47\051-0301.D
Sample Name: LJ-158-1

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :   3
    Acq. Instrument : Instrument 1                    Location : Vial 51
    Injection Date  : 5/9/2019 10:31:48 PM                 Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-158-1\LJ-158-1 2019-05-09 21-57-47\VWD-AD(1-2)-95-5-
                      0.5ML-5UL-254NM-30MIN.M
    Last changed    : 4/9/2019 4:22:03 PM
    Analysis Method : D:\METHOD\LG\VWD-AD(1-2)-100-0-0.2ML-1UL-220NM-100MIN.M
    Last changed    : 5/10/2019 2:57:58 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

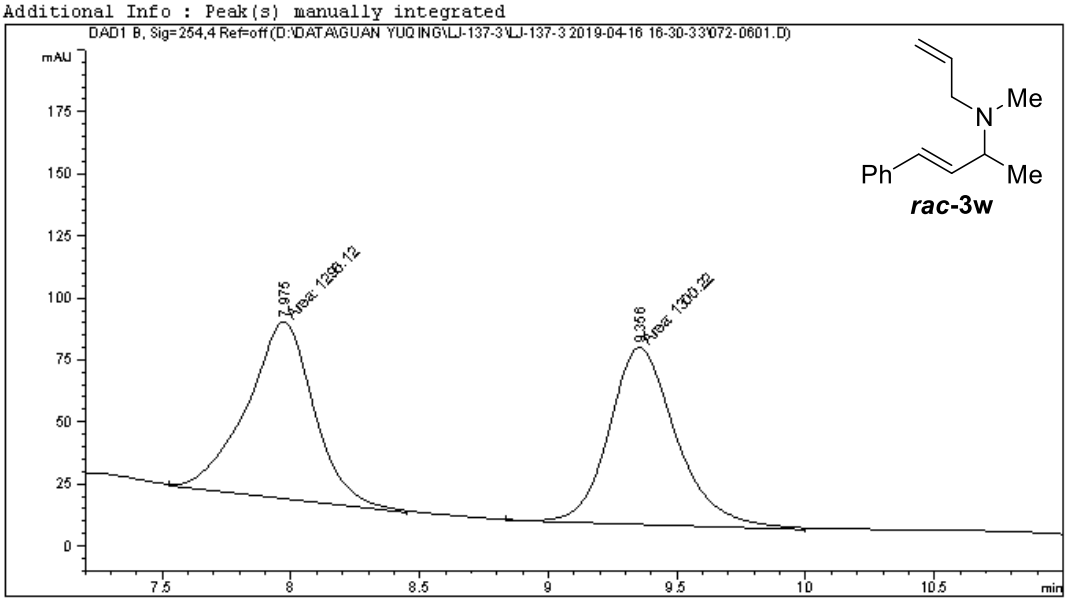



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1  12.678 BV    0.3434 4.06017e4  1785.04187  97.2820
       2  15.172 VB    0.4279 1134.37378   39.75301   2.7180

    Totals :                  4.17361e4  1824.79488
```


Figure S182. HPLC spectra of **3v**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-137-3\LJ-137-3 2019-04-16 16-30-33\072-0601.D
Sample Name: LJ-137-3-RAC

```
    ======================================================================
    Acq. Operator   :                               Seq. Line :   6
    Acq. Instrument : Instrument 2                   Location : Vial 72
    Injection Date  : 4/16/2019 5:30:41 PM               Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-137-3\LJ-137-3 2019-04-16 16-30-33\DAD-OD(1-2)-99-1-
                      0.5ML-5UL-ALL-40MIN.M
    Last changed    : 4/16/2019 5:44:26 PM
                      (modified after loading)
    Analysis Method : D:\DATA\GUAN YUQING\LJ-137-3\LJ-137-3 2019-04-16 16-30-33\DAD-OD(1-2)-99-1-
                      0.5ML-5UL-ALL-40MIN.M (Sequence Method)
    Last changed    : 4/17/2019 8:15:04 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```



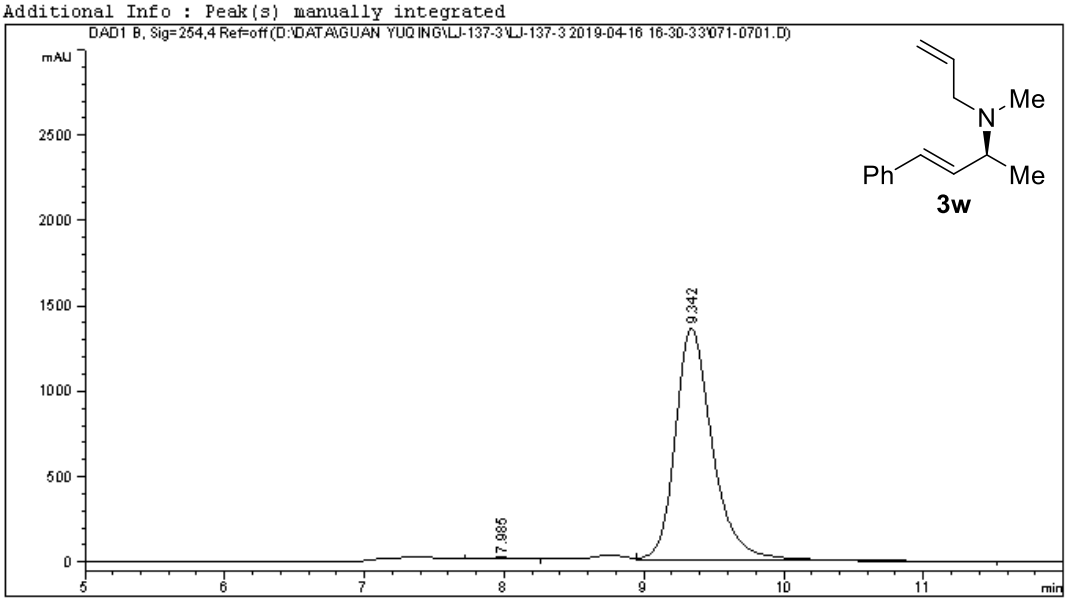
***rac*-3w**

```
    ======================================================================
                              Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 B, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1   7.975 MM    0.3028 1296.12183   71.34225  49.9210
       2   9.356 MM    0.3030 1300.22363   71.51093  50.0790

    Totals :                  2596.34546  142.85318
```


Figure S183. HPLC spectra of ***rac*-3w**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-137-3\LJ-137-3 2019-04-16 16-30-33\071-0701.D
Sample Name: LJ-137-3

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :   7
    Acq. Instrument : Instrument 2                    Location : Vial 71
    Injection Date  : 4/16/2019 5:51:42 PM                 Inj :   1
                                                    Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-137-3\LJ-137-3 2019-04-16 16-30-33\DAD-OD(1-2)-99-1-
                      0.5ML-5UL-ALL-40MIN.M
    Last changed    : 4/16/2019 5:44:26 PM
                      (modified after loading)
    Analysis Method : D:\DATA\GUAN YUQING\LJ-137-3\LJ-137-3 2019-04-16 16-30-33\DAD-OD(1-2)-99-1-
                      0.5ML-5UL-ALL-40MIN.M (Sequence Method)
    Last changed    : 4/17/2019 8:20:23 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

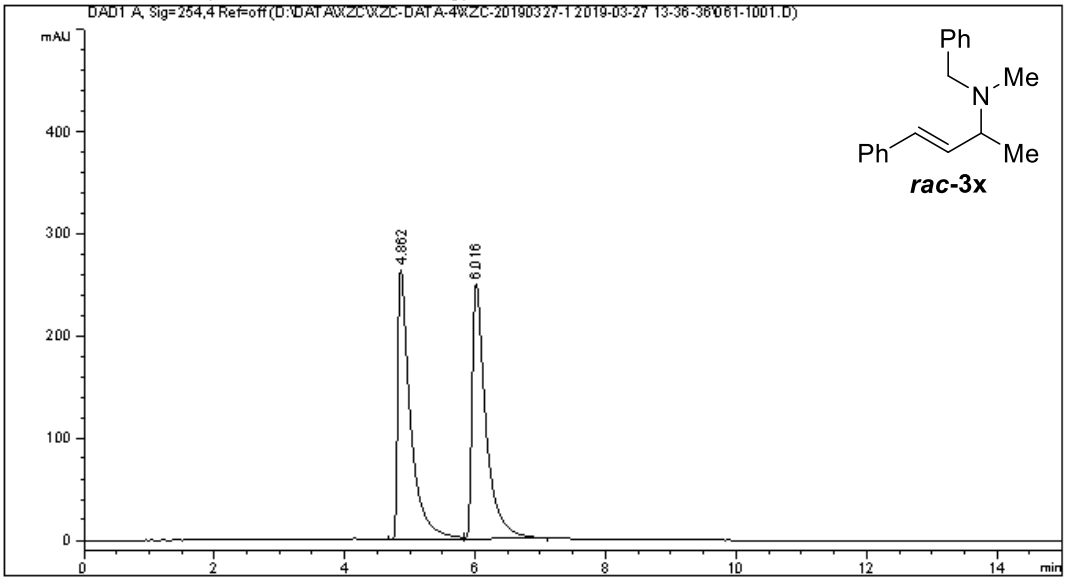



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 B, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1   7.985 BB    0.2119  103.08399    7.24746   0.4068
       2   9.342 VB    0.2788 2.52373e4  1357.84119  99.5932

    Totals :                  2.53404e4  1365.08865
```


Figure S184. HPLC spectra of **3w**, related to **Figure 3**.

Data File D:\DATA\XZC\XZC-DATA-4\XZC-20190327-1 2019-03-27 13-36-36\061-1001.D
Sample Name: LJ-113-1-RAC

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :  10
    Acq. Instrument : Instrument 2                  Location : Vial 61
    Injection Date  : 3/27/2019 11:37:02 PM              Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\XZC\XZC-DATA-4\XZC-20190327-1 2019-03-27 13-36-36\DAD-0D(1-2)-90-10
                      -1ML-5UL-ALL-20MIN.M
    Last changed    : 12/25/2018 5:41:36 PM
    Analysis Method : D:\METHOD\LG\DAD-0J(1-6)-80-20-1ML-5UL-ALL-60MIN.M
    Last changed    : 4/14/2019 9:23:10 PM
                      (modified after loading)
```

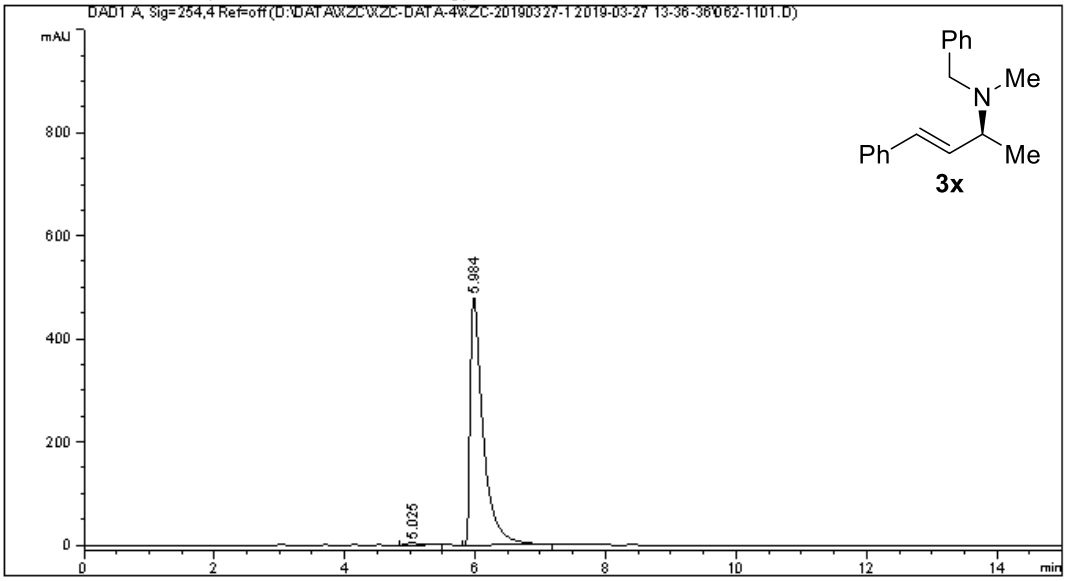



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1   4.862 BV    0.1923 3595.02271  264.92239  49.8359
       2   6.016 VB    0.2090 3618.70410  249.76396  50.1641

    Totals :                   7213.72681  514.68636


    ======================================================================
```


Figure S185. HPLC spectra of ***rac*-3x**, related to **Figure 3**.

Data File D:\DATA\XZC\XZC-DATA-4\XZC-20190327-1 2019-03-27 13-36-36\062-1101.D
Sample Name: LJ-113-1

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :  11
    Acq. Instrument : Instrument 2                    Location : Vial 62
    Injection Date  : 3/27/2019 11:58:01 PM              Inj :   1
                                                    Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\XZC\XZC-DATA-4\XZC-20190327-1 2019-03-27 13-36-36\DAD-0D(1-2)-90-10
                      -1ML-5UL-ALL-20MIN.M
    Last changed    : 12/25/2018 5:41:36 PM
    Analysis Method : D:\METHOD\LG\DAD-0J(1-6)-80-20-1ML-5UL-ALL-60MIN.M
    Last changed    : 4/14/2019 9:24:48 PM
                      (modified after loading)
```

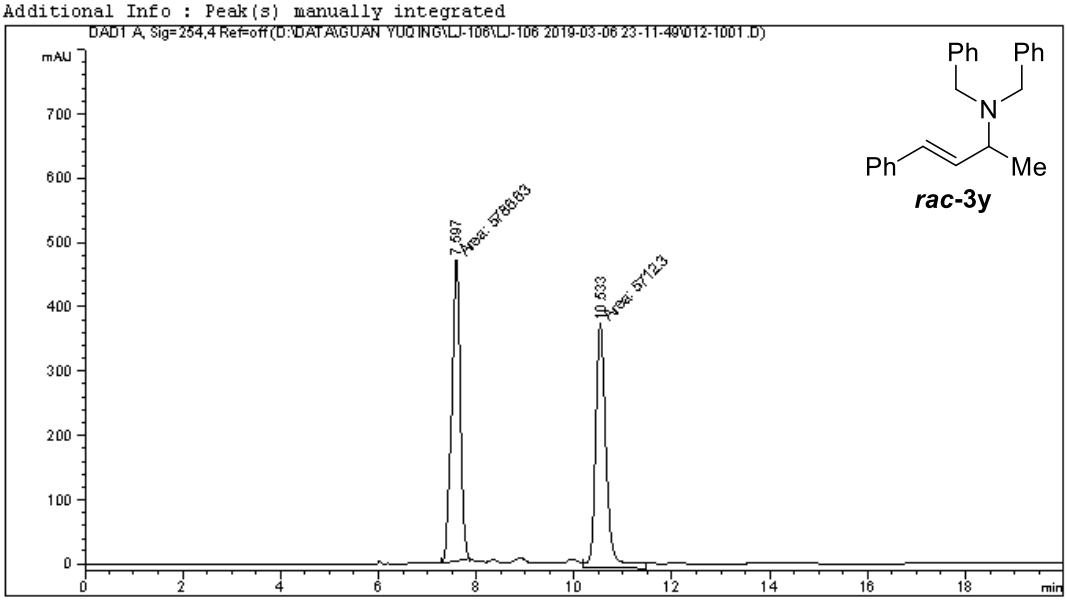



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1   5.025 BB    0.2364   70.61983    4.46831   1.0636
       2   5.984 BB    0.1998 6568.77344  479.64868  98.9364

    Totals :                   6639.39326  484.11699


    ======================================================================

Instrument 2 4/14/2019 9:24:53 PM                                  Page 1 of 1
```

Figure S186. HPLC spectra of **3x**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-106\LJ-106 2019-03-06 23-11-49\012-1001.D
Sample Name: LJ-103-4-RAC

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :  10
    Acq. Instrument : Instrument 2                  Location : Vial 12
    Injection Date  : 3/7/2019 2:17:08 AM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-106\LJ-106 2019-03-06 23-11-49\DAD-OD(1-2)-95-5-0.
                      5ML-5UL-ALL-20MIN.M
    Last changed    : 3/4/2019 3:12:24 PM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\DAD-IA(1-6)-95-5-0.5ML-5UL-ALL-40MIN.M
    Last changed    : 3/19/2019 10:07:49 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

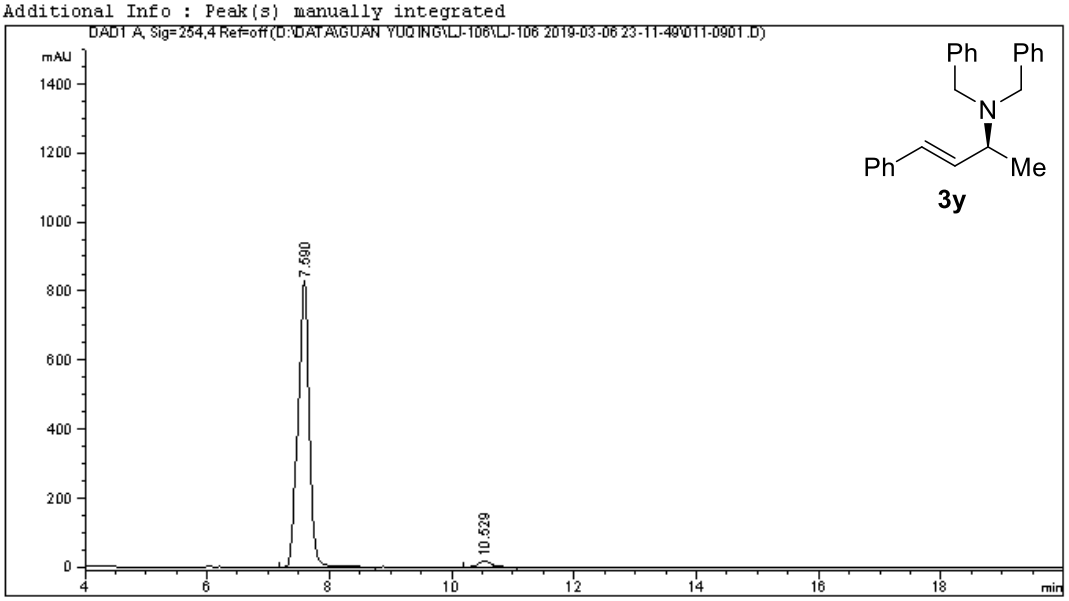



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1   7.597 MM    0.2056 5786.62988  469.13281  50.3232
       2  10.533 MM    0.2510 5712.29883  379.24442  49.6768

    Totals :                  1.14989e4   848.37723
```


Figure S187. HPLC spectra of ***rac*-3y**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-106\LJ-106 2019-03-06 23-11-49\011-0901.D
Sample Name: LJ-103-4

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :   9
    Acq. Instrument : Instrument 2                    Location : Vial 11
    Injection Date  : 3/7/2019 1:56:04 AM                 Inj :   1
                                                    Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-106\LJ-106 2019-03-06 23-11-49\DAD-0D(1-2)-95-5-0.
                      5ML-5UL-ALL-20MIN.M
    Last changed    : 3/4/2019 3:12:24 PM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\DAD-IA(1-6)-95-5-0.5ML-5UL-ALL-40MIN.M
    Last changed    : 3/19/2019 10:11:39 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

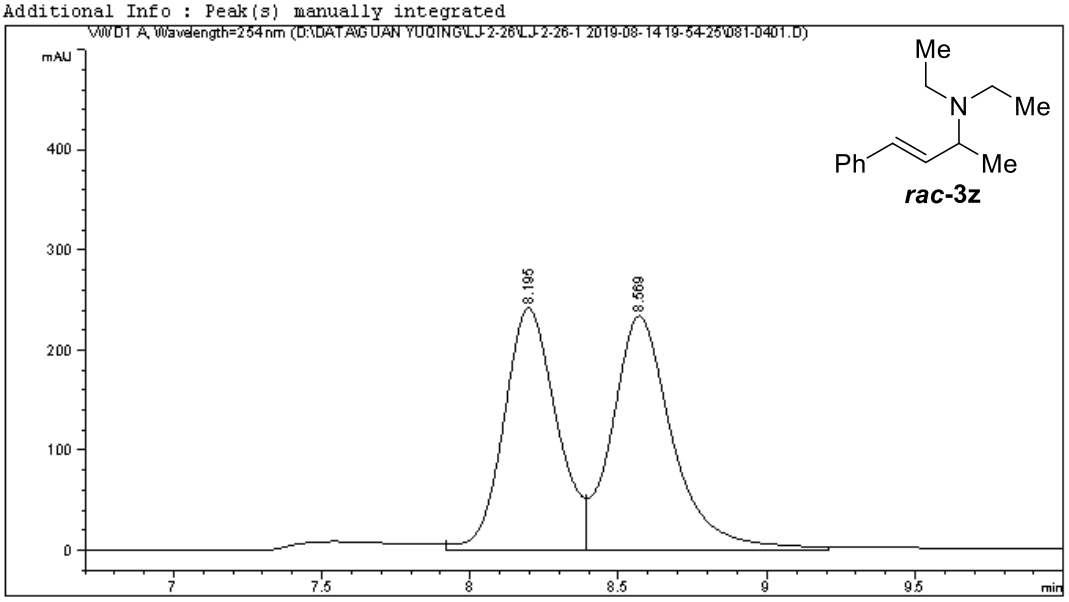



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1   7.590 BB    0.1842 1.0513le4   827.54132  97.6746
       2  10.529 BB    0.2115  250.29330   18.30650   2.3254

    Totals :                  1.07634e4   845.84782
```


Figure S188. HPLC spectra of **3y**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-2-26\LJ-2-26-1 2019-08-14 19-54-25\081-0401.D
Sample Name: LJ-2-26-4-RAC

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   4
    Acq. Instrument : Instrument 1                  Location : Vial 81
    Injection Date  : 8/14/2019 8:59:55 PM               Inj :   1
                                                  Inj Volume : 1.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-2-26\LJ-2-26-1 2019-08-14 19-54-25\VWD-0J(1-2)-95-5-
                      0.5ML-1UL-254NM-20MIN.M
    Last changed    : 8/14/2019 7:57:29 PM
    Analysis Method : D:\METHOD\LWD\DAD-AD(1-6)-95-5-1ML-3UL-ALL-30MIN-0813.M
    Last changed    : 8/15/2019 6:37:47 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

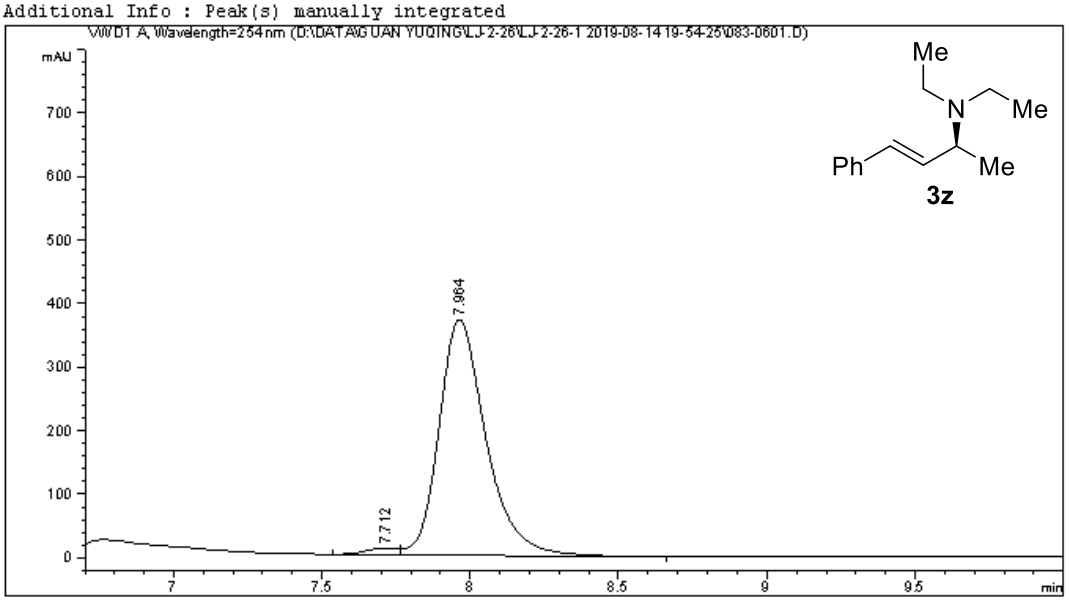



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1   8.195 VV    0.1880 2979.72461  241.35216  47.5267
       2   8.569 VV    0.2095 3289.85962  233.32156  52.4733

    Totals :                   6269.58423  474.67372
```


Figure S189. HPLC spectra of ***rac*-3z**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-2-26\LJ-2-26-1 2019-08-14 19-54-25\083-0601.D
Sample Name: LJ-2-26-3

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :   6
    Acq. Instrument : Instrument 1                    Location : Vial 83
    Injection Date  : 8/14/2019 9:41:26 PM                 Inj :   1
                                                   Inj Volume : 1.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-2-26\LJ-2-26-1 2019-08-14 19-54-25\VWD-0J(1-2)-95-5-
                      0.5ML-1UL-254NM-20MIN.M
    Last changed    : 8/14/2019 7:57:29 PM
    Analysis Method : D:\METHOD\LWD\DAD-AD(1-6)-95-5-1ML-3UL-ALL-30MIN-0813.M
    Last changed    : 8/15/2019 6:36:03 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

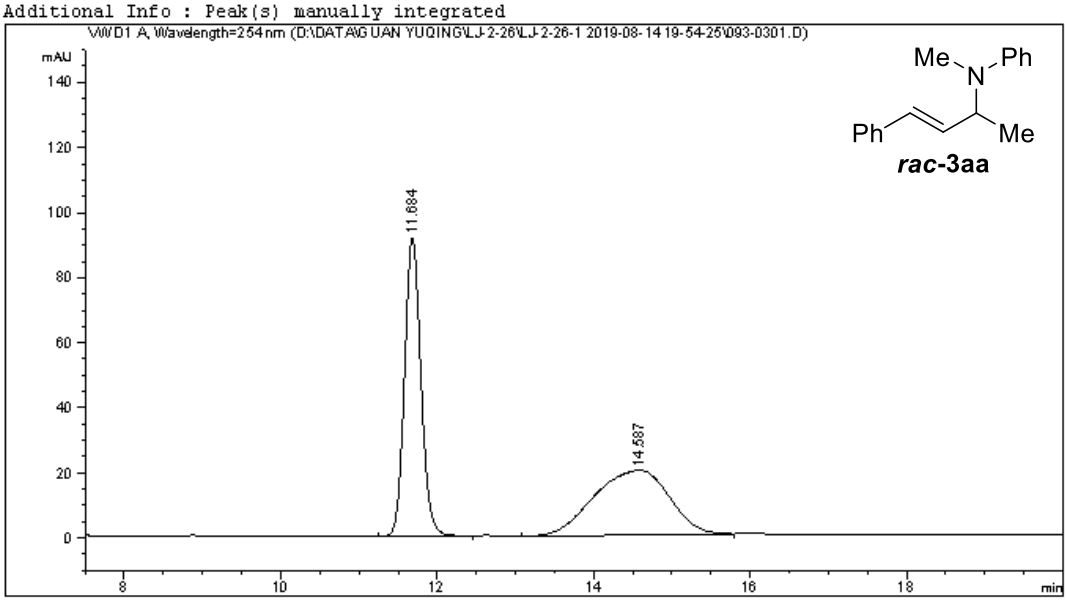



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1   7.712 BV    0.1156   78.80071   10.49263   1.8927
       2   7.964 VB    0.1663 4084.59766  371.36200  98.1073

    Totals :                   4163.39837  381.85463
```


Figure S190. HPLC spectra of **3z**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-2-26\LJ-2-26-1 2019-08-14 19-54-25\093-0301.D
Sample Name: LJ-2-26-1-RAC

```
    ======================================================================
    Acq. Operator   :                               Seq. Line :   3
    Acq. Instrument : Instrument 1                   Location : Vial 93
    Injection Date  : 8/14/2019 8:34:03 PM               Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-2-26\LJ-2-26-1 2019-08-14 19-54-25\VWD-0J(1-2)-95-5-
                      1.0ML-5UL-254NM-30MIN.M
    Last changed    : 8/14/2019 8:31:07 PM
                      (modified after loading)
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\VWD-0J(1-2)-95-5-0.5ML-1UL-254NM-20MIN.M
    Last changed    : 8/14/2019 9:00:54 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```



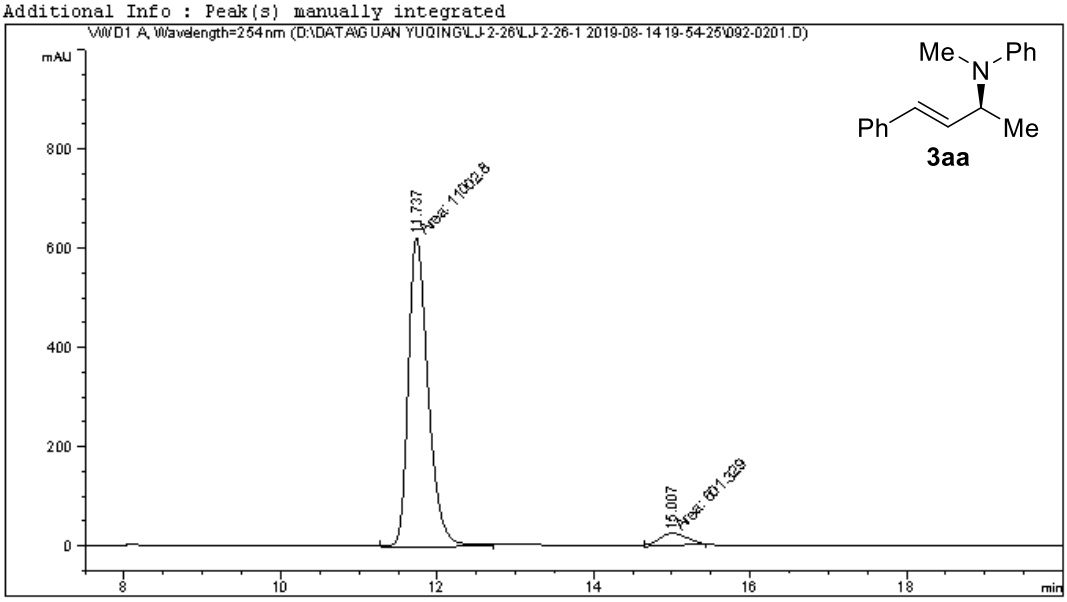
***rac*-3aa**

```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  11.684 BB    0.2247 1341.73059   91.71468  50.3192
       2  14.587 BB    1.0837 1324.70544   19.82213  49.6808

    Totals :                  2666.43604  111.53681
```


Figure S191. HPLC spectra of ***rac*-3aa**, related to **Figure 3**.

Data File D:\DATA\GUAN YUQING\LJ-2-26\LJ-2-26-1 2019-08-14 19-54-25\092-0201.D
Sample Name: LJ-2-26-1

```
    ======================================================================
    Acq. Operator   :                               Seq. Line :   2
    Acq. Instrument : Instrument 1                   Location : Vial 92
    Injection Date  : 8/14/2019 8:08:13 PM               Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-2-26\LJ-2-26-1 2019-08-14 19-54-25\VWD-0J(1-2)-95-5-
                      1.0ML-5UL-254NM-30MIN.M
    Last changed    : 8/14/2019 8:31:07 PM
                      (modified after loading)
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\VWD-0J(1-2)-95-5-0.5ML-1UL-254NM-20MIN.M
    Last changed    : 8/14/2019 9:03:25 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

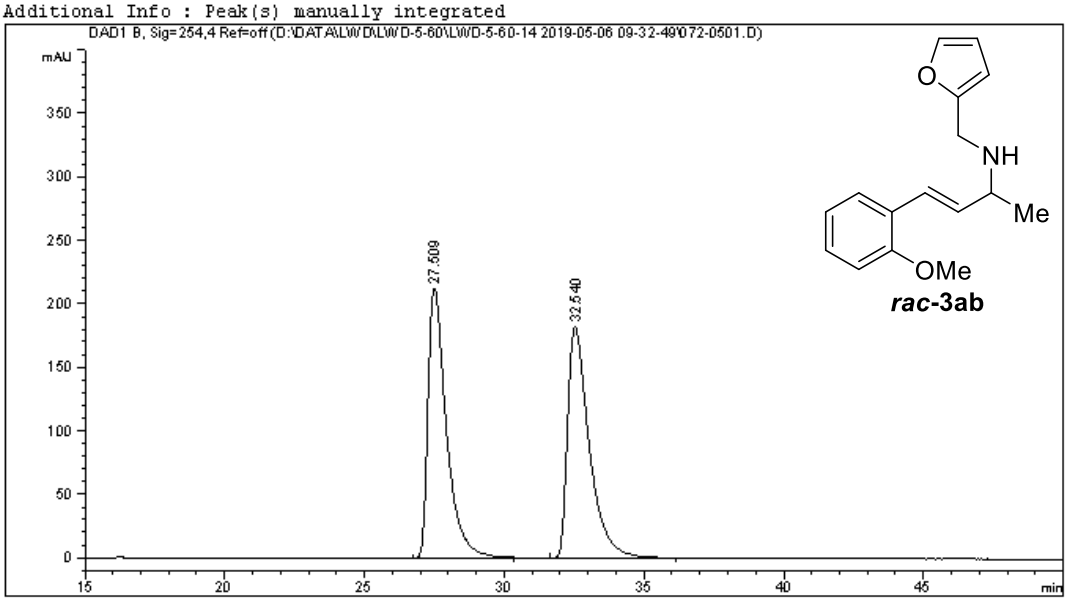



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  11.737 MM    0.2944 1.10028e4   622.86169  94.8180
       2  15.007 MM    0.4183  601.32904   23.95970   5.1820

    Totals :                  1.1604le4   646.82139
```


Figure S192. HPLC spectra of **3aa**, related to **Figure 3**.

Data File D:\DATA\LWD\LWD-5-60\LWD-5-60-14 2019-05-06 09-32-49\072-0501.D
Sample Name: LJ-157-8-RAC

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   5
    Acq. Instrument : Instrument 2                  Location : Vial 72
    Injection Date  : 5/6/2019 11:23:57 AM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LWD\LWD-5-60\LWD-5-60-14 2019-05-06 09-32-49\DAD-0J(1-6)-99-1-0.5ML
                      -5UL-ALL-60MIN.M
    Last changed    : 3/10/2019 2:55:21 PM
    Analysis Method : D:\DATA\LWD\LWD-5-60\LWD-5-60-14 2019-05-06 09-32-49\DAD-0J(1-6)-99-1-0.5ML
                      -5UL-ALL-60MIN.M (Sequence Method)
    Last changed    : 5/16/2019 9:39:12 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

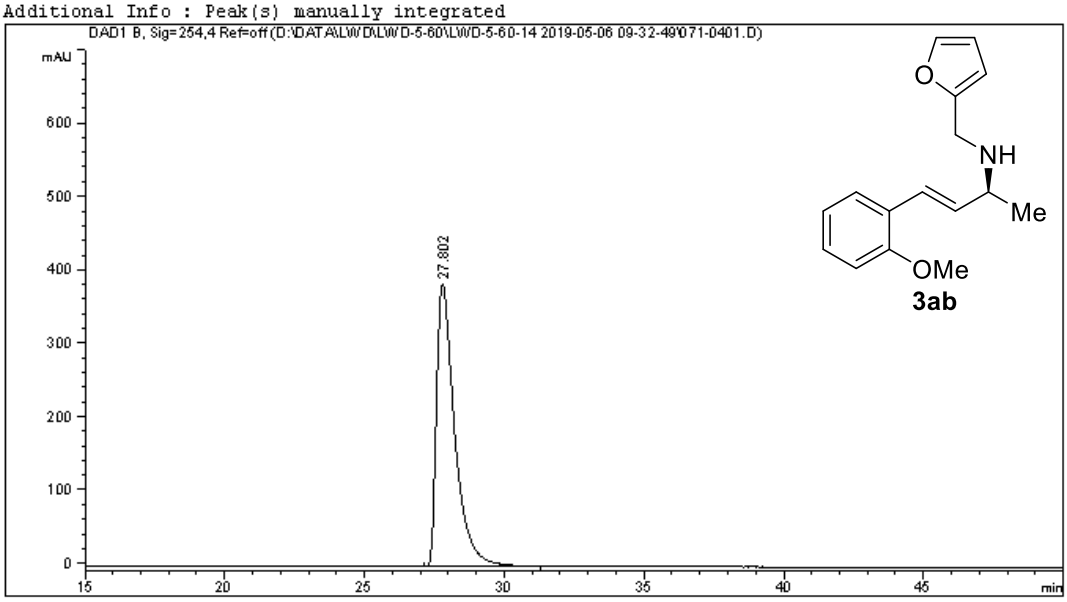



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 B, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  27.509 BB    0.6781 9748.92676  212.96362  49.7788
       2  32.540 BB    0.7825 9835.56641  182.56171  50.2212

    Totals :                  1.95845e4   395.52533
```


Figure S193. HPLC spectra of ***rac*-3ab**, related to **Figure 4**.

Data File D:\DATA\LWD\LWD-5-60\LWD-5-60-14 2019-05-06 09-32-49\071-0401.D
Sample Name: LJ-157-8

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   4
    Acq. Instrument : Instrument 2                  Location : Vial 71
    Injection Date  : 5/6/2019 10:22:58 AM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LWD\LWD-5-60\LWD-5-60-14 2019-05-06 09-32-49\DAD-0J(1-6)-99-1-0.5ML
                      -5UL-ALL-60MIN.M
    Last changed    : 3/10/2019 2:55:21 PM
    Analysis Method : D:\DATA\LWD\LWD-5-60\LWD-5-60-14 2019-05-06 09-32-49\DAD-0J(1-6)-99-1-0.5ML
                      -5UL-ALL-60MIN.M (Sequence Method)
    Last changed    : 5/16/2019 9:40:28 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

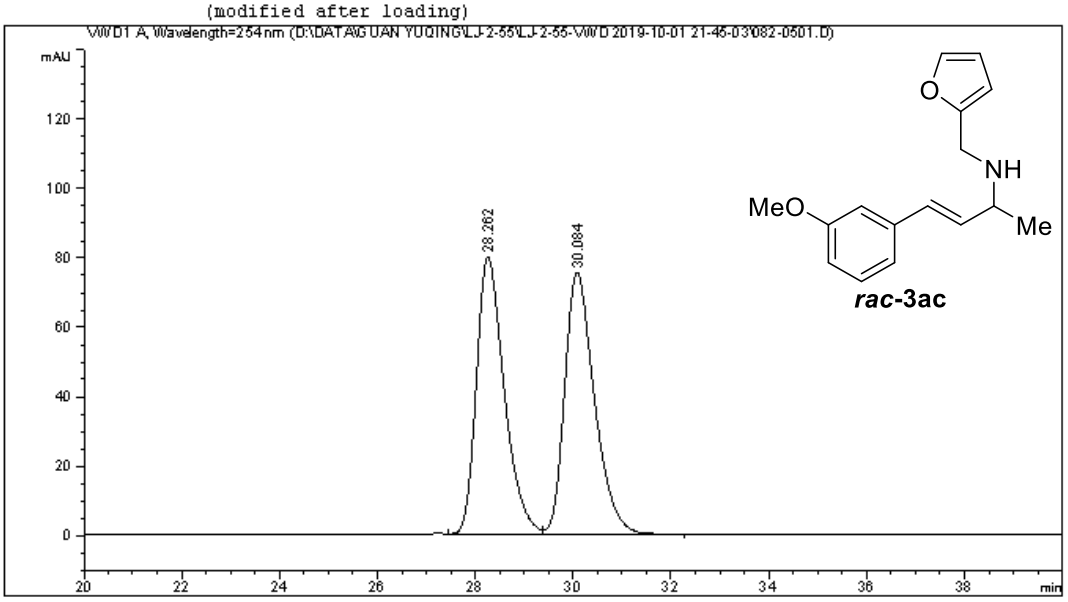



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 B, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  27.802 BB    0.6682 1.73284e4   385.65326 100.0000

    Totals :                  1.73284e4   385.65326
```


Figure S194. HPLC spectra of **3ab**, related to **Figure 4**.

Data File D:\DATA\GUAN YUQING\LJ-2-55\LJ-2-55-VWD 2019-10-01 21-45-03\082-0501.D
Sample Name: LJ-2-55-2

```
    ======================================================================
    Acq. Operator   :                               Seq. Line :   5
    Acq. Instrument : Instrument 1                   Location : Vial 82
    Injection Date  : 10/1/2019 11:21:53 PM              Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-2-55\LJ-2-55-VWD 2019-10-01 21-45-03\VWD-AD(1-2)-99-
                      1-0.5ML-5UL-254NM-40MIN.M
    Last changed    : 10/1/2019 10:33:36 PM
                      (modified after loading)
    Analysis Method : D:\METHOD\LGY\VWD-AS(1-6)-99-1-1ML-5UL-254NM-35MIN.M
    Last changed    : 10/2/2019 9:54:14 AM
                      (modified after loading)
```

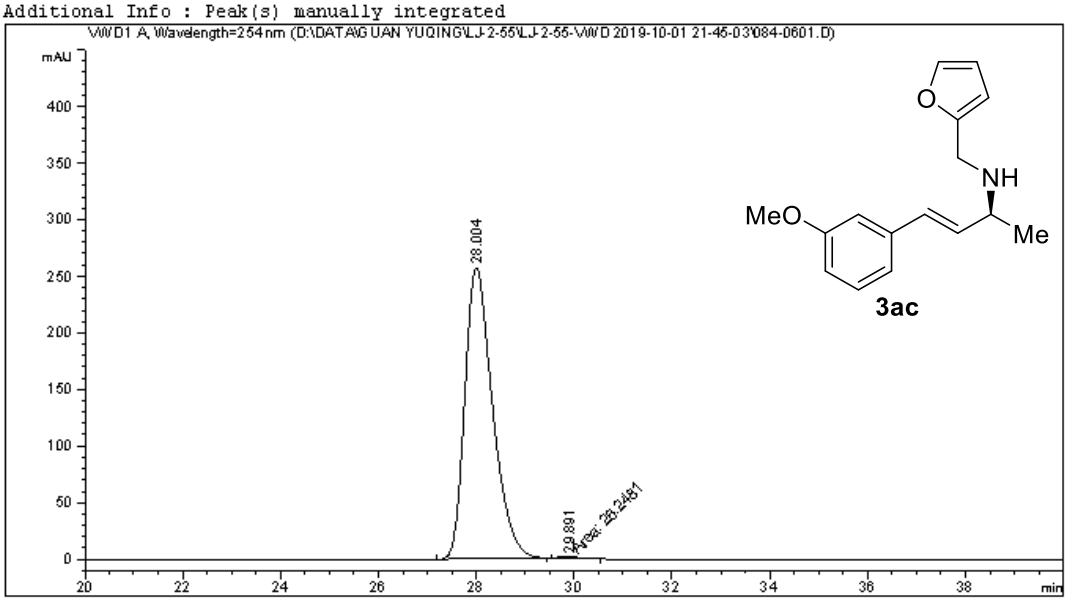



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  28.262 BV    0.6025 3147.13306   79.73415  49.7559
       2  30.084 VB    0.6431 3178.01807   75.34550  50.2441

    Totals :                  6325.15112  155.07965


Instrument 1 10/2/2019 9:54:23 AM                                Page 1 of 2
```

Figure S195. HPLC spectra of ***rac*-3ac**, related to **Figure 4**.

Data File D:\DATA\GUAN YUQING\LJ-2-55\LJ-2-55-VWD 2019-10-01 21-45-03\084-0601.D
Sample Name: LJ-2-56-2

```
    ======================================================================
    Acq. Operator   :                               Seq. Line :   6
    Acq. Instrument : Instrument 1                   Location : Vial 84
    Injection Date  : 10/2/2019 12:02:43 AM               Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-2-55\LJ-2-55-VWD 2019-10-01 21-45-03\VWD-AD(1-2)-99-
                      1-0.5ML-5UL-254NM-40MIN.M
    Last changed    : 10/1/2019 10:33:36 PM
                      (modified after loading)
    Analysis Method : D:\METHOD\LGY\VWD-AS(1-6)-99-1-1ML-5UL-254NM-35MIN.M
    Last changed    : 10/2/2019 9:57:02 AM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

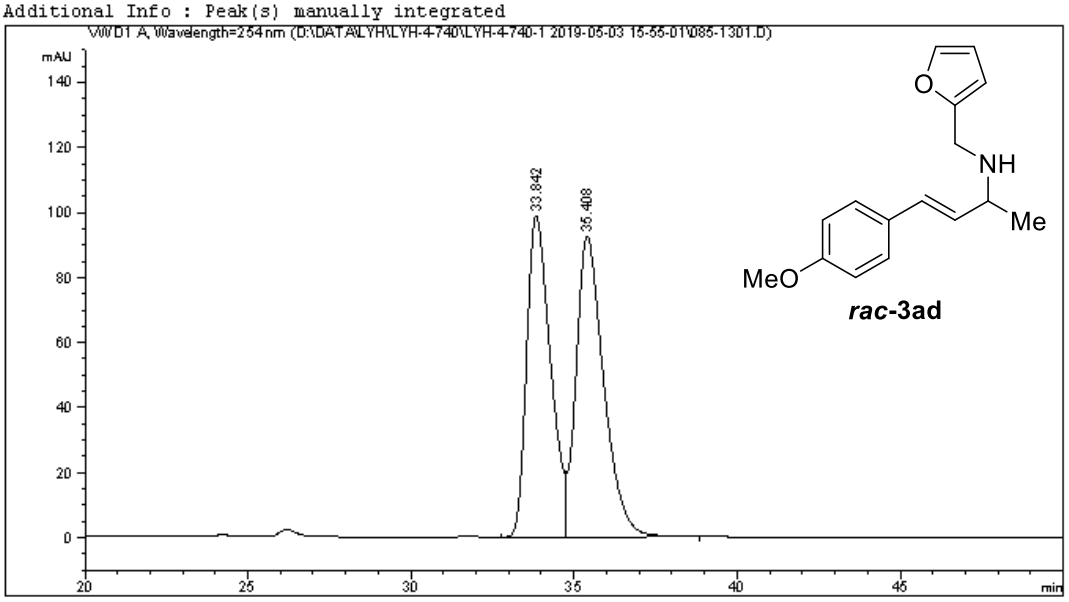



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  28.004 BB    0.5997 1.01024e4   256.95374  99.7409
       2  29.891 MM    0.4877   26.24809 8.96930e-1   0.2591

    Totals :                  1.01286e4   257.85067
```


Figure S196. HPLC spectra of **3ac**, related to **Figure 4**.

Data File D:\DATA\LYH\LYH-4-740\LYH-4-740-1 2019-05-03 15-55-01\085-1301.D
Sample Name: LJ-150-1-RAC

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :  13
    Acq. Instrument : Instrument 1                    Location : Vial 85
    Injection Date  : 5/3/2019 11:26:13 PM                 Inj :  1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LYH\LYH-4-740\LYH-4-740-1 2019-05-03 15-55-01\VWD-AD(1-2)-99-1-0.
                      5ML-5UL-254NM-60MIN.M
    Last changed    : 4/16/2019 4:38:17 PM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\VWD-AD(1-2)-70-30-0.5ML-5UL-254NM-40MIN.M
    Last changed    : 5/4/2019 10:06:22 AM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

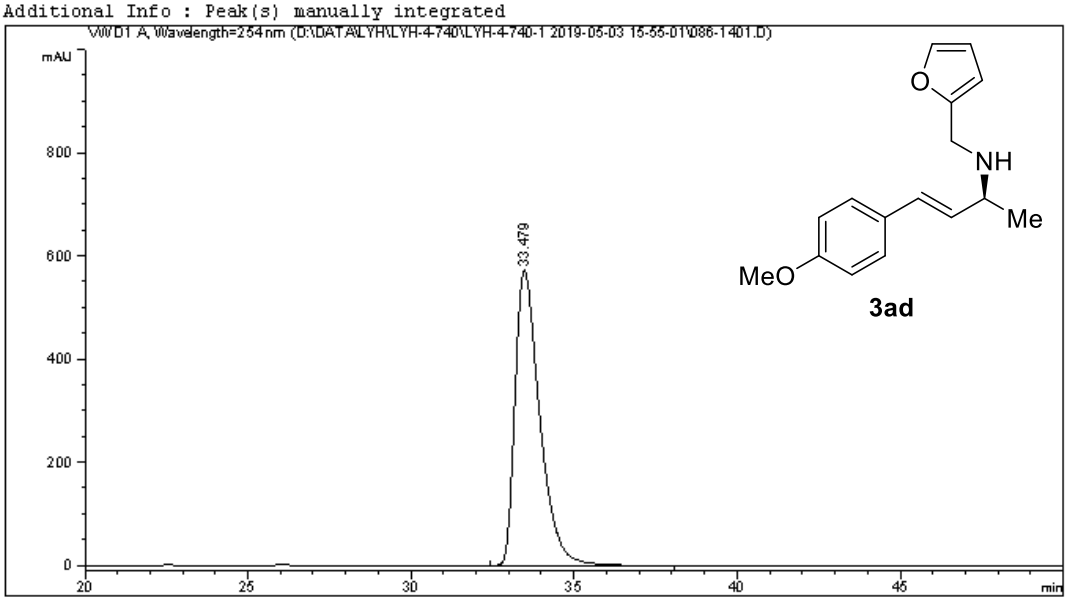



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  33.842 BV    0.7749 5006.37842   98.67974  47.8643
       2  35.408 VB    0.8798 5453.14893   92.50365  52.1357

    Totals :                  1.04595e4   191.18340
```


Figure S197. HPLC spectra of ***rac*-3ad**, related to **Figure 4**.

Data File D:\DATA\LYH\LYH-4-740\LYH-4-740-1 2019-05-03 15-55-01\086-1401.D
Sample Name: LJ-150-1

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :  14
    Acq. Instrument : Instrument 1                  Location : Vial 86
    Injection Date  : 5/4/2019 12:27:04 AM               Inj :  1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LYH\LYH-4-740\LYH-4-740-1 2019-05-03 15-55-01\VWD-AD(1-2)-99-1-0.
                      5ML-5UL-254NM-60MIN.M
    Last changed    : 4/16/2019 4:38:17 PM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\VWD-AD(1-2)-70-30-0.5ML-5UL-254NM-40MIN.M
    Last changed    : 5/4/2019 10:07:46 AM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

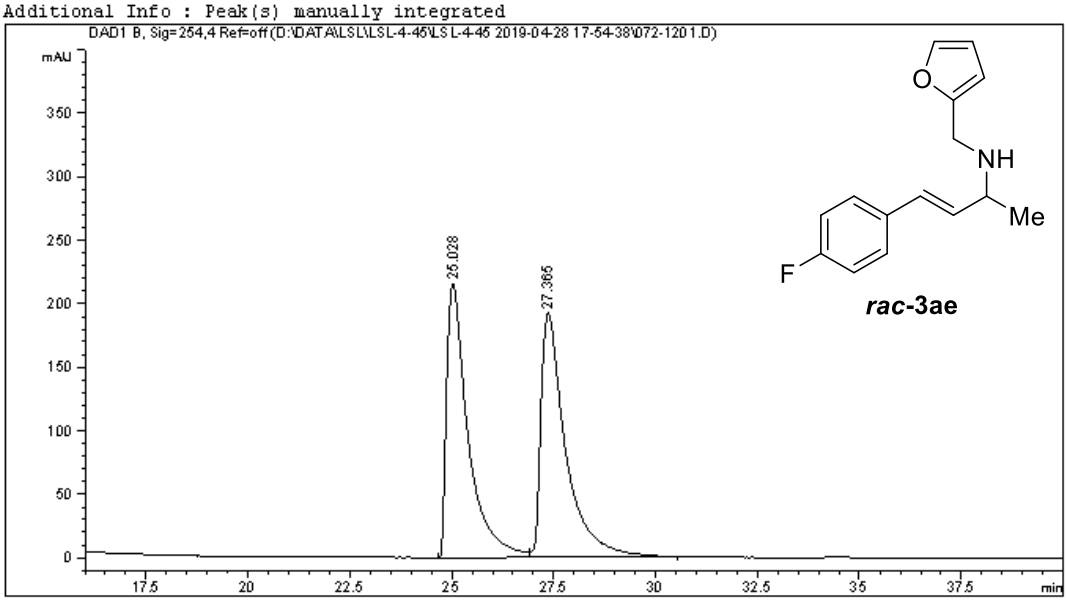



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1  33.479 BB    0.7929 3.00404e4   571.85364 100.0000

    Totals :                  3.00404e4   571.85364


    ======================================================================
```


Figure S198. HPLC spectra of **3ad**, related to **Figure 4**.

Data File D:\DATA\LSL\LSL-4-45\LSL-4-45 2019-04-28 17-54-38\072-1201.D
Sample Name: LJ-151-2

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :  12
    Acq. Instrument : Instrument 2                    Location : Vial 72
    Injection Date  : 4/28/2019 11:25:07 PM              Inj :   1
                                                    Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LSL\LSL-4-45\LSL-4-45 2019-04-28 17-54-38\DAD-0J(1-6)-99-1-0.5ML-
                      5UL-ALL-60MIN.M
    Last changed    : 3/10/2019 2:55:21 PM
    Analysis Method : D:\DATA\LSL\LSL-4-45\LSL-4-45 2019-04-28 17-54-38\DAD-0J(1-6)-99-1-0.5ML-
                      5UL-ALL-60MIN.M (Sequence Method)
    Last changed    : 5/3/2019 5:50:12 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

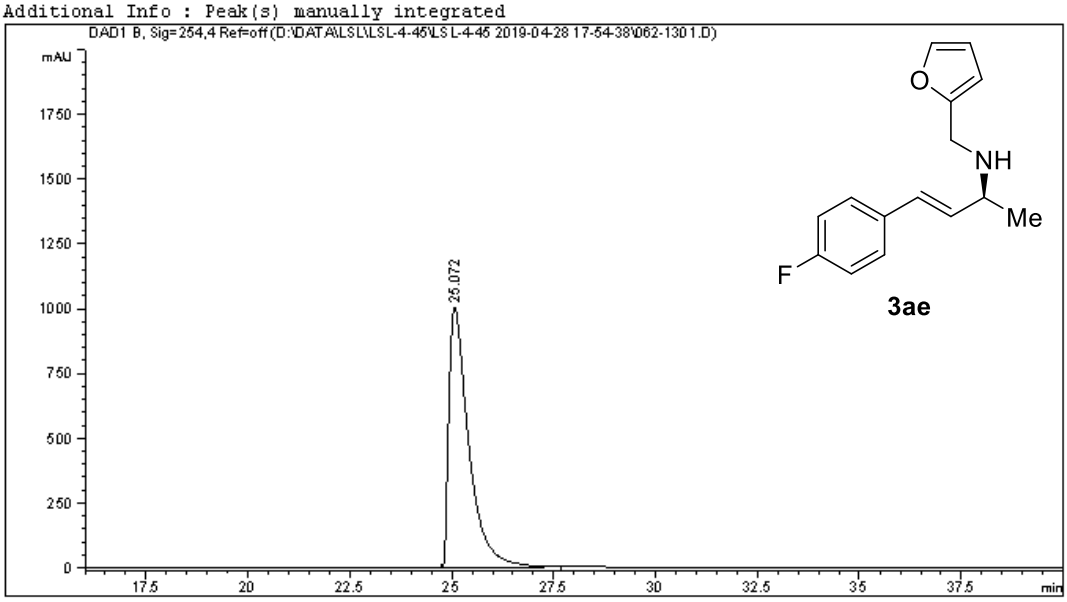



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 B, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  25.028 BV    0.5388 7893.84473  215.79332  49.4747
       2  27.365 VB    0.6179 8061.46973  191.99297  50.5253

    Totals :                  1.59553e4   407.78629
```


Figure S199. HPLC spectra of ***rac*-3ae**, related to **Figure 4**.

Data File D:\DATA\LSL\LSL-4-45\LSL-4-45 2019-04-28 17-54-38\062-1301.D
Sample Name: LJ-150-2

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :  13
    Acq. Instrument : Instrument 2                    Location : Vial 62
    Injection Date  : 4/29/2019 12:26:10 AM              Inj :   1
                                                    Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LSL\LSL-4-45\LSL-4-45 2019-04-28 17-54-38\DAD-0J(1-6)-99-1-0.5ML-
                      5UL-ALL-60MIN.M
    Last changed    : 3/10/2019 2:55:21 PM
    Analysis Method : D:\DATA\LSL\LSL-4-45\LSL-4-45 2019-04-28 17-54-38\DAD-0J(1-6)-99-1-0.5ML-
                      5UL-ALL-60MIN.M (Sequence Method)
    Last changed    : 5/3/2019 5:51:46 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

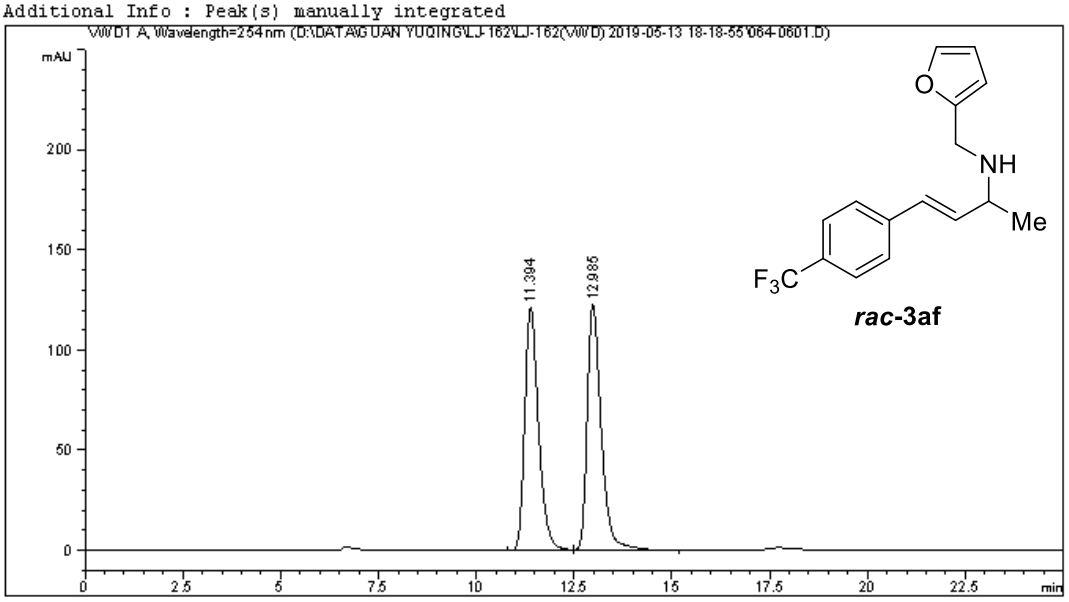



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 B, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  25.072 BB    0.5086 3.41880e4  1005.60474 100.0000

    Totals :                  3.41880e4  1005.60474
```


Figure S200. HPLC spectra of **3ae**, related to **Figure 4**.

Data File D:\DATA\GUAN YUQING\LJ-162\LJ-162(VWD) 2019-05-13 18-18-55\064-0601.D
Sample Name: LJ-162-2-RAC

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   6
    Acq. Instrument : Instrument 1                  Location : Vial 64
    Injection Date  : 5/13/2019 8:44:23 PM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-162\LJ-162(VWD) 2019-05-13 18-18-55\VWD-AS(1-6)-99-1
                      -0.5ML-5UL-254NM-40MIN.M
    Last changed    : 3/12/2019 10:38:44 AM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\VWD-AD(1-2)-99-1-0.5ML-5UL-254NM-40MIN.M
    Last changed    : 5/13/2019 9:39:08 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

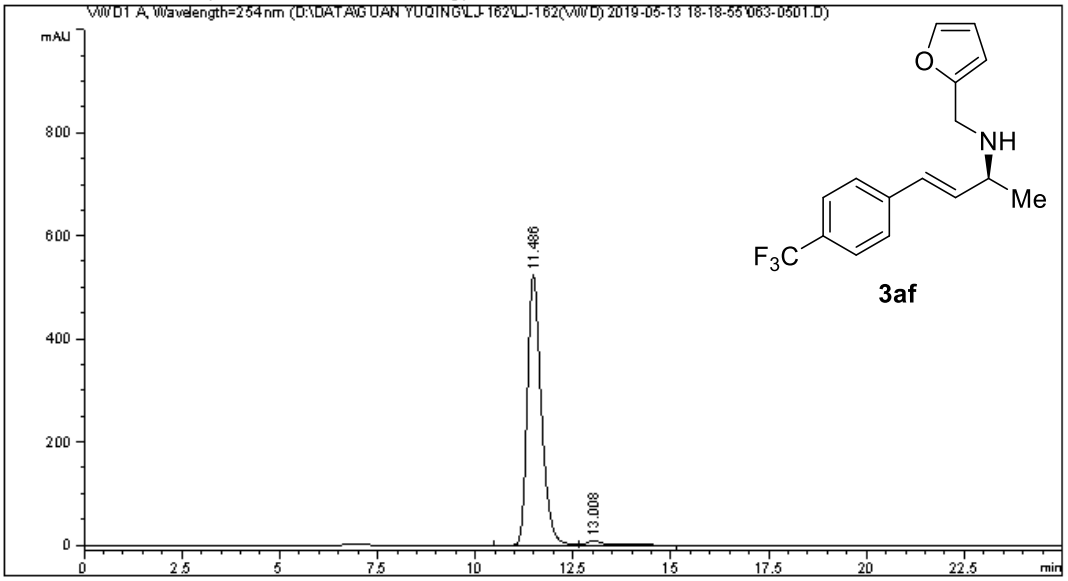



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  11.394 BB    0.3691 2954.75879  121.35410  49.4600
       2  12.985 BB    0.3738 3019.27490  122.38118  50.5400

    Totals :                  5974.03369  243.73528


Instrument 1 5/13/2019 9:39:13 PM                                Page 1 of 2
```

Figure S201. HPLC spectra of ***rac*-3af**, related to **Figure 4**.

Data File D:\DATA\GUAN YUQING\LJ-162\LJ-162(VWD) 2019-05-13 18-18-55\063-0501.D
Sample Name: LJ-162-2

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   5
    Acq. Instrument : Instrument 1                  Location : Vial 63
    Injection Date  : 5/13/2019 8:03:30 PM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-162\LJ-162(VWD) 2019-05-13 18-18-55\VWD-AS(1-6)-99-1
                      -0.5ML-5UL-254NM-40MIN.M
    Last changed    : 3/12/2019 10:38:44 AM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\VWD-AD(1-2)-99-1-0.5ML-5UL-254NM-40MIN.M
    Last changed    : 5/13/2019 9:40:43 PM
                      (modified after loading)
```

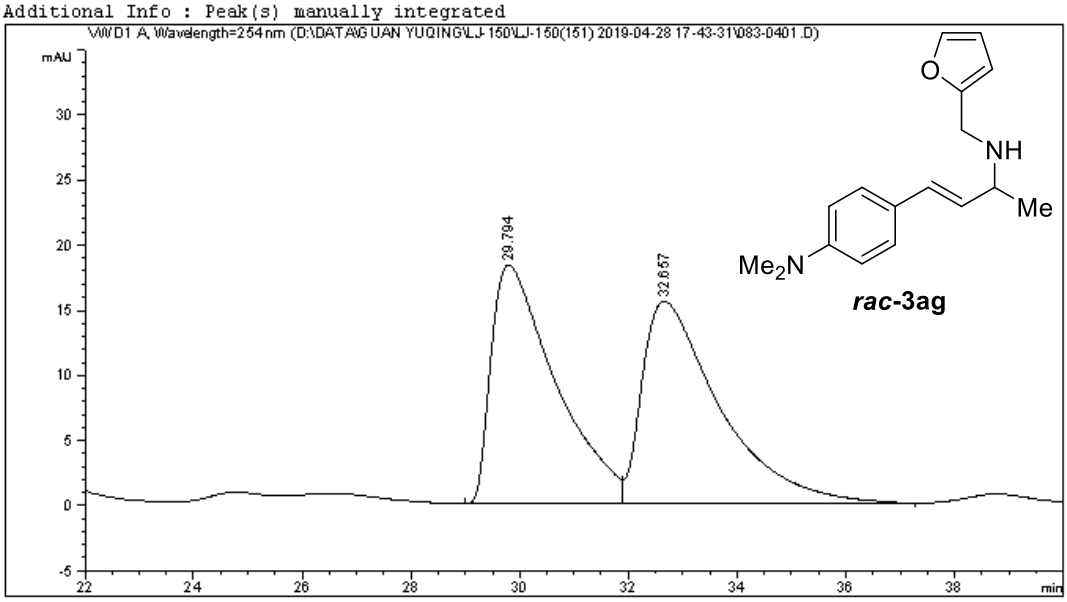



```
    ======================================================================
                              Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  11.486 BV    0.3762 1.30095e4   524.87543  98.0807
       2  13.008 VB    0.4413  254.57536    8.31177   1.9193

    Totals :                  1.3264le4   533.18720


    ======================================================================
```


Figure S202. HPLC spectra of **3af**, related to **Figure 4**.

Data File D:\DATA\GUAN YUQING\LJ-150\LJ-150(151) 2019-04-28 17-43-31\083-0401.D
Sample Name: LJ-151-3

```
    ======================================================================
    Acq. Operator   :                               Seq. Line :   4
    Acq. Instrument : Instrument 1                   Location : Vial 83
    Injection Date  : 4/28/2019 7:07:00 PM               Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-150\LJ-150(151) 2019-04-28 17-43-31\VWD-AD(1-2)-99-1
                      -0.6ML-5UL-254NM-40MIN.M
    Last changed    : 4/28/2019 7:44:37 PM
                      (modified after loading)
    Analysis Method : D:\DATA\GUAN YUQING\LJ-150\LJ-150(151) 2019-04-28 17-43-31\VWD-AD(1-2)-99-1
                      -0.6ML-5UL-254NM-40MIN.M (Sequence Method)
    Last changed    : 5/3/2019 5:58:38 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

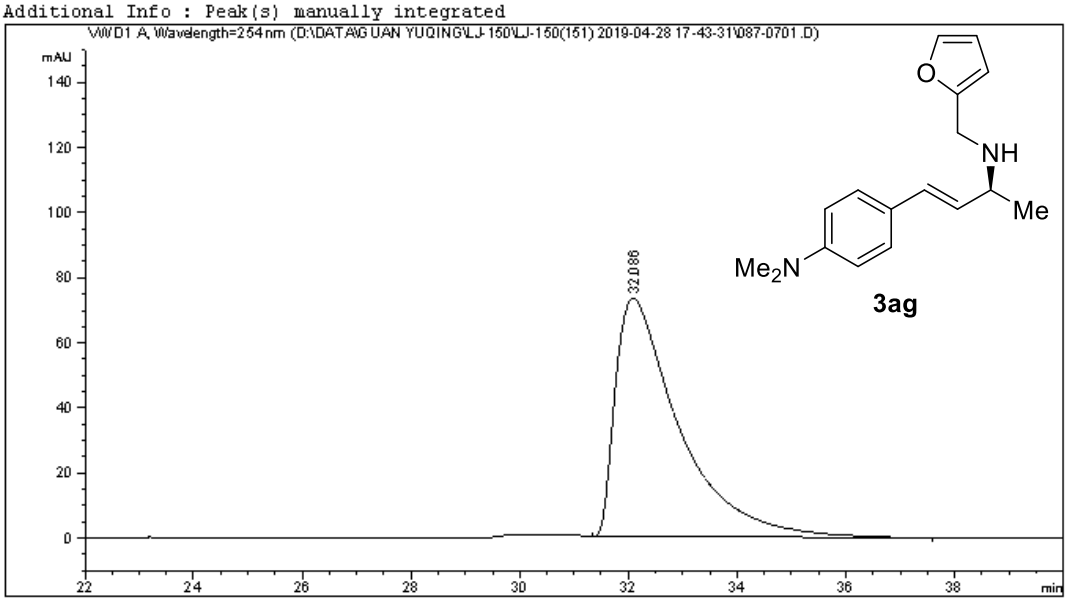



```
    ======================================================================
                              Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  29.794 BV    1.1567 1494.45447   18.30020  49.4599
       2  32.657 VB    1.3695 1527.09534   15.49839  50.5401

    Totals :                  3021.54980   33.79859
```


Figure S203. HPLC spectra of ***rac*-3ag**, related to **Figure 4**.

Data File D:\DATA\GUAN YUQING\LJ-150\LJ-150(151) 2019-04-28 17-43-31\087-0701.D
Sample Name: LJ-150-3

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   7
    Acq. Instrument : Instrument 1                  Location : Vial 87
    Injection Date  : 4/28/2019 9:09:34 PM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-150\LJ-150(151) 2019-04-28 17-43-31\VWD-AD(1-2)-99-1
                      -0.6ML-5UL-254NM-40MIN.M
    Last changed    : 4/28/2019 7:44:37 PM
                      (modified after loading)
    Analysis Method : D:\DATA\GUAN YUQING\LJ-150\LJ-150(151) 2019-04-28 17-43-31\VWD-AD(1-2)-99-1
                      -0.6ML-5UL-254NM-40MIN.M (Sequence Method)
    Last changed    : 5/3/2019 6:00:17 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

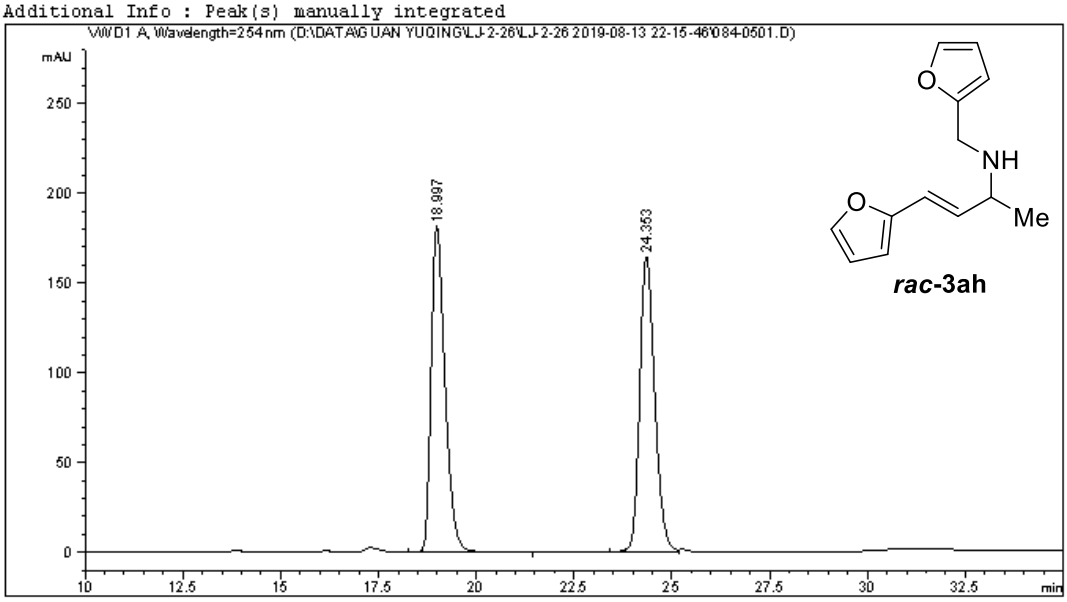



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  32.086 BB    1.1885 5973.43457   73.23915 100.0000

    Totals :                  5973.43457   73.23915
```


Figure S204. HPLC spectra of **3ag**, related to **Figure 4**.

Data File D:\DATA\GUAN YUQING\LJ-2-26\LJ-2-26 2019-08-13 22-15-46\084-0501.D
Sample Name: LJ-2-26-7-RAC

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :   5
    Acq. Instrument : Instrument 1                    Location : Vial 84
    Injection Date  : 8/14/2019 12:19:21 AM              Inj :   1
                                                    Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-2-26\LJ-2-26 2019-08-13 22-15-46\VWD-OJ(1-2)-95-5-0.
                      5ML-5UL-254NM-40MIN.M
    Last changed    : 8/13/2019 10:44:25 PM
                      (modified after loading)
    Analysis Method : D:\METHOD\LG\VWD-AD(1-2)-80-20-1ML-3UL-210NM-60MIN.M
    Last changed    : 8/14/2019 10:07:13 AM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

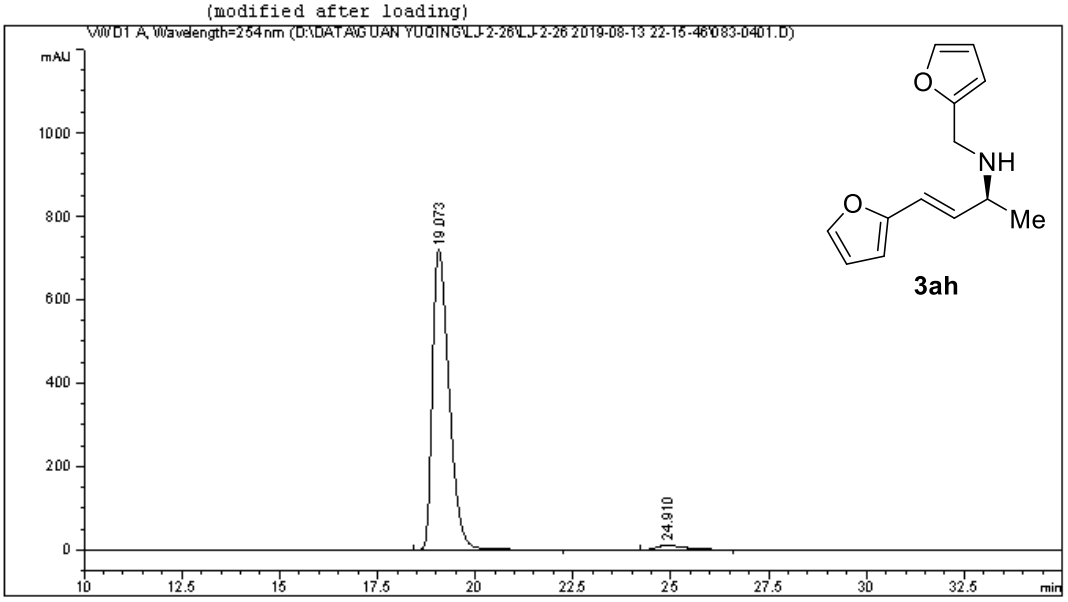



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  18.997 BB    0.3724 4454.71484  181.45822  50.2576
       2  24.353 BV    0.4114 4409.04004  164.66374  49.7424

    Totals :                  8863.75488  346.12196
```


Figure S205. HPLC spectra of ***rac*-3ah**, related to **Figure 4**.

Data File D:\DATA\GUAN YUQING\LJ-2-26\LJ-2-26 2019-08-13 22-15-46\083-0401.D
Sample Name: LJ-2-26-7

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :   4
    Acq. Instrument : Instrument 1                    Location : Vial 83
    Injection Date  : 8/13/2019 11:43:31 PM              Inj :   1
                                                    Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-2-26\LJ-2-26 2019-08-13 22-15-46\VWD-OJ(1-2)-95-5-0.
                      5ML-5UL-254NM-40MIN.M
    Last changed    : 8/13/2019 10:44:25 PM
                      (modified after loading)
    Analysis Method : D:\METHOD\LG\VWD-AD(1-2)-80-20-1ML-3UL-210NM-60MIN.M
    Last changed    : 8/14/2019 10:05:00 AM
                      (modified after loading)
```

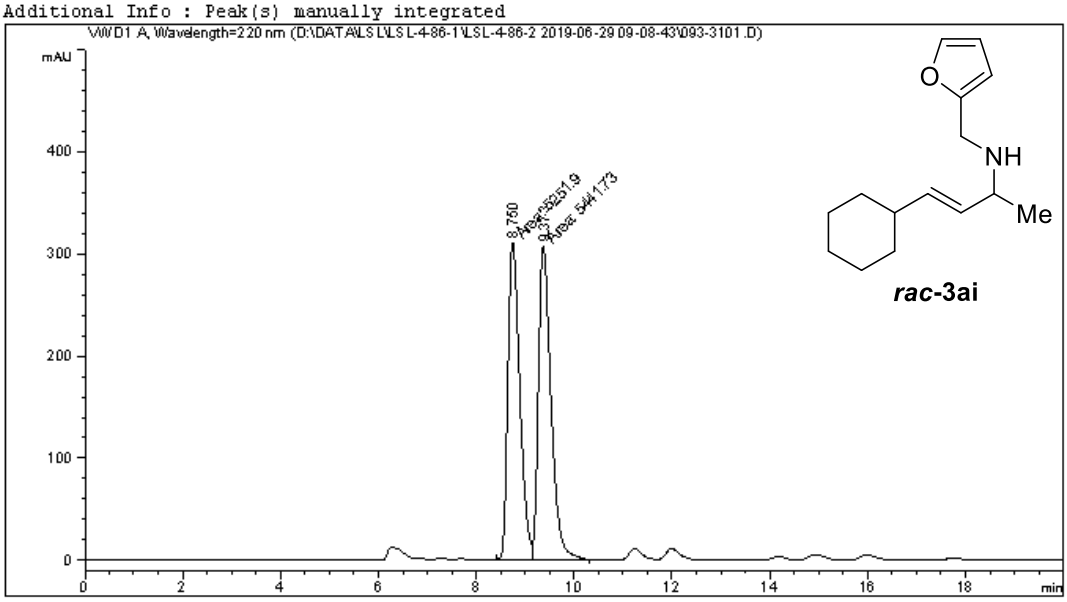



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  19.073 BB    0.4558 2.10885e4   719.88995  97.8563
       2  24.910 BB    0.6432  461.96768   10.62533   2.1437

    Totals :                  2.15505e4   730.51528
```


Figure S206. HPLC spectra of **3ah**, related to **Figure 4**.

Data File D:\DATA\LSL\LSL-4-86-1\LSL-4-86-2 2019-06-29 09-08-43\093-3101.D
Sample Name: LJ-2-1-2

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :  31
    Acq. Instrument : Instrument 1                    Location : Vial 93
    Injection Date  : 6/29/2019 9:16:35 PM                 Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LSL\LSL-4-86-1\LSL-4-86-2 2019-06-29 09-08-43\VWD-AD(1-2)-95-5-0.
                      5ML-5UL-220NM-40MIN.M
    Last changed    : 6/29/2019 9:54:18 PM
                      (modified after loading)
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\VWD-AS(1-6)-80-20-1.0ML-5UL-220NM-45MIN.M
    Last changed    : 6/29/2019 10:12:37 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```



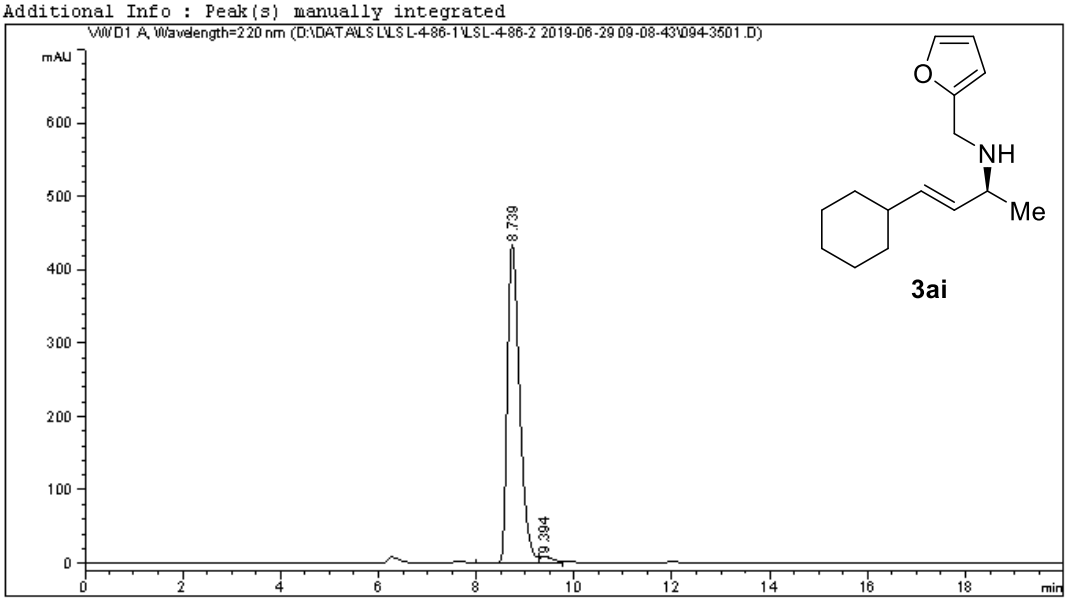

```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=220 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1   8.750 MF    0.2815 5251.89600  310.98474  49.1124
       2   9.373 FM    0.2955 5441.73340  306.92697  50.8876

    Totals :                  1.06936e4   617.91171
```

Instrument 1 6/29/2019 10:12:42 PM

Figure S207. HPLC spectra of ***rac*-3ai**, related to **Figure 4**.

Data File D:\DATA\LSL\LSL-4-86-1\LSL-4-86-2 2019-06-29 09-08-43\094-3501.D
Sample Name: LJ-2-2-2

```
    ====================================================================
    Acq. Operator   :                              Seq. Line :  35
    Acq. Instrument : Instrument 1                  Location : Vial 94
    Injection Date  : 6/29/2019 10:30:10 PM              Inj :  1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LSL\LSL-4-86-1\LSL-4-86-2 2019-06-29 09-08-43\VWD-AD(1-2)-95-5-0.
                      5ML-5UL-220NM-40MIN.M
    Last changed    : 6/29/2019 10:39:27 PM
                      (modified after loading)
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\VWD-AS(1-6)-80-20-1.0ML-5UL-220NM-45MIN.M
    Last changed    : 6/29/2019 10:51:26 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

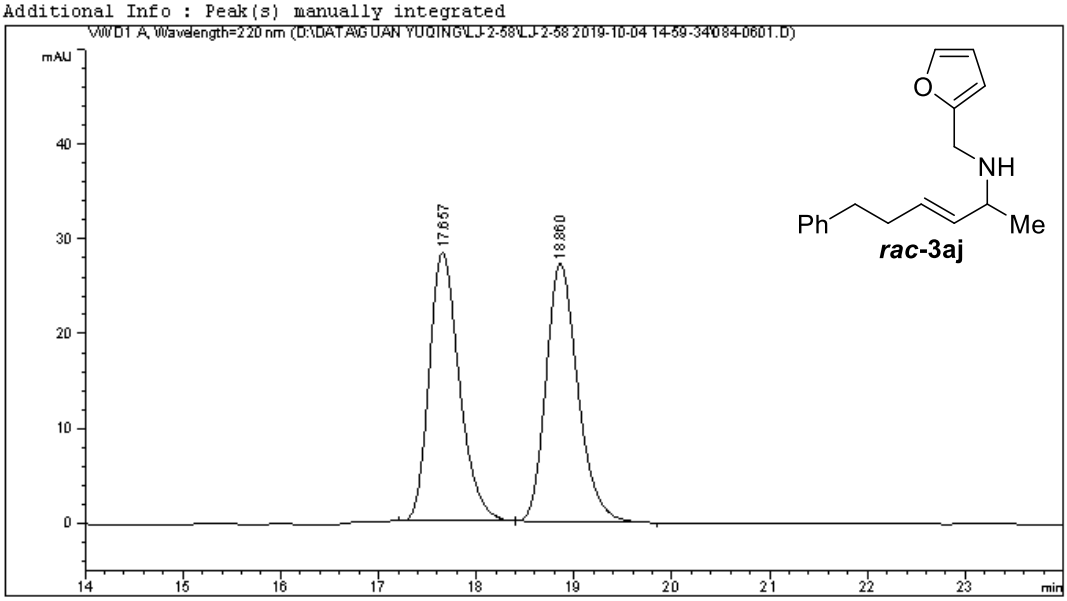



```
    ====================================================================
                           Area Percent Report
    ====================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=220 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1   8.739 BV    0.2663 7521.54541  433.75995  97.8275
       2   9.394 VV    0.2780  167.03423    8.62418   2.1725

    Totals :                   7688.57964  442.38413
```


Figure S208. HPLC spectra of **3ai**, related to **Figure 4**.

Data File D:\DATA\GUAN YUQING\LJ-2-58\LJ-2-58 2019-10-04 14-59-34\084-0601.D
Sample Name: LJ-2-58-2-RAC

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   6
    Acq. Instrument : Instrument 1                  Location : Vial 84
    Injection Date  : 10/4/2019 4:49:52 PM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-2-58\LJ-2-58 2019-10-04 14-59-34\VWD-OJ(1-6)-95-5-0.
                      5ML-5UL-220NM-25MIN.M
    Last changed    : 10/4/2019 2:55:51 PM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\VWD-OD(1-2)-95-5-0.5ML-5UL-254NM-10MIN.M
    Last changed    : 10/4/2019 7:02:46 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

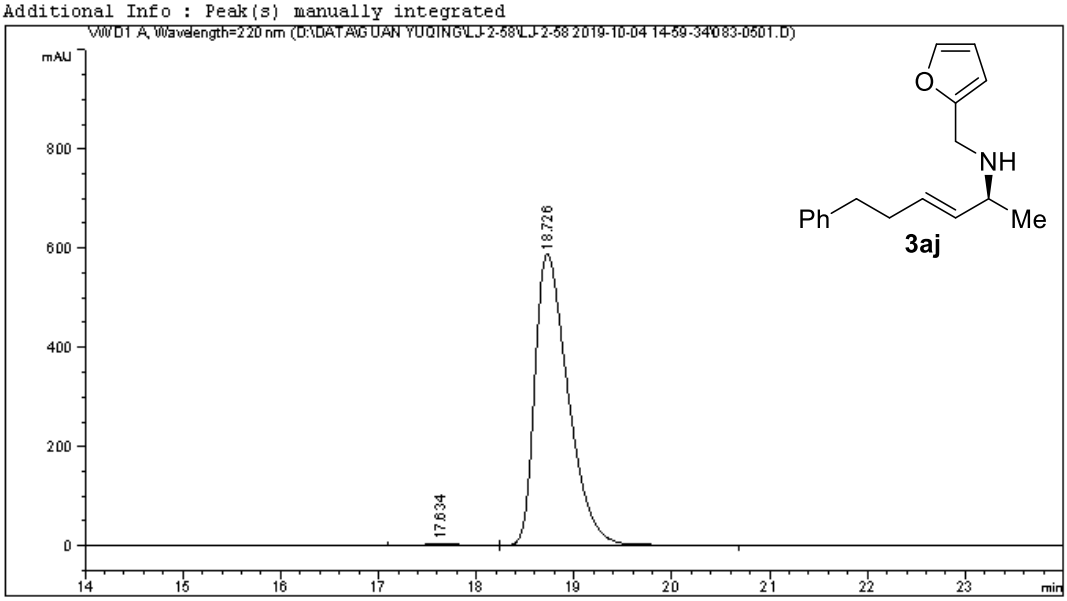



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=220 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  17.657 BB    0.3280  608.07892   28.37230  49.7003
       2  18.860 BB    0.3465  615.41345   27.25274  50.2997

    Totals :                  1223.49237   55.62503
```


Figure S209. HPLC spectra of ***rac*-3aj**, related to **Figure 4**.

Data File D:\DATA\GUAN YUQING\LJ-2-58\LJ-2-58 2019-10-04 14-59-34\083-0501.D
Sample Name: LJ-2-58-2

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   5
    Acq. Instrument : Instrument 1                  Location : Vial 83
    Injection Date  : 10/4/2019 4:24:02 PM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-2-58\LJ-2-58 2019-10-04 14-59-34\VWD-OJ(1-6)-95-5-0.
                      5ML-5UL-220NM-25MIN.M
    Last changed    : 10/4/2019 2:55:51 PM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\VWD-OD(1-2)-95-5-0.5ML-5UL-254NM-10MIN.M
    Last changed    : 10/4/2019 7:04:34 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

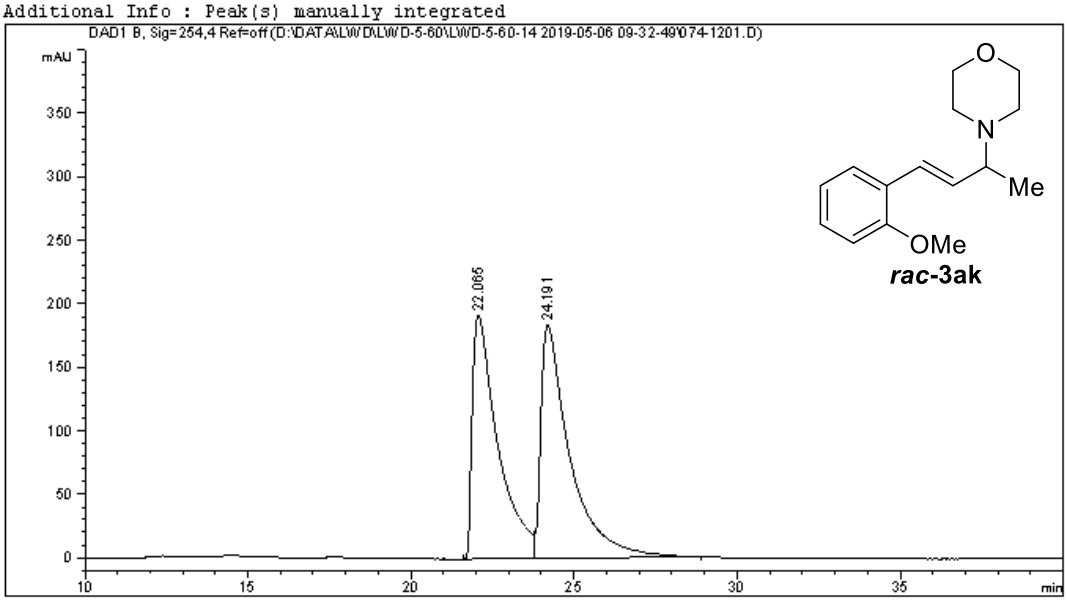



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=220 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  17.634 BB    0.3316   67.67126    3.10049   0.4848
       2  18.726 BB    0.3628 1.38897e4   587.63940  99.5152

    Totals :                  1.39574e4   590.73990
```


Figure S210. HPLC spectra of **3aj**, related to **Figure 4**.

Data File D:\DATA\LWD\LWD-5-60\LWD-5-60-14 2019-05-06 09-32-49\074-1201.D
Sample Name: LJ-157-7-RAC

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :  12
    Acq. Instrument : Instrument 2                  Location : Vial 74
    Injection Date  : 5/6/2019 3:51:09 PM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LWD\LWD-5-60\LWD-5-60-14 2019-05-06 09-32-49\DAD-OD(1-2)-99-1-0.5ML
                      -5UL-ALL-40MIN.M
    Last changed    : 3/8/2019 11:06:52 AM
    Analysis Method : D:\DATA\LWD\LWD-5-60\LWD-5-60-14 2019-05-06 09-32-49\DAD-OD(1-2)-99-1-0.5ML
                      -5UL-ALL-40MIN.M (Sequence Method)
    Last changed    : 5/16/2019 9:35:29 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

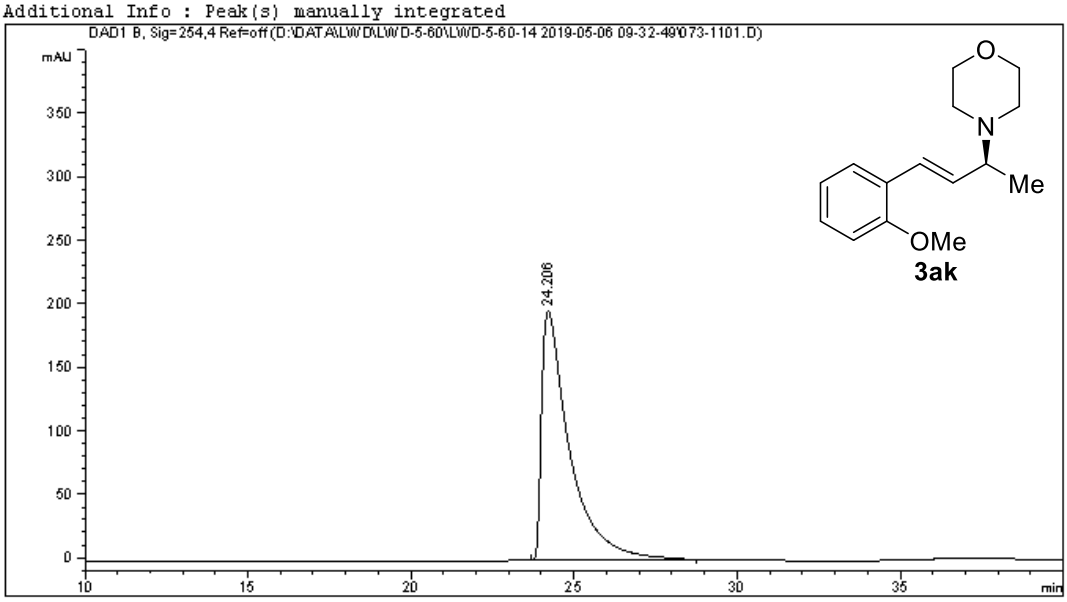



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 B, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  22.065 BV    0.7619 1.03696e4   192.05229  47.7532
       2  24.191 VB    0.8610 1.13454e4   183.57259  52.2468

    Totals :                  2.17150e4   375.62488
```


Figure S211. HPLC spectra of ***rac*-3ak**, related to **Figure 4**.

Data File D:\DATA\LWD\LWD-5-60\LWD-5-60-14 2019-05-06 09-32-49\073-1101.D
Sample Name: LJ-157-7

```
    ==================================================================
    Acq. Operator   :                              Seq. Line :  11
    Acq. Instrument : Instrument 2                  Location : Vial 73
    Injection Date  : 5/6/2019 3:10:06 PM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LWD\LWD-5-60\LWD-5-60-14 2019-05-06 09-32-49\DAD-0D(1-2)-99-1-0.5ML
                      -5UL-ALL-40MIN.M
    Last changed    : 3/8/2019 11:06:52 AM
    Analysis Method : D:\DATA\LWD\LWD-5-60\LWD-5-60-14 2019-05-06 09-32-49\DAD-0D(1-2)-99-1-0.5ML
                      -5UL-ALL-40MIN.M (Sequence Method)
    Last changed    : 5/16/2019 9:35:29 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

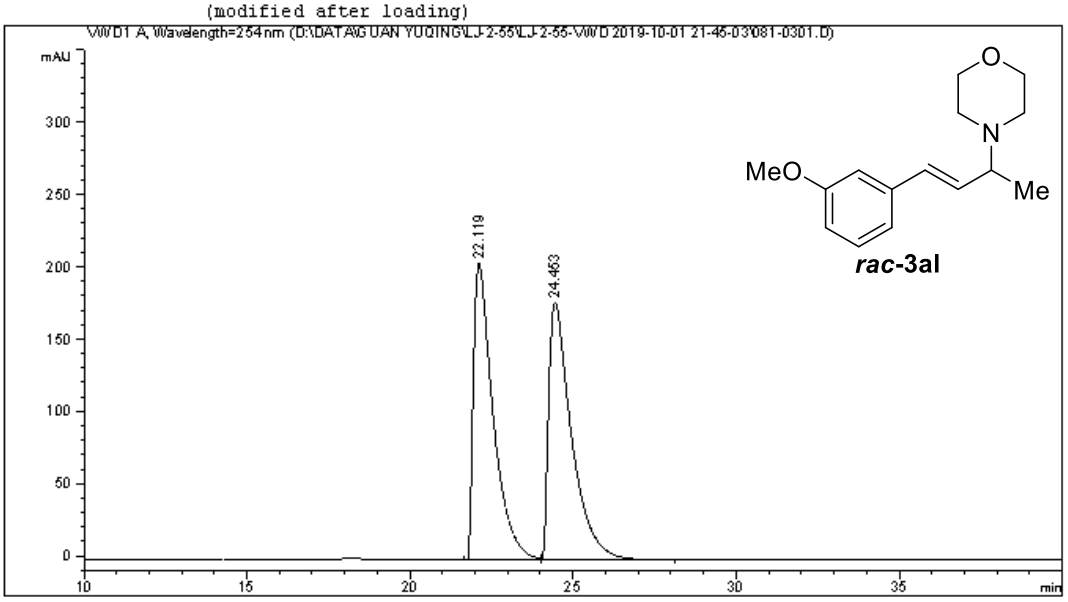



```
    ==================================================================
                          Area Percent Report
    ==================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 B, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  24.206 BB    0.8172 1.16287e4   196.28775 100.0000

    Totals :                  1.16287e4   196.28775
```


Figure S212. HPLC spectra of **3ak**, related to **Figure 4**.

Data File D:\DATA\GUAN YUQING\LJ-2-55\LJ-2-55-VWD 2019-10-01 21-45-03\081-0301.D
Sample Name: LJ-2-55-1

```
    ======================================================================
    Acq. Operator   :                               Seq. Line :   3
    Acq. Instrument : Instrument 1                   Location : Vial 81
    Injection Date  : 10/1/2019 10:00:10 PM              Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-2-55\LJ-2-55-VWD 2019-10-01 21-45-03\VWD-AD(1-2)-99-
                      1-0.5ML-5UL-254NM-40MIN.M
    Last changed    : 10/1/2019 10:33:36 PM
                      (modified after loading)
    Analysis Method : D:\METHOD\LGY\VWD-AS(1-6)-99-1-1ML-5UL-254NM-35MIN.M
    Last changed    : 10/2/2019 9:50:35 AM
                      (modified after loading)
```

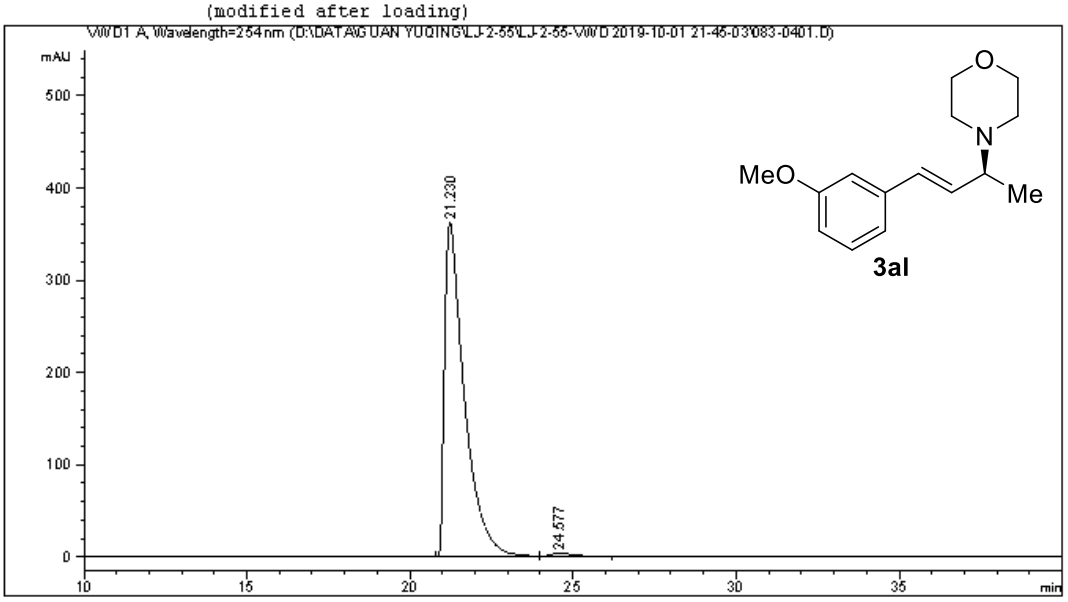



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  22.119 BV    0.6259 8631.62793  205.12622  49.9469
       2  24.453 VB    0.7208 8649.99707  178.04210  50.0531

    Totals :                  1.72816e4   383.16832
```


Figure S213. HPLC spectra of ***rac*-3al**, related to **Figure 4**.

Data File D:\DATA\GUAN YUQING\LJ-2-55\LJ-2-55-VWD 2019-10-01 21-45-03\083-0401.D
Sample Name: LJ-2-56-1

```
    ======================================================================
    Acq. Operator   :                               Seq. Line :   4
    Acq. Instrument : Instrument 1                   Location : Vial 83
    Injection Date  : 10/1/2019 10:41:00 PM              Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-2-55\LJ-2-55-VWD 2019-10-01 21-45-03\VWD-AD(1-2)-99-
                      1-0.5ML-5UL-254NM-40MIN.M
    Last changed    : 10/1/2019 10:33:36 PM
                      (modified after loading)
    Analysis Method : D:\METHOD\LGY\VWD-AS(1-6)-99-1-1ML-5UL-254NM-35MIN.M
    Last changed    : 10/2/2019 9:52:43 AM
                      (modified after loading)
```

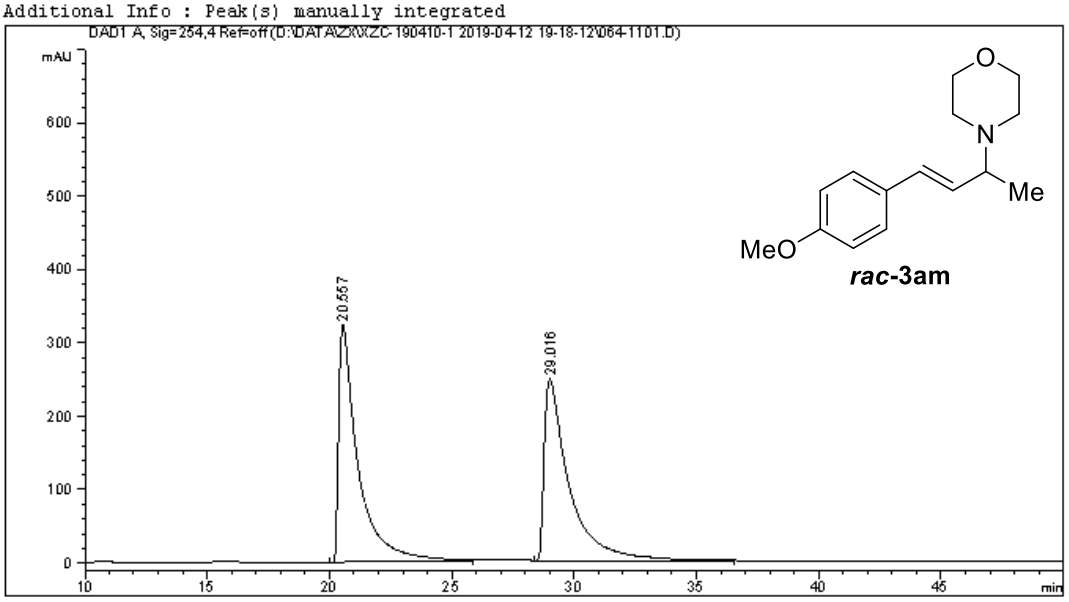



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  21.230 BB    0.6171 1.52116e4   361.37299  99.2011
       2  24.577 BB    0.6320  122.49827    2.78591   0.7989

    Totals :                  1.5334le4   364.15890
```


Figure S214. HPLC spectra of **3al**, related to **Figure 4**.

Data File D:\DATA\ZX\XZC-190410-1 2019-04-12 19-18-12\064-1101.D
Sample Name: LJ-133-1

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :  11
    Acq. Instrument : Instrument 2                    Location : Vial 64
    Injection Date  : 4/13/2019 1:19:47 AM                 Inj :  1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\ZX\XZC-190410-1 2019-04-12 19-18-12\DAD-0J(1-6)-95-5-1ML-5UL-ALL-
                      60MIN.M
    Last changed    : 7/6/2018 10:36:38 PM
    Analysis Method : D:\METHOD\LG\DAD-0J(1-6)-80-20-1ML-5UL-ALL-60MIN.M
    Last changed    : 4/14/2019 9:57:24 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

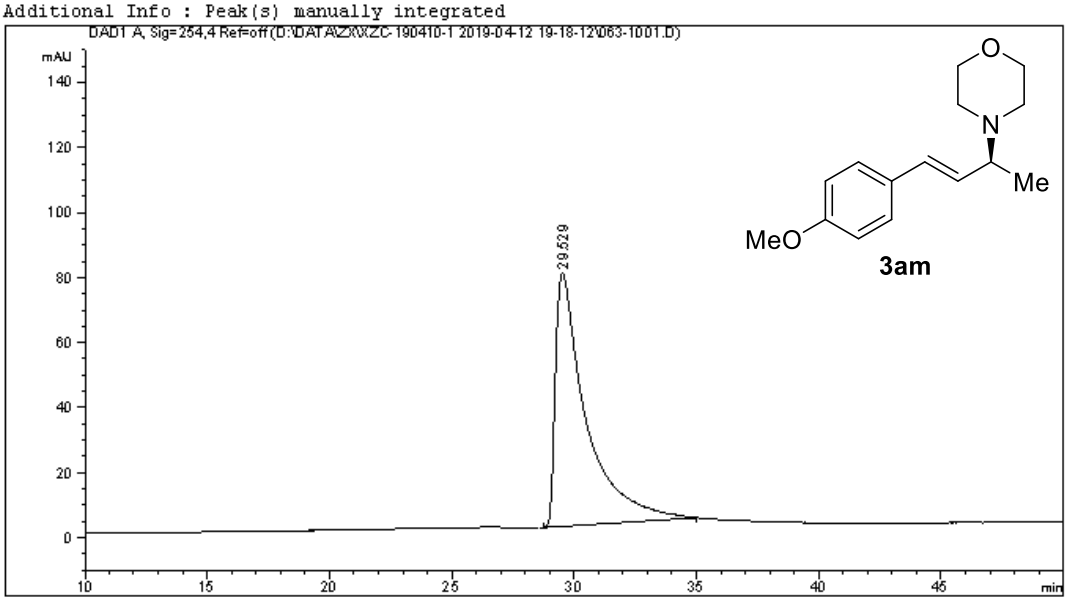



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1  20.557 BB    0.7647 1.77001e4   323.29202  50.1433
       2  29.016 BB    0.9701 1.75989e4   247.34940  49.8567

    Totals :                  3.52990e4   570.64142
```


Figure S215. HPLC spectra of ***rac*-3am**, related to **Figure 4**.

Data File D:\DATA\ZX\XZC-190410-1 2019-04-12 19-18-12\063-1001.D
Sample Name: LJ-132-1

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :  10
    Acq. Instrument : Instrument 2                    Location : Vial 63
    Injection Date  : 4/13/2019 12:18:46 AM              Inj :   1
                                                    Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\ZX\XZC-190410-1 2019-04-12 19-18-12\DAD-0J(1-6)-95-5-1ML-5UL-ALL-
                      60MIN.M
    Last changed    : 7/6/2018 10:36:38 PM
    Analysis Method : D:\METHOD\LG\DAD-0J(1-6)-80-20-1ML-5UL-ALL-60MIN.M
    Last changed    : 4/14/2019 9:58:32 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

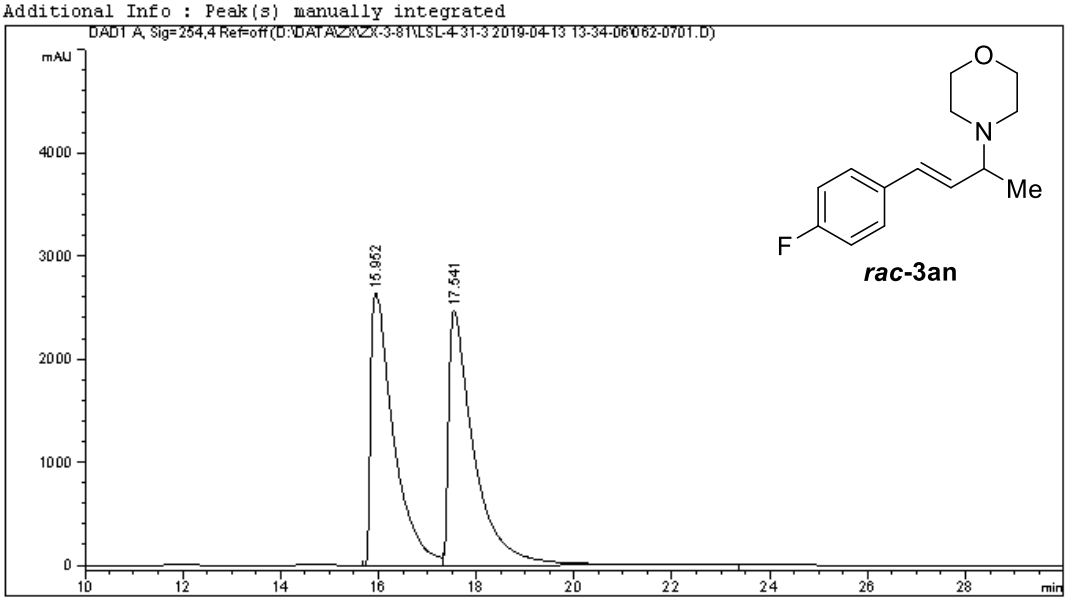



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1  29.529 BB    1.1823 6790.98779   77.80267 100.0000

    Totals :                  6790.98779   77.80267


    ======================================================================
```


Figure S216. HPLC spectra of **3am**, related to **Figure 4**.

Data File D:\DATA\ZX\ZX-3-81\LSL-4-31-3 2019-04-13 13-34-06\062-0701.D
Sample Name: LJ-133-2

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :   7
    Acq. Instrument : Instrument 2                    Location : Vial 62
    Injection Date  : 4/13/2019 5:51:17 PM                 Inj :   1
                                                    Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\ZX\ZX-3-81\LSL-4-31-3 2019-04-13 13-34-06\DAD-0J(1-6)-95-5-0.5ML-
                      5UL-ALL-30MIN.M
    Last changed    : 4/13/2019 3:13:40 PM
    Analysis Method : D:\METHOD\LG\DAD-0J(1-6)-80-20-1ML-5UL-ALL-60MIN.M
    Last changed    : 4/14/2019 10:00:29 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

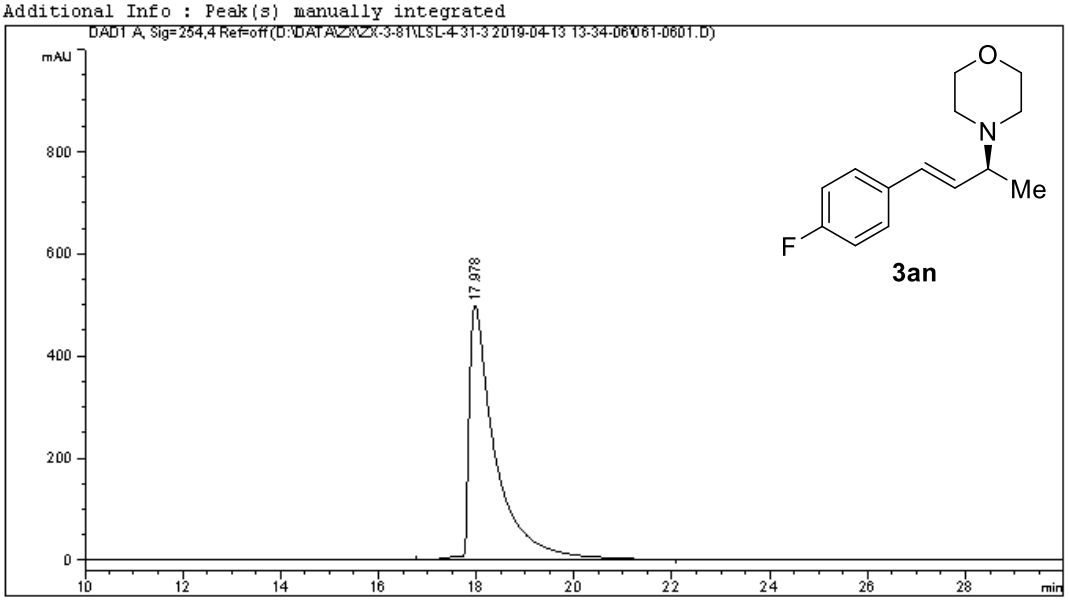



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1  15.952 BV    0.4176 8.50486e4  2641.95483  48.8532
       2  17.541 VB    0.4580 8.90417e4  2473.26196  51.1468

    Totals :                  1.74090e5  5115.21680
```


Figure S217. HPLC spectra of ***rac*-3an**, related to **Figure 4**.

Data File D:\DATA\ZX\ZX-3-81\LSL-4-31-3 2019-04-13 13-34-06\061-0601.D
Sample Name: LJ-132-2

```
    ====================================================================
    Acq. Operator   :                                Seq. Line :   6
    Acq. Instrument : Instrument 2                    Location : Vial 61
    Injection Date  : 4/13/2019 5:20:17 PM                 Inj :   1
                                                    Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\ZX\ZX-3-81\LSL-4-31-3 2019-04-13 13-34-06\DAD-0J(1-6)-95-5-0.5ML-
                      5UL-ALL-30MIN.M
    Last changed    : 4/13/2019 3:13:40 PM
    Analysis Method : D:\METHOD\LG\DAD-0J(1-6)-80-20-1ML-5UL-ALL-60MIN.M
    Last changed    : 4/14/2019 10:01:44 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

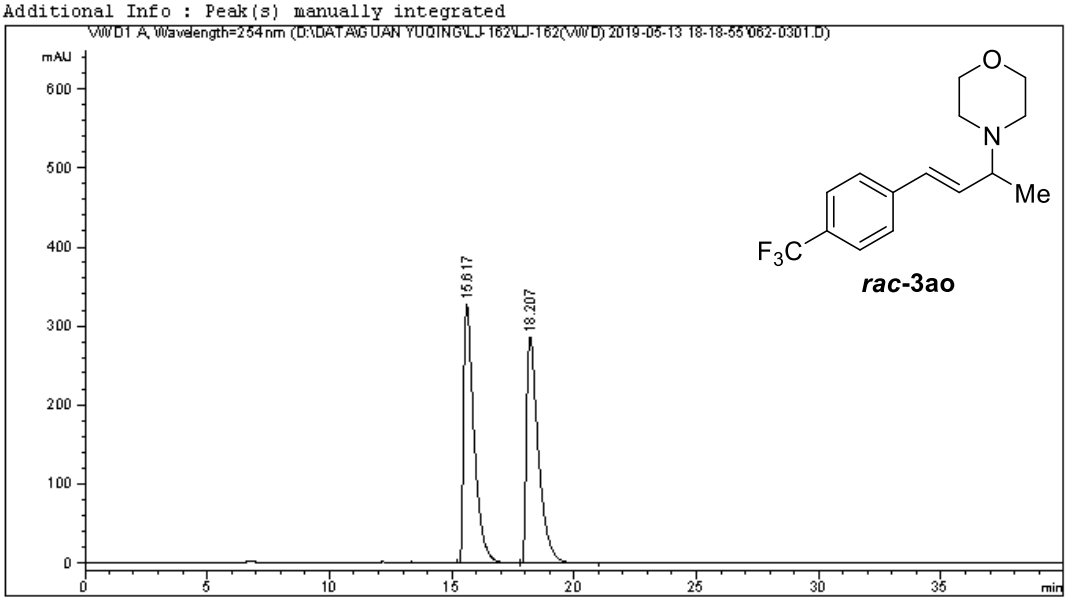



```
    ====================================================================
                           Area Percent Report
    ====================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1  17.978 BB    0.5250 1.86330e4   499.70447 100.0000

    Totals :                  1.86330e4   499.70447


    ====================================================================
```


Figure S218. HPLC spectra of **3an**, related to **Figure 4**.

Data File D:\DATA\GUAN YUQING\LJ-162\LJ-162(VWD) 2019-05-13 18-18-55\062-0301.D
Sample Name: LJ-162-1-RAC

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :   3
    Acq. Instrument : Instrument 1                    Location : Vial 62
    Injection Date  : 5/13/2019 7:11:38 PM                 Inj :   1
                                                    Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-162\LJ-162(VWD) 2019-05-13 18-18-55\VWD-AD(1-2)-99-1
                      -0.5ML-5UL-254NM-40MIN.M
    Last changed    : 5/13/2019 8:56:49 AM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\VWD-AD(1-2)-99-1-0.5ML-5UL-254NM-40MIN.M
    Last changed    : 5/13/2019 9:42:11 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

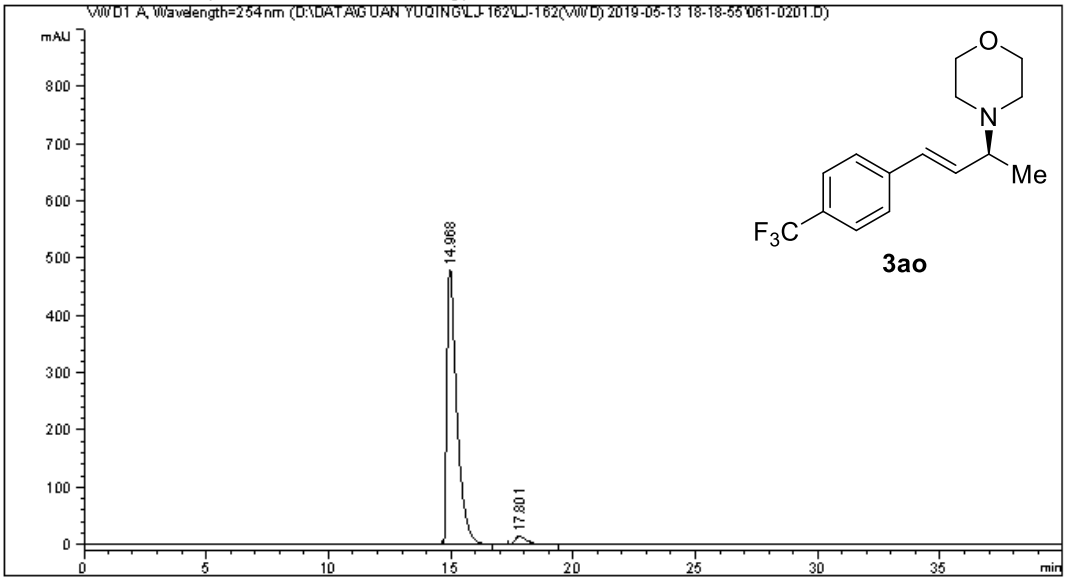



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  15.617 BB    0.4432 9690.17578  327.45148  49.9852
       2  18.207 BB    0.5098 9695.92480  285.80896  50.0148

    Totals :                  1.9386le4   613.26044
```


Figure S219. HPLC spectra of ***rac*-3ao**, related to **Figure 4**.

Data File D:\DATA\GUAN YUQING\LJ-162\LJ-162(VWD) 2019-05-13 18-18-55\061-0201.D
Sample Name: LJ-162-1

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :   2
    Acq. Instrument : Instrument 1                    Location : Vial 61
    Injection Date  : 5/13/2019 6:30:45 PM                 Inj :   1
                                                    Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-162\LJ-162(VWD) 2019-05-13 18-18-55\VWD-AD(1-2)-99-1
                      -0.5ML-5UL-254NM-40MIN.M
    Last changed    : 5/13/2019 8:56:49 AM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\VWD-AD(1-2)-99-1-0.5ML-5UL-254NM-40MIN.M
    Last changed    : 5/13/2019 9:43:18 PM
                      (modified after loading)
```

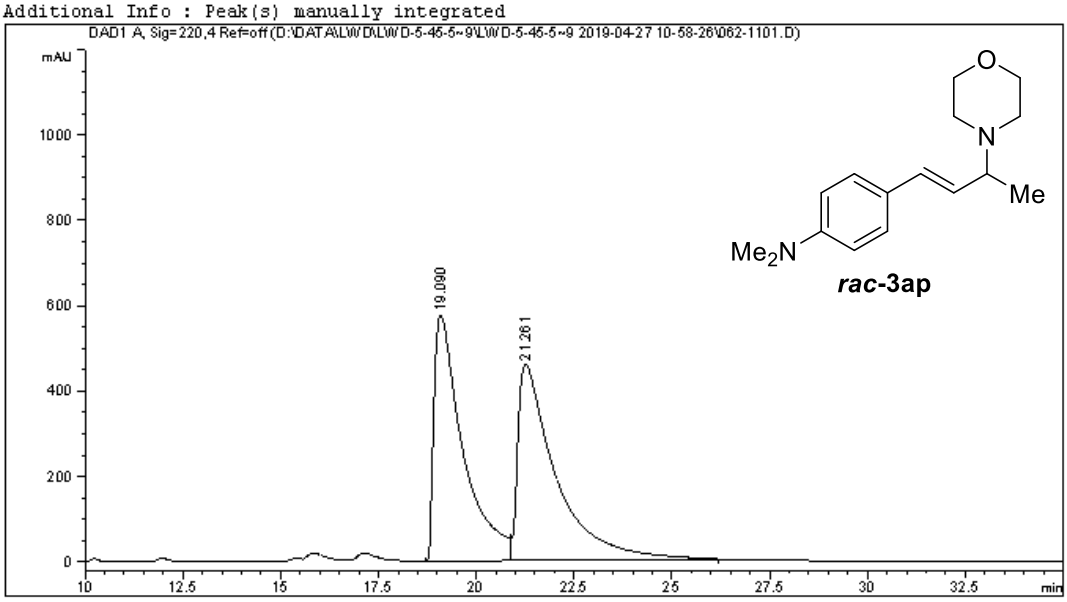



```
    ======================================================================
                              Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1  14.968 BB    0.4240 1.36424e4   480.86911  96.6598
       2  17.801 BB    0.5077  471.42413   13.93580   3.3402

    Totals :                  1.41138e4   494.80491


    ======================================================================

Instrument 1 5/13/2019 9:43:23 PM                                Page 1 of 1
```

Figure S220. HPLC spectra of **3ao**, related to **Figure 4**.

Data File D:\DATA\LWD\LWD-5-45-5~9\LWD-5-45-5~9 2019-04-27 10-58-26\062-1101.D
Sample Name: LJ-150-5-RAC

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :  11
    Acq. Instrument : Instrument 2                  Location : Vial 62
    Injection Date  : 4/27/2019 3:24:38 PM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LWD\LWD-5-45-5~9\LWD-5-45-5~9 2019-04-27 10-58-26\DAD-OD(1-2)-99-1-
                      0.5ML-5UL-ALL-40MIN.M
    Last changed    : 3/8/2019 11:06:52 AM
    Analysis Method : D:\DATA\LWD\LWD-5-45-5~9\LWD-5-45-5~9 2019-04-27 10-58-26\DAD-OD(1-2)-99-1-
                      0.5ML-5UL-ALL-40MIN.M (Sequence Method)
    Last changed    : 4/28/2019 6:43:34 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

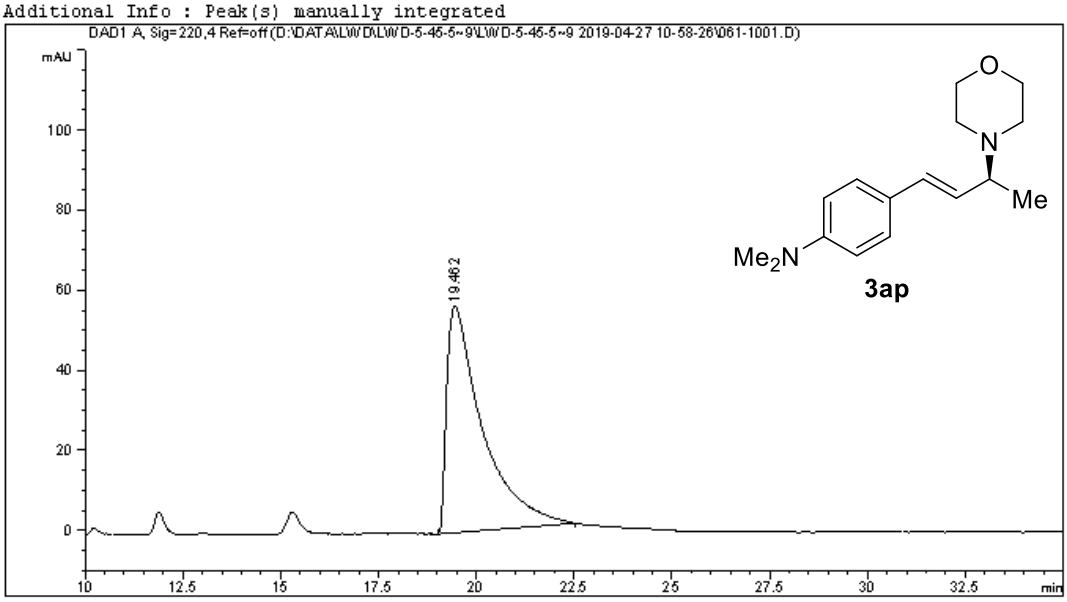



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=220,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  19.090 BV    0.7033 2.94362e4   576.84332  48.6728
       2  21.261 VB    0.8915 3.10416e4   458.71768  51.3272

    Totals :                  6.04778e4  1035.56100
```


Figure S221. HPLC spectra of ***rac*-3ap**, related to **Figure 4**.

Data File D:\DATA\LWD\LWD-5-45-5~9\LWD-5-45-5~9 2019-04-27 10-58-26\061-1001.D
Sample Name: LJ-150-5

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :  10
    Acq. Instrument : Instrument 2                  Location : Vial 61
    Injection Date  : 4/27/2019 2:43:37 PM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LWD\LWD-5-45-5~9\LWD-5-45-5~9 2019-04-27 10-58-26\DAD-0D(1-2)-99-1-
                      0.5ML-5UL-ALL-40MIN.M
    Last changed    : 3/8/2019 11:06:52 AM
    Analysis Method : D:\DATA\LWD\LWD-5-45-5~9\LWD-5-45-5~9 2019-04-27 10-58-26\DAD-0D(1-2)-99-1-
                      0.5ML-5UL-ALL-40MIN.M (Sequence Method)
    Last changed    : 4/28/2019 6:45:59 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

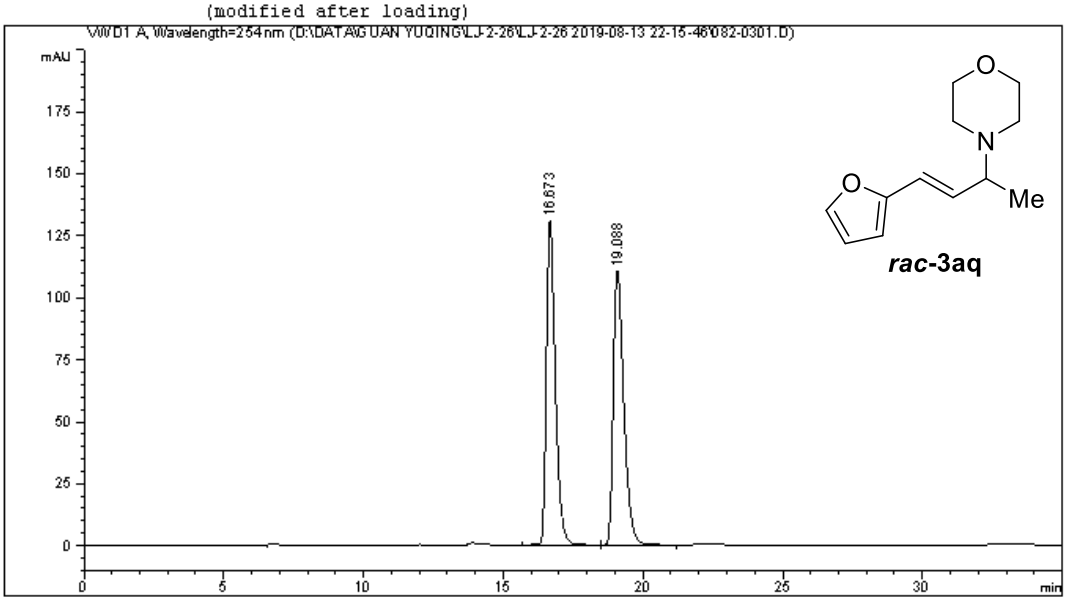



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=220,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  19.462 BB    0.7553 3590.59058   56.51189 100.0000

    Totals :                  3590.59058   56.51189
```


Figure S222. HPLC spectra of **3ap**, related to **Figure 4**.

Data File D:\DATA\GUAN YUQING\LJ-2-26\LJ-2-26 2019-08-13 22-15-46\082-0301.D
Sample Name: LJ-2-26-8-RAC

```
    ======================================================================
    Acq. Operator   :                               Seq. Line :   3
    Acq. Instrument : Instrument 1                   Location : Vial 82
    Injection Date  : 8/13/2019 11:07:37 PM              Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-2-26\LJ-2-26 2019-08-13 22-15-46\VWD-OJ(1-2)-95-5-0.
                      5ML-5UL-254NM-40MIN.M
    Last changed    : 8/13/2019 10:44:25 PM
                      (modified after loading)
    Analysis Method : D:\METHOD\LG\VWD-AD(1-2)-80-20-1ML-3UL-210NM-60MIN.M
    Last changed    : 8/14/2019 10:10:16 AM
                      (modified after loading)
```

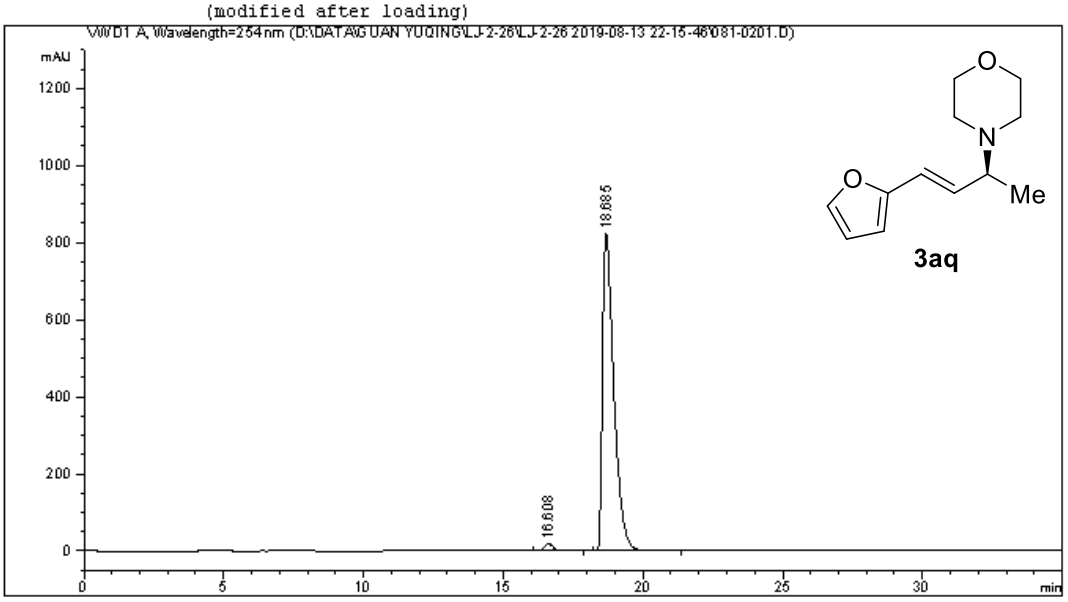



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  16.673 BB    0.3355 2905.79492  130.66414  50.0381
       2  19.088 BB    0.3975 2901.36499  110.80025  49.9619

    Totals :                  5807.15991  241.46439


Instrument 1 8/14/2019 10:10:21 AM                                Page 1 of 2
```

Figure S223. HPLC spectra of ***rac*-3aq**, related to **Figure 4**.

Data File D:\DATA\GUAN YUQING\LJ-2-26\LJ-2-26 2019-08-13 22-15-46\081-0201.D
Sample Name: LJ-2-26-8

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :   2
    Acq. Instrument : Instrument 1                    Location : Vial 81
    Injection Date  : 8/13/2019 10:31:48 PM              Inj :   1
                                                    Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-2-26\LJ-2-26 2019-08-13 22-15-46\VWD-OJ(1-2)-95-5-0.
                      5ML-5UL-254NM-40MIN.M
    Last changed    : 8/13/2019 10:44:25 PM
                      (modified after loading)
    Analysis Method : D:\METHOD\LG\VWD-AD(1-2)-80-20-1ML-3UL-210NM-60MIN.M
    Last changed    : 8/14/2019 10:13:25 AM
                      (modified after loading)
```

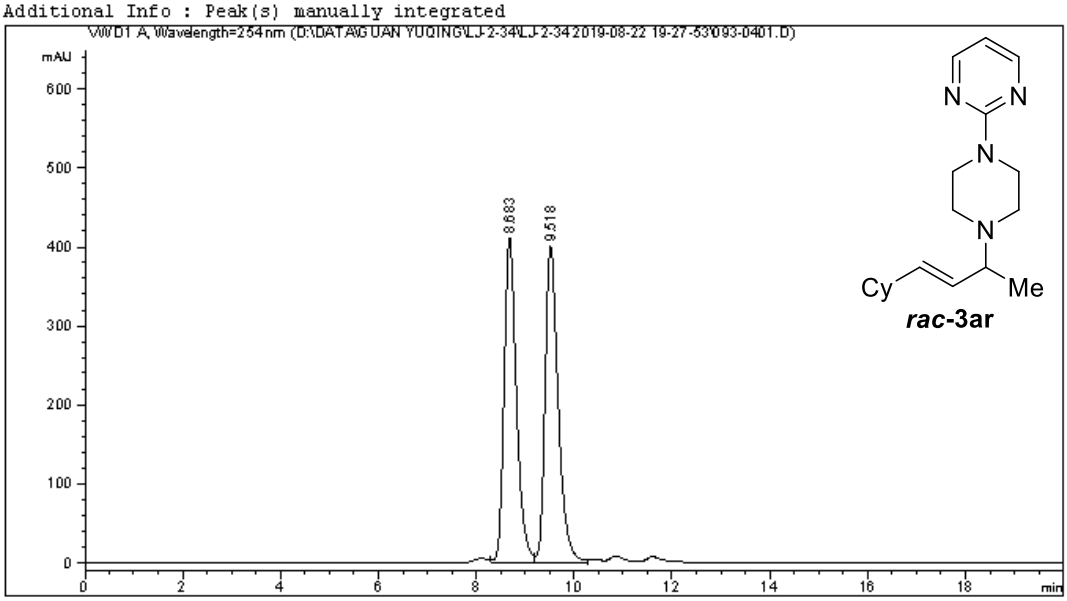



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  16.608 BB    0.3357  430.80255   19.50537   1.8249
       2  18.685 BB    0.4228 2.31767e4   822.39478  98.1751

    Totals :                  2.36075e4   841.90014
```


Figure S224. HPLC spectra of **3aq**, related to **Figure 4**.

Data File D:\DATA\GUAN YUQING\LJ-2-34\LJ-2-34 2019-08-22 19-27-53\093-0401.D
Sample Name: LJ-2-34-RAC

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :   4
    Acq. Instrument : Instrument 1                    Location : Vial 93
    Injection Date  : 8/22/2019 8:06:29 PM                 Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-2-34\LJ-2-34 2019-08-22 19-27-53\VWD-0J(1-2)-95-5-0.
                      5ML-5UL-254NM-20MIN.M
    Last changed    : 8/22/2019 7:29:22 PM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\VWD-0J(1-2)-95-5-0.5ML-5UL-254NM-20MIN.M
    Last changed    : 8/22/2019 8:24:04 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

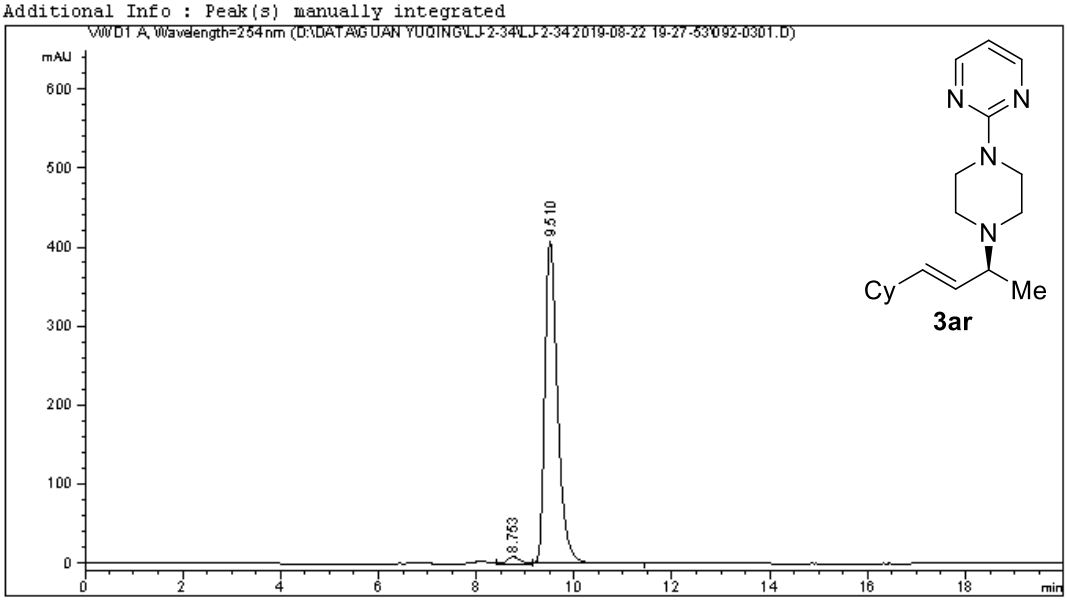



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1   8.683 VV    0.2682 7229.00488  410.94553  49.3700
       2   9.518 VV    0.2810 7413.50635  400.48196  50.6300

    Totals :                  1.46425e4   811.42749


Instrument 1 8/22/2019 8:26:59 PM                                Page 1 of 2
```

Figure S225. HPLC spectra of ***rac*-3ar**, related to **Figure 4**.

Data File D:\DATA\GUAN YUQING\LJ-2-34\LJ-2-34 2019-08-22 19-27-53\092-0301.D
Sample Name: LJ-2-34

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :   3
    Acq. Instrument : Instrument 1                    Location : Vial 92
    Injection Date  : 8/22/2019 7:45:39 PM                 Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-2-34\LJ-2-34 2019-08-22 19-27-53\VWD-0J(1-2)-95-5-0.
                      5ML-5UL-254NM-20MIN.M
    Last changed    : 8/22/2019 7:29:22 PM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\VWD-0J(1-2)-95-5-0.5ML-5UL-254NM-20MIN.M
    Last changed    : 8/22/2019 8:24:04 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

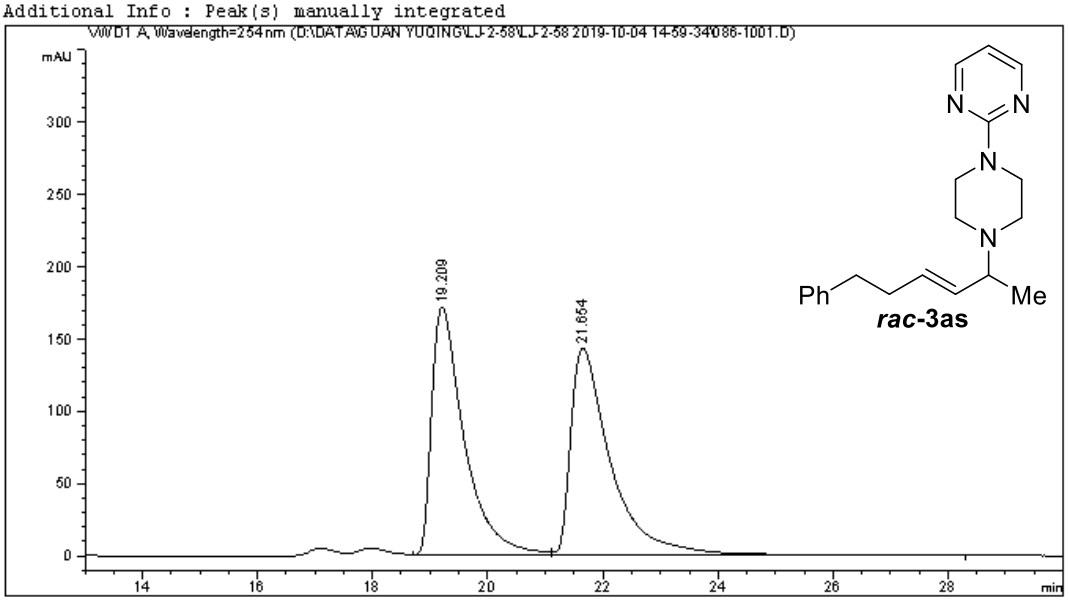



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1   8.753 VV    0.2816  161.11761    8.63663   2.1291
       2   9.510 VB    0.2766 7406.44824  408.39880  97.8709

    Totals :                   7567.56586  417.03543


Instrument 1 8/22/2019 8:24:12 PM                                Page 1 of 2
```

Figure S226. HPLC spectra of **3ar**, related to **Figure 4**.

Data File D:\DATA\GUAN YUQING\LJ-2-58\LJ-2-58 2019-10-04 14-59-34\086-1001.D
Sample Name: LJ-2-58-3-RAC

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :  10
    Acq. Instrument : Instrument 1                    Location : Vial 86
    Injection Date  : 10/4/2019 6:18:32 PM                 Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-2-58\LJ-2-58 2019-10-04 14-59-34\VWD-OD(1-2)-95-5-0.
                      5ML-5UL-254NM-30MIN.M
    Last changed    : 10/4/2019 3:08:34 PM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\VWD-OD(1-2)-95-5-0.5ML-5UL-254NM-10MIN.M
    Last changed    : 10/4/2019 7:06:32 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

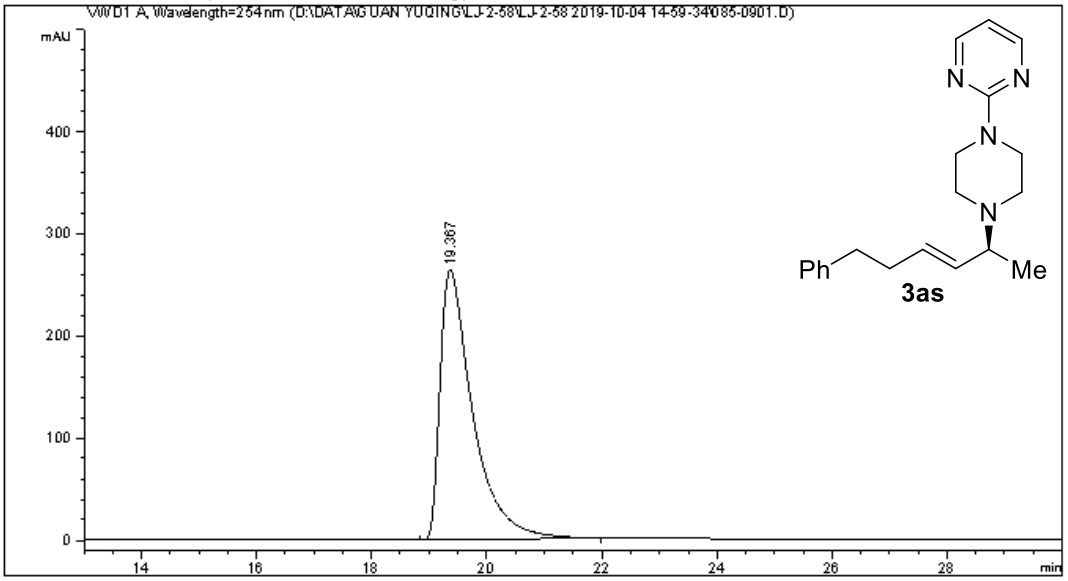



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  19.209 BV    0.5768 6710.61328  171.37782  49.2813
       2  21.654 VB    0.7120 6906.34668  143.11708  50.7187

    Totals :                  1.36170e4   314.49490
```


Figure S227. HPLC spectra of ***rac*-3as**, related to **Figure 4**.

Data File D:\DATA\GUAN YUQING\LJ-2-58\LJ-2-58 2019-10-04 14-59-34\085-0901.D
Sample Name: LJ-2-58-3

```
    ======================================================================
    Acq. Operator   :                               Seq. Line :   9
    Acq. Instrument : Instrument 1                   Location : Vial 85
    Injection Date  : 10/4/2019 5:47:42 PM               Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-2-58\LJ-2-58 2019-10-04 14-59-34\VWD-OD(1-2)-95-5-0.
                      5ML-5UL-254NM-30MIN.M
    Last changed    : 10/4/2019 3:08:34 PM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\VWD-OD(1-2)-95-5-0.5ML-5UL-254NM-10MIN.M
    Last changed    : 10/4/2019 7:07:41 PM
                      (modified after loading)
```

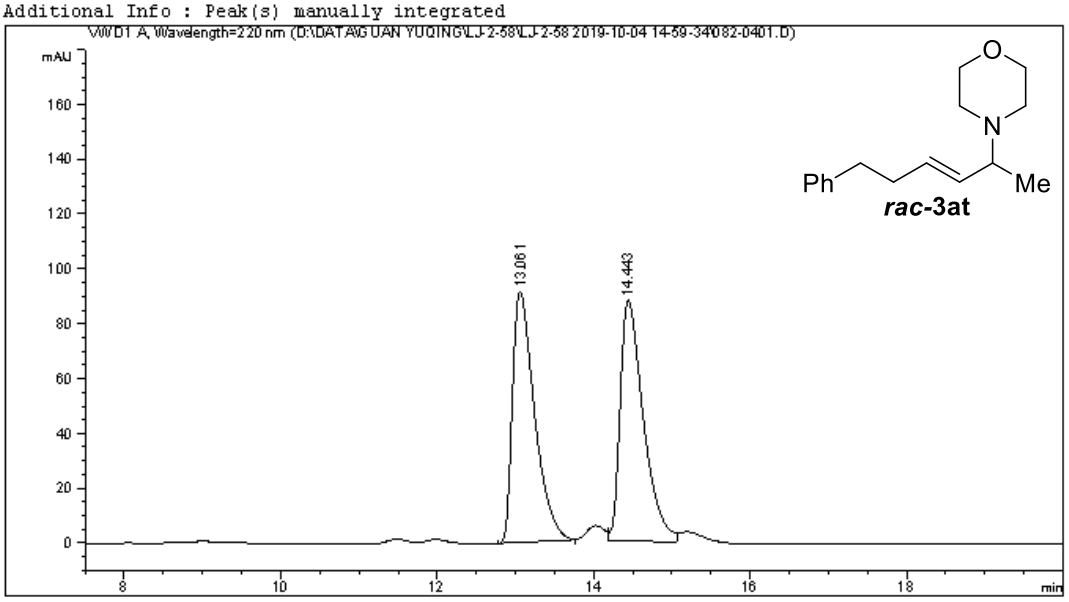



```
    ======================================================================
                              Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1  19.367 BB    0.5810 1.04212e4   264.28088 100.0000

    Totals :                  1.04212e4   264.28088


    ======================================================================
                              *** End of Report ***

Instrument 1 10/4/2019 7:07:57 PM                                Page 1 of 1
```

Figure S228. HPLC spectra of **3as**, related to **Figure 4**.

Data File D:\DATA\GUAN YUQING\LJ-2-58\LJ-2-58 2019-10-04 14-59-34\082-0401.D
Sample Name: LJ-2-58-1-RAC

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   4
    Acq. Instrument : Instrument 1                  Location : Vial 82
    Injection Date  : 10/4/2019 3:58:10 PM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-2-58\LJ-2-58 2019-10-04 14-59-34\VWD-OJ(1-6)-95-5-0.
                      5ML-5UL-220NM-25MIN.M
    Last changed    : 10/4/2019 2:55:51 PM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\VWD-OD(1-2)-95-5-0.5ML-5UL-254NM-10MIN.M
    Last changed    : 10/4/2019 6:56:30 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

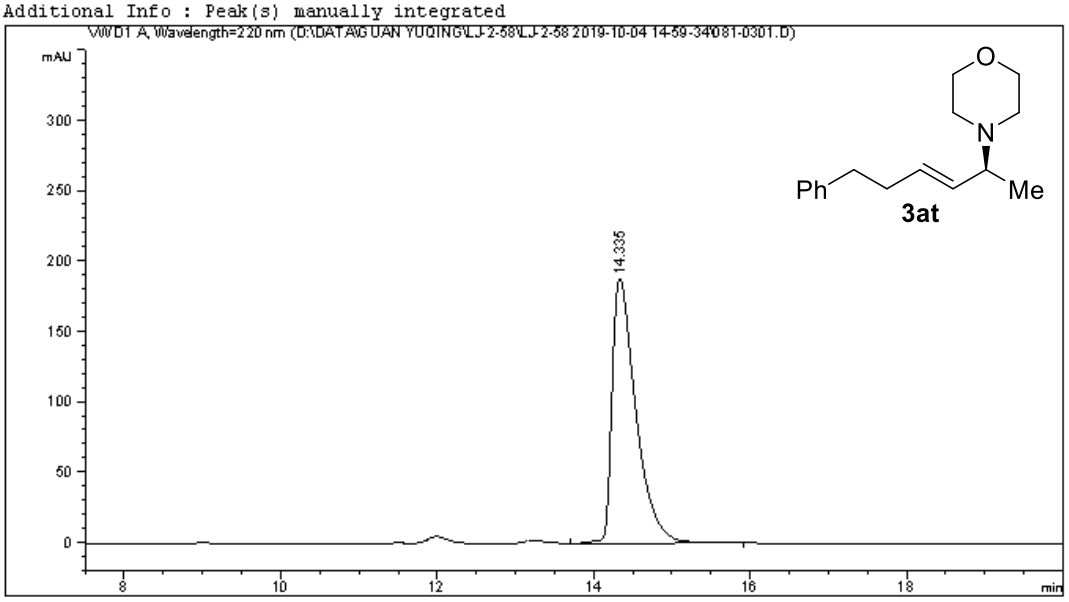



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=220 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  13.061 BB    0.2980 1793.32349   91.35478  49.7739
       2  14.443 VV    0.3104 1809.61426   87.80449  50.2261

    Totals :                  3602.93774  179.15927


Instrument 1 10/4/2019 6:56:39 PM                                Page 1 of 2
```

Figure S229. HPLC spectra of ***rac*-3at**, related to **Figure 4**.

Data File D:\DATA\GUAN YUQING\LJ-2-58\LJ-2-58 2019-10-04 14-59-34\081-0301.D
Sample Name: LJ-2-58-1

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :   3
    Acq. Instrument : Instrument 1                    Location : Vial 81
    Injection Date  : 10/4/2019 3:32:18 PM                Inj :   1
                                                    Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-2-58\LJ-2-58 2019-10-04 14-59-34\VWD-OJ(1-6)-95-5-0.
                      5ML-5UL-220NM-25MIN.M
    Last changed    : 10/4/2019 2:55:51 PM
    Analysis Method : D:\METHOD\GUAN YUQING\LONGJIAO\VWD-OD(1-2)-95-5-0.5ML-5UL-254NM-10MIN.M
    Last changed    : 10/4/2019 7:00:56 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```



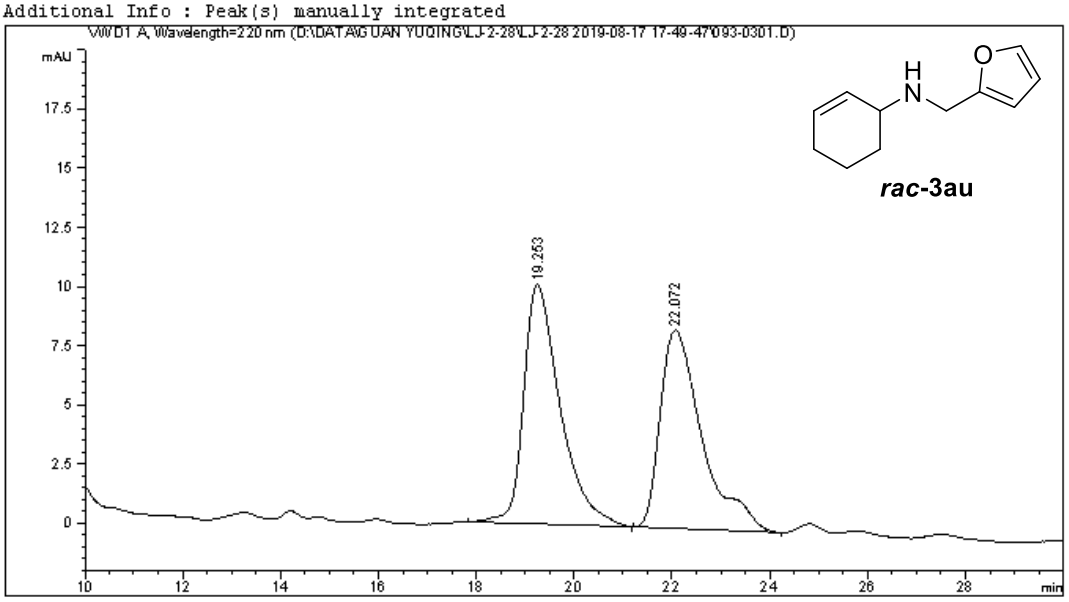

```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=220 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1  14.335 BB    0.3155 3957.84790  188.12329 100.0000

    Totals :                  3957.84790  188.12329


    ======================================================================
```

Instrument 1 10/4/2019 7:01:03 PM

Figure S230. HPLC spectra of **3at**, related to **Figure 4**.

Data File D:\DATA\GUAN YUQING\LJ-2-28\LJ-2-28 2019-08-17 17-49-47\093-0301.D
Sample Name: LJ-2-28-RAC

```
=====================================================================
Acq. Operator   :                              Seq. Line :   3
Acq. Instrument : Instrument 1                  Location : Vial 93
Injection Date  : 8/17/2019 7:08:37 PM               Inj :   1
                                              Inj Volume : 5.000 µl
Acq. Method     : D:\DATA\GUAN YUQING\LJ-2-28\LJ-2-28 2019-08-17 17-49-47\VWD-AS(1-6)-99-1-0.
                  5ML-5UL-220NM-60MIN.M
Last changed    : 4/29/2019 8:58:31 AM
Analysis Method : D:\METHOD\LWD\DAD-OD(1-2)-90-10-1ML-3ULALL-25MIN.M
Last changed    : 8/19/2019 9:39:21 AM
                  (modified after loading)
Additional Info : Peak(s) manually integrated
```

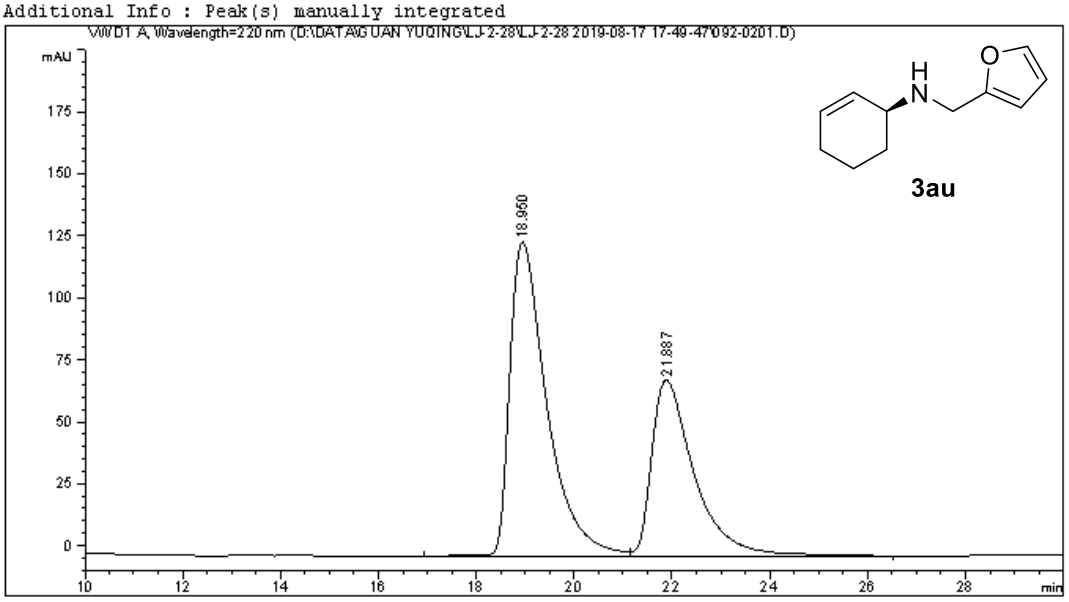



```
=====================================================================
                        Area Percent Report
=====================================================================

Sorted By             :      Signal
Multiplier            :      1.0000
Dilution              :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1  19.253 BB    0.7624  523.16156   10.09827  51.2498
   2  22.072 BB    0.8799  497.64478    8.36683  48.7502

Totals :                  1020.80634   18.46510
```


Figure S231. HPLC spectra of ***rac*-3au**, related to **Figure 4**.

Data File D:\DATA\GUAN YUQING\LJ-2-28\LJ-2-28 2019-08-17 17-49-47\092-0201.D
Sample Name: LJ-2-28

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :   2
    Acq. Instrument : Instrument 1                    Location : Vial 92
    Injection Date  : 8/17/2019 6:07:48 PM                 Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-2-28\LJ-2-28 2019-08-17 17-49-47\VWD-AS(1-6)-99-1-0.
                      5ML-5UL-220NM-60MIN.M
    Last changed    : 4/29/2019 8:58:31 AM
    Analysis Method : D:\METHOD\LWD\DAD-OD(1-2)-90-10-1ML-3ULALL-25MIN.M
    Last changed    : 8/19/2019 9:41:54 AM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

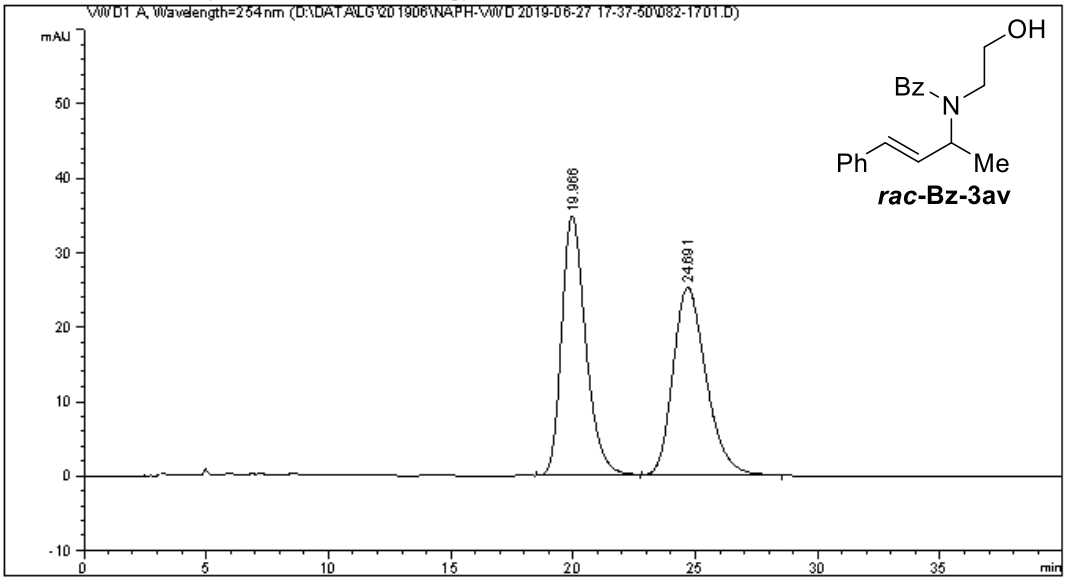



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=220 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1  18.950 BV    0.7841 6617.87891  126.55463  60.8880
       2  21.887 VB    0.8940 4251.05322   70.85488  39.1120

    Totals :                  1.08689e4   197.40951
```


Figure S232. HPLC spectra of **3au**, related to **Figure 4**.

Data File D:\DATA\LG\201906\NAPH-VWD 2019-06-27 17-37-50\082-1701.D
Sample Name: LJ-2-4-RAC

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :  17
    Acq. Instrument : Instrument 1                  Location : Vial 82
    Injection Date  : 6/28/2019 8:27:36 AM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LG\201906\NAPH-VWD 2019-06-27 17-37-50\VWD-AS(1-6)-85-15-1ML-5UL-
                      254NM-40MIN.M
    Last changed    : 6/27/2019 10:00:11 PM
    Analysis Method : D:\METHOD\LG\VWD-AS(1-6)-80-20-1.5ML-5UL-210NM-90MIN.M
    Last changed    : 6/28/2019 6:28:42 PM
                      (modified after loading)
```

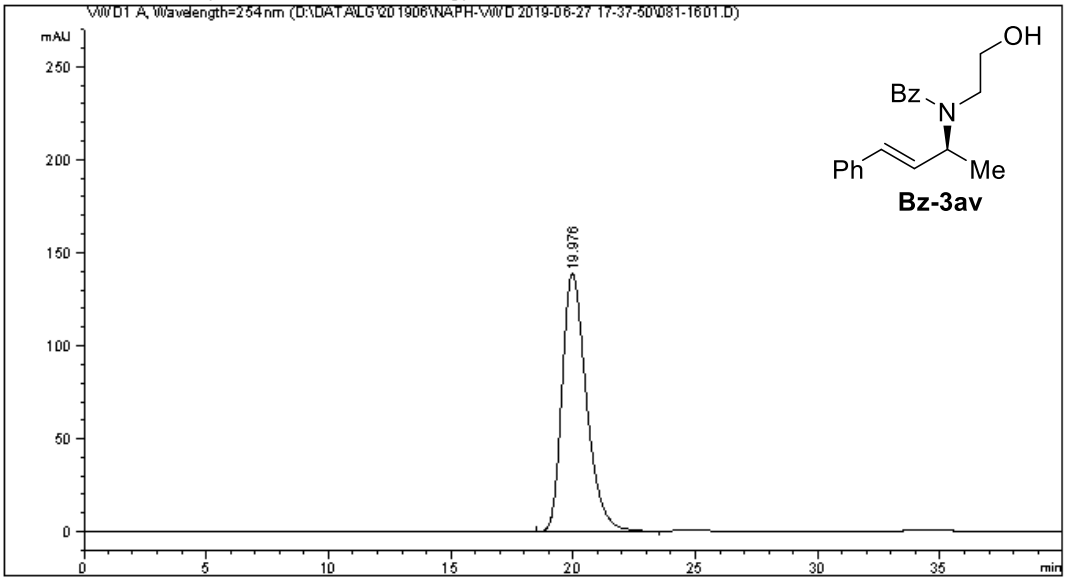



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1  19.966 BB    1.0252 2377.83325   34.84079  50.1265
       2  24.691 BB    1.4179 2365.83643   25.18684  49.8735

    Totals :                  4743.66968   60.02764


    ======================================================================
```


Figure S233. HPLC spectra of ***rac*-Bz-3av**, related to **Figure 5**.

Data File D:\DATA\LG\201906\NAPH-VWD 2019-06-27 17-37-50\081-1601.D
Sample Name: LJ-2-4

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :  16
    Acq. Instrument : Instrument 1                    Location : Vial 81
    Injection Date  : 6/28/2019 7:46:47 AM                 Inj :  1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LG\201906\NAPH-VWD 2019-06-27 17-37-50\VWD-AS(1-6)-85-15-1ML-5UL-
                      254NM-40MIN.M
    Last changed    : 6/27/2019 10:00:11 PM
    Analysis Method : D:\METHOD\LG\VWD-AS(1-6)-80-20-1.5ML-5UL-210NM-90MIN.M
    Last changed    : 6/28/2019 6:30:24 PM
                      (modified after loading)
```

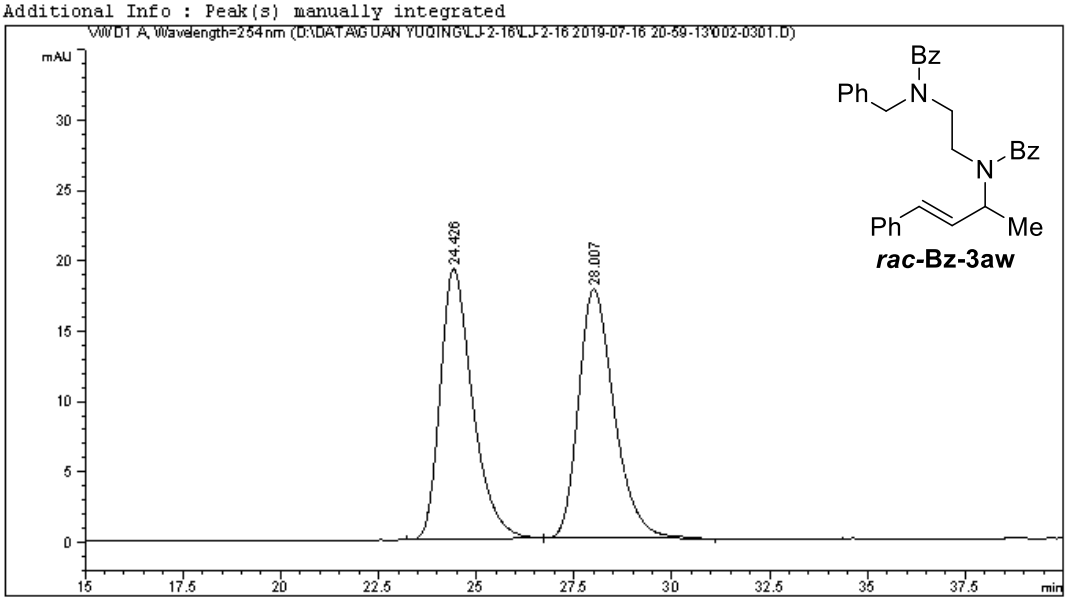



```
    ======================================================================
                              Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1  19.976 BB    1.0613 9551.57227  138.37770 100.0000

    Totals :                  9551.57227  138.37770


    ======================================================================
                              *** End of Report ***

Instrument 1 6/28/2019 6:30:32 PM                                Page 1 of 1
```

Figure S234. HPLC spectra of **Bz-3av**, related to **Figure 5**.

Data File D:\DATA\GUAN YUQING\LJ-2-16\LJ-2-16 2019-07-16 20-59-13\002-0301.D
Sample Name: LJ-2-16-RAC

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :   3
    Acq. Instrument : Instrument 1                    Location : Vial 2
    Injection Date  : 7/16/2019 9:56:06 PM                 Inj :   1
                                                    Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-2-16\LJ-2-16 2019-07-16 20-59-13\VWD-AD(1-2)-85-15-
                      1ML-5UL-254NM-40MIN.M
    Last changed    : 4/17/2019 5:00:46 PM
    Analysis Method : D:\METHOD\LSL\DAD-OD(1-2)-97-3-1ML-5UL-ALL-60MIN.M
    Last changed    : 7/19/2019 8:11:26 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

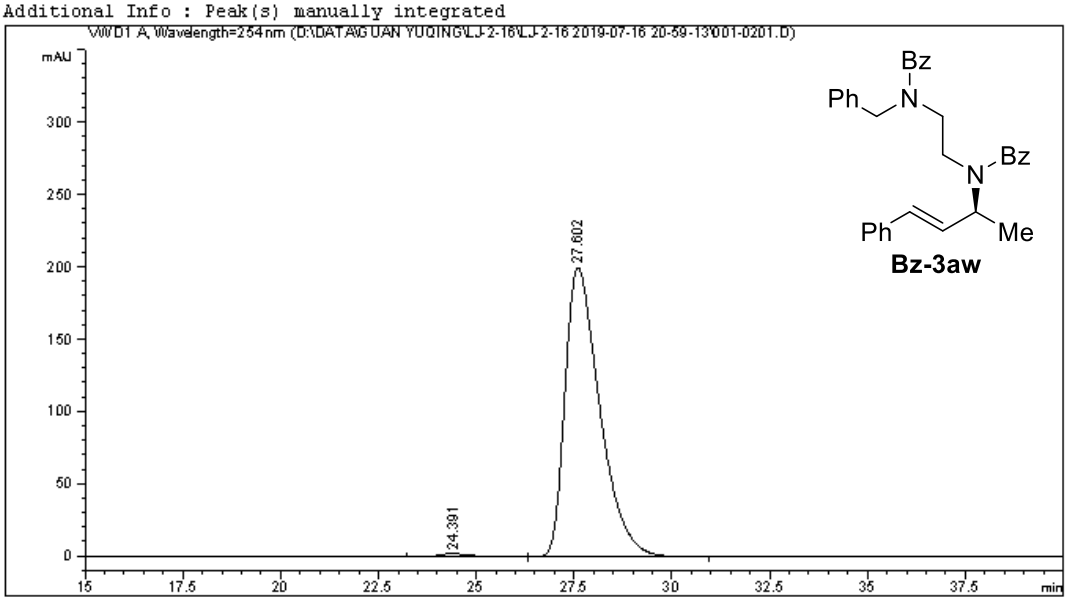



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1  24.426 BB    0.8642 1106.68665   19.20644  49.6651
       2  28.007 BB    0.9601 1121.61011   17.67954  50.3349

    Totals :                  2228.29675   36.88599
```


Figure S235. HPLC spectra of ***rac*-Bz-3aw**, related to **Figure 5**.

Data File D:\DATA\GUAN YUQING\LJ-2-16\LJ-2-16 2019-07-16 20-59-13\001-0201.D
Sample Name: LJ-2-16

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :   2
    Acq. Instrument : Instrument 1                    Location : Vial 1
    Injection Date  : 7/16/2019 9:15:17 PM                 Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-2-16\LJ-2-16 2019-07-16 20-59-13\VWD-AD(1-2)-85-15-
                      1ML-5UL-254NM-40MIN.M
    Last changed    : 4/17/2019 5:00:46 PM
    Analysis Method : D:\METHOD\LSL\DAD-OD(1-2)-97-3-1ML-5UL-ALL-60MIN.M
    Last changed    : 7/19/2019 8:13:02 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

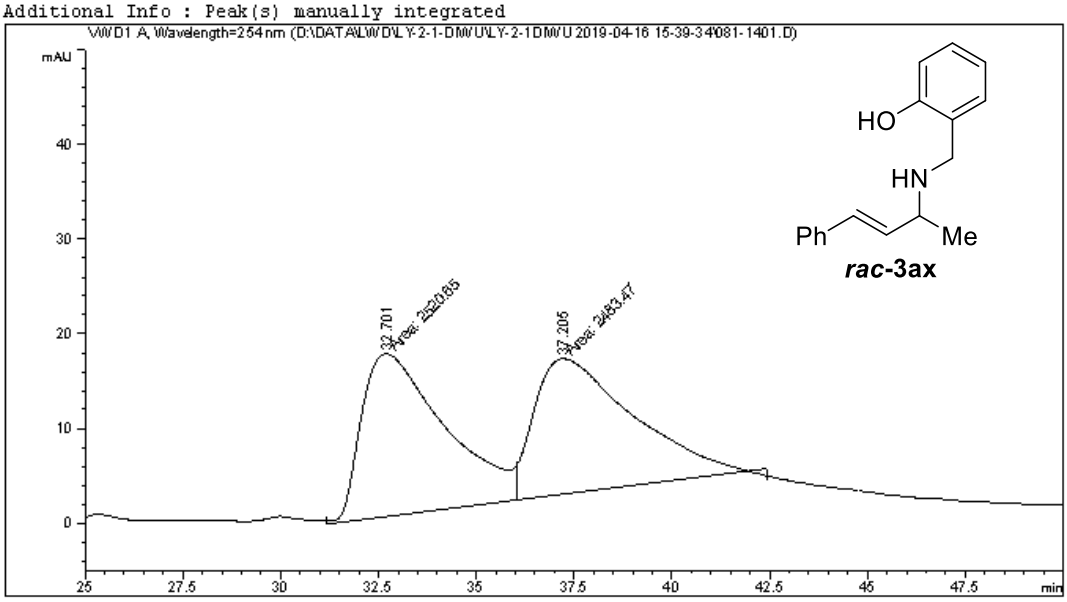



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  24.391 BB    0.8115  127.46741    2.11982   1.0228
       2  27.602 BB    0.9399 1.23356e4   199.90909  98.9772

    Totals :                  1.24631e4   202.02891
```


Figure S236. HPLC spectra of **Bz-3aw**, related to **Figure 5**.

Data File D:\DATA\LWD\LY-2-1-DIWU\LY-2-1DIWU 2019-04-16 15-39-34\081-1401.D
Sample Name: LJ-137-6-RAC

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :  14
    Acq. Instrument : Instrument 1                  Location : Vial 81
    Injection Date  : 4/16/2019 8:39:31 PM               Inj :  1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LWD\LY-2-1-DIWU\LY-2-1DIWU 2019-04-16 15-39-34\VWD-AD(1-2)-99-1-0.
                      5ML-5UL-254NM-60MIN.M
    Last changed    : 4/16/2019 4:38:17 PM
    Analysis Method : D:\DATA\LWD\LY-2-1-DIWU\LY-2-1DIWU 2019-04-16 15-39-34\VWD-AD(1-2)-99-1-0.
                      5ML-5UL-254NM-60MIN.M (Sequence Method)
    Last changed    : 4/17/2019 8:04:38 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

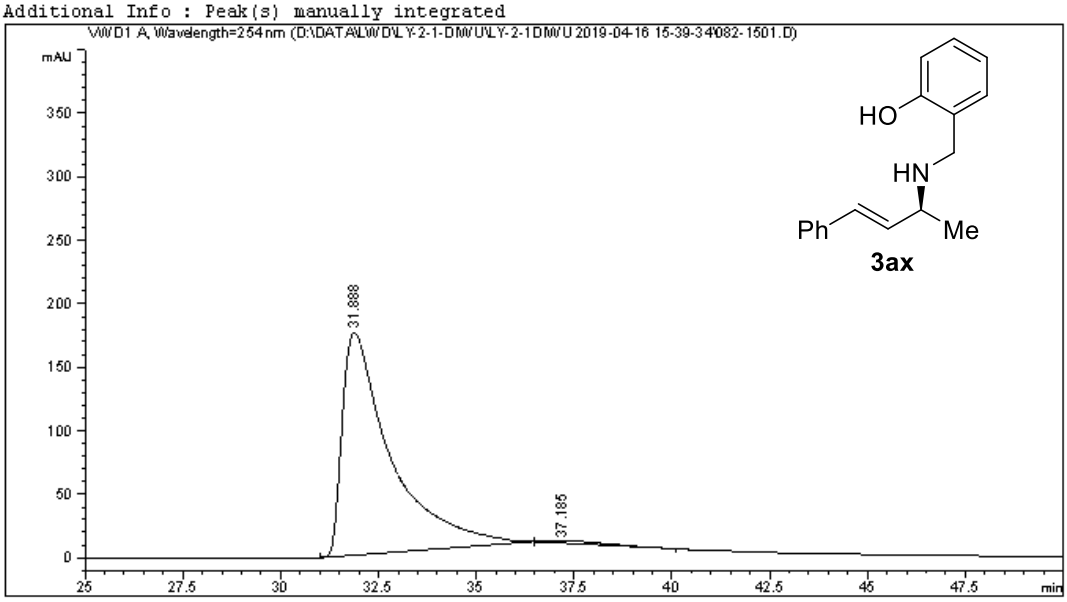



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  32.701 MF    2.4469 2520.65356   17.16935  50.3716
       2  37.205 FM    2.8903 2483.46680   14.32087  49.6284

    Totals :                  5004.12036   31.49022
```


Figure S237. HPLC spectra of ***rac*-3ax**, related to **Figure 5**.

Data File D:\DATA\LWD\LY-2-1-DIWU\LY-2-1DIWU 2019-04-16 15-39-34\082-1501.D
Sample Name: LJ-137-6

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :  15
    Acq. Instrument : Instrument 1                    Location : Vial 82
    Injection Date  : 4/16/2019 9:40:22 PM                 Inj :   1
                                                    Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LWD\LY-2-1-DIWU\LY-2-1DIWU 2019-04-16 15-39-34\VWD-AD(1-2)-99-1-0.
                      5ML-5UL-254NM-60MIN.M
    Last changed    : 4/16/2019 4:38:17 PM
    Analysis Method : D:\DATA\LWD\LY-2-1-DIWU\LY-2-1DIWU 2019-04-16 15-39-34\VWD-AD(1-2)-99-1-0.
                      5ML-5UL-254NM-60MIN.M (Sequence Method)
    Last changed    : 4/17/2019 8:07:01 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

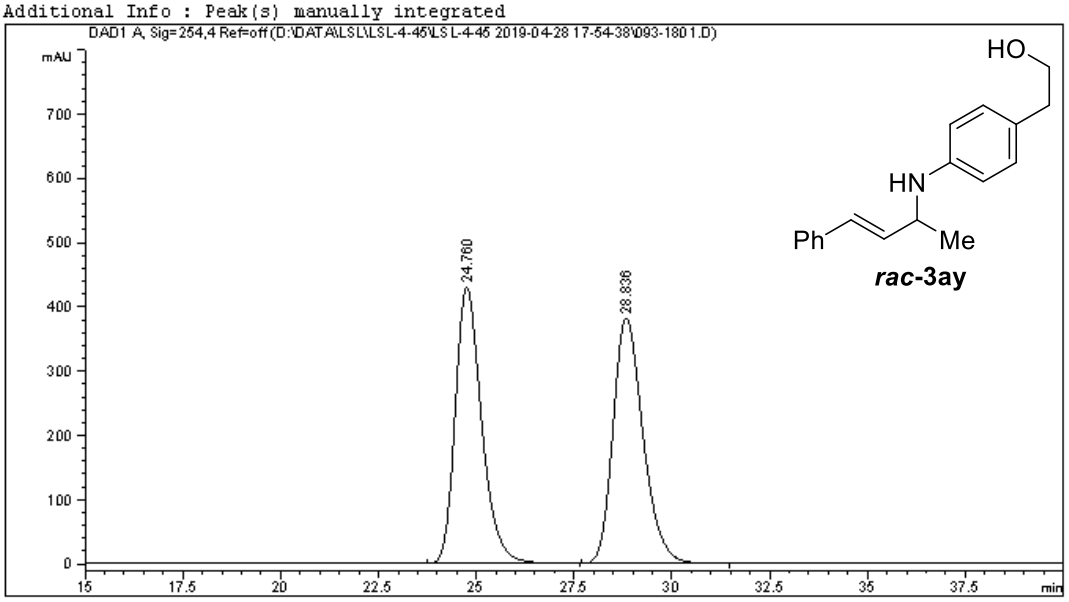



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  31.888 BB    1.2270 1.51677e4   175.21049  98.5994
       2  37.185 BB    1.4597  215.46088    1.73517   1.4006

    Totals :                  1.53832e4   176.94567
```


Figure S238. HPLC spectra of **3ax**, related to **Figure 5**.

Data File D:\DATA\LSL\LSL-4-45\LSL-4-45 2019-04-28 17-54-38\093-1801.D
Sample Name: LJ-148-4-RAC

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :  18
    Acq. Instrument : Instrument 2                    Location : Vial 93
    Injection Date  : 4/29/2019 4:26:23 AM                 Inj :  1
                                                    Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LSL\LSL-4-45\LSL-4-45 2019-04-28 17-54-38\DAD-OD(1-2)-80-20-0.5ML-
                      5UL-ALL-45MIN.M
    Last changed    : 4/28/2019 10:10:52 PM
    Analysis Method : D:\DATA\LSL\LSL-4-45\LSL-4-45 2019-04-28 17-54-38\DAD-OD(1-2)-80-20-0.5ML-
                      5UL-ALL-45MIN.M (Sequence Method)
    Last changed    : 5/3/2019 5:44:15 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

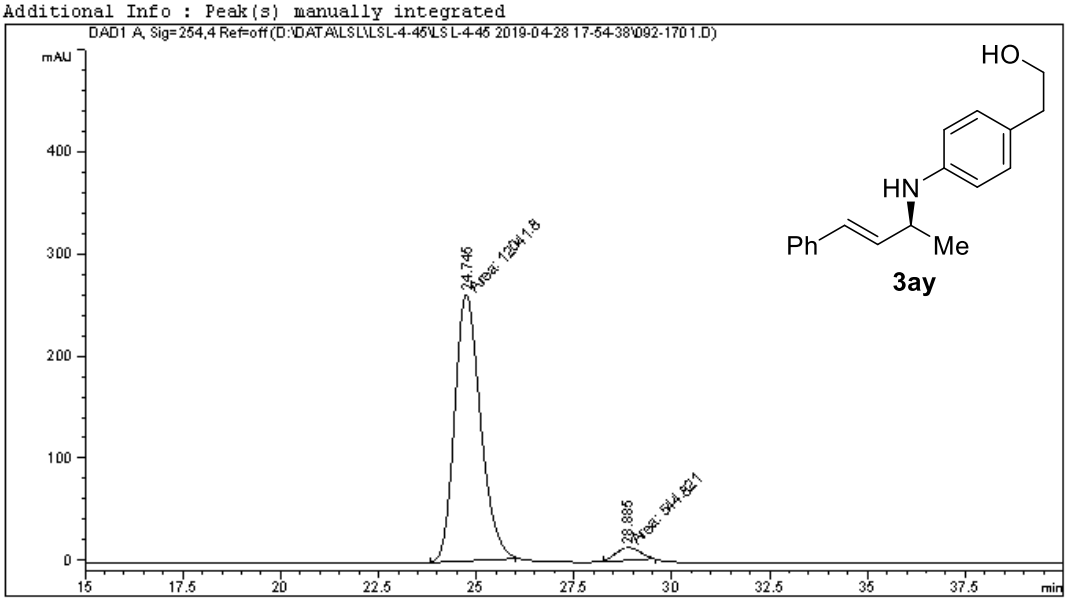



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  24.760 BB    0.7097 2.01640e4   429.50250  49.8858
       2  28.836 BB    0.8000 2.02563e4   381.19202  50.1142

    Totals :                  4.04203e4   810.69452
```


Figure S239. HPLC spectra of ***rac*-3ay**, related to **Figure 5**.

Data File D:\DATA\LSL\LSL-4-45\LSL-4-45 2019-04-28 17-54-38\092-1701.D
Sample Name: LJ-148-4

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :  17
    Acq. Instrument : Instrument 2                    Location : Vial 92
    Injection Date  : 4/29/2019 3:40:21 AM                 Inj :  1
                                                    Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\LSL\LSL-4-45\LSL-4-45 2019-04-28 17-54-38\DAD-OD(1-2)-80-20-0.5ML-
                      5UL-ALL-45MIN.M
    Last changed    : 4/28/2019 10:10:52 PM
    Analysis Method : D:\DATA\LSL\LSL-4-45\LSL-4-45 2019-04-28 17-54-38\DAD-OD(1-2)-80-20-0.5ML-
                      5UL-ALL-45MIN.M (Sequence Method)
    Last changed    : 5/3/2019 5:46:15 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

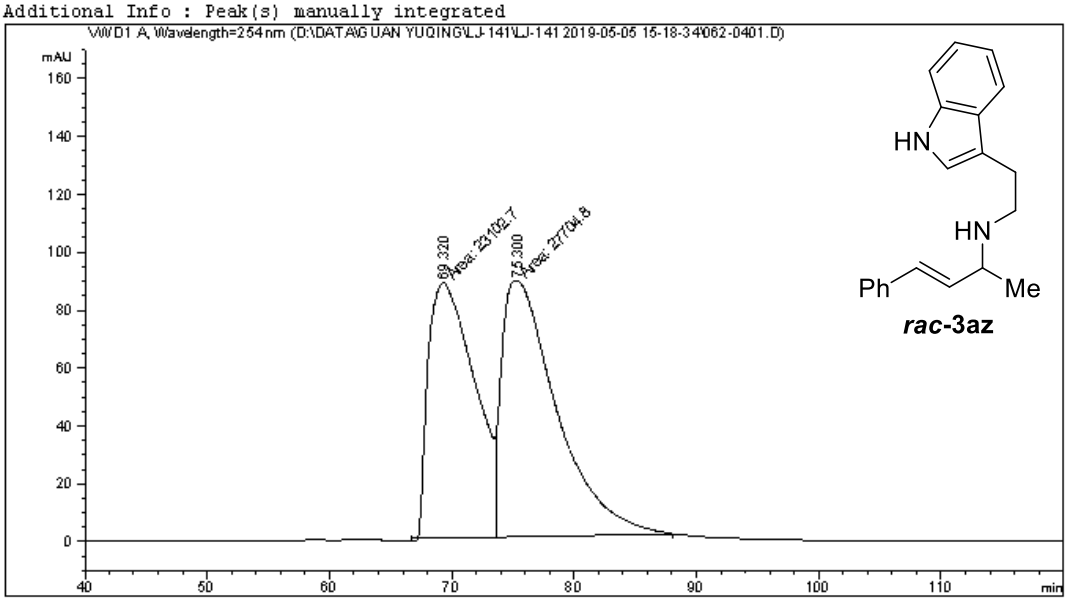



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=254,4 Ref=off

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  24.745 MM    0.7688 1.20418e4   261.04971  95.6714
       2  28.885 MM    0.7354  544.82092   12.34704   4.3286

    Totals :                  1.25866e4   273.39676
```


Figure S240. HPLC spectra of **3ay**, related to **Figure 5**.

Data File D:\DATA\GUAN YUQING\LJ-141\LJ-141 2019-05-05 15-18-34\062-0401.D
Sample Name: LJ-143-2

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :   4
    Acq. Instrument : Instrument 1                    Location : Vial 62
    Injection Date  : 5/5/2019 5:42:09 PM                 Inj :   1
                                                    Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-141\LJ-141 2019-05-05 15-18-34\VWD-AS(1-6)-99-1-0.
                      5ML-5UL-254NM-80MIN.M
    Last changed    : 5/5/2019 3:41:41 PM
                      (modified after loading)
    Analysis Method : D:\METHOD\YANG JIAXIN\VWD-IA-(1-2)-85-15-1.0ML-5UL-210NM-60MIN.M
    Last changed    : 5/31/2019 8:42:20 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

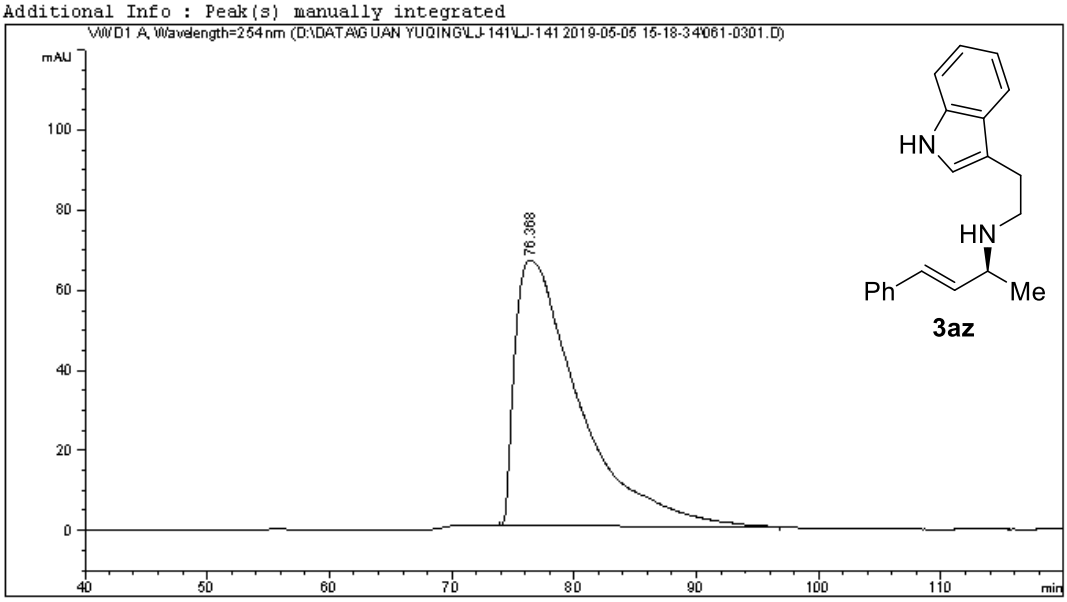



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1  69.320 MF    4.3691 2.31027e4    88.12956  45.4710
       2  75.300 FM    5.2276 2.77048e4    88.32815  54.5290

    Totals :                  5.08076e4   176.45771
```


Figure S241. HPLC spectra of ***rac*-3az**, related to **Figure 5**.

Data File D:\DATA\GUAN YUQING\LJ-141\LJ-141 2019-05-05 15-18-34\061-0301.D
Sample Name: LJ-141-2

```
    ======================================================================
    Acq. Operator   :                              Seq. Line :   3
    Acq. Instrument : Instrument 1                  Location : Vial 61
    Injection Date  : 5/5/2019 3:41:19 PM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-141\LJ-141 2019-05-05 15-18-34\VWD-AS(1-6)-99-1-0.
                      5ML-5UL-254NM-80MIN.M
    Last changed    : 5/5/2019 3:41:41 PM
                      (modified after loading)
    Analysis Method : D:\DATA\GUAN YUQING\LJ-141\LJ-141 2019-05-05 15-18-34\VWD-AS(1-6)-99-1-0.
                      5ML-5UL-254NM-80MIN.M (Sequence Method)
    Last changed    : 5/6/2019 10:41:26 AM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

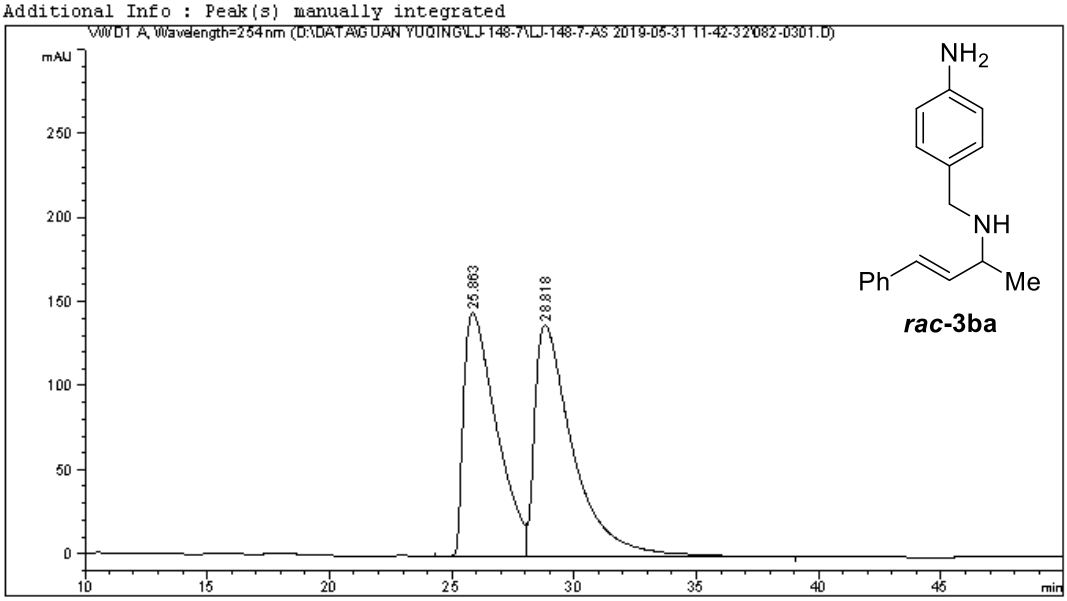



```
    ======================================================================
                           Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  76.368 BB    4.3045 2.42250e4    66.24274 100.0000

    Totals :                  2.42250e4    66.24274
```


Figure S242. HPLC spectra of **3az**, related to **Figure 5**.

Data File D:\DATA\GUAN YUQING\LJ-148-7\LJ-148-7-AS 2019-05-31 11-42-32\082-0301.D
Sample Name: LJ-148-7-RAC

```
    ======================================================================
    Acq. Operator   :                               Seq. Line :   3
    Acq. Instrument : Instrument 1                   Location : Vial 82
    Injection Date  : 5/31/2019 12:55:10 PM              Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-148-7\LJ-148-7-AS 2019-05-31 11-42-32\VWD-AS(1-6)-90
                      -10-0.5ML-5UL-254NM-60MIN.M
    Last changed    : 5/30/2019 9:54:14 PM
    Analysis Method : D:\METHOD\YANG JIAXIN\VWD-IA-(1-2)-85-15-1.0ML-5UL-210NM-60MIN.M
    Last changed    : 5/31/2019 8:06:48 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```

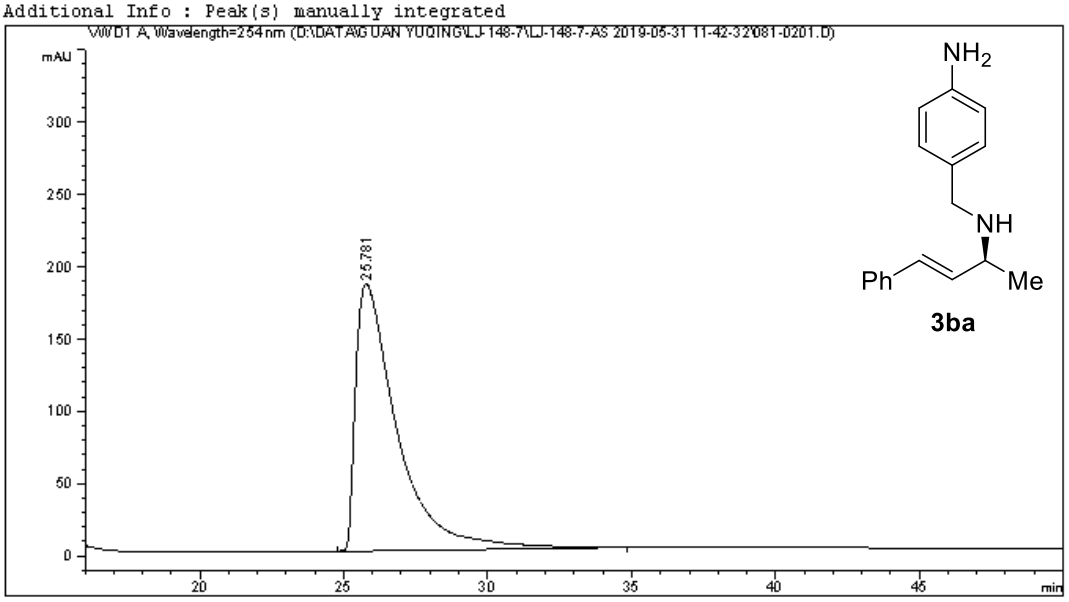



```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  25.863 BV    1.3984 1.34952e4   145.05293  47.2055
       2  28.818 VB    1.5954 1.50930e4   137.95860  52.7945

    Totals :                  2.85882e4   283.01154


Instrument 1 5/31/2019 8:06:56 PM                                Page 1 of 2
```

Figure S243. HPLC spectra of ***rac*-3ba**, related to **Figure 5**.

Data File D:\DATA\GUAN YUQING\LJ-148-7\LJ-148-7-AS 2019-05-31 11-42-32\081-0201.D
Sample Name: LJ-148-7

```
    ======================================================================
    Acq. Operator   :                                Seq. Line :   2
    Acq. Instrument : Instrument 1                    Location : Vial 81
    Injection Date  : 5/31/2019 11:54:19 AM              Inj :   1
                                                    Inj Volume : 5.000 µl
    Acq. Method     : D:\DATA\GUAN YUQING\LJ-148-7\LJ-148-7-AS 2019-05-31 11-42-32\VWD-AS(1-6)-90
                      -10-0.5ML-5UL-254NM-60MIN.M
    Last changed    : 5/30/2019 9:54:14 PM
    Analysis Method : D:\METHOD\YANG JIAXIN\VWD-IA-(1-2)-85-15-1.0ML-5UL-210NM-60MIN.M
    Last changed    : 5/31/2019 8:09:16 PM
                      (modified after loading)
    Additional Info : Peak(s) manually integrated
```




```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1  25.781 BB    1.4723 1.84618e4   184.20869 100.0000

    Totals :                  1.84618e4   184.20869


    ======================================================================
```


Figure S244. HPLC spectra of **3ba**, related to **Figure 5**.

Transparent Methods

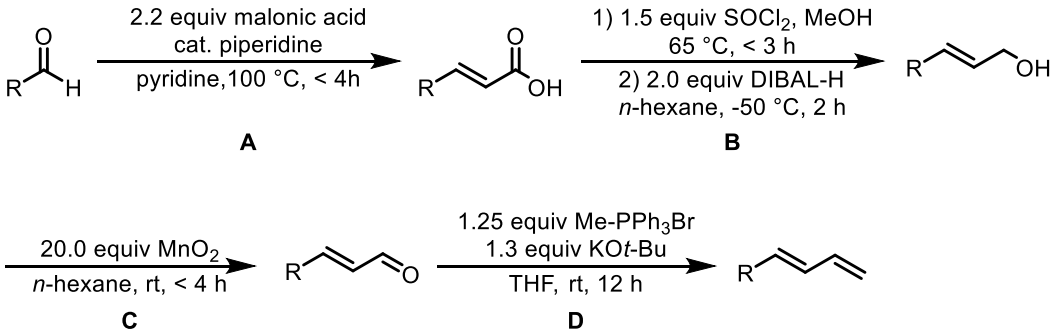
General Information

Unless otherwise noted, all reagents and solvents were purchased from commercial suppliers (Energy Chemical, Adamas-beta®, *J*&K and so on) and used without further purification. All reactions were performed under a dry argon atmosphere fitted on a glass tube or vial unless otherwise specified. All new compounds were characterized by ^{1}H NMR, ^{13}C NMR, ^{19}F NMR and HRMS. The known compounds were characterized by ^{1}H NMR, ^{13}C NMR. ^{1}H, ^{13}C and ^{19}F NMR data were recorded with Bruker 400 MHz with TMS as the internal standard. Data are reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, dd = doublet of doublet, dt = doublet of triplet, m = multiplet, br = broad), coupling constants and integration. All chemical shifts (δ) were reported in ppm and coupling constants (*J*) in Hz. All chemical shifts were reported relative to TMS (0.00 ppm) for ^{1}H NMR, $CDCl_3$ (77.00 ppm) for ^{13}C NMR, respectively. High resolution mass spectra (HRMS) were measured with a Waters Micromass GCT instrument. GC-MS spectra were recorded on a Varian GC-MS 3900 - 2100 T. GC analysis was performed on an Agilent 7890B gas chromatograph with an FID detector using a J & W DB-1 column (10 m, 0.1 mm I.D.). Optical rotation was determined using a Perkin Elmer 343 polarimeter. HPLC analysis was conducted on an Agilent 1260 Series instrument. Column Chromatography was performed with silica gel Merck 60 (300-400 mesh). Purification of the product amine were performed on deactivated silica gel. The deactivated silica gel was prepared by washing the silica gel with petroleum ether/triethylamine (20:1 v/v) prior to purification.

General Procedures for the Synthesis of Conjugated Dienes

Dienes **1a**-**1i** were prepared from commercially available cinnamic acids or cinnamaldehydes, the following scheme shows general procedures (Preuβ et al, 2013; Sardini & Brown, 2017):

Scheme S1 (related to **Figure 4**):



Step A: A mixture of aldehyde (125 mmol, 1.0 equiv) and malonic acid (28.7 g, 275 mmol, 2.2 equiv) was suspended in 65 mL pyridine. Piperidine (2.0 mL) was added and the mixture was

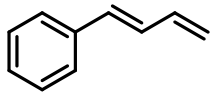
heated to 100 °C until no more gas formation was observed through a gas-washing bottle. The reaction mixture was then poured into ice-cold aqueous HCl solution (2 M, 500 mL) under continuous stirring. The pH-value was checked and adjusted with additional aqueous HCl solution to be strong acidic. The resulting suspension was filtered and the solid cinnamic acid was washed with aqueous HCl (2 M) until no basic reaction of the filtrate was observed. The cinnamic acid was obtained as a white solid which was dried under reduced pressure.

Step B: The cinnamic acid (50 mmol, 1.0 equiv) was suspended in 100 mL MeOH (2 mL *per* mmol acid) and $SOCl_2$ (5.4 mL, 75 mmol, 1.5 equiv) was added. The reaction mixture was heated to 65 °C for 2 h. Subsequently, the MeOH was removed under reduced pressure and the resulting solid was dissolved in dry *n*-hexane under an atmosphere of N_2. The solution was cooled to -50 °C and a solution of DIBAL-H in *n*-hexane (1 M, 100 mL, 100 mmol, 2.0 equiv) was added slowly. After complete addition, the reaction mixture was stirred for 2.5 h at -50 °C. Then 10 mL MeOH and 50 mL aqueous $NaHCO_3$ solution were added slowly and the mixture was allowed to reach room temperature. The resulting slurry was carefully acidified with aqueous HCl (1 M) until all solid was dissolved. The layers were separated and the aqueous layer was extracted with *n*-hexane (3×100 mL). The combined organic layers were dried with Na_2SO_4 and the solvents were removed under reduced pressure.

Step C: The resulting crude allylic alcohol was dissolved in 400 mL *n*-hexane. Then manganese dioxide (65.2 g, 750 mmol, 20.0 equiv) was added and the reaction mixture was stirred under an atmosphere of N_2. The progress of the reaction was monitored by thin layer chromatography and after complete conversion, the reaction mixture was filtered through silica gel. The solid residue was washed with EtOAc and the solvent was removed under reduced pressure. Finally, the crude product was purified by flash column chromatography to give the corresponding cinnamaldehyde.

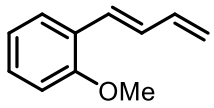
Step D: To a flame-dried round bottom flask was added phosphonium (1.25 equiv) and KO*t*-Bu (1.3 equiv). The flask was evacuated and backfilled with N_2 three times. THF (0.25 M) was then added via syringe. The solution was allowed to stir at ambient temperature for 30 min before adding aldehyde (1.0 equiv) dropwise over 10 minutes. The reaction was then allowed to stir at room temperature for 12 h. The reaction was then quenched with 100 mL saturated NH_4Cl solution, and the aqueous layer was extracted with diethyl ether (3×100 mL). The combined organic extracts were washed with brine (1×100 mL), dried over Na_2SO_4, and gravity filtered. The solvent was removed under reduced pressure, and the crude product was purified via silica gel column chromatography to give the desired diene.

(*E*)-buta-1,3-dien-1-ylbenzene (1a) (Preuβ et al, 2013): colorless liquid, 88% yield, step **D**. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.42-7.39 (m, 2H), 7.34-7.29 (m, 2H), 7.25-7.20 (m, 1H), 6.82-6.75 (m, 1H), 6.58-6.46 (m, 2H), 5.36-5.31 (m, 1H), 5.19-5.16

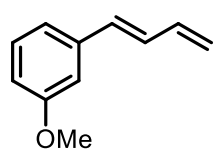


(m, 1H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 137.2, 137.1, 132.8, 129.6, 128.6, 127.6, 126.4, 117.6 ppm.

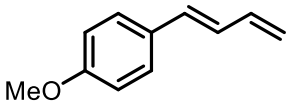
(*E*)-1-(buta-1,3-dien-1-yl)-2-methoxybenzene (1b) (Davenport & Fernandez, 2018): colorless liquid, 80% yield, step **D**. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.47 (dd, *J* = 7.7, 1.7 Hz, 1H), 7.24-7.19 (m, 1H), 6.94-6.77 (m, 4H), 6.54 (dt, *J* = 16.9, 10.1 Hz, 1H), 5.33-5.28 (m, 1H), 5.15-5.12 (m, 1H), 3.85 (s, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 156.7, 137.9, 130.2, 128.6, 127.6, 126.4, 126.0, 120.6, 117.0, 110.8, 55.4 ppm.



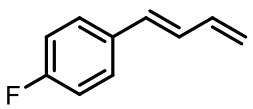
(*E*)-1-(buta-1,3-dien-1-yl)-3-methoxybenzene (1c) (Preuß et al, 2013): colorless solid, 41% yield, steps **A-D**. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.25-7.21 (m, 1H), 7.01-6.99 (m, 1H), 6.94 (dd, *J* = 2.6, 1.6 Hz, 1H), 6.81-6.74 (m, 2H), 6.56-6.45 (m, 2H), 5.36-5.31 (m, 1H), 5.19-5.16 (m, 1H), 3.82 (s, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 159.8, 138.6, 137.1, 132.7, 129.9, 129.5, 119.2, 117.8, 113.4, 111.6, 55.19 ppm.



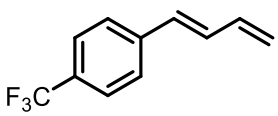
(*E*)-1-(buta-1,3-dien-1-yl)-4-methoxybenzene (1d) (Preuß et al, 2013): colorless solid, 85% yield, step **D**. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.36-7.33 (m, 2H), 6.88-6.84 (m, 2H), 6.70-6.64 (m, 1H), 6.53-6.44 (m, 2H), 5.28 (d, *J* = 16.0 Hz, 1H), 5.11 (d, *J* = 8.5 Hz, 1H), 3.81 (s, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 159.2, 137.3, 132.4, 129.9, 127.6, 116.5, 114.0, 55.3 ppm.



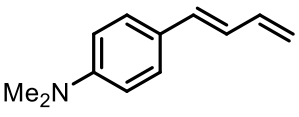
(*E*)-1-(buta-1,3-dien-1-yl)-4-fluorobenzene (1e) (Hu et al, 2018): colorless liquid, 90% yield, step **D**. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.37-7.34 (m, 2H), 7.03-6.97 (m, 2H), 6.73-6.66 (m, 1H), 6.53-6.43 (m, 2H), 5.32 (d, *J* = 15.6 Hz, 1H), 5.17 (d, *J* = 9.2 Hz, 1H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.3 (d, *J* = 247.2 Hz), 136.9, 133.2 (d, *J* = 3.4 Hz), 131.5, 129.3 (d, *J* = 2.4 Hz), 127.9 (d, *J* = 8.0 Hz), 117.7, 115.5 (d, *J* = 21.7 Hz) ppm; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -114.18 ppm.



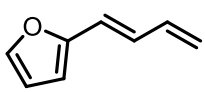
(*E*)-1-(buta-1,3-dien-1-yl)-4-(trifluoromethyl)benzene (1f) (Adamson & Malcolmson, 2017): colorless liquid, 28% overall yield, steps **B-D**. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.57-7.55 (m, 2H), 7.49-7.47 (m, 2H), 6.85 (dd, *J* = 15.7, 10.5 Hz, 1H), 6.59-6.47 (m, 2H), 5.43-5.38 (m, 1H), 5.28-5.25 (m, 1H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 140.5 (q, *J* = 1.4 Hz), 136.6, 131.9, 131.2, 129.2 (q, *J* = 32.4 Hz), 126.5, 125.5 (q, *J* = 3.9 Hz), 124.2 (q, *J* = 271.5 Hz), 119.4 ppm; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -62.40 ppm.



(*E*)-4-(buta-1,3-dien-1-yl)-N,N-dimethylaniline (1g) (Davenport & Fernandez, 2018): yellow solid, 37% yield, step **D**. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.31-7.29 (m, 2H), 6.69-6.67 (m, 2H), 6.63 (dd, *J* = 15.7, 10.4 Hz, 1H), 6.53-6.44 (m, 2H), 5.25-5.20 (m, 1H), 5.04 (d, *J* = 9.8 Hz, 1H), 2.96 (s, 6H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 150.0, 137.8, 133.1, 127.5, 125.6, 115.0, 112.4, 40.5 ppm.

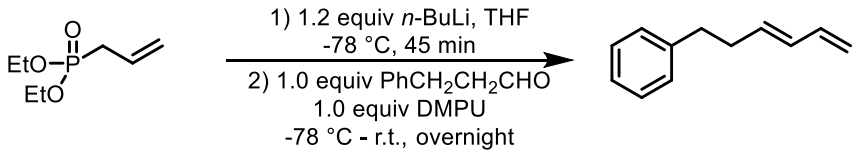


(*E*)-2-(buta-1,3-dien-1-yl)furan (1h) (Preuß et al, 2013): slight yellow liquid, 75% yield, step **D**. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.36 (d, *J* = 1.9 Hz, 1H), 6.73-6.67 (m, 1H), 6.48-6.41 (m, 1H), 6.39-6.34 (m, 2H), 6.27 (d, *J* = 3.2 Hz, 1H), 5.35-5.30 (m, 1H), 5.17-5.14 (m, 1H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 152.9, 142.2, 136.7, 128.2, 120.4, 117.8, 111.6, 108.5 ppm.



(*E*)-buta-1,3-dien-1-ylcyclohexane (1i) (Preuß et al, 2013): colorless liquid, 32% overall yield, steps **A-D**. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 6.35-6.25 (m, 1H), 6.05-5.98 (m, 1H), 5.66 (dd, *J* = 15.3, 6.9 Hz, 1H), 5.12-5.07 (m, 1H), 4.97-4.94 (m, 1H), 2.04-1.95 (m, 1H), 1.75-1.70 (m, 4H), 1.67-1.62 (m, 1H), 1.33-1.03 (m, 5H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 141.3, 137.6, 128.3, 114.7, 40.6, 32.7, 26.1, 26.0 ppm.

Scheme S2 (related to **Figure 4**):

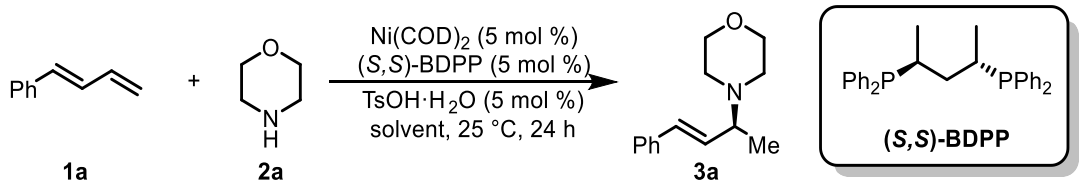


Synthesis of (*E*)-hexa-3,5-dien-1-ylbenzene (1j) (Adamson & Malcolmson, 2017): To a solution of diethyl allylphosphonate (4.28 g, 24 mmol, 1.2 equiv) in anhydrous THF (45 mL) was added dropwise *n*BuLi (2.5 M in hexanes, 9.6 mL, 24 mmol, 1.2 equiv) at -78 °C. After stirring for 45 min, a solution of phenylpropyl aldehyde (2.6 mL, 20 mmol, 1.0 equiv) in DMPU (2.4 mL, 20 mmol, 1.0 equiv) was added dropwise via cannula. The resulting solution was stirred for 2 h at -78 °C, and then allowed to warm to room temperature. Stirring was continued overnight at room temperature before quenching with saturated aqueous NH_4Cl solution. The mixture was extracted with diethyl ether (3×45 mL). The combined organic phases were washed with brine (100 mL), dried (Na_2SO_4) and concentrated to afford the crude product. Purification by flash chromatography (PE as eluent) gave the desired diene **1j** (1.23 g, 39% yield) as a colorless oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.30-7.26 (m, 2H), 7.20-7.17 (m, 3H), 6.35-6.26 (m, 1H), 6.12-6.05 (m, 1H), 5.78-5.71 (m, 1H), 5.12-5.07 (m, 1H), 4.99-4.96 (m, 1H), 2.73-2.69 (m, 2H), 2.44-2.38 (m, 2H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 141.7, 137.1, 134.2, 131.4, 128.4, 128.3, 125.8, 115.2, 35.6, 34.4 ppm.

Reaction Optimization

A reaction vial was charged with $Ni(COD)_2$ (2.8 mg, 0.01 mmol, 0.05 equiv *vs* amine), ligand (0.01 mmol, 0.05 equiv *vs* amine), morpholine (17 μL, 0.2 mmol, 1.0 equiv), 1-phenylbutadiene (40 μL, 0.3 mmol, 1.5 equiv), and 1.0 mL of solvent (toluene, THF, MTBE, EA, *n*-hexane, *i*-PrOH, CH_3CN or PhCN) in an argon-filled glovebox, then acid (0.00-0.20 equiv vs amine) was added. The reaction vessel was sealed using a PTFE septum and removed from the glovebox, and the mixture was stirred at 25 °C for 24 h. Yields were determined by gas chromatogram analysis, using naphthalene as the internal standard. The ee values were determined by HPLC on a chiral stationary phase.

Table S1. Solvent screening for the Ni-catalyzed asymmetric hydroamination of **1a**, related to **Figure 2**.[a]

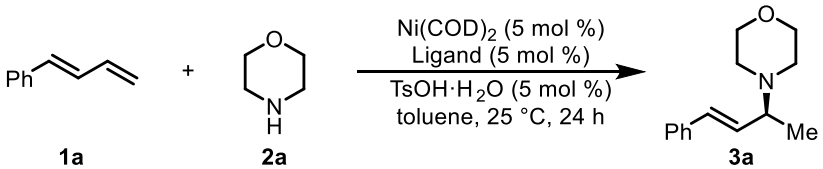


1a **2a** **3a**

Entry	Solvent	Yield [%][b]	ee [%][c]
1	*i*-PrOH	trace	ND[d]
2	PhMe	90	23
3	THF	42	9
4	MTBE	trace	ND
5	EtOAc	trace	ND
6	CH_3CN	trace	ND
7	PhCN	53	14
8	*n*-hexane	NP[e]	ND

[a] Unless otherwise noted, all reactions were carried out with 0.10 mmol amine, 0.15 mmol diene, 5.0 mol % $Ni(COD)_2$, 5.0 mol % (*S,S*)-BDPP, 5.0 mol % $TsOH·H_2O$ in 1 mL solvent at 25 °C for 24 h. [b] Yield was determined by gas chromatogram analysis, using naphthalene as the internal standard. [c] Determined by HPLC analysis using a chiral stationary phase. [d] Not determined. [e] No product.

Table S2. Ligand screening for Ni-catalyzed asymmetric hydroamination of **1a**, related to **Figure 2**.[a]

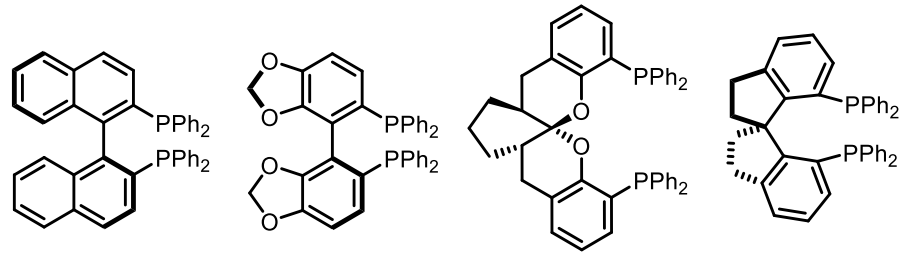


1a **2a** **3a**

Entry	Ligand	Yield [%][b]	ee [%][c]
1	**L1**	65	30
2	**L2**	42	21

3	**L3**	trace	ND[d]
4	**L4**	trace	ND
5	**L5**	24	12
6	**L6**	90	23
7	**L7**	86	84
8	**L8**	30	98
9[e]	**L8**	69[f]	98

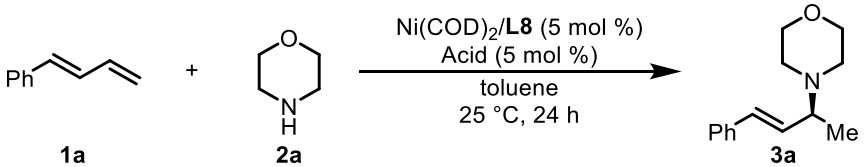
[a] Unless otherwise noted, all reactions were carried out with 0.10 mmol amine, 0.15 mmol diene, 5.0 mol % $Ni(COD)_2$, 5.0 mol % ligand, 5.0 mol % $TsOH·H_2O$ in 1 mL toluene at 25 °C for 24 h. [b] Yield was determined by gas chromatogram analysis, using naphthalene as the internal standard. [c] Determined by HPLC analysis using a chiral stationary phase. [d] Not determined. [e] The catalyst was stirred at room temperature one hour in advance. [f] Isolated yield.



L1: (*S*)-BINAP **L2**: (*S*)-SegPhos **L3**: (*S*)-SKP **L4**: (*R*)-SDP

L5: (*R*)-DIOP **L6:** (*S,S*)-BDPP **L7**: (R_C,S_P)-DuanPhos **L8**: (*S*,*S*)-Me-DuPhos

Table S3. Acid additives screening for Ni-catalyzed asymmetric hydroamination of **1a**, related to **Figure 2**.[a]

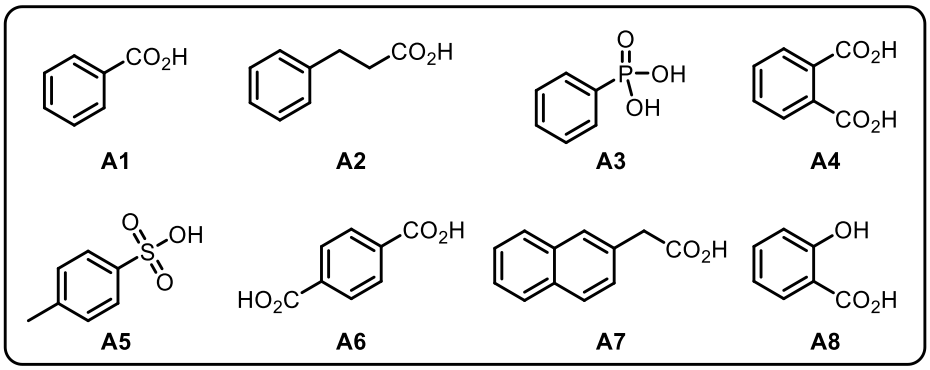


1a **2a** **3a**

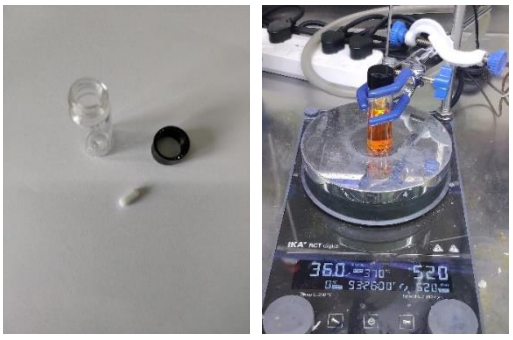
Entry	Acid	Yield[%][b]	ee[%][c]
1	**A1**	86	86
2	**A2**	86	98
3	**A3**	98	98
4	**A4**	94[d]	96

5	**A5**	85	95
6	**A6**	89	96
7	**A7**	72	90
8	**A8**	83	93
9[e]	**A3**	99	98
10[e]	**A4**	99	96

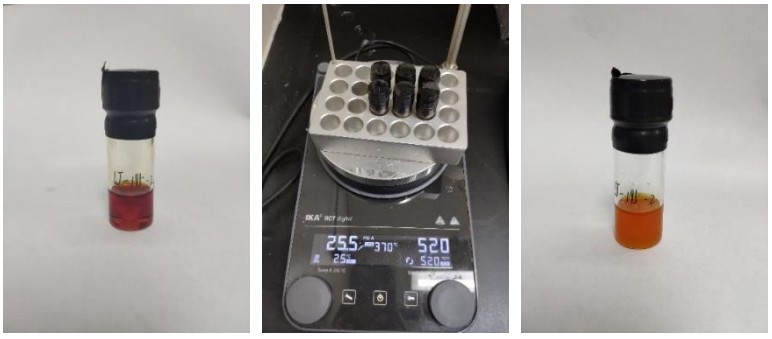
[a] Unless otherwise noted, all reactions were carried out with 0.20 mmol diene, 0.40 mmol amine, 5.0 mol % $Ni(COD)_2$/(*S,S*)-Me-DuPhos, 5.0 mol % acid in 1 mL toluene at 25 °C for 24 h; The catalyst was stirred at room temperature one hour in advance. [b] Yield was determined by gas chromatogram analysis, using naphthalene as the internal standard. [c] Determined by HPLC analysis using a chiral stationary phase. [d] Isolated yield. [e] With 0.30 mmol amine.



General Procedure for Ni-catalyzed Asymmetric Hydroamination of Conjugated Dienes

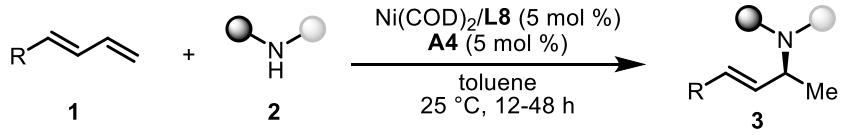


catalyst solution



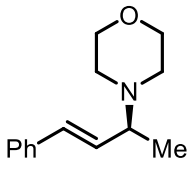
before reaction **after reaction**

Scheme S3 (related to **Figure 3**, **Figure 4** and **Figure 5**):

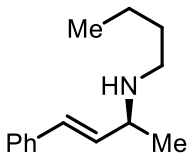


A stock solution was made by mixing $Ni(COD)_2$ with **L8** in a 1:1 molar ratio in toluene (0.01 M) at room temperature for 1 h in a argon-filled glovebox. An aliquot of the catalyst solution (1.0 mL, 0.01 mmol) was transferred by syringe into the vials charged with different 1,3-dienes (0.2 mmol for each) and amines (0.3 mmol for each), and then 0.01 mmol **A4** was added. The reaction vessel was sealed using a PTFE septum and removed from the glovebox, and the mixture was stirred at 25 °C for 12-48 h. The product was purified by column chromatography on deactivated silica gel using PE/EtOAc. The ee values of all compounds **3** were determined by HPLC on a chiral stationary phase.

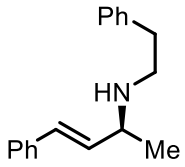
(*S,E*)-4-(4-phenylbut-3-en-2-yl)morpholine (3a): with **A3**, 12 h, obtained pale yellow oil 43.4 mg; Isolated yield: 99%; 98% ee; $[\alpha]_D^{25}$ = -72.0 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OD-H column, hexane: isopropanol = 90:10, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 11.4 min (minor), 14.4 min (major); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.39-7.36 (m, 2H), 7.33-7.29 (m, 2H), 7.25-7.21 (m, 1H), 6.47 (d, *J* = 15.9 Hz, 1H), 6.17 (dd, *J* = 15.9, 8.2 Hz, 1H), 3.73 (t, *J* = 4.7 Hz, 4H), 3.05-2.99 (m, 1H), 2.61-2.52 (m, 4H), 1.26 (d, *J* = 6.6 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 136.8, 132.0, 131.2, 128.6, 127.5, 126.2 , 67.2, 63.1, 50.8, 17.8 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{14}H_{19}NNaO$ = 240.1359**,** found: 240.1359.



(*S,E*)-N-butyl-4-phenylbut-3-en-2-amine (3b): with **A4**, 24 h**,** obtained colorless oil 37.7 mg; Isolated yield: 93%; > 99% ee; $[\alpha]_D^{25}$ = -60.3 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak AD-H column, hexane: isopropanol = 99:1, flow rate = 0.6 mL/min, UV detection at 254 nm, t_R = 9.2 min (major), 9.7 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.39-7.36 (m, 2H), 7.33-7.29 (m, 2H), 7.24-7.19 (m, 1H), 6.46 (d, *J* = 15.9 Hz, 1H), 6.08 (dd, *J* = 15.9, 8.0 Hz, 1H), 3.39-3.32 (m, 1H), 2.67-2.53 (m, 2H), 1.52-1.43 (m, 2H), 1.38-1.29 (m, 2H), 1.25 (d, *J* = 6.5 Hz, 3H), 0.91 (t, *J* = 7.3 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 137.1, 134.4, 129.7, 128.5, 127.2, 126.2, 56.4, 47.3, 32.4, 22.0, 20.5, 14.0 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{14}H_{21}NNa$ = 226.1566**,** found: 226.1565.

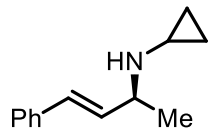


(*S*,*E*)-N-phenethyl-4-phenylbut-3-en-2-amine (3c): with **A4**, 24 h**,** obtained pale yellow oil



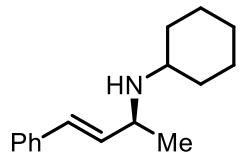
50.3 mg; Isolated yield: 99%; 92% ee; $[\alpha]_D^{25}$ = -76.8 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak AD-H column, hexane: isopropanol = 99:1, flow rate = 0.6 mL/min, UV detection at 254 nm, t_R = 13.9 min (major), 15.0 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.37-7.34 (m, 2H), 7.32-7.26 (m, 4H), 7.23-7.18 (m, 4H), 6.44 (d, *J* = 15.9 Hz, 1H), 6.05 (dd, *J* = 15.9, 8.0 Hz, 1H), 3.41-3.34 (m, 1H), 2.96-2.79 (m, 4H), 1.23 (d, *J* = 6.5 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 139.9, 136.9, 133.9, 129.9, 128.7, 128.5, 128.4, 127.3, 126.2, 126.1, 56.2, 48.8, 36.4, 21.9 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{18}H_{21}NNa$ = 274.1566**,** found: 274.1563.

(*S*,*E*)-N-(4-phenylbut-3-en-2-yl)cyclopropanamine (3d): with **A4**, 24 h**,** obtained colorless oil



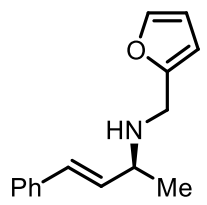
22.9 mg; Isolated yield: 61%; > 99% ee; $[\alpha]_D^{25}$ = -91.8 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OJ-H column, hexane: isopropanol = 95:5, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 10.5 min (major), 10.9 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.39-7.37 (m, 2H), 7.33-7.29 (m, 2H), 7.24-7.20 (m, 1H), 6.49 (d, *J* = 15.9 Hz, 1H), 6.12 (dd, *J* = 15.9, 7.9 Hz, 1H), 3.52-3.45 (m, *J* = 6.7 Hz, 1H), 2.18-2.13 (m, 1H), 2.02 (br, s 1H), 1.25 (d, *J* = 6.5 Hz, 3H), 0.47-0.33 (m, 4H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 137.2, 134.4, 129.4, 128.5, 127.2, 126.2, 56.5, 28.6, 21.8, 6.6, 6.4 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{13}H_{17}NNa$ = 210.1253**,** found: 210.1254.

(*S*,*E*)-N-(4-phenylbut-3-en-2-yl)cyclohexanamine (3e): with **A4**, 24 h**,** obtained pale yellow



oil 34.9 mg; Isolated yield: 76%; 92% ee; $[\alpha]_D^{25}$ = -66.1 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak AD-H column, hexane: isopropanol = 99:1, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 11.0 min (major), 12.1 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.49-7.37 (m, 2H), 7.33-7.29 (m, 2H), 7.24-7.20 (m, 1H), 6.44 (d, *J* = 15.9 Hz, 1H), 6.07 (dd, *J* = 15.9, 8.1 Hz, 1H), 3.59-3.52 (m, 1H), 2.55-2.48 (m, 1H), 2.01-1.97 (m, 1H), 1.84-1.58 (m, 3H), 1.69 (br, s, 1H), 1.26-0.98 (m, 9H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 137.1, 134.8, 129.3, 128.5, 127.2, 126.2, 53.5, 52.5, 34.4, 33.2, 26.1, 25.3, 25.0, 22.5 ppm. **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{16}H_{23}NNa$ = 252.1723**,** found: 252.1722.

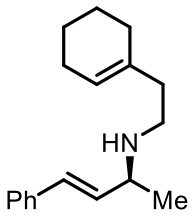
(*S,E*)-N-(furan-2-ylmethyl)-4-phenylbut-3-en-2-amine (3f): with **A4**, 24 h**,** obtained pale



yellow oil 45.5 mg; Isolated yield: 99%; 99% ee; $[\alpha]_D^{25}$ = -49.2 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OD-H column, hexane: isopropanol = 99:1, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 17.0 min (minor), 20.0 min (major); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.40-7.36 (m, 3H), 7.33-7.30 (m, 2H), 7.25-7.21 (m, 1H), 6.49 (d, *J* = 15.9 Hz, 1H), 6.31 (dd, *J* = 3.1, 1.9 Hz,1H), 6.16 (dd, *J* = 3.1, 0.5 Hz, 1H), 6.07 (dd, *J* = 15.9, 8.1 Hz, 1H), 3.83 (d, *J* = 14.4 Hz, 1H), 3.73 (d, *J* = 14.4 Hz, 1H), 3.42-3.35 (m, 1H),

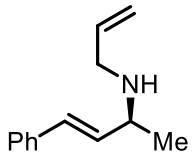
1.26 (d, *J* = 6.4 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 153.9, 141.8, 137.0, 133.7, 130.5, 128.5, 127.4, 126.3, 110.1, 106.8, 55.3, 43.8, 22.0 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{15}H_{18}NO$ = 228.1383**,** found: 228.1380.

(*S,E*)-N-(2-(cyclohex-1-en-1-yl)ethyl)-4-phenylbut-3-en-2-amine (3g): with **A4**, 24 h**,**



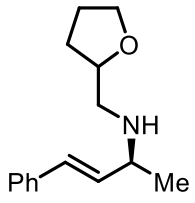
obtained pale yellow oil 50.9 mg; Isolated yield: 99%; 96% ee; $[\alpha]_D^{25}$ = -66.1 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak AD-H column, hexane: isopropanol = 95:5, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 11.0 min (minor), 11.6 min (major); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.39-7.36 (m, 2H), 7.33-7.29 (m, 2H), 7.24-7.20 (m, 1H), 6.46 (d, *J* = 15.9 Hz, 1H), 6.07 (dd, *J* = 15.9, 8.0 Hz, 1H), 5.48-5.45 (m, 1H), 3.38-3.31 (m, 1H), 2.74-2.59 (m, 2H), 2.14 (t, *J* = 6.9 Hz, 2H), 2.01-1.97 (m, 2H), 1.92-1.88 (m, 2H), 1.64-1.51 (m, 4H), 1.46 (br, s, 1H), 1.24 (d, *J* = 6.5 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ137.1, 135.4, 134.4, 129.7, 128.5, 127.2, 126.2, 122.8, 56.2, 45.2, 38.4, 28.1, 25.2, 22.9, 22.4, 22.1 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{18}H_{26}N$ = 256.2060**,** found: 256.2057.

(*S,E*)-N-allyl-4-phenylbut-3-en-2-amine (3h): with **A4**, 24 h**,** obtained pale yellow oil 29.1 mg;



Isolated yield: 78%; > 99% ee; $[\alpha]_D^{25}$ = -60.4 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OJ-H column, hexane: isopropanol = 99:1, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 11.9 min (major), 12.7 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.39-7.37 (m, 2H), 7.33-7.29 (m, 2H), 7.24-7.20 (m, 1H), 6.46 (d, *J* = 15.9 Hz, 1H), 6.06 (dd, *J* = 15.9, 8.1 Hz, 1H), 5.97-5.87 (m, 1H), 5.20-5.15 (m, 1H), 5.12-5.08 (m, 1H), 3.44-3.36 (m, 1H), 3.34-3.28 (m, 1H), 3.24-3.18 (m, 1H), 1.86 (br, s, 1H), 1.26 (d, *J* = 6.5 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 137.0, 136.8, 133.9, 130.1, 128.5, 127.3, 126.2, 115.9, 55.6, 50.0, 22.0 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{13}H_{17}NNa$ = 210.1253**,** found: 210.1258.

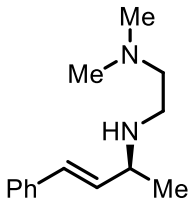
(*2S,E*)-4-phenyl-N-((tetrahydrofuran-2-yl)methyl)but-3-en-2-amine (3i): with **A4**, 24 h**,**



obtained pale yellow oil 46.4 mg; Isolated yield: 99%; 99% ee; dr = 1:1; $[\alpha]_D^{25}$ = -53.1 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak AD-H column, hexane: isopropanol = 99:1, flow rate = 0.6 mL/min, UV detection at 254 nm, t_{R1} = 15.3 min (major), 16.9 min (minor), t_{R2} = 19.8 min (minor), 21.2 min (major); **3i**: **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.39-7.37 (m, 2H), 7.33-7.29 (m, 2H), 7.24-7.20 (m, 1H), 6.50 (d, *J* = 5.7 Hz, 1H), 6.08 (dd, *J* = 8.1, 3.2 Hz, 1H), 4.08-3.98 (m, 1H), 3.88-3.82 (m, 1H), 3.78-3.72 (m, 1H), 3.45-3.38 (m, 1H), 2.77 (dd, *J* = 11.9, 3.4 Hz, 1H), 2.68 (d, *J* = 1.9 Hz, 1H), 2.02-1.84 (m, 3H), 1.58-1.46 (m, 1H), 1.29 (d, *J* = 3.3 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 136.9, 133.7, 130.4, 128.5, 127.3, 126.3, 78.5, 67.9, 56.8, 52.3, 29.4, 25.7, 21.9 ppm; **3i′: ^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.39-7.37 (m, 2H), 7.33-7.29 (m, 2H), 7.24-7.20 (m, 1H), 6.46 (d, *J* = 5.7 Hz, 1H), 6.12 (dd, *J* = 8.1, 3.2 Hz, 1H), 4.08-3.98 (m, 1H), 3.88-3.82 (m, 1H), 3.78-3.72 (m, 1H), 3.45-3.38 (m, 1H),

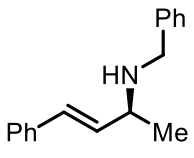
2.70 (s, 1H), 2.58 (dd, *J* = 11.9, 8.5 Hz, 1H) , 2.02-1.84 (m, 3H), 1.58-1.46 (m, 1H), 1.27 (d, *J* = 3.3 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 136.9, 133.7, 130.2, 128.5, 127.3, 126.3, 77.9, 67.9, 56.2, 51.7, 29.3, 25.7, 21.8 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{15}H_{22}NO$ = 232.1696**,** found: 232.1693.

(*S*,*E*)-N^1,N^1-dimethyl-N^2-(4-phenylbut-3-en-2-yl)ethane-1,2-diamine (3j): with **A4**, 24 h**,**



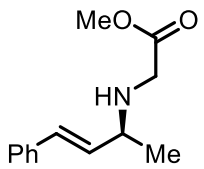
obtained pale yellow oil 42.0 mg; Isolated yield: 96%; 97% ee; $[\alpha]_D^{25}$ = -71.1 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by (converting it to compound **Bz-3j)** HPLC on Chiralpak AS-H column, hexane: isopropanol = 90:10, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 43.1 min (major), 50.8 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.39-7.37 (m, 2H), 7.32-7.29 (m, 2H), 7.24-7.20 (m, 1H), 6.47 (d, *J* = 15.9 Hz, 1H), 6.08 (dd, *J* = 15.9, 8.0 Hz, 1H), 3.39-3.32 (m, 1H), 2.78-2.62 (m, 2H), 2.46-2.43 (m, 3H), 2.22 (s, 6H), 1.27 (d, *J* = 6.5 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 137.0, 134.0, 130.0, 128.5, 127.3, 126.2, 59.0, 56.5, 45.4, 44.7, 22.0 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{14}H_{23}N_2$ = 219.1856**,** found: 219.1856.

(*S*,*E*)-N-benzyl-4-phenylbut-3-en-2-amine (3k): with **A4**, 24 h**,** obtained pale yellow oil 43.3



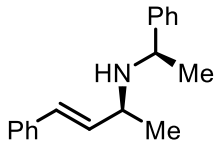
mg; Isolated yield: 91%; 95% ee; $[\alpha]_D^{25}$ = -99.5 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak AD-H column, hexane: isopropanol = 95:5, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 11.3 min (major), 12.2 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.40-7.38 (m, 2H), 7.33-7.30 (m, 6H), 7.27-7.20 (m, 2H), 6.48 (d, *J* = 15.9 Hz, 1H), 6.11 (dd, *J* = 15.9, 8.0 Hz, 1H), 3.85 (d, *J* = 13.1 Hz, 1H) 3.73 (d, *J* = 13.1 Hz, 1H), 3.44-3.37 (m, 1H), 1.27 (d, *J* = 6.5 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 140.5, 137.1, 134.2, 130.1, 128.5, 128.4, 128.1, 127.3, 126.9, 126.3, 55.5, 51.5, 22.1 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{17}H_{19}NNa$ = 260.1410**,** found: 260.1405.

methyl (*S*,*E*)-(4-phenylbut-3-en-2-yl)glycinate (3l): with **A3**, 48 h**,** obtained pale yellow oil

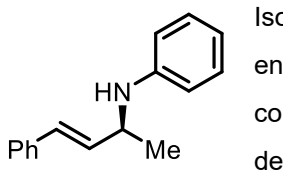


35.1 mg; Isolated yield: 80%; > 99% ee; $[\alpha]_D^{25}$ = -154.7 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak AD-H column, hexane: isopropanol = 99:1, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 27.2 min (major), 28.4 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.38-7.35 (m, 2H), 7.32-7.29 (m, 2H), 7.24-7.20 (m, 1H), 6.45 (d, *J* = 15.8 Hz, 1H), 6.01 (dd, *J* = 15.8, 8.2 Hz, 1H), 3.69 (s, 3H), 3.42 (d, *J* = 3.1 Hz, 2H), 3.39-3.32 (m, 1H), 2.17 (br, s, 1H), 1.27 (d, *J* = 6.5 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 173.2, 136.8, 133.2, 130.7, 128.5, 127.5, 126.3, 56.2, 51.8, 48.4, 22.0 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{13}H_{18}NO_2$ = 220.1332**,** found: 220.1331.

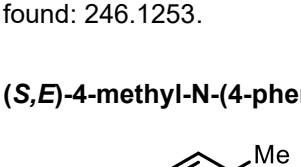
(*S*,*E*)-4-phenyl-N-((*R*)-1-phenylethyl)but-3-en-2-amine (3m): with **A4**, 48 h**,** obtained pale yellow oil 28.2 mg; Isolated yield: 56%; > 20:1 dr; $[\alpha]_D^{25}$ = -55.3 (c = 1.0, $CHCl_3$); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.34-7.27 (m, 8H), 7.25-7.19 (m, 2H), 6.42 (d, *J* = 15.9 Hz, 1H), 6.07 (dd, *J* = 15.9, 7.7 Hz, 1H), 3.95-3.90 (m, 1H), 3.38-3.31 (m, 1H), 1.76 (br, s, 1H), 1.37 (d, *J* = 6.6 Hz, 3H), 1.22 (d, *J* = 6.4 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 145.8, 137.1, 134.6, 129.2, 128.5, 127.2, 126.8, 126.5, 126.2, 54.8, 53.0, 23.7, 21.2 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{18}H_{21}NNa$ = 274.1566**,** found: 274.1566.



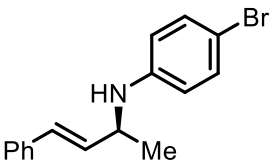
(*S*,*E*)-N-(4-phenylbut-3-en-2-yl)aniline (3n): with **A3**, 24 h, obtained colorless oil 34.7 mg; Isolated yield: 78%; 86% ee; $[\alpha]_D^{25}$ = -80.6 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OD-H column, hexane: isopropanol = 95:5, flow rate = 1.0 mL/min, UV detection at 254 nm, t_R = 11.6 min (major), 13.4 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.36-7.34 (m, 2H), 7.30-7.27 (m, 2H), 7.22-7.13 (m, 3H), 6.70-6.63 (m, 3H), 6.57 (d, *J* = 16.0 Hz, 1H), 6.21 (dd, *J* = 16.0, 5.8 Hz, 1H), 4.17-4.11 (m, 1H), 1.40 (d, *J* = 6.6 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 147.4, 136.9, 133.2, 129.2, 129.1, 128.5, 127.3, 126.3, 117.3, 113.4, 50.8, 22.1 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{16}H_{17}NNa$ = 246.1253**,** found: 246.1253.



(*S*,*E*)-4-methyl-N-(4-phenylbut-3-en-2-yl)aniline (3o): with **A4**, 48 h, obtained reddish orange oil 10.8 mg (or with **A3,** 36 h**,** obtained reddish orange oil 43.9 mg); Isolated yield: 23% (or 93%); 93% (or 73%) ee; $[\alpha]_D^{25}$ = -99.5 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak AD-H column, hexane: isopropanol = 95:5, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 14.6 min (major), 16.5 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.36-7.34 (m, 2H), 7.31-7.27 (m, 2H), 7.22-7.18 (m, 1H), 6.97 (d, *J* = 8.2 Hz, 2H), 6.59-6.55 (m, 3H), 6.21 (dd, *J* = 16.0, 5.9 Hz, 1H), 4.14-4.08 (m, 1H), 2.22 (s, 3H), 1.39 (d, *J* = 6.6 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 145.1, 136.9, 133.4, 129.6, 129.1, 128.5, 127.3, 126.5, 126.3, 113.6, 51.1, 22.1, 20.4 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{17}H_{19}NNa$ = 260.1410**,** found: 260.1405.

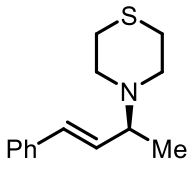


(*S*,*E*)-4-bromo-N-(4-phenylbut-3-en-2-yl)aniline (3p): with **A3**, 36 h**,** obtained reddish orange oil 29.2 mg; Isolated yield: 48%; 92% ee; $[\alpha]_D^{25}$ = -111.6 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OD-H column, hexane: isopropanol = 95:5, flow rate = 1.0 mL/min, UV detection at 254 nm, t_R = 13.5 min (minor), 17.2 min (major); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.35-7.32 (m, 2H), 7.31-7.27 (m, 2H), 7.24-7.19 (m, 3H), 6.56-6.49 (m, 3H), 6.16 (dd, *J* = 16.0, 5.8 Hz, 1H), 4.12-4.05 (m, 1H), 3.75 (br, s, 1H), 1.40 (d, *J* = 6.7 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 146.3, 136.7, 132.5, 131.8, 129.5, 128.5,

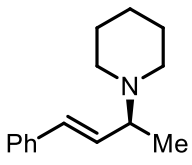


127.5, 126.3, 114.9, 108.8, 50.9, 22.0 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{16}H_{17}BrN$ = 302.0539**,** found: 302.0524.

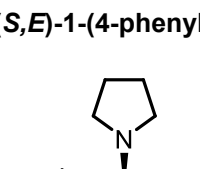
(*S*,*E*)-4-(4-phenylbut-3-en-2-yl)thiomorpholine (3q): with **A4,** 24 h**,** obtained colorless oil 42.9 mg; Isolated yield: 92%; 96% ee; $[\alpha]_D^{25}$ = -59.0 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OD-H column, hexane: isopropanol = 90:10, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 8.7 min (minor), 9.7 min (major); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.39-7.37 (m, 2H), 7.33-7.30 (m, 2H), 7.25-7.21 (m, 1H), 6.44 (d, *J* = 16.0 Hz, 1H), 6.21 (dd, *J* = 16.0, 7.2 Hz, 1H), 3.27-3.20 (m, 1H), 2.90-2.80 (m, 4H), 2.69 (t, *J* = 5.0 Hz, 4H), 1.25 (d, *J* = 6.7 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 136.9, 131.7, 130.9, 128.5, 127.4, 126.2, 62.7, 51.6, 28.3, 16.3 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{14}H_{19}NNaS$ = 256.1130**,** found: 256.1130.



(*S*,*E*)-1-(4-phenylbut-3-en-2-yl)piperidine (3r): with **A4**, 24 h**,** obtained pale yellow oil 40.8 mg; Isolated yield: 95%; 95% ee; $[\alpha]_D^{25}$ = -55.7 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OD-H column, hexane: isopropanol = 99:1, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 8.6 min (minor), 9.8 min (major); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.39-7.37 (m, 2H), 7.32-7.29 (m, 2H), 7.24 -7.19 (m, 1H), 6.43 (d, *J* = 16.0 Hz, 1H), 6.24 (dd, *J* = 15.9, 8.0 Hz, 1H), 3.11-3.05 (m, 1H), 2.52-2.50 (m, 4H), 1.63-1.57 (m, 4H), 1.46-1.42 (m, 2H), 1.26 (d, *J* = 6.6 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 137.2, 132.7, 130.5, 128.5, 127.2, 126.2, 63.0, 51.0, 26.2, 24.6, 17.7 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{15}H_{21}NNa$ = 238.1566**,** found: 238.1568.



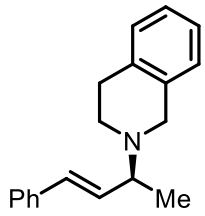
(*S*,*E*)-1-(4-phenylbut-3-en-2-yl)pyrrolidine (3s): with **A4**, 24 h**,** obtained pale yellow oil 36.7 mg; Isolated yield: 91%; 97% ee; $[\alpha]_D^{25}$ = -92.4 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OD-H column, hexane: isopropanol = 95:5, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 7.6 min (minor), 8.1 min (major); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.38-7.36 (m, 2H), 7.32-7.28 (m, 2H), 7.23-7.19 (m, 1H), 6.47 (d, *J* = 15.9 Hz, 1H), 6.24 (dd, *J* = 15.8, 8.6 Hz, 1H), 2.95-2.88 (m, 1H), 2.61-2.55 (m, 4H), 1.81-1.78 (m, 4H), 1.30 (d, *J* = 6.5 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 137.1, 133.9, 129.6, 128.5, 127.2, 126.2, 63.1, 52.2, 23.3, 21.0 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{14}H_{19}NNa$ = 224.1410**,** found: 224.1410.



(*S*,*E*)-1-(4-phenylbut-3-en-2-yl)indoline (3t): with **A3**, 24 h**,** obtained pale yellow oil 43.6 mg; Isolated yield: 87%; 97% ee; $[\alpha]_D^{25}$ = -109.4 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OD-H column, hexane: isopropanol = 95:5, flow rate = 0.5 mL/min; UV detection at 254 nm, t_R = 13.8 min (major), 14.6 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.37-7.34 (m, 2H), 7.31-7.27 (m, 2H), 7.23-7.19 (m, 1H), 7.07-7.02 (m, 2H), 6.64-6.60 (m, 1H),

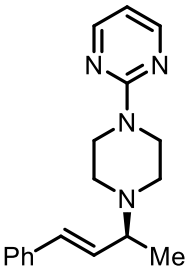
6.57-6.52 (m, 2H), 6.32 (dd, *J* = 16.1, 5.6 Hz, 1H), 4.39-4.33 (m, 1H), 3.46-3.36 (m, 2H), 2.95 (t, *J* = 8.4 Hz, 2H), 1.40 (d, *J* = 6.9 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 151.0, 136.9, 130.7, 130.4, 130.3, 128.5, 127.4, 127.2, 126.3, 124.4, 117.2, 107.6, 52.2, 47.3, 28.2, 16.1 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{18}H_{19}NNa$ = 272.1410**,** found: 272.1412.

(*S,E*)-2-(4-phenylbut-3-en-2-yl)-1,2,3,4-tetrahydroisoquinoline (3u): with **A4**, 24 h**,** obtained



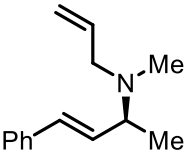
pale yellow oil 52.6 mg; Isolated yield: 99%; > 99% ee; $[\alpha]_D^{25}$ = -51.5 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OD-H column, hexane: isopropanol = 95:5, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 11.0 min (minor), 14.5 min (major); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.41-7.39 (m, 2H), 7.34-7.30 (m, 2H), 7.24-7.22 (m, 1H), 7.12-7.07 (m, 3H), 7.03-7.01 (m, 1H), 6.53 (d, *J* = 16.0 Hz, 1H), 6.30 (dd, *J* = 16.0, 7.9 Hz, 1H), 3.83-3.74 (m, 2H), 3.34-3.27 (m, 1H), 2.97-2.90 (m, 3H), 2.84-2.73 (m, 1H), 1.37 (d, *J* = 6.6 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 137.0, 134.9, 134.4, 132.3, 130.9, 128.6, 128.5, 127.4, 126.8, 126.3, 126.0, 125.5, 61.9, 53.0, 47.3, 29.4, 17.9 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{19}H_{21}NNa$ = 286.1566**,** found: 286.1563.

(*S,E*)-2-(4-(4-phenylbut-3-en-2-yl)piperazin-1-yl)pyrimidine (3v): with **A4**, 48 h**,** obtained



pale yellow oil 58.9 mg; Isolated yield: 99%; 95% ee; $[\alpha]_D^{25}$ = -68.1 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak AD-H column, hexane: isopropanol = 95:5, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 12.7 min (major), 15.2 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.29 (d, *J* = 4.7 Hz, 2H), 7.39-7.36 (m, 2H), 7.33-7.29 (m, 2H), 7.24-7.20 (m, 1H), 6.49-6.45 (m, 2H), 6.22 (dd, *J* = 15.9, 8.0 Hz, 1H), 3.84 (t, *J* = 5.2 Hz, 4H), 3.16-3.09 (m, 1H), 2.68-2.58 (m, 4H), 1.30 (d, *J* = 6.6 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 161.6, 157.7, 136.9, 132.1, 131.1, 128.6, 127.4, 126.3, 109.7, 62.6, 49.9, 43.9, 17.8 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{18}H_{22}N_4Na$ = 317.1737**,** found: 317.1730.

(*S,E*)-N-allyl-N-methyl-4-phenylbut-3-en-2-amine (3w): with **A4**, 24 h**,** obtained pale yellow



oil 33.2 mg; Isolated yield: 82%; 99% ee; $[\alpha]_D^{25}$ = -49.2 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OD-H column, hexane: isopropanol = 99:1, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 8.0 min (minor), 9.3 min (major); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.39-7.36 (m, 2H), 7.33-7.28 (m, 2H), 7.24-7.20 (m, 1H), 6.45 (d, *J* = 16.0 Hz, 1H), 6.22 (dd, *J* = 16.0, 7.6 Hz, 1H), 5.93-5.83 (m, 1H), 5.20-5.11 (m, 2H), 3.34-3.27 (m, 1H), 3.19-3.13 (m, 1H), 3.09-3.03 (m, 1H), 2.25 (s, 3H), 1.25 (d, *J* = 6.7 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 137.2, 136.3, 131.9, 130.8, 128.5, 127.3, 126.3, 117.3, 60.4, 57.4, 37.7, 17.2 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{14}H_{19}NNa$ = 224.1410**,** found: 224.1412.

(*S,E*)-N-benzyl-N-methyl-4-phenylbut-3-en-2-amine (3x): with **A3**, 24 h**,** obtained pale yellow oil 44.2 mg; Isolated yield: 88%; 98% ee; $[\alpha]_D^{25}$ = -91.9 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OD-H column, hexane: isopropanol = 90:10, flow rate = 1.0 mL/min, UV detection at 254 nm, t_R = 5.0 min (minor), 6.0 min (major); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.41-7.39 (m, 2H), 7.36-7.30 (m, 6H), 7.26-7.21 (m, 2H), 6.47 (d, *J* = 16.1 Hz, 1H), 6.31 (dd, *J* = 16.0, 7.3 Hz, 1H), 3.65 (d, *J* = 13.2 Hz, 1H), 3.51 (d, *J* = 13.2 Hz, 1H), 3.39-3.32 (m, 1H), 2.22 (s, 3H), 1.30 (d, *J* = 6.7 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 139.8, 137.2, 132.0, 130.8, 128.9, 128.5, 128.2, 127.3, 126.8, 126.2, 60.4, 58.2, 37.9, 16.9 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{18}H_{21}NNa$ = 274.1566**,** found: 274.1563.

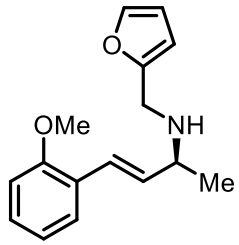
(*S,E*)-N,N-dibenzyl-4-phenylbut-3-en-2-amine (3y): with **A3**, 24 h**,** obtained pale yellow oil 34.6 mg**;** Isolated yield: 53%; 96% ee; $[\alpha]_D^{25}$ = -193.7 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OD-H column, hexane: isopropanol = 95:5, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 7.6 min (major), 10.5 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.42-7.38 (m, 6H), 7.34-7.29 (m, 6H), 7.24-7.20 (m, 3H), 6.43 (d, *J* = 16.2 Hz, 1H), 6.32 (dd, *J* = 16.1, 6.6 Hz, 1H), 3.71 (d, *J* = 13.9 Hz, 2H), 3.59 (d, *J* = 13.9 Hz, 2H), 3.51-3.44 (m, 1H), 1.29 (d, *J* = 6.8 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 140.6, 137.3, 131.6, 130.9, 128.52, 128.50, 128.2, 127.2, 126.7, 126.2, 54.8, 53.7, 15.8 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{24}H_{25}NNa$ = 350.1879**,** found: 350.1873.

(*S,E*)-N,N-diethyl-4-phenylbut-3-en-2-amine (3z): with **A3**, 36 h**,** obtained pale yellow oil 11.0 mg; Isolated yield: 27%; 96% ee; $[\alpha]_D^{25}$ = -26.8 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OJ-H column, hexane: isopropanol = 95:5, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 7.7 min (minor), 8.0 min (major); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.39-7.37 (m, 2H), 7.33-7.29 (m, 2H), 7.24-7.20 (m, 1H), 6.44 (d, *J* = 16.0 Hz, 1H), 6.24 (dd, *J* = 16.0, 7.5 Hz, 1H), 3.50-3.43 (m, 1H), 2.69-2.53 (m, 4H), 1.24 (d, *J* = 6.6 Hz, 3H), 1.06 (t, *J* = 7.2 Hz, 6H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 137.2, 133.0, 130.0, 128.5, 127.2, 126.2, 57.5, 43.4, 17.4, 12.8 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{14}H_{21}NNa$ = 226.1566**,** found: 226.1568.

(*S,E*)-N-methyl-N-(4-phenylbut-3-en-2-yl)aniline (3aa): with **A3**, 36 h**,** obtained pale yellow oil 10.4 mg; Isolated yield: 22%; 90% ee; $[\alpha]_D^{25}$ = -169.9 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OJ-H column, hexane: isopropanol = 95:5, flow rate = 1.0 mL/min, UV detection at 254 nm, t_R = 11.7 min (major), 15.0 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.38-7.35 (m, 2H), 7.32-7.20 (m, 5H), 6.86-6.83 (m, 2H), 6.75-6.71 (m, 1H), 6.48 (dd, *J* = 16.2, 1.9 Hz, 1H), 6.30 (dd, *J* = 16.2, 4.4 Hz, 1H), 4.69-4.62 (m, 1H), 2.79 (s, 3H), 1.37 (d, *J* = 6.8 Hz, 3H) ppm;

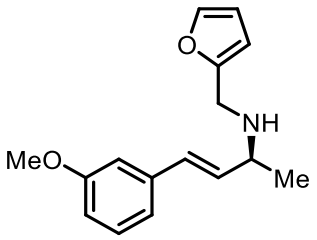
^{13}C NMR (100 MHz, $CDCl_3$) δ 150.0, 137.1, 131.3, 130.0, 129.2, 128.6, 127.4, 126.3, 116.8, 113.4, 54.9, 31.7, 16.2 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{17}H_{19}NNa$ = 260.1410**,** found: 260.1411.

(*S,E*)-N-(furan-2-ylmethyl)-4-(2-methoxyphenyl)but-3-en-2-amine (3ab): with **A4**, 24 h**,**



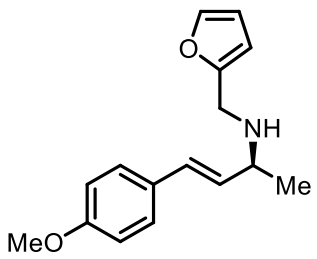
obtained pale yellow oil 51.5 mg; Isolated yield: 99%; > 99% ee; $[\alpha]_D^{25}$ = -114.1 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OJ-H column, hexane: isopropanol = 99:1, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 27.5 min (major), 32.5 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.46 (dd, *J* = 7.6, 1.8 Hz, 1H), 7.36 (dd, *J* = 1.9, 0.9 Hz, 1H), 7.23-7.19 (m, 1H), 6.94-6.90 (m, 1H), 6.87 (dd, *J* = 8.2, 1.1 Hz, 1H), 6.81 (d, *J* = 16.0 Hz, 1H), 6.31 (dd, *J* = 3.2, 1.8 Hz, 1H), 6.17 (dd, *J* = 3.2, 0.8 Hz, 1H), 6.07 (dd, *J* = 16.0, 8.2 Hz, 1H), 3.85 (s, 3H), 3.83 (d, *J* = 14.7 Hz, 1H), 3.74 (d, *J* = 14.4 Hz, 1H), 3.43-3.36 (m, 1H), 1.26 (d, *J* = 6.4 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 156.6, 154.1, 141.7, 134.3, 128.4, 126.7, 126.0, 125.2, 120.6, 110.8, 110.0, 106.8, 55.7, 55.4, 43.8, 22.1 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{16}H_{20}NO_2$ = 258.1489**,** found: 258.1484.

(*S,E*)-N-(furan-2-ylmethyl)-4-(3-methoxyphenyl)but-3-en-2-amine (3ac): with **A4**, 24 h**,**



obtained pale yellow oil 51.0 mg; Isolated yield: 99%; > 99% ee; $[\alpha]_D^{25}$ = -104.0 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak AD-H column, hexane: isopropanol = 99:1, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 28.0 min (major), 29.9 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.36 (dd, *J* = 1.9, 0.9 Hz, 1H), 7.23 (t, *J* = 7.9 Hz, 1H), 6.99-6.96 (m, 1H), 6.93-6.92 (m, 1H), 6.79 (ddd, *J* = 8.2, 2.6, 0.9 Hz, 1H), 6.46 (d, *J* = 15.9 Hz, 1H), 6.31 (dd, *J* = 3.1, 1.9 Hz, 1H), 6.16 (dd, *J* = 3.2, 0.8 Hz, 1H), 6.07 (dd, *J* = 15.9, 8.1 Hz, 1H), 3.83 (d, *J* = 14.4 Hz, 1H), 3.82 (s, 3H), 3.74 (d, *J* = 14.4 Hz, 1H), 3.42-3.35 (m, 1H), 1.88 (br, s, 1H), 1.26 (d, *J* = 6.4 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 159.8, 153.8, 141.8, 138.4, 133.9, 130.4, 129.5, 119.0, 113.2, 111.4, 110.1, 106.8, 55.2, 43.7, 21.9 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{16}H_{20}NO_2$ = 258.1489**,** found: 258.1481.

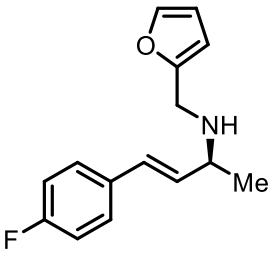
(*S,E*)-N-(furan-2-ylmethyl)-4-(4-methoxyphenyl)but-3-en-2-amine (3ad): with **A4**, 24 h**,**



obtained pale yellow oil 51.5 mg; Isolated yield: 99%; > 99% ee; $[\alpha]_D^{25}$ = -159.0 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak AD-H column, hexane: isopropanol = 99:1, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 33.8 min (major), 35.4 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.36 (dd, *J* = 2.0, 0.8 Hz, 1H), 7.34-7.30 (m, 2H), 6.88-6.84 (m, 2H), 6.43 (d, *J* = 15.9 Hz, 1H), 6.31 (dd, *J* = 3.2, 1.8 Hz, 1H), 6.16 (dd, *J* = 3.1, 0.8 Hz,

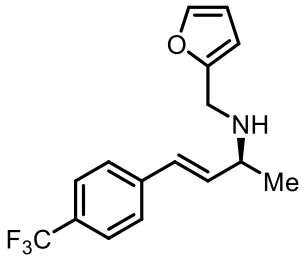
1H), 5.93 (dd, *J* = 15.8, 8.2 Hz, 1H), 3.83 (d, *J* = 13.2 Hz, 1H), 3.81 (s, 3H), 3.73 (d, *J* = 14.4 Hz, 1H), 3.39-3.33 (m, 1H), 1.86 (br, s, 1H), 1.25 (d, *J* = 6.4 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 159.0, 153.9, 141.8, 131.4, 130.0, 129.7, 127.4, 113.9, 110.1, 106.8, 55.33, 55.29, 43.8, 22.1 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{16}H_{19}NNaO_2$ = 280.1308**,** found: 280.1310.

(*S,E*)-4-(4-fluorophenyl)-N-(furan-2-ylmethyl)but-3-en-2-amine (3ae): with **A4**, 24 h**,**



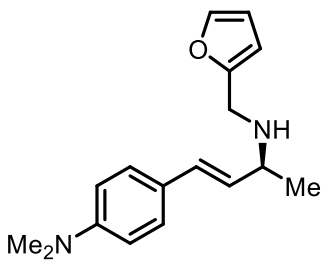
obtained pale yellow oil 49.1 mg; Isolated yield: 99%; > 99% ee; $[\alpha]_D^{25}$ = -137.4 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OJ-H column, hexane: isopropanol = 99:1, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 25.0 min (major), 27.4 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.37-7.32 (m, 3H), 7.03-6.97 (m, 2H), 6.45 (d, *J* = 15.8 Hz, 1H), 6.31 (dd, *J* = 3.1, 1.9 Hz, 1H), 6.16 (dd, *J* = 3.2, 0.8 Hz, 1H), 5.99 (dd, *J* = 15.8, 8.1 Hz, 1H), 3.82 (d, *J* = 14.4 Hz, 1H), 3.73 (d, *J* = 14.4 Hz, 1H), 3.41-3.34 (m, 1H), 1.83 (br, s, 1H), 1.25 (d, *J* = 6.4 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.1 (d, *J* = 246.5 Hz), 153.8, 141.8, 133.4 (d, *J* = 2.2 Hz), 133.1 (d, *J* = 3.2 Hz), 129.3, 127.7 (d, *J* = 7.9 Hz), 115.4 (d, *J* = 21.4 Hz), 110.1, 106.8, 55.2, 43.8, 22.0 ppm; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -114.82 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{15}H_{16}FNNaO$ = 268.1108**,** found: 268.1103.

(*S,E*)-N-(furan-2-ylmethyl)-4-(4-(trifluoromethyl)phenyl)but-3-en-2-amine (3af): with **A4**,



24 h**,** obtained pale yellow oil 59.2 mg; Isolated yield: 99%; 96% ee; $[\alpha]_D^{25}$ = -99.8 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak AS-H column, hexane: isopropanol = 99:1, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 11.5 min (major), 13.0 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.56 (d, *J* = 8.2 Hz, 2H), 7.46 (d, *J* = 8.2 Hz, 2H), 7.37 (dd, *J* = 1.9, 0.8 Hz, 1H), 6.52 (d, *J* = 15.9 Hz, 1H), 6.31 (dd, *J* = 3.2, 1.8 Hz, 1H), 6.21-6.15 (m, 2H), 3.82 (d, *J* = 14.5 Hz, 1H), 3.74 (d, *J* = 14.5 Hz, 1H), 3.45-3.38 (m, 1H), 1.82 (br, s, 1H), 1.27 (d, *J* = 6.5 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 153.7, 141.8, 140.5 (q, *J* = 1.6 Hz), 136.5, 129.11 (q, *J* = 32.2 Hz), 129.09, 126.4, 125.5 (q, *J* = 3.9 Hz), 124.2 (q, *J* = 270.5 Hz), 110.1, 106.9, 55.1, 43.8, 21.8 ppm; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -62.36 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{16}H_{17}F_3NO$ = 296.1257**,** found: 296.1250.

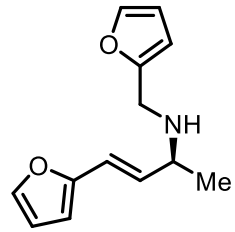
(*S,E*)-4-(3-((furan-2-ylmethyl)amino)but-1-en-1-yl)-N,N-dimethylaniline (3ag): with **A4**, 24 h**,**



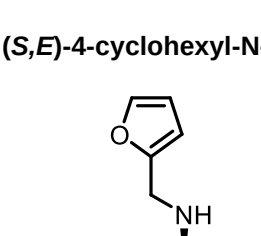
obtained pale yellow oil 49.8 mg; Isolated yield: 92%; > 99% ee; $[\alpha]_D^{25}$ = -167.1 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak AD-H column, hexane: isopropanol = 99:1, flow rate = 0.6 mL/min, UV detection at 254 nm, t_R = 29.8 min (minor), 32.1 min (major); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.36 (dd, *J* = 1.9, 0.8 Hz, 1H), 7.29-7.27 (m, 2H), 6.70-

6.67 (m, 2H), 6.39 (d, *J* = 15.8 Hz, 1H), 6.31 (dd, *J* = 3.2, 1.9 Hz, 1H), 6.16 (dd, *J* = 3.1, 0.8 Hz, 1H), 5.85 (dd, *J* = 15.8, 8.2 Hz, 1H), 3.83 (d, *J* = 14.4 Hz, 1H), 3.73 (d, *J* = 14.4 Hz, 1H), 3.38-3.31 (m, 1H), 2.95 (s, 6H), 2.24 (br, s, 1H), 1.25 (d, *J* = 6.4 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 153.9, 150.0, 141.7, 130.6, 129.1, 127.2, 125.4, 112.5, 110.0, 106.8, 55.5, 43.6, 40.6, 22.1 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{17}H_{23}N_2O$ = 271.1805**,** found: 271.1805.

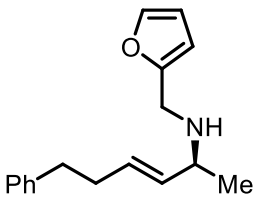
(*S,E*)-4-(furan-2-yl)-N-(furan-2-ylmethyl)but-3-en-2-amine (3ah): with **A4**, 36 h**,** obtained pale yellow oil 37.0 mg; Isolated yield: 85%; 96% ee; $[\alpha]_D^{25}$ = -124.5 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OJ-H column, hexane: isopropanol = 95:5, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 19.1 min (major), 24.9 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.36 (dd, *J* = 1.9, 0.9 Hz, 1H), 7.34 (d, *J* = 1.8 Hz, 1H), 6.36 (dd, *J* = 3.3, 1.8 Hz, 1H), 6.34-6.30 (m, 2H), 6.21 (d, *J* = 3.2 Hz, 1H), 6.16 (dd, *J* = 3.2, 0.8 Hz, 1H), 6.02 (dd, *J* = 15.8, 8.0 Hz, 1H), 3.82 (d, *J* = 14.5 Hz, 1H), 3.72 (d, *J* = 14.4 Hz, 1H), 3.37-3.30 (m, 1H), 1.24 (d, *J* = 6.5 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 154.0, 152.6, 141.8, 141.7, 132.5, 118.9, 111.2, 110.1, 107.2, 106.8, 54.9, 43.8, 22.0 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{13}H_{16}NO_2$ = 218.1176**,** found: 218.1177.



(*S,E*)-4-cyclohexyl-N-(furan-2-ylmethyl)but-3-en-2-amine (3ai): with **A4**, 24 h**,** obtained pale yellow oil 45.4 mg; Isolated yield: 97%; 96% ee; $[\alpha]_D^{25}$ = -51.0 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak AD-H column, hexane: isopropanol = 95:5, flow rate = 0.5 mL/min, UV detection at 220 nm, t_R = 8.7 min (major), 9.4 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.34 (dd, *J* = 1.9, 0.9 Hz, 1H), 6.30 (dd, *J* = 3.2, 1.8 Hz, 1H), 6.13 (dd, *J* = 3.1, 0.9 Hz, 1H), 5.48 (dd, *J* = 15.4, 6.6 Hz, 1H), 5.24-5.18 m, 1H), 3.77 (d, *J* = 14.5 Hz, 1H), 3.67 (d, *J* = 14.4 Hz, 1H), 3.16-3.09 (m, 1H), 1.99-1.90 (m, 1H), 1.74-1.69 (m, 4H), 1.67-1.64 (m, 1H), 1.29-1.16 (m, 3H), 1.14 (d, *J* = 6.4 Hz, 3H), 1.11-1.02 (m, 2H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 154.2, 141.6, 137.9, 130.9, 110.0, 106.6, 55.1, 43.6, 40.4, 33.1, 33.0, 26.2, 26.0, 22.1 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{15}H_{24}NO$ = 234.1852**,** found: 234.1853.

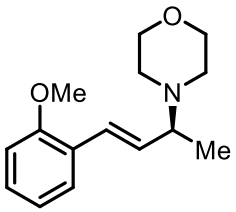


(*S,E*)-N-(furan-2-ylmethyl)-6-phenylhex-3-en-2-amine (3aj): with **A4**, 24 h**,** obtained pale yellow oil 51.0 mg; Isolated yield: 99%; 99% ee; $[\alpha]_D^{25}$ = -41.1 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OJ-H column, hexane: isopropanol = 95:5, flow rate = 0.5 mL/min, UV detection at 220 nm, t_R = 17.6 min (minor), 18.7 min (major); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.34 (dd, *J* = 1.9, 0.9 Hz, 1H), 7.29-7.25 (m, 2H), 7.19-7.15 (m, 3H), 6.29 (dd, *J* = 3.1, 1.9 Hz, 1H), 6.10 (dd, *J* = 3.2, 0.7 Hz, 1H), 5.55 (dt, *J* = 15.2, 6.6 Hz, 1H), 5.27 (ddt, *J* = 15.4, 8.1, 1.4 Hz, 1H), 3.69 (d, *J* = 14.4 Hz, 1H), 3.60 (d, *J* = 14.4 Hz, 1H), 3.17-3.10 (m, 1H), 2.76-2.65 (m, 2H), 2.39-2.33 (m, 2H), 1.12



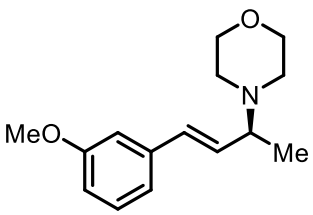
(d, *J* = 6.4 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 154.2, 141.8, 141.6, 134.6, 130.7, 128.5, 128.3, 125.8, 110.0, 106.6, 54.9, 43.6, 35.8, 34.0, 22.0 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{17}H_{22}NO$ = 256.1696**,** found: 256.1691.

(*S,E*)-4-(4-(2-methoxyphenyl)but-3-en-2-yl)morpholine (3ak): with **A4**, 24 h**,** obtained pale



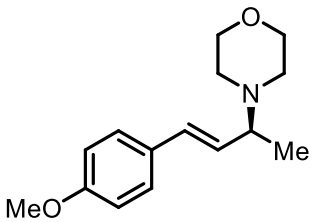
yellow oil 49.5 mg; Isolated yield: 99%; > 99% ee; $[\alpha]_D^{25}$ = -61.6 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OD-H column, hexane: isopropanol = 99:1, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 22.1 min (minor), 24.2 min (major); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.44 (dd, *J* = 7.6, 1.7 Hz, 1H), 7.23-7.19 (m, 1H), 6.93-6.89 (m, 1H), 6.86 (dd, *J* = 8.2, 1.2 Hz, 1H), 6.79 (d, *J* = 16.0 Hz, 1H), 6.17 (dd, *J* = 16.0, 8.3 Hz, 1H), 3.84 (s, 3H), 3.73 (t, *J* = 4.7 Hz, 4H), 3.06-2.99 (m, 1H), 2.62-2.52 (m, 4H), 1.26 (d, *J* = 6.6 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 156.5, 132.5, 128.5, 126.6, 125.9, 125.8, 120.6, 110.9, 67.2, 63.6, 55.4, 50.8, 17.9 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{15}H_{22}NO_2$ = 248.1645**,** found: 248.1641.

(*S,E*)-4-(4-(3-methoxyphenyl)but-3-en-2-yl)morpholine (3al): with **A4**, 24 h**,** obtained pale



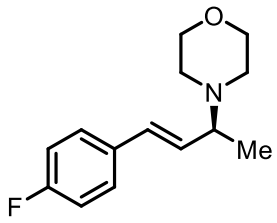
yellow oil 49.5 mg; Isolated yield: 99%; 98% ee; $[\alpha]_D^{25}$ = -58.7 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak AD-H column, hexane: isopropanol = 99:1, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 21.2 min (major), 24.6 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.23 (t, *J* = 7.9 Hz, 1H), 6.96 (d, *J* = 7.7 Hz, 1H), 6.92-6.91 (m, 1H), 6.79 (dd, *J* = 8.2, 2.4 Hz, 1H), 6.44 (d, *J* = 15.9 Hz, 1H), 6.17 (dd, *J* = 15.9, 8.2 Hz, 1H), 3.81 (s, 3H), 3.73 (t, *J* = 4.7 Hz, 4H), 3.06-2.99 (m, 1H), 2.61-2.52 (m, 4H), 1.26 (d, *J* = 6.5 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 159.8, 138.3, 132.3, 131.1, 129.5, 118.9, 113.2, 111.4, 67.1, 63.0, 55.1, 50.7, 17.6 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{15}H_{22}NO_2$ = 248.1645**,** found: 248.1637.

(*S,E*)-4-(4-(4-methoxyphenyl)but-3-en-2-yl)morpholine (3am): with **A4**, 24 h**,** obtained pale

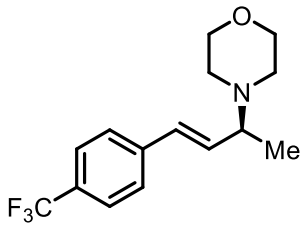


yellow oil 49.3 mg; Isolated yield: 99%; > 99% ee; $[\alpha]_D^{25}$ = -80.8 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OJ-H column, hexane: isopropanol = 95:5, flow rate = 1.0 mL/min, UV detection at 254 nm, t_R = 20.6 min (minor), 29.0 min (major); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.31 (d, *J* = 8.7 Hz, 2H), 6.85 (d, *J* = 8.7 Hz, 2H), 6.41 (d, *J* = 15.9 Hz, 1H), 6.02 (dd, *J* = 15.9, 8.3 Hz, 1H), 3.81 (s, 3H), 3.74 (t, *J* = 4.7 Hz, 4H), 3.03-2.96 (m, 1H), 2.61-2.53 (m, 4H), 1.26 (d, *J* = 6.5 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 159.1, 130.8, 129.6, 129.5, 127.4, 113.9, 67.10, 63.2, 55.3, 50.7, 17.8 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{15}H_{21}NNaO_2$ = 270.1465**,** found: 270.1464.

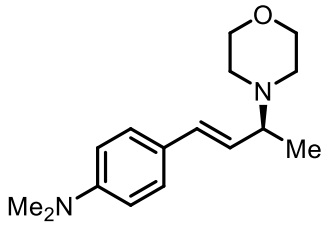
(*S*,*E*)-4-(4-(4-fluorophenyl)but-3-en-2-yl)morpholine (3an): with **A4**, 24 h**,** obtained pale yellow oil 47.2 mg; Isolated yield: 99%; > 99% ee; $[\alpha]_D^{25}$ = -70.3 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OJ-H column, hexane: isopropanol = 95:5, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 16.0 min (minor), 17.5 min (major); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.36-7.31 (m, 2H), 7.03-6.97 (m, 2H), 6.43 (d, *J* = 15.9 Hz, 1H), 6.08 (dd, *J* = 15.9, 8.2 Hz, 1H), 3.74 (t, *J* = 4.7 Hz, 4H), 3.04-2.97 (m, 1H), 2.58-2.54 (m, 4H), 1.25 (d, *J* = 6.6 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.2 (d, *J* = 246.6 Hz), 133.0 (d, *J* = 3.3 Hz), 131.8 (d, *J* = 2.1 Hz), 130.0, 127.7 (d, *J* = 7.9 Hz), 115.4 (d, *J* = 21.6 Hz), 67.2, 63.0, 50.7, 17.7 ppm; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -114.64 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{14}H_{19}FNO$ = 236.1445**,** found: 236.1442.



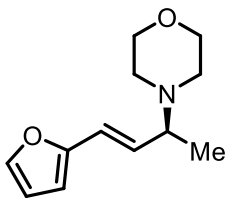
(*S,E*)-4-(4-(4-(trifluoromethyl)phenyl)but-3-en-2-yl)morpholine (3ao): with **A4**, 24 h**,** obtained pale yellow oil 57.1 mg; Isolated yield: 99%; 93% ee; $[\alpha]_D^{25}$ = -48.3 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak AD-H column, hexane: isopropanol = 99:1, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 15.0 min (major), 17.8 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.56 (d, *J* = 8.2 Hz, 2H), 7.46 (d, *J* = 8.4 Hz, 2H), 6.50 (d, *J* = 16.0 Hz, 1H), 6.28 (dd, *J* = 16.0, 8.0 Hz, 1H), 3.75-3.72 (m, 4H), 3.10-3.02 (m, 1H), 2.58-2.55 (m, 4H), 1.27 (d, *J* = 6.6 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 140.3 (q, *J* = 1.9 Hz), 135.0, 129.9, 129.2 (q, *J* = 32.4 Hz), 126.4, 125.5 (q, *J* = 3.8 Hz), 124.1 (q, *J* = 270.9 Hz), 67.1, 62.9, 50.7, 17.5 ppm; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -62.38 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{15}H_{19}F_3NO$ = 286.1413**,** found: 286.1418.



(*S,E*)-N,N-dimethyl-4-(3-morpholinobut-1-en-1-yl)aniline (3ap): with **A4**, 24 h**,** obtained pale yellow oil 38.8 mg; Isolated yield: 74%; > 99% ee; $[\alpha]_D^{25}$ = -98.5 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OD-H column, hexane: isopropanol = 99:1, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 19.5 min (major), 21.3 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.28-7.25 (m, 2H), 6.69-6.67 (m, 2H), 6.37 (d, *J* = 15.8 Hz, 1H), 5.94 (dd, *J* = 15.9, 8.3 Hz, 1H), 3.73 (t, *J* = 4.7 Hz, 4H), 3.00-2.97 (m, 1H), 2.95 (s, 6H), 2.61-2.52 (m, 4H), 1.25 (d, *J* = 6.5 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 150.0, 131.2, 127.5, 127.1, 125.4, 112.5, 67.2, 63.4, 50.8, 40.6, 18.0 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{16}H_{25}N_2O$ = 261.1961**,** found: 261.1960.

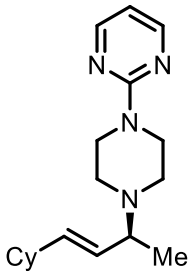


(*S,E*)-4-(4-(furan-2-yl)but-3-en-2-yl)morpholine (3aq): with **A4**, 36 h**,** obtained pale yellow oil



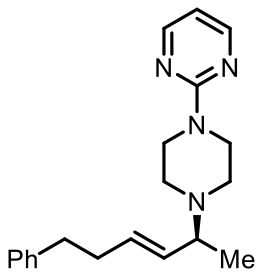
41.4 mg; Isolated yield: 99%; 96% ee; $[\alpha]_D^{25}$ = -73.8 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OJ-H column, hexane: isopropanol = 95:5, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 16.6 min (minor), 18.7 min (major); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.33 (d, *J* = 1.8 Hz, 1H), 6.36 (dd, *J* = 3.3, 1.8 Hz, 1H), 6.31-6.27 (m, 1H), 6.20 (d, *J* = 3.3 Hz, 1H), 6.11 (dd, *J* = 15.9, 8.1 Hz, 1H), 3.72 (t, *J* = 4.7 Hz, 4H), 3.04-2.97 (m, 1H), 2.60-2.50 (m, 4H), 1.23 (d, *J* = 6.6 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 152.5, 141.7, 130.7, 119.7, 111.2, 107.3, 67.2, 62.7, 50.5, 17.5 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{12}H_{18}NO_2$ = 208.1332**,** found: 208.1333.

(*S,E*)-2-(4-(4-cyclohexylbut-3-en-2-yl)piperazin-1-yl)pyrimidine (3ar): with **A4**, 24 h**,**



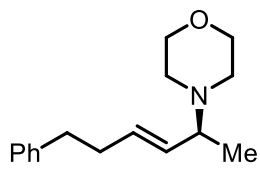
obtained colourless oil 34.7 mg; Isolated yield: 58%; 96% ee; $[\alpha]_D^{25}$ = -17.7 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OJ-H column, hexane: isopropanol = 95:5, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 8.8 min (minor), 9.5 min (major); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.29 (d, *J* = 4.7 Hz, 2H), 6.46 (t, *J* = 4.7 Hz, 1H), 5.47 (dd, *J* = 15.6, 6.4 Hz, 1H), 5.37-5.31 (m, 1H), 3.83-3.81 (m, 4H), 2.93-2.86 (m, 1H), 2.62-2.49 (m, 4H), 1.99-1.90 (m, 1H), 1.72-1.69 (m, 4H), 1.66-1.62 (m, 1H), 1.28-1.22 (m, 3H), 1.18 (d, *J* = 6.6 Hz, 3H), 1.14-1.02 (m, 2H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 161.6, 157.7, 138.5, 128.7, 109.6, 62.5, 49.6, 43.8, 40.4, 33.04, 32.97, 26.1, 26.0, 18.1 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{18}H_{29}N_4$ = 301.2387**,** found: 301.2380.

(*S,E*)-2-(4-(6-phenylhex-3-en-2-yl)piperazin-1-yl)pyrimidine (3as): with **A4**, 24 h**,** obtained

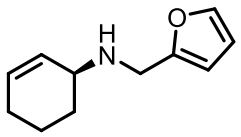


colorless oil 63.5 mg; Isolated yield: 98%; > 99% ee; $[\alpha]_D^{25}$ = -14.2 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OD-H column, hexane: isopropanol = 95:5, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 19.2 min (major), 21.7 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.30 (d, *J* = 4.7 Hz, 2H), 7.28-7.24 (m, 2H), 7.17-7.13 (m, 3H), 6.46 (t, *J* = 4.7 Hz, 1H), 5.52 (dt, *J* = 15.3, 6.5 Hz, 1H), 5.37 (ddt, *J* = 15.4, 8.0, 1.2 Hz, 1H), 3.78 (t, *J* = 5.2 Hz, 4H), 2.91-2.84 (m, 1H), 2.76-2.64 (m, 2H), 2.51-2.41 (m, 4H), 2.39-2.33 (m, 2H), 1.14 (d, *J* = 6.6 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 161.6, 157.7, 141.7, 132.6, 131.2, 128.5, 128.2, 125.8, 109.6, 62.3, 49.6, 43.8, 35.6, 34.0, 17.9 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{20}H_{27}N_4$ = 323.2230**,** found: 323.2224.

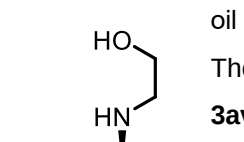
(*S*,*E*)-4-(6-phenylhex-3-en-2-yl)morpholine (3at): with **A4**, 24 h**,** obtained colorless oil 43.1 mg; Isolated yield: 88%; > 99% ee; $[\alpha]_D^{25}$ = -21.8 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OJ-H column, hexane: isopropanol = 95:5, flow rate = 0.5 mL/min, UV detection at 220 nm, t_R = 13.1 min (minor), 14.4 min (major); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.28-7.24 (m, 2H), 7.18-7.15 (m, 3H), 5.52 (dt, *J* = 15.2, 6.6 Hz, 1H), 5.32 (ddt, *J* = 15.3, 8.1, 1.4 Hz, 1H), 3.66 (t, *J* = 5.2 Hz, 4H), 2.79-2.64 (m, 3H), 2.40-2.33 (m, 6H), 1.10 (d, *J* = 6.5 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 141.7, 132.8, 131.3, 128.5, 128.3, 125.8, 67.2, 62.8, 50.5, 35.7, 34.0, 17.8 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{16}H_{24}NO$ = 246.1852**,** found: 246.1847.



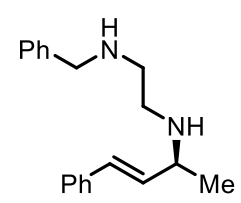
(*S*)-N-(furan-2-ylmethyl)cyclohex-2-en-1-amine (3au): with **A4,** 24 h**,** obtained pale yellow oil 17.4 mg; Isolated yield: 28%; 22% ee; $[\alpha]_D^{25}$ = -13.5 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak AS-H column, hexane: isopropanol = 99:1, flow rate = 0.5 mL/min, UV detection at 220 nm; t_R = 19.0 min (major), 21.9 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.35 (dd, *J* = 1.9, 0.9 Hz, 1H), 6.31 (dd, *J* = 3.1, 1.9 Hz, 1H), 6.18 (dd, *J* = 3.1, 0.8 Hz, 1H), 5.80-5.75 (m, 1H), 5.70-5.66 (m, 1H), 3.89-3.80 (m, 2H), 3.23-3.17 (m, 1H), 2.02-1.96 (m, 2H), 1.90-1.85 (m, 1H), 1.78-1.71 (m, 1H), 1.60-1.41 (m, 2H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 154.0, 141.7, 129.4, 129.2, 110.1, 106.7, 52.0, 43.4, 29.2, 25.2, 20.1 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{11}H_{16}NO$ = 178.1226**,** found: 178.1221.



(*S*,*E*)-2-((4-phenylbut-3-en-2-yl)amino)ethan-1-ol (3av): with **A4**, 24 h**,** obtained pale yellow oil 34.8 mg; Isolated yield: 91%; > 99% ee; $[\alpha]_D^{25}$ = -54.8 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by (converting it to compound **Bz-3av)** HPLC on Chiralpak AS-H column, hexane: isopropanol = 85:15; flow rate = 1.0 mL/min, UV detection at 254 nm, t_R = 20.0 min (major), 24.7 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.39-7.37 (m, 2H), 7.32-7.29 (m, 2H), 7.25-7.21 (m, 1H), 6.50 (d, *J* = 15.9 Hz, 1H), 6.12 (dd, *J* = 15.9, 8.1 Hz, 1H), 3.76-3.67 (m, 2H), 3.53-3.41 (m, 1H), 3.41 (br, s, 1H), 3.32 (br, s, 1H), 2.93-2.79 (m, 2H), 1.35 (d, *J* = 6.5 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 136.4, 131.6, 131.5, 128.5, 127.7, 126.4, 60.3, 56.3, 48.5, 21.2 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{12}H_{18}NO$ = 192.1383**,** found: 192.1381.

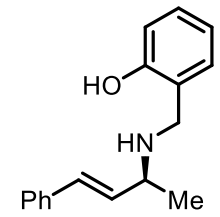


(*S*,*E*)-N1-benzyl-N1-(4-phenylbut-3-en-2-yl)ethane-1,2-diamine (3aw): with **A4**, 24 h**,** obtained pale yellow oil 46.5 mg; Isolated yield: 83%; 98% ee; $[\alpha]_D^{25}$ = -56.6 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by (converting it to compound **Bz-3aw)** HPLC on Chiralpak AD-H column, hexane: isopropanol = 85:15, flow rate = 1.0 mL/min, UV detection at 254 nm, t_R = 24.4 min (minor), 27.6 min (major); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.37-7.35 (m, 2H), 7.32-7.28 (m, 6H), 7.25- 7.19 (m, 2H), 6.44 (d, *J* = 15.9 Hz, 1H),

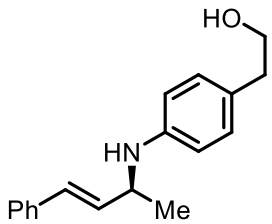


6.05 (dd, *J* = 15.9, 7.9 Hz, 1H), 3.79 (s, 2H), 3.35-3.28 (m, 1H), 2.81-2.65 (m, 4H), 1.25 (br, s, 2H), 1.25 (d, *J* = 6.5 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 140.3, 137.0, 134.2, 129.9, 128.5, 128.4, 128.1, 127.3, 126.9, 126.3, 56.3, 53.8, 48.8, 46.9, 22.0 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{19}H_{25}N_2$ = 281.2012**,** found: 282.2011.

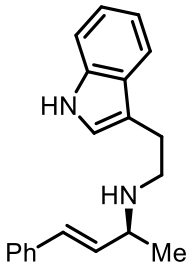
(*S,E*)-2-(((4-phenylbut-3-en-2-yl)amino)methyl)phenol (3ax): with **A4**, 24 h**,** obtained pale yellow oil 47.6 mg; Isolated yield: 94%; 97% ee; $[\alpha]_D^{25}$ = -110.6 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak AD-H column, hexane: isopropanol = 99:1, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 31.9 min (major), 37.2 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.38-7.30 (m, 4H), 7.26-7.22 (m, 1H), 7.18-7.14 (m, 1H), 6.96-6.94 (m, 1H), 6.84 (dd, *J* = 8.1, 1.2 Hz, 1H), 6.78-6.74 (m, 1H), 6.46 (d, *J* = 15.9 Hz, 1H), 6.03 (dd, *J* = 15.9, 8.2 Hz, 1H), 4.07 (d, *J* = 14.0 Hz, 1H), 3.91 (d, *J* = 13.9 Hz, 1H), 3.45-3.38 (m, 1H), 1.32 (d, *J* = 6.5 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 158.2, 136.5, 131.7, 131.5, 128.6, 128.6, 128.3, 127.7, 126.3, 122.7, 119.1, 116.4, 55.1, 50.0, 21.7 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{17}H_{19}NO$ = 276.1359**,** found: 276.1361.



(*S,E*)-2-(2-((4-phenylbut-3-en-2-yl)amino)phenyl)ethan-1-ol (3ay): with **A3**, 24 h**,** obtained white solid 31.4 mg; Isolated yield: 59%; 91% ee; $[\alpha]_D^{25}$ = -114.1 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak OD-H column, hexane: isopropanol = 80:20, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 24.7 min (major), 28.9 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.37-7.34 (m, 2H), 7.31-7.27 (m, 2H), 7.23- 7.19 (m, 1H), 7.03-7.00 (m, 2H), 6.63-6.60 (m, 2H), 6.57 (dd, *J* = 15.9, 1.3 Hz, 1H), 6.20 (dd, *J* = 15.9, 5.9 Hz, 1H), 4.15-4.08 (m, 1H), 3.78 (t, *J* = 6.5 Hz, 2H), 2.74 (t, *J* = 6.5 Hz, 2H), 1.40 (d, *J* = 6.6 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 146.0, 136.9, 133.2, 129.8, 129.2, 128.5, 127.3, 126.7, 126.3, 113.6, 63.9, 51.0, 38.2, 22.1 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{18}H_{21}NNaO$ = 290.1532**,** found: 290.1531.

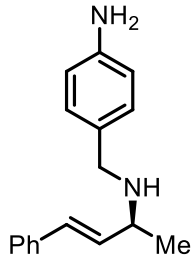


(*S,E*)-N-(2-(1H-indol-3-yl)ethyl)-4-phenylbut-3-en-2-amine (3az): with **A4**, 24 h**,** obtained pale yellow oil 58.2 mg; Isolated yield: 99%; > 99% ee; $[\alpha]_D^{25}$ = -76.2 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak AS-H column, hexane: isopropanol = 99:1, flow rate = 0.5 mL/min, UV detection at 254 nm; t_R = 69.3 min (minor), 75.3 min (major); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.12 (s, 1H), 7.62 (d, *J* = 7.9 Hz, 1H), 7.37-7.27 (m, 5H), 7.23-7.17 (m, 2H), 7.10 (t, *J* = 7.5 Hz, 1H), 7.04 (d, *J* = 2.3 Hz, 1H), 6.42 (d, *J* = 15.9 Hz, 1H), 6.06 (dd, *J* = 15.9, 8.0 Hz, 1H), 3.41-3.34 (m, 1H), 3.04-2.92 (m, 4H), 1.97 (br, s, 1H), 1.22 (d, *J* = 6.4 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 137.0, 136.4, 134.1, 129.9, 128.5, 127.4, 127.3, 126.2, 122.02, 121.98, 119.2, 118.9, 113.8, 111.1,

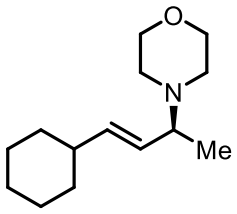


56.2, 47.4, 25.8, 22.0 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{20}H_{22}N_2Na$ = 313.1675**,** found: 313.1675.

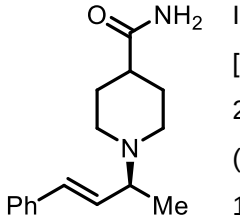
(*S*,*E*)-4-(((4-phenylbut-3-en-2-yl)amino)methyl)aniline (3ba): with **A3**, 24 h**,** obtained pale yellow oil 20.4 mg; Isolated yield: 40%; > 99% ee; $[\alpha]_D^{25}$ = -148.5 (c = 1.0, $CHCl_3$); The enantiomeric excess was determined by HPLC on Chiralpak AS-H column, hexane: isopropanol = 90:10, flow rate = 0.5 mL/min, UV detection at 254 nm, t_R = 25.8 min (major), 28.8 min (minor); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.40-7.37(m, 2H), 7.33-7.29 (m, 2H), 7.24-7.20 (m, 1H), 7.12-7.09 (m, 2H), 6.67-6.63 (m, 2H), 6.47 (d, *J* = 15.9 Hz, 1H), 6.11 (dd, *J* = 15.9, 8.0 Hz, 1H), 3.73 (d, *J* = 12.8 Hz, 1H), 3.61 (d, *J* = 12.9 Hz, 1H), 3.43-3.36 (m, 1H), 1.25 (d, *J* = 6.5 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 145.2, 137.1, 134.2, 130.4, 130.1, 129.3, 128.5, 127.3, 126.2, 115.1, 55.3, 51.0, 22.0 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{17}H_{21}N_2$ = 253.1699**,** found: 253.1670.



(*S*,*E*)-4-(4-cyclohexylbut-3-en-2-yl)morpholine (3bb): with **A4**, 24 h**,** obtained pale yellow oil 29.8 mg; Isolated yield: 67%; The enantiomeric excess couldn't be determined; $[\alpha]_D^{25}$ = -25.2 (c = 1.0, $CHCl_3$); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 5.47 (dd, *J* = 15.5, 6.5 Hz, 1H), 5.32-5.26 (m, 1H), 3.71 (t, *J* = 4.7 Hz, 4H), 2.81-2.74 (m, 1H), 2.55-2.42 (m, 4H), 1.97-1.89 (m, 1H), 1.74-1.67 (m, 4H), 1.67-1.62 (m, 1H), 1.32-1.16 (m, 3H), 1.14 (d, *J* = 6.5 Hz, 3H), 1.12-1.01 (m, 2H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 138.6, 128.9, 67.2, 62.9, 50.5, 40.4, 33.1, 33.0, 26.2, 26.0, 18.0 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{14}H_{26}NO$ = 224.2009**,** found: 224.2011.



(*S*,*E*)-1-(4-phenylbut-3-en-2-yl)piperidine-4-carboxamide (3bc): white solid 44.9 mg; Isolated yield: 87%; The enantiomeric excess couldn't be determined; $[\alpha]_D^{25}$ = -35.4 (c = 1.0, $CHCl_3$); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.38-3.36 (m, 2H), 7.33-7.29 (m, 2H), 7.24-7.20 (m, 1H), 6.44 (d, *J* = 15.9 Hz, 1H), 6.20 (dd, *J* = 15.9, 7.9 Hz, 1H), 5.52 (br, s, 2H), 3.16-3.07 (m, 2H), 3.05-3.00 (m, 1H), 2.18-2.09 (m, 3H), 1.94-1.87 (m, 2H), 1.80-1.67 (m, 2H), 1.25 (d, *J* = 6.6 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 177.7, 137.0, 132.2, 130.7, 128.5, 127.3, 126.2, 62.4, 49.7, 49.5, 43.0, 29.2, 29.1, 17.6 ppm; **HRMS (ESI)** calculated $[M+H]^+$ for $C_{16}H_{23}N_2O$ = 218.1176**,** found: 218.1177.



(*S*,*E*)-8-chloro-11-(1-(4-phenylbut-3-en-2-yl)piperidin-4-ylidene)-6,11-dihydro-5H-benzo[5,6]cyclohepta[1,2-b]pyridine (3bd): with **A4**, 48 h, obtained reddish orange oil 88.1 mg; Isolated yield: 99%; The enantiomeric excess couldn't be determined; $[\alpha]_D^{25}$ = -64.3 (c = 1.0, $CHCl_3$); **3ay**: **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.40-8.38 (m, 1H), 7.42 (dd, *J* = 7.7, 1.7 Hz, 1H), 7.37-7.28 (m, 4H), 7.24-7.20 (m, 1H), 7.14-7.11 (m, 3H), 7.09-7.06 (m, 1H), 6.42 (d, *J* = 15.9 Hz, 1H), 6.25-6.19 (m, 1H), 3.44-3.32 (m, 2H), 3.20-3.11 (m, 1H), 2.93-2.74 (m, 4H), 2.56-2.32 (m, 6H), 1.26 (d, *J* = 6.6 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 157.62, 146.57, 139.46, 139.09, 137.72, 137.20, 136.93, 133.40, 132.56, 132.38, 132.08, 130.90, 130.82, 128.93, 128.51, 127.34, 126.24, 125.94, 122.04, 62.38, 51.63, 51.42, 31.83, 31.40, 31.08, 30.87, 17.83 ppm; **3ay′**: **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.40-8.38 (m, 1H), 7.42 (dd, *J* = 7.7, 1.7 Hz, 1H), 7.37-7.28 (m, 4H), 7.24-7.20 (m, 1H), 7.14-7.11 (m, 3H), 7.09-7.06 (m, 1H), 6.42 (d, *J* = 15.9 Hz, 1H), 6.25-6.19 (m, 1H), 3.44-3.32 (m, 2H), 3.20-3.11 (m, 1H), 2.93-2.74 (m, 4H), 2.56-2.32 (m, 6H), 1.26 (d, *J* = 6.6 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, $CDCl_3$) δ 157.57, 146.57, 139.46, 139.09, 137.67, 137.16, 136.92, 133.40, 132.56, 132.38, 131.97, 130.87, 130.77, 128.90, 128.51, 127.34, 126.22, 125.94, 122.04, 62.35, 51.63, 51.37, 31.81, 31.38, 31.08, 30.80, 17.78 ppm; **HRMS (ESI)** calculated $[M+Na]^+$ for $C_{29}H_{29}ClN_2Na$ = 463.1911**,** found: 463.1907.

Non-reactive and inefficient substrates

we also have prepared two disubstituted dienes **1k** and **1l**, and examined them in the hydroamination reaction. It was found that substrate **1k** could participate in the reaction to afford the corresponding product **3be** in 22% yield and 68% ee. However, substrate **1l** failed to provide the desired product (**3bf** and **3bg**) under standard reaction condition.

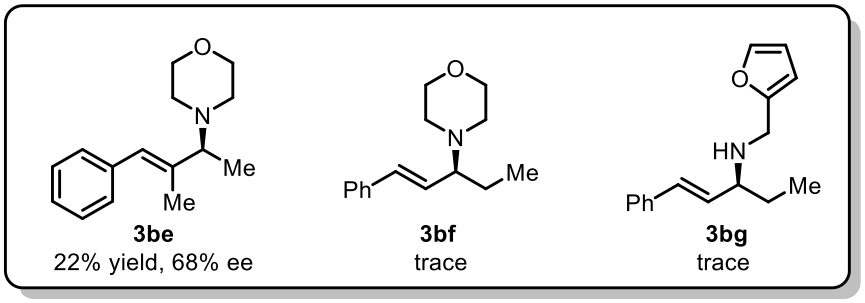
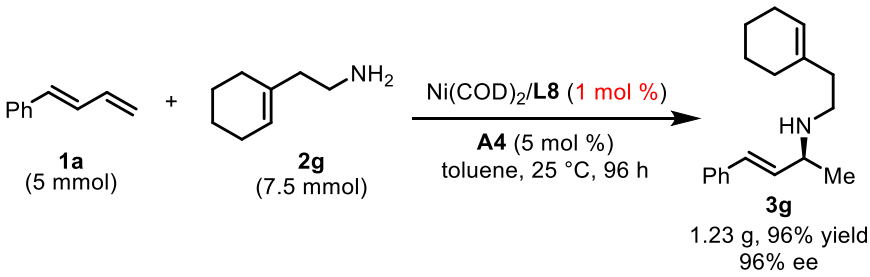


Figure S245. Non-reactive and inefficient dienes, related to **Figure 4**.

Scalability of Asymmetric Hydroamination

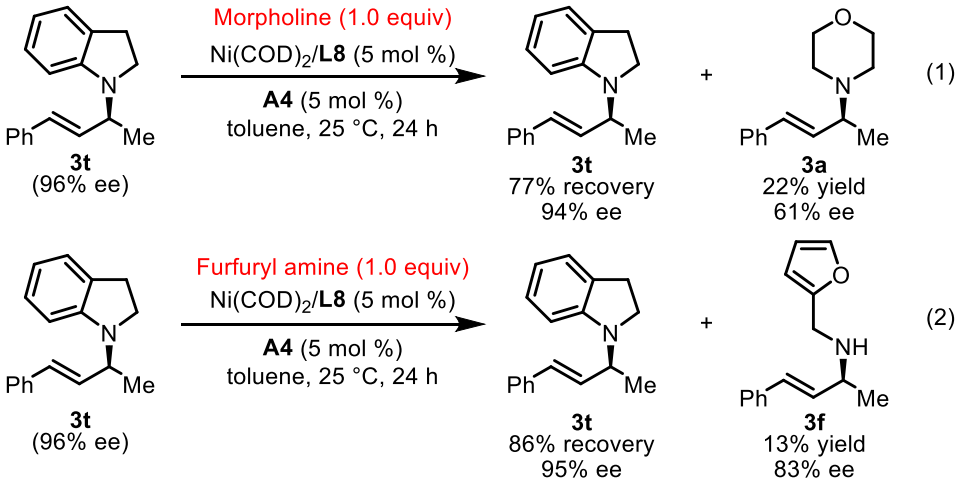
Scheme S4 (related to **Figure 3**):

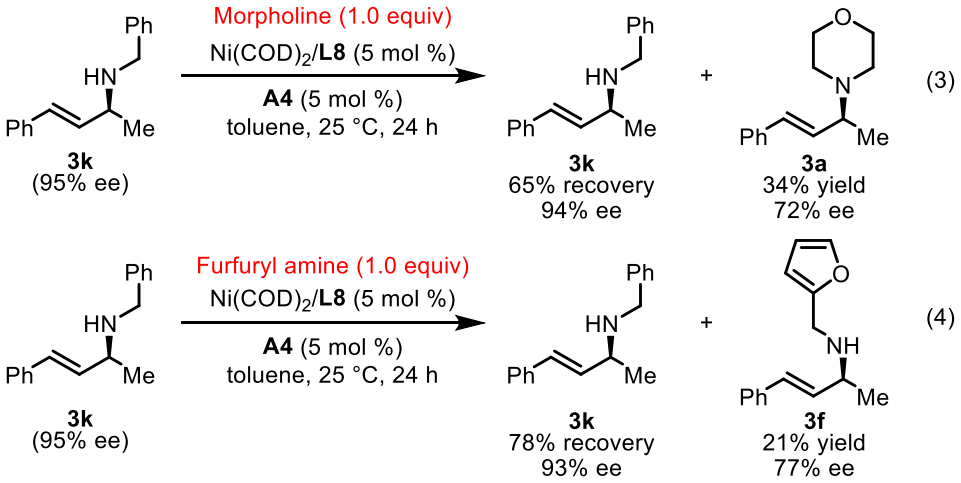


To a 20 mL vial was added the catalyst precursor $Ni(COD)_2$ (13.8 mg, 0.05 mmol), **L8** (15.3 mg, 0.05 mmol) and toluene (5 mL) in an argon-filled glovebox. The mixture was stirred for 1 h at room temperature to give a clear orange solution. Then 1-phenylbutadiene (651.0 mg, 5.0 mmol, 1.0 equiv), amine (939.1 mg, 7.5 mmol, 1.5 equiv), **A4** (41.5 mg, 0.25 mmol) and another 5 mL toluene was added in the catalyst solution. The reaction vessel was sealed using a PTFE septum and removed from the glovebox, and the mixture was stirred at 25 °C for 96 h. The product was purified by column chromatography on deactivated silica gel with PE/EtOAc=1:1 to yield 1.23 g of **3g** (96% yield, 96% ee), the enantiomeric excess was determined by HPLC on Chiralpak AD-H column.

Transamination Experiments

Scheme S5 (related to **Scheme 1**):

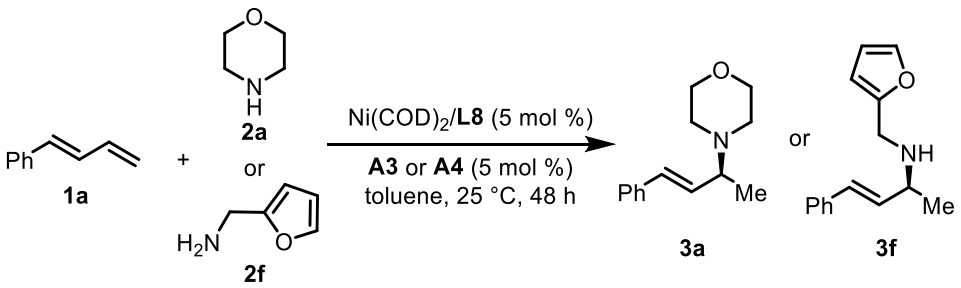




A stock solution was made by mixing $Ni(COD)_2$ with **L8** in a 1:1 molar ratio in toluene (0.01 M) at room temperature for 1 h in a argon-filled glovebox. An aliquot of the catalyst solution (0.5 mL, 0.005 mmol) was transferred by syringe into the vials charged with **3t** or **3k** (0.1 mmol, 1.0 equiv), amines (**2a** or **2f**, 0.1 mmol, 1.0 equiv) and naphthalene (3.2 mg, 0.025 mmol, 0.25 equiv), then 0.005 mmol **A4** and another 0.5 mL toluene were added. The reaction vessel was sealed using a PTFE septum and removed from the glovebox, and the mixture was stirred at 25 °C for 24 h. Yields were determined by gas chromatogram analysis, using naphthalene as the internal standard. The ee values were determined by HPLC on a chiral stationary phase.

Reaction Profiles

Scheme S6 (related to **Figure 6**) [a]:



A stock solution was made by mixing $Ni(COD)_2$ with **L8** in a 1:1 molar ratio in toluene (0.01 M) at room temperature for 1 h in a argon-filled glovebox. An aliquot of the catalyst solution (1.0 mL, 0.01 mmol) was transferred by syringe into the vials charged with **1a** (0.4 mmol), amines (0.6 mmol for each) and naphthalene (12.8 mg, 0.1 mmol, 0.25 equiv), then **A3** (3.2 mg, 0.02 mmol) or **A4** (3.3 mg, 0.02 mmol) and another 1.0 mL toluene were added. The reaction vessel was sealed using a PTFE septum and stirred at 25 °C in the glovebox. The reaction progress was monitored by GC with naphthalene as the internal standard. The ee values were determined by HPLC on a chiral stationary phase.

Time [h]	Yield [%]	ee [%]	Yield [%][b]	ee [%][b]	Yield [%][c]	ee [%][c]	Yield [%][d]	ee [%][d]
6 h	84	98	86	97	12	98	91	98
12 h	99	97	94	96	19	98	95	98
24 h	99	94	99	93	30	97	99	98
36 h	99	91	99	92	38	97	98	98
48 h	99	88	99	90	39	97	98	98

Reaction conditions: [a] 0.40 mmol **1a**, 0.60 mmol **2a**, 5.0 mol % $Ni(COD)_2$/**L8**, 5.0 mol % **A3**, 1 mL toluene, 25 °C, 48 h. [b] **A4** instead of **A3**. [c] **2f** instead of **2a**. [d] **2f** instead of **2a**, **A4** instead of **A3**.

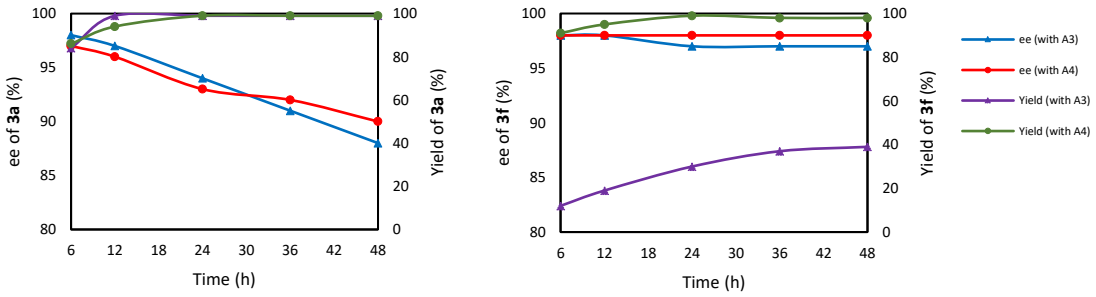
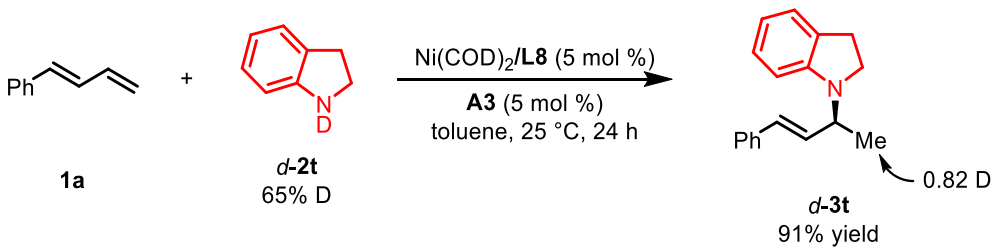


Figure S246. Time Course of **Scheme S6**.

Deuterium Labeling Experiments

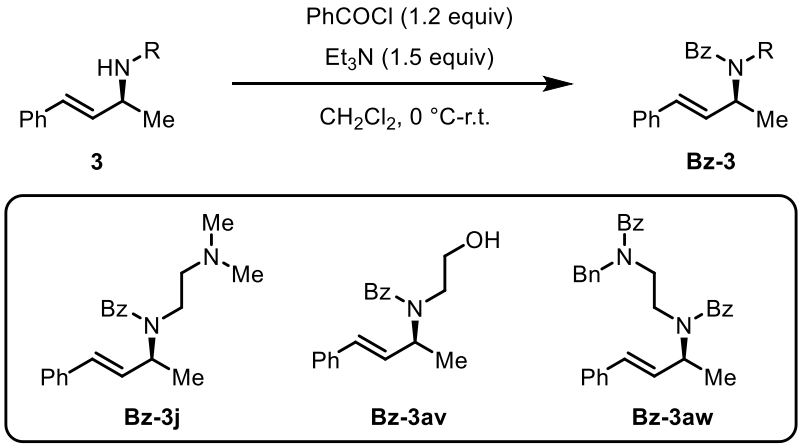
Scheme S7:



Reaction was carried as described in General Procedure for Ni-catalyzed Asymmetric Hydroamination of Conjugated Dienes. *d*-indoline was prepared by a known previously established method (Yi & Lee, 2009). The *d*-**3t** was determined by ^1H NMR and ^2H NMR analysis.

Amines Benzoylation for ee Determination (Wang et al, 2014)

Scheme S8 (related to **Figure 3** and **Figure 5**):



To a solution of chiral amine **3** (0.20 mmol, 1.0 equiv) and triethylamine (42 μL, 0.30 mmol, 1.5 equiv) in DCM (0.8 mL) at 0 °C was added dropwise a solution of benzoyl chloride (28 μL, 0.24 mmol, 1.2 equiv) in DCM (0.2 mL). The mixture was warmed to room temperature and stirred overnight. The mixture was quenched with water (1.0 mL) and extracted with DCM (5.0 mL), and the aqueous layer was extracted with DCM (3.0 mL). The organic layers were combined, dried over sodium sulfate, and concentrated. The residue was purified by silica gel chromatography, eluting with ethyl acetate/petroleum ether, to give amide **Bz-3**.

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