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Diastereoselective Synthesis of Spirocyclopropanes under Mild Conditions via Formal [2 + 1] Cycloadditions Using 2,3-Dioxo-4-benzylidene-pyrrolidines

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Abstract: A highly diastereoselective cyclopropanation of cyclic enones with sulfur ylides was developed under catalyst-free conditions, producing multifunctional spirocyclopropanes in generally excellent yields (up to 99% yield and >99:1 d.r.). The asymmetric version of this method was realized by using an easily available chiral sulfur ylide, affording products with moderate to good stereoselectivity.

Keywords: spirocyclopropanes; diastereoselective synthesis; catalyst free; sulfur ylide

1. Introduction

Spirocycles are significant structures found in various natural products and many potent synthetic drug candidates [1–3]. Due to their important physiological functions, the synthesis of spirocycles has become an attractive target in organic chemistry, especially in recent years [4–6]. Among various spirocycles, spirocyclopropanes have shown high potential pharmaceutical activities (Figure 1). For example, the illudins [7,8], sesquiterpene secondary metabolites of basidiomycetes, have demonstrated activity against cancer; acylfulvene and irofulven [9,10], which are derived from illudin via a semisynthetic approach, also show anti-tumor bioactivity. Ptaquiloside [11], a toxic derivative from bracken, is recently reported to depress tumor-infiltration in HPV-16 transgenic mice. The natural products CC-1065, duocarmycin A and AS [12,13] were identified as strong anticancer drug candidates as well. Recently, many spirocyclopropanes possessing a pyrrolidin-2-one moiety have been developed into useful drug candidates. For instance, ledipasvir [14,15], a drug developed by Gilead Sciences, is an effective inhibitor of the hepatitis C virus. Other compounds reported by Berman et al. [16] also exhibited biological activities; for example, the OPH carboxylic acid can affect the function of disintegrin and metalloproteinase domain-containing proteins.

Meanwhile, cyclopropanes can also be applied as versatile units for the construction of other frameworks due to their unique combination of reactivity and structural properties [17–20]. For instance, the ring-enlargement reactions of cyclopropanes with nucleophiles, such as amines, alcohols, and carboxylic acids, are efficient pathways to various heterocycles [21–27]. Consequently, numerous efforts have been devoted to the formation of three-membered carbocyclic rings during

the last few decades [28–36]. The reactions of carbenoids with alkenes such as the Simmons–Smith cyclo-propanation involving organozinc carbenes [37–40], or the addition of carbenes, generated from diazo compounds in the presence of transition metals, to double bonds [41–44] are the most significant and useful classical methods for the construction of cyclopropanes. In addition, base-promoted cyclopropanations between α-halogenated compounds and electron-deficient olefins [45–47] are also reliable approaches to cyclopropanes. However, these methods often require the use of metals or harsh conditions.

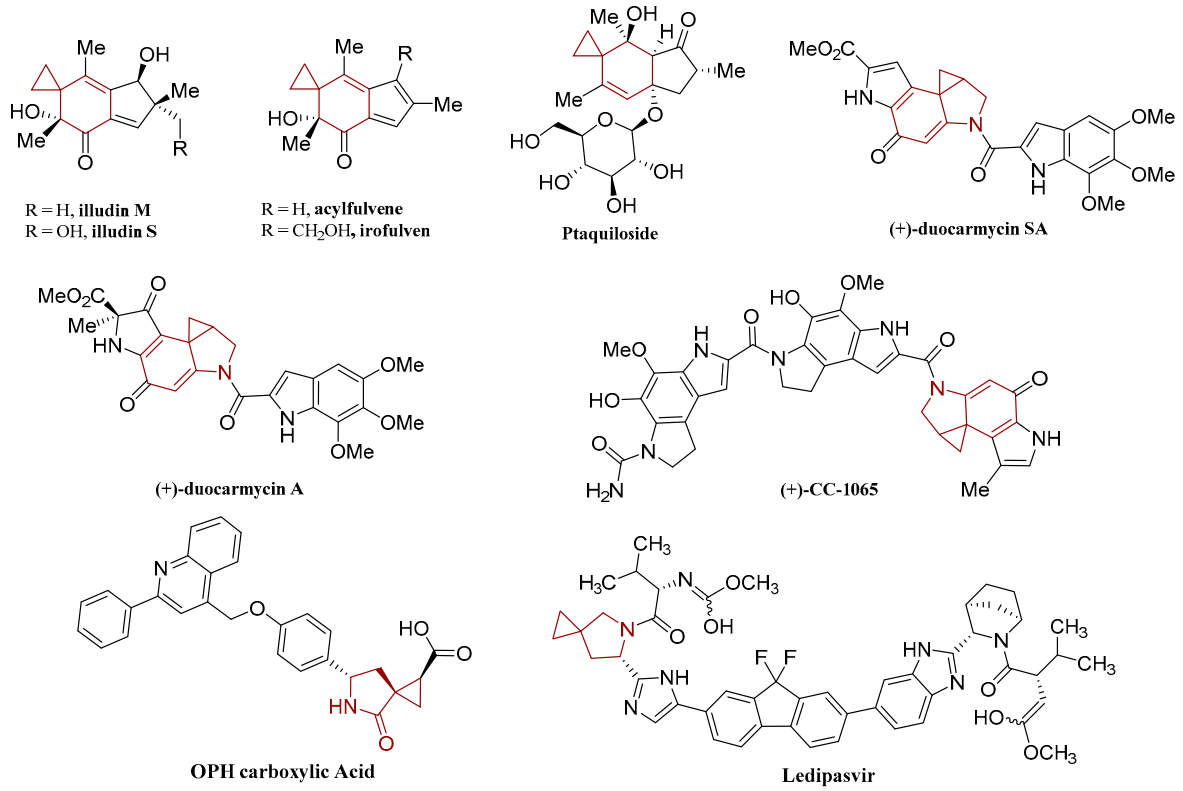


Figure 1. Selected products containing spirocyclopropanane possess biological activities.

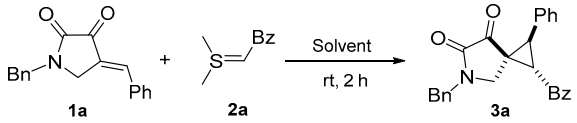
The cyclopropanation of electron-deficient olefins and ylides, including sulfonium [48–55], telluronium [56,57], arsonium [58–61], and ammonium ylides [62–65], represents one of the most efficient and straightforward strategies to construct cyclopropane-containing frameworks. Among them, sulfonium ylides, as well-developed active units, can also react with cyclic electron-withdrawing alkenes to access synthetically challenging spirocyclopropanes [51–55]. A great number of studies have been directed to the cyclopropanation with sulfonium ylides; however, harsh conditions such as strong base were usually required, which has limited the structural diversity of cyclopropane scaffolds as well as restricted functional group tolerance. Therefore, the demand on exploring cyclopropanation chemistry under mild conditions and further expanding the structural generality is still highly desirable. Recently, we developed some convenient synthetic strategies directly toward heterocyclic compounds bearing the pyrrolidin-2-one moiety by using 2,3-dioxobenzylidenepyrrolidine, a highly reactive cyclic enone [66,67]. Considering the potential capacity of this enone to serve as an electron-deficient alkene, we report herein an efficient catalyst-free cyclopropanation with 2,3-dioxopyrrolidine and sulfur ylides which leads to the diastereoselective synthesis of spirocyclopropanes.

2. Results

In our initial research, the reaction of readily available cyclic enone **1a** and sulfur ylide **2a** was carried out in dichloromethane (DCM) at room temperature (Table 1). We were pleased to find

that, under these conditions, **1a** underwent the desired cyclopropanation with sulfur ylide **2a** giving spirocyclopropane **3a** in good yield (86%) and with promising diastereoselectivity (d.r. = 93:7, Entry 1). Encouraged by this result, we proceeded to optimize the reaction by evaluating the effect of solvents. As outlined in Table 1, a series of solvents were examined (Entries 2–9) and 1,4-dioxane provided the best yield and diastereoselectivity (Entry 5). Meanwhile, since the reactions worked quite well at room temperature, a screening study of temperature effects was avoided. Therefore, 1,4-dioxane as the solvent at room temperature were determined as the optimal reaction conditions.

Table 1. Screening studies of the cyclopropanation reaction [a].



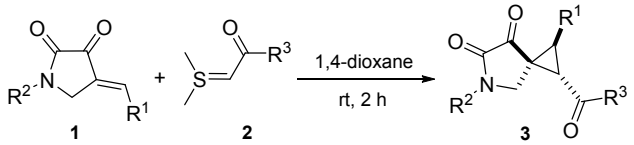
1a **2a** **3a**

Entry	Solvent	d.r. [b]	Yield (%) [c]
1	DCM	93:7	86
2	$CHCl_3$	96:4	94
3	DCE	94:6	90
4	THF	97:3	79
5	1,4-dioxane	98:2	92
6	MeOH	53:47	76
7	EtOH	68:32	74
8	MeCN	84:16	92
9	Toluene	87:13	88

[a] Reaction conditions: **1a** (0.1 mmol), **2a** (0.1 mmol), solvent (2 mL), r.t. DCE = 1,2-dichloroethane; Bn = benzyl; Bz = benzoyl; [b] Determined by ^{1}H-NMR spectroscopy of the crude reaction mixture; [c] Isolated yields.

After the optimal conditions of the reaction were established, we then investigated the generality of this reaction with a variety of 2,3-dioxopyrrolidine derivatives **1** as substrates (Table 2). By using different cyclic enones **1** bearing various kinds of substituents on phenyl ring, the reactions can finished rapidly in 2 h to afford the corresponding spirocyclopropane **3a**–**3n** in good to excellent yields with satisfactory diastereoselectivity (Entries 1–14). The reactions were also suitable for enone substrates with polycyclic or heteroaromatics, such as 1-naphthyl and thienyl rings (Entries 15 and 16) (For details, please see Supplementary File Part 2). Furthermore, the practicality of this methodology was illustrated by a scaled up reaction: 2.5 mmol of cyclic enone **1a** was treated with 2.5 mmol of sulfur ylide **2a** under the optimal conditions in 1,4-dioxane. The desired product **3a** was obtained in excellent yield with outstanding diastereoselectivity (96% yield and 97:3 d.r., see Scheme 1).

Table 2. Substrates scope of cyclopropanation of cyclic enones **1** with sulfur ylides **2** [a].



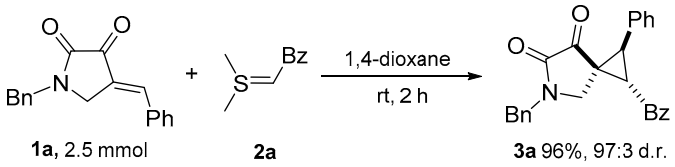
1 **2** **3**

Entry	R^1	R^2	R^3	Product	d.r. [b]	Yield (%) [c]
1	Ph	Bn	Ph	**3a**	98:2	92
2	3-MeC_6H_4	Bn	Ph	**3b**	92:8	83
3	4-MeC_6H_4	Bn	Ph	**3c**	98:2	93
4	2-$MeOC_6H_4$	Bn	Ph	**3d**	92:8	83
5	3-$MeOC_6H_4$	Bn	Ph	**3e**	97:3	91
6	4-$MeOC_6H_4$	Bn	Ph	**3f**	96:4	94
7	4-FC_6H_4	Bn	Ph	**3g**	96:4	88
8	2-ClC_6H_4	Bn	Ph	**3h**	97:3	98
9	3-ClC_6H_4	Bn	Ph	**3i**	97:3	94
10	4-ClC_6H_4	Bn	Ph	**3j**	96:4	59
11	3-BrC_6H_4	Bn	Ph	**3k**	94:6	84
12	4-BrC_6H_4	Bn	Ph	**3l**	96:4	57

Table 2. *Cont.*

Entry	R^1	R^2	R^3	Product	d.r. [b]	Yield (%) [c]
13	3,4-$(MeO)_2C_6H_3$	Bn	Ph	**3m**	98:2	81
14 [d]	2,4-$Cl_2C_6H_3$	Bn	Ph	**3n**	>99:1	99
15	1-Naphthyl	Bn	Ph	**3o**	94:6	94
16	2-Thienyl	Bn	Ph	**3p**	98:2	86
17	Ph	PMB	Ph	**3q**	98:2	90
18 [e]	Ph	Bn	OEt	**3r**	92:8	99
19 [e]	Ph	Bn	O*t*-Bu	**3s**	90:10	99

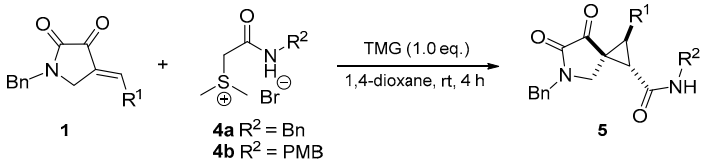
[a] Unless otherwise noted, reaction was carried out with **1** (0.1 mmol), **2** (0.1 mmol) in 2 mL of 1,4-dioxane at r.t. PMB = *p*-methoxybenzyl; [b] Determined by ^{1}H-NMR spectroscopy of the crude reaction mixture; [c] Isolated yields; [d] The absolute configuration of **3n** was determined by X-ray analysis. Other products were assigned by analogy; [e] Sulfonium bromide salts and 0.1 mmol extra TMG was used instead of **2**.



Scheme 1. Scale-up experiment of the cyclopropanation reaction.

On the other hand, the amide functional group commonly exists in many bioactive natural products and medicinal molecules [68,69]. With the intention of preparing amide-containing spirocyclopropanes, benzyl or PMB substituted amidic sulfonium salts **4a** and **4b** were prepared for further investigation. A simple attempt to cyclopropanate enone **1a** with an amidic sulfur ylide of **4a** was not successful. However, to our satisfaction, the reactions of cyclic enones **1** and amidic sulfonium salt **4** in the presence of 1,1,3,3-tetramethylguanidine (TMG) in 1,4-dioxone at room temperature proceeded efficiently to access the desired products within 4 h. As shown in Table 3, several cyclic enones bearing different substituents on the phenyl ring smoothly reacted with sulfonium salts **4a** or **4b**, to obtain an array of amide-containing spirocyclopropanes with good results (Entries 1–6). Moreover, the 1-naphthyl and 2-thienyl cyclic enones showed lower reactivity but also gave the corresponding products in good yields with excellent diastereoselectivity, albeit with longer reaction times (Entries 7–10) (For details, please see Supplementary File Part 3).

Table 3. Further studies of the cyclopropanation of cyclic enone **1** and sulfonium salts **4** [a].

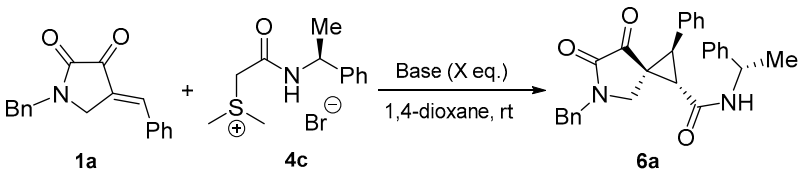


Entry	R^1	R^2	Product	d.r. [b]	Yield (%) [c]
1	Ph	Bn	**5a**	96:4	98
2	Ph	PMB	**5b**	>99:1	99
3	3-MeC_6H_4	Bn	**5c**	97:3	99
4	3-MeC_6H_4	PMB	**5d**	94:6	92
5	4-ClC_6H_4	Bn	**5e**	91:9	99
6	2-ClC_6H_4	PMB	**5f**	94:6	98
7 [d]	2-Naphthyl	Bn	**5g**	> 99:1	85
8 [d]	2-Naphthyl	PMB	**5h**	> 99:1	90
9 [d]	2-Thienyl	Bn	**5i**	> 99:1	83
10 [d]	2-Thienyl	PMB	**5j**	> 99:1	81

[a] Unless otherwise noted, reactions were carried out with **1** (0.1 mmol), **4** (0.1 mmol) and TMG (0.1 mmol) in 2 mL of 1,4-dioxane at rt for 4 h; [b] Determined by ^{1}H-NMR spectroscopy of the crude reaction mixture; [c] Isolated yields; [d] Reaction time was 36 h.

Encouraged by the selective reaction outcomes of amide substrates **4a** and **4b**, further investigation of asymmetric synthesis of chiral spirocyclopropanes were evaluated by introducing a chirality-inducing group on the amidic sulfonium salt. As outlined in Table 4, the easily available chiral *N*-phenylethyl sulfur ylide precursor **4c** was utilized to react with cyclic enone **1a** in 1,4-dioxane at room temperature, which was promoted by a series of organic and inorganic bases. Chiral spirocyclopropane **6a** was generally obtained in excellent yields with moderate diastereoselectivity (Entries 1–5), and TMG was demonstrated to be the optimal base. Notably, both the two diastereoisomers which are enantiopure products could be easily obtained by simple flash chromatography.

Table 4. Optimization of reaction condition for the synthesis of chiral spirocyclopropane **6a** [a].

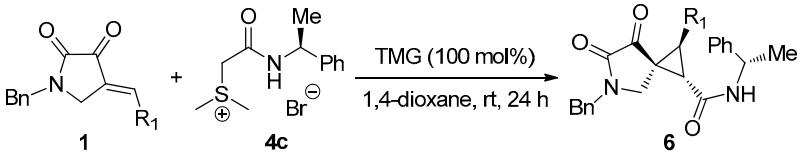


Entry	Base	X (eq.)	Time	d.r. [b]	Yield (%) [c]
1	TMG	1.0	24 h	72:28	99
2	DBU	1.0	24 h	62:38	99
3	KOH	1.5	15 min	65:35	99
4	*t*BuOK	1.5	10 min	68:32	95
5	K_2CO_3	2.0	72 h	68:32	92

[a] Unless otherwise noted, reaction was carried out with **1** (0.1 mmol), **4c** (0.1 mmol) and corresponding base in 2 mL of 1,4-dioxane at r.t.; [b] Determined by ^{1}H-NMR spectroscopy of the crude reaction mixture; [c] Isolated yields of both diastereoisomers.

Having established the optimized conditions for the asymmetric cyclopropanation, we then investigated the performance of a variety of cyclic enone **1** in the reaction system promoted by TMG. The results are summarized in Table 5.

Table 5. Substrates scope of cyclopropanation of cyclic enones **1** with chiral sulfonium salt **4c** [a].

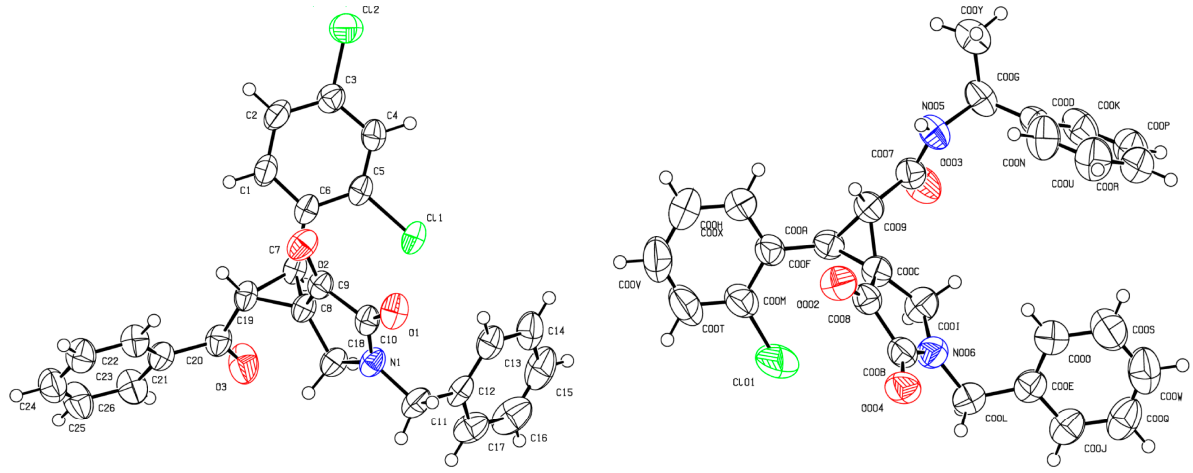


Entry	R^1	Product	d.r. [b]	Yield(%) [c]
1	Ph	**6a**	72:28	99
2	4-MeC_6H_4	**6b**	70:30	97
3	4-MeOC_6H_4	**6c**	64:36	91
4	4-FC_6H_4	**6d**	81:19	92
5 [d]	2-ClC_6H_4	**6e**	70:30	90
6	4-BrC_6H_4	**6f**	62:38	81
7 [e]	1-Naphthyl	**6g**	72:28	97
8 [e]	2-Naphthyl	**6h**	77:23	99
9 [e]	2-Thienyl	**6i**	60:40	90

[a] Unless otherwise noted, reaction was carried out with **1** (0.1 mmol), **4** (0.1 mmol) and TMG (0.1 mmol) in 2 mL of 1,4-dioxane at r.t. for 24 h; [b] Determined by ^{1}H-NMR spectroscopy of the crude reaction mixture; [c] Isolated yields of both diastereoisomers; [d] The absolute configuration of **6e** was determined by X-ray analysis. Other products were assigned by analogy; [e] Reaction time was 36 h.

Enone substrates with electron-withdrawing or electron-donating groups on the phenyl ring were well tolerated, delivering the desired products **6a**–**6g** in high yields with moderate to good diastereoselectivity (Entries 1–6). Furthermore, enones bearing diverse aryl or heteroaryl groups, such

as 1-naphthyl, 2-naphthyl and 2-thienyl were also tolerated to produce **6h–6j** with similar results (Entries 7–9) (For details, please see Supplementary File Part 4). Moreover, structural correctness and the absolute configuration of the spirocyclopropanes were confirmed by X-ray diffraction analysis of the representative products **3n** and the enantiopure **6e** (Figure 2) [70]. (For details, please see Supplementary File Parts 5 and 6).



3n **6e**

Figure 2. Single crystal X-ray diffraction analysis of products **3n** and **6e**.

3. Materials and Methods

3.1. General Information

Commercial reagents and solvents were obtained from Adamas-beta (Shanghai, China), Aldrich Chemical Co. (Darmstadt, Germany), Alfa Aesar (Shanghai, China), Macklin (Shanghai, China) and Energy Chemical (Shanghai, China) and used as received with the following exceptions: THF, and toluene were purified by refluxing over Na-benzophenone under positive argon pressure followed by distillation [71–73]. The enone substrates were prepared according to literature procedure [74].

Proton nuclear magnetic resonance (^{1}H-NMR, 400 MHz) and carbon-13 nuclear magnetic resonance (^{13}C-NMR, 100 MHz) spectra were recorded in $CDCl_3$ on an AV 400 MHz spectrometer (Bruker, Billerica, MA, USA). Proton chemical shifts are reported in parts per million (δ scale), and are referenced using residual protons in the NMR solvent ($CHCl_3$ δ 7.26). Carbon chemical shifts are reported in parts per million (δ scale), and are referenced using the carbon resonances of the solvent ($CDCl_3$: triplet centered at δ 77.01). High resolution mass spectra (HRMS) were recorded on a SYNAPT G2 system (Waters, Milford, CT, USA) using an electrospray (ESI) ionization source.

3.2. Synthesis

3.2.1. General Procedure for the Synthesis of Multi-Substituted Spirocyclopropane **3**

A dried glass tube was charged with cyclic enone **1** (0.1 mmol) and sulfur ylide **2** (0.1 mmol) in 1,4-dioxane (0.5 M, 2 mL). The reaction vessel was sealed with a Teflon cap and stirred at room temperature for about 2 h. When the reaction was complete, the reaction mixture was concentrated and the residue was purified by flash chromatography on silica gel (petroleum ether/ethyl acetate) to afford the corresponding spirocyclopropane **3**, which was dried under vacuum oven and further analyzed by ^{1}H-NMR, ^{13}C-HMR, HRMS, etc.

1-Benzoyl-5-benzyl-2-phenyl-5-azaspiro[2.4]heptane-6,7-dione (**3a**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 4:1) to afford the corresponding

3a as a white solid with 98:2 dr, 92% yield. ^{1}H-NMR δ 8.05–7.99 (m, 2H), 7.69–7.60 (m, 1H), 7.52 (t, *J* = 7.7 Hz, 2H), 7.41–7.28 (m, 7H), 7.28–7.21 (m, 3H), 4.84–4.66 (dd, *J* = 14.4 Hz, 2H), 4.23 (d, *J* = 7.2 Hz, 1H), 3.88 (d, *J* = 12.2 Hz, 1H), 3.69 (d, *J* = 12.1 Hz, 1H), 3.59 (d, *J* = 7.2 Hz, 1H); ^{13}C-NMR δ 194.9, 193.4, 159.2, 136.6, 134.5, 134.2, 131.7, 129.0, 129.0, 129.0, 128.6, 128.4, 128.4, 128.4, 128.1, 48.7, 47.3, 44.3, 41.1, 36.6; HRMS: *m*/*z* calculated for $C_{21}H_{17}N_3O_2Na^+$: 366.1218, found: 366.1227.

1-Benzoyl-5-benzyl-2-(m-tolyl)-5-azaspiro[2.4]heptane-6,7-dione (**3b**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 4:1) to afford the corresponding **3b** as a white solid with 92:8 d.r., 83% yield. ^{1}H-NMR δ (ppm) 8.06–7.99 (m, 2H), 7.68–7.61 (m, 1H), 7.52 (t, *J* = 7.8 Hz, 2H), 7.40–7.28 (m, 5H), 7.20 (t, *J* = 8.0 Hz, 1H), 7.06 (m, 3H), 4.74 (q, *J* = 14.4 Hz, 2H), 4.22 (d, *J* = 7.2 Hz, 1H), 3.87 (d, *J* = 12.4 Hz, 1H), 3.68 (d, *J* = 12.4 Hz, 1H), 3.55 (d, *J* = 7.2 Hz, 1H), 2.33 (s, 3H); ^{13}C-NMR δ (ppm): 194.9, 193.4, 159.3, 138.1, 136.6, 134.5, 134.2, 131.6, 129.6, 129.0, 129.0, 128.9, 128.7, 128.6, 128.4, 128.3, 126.0, 48.7, 47.4, 44.4, 41.1, 36.6, 21.3; HRMS: *m*/*z* calculated for $C_{27}H_{23}NO_3Na^+$: 432.1576, found: 432.1573.

1-Benzoyl-5-benzyl-2-(p-tolyl)-5-azaspiro[2.4]heptane-6,7-dione (**3c**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 4:1) to afford the corresponding **3c** as a white solid with 98:2 d.r., 93% yield; ^{1}H-NMR δ (ppm) 8.10–7.86 (m, 2H), 7.68–7.60 (m, 1H), 7.52 (t, *J* = 7.8 Hz, 2H), 7.41–7.28 (m, 5H), 7.18–7.04 (m, 4H), 4.78 (d, *J* = 14.4 Hz, 1H), 4.69 (d, *J* = 14.4 Hz, 1H), 4.20 (d, *J* = 7.2 Hz, 1H), 3.87 (d, *J* = 12.0 Hz, 1H), 3.68 (d, *J* = 12.0 Hz, 1H), 3.55 (d, *J* = 7.2 Hz, 1H), 2.31 (s, 3H); ^{13}C-NMR δ (ppm) 195.0, 193.4, 159.3, 137.9, 136.6, 134.5, 134.2, 129.1, 129.0, 129.0, 128.8, 128.7, 128.6, 128.6, 128.3, 48.7, 47.3, 44.3, 41.2, 36.6, 21.1; HRMS: *m*/*z* calculated for $C_{27}H_{23}NO_3Na^+$: 432.1576, found: 432.1579.

1-Benzoyl-5-benzyl-2-(2-methoxyphenyl)-5-azaspiro[2.4]heptane-6,7-dione (**3d**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 4:1) to afford the corresponding **3d** as a white solid with 92:8 d.r., 83% yield; ^{1}H-NMR δ (ppm) 8.11–7.99 (m, 2H), 7.70–7.61 (m, 1H), 7.57–7.48 (m, 2H), 7.43–7.31 (m, 5H), 7.30–7.21 (m, 2H), 6.96 (m, 1H), 6.78 (dd, *J* = 8.4, 0.8 Hz, 1H), 5.01 (d, *J* = 14.4 Hz, 1H), 4.54 (d, *J* = 14.4 Hz, 1H), 4.04 (d, *J* = 7.0 Hz, 1H), 3.95 (d, *J* = 11.8 Hz, 1H), 3.69 (d, *J* = 11.8 Hz, 1H), 3.62 (s, 3H); ^{13}C-NMR δ (ppm): 195.2, 192.6, 159.8, 157.0, 136.8, 135.0, 134.1, 130.3, 130.1, 129.4, 129.0, 128.6, 128.4, 128.3, 121.2, 120.7, 110.3, 55.1, 48.5, 47.4, 39.8, 39.1, 36.7; HRMS: *m*/*z* calculated for $C_{27}H_{23}NO_4Na^+$: 448.1525, found: 448.1529.

1-Benzoyl-5-benzyl-2-(3-methoxyphenyl)-5-azaspiro[2.4]heptane-6,7-dione (**3e**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 4:1) to afford the corresponding **3e** as a white solid with 97:3 d.r., 91% yield; ^{1}H-NMR δ (ppm) 8.05–7.97 (m, 2H), 7.69–7.60 (m, 1H), 7.52 (t, *J* = 7.6 Hz, 2H), 7.41–7.27 (m, 5H), 7.22 (m, 1H), 6.87–6.75 (m, 3H), 4.79 (d, *J* = 14.4 Hz, 1H), 4.69 (d, *J* = 14.4 Hz, 1H), 4.21 (d, *J* = 7.2 Hz, 1H), 3.87 (d, *J* = 12.0 Hz, 1H), 3.79 (s, 3H), 3.68 (d, *J* = 12.0 Hz, 1H), 3.55 (d, *J* = 7.2 Hz, 1H); ^{13}C-NMR δ (ppm): 194.8, 193.4, 159.5, 159.2, 136.6, 134.5, 134.2, 133.2, 129.4, 129.0, 129.0, 128.7, 128.5, 128.4, 121.3, 115.1, 113.2, 55.2, 48.7, 47.3, 44.2, 41.1, 36.6; HRMS: *m*/*z* calculated for $C_{27}H_{23}NO_4Na^+$: 448.1525, found: 448.1523.

1-Benzoyl-5-benzyl-2-(4-methoxyphenyl)-5-azaspiro[2.4]heptane-6,7-dione (**3f**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 4:1) to afford the corresponding **3f** as a white solid with 96:4 d.r., 94% yield; ^{1}H-NMR δ (ppm) 8.06–7.95 (m, 2H), 7.69–7.60 (m, 1H), 7.52 (t, *J* = 7.6 Hz, 2H), 7.40–7.28 (m, 5H), 7.22–7.13 (m, 2H), 6.89–6.78 (m, 2H), 4.78 (d, *J* = 14.4 Hz, 1H), 4.69 (d, *J* = 14.4 Hz, 1H), 4.19 (d, *J* = 7.2 Hz, 1H), 3.86 (d, *J* = 12.4 Hz, 1H), 3.78 (s, 3H), 3.68 (d, *J* = 12.0 Hz, 1H), 3.54 (d, *J* = 7.2 Hz, 1H); ^{13}C-NMR δ (ppm) 195.0, 193.4, 159.4, 136.6, 134.5, 134.2, 130.1, 129.1, 129.0, 128.6, 128.4, 128.4, 128.0, 123.6, 113.9, 55.3, 48.7, 47.4, 44.2, 41.3, 36.8; HRMS: *m*/*z* calculated for $C_{27}H_{23}NO_4Na^+$: 448.1525, found: 448.1521.

1-Benzoyl-5-benzyl-2-(4-fluorophenyl)-5-azaspiro[2.4]heptane-6,7-dione (**3g**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 4:1) to afford the corresponding **3g** as a white solid with 96:4 d.r., 88% yield; ^{1}H-NMR δ (ppm) 8.05–7.96 (m, 2H), 7.66 (t, *J* = 7.6 Hz, 1H), 7.53 (t, *J* = 7.7 Hz, 2H), 7.35 (m, 3H), 7.30 (m, 2H), 7.27–7.17 (m, 2H), 7.00 (t, *J* = 8.6 Hz, 2H), 4.79 (d, *J* = 14.4 Hz, 1H), 4.68 (d, *J* = 14.4 Hz, 1H), 4.17 (d, *J* = 7.2 Hz, 1H), 3.86 (d, *J* = 12.0 Hz, 1H), 3.67 (d, *J* = 12.0 Hz, 1H), 3.55 (d, *J* = 7.2 Hz, 1H); ^{13}C-NMR δ (ppm) 194.6, 193.5, 159.1, 136.5, 134.4, 134.3, 130.7, 130.6, 129.1, 129.0, 128.6, 128.4, 128.4, 115.5, 115.3, 48.7, 47.2, 43.3, 41.0, 36.8; HRMS: *m*/*z* calculated for $C_{26}H_{20}FNO_3Na^+$: 436.1325, found: 436.1322.

1-Benzoyl-5-benzyl-2-(2-chlorophenyl)-5-azaspiro[2.4]heptane-6,7-dione (**3h**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 4:1) to afford the corresponding **3h** as a white solid with 97:3 d.r., 98% yield; ^{1}H-NMR δ (ppm) 8.15–7.95 (m, 2H), 7.77–7.60 (m, 1H), 7.54 (t, *J* = 7.6 Hz, 2H), 7.41–7.29 (m, 7H), 7.27–7.20 (m, 2H), 5.06 (d, *J* = 14.4 Hz, 1H), 4.45 (d, *J* = 14.4 Hz, 1H), 4.16 (d, *J* = 6.8 Hz, 1H), 3.94 (d, *J* = 12.0 Hz, 1H), 3.67 (d, *J* = 12.0 Hz, 1H), 3.44 (d, *J* = 7.2 Hz, 1H); ^{13}C-NMR δ (ppm) 194.4, 193.0, 159.2, 136.5, 135.2, 134.5, 134.4, 130.7, 130.6, 129.5, 129.4, 129.1, 129.0, 128.7, 128.4, 128.4, 126.8, 48.6, 46.5, 41.4, 39.9, 36.6; HRMS: *m*/*z* calculated for $C_{26}H_{20}ClNO_3Na^+$: 452.1029, found: 452.1028.

1-Benzoyl-5-benzyl-2-(3-chlorophenyl)-5-azaspiro[2.4]heptane-6,7-dione (**3i**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 4:1) to afford the corresponding **3i** as a white solid with 97:3 d.r., 94% yield; ^{1}H-NMR δ (ppm) 8.05–7.97 (m, 2H), 7.70–7.62 (m, 1H), 7.53 (t, *J* = 7.8 Hz, 2H), 7.41–7.28 (m, 5H), 7.25 (m, 3H), 7.13 (m, 1H), 4.78 (d, *J* = 14.4 Hz, 1H), 4.69 (d, *J* = 14.4 Hz, 1H), 4.18 (d, *J* = 7.2 Hz, 1H), 3.86 (d, *J* = 12.0 Hz, 1H), 3.65 (d, *J* = 12.0 Hz, 1H), 3.54 (d, *J* = 7.2 Hz, 1H); ^{13}C-NMR δ (ppm) 194.4, 193.4, 159.0, 136.4, 134.4, 134.4, 134.3, 133.7, 129.6, 129.1, 129.1, 129.1, 128.6, 128.4, 128.4, 128.3, 127.2, 48.8, 47.1, 43.0, 40.8, 36.5 HRMS: *m*/*z* calculated for $C_{26}H_{20}ClNO_3Na^+$: 452.1029, found: 452.1028.

1-Benzoyl-5-benzyl-2-(4-chlorophenyl)-5-azaspiro[2.4]heptane-6,7-dione (**3j**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 4:1) to afford the corresponding **3j** as a white solid with 96:4 d.r., 59% yield; ^{1}H-NMR δ (ppm) 8.04–7.97 (m, 2H), 7.70–7.61 (m, 1H), 7.53 (t, *J* = 7.6 Hz, 2H), 7.35 (m, 2H), 7.32–7.24 (m, 5H), 7.22–7.15 (m, 2H), 4.79 (d, *J* = 14.4 Hz, 1H), 4.68 (d, *J* = 14.4 Hz, 1H), 4.17 (d, *J* = 7.2 Hz, 1H), 3.86 (d, *J* = 12.0 Hz, 1H), 3.66 (d, *J* = 12.0 Hz, 1H), 3.54 (d, *J* = 7.2 Hz, 1H); ^{13}C-NMR δ (ppm) 194.6, 193.5, 159.1, 136.5, 134.5, 134.4, 134.1, 130.4, 130.3, 129.1, 129.1, 128.7, 128.6, 128.5, 128.4, 48.8, 47.2, 43.2, 41.0, 36.7; HRMS: *m*/*z* calculated for $C_{26}H_{20}ClNO_3Na^+$: 452.1029, found: 452.1028.

1-Benzoyl-5-benzyl-2-(3-bromophenyl)-5-azaspiro[2.4]heptane-6,7-dione (**3k**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 3:1) to afford the corresponding **3k** as a white solid with 94:6 d.r., 84% yield; ^{1}H-NMR δ (ppm) 8.05–7.96 (m, 2H), 7.70–7.61 (m, 1H), 7.53 (t, *J* = 7.6 Hz, 2H), 7.45–7.38 (m, 2H), 7.35 (m, 3H), 7.30 (m, 2H), 7.21–7.15 (m, 2H), 4.78 (d, *J* = 14.4 Hz, 1H), 4.69 (d, *J* = 14.4 Hz, 1H), 4.18 (d, *J* = 7.2 Hz, 1H), 3.86 (d, *J* = 12.0 Hz, 1H), 3.65 (d, *J* = 12.0 Hz, 1H), 3.54 (d, *J* = 7.2 Hz, 1H); ^{13}C-NMR δ (ppm) 194.4, 193.4, 159.0, 136.4, 134.4, 134.4, 134.0, 132.0, 131.3, 129.9, 129.1, 129.0, 128.6, 128.4, 128.4, 127.6, 122.4, 48.8, 47.1, 42.9, 40.8, 36.5; HRMS: *m*/*z* calculated for $C_{26}H_{20}BrNO_3Na^+$: 496.0524, found: 496.0526.

1-Benzoyl-5-benzyl-2-(4-bromophenyl)-5-azaspiro[2.4]heptane-6,7-dione (**3l**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 3:1) to afford the corresponding **3l** as a white solid with 96:4 d.r., 57% yield; ^{1}H-NMR δ (ppm) 8.05–7.95 (m, 2H), 7.66 (t, *J* = 7.4 Hz, 1H), 7.53 (t, *J* = 7.6 Hz, 2H), 7.47–7.41 (m, 2H), 7.35 (m, 3H), 7.30 (m, 2H), 7.13 (d, *J* = 8.4 Hz, 2H), 4.79 (d, *J* = 14.4 Hz, 1H), 4.68 (d, *J* = 14.4 Hz, 1H), 4.17 (d, *J* = 7.2 Hz, 1H), 3.86 (d, *J* = 12.0 Hz, 1H), 3.66 (d, *J* = 12.0 Hz, 1H), 3.52 (d, *J* = 7.2 Hz, 1H); ^{13}C-NMR δ (ppm) 194.5, 193.5, 159.0,

136.5, 134.4, 134.4, 131.6, 130.8, 130.6, 129.1, 129.1, 128.6, 128.4, 128.4, 122.2, 48.8, 47.3, 43.2, 40.9, 36.6; HRMS: *m*/*z* calculated for $C_{26}H_{20}BrNO_3Na^+$: 496.0524, found: 496.0522.

1-Benzoyl-5-benzyl-2-(3,4-dimethoxyphenyl)-5-azaspiro[2.4]heptane-6,7-dione (**3m**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 2:1) to afford the corresponding **3m** as a white solid with 98:2 d.r., 81% yield; ^{1}H-NMR δ (ppm): 8.01 (m, 2H), 7.69–7.61 (m, 1H), 7.52 (t, *J* = 7.8 Hz, 2H), 7.40–7.28 (m, 5H), 6.87–6.76 (m, 3H), 4.79 (d, *J* = 14.4 Hz, 1H), 4.69 (d, *J* = 14.4 Hz, 1H), 4.19 (d, *J* = 7.6 Hz, 1H), 3.88 (s, 3H), 3.85 (s, 4H), 3.68 (d, *J* = 12.0Hz, 1H), 3.54 (d, *J* = 7.2 Hz, 1H); ^{13}C-NMR δ (ppm): 194.8, 193.5, 159.3, 148.9, 148.7, 136.6, 134.5, 134.2, 129.0, 129.0, 128.5, 128.3, 128.3, 124.2, 121.5, 112.0, 110.9, 56.0, 55.9, 48.7, 47.3, 44.4, 41.4, 37.0; HR-MS (ESI): *m*/*z* calculated for $C_{28}H_{25}NO_5Na^+$: 478.1630, found: 478.1628.

1-Benzoyl-5-benzyl-2-(2,4-dichlorophenyl)-5-azaspiro[2.4]heptane-6,7-dione (**3n**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 4:1) to afford the corresponding **3n** as a white solid with >99:1 d.r., 99% yield; ^{1}H-NMR δ (ppm) 8.07–7.98 (m, 2H), 7.72–7.62 (m, 1H), 7.54 (t, *J* = 7.6 Hz, 2H), 7.42–7.20 (m, 8H), 5.05 (d, *J* = 14.4 Hz, 1H), 4.42 (d, *J* = 14.4 Hz, 1H), 4.11 (d, *J* = 7.2 Hz, 1H), 3.91 (d, *J* = 12.0 Hz, 1H), 3.65 (d, *J* = 12.0 Hz, 1H), 3.38 (d, *J* = 7.2 Hz, 1H); ^{13}C-NMR δ (ppm) 194.0, 193.0, 159.0, 136.3, 135.8, 134.7, 134.4, 131.4, 129.4, 129.2, 129.1, 128.9, 128.9, 128.7, 128.6, 128.4, 127.2, 48.6, 46.4, 40.4, 39.7, 36.4; HRMS: *m*/*z* calculated for $C_{26}H_{19}Cl_2NO_3Na^+$: 486.0640, found: 486.0641.

1-Benzoyl-5-benzyl-2-(naphthalen-1-yl)-5-azaspiro[2.4]heptane-6,7-dione (**3o**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 3:1) to afford the corresponding **3o** as a white solid with 94:6 d.r., 94% yield; ^{1}H-NMR δ (ppm) 8.15–8.08 (m, 2H), 7.84 (d, *J* = 8.2 Hz, 1H), 7.80 (d, *J* = 8.0 Hz, 1H), 7.71–7.65 (m, 1H), 7.61–7.51 (m, 3H), 7.51–7.44 (m, 5H), 7.40 (m, 4H), 5.20 (d, *J* = 14.4 Hz, 1H), 4.39 (d, *J* =6.8 Hz, 2H), 4.35 (d, *J* = 14.4 Hz, 2H), 4.14 (d, *J* = 12.4 Hz, 1H), 3.85 (s, 1H), 3.82 (d, *J* = 4.8Hz, 1H); ^{13}C-NMR δ (ppm) 194.9, 192.6, 159.1, 136.6, 134.8, 134.3, 133.6, 132.5, 129.2, 129.1, 129.1, 129.0, 128.6, 128.5, 128.5, 128.0, 127.0, 126.9, 126.0, 125.0, 122.2, 48.6, 47.0, 42.0, 40.4, 36.1; HRMS: *m*/*z* calculated for $C_{28}H_{25}NO_5Na^+$: 468.1576, found: 468.1573.

Ethyl-5-benzyl-6,7-dioxo-2-phenyl-5-azaspiro[2.4]heptane-1-carboxylate (**3p**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 3:1) to afford the corresponding **3p** as a white solid with 98:2 d.r., 86% yield; ^{1}H-NMR δ (ppm) 8.04–7.95 (m, 2H), 7.68–7.60 (m, 1H), 7.55–7.47 (m, 2H), 7.39–7.27 (m, 5H), 7.20 (dd, *J* = 5.2, 1.2 Hz, 1H), 7.04 (m, 1H), 6.95 (m, 1H), 4.76 (d, *J* = 14.4 Hz, 1H), 4.71 (d, *J* = 14.4 Hz, 1H), 4.18 (d, *J* = 7.0 Hz, 1H), 3.85 (d, *J* = 12.0 Hz, 1H), 3.66 (d, *J* = 12.0 Hz, 1H), 3.62 (dd, *J* = 7.0, 0.8Hz, 1H); ^{13}C-NMR (100 MHz, $CDCl_3$) δ (ppm) 194.2, 192.6, 159.1, 136.4, 134.4, 134.4, 134.2, 129.0, 128.9, 128.5, 128.3, 128.3, 127.5, 126.9, 125.6, 48.6, 47.0, 41.4, 38.5, 37.9; HRMS: *m*/*z* calculated for $C_{24}H_{19}NO_3SNa^+$: 424.0983, found: 424.0981.

1-Benzoyl-5-(4-methoxybenzyl)-2-phenyl-5-azaspiro[2.4]heptane-6,7-dione (**3q**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 4:1) to afford the corresponding **3q** as a white solid with 98:2 d.r., 90% yield; ^{1}H-NMR δ (ppm) 8.04–7.98 (m, 2H), 7.69–7.60 (m, 1H), 7.52 (t, *J* = 8.0 Hz, 2H), 7.35–7.27 (m, 3H), 7.27–7.19 (m, 5H), 6.92–6.84 (m, 2H), 4.72 (d, *J* = 14.4 Hz, 1H), 4.64 (d, *J* = 14.4 Hz, 1H), 4.22 (d, *J* = 7.2 Hz, 1H), 3.86 (d, *J* = 12.0 Hz, 1H), 3.80 (s, 3H), 3.66 (d, *J* = 12.0 Hz, 1H), 3.58 (d, *J* = 7.2 Hz, 1H); ^{13}C-NMR (100 MHz, $CDCl_3$) δ (ppm) 194.9, 193.6, 159.6, 159.1, 136.6, 134.2, 131.7, 130.0, 129.0, 128.4, 128.4, 128.1, 126.5, 114.4, 55.3, 48.1, 47.1, 44.2, 41.1, 36.6; HRMS: *m*/*z* calculated for $C_{27}H_{23}NO_4Na^+$: 448.1525, found: 448.1528.

Ethyl-5-benzyl-6,7-dioxo-2-phenyl-5-azaspiro[2.4]heptane-1-carboxylate (**3r**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 4:1) to afford the corresponding **3r** as a white solid with 92:8 d.r., 99% yield; ^{1}H-NMR δ (ppm) 7.42–7.34 (m, 3H),

7.34–7.30 (m, 2H), 7.29 (d, *J* = 1.8 Hz, 1H), 7.28–7.25 (m, 2H), 7.22–7.17 (m, 2H), 4.75 (s, 2H), 4.19 (qd, *J* = 7.2, 2.8 Hz, 2H), 3.77 (q, *J* = 12.0 Hz, 2H), 3.33 (d, *J* = 7.2 Hz, 1H), 3.21 (d, *J* = 7.2 Hz, 1H), 1.28 (t, *J* = 7.2 Hz, 3H); ^{13}C-NMR δ (ppm) 192.9, 169.3, 159.1, 134.5, 131.1, 129.0, 128.9, 128.5, 128.3, 128.3, 128.0, 61.8, 48.6, 47.4, 42.9, 38.1, 33.5, 14.0; HRMS: *m*/*z* calculated for $C_{22}H_{21}NO_4Na^+$: 386.1386, found: 386.1385.

Tert-butyl-5-benzyl-6,7-dioxo-2-phenyl-5-azaspiro[2.4]heptane-1-carboxylate (**3s**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 4:1) to afford the corresponding **3s** as a white solid with 90:10 d.r., 99% yield; ^{1}H-NMR δ (ppm) 7.30 (m, 3H), 7.28–7.24 (m, 2H), 7.22 (dd, *J* = 7.1, 1.8 Hz, 2H), 7.20–7.18 (m, 1H), 7.15–7.11 (m, 2H), 4.67 (s, 2H), 3.68 (d, *J* = 12.0 Hz, 1H), 3.62 (d, *J* = 12.0 Hz, 1H), 3.21 (d, *J* = 7.2 Hz, 1H), 3.05 (d, *J* = 7.2 Hz, 1H), 1.36 (s, 9H); ^{13}C-NMR δ (ppm) 192.1, 167.3, 158.2, 133.5, 130.3, 128.0, 127.9, 127.5, 127.3, 127.2, 126.9, 81.8, 47.5, 46.3, 41.6, 37.0, 33.9, 27.0; HRMS: *m*/*z* calculated for $C_{24}H_{25}NO_4Na^+$: 414.1681, found: 414.1680.

3.2.2. General Procedure for the Synthesis of Multi-Substituted Spirocyclopropane **5**

A dried glass tube was charged with cyclic enones **1** (0.1 mmol) and amidic sulfonium salt **4** (0.1 mmol) at the presence of TMG (13 μL, 0.1 mmol, 1.0 equiv.) in 1,4-dioxane (0.5 M, 2 mL). The reaction was sealed with a Teflon cap and stirred at room temperature overnight. When the reaction was complete, the reaction mixture was concentrated and the residue was purified by flash chromatography on silica gel (petroleum ether/ethyl acetate) to afford the corresponding spirocyclopropane **5**, which was dried under vacuum oven and further analyzed by ^{1}H-NMR, ^{13}C-HMR, HRMS, etc.

N,5-Dibenzyl-6,7-dioxo-2-phenyl-5-azaspiro[2.4]heptane-1-carboxamide (**5a**). Purification of the crude product via flash chromatography on silicagel (petroleum ether/ethyl acetate = 2:1) to afford the corresponding **5a** as a white solid with 96:4 d.r., 98% yield; ^{1}H-NMR δ (ppm) 8.27 (s, 1H), 7.36–7.30 (m, 3H), 7.26 (m, 5H), 7.21 (m, 2H), 7.14 (m, 4H), 4.73 (d, *J* = 4.4 Hz, 2H), 4.48 (dd, *J* = 15.2, 6.4 Hz, 1H), 4.36 (dd, *J* = 15.2, 5.6 Hz, 1H), 3.68 (d, *J* = 5.2 Hz, 2H), 3.53 (d, *J* = 7.6 Hz, 1H), 3.15 (d, *J* = 7.2 Hz, 1H); ^{13}C-NMR δ (ppm) 195.1, 167.0, 160.3, 138.1, 134.2, 132.3, 129.2, 129.1, 128.9, 128.4, 128.2, 128.2, 127.6, 127.3, 126.9, 48.7, 47.7, 43.6, 41.4, 38.1, 36.9; HRMS: *m*/*z* calculated for $C_{27}H_{24}N2O_3Na^+$: 447.1685, found: 447.1684.

5-Benzyl-N-(4-methoxybenzyl)-6,7-dioxo-2-phenyl-5-azaspiro[2.4]heptane-1-carboxamide (**5b**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 2:1) to afford the corresponding **5b** as a white solid with >99:1 d.r., 99% yield; ^{1}H-NMR δ (ppm) 7.91 (t, *J* = 5.6 Hz, 1H), 7.27–7.24 (m, 3H), 7.24–7.16 (m, 5H), 7.10–7.03 (m, 4H), 6.69–6.60 (m, 2H), 4.67 (s, 2H), 4.32 (dd, *J* = 15.0, 6.2 Hz, 1H), 4.24 (dd, *J* = 14.8, 5.4 Hz, 1H), 3.70 (s, 3H), 3.62 (d, *J* = 8.8 Hz, 2H), 3.45 (d, *J* = 7.2 Hz, 1H), 3.03 (d, *J* = 7.6 Hz, 1H); ^{13}C-NMR δ (ppm) 195.0, 166.9, 160.3, 158.6, 134.2, 132.3, 130.2, 129.2, 129.1, 128.7, 128.2, 128.2, 128.2, 127.6, 113.8, 55.2, 48.7, 47.7, 43.2, 41.4, 38.1, 37.0; HRMS: *m*/*z* calculated for $C_{28}H_{26}N_2O_4Na^+$: 477.1790, found: 477.1785.

N,5-Dibenzyl-6,7-dioxo-2-(p-tolyl)-5-azaspiro[2.4]heptane-1-carboxamide (**5c**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 2:1) to afford the corresponding **5c** as a white solid with 97:3 d.r., 99% yield; ^{1}H-NMR δ (ppm) 7.92 (s, 1H), 7.27–7.23 (m, 3H), 7.21–7.20 (m, 3H), 7.16–7.13 (m, 2H) , 7.12–7.09 (m, 2H), 7.02–6.92 (m, 4H), 4.67 (s, 2H), 4.41 (dd, *J* = 15.2, 6.0 Hz, 1H), 4.31 (dd, *J* = 15.2, 5.6 Hz, 1H), 3.62 (q, *J* = 16.8, 12.4 Hz, 2H), 3.43 (d, *J* = 7.4 Hz, 1H), 3.02 (d, *J* = 7.6 Hz, 1H), 2.26 (s, 3H); ^{13}C-NMR δ (ppm) 194.9, 167.1, 160.3, 138.0, 137.3, 134.3, 129.2, 129.1, 129.0, 128.9, 128.4, 128.3, 128.2, 127.4, 127.0, 48.7, 47.8, 43.7, 41.5, 38.3, 36.9, 21.1; HRMS: *m*/*z* calculated for $C_{28}H_{26}N_2O_3Na^+$: 461.1841, found: 461.1838.

5-Benzyl-N-(4-methoxybenzyl)-6,7-dioxo-2-(p-tolyl)-5-azaspiro[2.4]heptane-1-carboxamide (**5d**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 2:1) to afford the corresponding **5d** as a white solid with 94:6 d.r., 92% yield; ^{1}H-NMR δ (ppm) 7.97 (t, *J* = 5.8 Hz, 1H), 7.27–7.16 (m, 5H), 7.10–7.03 (m, 2H), 7.01–6.92 (m, 4H), 6.67–6.60 (m, 2H), 4.66 (s, 2H), 4.27 (qd, *J* = 15.0, 5.8 Hz, 2H), 3.69 (s, 3H), 3.67–3.55 (m, 2H), 3.41 (d, *J* = 7.2 Hz, 1H), 3.01 (d, *J* = 7.6 Hz, 1H); ^{13}C-NMR δ (ppm) 195.0, 167.0, 160.3, 158.6, 137.3, 134.3, 130.2, 129.2, 129.1, 129.0, 128.9, 128.7, 128.2, 128.2, 113.8, 55.2, 48.6, 47.7, 43.1, 41.3, 38.2, 37.1, 21.1; HRMS: *m*/*z* calculated for $C_{29}H_{28}N_2O_4Na^+$: 491.1947, found: 491.1958.

N,5-Dibenzyl-2-(4-chlorophenyl)-6,7-dioxo-5-azaspiro[2.4]heptane-1-carboxamide (**5e**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 2:1) to afford the corresponding **5e** as a white solid with 91:9 d.r., 99% yield; ^{1}H-NMR δ (ppm) 8.24 (t, *J* = 6.0 Hz, 1H), 7.40–7.29 (m, 3H), 7.29–7.24 (m, 3H), 7.24–7.13 (m, 6H), 7.11–7.01 (m, 2H), 4.80 (d, *J* = 14.4 Hz, 1H), 4.68 (d, *J* = 14.4 Hz, 1H), 4.52 (dd, *J* = 15.2, 6.4 Hz, 1H), 4.35 (dd, *J* = 15.2, 5.6 Hz, 1H), 3.68 (q, *J* = 15.6, 12.4 Hz, 2H), 3.50 (d, *J* = 7.4 Hz, 1H), 3.10 (d, *J* = 7.6 Hz, 1H); ^{13}C-NMR δ (ppm) 195.2, 166.7, 160.2, 137.9, 134.0, 133.5, 130.8, 130.5, 129.2, 128.4, 128.4, 128.4, 128.1, 127.3, 127.1, 48.7, 47.6, 43.7, 40.4, 37.9, 37.1; HRMS: *m*/*z* calculated for $C_{27}H_{23}ClN_2O_3Na^+$: 481.1295, found: 481.1296.

5-Benzyl-2-(2-chlorophenyl)-N-(4-methoxybenzyl)-6,7-dioxo-5-azaspiro[2.4]heptane-1-carboxamide (**5f**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 2:1) to afford the corresponding **5f** as a white solid with 94:6 d.r., 98% yield; ^{1}H-NMR δ (ppm) 8.25–8.08 (m, 1H), 7.27–7.20 (m, 4H), 7.20–7.11 (m, 5H), 7.10–7.03 (m, 2H), 6.71–6.63 (m, 2H), 4.88 (d, *J* = 14.4 Hz, 1H), 4.40 (d, *J* = 14.4 Hz, 1H), 4.28 (qd, *J* = 14.8, 5.6 Hz, 2H), 3.72 (s, 3H), 3.68 (d, *J* = 12.2 Hz, 1H), 3.54 (d, *J* = 12.2 Hz, 1H), 3.22 (d, *J* = 7.4 Hz, 1H), 3.00–2.87 (m, 1H); ^{13}C-NMR δ (ppm) 194.6, 166.6, 160.2, 158.7, 135.2, 134.3, 131.4, 130.9, 130.2, 129.2, 129.0, 129.0, 129.0, 128.8, 128.6, 128.2, 126.7, 113.8, 55.2, 48.5, 47.0, 43.3, 38.9, 37.0; HRMS: *m*/*z* calculated for $C_{28}H_{25}ClN_2O_4Na^+$: 511.1401, found: 511.1401.

N,5-Dibenzyl-2-(naphthalen-2-yl)-6,7-dioxo-5-azaspiro[2.4]heptane-1-carboxamide (**5g**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 2:1) to afford the corresponding **5g** as a white solid with >99:1 d.r., 85% yield; ^{1}H-NMR δ (ppm) 7.92 (t, *J* = 6.0 Hz, 1H), 7.82–7.80 (m, 1H), 7.76–7.68 (m, 1H), 7.63 (d, *J* = 1.6 Hz, 1H), 7.54–7.40 (m, 2H), 7.31–7.15 (m, 9H), 7.14–7.06 (m, 1H), 7.06–6.98 (m, 2H), 4.76 (s, 2H), 4.49 (dd, *J* = 15.2, 6.4 Hz, 1H), 4.35 (dd, *J* = 15.2, 5.2 Hz, 1H), 3.76 (d, *J* = 12.4 Hz, 1H), 3.72–3.62 (m, 2H), 3.22 (d, *J* = 7.6 Hz, 1H); ^{13}C-NMR δ (ppm) 194.9, 167.0, 160.2, 137.9, 134.2, 133.0, 132.8, 129.8, 129.1, 128.4, 128.3, 128.3, 128.2, 128.0, 127.9, 127.6, 127.3, 127.1, 127.0, 126.3, 126.2, 48.7, 47.7, 43.7, 41.5, 38.1, 37.0; HRMS: *m*/*z* calculated for $C_{31}H_{26}N_2O_3Na^+$: 497.1841, found: 497.1841.

5-Benzyl-N-(4-methoxybenzyl)-2-(naphthalen-2-yl)-6,7-dioxo-5-azaspiro[2.4]heptane-1-carboxamide (**5h**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 2:1) to afford the corresponding **5h** as a white solid with >99:1 d.r., 90% yield; ^{1}H-NMR δ (ppm) 7.76–7.61 (m, 3H), 7.58 (s, 1H), 7.43–7.33 (m, 2H), 7.20 (d, *J* = 9.1 Hz, 7H), 7.14–7.12 (m, 1H), 7.09–7.02 (m, 2H), 6.63 (d, *J* = 8.4 Hz, 2H), 4.68 (dq, *J* = 12.6, 14.4 Hz, 2H), 4.29 (dd, *J* = 5.7, 3.3 Hz, 2H), 4.33–4.26 (m, 2H), 3.77–3.70 (m, 2H), 3.66 (s, 3H), 3.63–3.56 (m, 1H), 3.08 (d, *J* = 7.4 Hz, 1H); ^{13}C-NMR δ (ppm) 195.0, 166.8, 160.2, 158.7, 134.2, 133.0, 132.7, 130.0, 129.8, 129.1, 128.8, 128.3, 128.2, 128.2, 127.9, 127.8, 127.6, 127.0, 126.3, 126.1, 113.8, 55.2, 48.7, 47.7, 43.3, 41.5, 38.1, 37.2; HRMS: *m*/*z* calculated for $C_{32}H_{28}N_2O_4Na^+$: 527.1947, found: 527.1943.

N,5-Dibenzyl-6,7-dioxo-2-(thiophen-2-yl)-5-azaspiro[2.4]heptane-1-carboxamide (**5i**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 2:1) to afford the corresponding **5i** as a white solid with >99:1 d.r., 83% yield; ^{1}H-NMR δ (ppm) 8.44–8.21 (m, 1H),

7.32–7.25 (m, 3H), 7.23–7.20 (m, 2H), 7.18–7.13 (m, 2H), 7.13–7.09 (m, 4H), 6.86–6.76 (m, 2H), 4.74 (d, *J* = 14.6 Hz, 1H), 4.61 (d, *J* = 14.6 Hz, 1H), 4.43 (dd, *J* = 15.2, 6.4 Hz, 1H), 4.28 (dd, *J* = 15.2, 5.4 Hz, 1H), 3.61 (s, 2H), 3.51 (d, *J* = 6.8 Hz, 1H), 3.11–2.97 (m, 1H); ^{13}C-NMR δ (ppm) 194.3, 166.5, 160.3, 138.0, 135.2, 134.2, 129.1, 128.4, 128.3, 127.4, 127.3, 127.0, 126.7, 125.3, 48.7, 47.5, 43.7, 38.6, 38.3, 35.9; HRMS: *m*/*z* calculated for $C_{25}H_{22}N_2O_3SNa^+$: 453.1249, found: 453.1250.

5-Benzyl-N-(4-methoxybenzyl)-6,7-dioxo-2-(thiophen-2-yl)-5-azaspiro[2.4]heptane-1-carboxamide (**5j**). Purification of the crude product via flash chromatography on silica gel (petroleum ether/ethyl acetate = 2:1) to afford the corresponding **5j** as a white solid with >99:1 d.r., 81% yield; ^{1}H-NMR δ (ppm) 8.20–8.01 (m, 1H), 7.39–7.32 (m, 3H), 7.32–7.28 (m, 2H), 7.21–7.11 (m, 3H), 6.92–6.89 (m, 1H), 6.89–6.82 (m, 1H), 6.77–6.69 (m, 2H), 4.80 (d, *J* = 14.6 Hz, 1H), 4.70 (d, *J* = 14.6 Hz, 1H), 4.42 (dd, *J* = 14.9, 6.2 Hz, 1H), 4.30 (dd, *J* = 14.8, 6.0 Hz, 1H), 3.77 (s, 3H), 3.69 (d, *J* = 1.8 Hz, 2H), 3.58 (d, *J* = 7.2, 1H), 3.07 (d, *J* = 7.2 Hz, 1H); ^{13}C-NMR δ (ppm) 194.2, 166.3, 160.2, 158.7, 135.2, 134.2, 130.1, 129.1, 128.7, 128.3, 127.4, 126.7, 125.3, 113.9, 55.2, 48.7, 47.5, 43.3, 38.6, 38.3, 35.9; HRMS: *m*/*z* calculated for $C_{26}H_{24}N_2O_4Na^+$: 483.1354, found: 483.1356.

3.2.3. General Procedure for the Synthesis of Multi-substituted Chiral Spirocyclopropane **6**

A dried glass tube was charged with cyclic enone **1** (0.1 mmol) and (*S*)-dimethyl(2-oxo-2-((1-phenylethyl)amino)ethyl)sulfonium bromide **4c** (0.1 mmol) at the presence of TMG (13 μL, 0.1 mmol, 1.0 equiv.) in 1,4-dioxane (0.5 M, 2 mL). The reaction was sealed with a Teflon cap and stirred at room temperature overnight. When the reaction was complete, the reaction mixture was concentrated and the residue was purified by flash chromatography on silica gel (methanol/dichloromethane) to afford the corresponding chiral spirocyclopropane **6**, which was dried under vacuum oven and further analyzed by ^{1}H-NMR, ^{13}C-HMR, HRMS, etc.

(1S,2R,3S)-5-Benzyl-6,7-dioxo-2-phenyl-N-((S)-1-phenylethyl)-5-azaspiro[2.4]heptane-1-carboxamide (**6a**). Purification of the crude product via flash chromatography on silica gel (methanol/dichloromethane = 1:300) to afford the corresponding 6a as a white solid with 72:28 d.r., 99% yield, $[\alpha]_D^{20}$ = +94.6 (*c* = 0.84 in $CHCl_3$); ^{1}H-NMR δ (ppm) 7.31–7.23 (m, 3H), 7.23–7.14 (m, 10H), 7.14–7.08 (m, 2H), 7.01 (d, *J* = 7.6 Hz, 1H), 5.03–4.86 (m, 1H), 4.73 (d, *J* = 14.4 Hz, 1H), 4.34 (d, *J* = 14.4 Hz, 1H), 3.57 (d, *J* = 12.2 Hz, 1H), 3.46–3.32 (m, 2H), 2.99 (d, *J* = 7.2 Hz, 1H), 1.38 (d, *J* = 7.0 Hz, 3H); ^{13}C-NMR δ (ppm) 194.9, 166.1, 159.5, 143.3, 134.5, 132.1, 129.2, 129.0, 128.6, 128.5, 128.2, 128.2, 127.7, 127.2, 126.2, 49.8, 48.6, 47.5, 41.4, 38.1, 36.6, 21.8; HRMS: *m*/*z* calculated for $C_{28}H_{26}N_2O_3Na^+$: 461.1841, found: 461.1832.

(1S,2R,3S)-5-Benzyl-6,7-dioxo-N-((S)-1-phenylethyl)-2-(p-tolyl)-5-azaspiro[2.4]heptane-1-carboxamide (**6b**). Purification of the crude product via flash chromatography on silica gel (methanol/dichloromethane = 1:300) to afford the corresponding **6b** as a white solid with 70:30 d.r., 97% yield, $[\alpha]_D^{20}$ = +96.6 (*c* = 0.54 in $CHCl_3$); ^{1}H-NMR δ (ppm) 7.35–7.30 (m, 3H), 7.28–7.19 (m, 7H), 7.07 (s, 4H), 7.04–7.01 (m, 1H), 5.07–4.97 (m, 1H), 4.79 (d, *J* = 14.4 Hz, 1H), 4.47 (d, *J* = 14.4 Hz, 1H), 3.64 (d, *J* = 12.2 Hz, 1H), 3.50–3.41 (m, 2H), 3.03 (d, *J* = 7.2 Hz, 1H), 2.31 (s, 3H), 1.46 (d, *J* = 7.0 Hz, 3H); ^{13}C-NMR δ (ppm) 194.8, 166.2, 159.6, 143.3, 137.4, 134.6, 129.1, 129.0, 129.0, 128.9, 128.6, 128.5, 128.2, 127.2, 126.1, 49.7, 48.6, 47.5, 41.5, 38.3, 36.6, 21.9, 21.1; HRMS: *m*/*z* calculated for $C_{29}H_{28}N_2O_3Na^+$: 475.1998, found: 475.1995.

(1S,2R,3S)-5-Benzyl-2-(4-methoxyphenyl)-6,7-dioxo-N-((S)-1-phenylethyl)-5-azaspiro[2.4]heptane-1-carboxamide (**6c**). Purification of the crude product via flash chromatography on silica gel (methanol/dichloromethane = 1:300) to afford the corresponding **6c** as a white solid with 64:36 d.r., 91% yield, $[\alpha]_D^{20}$ = +94.6 (*c* = 0.84 in $CHCl_3$); ^{1}H-NMR δ (ppm) 7.35–7.27 (m, 6H), 7.25–7.18 (m, 5H), 7.11 (d, *J* = 8.0 Hz, 2H), 6.82–6.75 (m, 2H), 5.06–4.97 (m, 1H), 4.79 (d, *J* = 14.4 Hz, 1H), 4.39 (d, *J* = 14.4 Hz, 1H), 3.76 (s, 3H), 3.62 (d, *J* = 12.2 Hz, 1H), 3.49–3.39 (m, 2H), 3.09 (d, *J* = 7.2 Hz, 1H), 1.44 (d, *J* = 7.0 Hz, 3H); ^{13}C-NMR δ (ppm) 194.9, 166.2, 159.6, 159.0, 143.4, 134.6, 130.3, 128.9, 128.5, 128.4, 128.2, 127.1, 126.2,

124.0, 113.5, 55.2, 49.7, 48.6, 47.5, 41.2, 38.4, 36.8, 21.8; HRMS: *m*/*z* calculated for $C_{29}H_{28}N_2O_4Na$+: 491.1947, found: 491.1947.

(1S,2R,3S)-5-Benzyl-2-(4-fluorophenyl)-6,7-dioxo-N-((S)-1-phenylethyl)-5-azaspiro[2.4]heptane-1-carboxamide (**6d**). Purification of the crude product via flash chromatography on silica gel (methanol/dichloromethane = 1:300) to afford the corresponding **6d** as a white solid with 81:19 d.r., 92% yield, $[\alpha]_D^{20}$ = +112.0 (*c* = 0.97 in $CHCl_3$); ^{1}H-NMR δ (ppm) 7.36–7.27 (m, 6H), 7.26–7.20 (m, 5H), 7.17–7.12 (m, 2H), 6.96–6.89 (m, 2H), 5.07–4.98 (m, 1H), 4.79 (d, *J* = 14.4 Hz, 1H), 4.41 (d, *J* = 14.4 Hz, 1H), 3.63 (d, *J* = 12.2 Hz, 1H), 3.47–3.39 (m, 2H), 3.06 (d, *J* = 7.2 Hz, 1H), 1.47 (d, *J* = 7.0 Hz, 3H); ^{13}C-NMR δ (ppm) 195.0, 165.9, 159.5, 143.3, 134.4, 130.9, 130.8, 129.0, 128.5, 128.5, 128.3, 127.2, 126.2, 115.2, 115.0, 49.8, 48.7, 47.4, 40.5, 38.0, 36.8, 21.8; HRMS: *m*/*z* calculated for $C_{28}H_{25}FN_2O_3Na^+$: 479.1747, found: 479.1749.

(1S,2S,3S)-5-Benzyl-2-(2-chlorophenyl)-6,7-dioxo-N-((S)-1-phenylethyl)-5-azaspiro[2.4]heptane-1-carboxamide (**6e**). Purification of the crude product via flash chromatography on silica gel (methanol/dichloromethane = 1:300) to afford the corresponding **6e** as a white solid with 70:30 d.r., 90% yield, $[\alpha]_D^{20}$ = +104.3 (*c* = 1.01 in $CHCl_3$); ^{1}H-NMR δ (ppm) 7.38–7.28 (m, 7H), 7.27–7.20 (m, 7H), 7.19–7.13 (m, 1H), 5.09–4.93 (m, 2H), 4.22 (d, *J* = 14.4 Hz, 1H), 3.71 (d, *J* = 12.2 Hz, 1H), 3.44 (d, *J* = 12.2 Hz, 1H), 3.28 (d, *J* = 7.2 Hz, 1H), 2.96 (d, *J* = 7.2 Hz, 1H), 1.48 (d, *J* = 7.0 Hz, 3H); ^{13}C-NMR δ (ppm) 194.5, 165.7, 159.4, 143.4, 135.3, 134.5, 131.2, 130.9, 129.1, 129.1, 128.9, 128.6, 128.5, 128.2, 127.2, 126.5, 126.2, 49.8, 48.5, 48.5, 46.7, 39.0, 37.0, 36.5, 21.8; HRMS: *m*/*z* calculated for $C_{28}H_{25}ClN_2O_3Na^+$: 495.1451, found: 495.1449.

(1S,2R,3S)-5-Benzyl-2-(4-bromophenyl)-6,7-dioxo-N-((S)-1-phenylethyl)-5-azaspiro[2.4]heptane-1-carboxamide (**6f**). Purification of the crude product via flash chromatography on silica gel (methanol/dichloromethane = 1:300) to afford the corresponding **6f** as a white solid with 62:38 d.r., 81% yield, $[\alpha]_D^{20}$ = +106.8 (*c* = 0.44 in $CHCl_3$); ^{1}H-NMR δ (ppm) 7.40–7.32 (m, 5H), 7.31–7.27 (m, 2H), 7.27–7.21 (m, 5H), 7.06–6.98 (m, 3H), 5.09–4.99 (m, 1H), 4.79 (d, *J* = 14.4 Hz, 1H), 4.42 (d, *J* = 14.4 Hz, 1H), 3.64 (d, *J* = 12.2 Hz, 1H), 3.46 (d, *J* = 12.2 Hz, 1H), 3.40 (d, *J* = 7.2 Hz, 1H), 2.99 (d, *J* = 7.2 Hz, 1H), 1.49 (d, *J* = 7.0 Hz, 3H); ^{13}C-NMR δ (ppm) 194.8, 165.7, 159.3, 143.1, 134.4, 131.3, 131.1, 130.9, 129.0, 128.6, 128.5, 128.3, 127.3, 126.2, 121.7, 49.8, 48.7, 47.4, 40.5, 37.9, 36.6, 21.7; HRMS: *m*/*z* calculated for $C_{28}H_{25}BrN_2O_3Na^+$: 539.0946, found: 539.0935.

(1S,2R,3S)-5-Benzyl-2-(naphthalen-1-yl)-6,7-dioxo-N-((S)-1-phenylethyl)-5-azaspiro[2.4]heptane-1-carboxamide (**6g**). Purification of the crude product via flash chromatography on silica gel (methanol/dichloromethane = 1:300) to afford the corresponding **6g** as a white solid with 77:28 d.r., 97% yield, $[\alpha]_D^{20}$ = +116.9 (*c* = 0.12 in $CHCl_3$); ^{1}H-NMR δ (ppm) 7.78–7.70 (m, 2H), 7.41–7.31 (m, 6H), 7.29–7.23 (m, 4H), 7.22–7.15 (m, 5H), 6.85 (d, *J* = 7.8 Hz, 1H), 5.07 (d, *J* = 14.4 Hz, 1H), 4.99–4.90 (m, 1H), 4.09 (d, *J* = 14.4 Hz, 1H), 3.82 (d, *J* = 12.2 Hz, 1H), 3.63 (d, *J* = 7.2 Hz, 1H), 3.51 (d, *J* = 12.2 Hz, 1H), 3.08 (d, *J* = 7.2 Hz, 1H), 1.32 (d, *J* = 7.0 Hz, 3H); ^{13}C-NMR δ (ppm) 194.0, 166.1, 159.3, 143.3, 134.8, 133.5, 132.6, 129.0, 129.0, 128.7, 128.6, 128.5, 128.4, 128.4, 127.3, 127.1, 126.8, 126.2, 125.9, 124.9, 122.4, 49.9, 48.5, 47.1, 39.4, 37.6, 36.0, 21.8; HRMS: *m*/*z* calculated for $C_{32}H_{28}N_2O_3Na^+$: 511.1998, found: 511.2004.

(1S,2R,3S)-5-Benzyl-2-(naphthalen-2-yl)-6,7-dioxo-N-((S)-1-phenylethyl)-5-azaspiro[2.4]heptane-1-carboxamide (**6h**). Purification of the crude product via flash chromatography on silica gel (methanol/dichloromethane = 1:300) to afford the corresponding **6h** as a white solid with 77:23 d.r., 99% yield, $[\alpha]_D^{20}$ = +120.0 (*c* = 0.40 in $CHCl_3$); ^{1}H-NMR δ (ppm) 7.83–7.76 (m, 2H), 7.73–7.66 (m, 2H), 7.51–7.45 (m, 2H), 7.34 (q, *J* = 3.8 Hz, 3H), 7.30–7.22 (m, 8H), 6.53 (d, *J* = 7.6 Hz, 1H), 5.11–5.00 (m, 1H), 4.79 (d, *J* = 14.4 Hz, 1H), 4.53 (d, *J* = 14.4 Hz, 1H), 3.74 (d, *J* = 12.2 Hz, 1H), 3.61 (d, *J* = 7.4 Hz, 1H), 3.56 (d, *J* = 12.2 Hz, 1H), 3.07 (d, *J* = 7.4 Hz, 1H), 1.47 (d, *J* = 7.0 Hz, 3H); ^{13}C-NMR δ (ppm) 194.5, 166.1, 159.4, 144.1, 135.5, 132.5, 132.2, 130.8, 128.8, 128.3, 128.0, 127.8, 127.7, 127.5, 127.5, 127.4, 126.7, 126.3, 126.0, 125.8, 48.4, 47.5, 47.4, 40.6, 38.1, 34.7, 22.5; HRMS: *m*/*z* calculated for $C_{32}H_{28}N_2O_3Na^+$: 511.1998, found: 511.1997.

(1S,2S,3R)-5-Benzyl-6,7-dioxo-N-((S)-1-phenylethyl)-2-(thiophen-2-yl)-5-azaspiro[2.4]heptane-1-carboxamide (**6i**). Purification of the crude product via flash chromatography on silica gel (methanol/dichloromethane = 1:300) to afford the corresponding **6i** as a white solid with 60:40 d.r., 90% yield, $[\alpha]_D^{20}$ = +97.6 (*c* = 0.54 in $CHCl_3$); ^{1}H-NMR δ (ppm) 7.38–7.32 (m, 3H), 7.31–7.22 (m, 7H), 7.20–7.17 (m, 1H), 7.00–6.96 (m, 1H), 6.95–6.90 (m, 1H), 6.83 (d, *J* = 7.6 Hz, 1H), 5.11–4.97 (m, 1H), 4.76 (d, *J* = 14.4 Hz, 1H), 4.52 (d, *J* = 14.4 Hz, 1H), 3.65 (d, *J* = 12.2 Hz, 1H), 3.56–3.43 (m, 2H), 3.04 (d, *J* = 7.0 Hz, 1H), 1.49 (d, *J* = 7.0 Hz, 3H); ^{13}C-NMR δ (ppm) 193.8, 165.5, 159.4, 143.0, 134.8, 134.5, 129.0, 128.7, 128.5, 128.3, 127.6, 127.4, 126.8, 126.1, 125.5, 49.9, 48.7, 47.2, 38.7, 37.7, 36.1, 21.8; HR-MS (ESI): *m*/*z* calculated for $C_{26}H_{24}N_2O_3SNa^+$: 467.1405, found: 467.1406.

4. Conclusions

In conclusion, we have developed a highly diastereoselective cyclopropanation reaction of readily available cyclic enones with sulfur ylides. An array of ketone or amide substituted spirocyclopanane derivatives with high molecular complexity were efficiently produced in a concise procedure. A series of chiral spirocyclopananes were also successfully accessed by using a chiral amidic sulfur ylide in excellent yields with moderate to good stereoselectivity. Currently the development of a catalytic asymmetric version of this cyclopropanation is under investigation in our laboratory.

Supplementary Materials: Supplementary Files are available online.

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70. CCDC 1478324 (**3n**) and CCDC 1524538 (**6e**) Contain the Supplementary Crystallographic Data for This Paper. These Data can Be Obtained Free of Charge from the Cambridge Crystallographic Data Centre via www.ccdc.cam.ac.uk/data_request/cif.
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Sample Availability: All samples **3**, **5** and **6** are available from the authors.