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Synthesis of oleophilic electron-rich phenylhydrazines

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Abstract

Phenylhydrazines **1** substituted with two or three long-chain alkyl, alkoxy or alkylsulfanyl groups were successfully prepared by acid-induced removal of the Boc group in hydrazides **2**. The reaction is carried out with 5 equivalents of TfOH in CF_3CH_2OH/CH_2Cl_2 at −40 °C for 1.5 min. Under these conditions, the deprotected hydrazine **1** is fully protonated, which increases its stability in the reaction medium. The hydrazines were isolated in 60–86% yields and purities >90%. The hydrazides **2** were obtained in 43–71% yields from aryl bromides **5**, which were lithiated with *t*-BuLi and subsequently reacted with di-*tert*-butyl azodicarboxylate (DTBAD).

Introduction

Mono-arylhydrazines **I** are important intermediates in the synthesis of a number of heterocycles, including indoles [1] and some azoles (for example [2,3]), many of which exhibit biological activity and are used in drug development [4-6]. Arylhydrazines are also key intermediates in the preparation of stable radicals such as verdazyl [7-9] and benzo[1,2,4]triazinyls [10-12].

The parent phenylhydrazine and many of its electron-deficient derivatives, such as *p*-nitrophenylhydrazine, are stable under ambient conditions and are conveniently obtained by using classical methods, such as the reduction of diazonium salts [13-15]. In contrast, electron-rich arylhydrazines are far less numerous and their preparation is complicated by oxidative instability.

To access functionalized and sensitive arylhydrazines several methods involving the deprotection of hydrazides **II** have been developed (Figure 1). Hydrazides **II** are efficiently obtained by the addition of organometallic reagents **III**, prepared from aryl halide **IV**, to azodicarboxylate diesters (**AD**) [16,17]. Alternatively, **II** can be obtained in the Pd(0)- or Cu^{2+}-catalyzed reaction of arylboronic acid **V** to **AD** [18-20]. The latter method is especially suited for arylhydrazides substituted with sensitive functional groups. Protected electron-rich arylhydrazines,

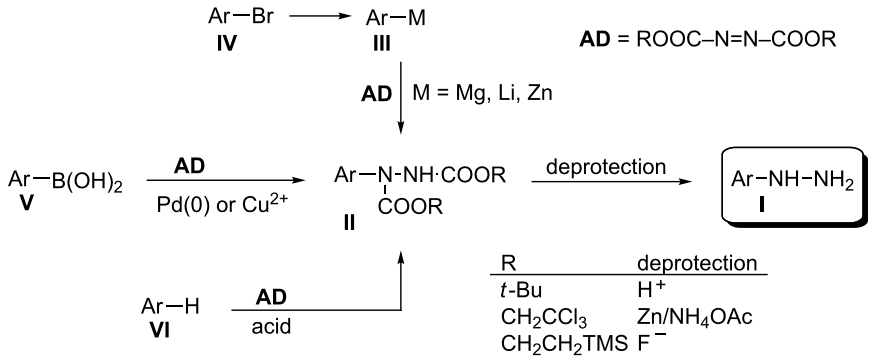
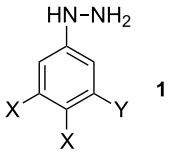


Figure 1: Selected methods for the preparation of arylhydrazines **I** through hydrazides **II**.

hydrazides **II**, containing the 2,2,2-trichloroethyl group (R = CH_2CCl_3) are conveniently prepared by direct electrophilic amination of arenes **VI** with bis(2,2,2-trichloroethyl) azodicarboxylate (BTCEAD) under Lewis [21,22] or Brønsted [23] acid conditions.

By judicious choice of the substituent R, the removal of the protecting group in **II** and formation of arylhydrazines **I** can be accomplished under acidic (R = *t*-Bu) [16], reductive (R = CH_2CCl_3) [24], or nearly neutral (R = CH_2CH_2TMS) conditions [22,25]. Among the three methods, the most straightforward is the removal of the Boc group under acidic conditions. Unfortunately, the literature method for deprotection (HCl in isopropanol, 70 °C) has limited scope, and electron-rich 3,4-dimethoxyphenylhydrazine could not be obtained under these conditions, although 4-pentyloxyphenylhydrazine hydrochloride was isolated in 60% yield [16]. The controlled reduction of 2,2,2-trichloroethyl esters (**II**, R = CH_2CCl_3) with Zn in aqueous MeOH containing NH_4OAc gave access to a number of small, electron-rich phenylhydrazines, including 3,4-dimethoxyphenylhydrazine isolated in 76% yield as hydrochloride [24].

In the context of our research program in liquid-crystalline verdazyl derivatives [26], we needed phenylhydrazines **1** (Figure 2) substituted with multiple long-chain alkyl, alkoxy and alkylsulfanyl groups. Here we demonstrate an efficient method for the preparation of several hydrophobic di- and trisubstituted phenylhydrazines in purities sufficient for further chemical transformations. Finally, we demonstrate the application of one of the phenylhydrazines for the preparation of a discotic liquid crystal.



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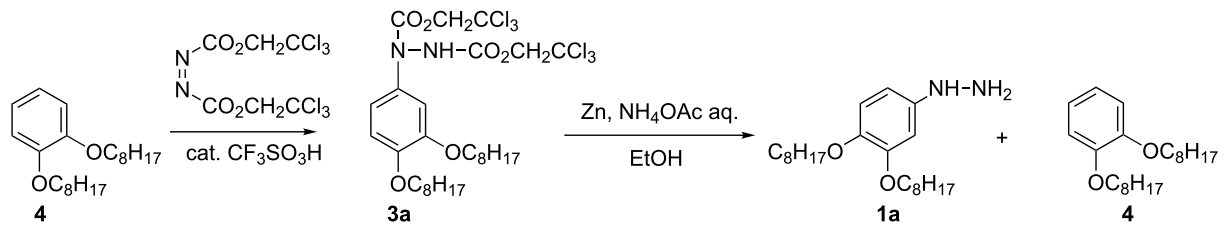
a: X = OC_8H_{17}, Y = H
b: X = $C_{10}H_{21}$, Y = H
c: X = Y = SC_6H_{13}
d: X = Y = SC_8H_{17}
e: X = Y = $SC_{10}H_{21}$
f: X = Y = $SC_{12}H_{25}$
g: X = Y = OC_8H_{17}
h: X = Y = $OC_{10}H_{21}$

Figure 2: The structures for hydrazines **1a**–**1h**.

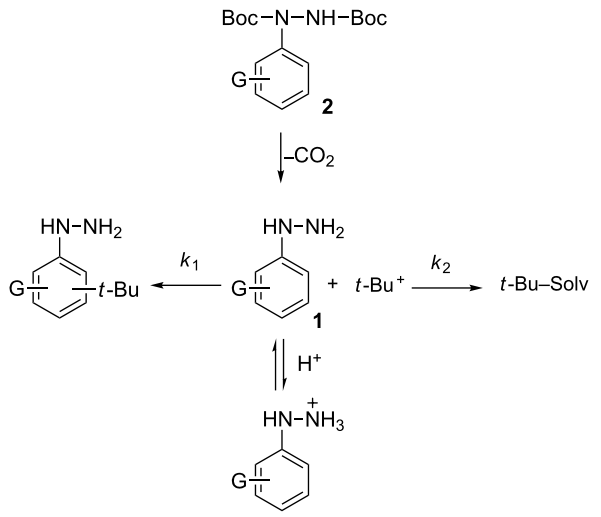
Results and Discussion

Our initial attempts at the preparation of 3,4-dioctyloxyphenylhydrazine (**1a**) focused on deprotection of the trichloroethyl ester **3a** under buffered reductive conditions, according to the general literature procedure [24]. In aqueous MeOH hydrazide **3a** was practically insoluble, and the reaction mixture was triphasic. Under these conditions no formation of hydrazine **1a** was observed. Changing MeOH to EtOH and increasing its volume by two-fold gave homogenous solutions within which the desired hydrazine **1a** was formed along with significant quantities of **4** as the major products (Scheme 1). The deamination product **4** was isolated and identified by comparison with the authentic sample. The yield and proportions of the two products, **1a** and **4**, varied from run to run, according to the ^{1}H NMR spectra. Therefore, we focused on the acid-catalyzed deprotection of Boc-substituted hydrazines (Scheme 2), hydrazides **2**, expecting that the reaction could be performed under fully homogenous conditions.

Analysis of the reaction mechanism for the deprotection of **2** under acidic conditions shows that removal of the Boc group generates *t*-Bu^+, which reacts with the solvent, or alternatively it can alkylate the benzene ring of arylhydrazine (Scheme 2). For less reactive arylhydrazines the former process is faster, $k_1 << k_2$, and deprotection with HCl in iPrOH is effective [16]. For dialkoxyphenylhydrazines apparently $k_1 >> k_2$ and the desired hydrazine is not obtained [16].



Scheme 1: Formation and deprotection of **3a** under reductive conditions.



Scheme 2: General mechanism for the deprotection of arylhydrazides. G represents a substituent.

The nucleophilicity of the hydrazine can be suppressed by its fast and complete protonation with a strong acid (Scheme 2). In this situation, the transient *t*-Bu^+ is trapped with the solvent, forming volatile products, which simplifies isolation of the hydrazine as a crude product. We have focused on this approach to arylhydrazines employing trifluoromethanesulfonic acid (TfOH), which was used as an effective catalyst in the deprotection of *tert*-butyl aryl ethers [27].

Addition of catalytic amounts of the TfOH acid (10 mol %) to solutions of hydrazide **2a** (Figure 3) in a mixture of CF_3CH_2OH/CH_2Cl_2 at −40 °C gave little conversion to hydrazine **1a**. With 1.5 equiv of TfOH, hydrazide **2a** was only partially converted to hydrazine **1a**. With 5 equiv of TfOH the reaction was complete in less than 2 min and the crude hydrazine **1a** was isolated as the sole product. Reaction times under 2 min appear to be optimum; the purity of the hydrazine decreased with increasing reaction times.

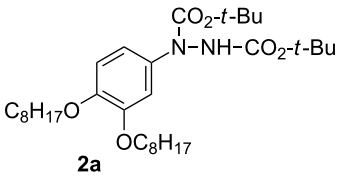
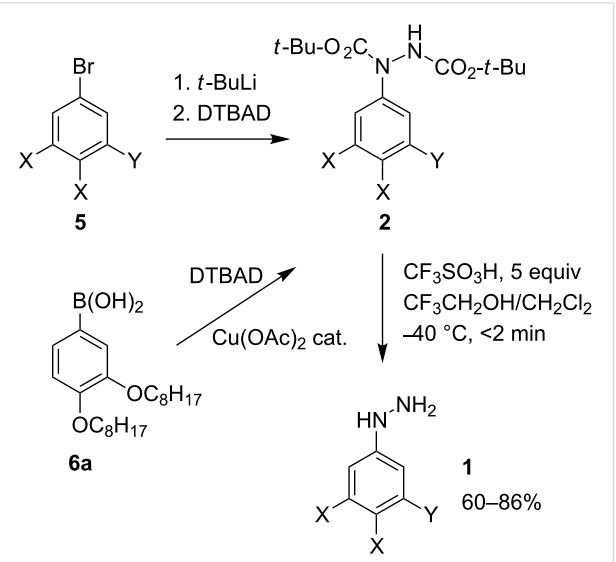


Figure 3: Structure of hydrazide **2a**.

By using this protocol, hydrazines **1** were isolated as viscous oils in purities >90% and yields of 60–86%, according to ^{1}H NMR analysis with 1,4-dimethoxybenzene as the internal standard (Scheme 3). Attempts at the preparation of crystalline hydrochlorides of **1** were unsuccessful and the viscous salts rapidly darkened and decomposed.

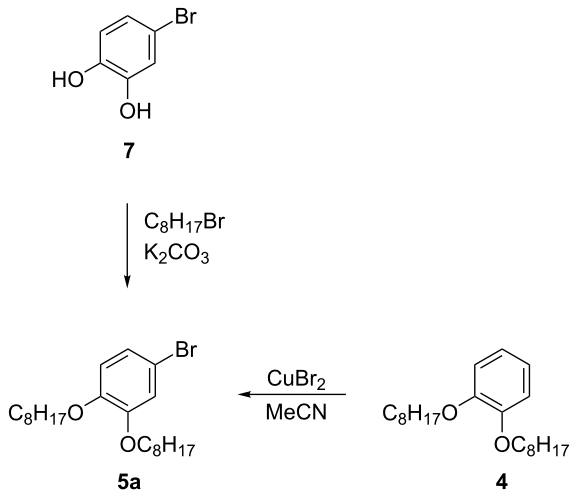


Scheme 3: Synthesis of arylhydrazines **1**. Substituents X and Y are defined in Figure 2.

The Boc-protected arylhydrazines, hydrazides **2**, were conveniently obtained by direct addition of aryllithium to di-*tert*-butyl azodicarboxylate (DTBAD, Scheme 3). The latter was prepared by lithiation of aryl bromides **5** with *t*-BuLi to avoid the formation of *n*-BuBr with *n*-BuLi and N-butylation of hydrazide **2**. Hydrazide **2a** was also obtained by the Cu^{2+}-catalyzed addition [18] of arylboronic acid **6a** [28] to DTBAD. The yields of both syntheses of **2a** were comparable.

The trichloroethyl hydrazide **3a** was prepared by acid-catalyzed amination of 1,2-dioctyloxybenzene (**4**) with BTCEAD in the presence of catalytic amounts of TfOH, according to a general literature procedure [23] (Scheme 1).

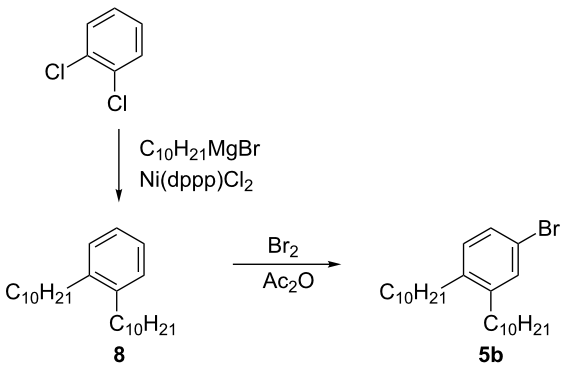
The requisite bromobenzene **5a** was prepared by bromination of 1,2-dioctyloxybenzene (**4**) [29] with $CuBr_2$ in MeCN according to a literature method [30] (Scheme 4). This method is a convenient alternative to the alkylation of the less readily accessible 4-bromocatechol (**7**) [28].



Scheme 4: Preparation of bromide **5a**.

1-Bromo-3,4-didecylbenzene (**5b**) was obtained by bromination of 1,2-didecylbenzene (**8**) [31], obtained by the Kumada method [32], with Br_2 in acetic anhydride (Scheme 5). Typically, the electrophilic bromination of 1,2-dialkylbenzenes results in 4,5-dibromo derivatives as the major products [33,34]. In contrast, the present method permits selective monobromination, although the bromo derivative **5b** was isolated only in about 85% purity. The product could not be purified rigorously from several unidentified contaminants either by chromatography or by distillation due to the lack of separation or partial decomposition. Therefore, crude **5b** was used for the preparation of hydrazide **2b**, which was easily purified by chromatographic methods.

The attempted monoiodination of **8** with BTMA·ICl_2 by using a general literature method [35] gave only traces of the product and nearly all of the starting material was recovered. Iodination under the Kern conditions [36,37] (HIO_3/I_2) gave a mixture of mono- and diiodo derivatives, which were difficult to separate. Manipulation of the reaction time and temperature failed to give the desired monoiodo derivative as the major product.



Scheme 5: Preparation of **5b**.

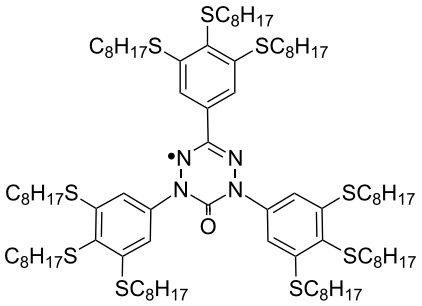
The preparation of bromobenzenes substituted with alkylsulfanyl groups, **5c**–**5f**, is described elsewhere [38]. Bromides **5g** [39,40] and **5h** [41] were obtained according to the respective literature procedures by alkylation of 5-bromopyrogallol.

The 3,4,5-trialkylsulfanylphenylhydrazines **1c**–**1f** have been used in the preparation of 6-oxoverdazyl derivatives that exhibit liquid-crystalline properties [26]. For instance, radical **9**, prepared from **1d** (Figure 4), exhibits a monotropic columnar rectangular phase (Cr 62 (Col_r 60) I), a broad absorption band in the visible region, and redox potentials $E^{0/+1}{}_{1/2}$ = +0.99 V and $E^{0/-1}{}_{1/2}$ = −0.45 V versus SCE. Photovoltaic studies of **9** demonstrated hole mobility $\mu_h = 1.52 \times 10^{-3}$ cm^2 $V^{-1}s^{-1}$ in the mesophase with an activation energy E_a = 0.06 ± 0.01 eV.

Conclusion

We have developed a synthetic protocol for the efficient preparation of electron-rich phenylhydrazines **1** substituted with alkylsulfanyl, alkyl and alkoxy groups from Boc hydrazides **2**. Experiments demonstrate that the addition of hydrazides **2** to a large excess of TfOH (5 equiv) at −40 °C gives hydrazines **1** in yields ranging from 60–86% and with purity >90%, which is sufficient for subsequent chemical transformations. The optimum reaction time is less than 2 min, typically 90 sec, and longer times lead to a lower purity of the product.

The presented method for the preparation of phenylhydrazines is an attractive alternative to Leblanc's method, which relies on the reductive deprotection of trichloroethyl hydrazide **3** under heterogenous conditions. Our method involves homogenous solutions, low temperatures and short reaction times, and is particularly suited to oleophilic ("greasy") arylhydrazines such as **1**, which are important intermediates for the preparation of verdazyls and other heterocycles that may exhibit, e.g., liquid-crystalline properties (e.g., **9**). In comparison with Leblanc's protocol, our method is also a regiocontrolled hydrazinylation



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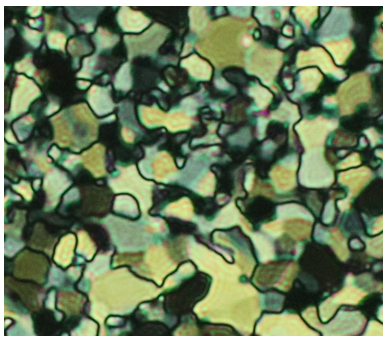

Figure 4: The structure of verdazyl radical **9** and a texture of the Col_r phase.

of the aromatics with the more accessible DTBAD through the organolithium. Although we focus on long-chain-substituted phenylhydrazines, we believe that this method can be used for other electron-rich arylhydrazines.

Experimental

Reagents and solvents were obtained commercially. Reactions were carried out under Ar. ^{1}H NMR spectra were obtained at 400 MHz in $CDCl_3$ and referenced to the solvent, unless specified otherwise.

Arylhydrazines **1**

General procedure

A solution of hydrazide **2** (1 mmol) in a mixture of CH_2Cl_2 (3 mL)/CF_3CH_2OH (1 mL) was rapidly added to a solution of TfOH (0.750 g, 0.44 mL, 5 mmol) in CF_3CH_2OH (1 mL) at −40 °C under Ar. The mixture was stirred for 1.5 min, and CH_2Cl_2 (5 mL) followed by sat. $NaHCO_3$ (10 mL) were added under very vigorous stirring. The organic layer was separated and the aqueous layer extracted (3 × CH_2Cl_2). Then the extracts were dried (Na_2SO_4) and the solvents were evaporated to give crude arylhydrazine **1** in purities typically >90% as a viscous, yellow to orange oil that darkened upon standing. The quantitative analysis of the deprotection reaction was conducted with 0.2 mmol of **2** as described above. The yield of the hydrazines was established by adding known quantities of 1,4-dimethoxybenzene (2.0 mL of 25 mM solution in CH_2Cl_2, 0.05 mmol) to the CH_2Cl_2 extract, evaporation of the resulting solution, and integration of the low-field ^{1}H NMR signals.

3,4-Dioctyloxyphenylhydrazine (1a): ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.88 (t, *J* = 6.8 Hz, 6H), 1.26–1.36 (m, 16H), 1.37–1.47 (m, 4H), 1.70–1.85 (m, 4H), 3.92 (t, *J* = 6.7 Hz, 2H), 3.96 (t, *J* = 6.7 Hz, 2H), 6.34 (dd, J_1 = 8.5 Hz, J_2 = 2.6 Hz, 1H), 6.46 (d, *J* = 2.6 Hz, 1H), 6.82 (d, *J* = 8.5 Hz, 1H); ^{1}H NMR (500 MHz, DMSO-d_6) δ 0.86 (t, *J* = 6.7 Hz, 6H), 1.20–1.36 (m, 16H), 1.37–1.46 (m, 4H), 1.61 (quint, *J* = 7.0 Hz, 2H), 1.68 (quint, *J* = 6.9 Hz, 2H), 3.78 (t, *J* = 6.4 Hz, 2H), 3.87 (t, *J* = 6.3 Hz, 2H), 6.24 (dd, J_1 = 8.5 Hz, J_2 = 2.3 Hz, 1H), 6.47 (d, *J* = 2.3 Hz, 1H), 6.71 (d, *J* = 8.6 Hz, 1H).

3,4-Didecylphenylhydrazine (1b): ^{1}H NMR (500 MHz, $CDCl_3$) δ 0.88 (t, *J* = 6.9 Hz, 6H), 1.22–1.40 (m, 28H), 1.47–1.58 (m, 4H), 2.51 (t, *J* = 7.0 Hz, 2H), 2.53 (t, *J* = 7.1 Hz, 2H), 2.6 (brs, 3H), 6.59–6.65 (m, 2H), 7.01 (d, *J* = 8.0 Hz, 1H).

3,4,5-Trihexylsulfanylphenylhydrazine (1c): ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.87 (t, *J* = 6.9 Hz, 3H), 0.89 (t, *J* = 6.8 Hz, 6H), 1.20–1.35 (m, 12H), 1.36–1.52 (m, 6H), 1.59 (quint, *J* = 7.5 Hz, 2H), 1.71 (quint, *J* = 7.4 Hz, 4H), 2.77 (t, *J* = 7.4 Hz, 2H), 2.83 (t, *J* = 7.3 Hz, 4H), 3.2 (brs, 3H), 6.41 (s, 2H).

3,4,5-Trioctylsulfanylphenylhydrazine (1d): ^{1}H NMR (500 MHz, $CDCl_3$) δ 0.87 (t, *J* = 6.9 Hz, 3H), 0.88 (t, *J* = 6.6 Hz, 6H), 1.20–1.34 (m, 24H), 1.38–1.43 (m, 2H), 1.44–1.53 (m, 4H), 1.59 (quint, *J* = 7.5 Hz, 2H), 1.72 (quint, *J* = 7.5 Hz, 4H), 2.77 (t, *J* = 7.5 Hz, 2H), 2.84 (t, *J* = 7.4 Hz, 4H), 6.40 (s, 2H).

3,4,5-Tridecylsulfanylphenylhydrazine (1e): ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.87 (t, *J* = 6.8 Hz, 3H), 0.88 (t, *J* = 6.8 Hz, 6H), 1.20–1.35 (m, 36H), 1.36–1.52 (m, 6H), 1.59 (quint, *J* = 7.6 Hz, 2H), 1.71 (quint, *J* = 7.3 Hz, 4H), 2.76 (t, *J* = 7.5 Hz, 2H), 2.83 (t, *J* = 7.3 Hz, 4H), 6.40 (s, 2H).

3,4,5-Tridodecylsulfanylphenylhydrazine (1f): ^{1}H NMR (500 MHz, $CDCl_3$) δ 0.88 (t, *J* = 6.8 Hz, 9H), 1.20–1.35 (m, 48H), 1.36–1.51 (m, 6H), 1.59 (quint, *J* = 7.5 Hz, 2H), 1.71 (quint, *J* = 7.4 Hz, 4H), 2.77 (t, *J* = 7.4 Hz, 2H), 2.84 (t, *J* = 7.1 Hz, 4H), 6.40 (s, 2H).

3,4,5-Trioctyloxyphenylhydrazine (1g): Soft yellow solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.88 (t, *J* = 6.7 Hz, 9H),

1.22–1.38 (m, 24H), 1.42–1.53 (m, 6H), 1.72 (quint, *J* = 7.1 Hz, 2H), 1.79 (quint, *J* = 7.1 Hz, 4H), 3.86 (t, *J* = 6.6 Hz, 2H), 3.95 (t, *J* = 6.6 Hz, 4H), 6.06 (s, 2H).

3,4,5-Tridecyloxyphenylhydrazine (1h): ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.88 (t, *J* = 6.8 Hz, 9H), 1.21–1.38 (m, 36H), 1.39–1.64 (m, 6H), 1.65–1.84 (m, 6H), 3.86 (t, *J* = 6.6 Hz, 2H), 3.95 (t, *J* = 6.6 Hz, 4H), 6.06 (s, 2H); ^{1}H NMR (400 MHz, C_6D_6) δ 0.92 (t, *J* = 6.8 Hz, 9H), 1.22–1.58 (m, 38H), 1.63–1.73 (m, 4H), 1.78 (quint, *J* = 7.1 Hz, 4H), 1.97 (quint, *J* = 8.3 Hz, 2H), 3.89 (t, *J* = 6.4 Hz, 4H), 4.23 (t, *J* = 6.5 Hz, 2H), 6.03 (s, 2H).

Preparation of hydrazides **2**

General procedure

To a solution of the substituted bromobenzene **5** (1.0 mmol) in dry THF (10 mL), *t*-BuLi (1.7 M in pentane, 2.2 mmol) was added under Ar at −78 °C. After 1.5 h a THF (1 mL) solution of di-*tert*-butyl azodicarboxylate (DTBAD, 345 mg, 1.5 mmol) was added dropwise. The mixture was stirred at −78 °C for 0.5 h, then 1 h at rt, and quenched with 5% HCl. The organic products were extracted (Et_2O), the extracts dried (Na_2SO_4), the solvents evaporated, and the residue was passed through a short silica-gel column (hexane/CH_2Cl_2 then CH_2Cl_2) to give hydrazides **2** as white solids.

1,2-Bis(*tert*-butoxycarbonyl)-1-(3,4-dioctyloxyphenyl)-hydrazine (2a): Yield 71%; mp 55–57 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 0.88 (t, *J* = 6.9 Hz, 6H), 1.22–1.38 (m, 16H), 1.39–1.51 (m, 4H), 1.49 (s, 18H), 1.73–1.84 (m, 4H), 3.96 (t, *J* = 6.6 Hz, 2H), 3.97 (t, *J* = 6.6 Hz, 2H), 6.71 (brs, 1H), 6.80 (d, *J* = 8.6 Hz, 1H), 6.86–6.92 (m, 1H), 6.93–7.02 (m, 1H); Anal. calcd for $C_{32}H_{56}N_2O_6$: C, 68.05; H, 9.99; N, 4.96; found: C, 68.35; H, 9.82; N, 5.02.

Method B: To a solution of 3,4-dioctyloxyphenylboronic acid (**6a**, 50 mg, 0.13 mmol) in THF (2 mL), di-*tert*-butyl azodicarboxylate (DTBAD, 30 mg, 0.13 mmol) was added followed by $Cu(OAc)_2$ (cat) under an Ar atmosphere. The mixture was stirred at rt overnight, the solvent was evaporated and the residue was purified on a short silica-gel column (CH_2Cl_2) to give 50 mg (68% of yield) of hydrazide **2a**.

1,2-Bis(*tert*-butoxycarbonyl)-1-(3,4-didecylphenyl)hydrazine (2b): Yield 63%; mp 37–38 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 0.88 (t, *J* = 6.8 Hz, 6H), 1.23–1.40 (m, 28H), 1.49 (s, 18H), 1.48–1.59 (m, 4H), 2.52–2.59 (m, 4H), 6.70 (brs, 1H), 7.06 (d, *J* = 8.2 Hz, 1H), 7.08–7.21 (br m, 2H); Anal. calcd for $C_{36}H_{64}N_2O_4$: C, 73.42; H, 10.95; N, 4.76; found: C, 73.06; H, 10.88; N, 4.74.

1,2-Bis(*tert*-butoxycarbonyl)-1-(3,4,5-trihexylsulfanyl-phenyl)hydrazine (2c): Yield 43%; mp 74–75 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.87 (t, *J* = 6.9 Hz, 3H), 0.88 (t, *J* = 6.9 Hz, 6H), 1.23–1.37 (m, 12H), 1.38–1.52 (m, 6H), 1.51 (s, 18H), 1.60 (quint, *J* = 7.4 Hz, 2H), 1.72 (quint, *J* = 7.2 Hz, 4H), 2.81 (t, *J* = 7.5 Hz, 2H), 2.84 (t, *J* = 7.4 Hz, 4H), 6.69 (brs, 1H), 6.99 (brs, 2H); Anal. calcd for $C_{34}H_{60}N_2O_4S_3$: C, 62.15; H, 9.20; N, 4.26; found: C, 62.35; H, 9.34; N, 4.22.

1,2-Bis(*tert*-butoxycarbonyl)-1-(3,4,5-trioctylsulfanyl-phenyl)hydrazine (2d): Yield 55% yield; mp 51–52 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.84–0.91 (m, 9H), 1.21–1.35 (m, 24H), 1.36–1.50 (m, 6H), 1.51 (s, 18H), 1.60 (quint, *J* = 7.4 Hz, 2H), 1.72 (quint, *J* = 7.5 Hz, 4H), 2.81 (t, *J* = 7.5 Hz, 4H), 2.83 (t, *J* = 7.4 Hz, 2H), 6.69 (brs, 1H), 6.98 (brs, 2H); the analytically pure sample was obtained by recrystallization (MeCN); Anal. calcd for $C_{40}H_{72}N_2O_4S_3$: C, 64.82; H, 9.79; N, 3.78; found: C, 64.92; H, 9.56; N, 3.91.

1,2-Bis(*tert*-butoxycarbonyl)-1-(3,4,5-tridecylsulfanyl-phenyl)hydrazine (2e): Yield 56%; mp 50–51 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 0.87 (t, *J* = 6.8 Hz, 3H), 0.88 (t, *J* = 7.0 Hz, 6H), 1.21–1.36 (m, 38H), 1.37–1.51 (m, 6H), 1.51 (s, 18H), 1.60 (quint, *J* = 7.4 Hz, 2H), 1.71 (quint, *J* = 7.4 Hz, 4H), 2.81 (t, *J* = 7.6 Hz, 2H), 2.83 (t, *J* = 7.4 Hz, 4H), 6.70 (brs, 1H), 6.98 (brs, 2H); Anal. calcd for $C_{46}H_{86}N_2O_4S_3$: C, 66.78; H, 10.48; N, 3.39; found: C, 66.75; H, 10.07; N, 3.43.

1,2-Bis(*tert*-butoxycarbonyl)-1-(3,4,5-tridodecylsulfanyl-phenyl)hydrazine (2f): Yield 50%; mp 49–51 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 0.88 (t, *J* = 6.7 Hz, 9H), 1.22–1.36 (m, 50H), 1.35–1.51 (m, 6H), 1.51 (s, 18H), 1.60 (quint, *J* = 7.4 Hz, 2H), 1.71 (quint, *J* = 7.2 Hz, 4H), 2.81 (t, *J* = 7.4 Hz, 2H), 2.83 (t, *J* = 7.2 Hz, 4H), 6.69 (brs, 1H), 6.98 (brs, 2H); Anal. calcd for $C_{52}H_{98}N_2O_4S_3$: C, 68.52; H, 10.84; N, 3.07; found: C, 68.82; H, 10.83; N, 3.06.

1,2-Bis(*tert*-butoxycarbonyl)-1-(3,4,5-trioctyloxy-phenyl)hydrazine (2g): Yield 45%; white crystals (MeCN/EtOAc); mp 73–74 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.88 (t, *J* = 6.8 Hz, 9H), 1.23–1.38 (m, 24H), 1.38–1.52 (m, 6H), 1.50 (s, 18H), 1.73 (quint, *J* = 7.4 Hz, 2H), 1.77 (quint, *J* = 6.9 Hz, 4H), 3.92 (t, *J* = 6.8 Hz, 2H), 3.93 (t, *J* = 6.6 Hz, 4H), 6.64 (brs, 2H), 6.68 (brs, 1H); Anal. calcd for $C_{40}H_{72}N_2O_7$: C, 69.32; H, 10.47; N, 4.04; found: C, 69.61; H, 10.43; N, 3.91.

1,2-Bis(*tert*-butoxycarbonyl)-1-(3,4,5-tridecyloxy-phenyl)hydrazine (2h): Yield 64%; mp 55–57 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.88 (t, *J* = 6.8 Hz, 9H), 1.21–1.38 (m, 38H), 1.41–1.54 (m, 6H), 1.50 (s, 18H), 1.67–1.82 (m, 6H), 3.91 (t, *J* = 6.8 Hz, 2H), 3.93 (t, *J* = 6.6 Hz, 4H), 6.64 (brs, 2H),

6.68 (brs, 1H); Anal. calcd for $C_{46}H_{86}N_2O_7$: C, 70.91; H, 11.12; N, 3.60; found: C, 71.31; H, 11.08; N, 3.65.

1,2-Bis(2,2,2-trichloroethoxycarbonyl)-1-(3,4-dioctyloxyphenyl)hydrazine (3a): To the solution of 1,2-dioctyloxybenzene (**4**, 1.10 g, 3.31 mmol) in dry CH_2Cl_2 (20 mL), one drop of CF_3SO_3H was added under Ar at −78 °C followed by a solution of bis(2,2,2-trichloroethyl) azodicarboxylate (BTCEAD, 1.50 g, 3.97 mmol) in CH_2Cl_2 (3 mL). The reaction mixture was stirred for 20 min, warmed up to rt, stirred for 10 min, and quenched with 25% NH_4OAc. The organic products were extracted (CH_2Cl_2), the extracts dried (Na_2SO_4), and the solvent evaporated. The viscous residue was passed through a silica-gel plug (hexane/CH_2Cl_2 then CH_2Cl_2) to give 1.03 g (36% yield) of the hydrazide **3a** as a viscous oil: ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.88 (t, J = 6.7 Hz, 3H), 0.89 (t, J = 7.2 Hz, 3H), 1.24–1.39 (m, 16H), 1.41–1.50 (m, 4H), 1.80 (quint, J = 7.0 Hz, 4H), 3.96 (t, J = 6.6 Hz, 2H), 3.99 (t, J = 6.6 Hz, 2H), 4.82 (s, 4H), 6.83 (d, J = 8.6 Hz, 1H), 6.97 (d, J = 8.2 Hz, 1H), 7.02 (brs, 1H), 7.39 (brs, 1H); Anal. calcd for $C_{28}H_{42}Cl_6N_2O_6$: C, 47.01; H, 5.92; N, 3.92; found: C, 46.27; H, 5.72; N, 3.92.

1-Bromo-3,4-didecylbenzene (5b): To a solution of 1,2-didecylbenzene (**8**, 1.00 g, 2.8 mmol) in a mixture of Ac_2O (3 mL) and CH_2Cl_2 (3 mL), Br_2 (0.30 mL, 5.6 mmol) and catalytic amounts of I_2 were added. The reaction mixture was stirred overnight at rt, water was added, the organic products were extracted (hexane), the extracts dried (Na_2SO_4), and the solvents evaporated. The residue was passed through a silica-gel plug (hexane) to give 1.20 g (~85% yield, based on NMR, contained ~15% of at least two impurities) of 4-bromo-1,2-didecylbenzene (**5b**) as a colorless oil: ^{1}H NMR (500 MHz, $CDCl_3$) major signals δ 0.88 (t, J = 6.8 Hz, 6H), 1.20–1.40 (m, 28H), 1.49–1.58 (m, 4H), 2.53 (t, J = 7.4 Hz, 2H), 2.55 (t, J = 7.5 Hz, 2H), 6.98 (d, J = 8.2 Hz, 1H), 7.22 (dd, J_1 = 8.2 Hz, J_2 = 1.8 Hz, 1H), 7.25–7.27 (m, 1H); ^{1}H NMR (400 MHz, CD_2Cl_2) major signals δ 0.86 (t, J = 6.8 Hz, 6H), 1.20–1.40 (m, 28H), 1.49–1.58 (m, 4H), 2.52 (t, J = 7.4 Hz, 2H), 2.55 (t, J = 7.5 Hz, 2H), 6.99 (d, J = 8.2 Hz, 1H), 7.19 (dd, J_1 = 8.1 Hz, J_2 = 2.2 Hz, 1H), 7.25 (d, J = 2.1 Hz, 1H); HRMS-EI (m/z): $[M]^+$ calcd for $C_{26}H_{45}Br$, 436.2705; found, 436.2726; since **5b** undergoes partial decomposition during attempted short-path distillation (>260 °C/0.2 mmHg), it was used without further purification for the preparation of **2b**.

1,2-Didecylbenzene (8): Following a general procedure [31], a solution of 1,2-dichlorobenzene (10.0 g, 68.0 mmol), Ni(dppp)Cl_2 (370 mg, 0.68 mmol), and *n*-decylmagnesium bromide (272 mmol) in a dry THF (100 mL) was heated under reflux overnight. The crude product was passed through a silica-gel plug (hexane) and short-path distilled (220–230 °C/0.3 mmHg) to collect 11.4 g (48% yield) of 1,2-didecylbenzene (**8**) as a colorless oil: ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.88 (t, J = 6.8 Hz, 6H), 1.20–1.43 (m, 28H), 1.57 (quint, J = 7.7 Hz, 4H), 2.59 (t, J = 8.0 Hz, 4H), 7.06–7.16 (m, 4H); HRMS–EI (m/z): $[M]^+$ calcd for $C_{26}H_{46}$, 358.3600; found, 358.3583.

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