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SYNTHESIS OF NEW 3-SUBSTITUTED 1-HYDROXY-2-PHENYLINDOLES USING SULFUR-CONTAINING NUCLEOPHILES

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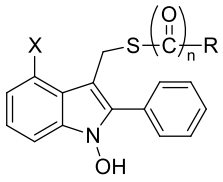
Abstract – The synthesis of new 3-[(acyl(or alkyl)thio)methyl]-1-hydroxy-2-phenylindoles **1** are presented. The substrates **2** obtained by each efficient three-step synthesis were treated, in the presence of $SnCl_2 \cdot 2H_2O$, with nucleophiles such as thiocarboxylic acids and thiols to provide target compounds **1** by successive processes of nitro reduction and intramolecular condensation, followed by addition of nucleophile. Analyses of the reaction mechanism, including the effects of substituents along with the reactivity of nucleophiles, are described.

INTRODUCTION

1-Hydroxyindole derivatives have recently been prominent topics of research due to their unique structure and related biological significance. As intriguing chemical entities, they display different physicochemical properties and medicinal profiles compared to indoles due to the presence of the hydroxy group at N(1). Although they were reported several decades ago by Acheson *et al.*,[1] the studies on these compounds have not been broadly conducted until recently. In 1997, Henmi *et al.* reported for the first time 1-hydroxyindoles as suitable forms for recording spectra.[2] Subsequently, general features and properties of 1-hydroxyindoles were described with an appropriate level of chemical information.[3,4] Compared with indoles, 1-hydroxyindoles are known to display somewhat different physicochemical properties, and in some cases, show much different biological and medicinal properties.[3] In particular, the presence of 1-hydroxytryptophan and 1-hydroxytryptamine derivatives in living organisms demonstrated the importance of 1-hydroxyindoles.[4] Biological studies with a limited range of 1-hydroxyindole compounds have shown potential to possess antiproliferative,[5] antibiotic,[6] and platelet aggregation inhibitory activities.[7] Despite the chemical interest and biological significance, further studies on these compounds suffered from the limited range of identified compounds and the lack of the efficient synthetic

methods for diverse derivatization. Thus, the development of tolerable synthetic methodologies for diverse 1-hydroxyindoles has been in strong demand.

In our program to generate multisubstituted 1-hydroxyindoles, we previously reported the synthesis of 1-hydroxyindole-2-carboxylate derivatives.[8-12] We also reported the synthesis of 1-hydroxy-2-phenylindoles with a limited number of derivatives.[13] Based on these initial successes, we attempted to expand our studies and generate more diverse derivatives. Thus, we here report the synthesis of new 3-[(acyl(or alkyl)thio)methyl]-1-hydroxy-2-phenylindoles **1** and their mechanistic investigations.

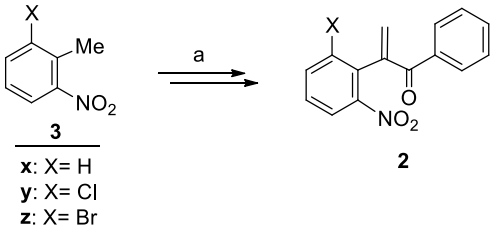


1

X= H, Cl, Br
R= alkyl, aryl
n= 1, 0

RESULTS AND DISCUSSION

Before synthesizing the targeted 1-hydroxy-2-phenylindoles, we prepared the corresponding substrates according to previous procedures[13,14] with minor modification. As shown in Scheme 1, starting from toluene compounds **3**, we accomplished efficient three-step synthesis of the substrates, conjugate nitro ketones **2x**,[13,15] **2y**,[13] and **2z**[13] in good yields (50–55%, for three steps).



3

x: X= H
y: X= Cl
z: X= Br

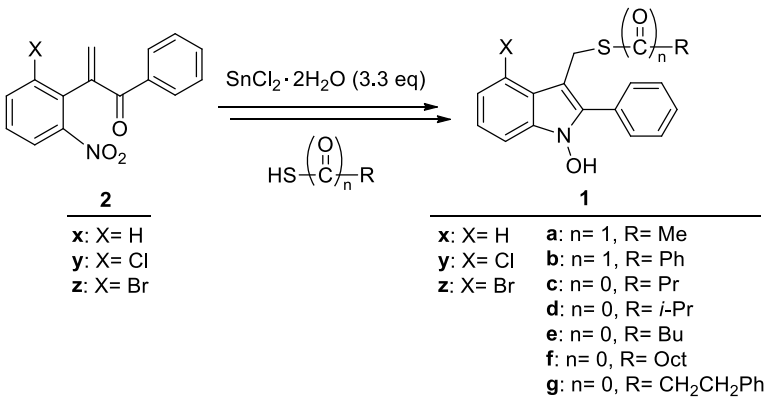
2

Scheme 1. Synthesis of substrates, conjugate nitro ketones **2**

[a]Reagents and conditions: i) PhCHO, DBU, ii) pyridinium chlorochromate, iii) NaH, $CH_2=N^+Me_2Cl^-$, **2x**, **2y**, **2z** (55–58%, for three steps).

We then attempted to synthesize new derivatives of 1-hydroxy-2-phenylindoles, employing conjugate nitro ketones **2** as substrates and sulfur-containing nucleophiles in the presence of a reducing agent. Here, we also chose $SnCl_2 \cdot 2H_2O$ as a reducing agent, according to previous studies.[13,16] The substrates **2** were added to the pre-treated mixture of nucleophile (5 equiv), $SnCl_2 \cdot 2H_2O$ (3.3 equiv) and 4Å molecular sieve in DME to afford new 3-[(acyl(or alkyl)thio)methyl]-1-hydroxy-2-phenylindoles **1**, as shown in Scheme 2. Here, we employed two thiocarboxylic acids and five thiols as nucleophiles and the results are

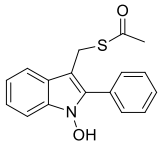
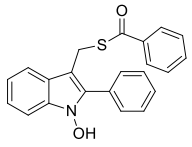
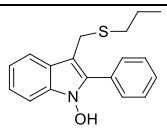
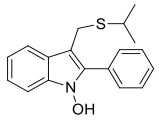
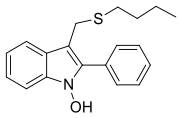
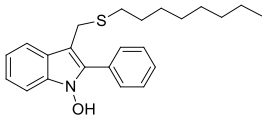
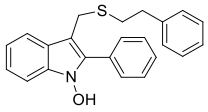
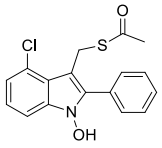
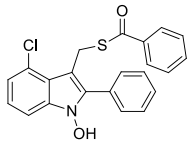
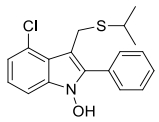
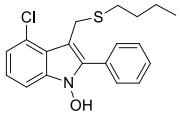
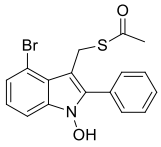
summarized in Table 1. Notably, we were highly interested in employing nucleophiles of low reactivity such as thiocarboxylic acids to produce new 3-[(acylthio)methyl]-1-hydroxy-2-phenylindoles **1** that might be difficult to construct otherwise.

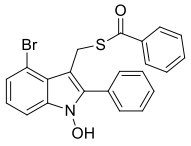
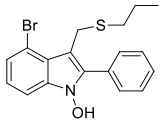
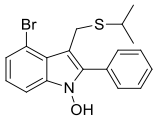
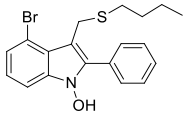
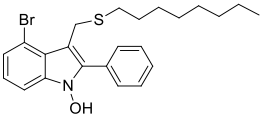
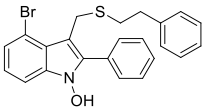


Scheme 2. Synthesis of target compounds **1**

First, the reactions of substrate **2x** (X= H) with thiocarboxylic acids were examined (entries 1–2). Both thiolacetic acid and thiobenzoic acid provided the products **1xa** and **1xb** in good yields (73 and 81%, respectively). Considering the low reactivity of thiocarboxylic acids, these results were surprising and implicated the involvement of highly reactive electrophiles in these reactions, which was also observed in our previous studies with different substrates, methyl 3-(2'-nitrophenyl)-2-oxobut-3-enoates.[12] Then, reactions of **2x** with thiol nucleophiles were conducted. These reactions using primary and secondary thiols produced the products **1xc**–**1xg** in good to modest yields (55–80%). Second, we performed reactions of the substrate **2y** (X= Cl) with thiocarboxylic acids (entries 8 and 9) to obtain the products **1ya** and **1yb** in modest yields (60% and 41%, respectively), which were slightly lower than those using substrate **2x**. Then, the reactions using primary and secondary thiols produced the products **1yd** and **1ye** in modest yields (60 and 52%, respectively). Finally, we investigated the reactions of substrate **2z** (X= Br) with thiocarboxylic acids (entries 12 and 13) to give the products **1za** and **1zb** in modest yields (62% and 51%, respectively), which were similar to those using substrate **2y**. Then, the reactions using primary and secondary thiols provided the products **1zc**–**1zg** in modest yields (43–57%). In order to verify the applicability of this methodology, we performed a large-scale reaction using **2z** (1 g) and *n*-PrSH providing **1zc** in a similar result (59%), and therefore, confirmed the reproducibility in large-scale synthesis. Taken together, we achieved efficient synthesis of eighteen new derivatives of **1**.

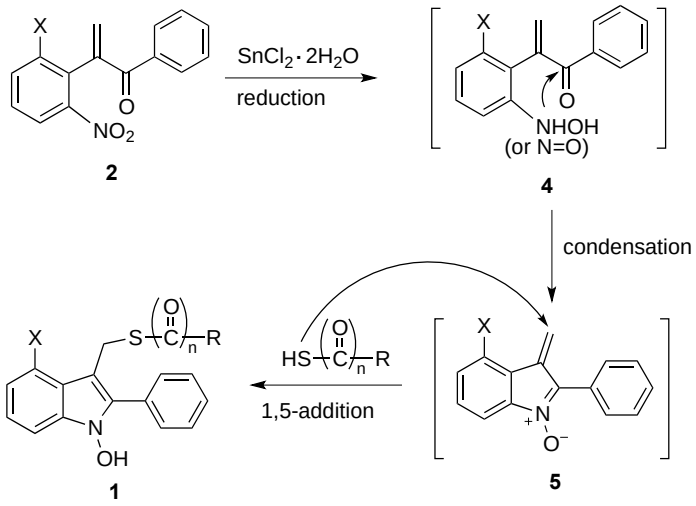
Table 1. Synthesis of 1-hydroxyindoles **1**[a]

Entry	Substrate **2**	NuH	Time (h)	Product	Yield (%)[b]
1	**2x**	MeC(O)SH	9	 **1xa**	73
2	**2x**	PhC(O)SH	5	 **1xb**	81
3	**2x**	*n*-PrSH	6	 **1xc**	63
4	**2x**	*i*-PrSH	6	 **1xd**	78
5	**2x**	*n*-BuSH	3	 **1xe**	80
6	**2x**	*n*-OctSH	4	 **1xf**	55
7	**2x**	$PhCH_2CH_2SH$	3	 **1xg**	78
8	**2y**	MeC(O)SH	2	 **1ya**	60
9	**2y**	PhC(O)SH	2	 **1yb**	41
10	**2y**	*i*-PrSH	5	 **1yd**	60
11	**2y**	*n*-BuSH	5	 **1ye**	52
12	**2z**	MeC(O)SH	4	 **1za**	62

13	**2z**	PhC(O)SH	4	 **1zb**	51
14	**2z**	*n*-PrSH	5	 **1zc**	57
15	**2z**	*i*-PrSH	2	 **1zd**	46
16	**2z**	*n*-BuSH	6	 **1ze**	43
17	**2z**	*n*-OctSH	4	 **1zf**	52
18	**2z**	$PhCH_2CH_2SH$	2	 **1zg**	45

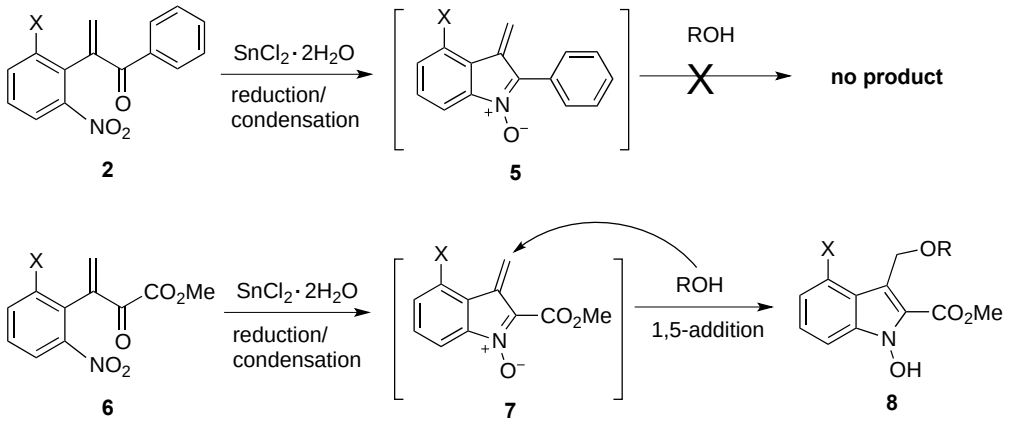
[a]All reactions were run in 0.1 mmol scale of **2**. [b]Isolated yields.

Furthermore, we tried to elucidate the mechanistic aspects of these reactions as well as compare of the results of **2x**, **2y**, and **2z**. As shown in Scheme 3, we proposed a reaction pathway using sulfur-containing nucleophiles, which is consistent with that in our previous study.[13] It is suggested that reduction of the nitro group in substrates **2** by $SnCl_2 \cdot 2H_2O$ would provide intermediates, hydroxylamino (or nitroso) ketones **4**, which then undergo intramolecular condensation to afford second intermediates, conjugate nitrones **5**. Reactions of **5** with nucleophiles would finally provide the products **1**. Extensive efforts to isolate and identify the interesting intermediates **4** and/or **5** were not successful. In particular, careful analysis of the reactions to detect the conjugate nitrones **5** or its hydrate forms still led to inconclusive results, due mainly to their chemical instability. When we compared the results according to the substituent (X) in the substrates (**2x**, **2y**, and **2z**), we found that the best yields (*e.g.*, **1xb** and **1xe**) were observed with the substrate **2x** (X= H) containing no substituent, which was consistent with our previous observations.[13] Interestingly, when we compared the results according to the thiocarboxylic acid nucleophiles of our interest, we also found that the substrate **2x** provided better yields than did substrates **2y** and **2z**. It is believed that the electronegative substituents (X= Cl and Br) in **2y** and **2z** could decrease the nucleophilicity of the corresponding hydroxylamino (or nitroso) group in intermediates **4**, eventually leading to lower yields of final products **1y** and **1z** compared to **1x**. Accordingly, these observations are believed to support validity of the proposed pathway.



Scheme 3. Reaction pathway for **1**

We then examined other nucleophiles, such as carboxylic acids and alcohols. Carboxylic acids such as acetic acid and benzoic acid did not result in the desired products even in harsh conditions (higher amounts of $SnCl_2 \cdot 2H_2O$ and nucleophile, and/or at higher temperature). Surprisingly, even alcohols such as BnOH and BuOH did not lead to successful results. When we conducted the reactions using **2** with BnOH or BuOH in harsh conditions (*e.g.*, 5 equiv of $SnCl_2 \cdot 2H_2O$ and 10 equiv of nucleophile at 80 °C), the products were not formed (Scheme 4). These unsuccessful results of substrates **2** with alcohol nucleophiles were highly disappointing when compared with the successful results of other substrates, methyl 3-(2'-nitrophenyl)-2-oxobut-3-enoates **6**[10,11] with alcohol nucleophiles. As shown in Scheme 4, the only difference between substrates **2** and **6** was the presence of phenyl and carboxylate groups, respectively. Comparing the corresponding intermediates, conjugate nitrones **5** and **7**, we surmised that the reactivity of these conjugate nitrones would be affected by the functional group at C(2). In reality, in the case of intermediates **7**, the carboxylate group was believed to be electron-withdrawing enough to increase the electrophilicity of the terminal carbon of conjugate nitrones **7**, thereby inducing the attack of alcohol to provide **8**. However, in the case of **5**, the phenyl group did not seem to be sufficiently electron-withdrawing compared to the carboxylate group, and the lowered reactivity of conjugate nitrones did not allow the attack of alcohols, finally leading to unsuccessful results. Here, the steric effects of the substituents at C(2) in **5** and **7** did not seem to give significant influences on these reactions, since small-sized primary alcohols such as methanol and ethanol also did not work for substrates **2**. Further efforts are required to improve the results of the reactions with alcohol nucleophiles and to better elucidate the mechanistic aspects.



Scheme 4. Reactions of different substrates **2** and **4** with alcohol nucleophiles

CONCLUSIONS

We report the synthesis of new 3-[(acyl(or alkyl)thio)methyl]-1-hydroxy-2-phenylindoles **1** and the corresponding investigations on reaction mechanism. Using the substrates **2** obtained by each three-step synthetic sequence, we achieved efficient synthesis of **1** in one-pot reaction through the following consecutive processes: nitro reduction ($SnCl_2 \cdot 2H_2O$), intramolecular condensation, and addition of sulfur-containing nucleophiles. In particular, the nucleophiles of low reactivity such as thiocarboxylic acids did work for these reactions. Mechanistic investigations suggested that the electron-withdrawing substituents (X= Cl and Br) in the aromatic ring could decrease the nucleophilicity of the hydroxylamino (or nitroso) group in intermediates **4**, thereby lowering the yields. Based on the unsuccessful results of **2** with alcohol nucleophiles compared with other substrates **6**, the substituent at C(2) in intermediates **5** or **7** seemed to crucially affect the electrophilicity of conjugate nitrones and thus, the final results of the reactions.

EXPERIMENTAL

General Methods

Most of the reagents were obtained commercially and used without further purification unless otherwise noted. Reactions were monitored by thin-layer chromatography (TLC) carried out on 0.25 mm Merck silica gel plates (60F-254). Preparative TLC (PTLC) separations were conducted on the same silica gel plates, and column chromatography was performed using Merck silica gels (230-400 mesh). Melting points were determined in open capillary tubes using a Büchi B-545 melting point apparatus and are uncorrected. FT-IR spectra were recorded on a Perkin-Elmer Spectrum GX spectrometer and frequencies (ν) are given in reciprocal centimeters (cm^{-1}). ^1H (300 MHz) and ^{13}C (75 MHz) NMR spectra were obtained using a Bruker DRX 300 spectrometer with tetramethylsilane (TMS) as an internal reference and CD_3CN as the solvent, unless otherwise noted. Mass spectra (EI or ESI) were obtained by Dr. Sung Hong

Kim using a Jeol JMS700 mass spectrometer at the Korea Basic Science Center (KBSI), Daegu, Korea. HPLC analyses were performed using the following Waters Associate Units: 515 A pump, 515 B pump, dual λ absorbance 2487 detector, 717 plus autosampler, and C_{18} μBondapak (stainless steel) column (3.9 x 300 mm). The product analyses were performed using linear gradient condition: from 100% A (aqueous 0.025 M triethylammonium acetate, pH 6.5) and 0% B (acetonitrile) to 80% A and 20% B in 1 min, then to 10% A and 90% B in 30 min. The flow rate was 1 mL/min, and the eluent was monitored at 254 nm. The HPLC solvents were filtered (aqueous solution with Millipore HVLP, 0.45 mm; acetonitrile with Millipore HV, 0.45 mm) and degassed before utilization.

General procedure for the synthesis of conjugate nitro ketones 2[13,15]

Conjugate nitro ketones **2** were prepared according to our previous procedure.[13] Nitrotoluenes **3** (1.0 mmol, 1.0 equiv) were treated with benzaldehyde in the presence of 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU) in DMSO (3 mL) to give the corresponding nitro alcohols. Nitro alcohols were oxidized to nitro ketones by the action of pyridinium chlorochromate (PCC) in CH_2Cl_2. Subsequent treatment of nitro ketones with NaH and dimethylmethyleneammonium chloride provided conjugate nitro ketones **2** (50–55%, for three steps).

General procedure for the synthesis of 2-phenyl-1-hydroxyindoles (1)

To a stirred mixture of $SnCl_2 \cdot 2H_2O$ (3.3 equiv) and 4 Å molecular sieves (10 wt%) in DME (0.35 mL) was added nucleophile (5.0 equiv), and the mixture was stirred for 30 min at room temperature. Then, conjugate nitro ketones (**2**, 0.10 mmol, 1.0 equiv) were added at 25 °C and the reaction mixture was warmed to 40 °C. After stirring for 2–9 h in the dark, the reaction mixture was cooled to room temperature and purified by PTLC or column chromatography to afford the title compounds **1**.

3-[(Acetylthio)methyl]-1-hydroxy-2-phenyl-1*H*-indole (1xa)

Use of **2x** and thiolacetic acid (36 μL, 0.50 mmol, 5.0 equiv) as a nucleophile in general procedure (9 h) afforded the title compound **1xa** (22 mg, 73%) as a white solid. Mp 121–122 °C; R_f 0.63 (5:95 EtOAc/$CHCl_3$); HPLC t_R 22.4 min; IR (KBr) 3435, 3025, 1601, 1493, 1452, 699 cm^{-1}; ^1H NMR (300 MHz, CD_3CN) δ 8.58 (br s, 1H, N(1)OH), 7.66–7.38 (m, 7H, Ar), 7.26 (t, J = 7.3 Hz, 1H, Ar), 7.13 (t, J = 7.3 Hz, 1H, Ar), 4.34 (s, 2H, C(3)CH_2S), 2.29 (s, 3H, SCOCH_3); ^{13}C NMR (75 MHz, CD_3CN) δ 196.8 (C=O), 138.1 (Ar), 136.6 (Ar), 131.6 (Ar), 131.2 (Ar), 130.6 (Ar), 130.1 (Ar), 130.0 (Ar), 129.8 (Ar), 124.3 (Ar), 121.6 (Ar), 110.3 (Ar), 105.5 (Ar), 31.0 (C(3)*C*H_2S), 25.6 (SCO*C*H_3); MS *m/z* 297 $[M]^+$; HRMS (+EI) calcd for $C_{17}H_{15}NO_2S$ $[M]^+$ 297.0824, found 297.0827.

3-[(Benzoylthio)methyl]-1-hydroxy-2-phenyl-1*H*-indole (1xb)

Use of **2x** and thiobenzoic acid (59 μL, 0.50 mmol, 5.0 equiv) as a nucleophile in general procedure (5 h) afforded the title compound **1xb** (29 mg, 81%) as a white solid. Mp 42–43 °C; R_f 0.43 (1:99 EtOAc/$CHCl_3$); HPLC t_R 23.3 min; IR (KBr) 3434, 3025, 1601, 1493, 1452, 696 cm^{-1}; ^1H NMR (300

MHz, CD_3CN) δ 8.53 (br s, 1H, N(1)OH), 7.93 (d, J = 7.7 Hz, 2H, Ar), 7.67–7.58 (m, 4H, Ar), 7.58–7.42 (m, 6H, Ar), 7.27 (t, J = 7.7 Hz, 1H, Ar), 7.14 (t, J = 7.7 Hz, 1H, Ar), 4.55 (s, 2H, C(3)CH_2S); ^{13}C NMR (75 MHz, CD_3CN) δ 193.0 (C=O), 138.3 (Ar), 136.5 (Ar), 135.0 (Ar), 131.6 (Ar), 131.1 (Ar), 131.0 (Ar), 130.3 (Ar), 129.9 (Ar), 129.8 (Ar), 128.4 (Ar), 124.6 (Ar), 124.3 (Ar), 121.7 (Ar), 120.2 (Ar), 110.3 (Ar), 105.0 (Ar), 25.8 (C(3)*C*H_2S); MS *m/z* 359 $[M]^+$; HRMS (+EI) calcd for $C_{22}H_{17}NO_2S$ $[M]^+$ 359.0980, found 359.0981.

1-Hydroxy-2-phenyl-3-[(*n*-propylthio)methyl]-1*H*-indole (1xc)

Use of **2x** and *n*-propanethiol (45 μL, 0.50 mmol, 5.0 equiv) as a nucleophile in general procedure (6 h) afforded the title compound **1xc** (19 mg, 63%) as a white solid. Mp 52–53 °C; R_f 0.52 (1:49 EtOAc/$CHCl_3$); HPLC t_R 25.1 min; IR (KBr) 3434, 3025, 1601, 1493, 1452, 702 cm^{-1}; ^{1}H NMR (300 MHz, CD_3CN) δ 8.75 (br s, 1H, N(1)OH), 7.68 (t, J = 8.4 Hz, 3H, Ar), 7.57–7.35 (m, 5H, Ar), 7.30–7.23 (m, 1H, Ar), 3.95 (s, 2H, C(3)CH_2S), 2.38 (t, J = 7.3 Hz, 2H, SC*H*$_2$$CH_2$), 1.43 (sextet, J = 7.3 Hz, 2H, C*H*$_2$$CH_3$), 0.85 (t, J = 7.3 Hz, 3H, CH_2C*H*$_3$); ^{13}C NMR (75 MHz, CD_3CN) δ 139.3 (Ar), 137.6 (Ar), 131.9 (Ar), 130.7 (Ar), 130.0 (Ar), 129.7 (Ar), 125.9 (Ar), 124.7 (Ar), 122.1 (Ar), 115.0 (Ar), 109.6 (Ar), 107.8 (Ar), 35.0 (S*C*H$_2$$CH_2$), 27.4 (C(3)*C*$H_2$S), 24.0 (*C*$H_2$$CH_3$), 14.1 ($CH_2$*C*$H_3$); MS *m/z* 297 $[M]^+$; HRMS (+EI) calcd for $C_{18}H_{19}NOS$ $[M]^+$ 297.1187, found 297.1189.

1-Hydroxy-3-[(isopropylthio)methyl]-2-phenyl-1*H*-indole (1xd)

Use of **2x** and isopropanethiol (46 μL, 0.50 mmol, 5.0 equiv) as a nucleophile in general procedure (6 h) afforded the title compound **1xd** (23 mg, 78%) as a white solid. Mp 40–42 °C; R_f 0.55 (1:3 EtOAc/hexanes); HPLC t_R 24.7 min; IR (KBr) 3433, 3025, 1601, 1493, 1452, 700 cm^{-1}; ^{1}H NMR (300 MHz, CD_3CN) δ 8.60 (s, 1H, N(1)OH), 7.73–7.64 (m, 3H, Ar), 7.52 (t, J = 7.3 Hz, 2H, Ar), 7.48–7.38 (m, 2H, Ar), 7.25 (t, J = 7.3 Hz, 1H, Ar), 7.13 (t, J = 7.3 Hz, 1H, Ar), 3.98 (s, 2H, C(3)CH_2S), 2.85 (heptet, J = 6.7 Hz 1H, SC*H*(CH_3)$_2$), 1.16 (d, J = 6.7 Hz, 6H, SCH(C*H*$_3$)$_2$); ^{13}C NMR (75 MHz, CD_3CN) δ 137.6 (Ar), 136.8 (Ar), 130.9 (Ar), 129.8 (Ar), 129.5 (Ar), 129.0 (Ar), 124.0 (Ar), 121.2 (Ar), 120.5 (Ar), 115.1 (Ar), 110.2 (Ar), 107.4 (Ar), 36.5 (S*C*H(CH_3)$_2$), 26.3 (C(3)*C*H_2S), 24.0 (SCH(*C*H_3)$_2$); MS *m/z* 297 $[M]^+$; HRMS (+EI) calcd for $C_{18}H_{19}NOS$ $[M]^+$ 297.1187, found 297.1183.

3-[(*n*-Butylthio)methyl]-1-hydroxy-2-phenyl-1*H*-indole (1xe)

Use of **2x** and *n*-butanethiol (54 μL, 0.50 mmol, 5.0 equiv) as a nucleophile in general procedure (3 h) afforded the title compound **1xe** (25 mg, 80%) as a white solid. Mp 101–102 °C; R_f 0.36 (1:2 EtOAc/hexanes); HPLC t_R 26.1 min; IR (KBr) 3434, 3025, 1601, 1492, 1451, 702 cm^{-1}; ^{1}H NMR (300 MHz, CD_3CN) δ 8.40 (br s, 1H, N(1)OH), 7.72–7.62 (m, 2H, Ar), 7.57–7.33 (m, 4H, Ar), 7.29–7.19 (m, 1H, Ar), 7.17–7.03 (m, 1H, Ar), 6.81–6.72 (m, 1H, Ar), 3.95 (s, 2H, C(3)CH_2S), 2.38 (t, J = 7.2 Hz, 2H, SC*H*$_2$$CH_2$), 1.43–1.17 (m, 4H, (C*H*$_2$)$_2$$CH_3$), 0.81 (t, J = 7.2 Hz, 3H, CH_2C*H*$_3$); ^{13}C NMR (75 MHz, CD_3CN) δ 137.8 (Ar), 132.8 (Ar), 131.3 (Ar), 130.4 (Ar), 129.9 (Ar), 129.8 (Ar), 129.5 (Ar), 125.7 (Ar),

124.7 (Ar), 122.7 (Ar), 110.6 (Ar), 101.5 (Ar), 33.1 (S*C*H$_2$CH$_2$), 33.0 (SCH$_2$*C*H$_2$), 23.2 (C(3)*C*H$_2$S), 22.9 (*C*H$_2$CH$_3$), 14.4 (CH$_2$*C*H$_3$); MS *m/z* 311 [M]$^+$; HRMS (+EI) calcd for $C_{19}H_{21}NOS$ [M]$^+$ 311.1344, found 311.1341.

1-Hydroxy-3-[(*n*-octylthio)methyl]-2-phenyl-1*H*-indole (1xf)

Use of **2x** and *n*-octanethiol (87 μL, 0.50 mmol, 5.0 equiv) as a nucleophile in general procedure (4 h) afforded the title compound **1xf** (20 mg, 55%) as a white solid. Mp 48–50 °C; R_f 0.51 (1:49 EtOAc/$CHCl_3$); HPLC t_R 31.0 min; IR (KBr) 3434, 3025, 1601, 1493, 1452, 697 cm^{-1}; ^{1}H NMR (300 MHz, CD_3CN) δ 8.63 (s, 1H, N(1)OH), 7.74–7.61 (m, 3H, Ar), 7.52 (t *J* = 7.3 Hz, 2H, Ar), 7.44 (t, *J* = 8.1 Hz, 2H, Ar), 7.24 (t, *J* = 8.1 Hz, 1H, Ar), 7.12 (t, *J* = 7.3 Hz, 1H, Ar), 3.94 (s, 2H, C(3)CH$_2$S), 2.36 (t, *J* = 7.3 Hz, 2H, SC*H*$_2$CH$_2$), 1.44–1.12 (m, 12H, (C*H*$_2$)$_6$CH$_3$), 0.88 (t, *J* = 7.3 Hz, 3H, (CH$_2$)$_6$C*H*$_3$); ^{13}C NMR (75 MHz, CD_3CN) δ 137.8 (Ar), 136.8 (Ar), 131.5 (Ar), 129.8 (Ar), 129.5 (Ar), 124.9 (Ar), 124.0 (Ar), 121.2 (Ar), 120.6 (Ar), 115.1 (Ar), 110.2 (Ar), 107.6 (Ar), 33.0 (S*C*H$_2$CH$_2$), 32.9 (SCH$_2$*C*H$_2$), 30.8 (*C*H$_2$CH$_2$CH$_3$), 30.3 (C(3)*C*H$_2$S), 30.2 (*C*H$_2$(CH$_2$)$_2$CH$_3$), 30.0 (*C*H$_2$(CH$_2$)$_3$CH$_3$), 27.2 (S(CH$_2$)$_2$*C*H$_2$), 23.8 (*C*H$_2$CH$_3$), 14.8 (CH$_2$*C*H$_3$); MS *m/z* 367 [M]$^+$; HRMS (+EI) calcd for $C_{23}H_{29}NOS$ [M]$^+$ 367.1970, found 367.1971.

1-Hydroxy-2-phenyl-3-[(phenylethylthio)methyl]-1*H*-indole (1xg)

Use of **2x** and phenylethylmercaptan (67 μL, 0.50 mmol, 5.0 equiv) as a nucleophile in general procedure (3 h) afforded the title compound **1xg** (26 mg, 78%) as a white solid. Mp 51–52 °C; R_f 0.19 (1:1 CH_2Cl_2/hexanes); HPLC t_R 26.3 min; IR (KBr) 3433, 3025, 1601, 1493, 1452, 703 cm^{-1}; ^{1}H NMR (300 MHz, CD_3CN) δ 8.60 (s, 1H, N(1)OH), 7.68 (t, *J* = 7.5 Hz, 3H, Ar), 7.53 (t, *J* = 7.5 Hz, 2H, Ar), 7.45 (t, *J* = 6.7 Hz, 2H, Ar), 7.32–7.12 (m, 5H, Ar), 7.06 (d, *J* = 6.7 Hz, 2H, Ar), 4.14 (s, 2H, C(3)CH$_2$S), 2.62–2.53 (m, 4H, S(C*H*$_2$)$_2$Ph); ^{13}C NMR (75 MHz, CD_3CN) δ 142.2 (Ar), 137.8 (Ar), 136.8 (Ar), 131.5 (Ar), 131.3 (Ar), 129.9 (Ar), 129.8 (Ar), 129.7 (Ar), 129.6 (Ar), 127.5 (Ar), 124.9 (Ar), 124.0 (Ar), 121.3 (Ar), 120.6 (Ar), 110.2 (Ar), 107.4 (Ar), 37.1 (S*C*H$_2$), 34.7 (*C*H$_2$Ph), 27.5 (C(3)*C*H$_2$S); MS *m/z* 359 [M]$^+$; HRMS (+EI) calcd for $C_{23}H_{21}NOS$ [M]$^+$ 359.1344, found 359.1343.

3-[(Acetylthio)methyl]-4-chloro-1-hydroxy-2-phenyl-1*H*-indole (1ya)

Use of **2y** and thiolacetic acid (35 μL, 0.50 mmol, 5.0 equiv) as a nucleophile in general procedure (2 h) afforded the title compound **1ya** (20 mg, 60%) as a white solid. Mp 40–41 °C; R_f 0.23 (1:3 EtOAc/hexanes); HPLC t_R 23.8 min; IR (KBr) 3437, 3025, 1601, 1493, 1452, 703 cm^{-1}; ^{1}H NMR (300 MHz, CD_3CN) δ 8.80 (br s, 1H, N(1)OH), 7.59–7.44 (m, 5H, Ar), 7.40 (d, *J* = 7.5 Hz, 1H, Ar), 7.19 (t, *J* = 7.5 Hz, 1H, Ar), 7.11 (d, *J* = 7.5 Hz, 1H, Ar), 4.47 (s, 2H, C(3)CH$_2$S), 2.26 (s, 3H, SCOCH$_3$); ^{13}C NMR (75 MHz, CD_3CN) δ 196.3 (C=O), 139.5 (Ar), 137.4 (Ar), 131.8 (Ar), 130.3 (Ar), 129.8 (Ar), 126.7 (Ar), 124.6 (Ar), 123.6 (Ar), 122.5 (Ar), 120.9 (Ar), 109.3 (Ar), 104.1 (Ar), 30.8 (C(3)CH$_2$S), 26.6 (SCOCH$_3$); MS *m/z* 331 [M]$^+$; HRMS (+EI) calcd for $C_{17}H_{14}ClNO_2S$ [M]$^+$ 331.0434, found 331.0435.

3-[(Benzoylthio)methyl]-4-chloro-1-hydroxy-2-phenyl-1*H*-indole (1yb)

Use of **2y** and thiobenzoic acid (59 μL, 0.50 mmol, 5.0 equiv) as a nucleophile in general procedure (2 h) afforded the title compound **1yb** (16 mg, 41%) as a white solid. Mp 131–132 °C; R_f 0.43 (1:1 EtOAc/hexanes); HPLC t_R 26.7 min; IR (KBr) 3437, 3025, 1601, 1493, 1452, 703 cm^{-1}; ^{1}H NMR (300 MHz, CD_3CN) δ 9.23 (s, 1H, N(1)OH), 7.92 (d, J = 7.8 Hz, 2H, Ar), 7.66–7.57 (m, 3H, Ar), 7.57–7.42 (m, 6H, Ar), 7.25–7.08 (m, 2H, Ar), 4.67 (s, 2H, C(3)CH_2S); ^{13}C NMR (75 MHz, CD_3CN) δ 192.5 (C=O), 138.5 (Ar), 137.6 (Ar), 135.0 (Ar), 131.8 (Ar), 131.4 (Ar), 130.7 (Ar), 130.3 (Ar), 129.9 (Ar), 129.3 (Ar), 128.3 (Ar), 127.0 (Ar), 124.7 (Ar), 122.6 (Ar), 121.0 (Ar), 109.5 (Ar), 103.8 (Ar), 26.9 (C(3)CH_2S); MS *m/z* 393 [M]$^+$; HRMS (+EI) calcd for $C_{22}H_{16}ClNO_2S$ [M]$^+$ 393.0590, found 393.0589.

4-Chloro-1-hydroxy-3-[(isopropylthio)methyl]-2-phenyl-1*H*-indole (1yd)

Use of **2y** and isopropanethiol (46 μL, 0.50 mmol, 5.0 equiv) as a nucleophile in general procedure (5 h) afforded the title compound **1yd** (20 mg, 60%) as a white solid. Mp 114–116 °C; R_f 0.29 (1:9 EtOAc/hexanes); HPLC t_R 26.1 min; IR (KBr) 3433, 3025, 1601, 1493, 1452, 704 cm^{-1}; ^{1}H NMR (300 MHz, CD_3CN) δ 8.72 (br s, 1H, N(1)OH), 7.70 (d, J = 8.0 Hz, 2H, Ar), 7.61–7.44 (m, 3H, Ar), 7.38 (d, J = 8.0 Hz, 1H, Ar), 7.17 (t, J = 8.0 Hz, 1H, Ar), 7.70 (d, J = 8.0 Hz, 1H, Ar), 4.12 (s, 2H, C(3)CH_2S), 2.81 (heptet, J = 6.7 Hz 1H, SC*H*$(CH_3)_2$), 1.08 (d, J = 6.7 Hz, 6H, SCH(C*H*$_3)_2$); ^{13}C NMR (75 MHz, CD_3CN) δ 139.0 (Ar), 137.8 (Ar), 131.9 (Ar), 130.7 (Ar), 130.0 (Ar), 129.8 (Ar), 127.1 (Ar), 124.4 (Ar), 122.4 (Ar), 121.0 (Ar), 109.1 (Ar), 107.3 (Ar), 36.4 (S*C*H$(CH_3)_2$), 26.9 (C(3)*C*H_2S), 24.0 (SCH(*C*$H_3)_2$); MS *m/z* 331 [M]$^+$; HRMS (+EI) calcd for $C_{18}H_{18}ClNOS$ [M]$^+$ 331.0798, found 331.0795.

3-[(*n*-Butylthio)methyl]-4-chloro-1-hydroxy-2-phenyl-1*H*-indole (1ye)

Use of **2y** and *n*-butanethiol (71 μL, 0.50 mmol, 5.0 equiv) as a nucleophile in general procedure (5 h) afforded the title compound **1ye** (20 mg, 52%) as a white solid. Mp 54–56 °C; R_f 0.50 (1:49 EtOAc/$CHCl_3$); HPLC t_R 27.5 min; IR (KBr) 3434, 3026, 1601, 1493, 1452, 696 cm^{-1}; ^{1}H NMR (300 MHz, CD_3CN) δ 8.79 (br s, 1H, N(1)OH), 7.67 (d, J = 7.4 Hz, 2H, Ar), 7.60–7.47 (m, 3H, Ar), 7.38 (d, J = 7.8 Hz, 1H, Ar), 7.17 (t, J = 7.8 Hz, 1H, Ar), 7.10 (d, J = 7.8 Hz, 1H, Ar), 4.09 (s, 2H, C(3)CH_2S), 2.32 (t, J = 7.2 Hz, 2H, SC*H*$_2$$CH_2$), 1.33–1.16 (m, 4H, (C*H*$_2)_2$$CH_3$), 0.78 (t, J = 7.2 Hz, 3H, CH_2C*H*$_3$); ^{13}C NMR (75 MHz, CD_3CN) δ 139.1 (Ar), 137.8 (Ar), 131.9 (Ar), 130.7 (Ar), 130.0 (Ar), 129.8 (Ar), 127.1 (Ar), 124.4 (Ar), 123.4 (Ar), 120.9 (Ar), 109.1 (Ar), 107.5 (Ar), 32.9 (S*C*$H_2$$CH_2$), 32.6 (SCH$_2$*C*$H_2$), 27.8 (C(3)*C*$H_2$S), 23.0 (*C*$H_2$$CH_3$), 14.3 ($CH_2$*C*$H_3$); MS *m/z* 345 [M]$^+$; HRMS (+EI) calcd for $C_{19}H_{20}ClNOS$ [M]$^+$ 345.0954, found 345.0955.

3-[(Acetylthio)methyl]-4-bromo-1-hydroxy-2-phenyl-1*H*-indole (1za)

Use of **2z** and thiolacetic acid (36 μL, 0.50 mmol, 5.0 equiv) as a nucleophile in general procedure (4 h) afforded the title compound **1za** (23 mg, 62%) as a white solid. Mp 55–56 °C; R_f 0.35 (1:5 EtOAc/hexanes); HPLC t_R 25.2 min; IR (KBr) 3434, 3025, 1601, 1493, 1452, 699 cm^{-1}; ^{1}H NMR (300

MHz, CD_3CN) δ 8.62 (br s, 1H, N(1)OH), 7.70–7.48 (m, 5H, Ar), 7.45 (d, J = 7.9 Hz, 1H, Ar), 7.31 (d, J = 7.9 Hz, 1H, Ar), 7.12 (t, J = 7.9 Hz, 1H, Ar), 4.48 (s, 2H, C(3)CH_2S), 2.25 (s, 3H, SCOCH_3); ^{13}C NMR (75 MHz, CD_3CN) δ 196.2 (C=O), 139.8 (Ar), 137.3 (Ar), 131.8 (Ar), 130.3 (Ar), 130.2 (Ar), 129.8 (Ar), 126.1 (Ar), 124.9 (Ar), 122.2 (Ar), 114.5 (Ar), 109.8 (Ar), 104.6 (Ar), 30.9 (C(3)*C*H_2S), 26.4 (SCO*C*H_3); MS *m/z* 374 $[M]^+$; HRMS (+EI) calcd for $C_{17}H_{14}BrNO_2S$ $[M]^+$ 374.9929, found 374.9930.

3-[(Benzoylthio)methyl]-4-bromo-1-hydroxy-2-phenyl-1*H*-indole (1zb)

Use of **2z** and thiobenzoic acid (59 μL, 0.50 mmol, 5.0 equiv) as a nucleophile in general procedure (4 h) afforded the title compound **1zb** (22 mg, 51%) as a white solid. Mp 142–144 °C; R_f 0.29 (1:3 EtOAc/hexanes); HPLC t_R 27.2 min; IR (KBr) 3445, 3025, 1601, 1493, 1452, 702 cm^{-1}; ^{1}H NMR (300 MHz, CD_3CN) δ 8.80 (br s, 1H, N(1)OH), 7.91 (d, J = 8.5 Hz, 2H, Ar), 7.66–7.57 (m, 3H, Ar), 7.56–7.42 (m, 6H, Ar), 7.31 (d, J = 7.8 Hz, 1H, Ar), 7.13 (t, J = 7.8 Hz, 1H, Ar), 4.68 (s, 2H, C(3)CH_2S); ^{13}C NMR (75 MHz, CD_3CN) δ 192.5 (C=O), 140.0 (Ar), 138.4 (Ar), 137.3 (Ar), 134.9 (Ar), 131.8 (Ar), 130.3 (Ar), 130.2 (Ar), 130.1 (Ar), 129.9 (Ar), 128.3 (Ar), 126.1 (Ar), 125.0 (Ar), 122.3 (Ar), 114.5 (Ar), 109.9 (Ar), 104.1 (Ar), 26.7 (C(3)*C*H_2S); MS *m/z* 437 $[M]^+$; HRMS (+EI) calcd for $C_{22}H_{16}BrNO_2S$ $[M]^+$ 437.0085, found 437.0087.

4-Bromo-1-hydroxy-2-phenyl-3-[(*n*-propylthio)methyl]-1*H*-indole (1zc)

Use of **2z** and *n*-propanethiol (54 μL, 0.50 mmol, 5.0 equiv) as a nucleophile in general procedure (5 h) afforded the title compound **1zc** (21 mg, 57%) as a white solid. Mp 137–138 °C; R_f 0.24 (9:11 CH_2Cl_2/hexanes); HPLC t_R 26.6 min; IR (KBr) 3437, 3025, 1601, 1493, 1452, 697 cm^{-1}; ^{1}H NMR (300 MHz, CD_3CN) δ 8.73 (s, 1H, N(1)OH), 7.67 (d, J = 7.9 Hz, 2H, Ar), 7.58–7.46 (m, 3H, Ar), 7.42 (d, J = 7.9 Hz, 1H, Ar), 7.33–7.26 (m, 1H, Ar), 7.09 (t, J = 7.9 Hz, 1H, Ar), 4.10 (s, 2H, C(3)CH_2S), 2.31 (t, J = 7.3 Hz, 2H, S*C*$H_2$$CH_2$), 1.33 (sextet, J = 7.3 Hz, 2H, *C*$H_2$$CH_3$), 0.80 (t, J = 7.3 Hz, 3H, CH_2*C*H_3); ^{13}C NMR (75 MHz, CD_3CN) δ 139.3 (Ar), 137.6 (Ar), 131.9 (Ar), 130.7 (Ar), 130.0 (Ar), 129.7 (Ar), 125.9 (Ar), 124.7 (Ar), 122.1 (Ar), 115.0 (Ar), 109.6 (Ar), 107.8 (Ar), 35.0 (S*C*$H_2$$CH_2$), 27.4 (C(3)*C*$H_2$S), 24.0 (*C*$H_2$$CH_3$), 14.1 ($CH_2$*C*$H_3$); MS *m/z* 375 $[M]^+$; HRMS (+EI) calcd for $C_{18}H_{18}BrNOS$ $[M]^+$ 375.0292, found 375.0294.

4-Bromo-1-hydroxy-3-[(isopropylthio)methyl]-2-phenyl-1*H*-indole (1zd)

Use of **2z** and isopropanethiol (46 μL, 0.50 mmol, 5.0 equiv) as a nucleophile in general procedure (2 h) afforded the title compound **1zd** (17 mg, 46%) as a white solid. Mp 113–114 °C; R_f 0.30 (1:8 EtOAc/hexanes); HPLC t_R 26.4 min; IR (KBr) 3434, 3025, 1601, 1493, 1452, 699 cm^{-1}; ^{1}H NMR (300 MHz, CD_3CN) δ 8.61 (s, 1H, N(1)OH), 7.70 (d, J = 8.3 Hz, 2H, Ar), 7.58–7.48 (m, 3H, Ar), 7.43 (d, J = 8.0 Hz, 1H, Ar), 7.30 (d, J = 8.0 Hz, 1H, Ar), 7.10 (t, J = 8.0 Hz, 1H, Ar), 4.14 (s, 2H, C(3)CH_2S), 2.81 (heptet, J = 6.7 Hz 1H, S*C*H(CH_3)$_2$), 1.08 (d, J= 6.7 Hz, 6H, SCH(*C*H_3)$_2$); ^{13}C NMR (75 MHz, CD_3CN) δ 139.2 (Ar), 137.7 (Ar), 132.0 (Ar), 130.7 (Ar), 130.1 (Ar), 129.8 (Ar), 126.0 (Ar), 124.7 (Ar), 122.2 (Ar),

115.0 (Ar), 109.7 (Ar), 107.8 (Ar), 36.4 (S*C*H(CH$_3$)$_2$), 26.6 (C(3)*C*H$_2$S), 24.0 (SCH(*C*H$_3$)$_2$); MS *m/z* 375 [M]$^+$; HRMS (+EI) calcd for C$_{18}$H$_{18}$BrNOS [M]$^+$ 375.0292, found 375.0289.

4-Bromo-3-[(*n*-butylthio)methyl]-1-hydroxy-2-phenyl-1*H*-indole (1ze)

Use of **2z** and *n*-butanethiol (54 μL, 0.50 mmol, 5.0 equiv) as a nucleophile in general procedure (6 h) afforded the title compound **1ze** (17 mg, 43%) as a white solid. Mp 62–64 ^{o}C; R_f 0.67 (2:98 EtOAc/CHCl$_3$); HPLC t$_R$ 27.9 min; IR (KBr) 3433, 3025, 1601, 1493, 1452, 704 cm^{-1}; ^{1}H NMR (300 MHz, CD$_3$CN) δ 8.67 (s, 1H, N(1)OH), 7.67 (d, *J* = 8.0 Hz, 2H, Ar), 7.60–7.48 (m, 3H, Ar), 7.43 (d, *J* = 8.0 Hz, 1H, Ar), 7.30 (d, *J* = 8.0 Hz, 1H, Ar), 7.22–7.02 (m, 1H, Ar), 4.11 (s, 2H, C(3)CH$_2$S), 2.32 (t, *J* = 7.3 Hz, 2H, SC*H*$_2$CH$_2$), 1.64 (quintet, *J* = 7.3 Hz, 2H, C*H*$_2$CH$_2$CH$_3$), 1.40 (sextet, *J* = 7.3 Hz, 2H, C*H*$_2$CH$_3$), 0.78 (t, *J* = 7.3 Hz, 3H, CH$_2$C*H*$_3$); ^{13}C NMR (75 MHz, CD$_3$CN) δ 139.5 (Ar), 137.8 (Ar), 132.0 (Ar), 130.8 (Ar), 130.1 (Ar), 129.9 (Ar), 126.1 (Ar), 124.8 (Ar), 122.3 (Ar), 115.1(Ar), 109.8 (Ar), 108.0 (Ar), 33.0 (S*C*H$_2$CH$_2$), 32.7 (SCH$_2$*C*H$_2$), 27.6 (C(3)*C*H$_2$S), 23.2 (*C*H$_2$CH$_3$), 14.4 (CH$_2$*C*H$_3$); MS *m/z* 389 [M]$^+$; HRMS (+EI) calcd for C$_{19}$H$_{20}$BrNOS [M]$^+$ 389.0449, found 389.0449.

4-Bromo-1-hydroxy-3-[(*n*-octylthio)methyl]-2-phenyl-1*H*-indole (1zf)

Use of **2z** and *n*-octanethiol (87 μL, 0.50 mmol, 5.0 equiv) as a nucleophile in general procedure (4 h) afforded the title compound **1zf** (23 mg, 52%) as a white solid. Mp 57–58 ^{o}C; R_f 0.25 (1:1 CH$_2$Cl$_2$/hexanes); HPLC t$_R$ 32.5 min; IR (KBr) 3444, 3025, 1601, 1493, 1452, 701 cm^{-1}; ^{1}H NMR (300 MHz, CD$_3$CN) δ 8.83 (s, 1H, N(1)OH), 7.65 (d, *J* = 7.2 Hz, 2H, Ar), 7.56–7.36 (m, 4H, Ar), 7.33–7.23 (m, 1H, Ar), 7.08 (t, *J* = 7.9 Hz, 1H, Ar), 4.09 (s, 2H, C(3)CH$_2$S), 2.30 (t, *J* = 6.7 Hz, 2H, SC*H*$_2$CH$_2$), 1.39–1.08 (m, 12H, (C*H*$_2$)$_6$CH$_3$), 0.88 (t, *J* = 6.7 Hz, 3H, (CH$_2$)$_6$C*H*$_3$); ^{13}C NMR (75 MHz, CD$_3$CN) δ 139.4 (Ar), 137.7 (Ar), 132.0 (Ar), 130.0 (Ar), 129.8 (Ar), 128.8 (Ar), 126.0 (Ar), 124.7 (Ar), 122.2 (Ar), 115.1 (Ar), 109.7 (Ar), 107.9 (Ar), 33.0 (S*C*H$_2$CH$_2$), 30.8 (SCH$_2$*C*H$_2$), 30.4 (*C*H$_2$CH$_2$CH$_3$), 30.3 (C(3)*C*H$_2$S), 30.0 (*C*H$_2$(CH$_2$)$_2$CH$_3$), 29.5 (*C*H$_2$(CH$_2$)$_3$CH$_3$), 27.6 (S(CH$_2$)$_2$*C*H$_2$), 23.8 (*C*H$_2$CH$_3$), 14.8 (CH$_2$*C*H$_3$); MS *m/z* 445 [M]$^+$; HRMS (+EI) calcd for C$_{23}$H$_{28}$BrNOS [M]$^+$ 445.1075, found 445.1073.

4-Bromo-1-hydroxy-2-phenyl-3-[(phenylethylthio)methyl]-1*H*-indole (1zg)

Use of **2z** and phenylethanethiol (67 μL, 0.50 mmol, 5.0 equiv) as a nucleophile in general procedure (2 h) afforded the title compound **1zg** (20 mg, 45%) as a white solid. Mp 53–54 ^{o}C; R_f 0.40 **(**2:98 EtOAc/CHCl$_3$); HPLC t$_R$ 29.3 min; IR (KBr) 3439, 3025, 1601, 1493, 1452, 699 cm^{-1}; ^{1}H NMR (300 MHz, CD$_3$CN) δ 8.82 (s, 1H, N(1)OH), 7.66 (d, *J* = 8.1 Hz, 2H, Ar), 7.58–7.47 (m, 3H, Ar), 7.43 (d, *J* = 8.0 Hz, 1H, Ar) 7.34–7.15 (m, 4H, Ar), 7.11 (t, *J* = 8.0 Hz, 1H, Ar), 7.03 (d, *J* = 8.1 Hz, 2H, Ar), 4.17 (s, 2H, C(3)CH$_2$S), 2.68–2.61 (m, 4H, S(C*H*$_2$)$_2$Ph); ^{13}C NMR (75 MHz, CD$_3$CN) δ 142.3 (Ar), 141.7 (Ar), 139.3 (Ar), 137.7 (Ar), 132.0 (Ar), 130.1 (Ar), 129.9 (Ar), 129.8 (Ar), 129.7 (Ar), 129.6 (Ar), 127.4 (Ar), 126.0 (Ar), 122.2 (Ar), 115.0 (Ar), 109.7 (Ar), 107.8 (Ar), 37.1 (S*C*H$_2$CH$_2$), 34.8 (*C*H$_2$Ph), 27.9 (C(3)*C*H$_2$S); MS *m/z* 437 [M]$^+$; HRMS (+EI) calcd for C$_{23}$H$_{20}$BrNOS [M]$^+$ 437.0449, found 437.0446.

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