Novel, Metal-Catalyzed Carbonylation of Acyclic Organic Compounds. The Regiospecific Carbonylation of *N,S*-Acetals

Kanjai Khumtaveeporn and Howard Alper*

Department of Chemistry, University of Ottawa, 10 Marie Curie Street, Ottawa, Ontario, Canada K1N 6N5

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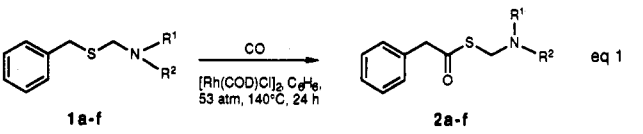
The rhodium(I) complex, $[Rh(CO)_2Cl]_2$, catalyzes the regiospecific carbonylation of *N,S*-acetals of structural type $PhCH_2SCH_2NR^1R^2$ to form $PhCH_2COSCH_2NR^1R^2$ in 68–92% isolated yields. Exclusive insertion of carbon monoxide occurs into the other sulfur–carbon bond of RSCH(Ph)-NR^3R^4 (R = $PhCH_2$, *n*-$C_{11}H_{23}$) affording RSCOCH(Ph)NR^3R^4 in 46–83% yield.

Metal complex catalyzed carbonylation reactions have been widely used in synthetic organic chemistry.[1] The ring expansion of cyclic systems containing heteroatoms has been extensively studied and, with one exception (pyrrolidine),[2] all of the reported substrates are 3- or 4-membered rings. Aziridines,[3,4] azirines,[5] azetidines,[6] oxetanes, and thietanes[7] have been successfully carbonylated under reasonably mild conditions. In all of these reactions, the ring expansion is accompanied by release of ring strain. A challenging problem in organic chemistry is the achievement of the carbonylation of acyclic, unstrained compounds. This rare process has been reported by Murahashi and co-workers[8] for the palladium(0)-catalyzed carbonylation of allylamines to the corresponding amides. The driving force in the latter case is the generation of a π-allyl palladium intermediate. We were intrigued by the possibility of realizing carbonyl insertion in an acyclic system for which there is no stabilization by a π-allyl–metal complex. *N,S*-Acetals[9] appeared to be excellent candidates for such an investigation as insertion could, in principle, occur in any of the carbon–sulfur or carbon–nitrogen bonds. It was gratifying to observe regiospecific rhodium(I)-catalyzed insertion of carbon monoxide into one of the two carbon–sulfur bonds, the regiospecificity being subject to the nature of the reactant. We now describe the fascinating results of this investigation.

Results and Discussion

The carbonylation of a series of *N,S*-acetals (**1a–f**) was carried out in dry benzene at 53 atm of carbon monoxide and 140 °C for 24 h in the presence of 1 mol % $[Rh(COD)Cl]_2$. Thioesters **2a–f** were obtained as the only products in 68–92% isolated yields (eq 1).

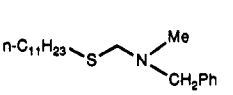


	R^1	R^2	% 2*
a	Ethyl	Ethyl	74
b	i-Butyl	i-Butyl	82
c	Cyclohexyl	Cyclohexyl	92
d	Methyl	Cyclohexyl	81
e	Allyl	Cyclohexyl	68
f	Methyl	Benzyl	81

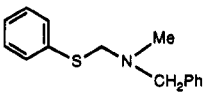
* isolated yield

The structure of the products **2a–f** was assigned on the basis of spectral data (see Experimental Section). The ^1H NMR spectra show that, after the reaction, the protons at the benzylic position next to sulfur resonated upfield by approximately 0.5 ppm compared to **1a–f**. The ^{13}C NMR spectra show a carbonyl carbon at 200.91–207.22 ppm due to C(O)S. Molecular ion peaks consistent with structure **2** were observed in the mass spectra.

A benzyl group attached to sulfur is required in order to affect the carbon monoxide insertion. Neither alkyl (**1g**) nor aryl (**1h**) sulfides react, with only starting material



1g



1h

and decomposition products observed in these cases. No carbon monoxide insertion into the C–N bond was found, even when the amine is benzylated as in **1f**.

The regiospecific carbon monoxide insertion into the C–S bond in this series is quite unusual. To our knowledge, in cyclic systems the ease of carbonylation is of the order of C–N > C–S > C–O.[6,7] In addition, carbon monoxide inserts exclusively into the C–N bond rather than the C–S bond of thiazolidines.[10]

Although no carbonylation of the C–N bond is observed, the presence of this functionality is crucial to the success of insertion of CO into a C–S bond. For instance, benzyl ethyl sulfide (**3**) is recovered unchanged under the conditions described for the *N,S*-acetal carbonylation, even with added diisopropylethylamine. Furthermore, not only is it necessary to have nitrogen in the molecule, it must be in a 1,3-relationship with respect to sulfur. 1,4-Thioamines are completely unreactive under the described

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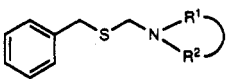
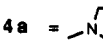
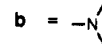
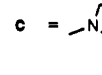
conditions. Since the 1,3-*N,S* functionality is necessary for catalysis, it is likely that the substrate is binding to the rhodium in a bidentate manner. Surprisingly, when the nitrogen atom is part of a heterocyclic ring (**4a–c**), there was no reaction under the standard conditions, with decomposition at higher temperatures (e.g., 170 °C). The reason for this reactivity difference is unclear.

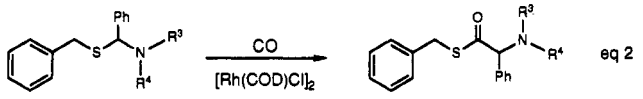


4a = 

b = 

c = 

In order to investigate the regiospecificity of the carbonylation reaction we synthesized compounds **5a–c** where both carbons which are bound to sulfur are benzylic in nature. Treatment of these substrates, with carbon monoxide and rhodium(I) catalysts, under standard conditions, led to the exclusive insertion of carbon monoxide into the C–S bond adjacent to nitrogen (46–83% yield) (eq 2). Contrary to the results described above, carbon-



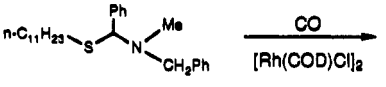
eq 2

5a-c **6a-c**

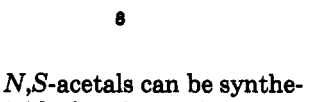
	R^3	R^4	% 6*
a	Ethyl	Ethyl	83
b	Methyl	Benzyl	46
c	$-CH_2CH_2OCH_2CH_2-$		80

* isolated yield

ylation proceeded in good yield when the nitrogen atom was part of a heterocyclic ring (i.e., **5c** → **6c**). It is conceivable that the other benzylic unit, furthest from nitrogen, may not be required for reaction to occur. Indeed, compound **7**, in which an *n*-undecyl group is substituted for the benzyl substituent, experienced carbonyl insertion to form the expected carbonylated product **8** in 55% isolated yield (eq 3).



7



eq 3

8

In conclusion, thioesters of *N,S*-acetals can be synthesized in good to excellent yields by the regiospecific carbonylation of the C–S bond using $[Rh(COD)Cl]_2$ as the catalyst. The regiospecificity can be completely controlled by position modification of substituents in the molecule. These results also demonstrate the importance of chelation control in these reactions.

Experimental Section

General. Spectral data were obtained by use of the following instruments: Bomem MB-100 (FT-IR), Bruker AMX-500 MHz, Varian XL 300, or Gemini 200 MHz (NMR), VG 7070 (MS). Elemental analyses were carried out by MHW Laboratories, Phoenix, AZ. $[Rh(COD)Cl]_2$ was prepared according to a literature procedure.[11]

General Procedure for the Preparation of *N,S*-Acetals.[12] To the thiol (10 mmol), in a round-bottom flask equipped with a stirrer, was added the amine (10 mmol). An exothermic reaction commenced immediately with the solution temperature rising to 65 °C. The aldehyde was introduced in one portion into the reaction mixture (10 mmol), and the reaction was then refluxed for 30 min. After cooling, the reaction mixture was washed with 10% NaOH and CH_2Cl_2. The organic layer was dried ($MgSO_4$), filtered, and concentrated in vacuo. The residue was purified by distillation under reduced pressure. In the cases where benzaldehyde was employed, the crude products were used in the next step without distillation due to decomposition resulting from the distillation.

Yields and Characterization Data for Reactants. 1a: 92% yield; ^1H NMR ($CDCl_3$) δ 1.05 (t, 6H, 2 × CH_3CH_2), 2.58 (q, 4H, 2 × CH_2CH_3), 3.75 (s, 2H, PhCH_2S), 4.10 (s, 2H, SCH_2N), 7.13–7.47 (m, 5H, aromatic protons); ^{13}C NMR ($CDCl_3$) δ 13.32 (CH_3), 37.09 ($PhCH_2S$), 46.92 (NCH_2CH_3), 58.20 (SCH_2N), 127.47, 128.99, 129.05, 129.36, 129.42, 139.76 (aromatic carbons); MS *m/e* 209 [M^+].

1b: 98% yield; ^1H NMR ($CDCl_3$) δ 0.87 (d, 12H, 4 × CH_3CH), 1.63 (m, 2H, 2 × $CH(CH_3)_2$), 2.24 (d, 4H, 2 × CH_2CH), 3.75 (s, 2H, PhCH_2S), 4.05 (s, 2H, SCH_2N), 7.20–7.44 (m, 5H, aromatic protons); ^{13}C NMR ($CDCl_3$) δ 20.74 (CH_3), 26.13 ($CH(CH_3)_2$), 36.73 ($PhCH_2S$), 60.49 (NCH_2CH), 61.76 (SCH_2N), 126.80, 128.42, 128.77, 139.36 (aromatic carbons); MS *m/e* 265 [M^+].

1c: 73% yield; ^1H NMR ($CDCl_3$) δ 1.10–1.90 (m, 20H, 2 × cyclohexyl protons), 2.65 (m, 2H, 2 × NCH), 3.75 (s, 2H, PhCH_2S), 4.15 (s, 2H, SCH_2N), 7.14–7.40 (m, 5H, aromatic protons); ^{13}C NMR ($CDCl_3$) δ 25.93, 26.64, 26.82, 26.93, 32.95 (cyclohexyl carbons), 36.14 ($PhCH_2S$), 54.57 (NCH), 57.95 (SCH_2N), 127.16, 128.94, 129.42, 140.15 (aromatic carbons); MS *m/e* 317 [M^+].

1d: 80% yield; ^1H NMR ($CDCl_3$) δ 1.10–1.90 (m, 10H, cyclohexyl protons), 2.35 (s, 3H, NCH_3), 2.45 (m, 1H, NCH), 3.75 (s, 2H, PhCH_2S), 3.97 (s, 2H, SCH_2N), 7.25–7.35 (m, 5H, aromatic protons); ^{13}C NMR ($CDCl_3$) δ 26.16, 26.66, 30.67 (cyclohexyl carbons), 36.69 ($PhCH_2S$), 37.81 (NCH_3), 59.95 (NCH), 61.27 (SCH_2N), 127.37, 128.99, 129.47, 139.79 (aromatic carbons); MS *m/e* 249 [M^+].

1e: 80% yield; ^1H NMR ($CDCl_3$) δ 1.10–1.90 (m, 10H, cyclohexyl protons), 2.58 (m, 1H, NCH), 3.28 (d, 2H, $NCH_2CH{=}CH_2$), 3.70 (s, 2H, PhCH_2S), 4.04 (s, 2H, SCH_2N), 5.10–5.30 (ABC, 2H, $CH_2{=}CH$), 5.80 (ABC, 1H, $CH{=}CH_2$), 7.15–7.40 (m, 5H, aromatic protons); ^{13}C NMR ($CDCl_3$) δ 26.50, 26.73, 31.24 (cyclohexyl carbons), 36.59 ($PhCH_2S$), 52.28 ($NCH_2CH{=}CH_2$), 56.77 (NCH), 60.57 (SCH_2N), 117.38 ($CH_2{=}CH$), 127.32, 128.99, 129.41, 137.51, 139.94 (aromatic carbons and $CH{=}CH_2$); MS *m/e* 275 [M^+].

1f: 84% yield; ^1H NMR ($CDCl_3$) δ 2.33 (s, 3H, NCH_3), 3.65 (s, 2H, NCH_2Ph), 3.75 (s, 2H, PhCH_2S), 3.92 (s, 2H, SCH_2N), 7.20–7.40 (m, 10H, aromatic protons); ^{13}C NMR ($CDCl_3$) δ 36.70 ($PhCH_2S$), 40.88 (NCH_3), 59.19 (NCH_2Ph), 61.02 (SCH_2N), 126.88, 127.17, 128.37, 128.47, 128.91, 129.03, 138.48, 138.98 (aromatic carbons); MS *m/e* 257 [M^+].

1g: 74% yield; ^1H NMR ($CDCl_3$) δ 0.85 (t, 3H, CH_3), 1.23 (br s, 17H, CH_2), 1.55 (m, 2H, CH_2), 2.26 (s, 3H, NCH_3), 2.53 (m, 2H, SCH_2), 3.63 (s, 2H, $PhCH_2N$), 3.97 (s, 2H, SCH_2N), 7.38 (m, 5H, aromatic protons); ^{13}C NMR ($CDCl_3$) δ 14.17 (CH_3), 22.73, 28.97, 29.29, 29.38, 29.58, 29.65, 30.57, 31.95 (CH_2), 33.47 (SCH_2), 40.81 (NCH_3), 59.04 ($PhCH_2N$), 62.36 (NCH_2S), 127.11, 128.28, 129.01, 138.51 (aromatic carbons); MS *m/e* 321 [M^+].

1h: 68% yield; ^1H NMR ($CDCl_3$) δ 2.40 (s, 3H, NCH_3), 3.68 (s, 2H, NCH_2Ph), 4.53 (s, 2H, SCH_2N), 7.20–7.55 (m, 10H, aromatic protons).

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4a: 80% yield; ^{1}H NMR ($CDCl_3$) δ 1.78 (m, 4H, 2 × CH_2CH_2N), 2.66 (m, 4H, 2 × NCH_2CH_2), 3.75 (s, 2H, $PhCH_2S$), 3.97 (s, 2H, SCH_2N), 7.20–7.40 (m, 5H, aromatic protons); ^{13}C NMR ($CDCl_3$) δ 24.51 (CH_2CH_2N), 37.67 ($PhCH_2S$), 51.55 (NCH_2CH_2), 58.28 (SCH_2N), 127.47, 129.04, 129.25, 129.54, 139.58 (aromatic carbons); MS *m/e* 207 [M$^+$].

4b: 82% yield; ^{1}H NMR ($CDCl_3$) δ 2.55 (m, 4H, 2 × NCH_2CH_2O), 3.70 (m, 6H, 2 × OCH_2CH_2N, $PhCH_2S$), 3.80 (s, 2H, SCH_2N), 7.20–7.45 (m, 5H, aromatic protons); ^{13}C NMR ($CDCl_3$) δ 36.80 (NCH_2CH_2O), 51.87 ($PhCH_2S$), 61.69 (SCH_2N), 67.54 (OCH_2CH_2N), 127.55, 129.05, 129.21, 129.62, 139.22 (aromatic carbons); MS *m/e* 223 [M$^+$].

4c: 80% yield; ^{1}H NMR ($CDCl_3$) δ 1.10–2.00 (m, 11H, CH_2, CH of saturated ring), 2.70 (m, 2H, NCH_2 ring), 2.96 (m, 1H, NCH ring), 3.75 (s, 2H, $PhCH_2S$), 4.10 (s, 2H, SCH_2N), 7.20–7.40 (m, 5H, aromatic protons).

5a: 89% yield; ^{1}H NMR ($CDCl_3$) δ 0.95 (t, 6H, 2 × CH_3), 2.60 (q, 4H, 2 × CH_2), 3.65 (AB, 2H, $PhCH_2S$), 5.10 (s, 1H, SCH(Ph)N), 7.10–7.80 (m, 10H, aromatic protons); ^{13}C NMR ($CDCl_3$) δ 14.32 (CH_3), 36.34 ($PhCH_2S$), 44.41 (NCH_2), 73.43 (SCH(Ph)N), 127.46, 127.97, 128.68, 128.95, 128.99, 129.56, 129.63, 129.68, 139.57, 140.51 (aromatic carbons); MS *m/e* 285 [M$^+$].

5b: 68% yield; ^{1}H NMR ($CDCl_3$) δ 2.30 (s, 3H, NCH_3), 3.75 (m, 4H, 2 × CH_2Ph), 5.10 (s, 1H, SCH(Ph)N), 7.20–7.70 (m, 10H, aromatic protons); ^{13}C NMR ($CDCl_3$) δ 36.39 ($PhCH_2S$), 38.15 (NCH_3), 58.66 (NCH_2Ph), 75.62 (SCH(Ph)N), 127.59, 127.69, 128.35, 128.82, 129.02, 129.12, 129.30, 129.36, 129.50, 129.62, 139.21, 139.40, 139.85 (aromatic carbons); MS *m/e* 333 [M$^+$].

5c: 78% yield; ^{1}H NMR ($CDCl_3$) δ 2.58 (m, 4H, 2 × CH_2N), 3.52–3.88 (m, 6H, 2 × CH_2O, CH_2S), 4.68 (s, 1H, SCH(Ph)N), 7.18–7.50 (m, 10H, aromatic protons); ^{13}C NMR ($CDCl_3$) δ 36.04 ($PhCH_2S$), 49.99 (NCH_2), 67.69 (CH_2O), 75.07 (SCH(Ph)N), 127.55, 128.51, 128.64, 128.76, 129.02, 129.34, 129.62, 137.79, 139.10 (aromatic carbons); MS *m/e* 299 [M$^+$].

7: 82% yield; ^{1}H NMR ($CDCl_3$) δ 0.85 (t, 3H, CH_3), 1.24 (br s, 18H, CH_2), 1.53 (m, 1H, CH_2), 2.20 (s, 3H, NCH_3), 2.48 (m, 2H, SCH_2), 3.70 (AB, 2H, $PhCH_2N$), 5.05 (s, 1H, $SCHPh$), 7.20–7.65 (m, 10H, aromatic protons); ^{13}C NMR ($CDCl_3$) δ 14.77 (CH_3), 23.32, 29.62, 29.71, 29.85, 29.97, 30.16, 30.24, 30.40, 30.75, 32.55 (CH_2), 38.07 (NCH_3), 58.71 (NCH_2Ph), 76.47 (SCH(Ph)N), 127.63, 128.09, 128.63, 128.78, 128.90, 129.44, 129.59, 139.86, 139.92 (aromatic carbons); MS *m/e* 397 [M$^+$].

Ethyl Benzyl Sulfide (3). A mixture of benzyl mercaptan (1.24 g, 10 mmol), ethyl iodide (2.34 g, 15 mmol), sodium hydroxide (2 g, 50 mmol) and 18-crown-6 (0.13 g, 0.5 mmol) was stirred overnight in benzene (10 mL). The reaction mixture was then worked up by extraction with CH_2Cl_2. The organic phase was washed with water, dried over $MgSO_4$, filtered, and concentrated under vacuum. The product was purified from the crown ether by column chromatography using silica gel and 10% of ethyl acetate in hexane as the eluant to yield (**3**) in 92% yield; ^{1}H NMR ($CDCl_3$) δ 1.24 (t, 3H, CH_3), 2.42 (q, 2H, CH_2), 3.75 (s, 2H, SCH_2), 7.20–7.40 (m, 5H, aromatic protons); ^{13}C NMR ($CDCl_3$) δ 14.42 (CH_3), 25.21 (CH_2CH_3), 35.89 ($PhCH_2S$), 126.87, 128.46, 128.82, 138.61 (aromatic carbons); MS *m/e* 152 [M$^+$].

General Procedure for the Carbonylation of *N,S*-Acetals. A mixture of the *N,S*-acetal (5 mmol), $[Rh(COD)Cl]_2$ (0.025 g, 0.05 mmol), and benzene (10 mL) was placed in an autoclave containing a glass liner and stirring bar. The autoclave was purged several times with carbon monoxide and pressurized to 53 atm, and the reaction mixture was stirred at 140 °C for 24 h. The reaction mixture was then cooled to room temperature and filtered through acidic alumina using CH_2Cl_2 and then ethyl acetate as eluants. In all cases, except **1f**, the less polar fraction contains the product. In the case of **1f**, the product is in the ethyl acetate fraction. The fraction containing the product was then purified by preparative thin-layer chromatography using 20% ethyl acetate in hexane as developer.

2a: 74% yield; IR (neat) ν(CO) 1686 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 1.07 (t, 6H, 2 × CH_3CH_2), 2.66 (q, 4H, 2 × CH_2CH_3), 3.32 (s, 2H, $PhCH_2CO$), 4.07 (s, 2H, SCH_2N), 7.13–7.40 (m, 5H, aromatic protons); ^{13}C NMR ($CDCl_3$) δ 12.58 (CH_3), 33.58 ($PhCH_2S$), 48.72 (NCH_2CH_3), 63.24 (SCH_2N), 127.63, 128.07, 129.13, 129.49, 130.02, 138.58 (aromatic carbons), 202.93 (CO); MS *m/e* 237 [M$^+$]. Anal. Calcd for $C_{13}H_{19}NOS$: C, 65.82; H, 8.02; N, 5.91. Found: C, 66.20; H, 8.04; N, 5.99.

2b: 82% yield; IR (neat) ν(CO) 1681 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 0.95 (d, 12H, 4 × CH_3CH), 1.72 (m, 2H, 2 × $CH(CH_3)_2$), 2.22 (d, 4H, 2 × CH_2CH), 3.30 (s, 2H, $PhCH_2CO$), 4.05 (s, 2H, SCH_2N), 7.20–7.35 (m, 5H, aromatic protons); ^{13}C NMR ($CDCl_3$) δ 20.89 (CH_3), 26.61 ($CH(CH_3)_2$), 32.76 ($PhCH_2S$), 63.88 (NCH_2CH), 65.79 (SCH_2N), 126.97, 128.47, 128.73, 128.84, 129.40, 138.04, (aromatic carbons), 201.89 (CO); MS *m/e* 293 [M$^+$]. Anal. Calcd for $C_{17}H_{27}NOS$: C, 69.62; H, 9.215; N, 4.78. Found: C, 69.61; H, 9.33; N, 5.01.

2c: 92% yield; IR (neat) ν(CO) 1680 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 1.10–1.90 (m, 20H, 2 × cyclohexyl protons), 2.55 (m, 2H, 2 × NCH), 3.43 (s, 2H, $PhCH_2CO$), 4.00 (s, 2H, SCH_2N), 7.20–7.45 (m, 5H, aromatic protons); ^{13}C NMR ($CDCl_3$) δ 26.66, 26.90, 32.14 (cyclohexyl carbons), 33.70 ($PhCH_2S$), 57.54 (NCH), 59.54 (SCH_2N), 127.43, 129.03, 129.47, 138.99 (aromatic carbons), 207.22 (CO); MS *m/e* 345 [M$^+$]. Anal. Calcd for $C_{21}H_{31}NOS$: C, 73.04; H, 8.99; N, 4.06. Found: C, 73.23; H, 8.96; N, 3.96.

2d: 81% yield; IR (neat) ν(CO) 1680 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 1.10–1.90 (m, 10H, cyclohexyl protons), 2.33 (s, 3H, NCH_3), 2.45 (m, 1H, NCH), 3.35 (s, 2H, $PhCH_2CO$), 4.05 (s, 2H, SCH_2N), 7.10–7.40 (m, 5H, aromatic protons); ^{13}C NMR ($CDCl_3$) δ 26.37, 26.67, 29.48 (cyclohexyl carbons), 33.53 ($PhCH_2S$), 43.86 (NCH_3), 63.61 (NCH), 63.70 (SCH_2N), 127.61, 129.12, 129.50, 130.02, 138.65 (aromatic carbons), 203.48 (CO); MS *m/e* 277 [M$^+$]. Anal. Calcd for $C_{16}H_{23}NOS$: C, 69.31; H, 8.30; N, 5.05. Found: C, 69.58; H, 8.01; N, 5.32.

2e: 80% yield; IR (neat) ν(CO) 1684 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 1.10–1.95 (m, 10H, cyclohexyl protons), 2.55 (m, 1H, NCH), 3.21 (d, $NCH_2CH{=}CH_2$), 3.35 (s, 2H, $PhCH_2CO$), 4.02 (s, 2H, SCH_2N), 5.18 (ABC, 2H, $CH_2{=}CH$), 5.90 (ABC, 1H, $CH{=}CH_2$), 7.15–7.45 (m, 5H, aromatic protons); ^{13}C NMR ($CDCl_3$) δ 26.54, 26.74, 29.65 (cyclohexyl carbons), 33.65 ($PhCH_2S$), 55.35 ($NCH_2CH{=}CH_2$), 60.02 (NCH), 61.13 (SCH_2N), 118.00 ($CH_2{=}CH$), 127.52, 129.07, 129.50, 129.60, 137.08, 138.77 (aromatic carbons and $CH{=}CH_2$), 205.06 (CO); MS *m/e* 303 [M$^+$]. Anal. Calcd for $C_{18}H_{25}NOS$: C, 71.29; H, 8.25; N, 4.62. Found: C, 71.25; H, 8.33; N, 4.47.

2f: 85% yield; IR (neat) ν(CO) 1686 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 2.37 (s, 3H, NCH_3), 3.31 (s, 2H, $PhCH_2CO$), 3.65 (s, 2H, $PhCH_2N$), 4.08 (s, 2H, SCH_2N), 7.15–7.45 (m, 5H, aromatic protons); ^{13}C NMR ($CDCl_3$) δ 32.75 ($PhCH_2S$), 42.87 (NCH_3), 62.05 (NCH_2Ph), 66.25 (SCH_2N), 127.09, 127.35, 128.35, 128.55, 128.80, 128.90, 137.85, 138.02, (aromatic carbons), 200.91 (CO); MS *m/e* 285 [M$^+$]. Anal. Calcd for $C_{17}H_{19}NOS$: C, 71.58; H, 6.67; N, 4.91. Found: C, 71.27; H, 6.92; N, 4.98.

6a: 83% yield; IR (neat) ν(CO) 1686 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 1.05 (t, 6H, 2 × CH_3), 2.48 (m, 2H, CH_2), 2.70 (m, 2H, CH_2), 4.10 (s, 2H, SCH_2Ph), 4.60 (s, 1H, $COCH$(Ph)N), 7.15–7.40 (m, 10H, aromatic protons); ^{13}C NMR ($CDCl_3$) δ 12.56 (CH_3), 34.00 ($PhCH_2S$), 44.47 (NCH_2), 76.75 ($COCH$(Ph)N), 127.67, 128.68, 128.93, 129.15, 129.52, 130.21, 136.14, 138.52 (aromatic carbons), 202.68 (CO); MS *m/e* 313 [M$^+$]. Anal. Calcd for $C_{19}H_{23}NOS$: C, 72.84; H, 7.35; N, 4.47. Found: C, 73.07; H, 7.13; N, 4.47.

6b: 46% yield; IR (neat) ν(CO) 1688 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 2.20 (s, 3H, NCH_3), 3.60 (AB, 2H, NCH_2Ph), 4.12 (s, 2H, SCH_2Ph), 4.43 (s, 1H, $COCH$(Ph)N), 7.15–7.50 (m, 10H, aromatic protons); ^{13}C NMR ($CDCl_3$) δ 33.87 ($PhCH_2S$), 40.19 (NCH_3), 59.98 (NCH_2Ph), 79.72 (COCH(Ph)N), 127.75, 127.80, 127.93, 128.06, 128.96, 129.07, 129.11, 129.17, 129.40, 129.51, 129.63, 129.79, 130.05, 130.19, 135.40, 137.99, 138.32, 139.55 (aromatic carbons), 201.55 (CO); MS *m/e* 361 [M$^+$]. Anal. Calcd for $C_{23}H_{23}NOS$, C, 76.45; H, 6.37; N, 3.88. Found: C, 76.09; H, 6.42; N, 3.84.

6c: 80% yield; IR (neat) ν(CO) 1686 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 2.55 (m, 4H, 2 × CH_2N), 3.73 (m, 6H, 2 × CH_2O), 4.05 (s, 2H, SCH_2Ph), 4.15 (s, 1H, $COCH$(Ph)N), 7.20–7.50 (m, 10H, aromatic protons); ^{13}C NMR ($CDCl_3$) δ 33.16 ($PhCH_2S$), 51.87 (NCH_2), 66.81 (CH_2O), 81.16 ($COCH$(Ph)N), 127.18, 128.56, 128.61, 128.81, 129.29, 134.39, 137.33 (aromatic carbons), 199.89 (CO); MS *m/e* 327 [M$^+$]. Anal. Calcd for $C_{19}H_{21}NO_2S$: C, 62.81; H, 5.70; N, 7.25. Found: C, 61.96; H, 5.55; N, 7.25.

8: 55% yield; IR (neat) ν(CO) 1686 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 0.87 (t, 3H, CH_3), 1.20–1.40 (m, 18H, CH_2), 1.55 (m, 1H, CH_2), 2.16 (s, 3H, NCH_3), 2.85 (t, 2H, SCH_2), 3.55 (AB, 2H, $PhCH_2N$), 4.35 (s, 1H, SCHPh), 7.20–7.50 (m, 5H, aromatic protons); ^{13}C

NMR ($CDCl_3$) δ 14.73 (CH_3), 23.29, 28.99, 29.32, 29.46, 29.71, 29.94, 30.08, 30.20, 32.51, 34.67, (CH_2), 40.16 (NCH_3), 59.88 (NCH_2-Ph), 80.17 (COCH(Ph)N), 127.70, 128.80, 128.89, 129.01, 129.38, 130.00, 136.01, 139.33, (aromatic carbons), 201.82 (CO); MS *m/e* 425 [M^+]. Anal. Calcd for $C_{27}H_{39}NOS$: C, 76.24; H, 9.18; N, 3.29. Found: C, 76.29; H, 9.34; N, 3.14.

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Supplementary Material Available: Nuclear magnetic resonance (NMR) spectra for **1a–h, 3, 4a–c, 5a–c,** and **7** (30 pages). This material is contained in libraries on microfiche, immediately follows this article in microfilm version of the journal, and can be ordered from the ACS; see any current masthead page for ordering information.