161.4, 152.2, 134.1, 130.8, 128.7, 38.2, 32.0, 21.7. Anal. Calcd for C_9H_8ClNO: C, 59.52; H, 4.44; N, 7.71. Found: C, 59.60; H, 4.19; N, 7.65.

3-Bromo-5-chloro-2-[2(*S*)-methyl-4-[(tetrahydro-2*H*-pyran-2-yl)oxy]butyl]pyridine (7). This series was synthesized using the same conditions employed for the desmethyl series (4.97 g, 65%): IR 2931, 2865, 1453, 1440, 1430, 1373, 1355, 1354, 1185, 1117, 1071, 1020, 975 cm^{-1}; ^1H NMR δ 8.41 (d, J = 2.5 Hz, 1 H), 7.82 (d, J = 2.5 Hz, 1 H), 4.55 (bs 1 H), 3.80 (m, 2 H), 3.42 (m, 2 H), 2.90 (m, 2 H), 1.62 (m, 9 H), 0.95, (d, J = 7 Hz, 1.5 H), 0.89 (d, J = 7 Hz, 1.5 H); α_D = +1.32° (c = 1.06; EtOH). Anal. Calcd for $C_{15}H_{21}BrClNO_2$: C, 49.67; H, 5.84; N, 3.86. Found: C, 49.89; H, 5.85; N, 3.94.

3-Bromo-5-chloro-2-(4-hydroxy-2(*S*)-methylbutyl)pyridine (8) (3.09 g, 84%): IR 3606, 3396, 2949, 2926, 2874, 1566, 1428, 1374, 1191, 1033, 997 cm^{-1}; ^1H NMR δ 8.42 (d, J = 2 Hz, 1 H), 7.85 (d, J = 2 Hz, 1 H), 3.72 (m, 2 H), 2.89 (dq, J = 6, 7 Hz, 2 H), 2.23 (dq, J = 6, 7 Hz, 1 H) 2.09 (m, 1 H), 1.59 (m, 2 H), 0.97 (d, J = 7 Hz, 3 H); ^{13}C NMR δ 157.8, 146.2, 139.7, 129.5, 121.6, 60.6, 43.2, 39.3, 29.7, 19.9; α_D = −2.29 (c = 1.04 acetone). Anal. Calcd for $C_{10}H_{13}BrClNO$: C, 43.12; H, 4.70; N, 5.03. Found: C, 43.31; H, 4.65; N, 5.02.

3-Bromo-5-chloro-2-[2(*S*)-methyl-3-carboxypropyl]-pyridine (11) (755 mg, 68%): mp 59–60 °C; IR 3496, 2958, 1711, 1565, 1513, 1429, 1374, 1271, 1193, 1119, 1033 cm^{-1}; ^1H NMR δ 8.45 (d, J = 2 Hz, 1 H), 7.88 (d, J = 2 Hz, 1 H), 2.96 (d, J = 7 Hz, 2 H), 2.55 (m, 1 H), 2.35 (m, 2 H), 1.05 (d, J = 7 Hz, 3 H); ^{13}C NMR δ 178.0, 156.9, 146.3, 139.8, 129.9, 121.7, 42.6, 40.7, 30.0, 19.8. Anal. Calcd for $C_{10}H_{11}BrClNO_2$: C, 41.06; H, 3.79; N, 4.79. Found: C, 41.36; H, 3.68; N, 4.77.

3-Bromo-5-chloro-2-[2(*S*)-methyl-3-[(*N*,*N*'-dimethylamino)carbonyl]propyl]pyridine (12) (190 mg, 41%): IR 3419, 2958, 2870, 1632, 1565, 1495, 1440, 1427, 1400, 1373, 1350, 1195, 1117, 1055, 1032 cm^{-1}; ^1H NMR δ 8.38 (d, J = 2 Hz, 1 H), 7.80 (d, J = 2 Hz, 1 H), 2.95 (s, 3 H), 2.87 (m, 2 H), 2.86 (s, 3 H), 2.61 (dq, J = 7, 6 Hz, 1 H), 2.29 (dq, J = 6, 7 Hz, 2 H), 0.98 (d, J = 7 Hz, 3 H); ^{13}C NMR δ 171.9, 157.5, 146.3, 139.4, 129.5, 121.5, 43.6, 39.9, 37.4, 35.4, 29.9, 20.2. Anal. Calcd for $C_{12}H_{16}BrClN_2O$: C, 45.09; H, 5.05; N, 8.76. Found: C, 44.86; H, 5.11; N, 8.96.

(7*S*)-3-Chloro-7,8-dihydro-7-methyl-5(2*H*)-quinolinone (16) (15.4 mg, 57%): mp 50–52 °C; IR 2953, 1693, 1578, 1555, 1445, 1382, 1348, 1271, 1203, 1159, 907 cm^{-1}; ^1H NMR δ 8.62 (d, J = 2.5 Hz, 1 H), 8.20 (d, J = 2.5 Hz, 1 H), 3.11 (m, 1 H), 2.77 (m, 2 H), 2.38 (m, 2 H), 1.15 (d, J = 6 Hz, 3 H); ^{13}C NMR δ 196.9, 160.8, 152.4, 134.1, 130.8, 128.2, 46.3, 40.2, 29.2, 21.2; HRMS (EI) m/z (M^+) 195.044 34 (calcd for $C_{10}H_{10}ClNO$ 195.0449); α_D = +27 (c = 0.8 $CDCl_3$). Anal. Calcd for $C_{10}H_{10}ClNO$: C, 61.39; H, 5.15; N, 7.16. Found: C, 61.62; H, 5.24; N, 7.43.

2-Bromo-3-(4-hydroxy-1-oxobutyl)-5-chloropyridine (17). 2,3-Dibromo-5-chloropyridine **2** (4.0 g, 14.7 mmol) in diisopropyl ether (27 mL) was added dropwise to a solution of *n*-butyllithium (9.7 mL, 14.7 mmol) in isopropyl ether (40 mL) at −78 °C over 30 min. A creamy yellow precipitate formed on addition of **2** which was stirred 10 min after the addition was complete. Butyrolactone (2.53 g, 29.4 mmol) was added neat to the suspension and stirred for 10 min. The reaction was quenched with water and aqueous saturated ammonium chloride (1:1, 20 mL), and the contents were allowed to warm to ambient temperature, and extracted with ether (100 mL). The organic phase was washed with water (3 × 50 mL) and brine (50 mL) and treated with magnesium sulfate, and solvents were removed under vacuum to afford the crude product as a thick yellow oil (3.79 g). The crude product could be employed directly for the pyridinium chlorochromate oxidation or purified by chromatography to yield an off-white solid (2.59 g, 63%), mp 62–63 °C: IR 3598, 3443, 2928, 2877, 1705, 1600, 1565, 1522, 1395, 1194, 1122 cm^{-1}; ^1H NMR δ 8.35 (d, J = 2.5 Hz, 1 H), 7.62 (d, J = 2.5 Hz, 1 H), 3.70 (dd, J = 5, 6 Hz, 2 H), 3.03 (t, J = 7 Hz, 2 H), 1.96 (dd, J = 7, 6 Hz, 2 H), 1.41 (t, J = 5 Hz, 1 H); ^{13}C NMR δ 201.4, 149.8, 139.2, 136.6, 135.0, 131.7, 61.7, 39.3, 26.6. Anal. Calcd for $C_9H_9BrClNO_2$: C, 38.81; H, 3.26; N, 5.03. Found: C, 38.91; H, 3.22; N, 4.95.

2-Bromo-3-(5-hydroxy-1-oxopentyl)-5-chloropyridine (18). 2,3-Dibromo-5-chloropyridine **2** (3.0 g, 11.1 mmol) in diisopropyl ether (20 mL) was added to a solution of *n*-butyllithium (7.4 mL, 11.1 mmol in hexane) in diisopropyl ether (20 mL) at −78 °C. Five minutes after the addition of **2**, δ-valerolactone was added neat to the resulting yellow suspension. The reaction was stirred 10 min at −78 °C, water (2 mL) was then added, and the contents were allowed to warm to ambient temperature. Methylene chloride and water were added, the phases were separated, the organic phase was washed with brine and treated with sodium sulfate, and the solvent was removed under vacuum to yield an oil (2.47 g) which crystallized, mp 84–88 °C. Recrystallization of the crude product from cyclohexane yielded **18** as a white solid, mp 90–92 °C (1.2 g, 49%).

2-Bromo-3-(1,4-dioxobutyl)-5-chloropyridine (19). A suspension of pyridinium chlorochromate (112 mg, 0.539 mmol) in methylene chloride (0.7 mL) was charged with keto alcohol **17** (100 mg, 0.359 mmol) in methylene chloride (1.0 mL). After the reaction stirred for 3 h at ambient temperature it was diluted with ether (0.7 mL) and the organic phase decanted from a black gum. The gum was extracted with ether (2 × 0.7 mL), the combined organic extracts were filtered through a pad of silica, and solvents were removed under vacuum to afford a light brown oil (80 mg). Chromatography on silica eluting with 10% ethyl acetate/hexane yielded the product as a white solid (44 mg, 57% overall from **2**), mp 32–37 °C: IR 2981, 2901, 1709, 1200, 1524, 1533, 1391, 1353, 1121 cm^{-1}; ^1H NMR δ 9.83 (s, 1 H), 8.41 (d, J = 2.2 Hz, 1 H), 7.78 (d, J = 2.2 Hz, 1 H), 3.16 (dd, J = 6, 7 Hz, 2 H), 3.0 (dd, J = 5, 7 Hz, 2 H); ^{13}C NMR δ 199.7, 199.3, 150.0, 138.9, 137.0, 134.8, 131.8, 38.1, 34.8. Anal. Calcd for $C_9H_7BrClNO_2$: C, 39.09; H, 2.55; N, 5.07. Found: C, 39.16; H, 2.30; N, 5.03.

Registry No. **1**, 137628-16-1; **2**, 137628-17-2; **3**, 137628-32-1; **4**, 137628-33-2; **5**, 137628-18-3; **7**, 137628-20-7; **8**, 137628-21-8; **9**, 137628-22-9; **10**, 137628-23-0; **11**, 137628-24-1; **12**, 137628-25-2; **13**, 137628-26-3; **14**, 137628-27-4; **15**, 127724-75-8; **16**, 137628-28-5; **17**, 137628-29-6; **18**, 137628-30-9; **19**, 137628-31-0; dimethylamine, 124-40-3; butyrolactone, 96-48-0; δ-valerolactone, 542-28-9.

Simple Performic Acid Oxidation of Acetylthio Group to Sulfonic Acid and Its Application in Syntheses of 2-Substituted Taurines[1]

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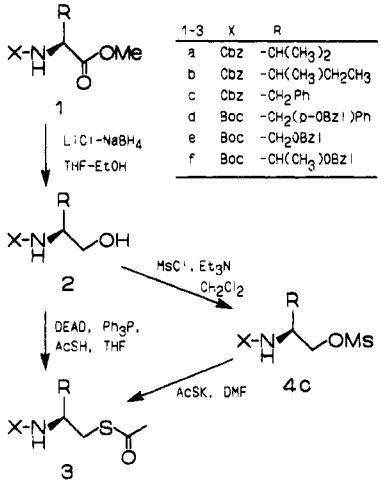
The acetylthio group is convertible into a sulfonic acid group by several oxidative reagents such as peracetic acid,[2] potassium persulfate,[3] etc. Since such oxidants often require severe reaction conditions and/or complicated workups, we sought other reagents to circumvent these problems. Performic acid, containing 30% hydrogen peroxide and 98% formic acid in a 1:10 ratio, was found to give the best results. We now describe the successful application of this oxidant to the syntheses of 2-substituted taurines **5**, which we have previously prepared[4] by the substitution method.[5] Among the 2-substituted taurines, D-cysteinolic acid (**5e**)[4] is a marine taurine derivative.[6]

Six (hydroxyethyl)carbamates **2** were prepared from protected α-amino acids **1** by the reported method[4,7] as

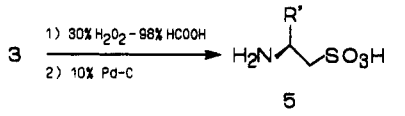
(1) This work was partially presented at the 110th Annual Meeting of Japanese Pharmaceutical Society in Sapporo, Japan, Aug 1990.
(2) Showell, J. S.; Russell, J. R.; Swern, D. *J. Org. Chem.* **1962**, *27*, 2853.
(3) Reddie, R. N. *Synth. Commun.* **1987**, *17*, 1129.
(4) Higashiura, K.; Morino, H.; Matsuura, H.; Toyomaki, Y.; Ienaga, K. *J. Chem. Soc., Perkin Trans. 1* **1989**, 1476.
(5) Higashiura, K.; Toyomaki, Y.; Ienaga, K. *J. Chem. Soc., Chem. Commun.* **1989**, 521.
(6) Wickberg, B. *Acta Chem. Scand.* **1957**, *11*, 506.

0022-3263/92/1957-0764$03.00/0

Scheme I



Scheme II



precursors for protected 2-(aminoethyl)ethanethioates **3**. Conversion of alcohol **2** to the acetylthio derivative **3** was carried out by two routes (Scheme I), either directly by using the Mitsunobu reaction or indirectly by using a substitution reaction via the mesylate **4**. Thus, **2** was reacted with diethyl azodicarboxylate (DEAD), triphenylphosphine, and thioacetic acid in THF below room temperature to give **3** in one step in 80–95% yield. Alternatively, after mesylation of **2c**,[4] the mesylate **4c** was reacted with potassium thioacetate in DMF at room temperature to also yield **3c** quantitatively. The products **3c** obtained by both methods were identical.

Performic acid was prepared by mixing 30% hydrogen peroxide and 98% formic acid in a 1:10 ratio at room temperature. The thioacetate **3** dissolved in formic acid was added slowly to the oxidant solution at 0 °C in order to control the exothermic reaction. During the course of the reaction, the Boc group was deprotected by formic acid.[8] After the oxidation was completed, the remaining oxidant was decomposed with Pd–C. Pd–C not only decomposes the oxidant but also induces catalytic hydrogen-transfer reduction[9] with formic acid to deprotect Cbz and benzyl groups. Therefore, oxidation–deprotection proceeds during the reaction and workup in one pot (Scheme II). All products (**5**) including D-cysteinolic acid (**5e**) were obtained as pure crystalline compounds after removal of the catalyst and concentration (Table I). Compounds **5a**, **5c**, and **5e** were identical with those prepared by the substitution method.[4]

Performic acid oxidation is a key reaction in this alternative conversion from the α-amino acids to 2-substituted taurines. This oxidation should be applicable to other syntheses.

Experimental Section

Melting points are uncorrected. ^{1}H NMR spectra were measured in $CDCl_3$ or in 0.2 N NaOD–D_2O solution; chemical shifts are in δ from TMS or *tert*-butyl alcohol (1.23) as internal standards.

Table I. Performic Acid Oxidation of 3

	3		5	yield of
	X	R	R′	5[a] %
a	Cbz	$-CH(CH_3)_2$	$-CH(CH_3)_2$	96
b	Cbz	$-CH(CH_3)CH_2CH_3$	$-CH(CH_3)CH_2CH_3$	73
c	Cbz	$-CH_2Ph$	$-CH_2Ph$	88
d	Boc	$-CH_2(p\text{-}BzlOC_6H_4)$	$-CH_2(p\text{-}HOC_6H_4)$	79
e	Boc	$-CH_2OBzl$	$-CH_2OH$	86
f	Boc	$-CH(CH_3)OBzl$	$-CH(CH_3)OH$	89

[a] Yields reported are isolated yields.

Preparation of N-Protected 2-Substituted Aminoethanol 2a–f. Three *N*-Cbz- **2a–c** and three *N*-Boc-aminoethanols **2d–f** were prepared quantitatively from the corresponding Cbz- and Boc-α-amino acids **1a–c** and **1d–f** respectively, by the known method using $LiBH_4$ in ethanol:[4,9] **2c–f**[10] were identical with those described in the literature.

(*S*)-2-[(Benzyloxycarbonyl)amino]-3-methylbutan-1-ol (2a): 87%; mp 58–59 °C; $[\alpha]_D$ −24.6° (*c* 1, $CHCl_3$); ^{1}H NMR δ ($CDCl_3$) 0.93 (d, *J* = 7 Hz, 3 H), 0.96 (d, *J* = 7 Hz, 3 H), 1.86 (dqq, *J* = 7, 7, 7 Hz, 1 H), 2.14–2.30 (brs, 1 H, OH), 3.47–3.55 (m, 1 H), 3.64 (dd, *J* = 6, 11 Hz, 1 H), 3.71 (dd, *J* = 4, 11 Hz, 1 H), 4.92 (d, *J* = 8 Hz, 1 H, NH), 5.10 (s, 2 H), 7.28–7.39 (m, 5 H). Anal. Calcd for $C_{13}H_{19}NO_3$: C, 65.80; H, 8.07; N, 5.90. Found: C, 65.53; H, 8.13; N, 5.80.

(2*S*,3*S*)-2-[(Benzyloxycarbonyl)amino]-3-methylpentan-1-ol (2b): 92%; mp 61–62 °C; $[\alpha]_D$ −24.4° (*c* 1, $CHCl_3$); ^{1}H NMR δ ($CDCl_3$) 0.90 (t, *J* = 7 Hz, 3 H), 0.92 (d, *J* = 7 Hz, 3 H), 1.07–1.20 (m, 1 H), 1.44–1.66 (m, 2 H), 2.17–2.42 (brs, 1 H, OH), 3.52–3.61 (m, 1 H), 3.63 (dd, *J* = 6 and 11 Hz, 1 H), 3.72 (dd, *J* = 3, 11 Hz, 1 H), 4.97 (d, *J* = 8 Hz, 1 H, NH), 5.10 (s, 2 H), 7.28–7.39 (m, 5 H). Anal. Calcd for $C_{14}C_{21}NO_3$: C, 66.91; H, 8.42; N, 5.57. Found: C, 66.77; H, 8.18; N, 5.52.

General Procedure for the Preparation of Acetylthio Derivatives 3a–f. Under an argon atmosphere, to an ice-cooled mixture of N-protected aminoethanol **2a–f** (20 mmol) and Ph_3P (22 mmol) in THF (100 mL) were added DEAD (22 mmol) and AcSH (22 mmol) successively. After additional stirring for 2 h in the ice bath and for 20 h at room temperature, the solvent was evaporated in vacuo and the residue was applied to a silica gel column chromatography to give acetylthio derivatives **3a–f**.

(*S*)-2-[(Benzyloxycarbonyl)amino]-3-methylbutyl ethanethioate (3a): 93%; mp 82–83 °C; $[\alpha]_D$ −15.8° (*c* 1, $CHCl_3$); ^{1}H NMR δ ($CDCl_3$) 0.94 (d, *J* = 7 Hz, 3 H), 0.96 (d, *J* = 7 Hz, 3 H), 1.75–1.88 (m, 1 H), 2.29 (s, 3 H), 3.00 (dd, *J* = 9, 14 Hz, 1 H), 3.05 (dd, *J* = 4.5, 14 Hz, 1 H), 3.65 (dddd, *J* = 4.5, 5, 9, 9 Hz, 1 H), 4.74 (d, *J* = 9 Hz, 1 H, NH), 5.06 and 5.13 (ABq, *J* = 12 Hz, 2 H), 7.28–7.39 (m, 5 H). Anal. Calcd for $C_{15}H_{21}NO_3S$: C, 60.99; H, 7.17; N, 4.74. Found: C, 60.74; H, 7.38; N, 4.75.

(2*S*,3*S*)-2-[(Benzyloxycarbonyl)amino]-3-methylpentyl ethanethioate (3b): 90%; mp 74–75 °C; $[\alpha]_D$ −10.4° (*c* 1, $CHCl_3$); ^{1}H NMR δ ($CDCl_3$) 0.91 (t, *J* = 7 Hz, 3 H), 0.93 (d, *J* = 7 Hz, 3 H), 1.08–1.20 (m, 1 H), 1.47–1.64 (m, 2 H), 2.28 (s, 3 H), 2.98 (dd, *J* = 9.5, 14 Hz, 1 H), 3.05 (dd, *J* = 4, 14 Hz, 1 H), 3.70 (dddd, *J* = 4, 6, 9.5, 9.5 Hz, 1 H), 4.78 (d, *J* = 9.5 Hz, 1 H, NH), 5.05 and 5.12 (ABq, *J* = 12 Hz, 2 H), 7.28–7.40 (m, 5 H). Anal. Calcd for $C_{16}H_{23}NO_3S$: C, 62.11; H, 7.49; N, 4.54. Found: C, 62.08; H, 7.55; N, 4.48.

(*S*)-2-[(Benzyloxycarbonyl)amino]-3-phenylpropyl ethanethioate (3c): 96%; mp 89–90 °C; $[\alpha]_D$ −5.2° (*c* 1, $CHCl_3$); ^{1}H NMR δ ($CDCl_3$) 2.33 (s, 3 H), 2.80 (dd, *J* = 7, 14 Hz, 1 H), 2.93 (dd, *J* = 6.5, 14 Hz, 1 H), 2.97 (dd, *J* = 8, 14.5 Hz, 1 H), 3.02 (dd, *J* = 4.5, 14.5 Hz, 1 H), 4.00–4.10 (m, 1 H), 4.88 (d, *J* = 8 Hz, 1 H, NH), 5.07 (s, 2 H), 7.15–7.38 (m, 10 H). Anal. Calcd for $C_{19}H_{21}NO_3S$: C, 66.45; H, 6.16; N, 4.08. Found: C, 66.53; H, 6.27; N, 4.06.

(*S*)-2-[(*tert*-Butoxycarbonyl)amino]-3-[4-(benzyloxy)phenyl]propyl ethanethioate (3d): 74%; mp 124–125 °C; $[\alpha]_D$ +3.6° (*c* 1, $CHCl_3$); ^{1}H NMR δ ($CDCl_3$) 1.41 (s, 9 H), 2.36 (s, 3

(7) Hamada, Y.; Shibata, M.; Sugiura, T.; Kato, S.; Shioiri, T. *J. Org. Chem.* **1987**, *52*, 1252.
(8) Sivanandaiah, K. M.; Gursiddappa, S. *J. Chem. Res.* **1979**, 108.
(9) Harpern, B.; Nikecki, D. E. *Tetrahedron Lett.* **1967**, 3031.
(10) (a) **2c**: Ito, A.; Takahashi, R.; Baba, Y. *Chem. Pharm. Bull.* **1975**, *23*, 3081. (b) **2d**: Spaltenstein, A.; Carpino, P. A.; Miyake, F.; Hopkins, P. B. *J. Org. Chem.* **1981**, *46*, 4797. (c) **2e**: Kokotos, G. *Synthesis* **1990**, 299. (d) **2f**: Rodriguez, M.; Llinares, M.; Doulut, S.; Heitz, A.; Martinez, J. *Tetrahedron Lett.* **1991**, *32*, 923.

H), 2.71 (dd, J = 7, 14 Hz, 1 H), 2.84 (dd, J = 6, 14 Hz, 1 H), 2.92 (dd, J = 8, 14 Hz, 1 H), 3.06 (dd, J = 5, 14 Hz, 1 H), 3.88–3.98 (m, 1 H), 4.60 (d, J = 8 Hz, 1 H, NH), 5.03 (s, 2 H), 6.91 (d, J = 8 Hz, 2 H), 7.10 (d, J = 8 Hz, 2 H), 7.29–7.44 (m, 5 H). Anal. Calcd for $C_{23}H_{29}NO_4S$: C, 66.48; H, 7.03; N, 3.37. Found: C, 66.67; H, 7.18; N, 3.32.

(*S*)-3-(Benzyloxy)-2-[(*tert*-butoxycarbonyl)amino]propyl ethanethioate (3e): 95%; oily substance; $[\alpha]_D$ +17.9° (c 1, $CHCl_3$); ^1H NMR δ ($CDCl_3$) 1.43 (s, 9 H), 2.33 (s, 3 H), 3.11 (dd, J = 7, 13.5 Hz, 1 H), 3.17 (dd, J = 6, 13.5 Hz, 1 H), 3.47 (dd, J = 5, 9 Hz, 1 H), 3.56 (dd, J = 4, 9 Hz, 1 H), 3.86–3.96 (m, 1 H), 4.50 and 4.52 (ABq, J = 12 Hz, 2 H), 4.92 (d, J = 7.5 Hz, 1 H, NH), 7.26–7.38 (m, 5 H); ^{13}C NMR δ ($CDCl_3$) 28.4 (q), 30.5 (q), 31.0 (t), 50.3 (d), 70.9 (t), 73.3 (t), 79.5 (s), 127.7 (d), 128.4 (d), 137.9 (s), 155.4 (s), 195.6 (s); MS (SIMS) m/z 340 $(M + H)^+$.

(2*S*,3*R*)-3-(Benzyloxy)-2-[(*tert*-butoxycarbonyl)amino]-butyl ethanethioate (3f): 97%; oily substance; $[\alpha]_D$ +11.0° (c 1, $CHCl_3$); ^1H NMR δ ($CDCl_3$) 1.21 (d, J = 6 Hz, 3 H), 1.43 (s, 9 H), 2.33 (s, 3 H), 3.06 (dd, J = 8, 13 Hz, 1 H), 3.11 (dd, J = 6, 13 Hz, 1 H), 3.65–3.75 (m, 2 H), 4.40 and 4.60 (ABq, J = 11.5 Hz, 2 H), 4.87 (d, J = 9.5 Hz, 1 H, NH), 7.27–7.39 (m, 5 H); ^{13}C NMR δ ($CDCl_3$) 16.2 (q), 28.4 (q), 30.5 (q), 31.6 (t), 54.6 (d), 71.0 (t), 74.7 (d), 79.3 (s), 127.8 (d), 127.9 (d), 128.4 (d), 138.2 (s), 155.9 (s), 195.5 (s); MS (SIMS) m/z 354 $(M + H)^+$.

Preparation of 3c via (*S*)-2-[(Benzyloxycarbonyl)-amino]-3-phenylpropyl Methanesulfonate (4c): To an ice-cooled solution of **2c** (50 mmol) and Et_3N (55 mmol) in CH_2Cl_2 (200 mL) was added a solution of MsCl (52 mmol) in CH_2Cl_2 (50 mL) dropwise over 30 min. The mixture was evaporated in vacuo, and the residue was treated with EtOAc and H_2O. The separated organic layer was washed with 5% aqueous $NaHCO_3$ and brine. After drying over Na_2SO_4, the solvent was evaporated in vacuo to give the crystalline methanesulfonate **4c** in 97% yield: mp 109–110 °C; $[\alpha]_D$ −21.1° (c 1, $CHCl_3$); ^1H NMR δ ($CDCl_3$) 2.84–2.97 (m, 2 H), 2.95 (s, 3 H), 4.13 (dd, J = 4, 10 Hz, 1 H), 4.15–4.22 (m, 1 H), 4.26 (dd, J = 3.5, 10 Hz, 1 H), 5.00 (d, J = 9 Hz, 1 H), 5.07 and 5.09 (ABq, J = 12.5 Hz, 2 H), 7.18–7.38 (m, 10 H). Anal. Calcd for $C_{18}H_{21}NO_5S$: C, 59.49; H, 5.82; N, 3.85. Found: C, 59.17; H, 5.83; N, 3.69.

(*S*)-2-[(Benzyloxycarbonyl)amino]-3-phenylpropyl Ethanethioate (3c). A solution of **4c** (30 mmol) and KSAc (33 mmol) in DMF (150 mL) was stirred at room temperature for 20 h. The reaction mixture was poured into water and extracted with EtOAc. The extract was washed with H_2O, 5% aqueous $NaHCO_3$, and brine. After drying over Na_2SO_4, the solvent was evaporated in vacuo to give a crystalline solid **3c** (96%), mp 89–90 °C, $[\alpha]_D$ −5.2° (c 1, $CHCl_3$).

General Preparation of 2-Substituted Taurines 5a–f. To a performic acid solution, prepared by mixing and stirring 30% H_2O_2 (9 mL) and 98% HCOOH (90 mL) at room temperature for 1 h and cooled in an ice bath, were added acetylthio derivatives **3a–f** (15 mmol) in 98% HCOOH (20 mL) dropwise, keeping the temperature at 0 °C. After the mixture was stirred at 0 °C for additional 2 h and at room temperature for 20 h, 10% Pd–C (0.5 g) was added in order to decompose the remaining peroxide. After the mixture was stirred for a further 20 h under a hydrogen atmosphere at room temperature, the catalyst was removed by suction and the filtrate was evaporated in vacuo. The residue was crystallized from aqueous EtOH to give the pure 2-substituted taurines **5a–f**.

(*S*)-2-Amino-3-methylbutanesulfonic acid (5a): mp >330 °C; $[\alpha]_D$ +29.8° (c 1, H_2O); for $C_5H_{13}NO_3S$ [lit.[4] mp 325–326 °C dec; $[\alpha]_D$ +29.8° (c 1, H_2O); for $C_5H_{13}NO_3S$].

(2*S*,3*S*)-2-Amino-3-methylpentanesulfonic acid (5b): mp 292–293 °C; $[\alpha]_D$ +24.8° (c 1, H_2O); ^1H NMR δ (0.2 N NaOD) 0.86 (d, J = 7.5 Hz, 3 H), 0.89 (t, J = 7.5 Hz, 3 H), 1.12–1.24 (m, 1 H), 1.31–1.42 (m, 1 H), 1.46–1.57 (m, 1 H), 2.75 (dd, J = 10, 15 Hz, 1 H), 3.03 (dd, J = 2, 15 Hz, 1 H), 3.15–3.20 (m, 1 H). Anal. Calcd for $C_6H_{15}NO_3S$: C, 39.76; H, 8.34; N, 7.73. Found: C, 39.81; H, 8.52; N, 7.62.

(*S*)-2-Amino-3-phenylpropanesulfonic acid (5c): mp >330 °C; $[\alpha]_D$ −3.6° (c 1, H_2O); for $C_9H_{13}NO_3S$ [lit.[4] mp >330 °C dec; $[\alpha]_D$ −3.5° (c 1, H_2O); for $C_9H_{13}NO_3S$].

(*S*)-2-Amino-3-(4-hydroxyphenyl)propanesulfonic acid (5d): mp >330 °C; $[\alpha]_D$ −4.7° (c 1, H_2O); ^1H NMR δ (0.2 N NaOD) 2.50 (dd, J = 8, 14 Hz, 1 H), 2.69 (dd, J = 5.5, 14 Hz, 1 H), 2.83 (dd, J = 9, 14 Hz, 1 H), 3.06 (dd, J = 3, 14 Hz, 1 H), 3.38–3.45 (m, 1 H), 6.56–7.03 (m, 4 H). Anal. Calcd for $C_9H_{13}NO_4S$: C, 46.75; H, 5.76; N, 6.06. Found: C, 46.68; H, 5.86; N, 6.16.

(*S*)-2-Amino-3-hydroxypropanesulfonic acid (5e; D-cysteinolic acid): mp 279–281 °C; $[\alpha]_D$ +7.3° (c 1, H_2O); for $C_3H_9NO_4S$ [lit.[4] mp 279–281 °C; $[\alpha]_D$ +7.5° (c 1, H_2O); $C_3H_9NO_4S$].

(2*S*,3*R*)-2-Amino-3-hydroxybutanesulfonic acid (5f): mp 220–222 °C; $[\alpha]_D$ +15.5° (c 1, H_2O); ^1H NMR δ (0.2 N NaOD) 1.17 (d, J = 6.5 Hz, 3 H), 2.83 (dd, J = 9, 14 Hz, 1 H), 3.10 (dd, J = 2.5, 14 Hz, 1 H), 3.11–3.17 (m, 1 H), 3.77–3.84 (m, 1 H). Anal. Calcd for $C_4H_{11}NO_4S$: C, 28.40; H, 6.55; N, 8.28. Found: C, 28.10; H, 6.35; N, 7.95.

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Registry No. **1a**, 24210-19-3; **1b**, 42807-91-0; **1c**, 35909-92-3; **1d**, 27513-44-6; **1e**, 80963-10-6; **1f**, 137719-70-1; **2a**, 6216-65-5; **2b**, 6216-62-2; **2c**, 6372-14-1; **2d**, 66605-58-1; **2e**, 79069-15-1; **2f**, 79069-63-9; **3a**, 137719-71-2; **3b**, 137719-72-3; **3c**, 82001-62-5; **3d**, 137719-73-4; **3e**, 137719-74-5; **3f**, 137719-75-6; **4c**, 135731-20-3; **5a**, 126301-31-3; **5b**, 137719-76-7; **5c**, 126301-32-4; **5d**, 137719-77-8; **5e**, 16421-58-2; **5f**, 137719-78-9; performic acid, 107-32-4.

Supplementary Material Available: ^{13}C NMR spectra for compounds **3e** and **3f** (2 pages). Ordering information is given on any current masthead page.

An Improved Procedure for the Synthesis of Macrocyclic Poly(thialactones). The Dramatic Effect of Reactant Mixing[1]

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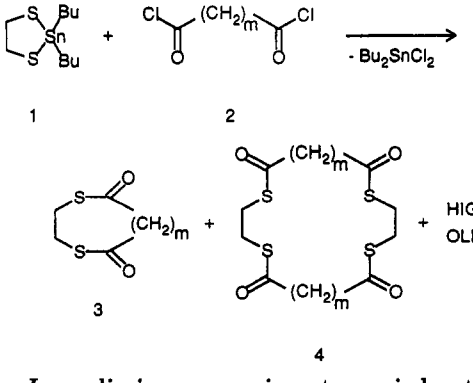
In the course of our studies aimed at modeling the behavior of systems where simultaneous macrocyclization and polymerization takes place,[2] our attention was attracted by the reaction of the stannadithiane **1** with diacyl chlorides **2** as an example of a kinetically controlled[3] double ring-closure reaction of the type A---A + B---B.



In preliminary experiments carried out with pimeloyl chloride (**2**, m = 5) and azelaoyl chloride (**2**, m = 7), the effect of the reactant mixing technique was investigated by performing the reaction batchwise, by simultaneous

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