TABLE I

N,N-DIPHENYLTHIOCARBAMATE DERIVATIVES OF MERCAPTANS

Mercaptan	M.P.[a] (±1°)	Calcd. for	Calcd., % C	Calcd., % H	Found, % C	Found, % H
C_2H_5SH	(108)[c]					
i-C_3H_7SH	124.0	$C_{16}H_{17}NOS$	70.85	6.32	70.75	6.14
n-C_4H_9SH	60.0	$C_{17}H_{19}NOS$	71.58	6.71	71.59	6.70
n-$C_6H_{13}SH$	48.0	$C_{19}H_{23}NOS$	72.80	7.40	72.52	7.41
n-$C_7H_{15}SH$	50.0	$C_{20}H_{25}NOS$	73.35	7.70	73.63	7.59
p-$CH_3OC_6H_4CH_2SH$	131.4	$C_{21}H_{19}NO_2S$	72.17	5.48	72.17	5.51
$C_6H_5CH_2SH$	124 (125)[c]					
$HOCH_2CH_2SH$	84.8	$C_{15}H_{15}NO_2S$	65.97	5.53	66.02	5.66
C_6H_5SH	125	$C_{19}H_{15}NOS$	74.72	4.95	74.87	4.94
o-$CH_3C_6H_4SH$	94.5	$C_{20}H_{17}NOS$	75.20	5.36	75.44	5.40
m-$CH_3C_6H_4SH$	121.5	$C_{20}H_{17}NOS$	75.20	5.36	75.25	5.48
p-$CH_3C_6H_4SH$	174.2 (180–182)[c]	$C_{20}H_{17}NOS$	75.20	5.36	75.22	5.44
o-$NH_2C_6H_4SH$	145.3	$C_{19}H_{16}N_2OS$	71.23	5.04	71.53	5.32
$CH_3O_2CCH_2SH$	116.5	$C_{16}H_{15}NO_3S$	63.76	5.02	64.14	5.23
$CH_3O_2CCH_2CH_2SH$[b]	96.5	$C_{17}H_{17}NO_3S$	64.74	5.43	64.80	5.33
$C_2H_5O_2CCH_2SH$[b]	101.6	$C_{17}H_{17}NO_3S$	64.73	5.43	64.50	5.43
CH_3O_2CCHSH[b] | $CH_3O_2CCH_2$	101.5	$C_{19}H_{19}NO_5S$	61.11	5.13	61.02	5.14
$C_6H_5COCH_2SH$	136.2	$C_{21}H_{17}NO_2S$	72.60	4.93	72.91	5.01

[a] All melting points (capillary) are corrected. Elemental analysis by Micro-Tech Laboratories, Skokie, Ill. [b] Generous samples of β-mercaptopropionic acid and α-mercaptosuccinic acid were kindly supplied by Evans Chemetics, Inc., New York, N. Y. [c] R. L. Evans and W. M. Dehn, *J. Am. Chem. Soc.*, 52, 3645 (1930).

in the presence of cyanide ion and alcohol. Although a number of alkylating agents and unsaturated compounds have been employed as mercaptan reagents, very few were suitable under the necessary conditions. The suggested use[4] of *N,N*-diphenylcarbamyl chloride (I) as a mercaptan acylating agent prompted a study of this substance. Mercaptides were found to react readily with I in the presence of cyanide ion or alcoholates and, in fact, afforded such easily purified adducts that use as a general characterizing agent for mercaptans seemed appropriate. The derivatives obtained (80–95%) are listed in Table I.

EXPERIMENTAL

The mercaptans used were obtained commercially or were prepared by known procedures. The *N,N*-diphenylcarbamyl chloride was obtained from Eastman Organic Chemicals.

Preparation of N,N-diphenylthiocarbamate derivatives. A solution containing 0.23 g. (0.01 g.-atom) of sodium in 30 ml. of alcohol was treated with 0.01 mole of mercaptan. The solution of mercaptide was then added to a solution of 2.31 g. (0.01 mole) of *N,N*-diphenylcarbamyl chloride in 20 ml. of alcohol. The solution was warmed on a steam bath for 5 min., the precipitated salt filtered, and the derivative allowed to crystallize. Cooling was sometimes necessary to induce crystallization. Recrystallization was easily effected from alcohol. In general, the melting point was not raised after one recrystallization.

The only mercaptans studied which did not afford derivatives in high yield were *p*-nitrobenzyl mercaptan, β-mercaptopropionic acid, and α-mercaptosuccinic acid.

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(4) E. E. Reid, *Organic Chemistry of Bivalent Sulfur*, Vol. I, Chemical Pub. Co., Inc., New York, N. Y., 1958, p. 163.

Some Aminoethylpiperidines and -pyridines

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Several previously unreported compounds were synthesized during preparation of a series of aminoethylpiperidines.

Addition of amines[1] or ammonia[1c] to 2- or 4-vinylpyridine gave aminoethylpyridines which were catalytically reduced to piperidines.

An attempt to pyridylethylate ammonia as described by Magnus and Levine[1c] gave principally bis[2-(2-pyridyl)ethyl]amine rather than 2-(2-aminoethyl)pyridine. The latter could be made by variation of the conditions of this reaction.

(1) (a) H. E. Reich and R. Levine, *J. Am. Chem. Soc.*, 77, 4913 (1955). (b) H. E. Reich and R. Levine, *J. Am. Chem. Soc.*, 77, 5434 (1955). (c) G. Magnus and R. Levine, *J. Am. Chem. Soc.*, 78, 4127 (1956). (d) A. P. Phillips, *J. Am. Chem. Soc.*, 78, 4441 (1956).

EXPERIMENTAL[2]

Reaction of 2-vinylpyridine with ammonium chloride. (A). Freshly distilled (b.p. 48°/9 mm.) 2-vinylpyridine (32.97 g.; 0.314 mole) was heated for 8 hr. under reflux with 33.6 g. (0.628 mole) of ammonium chloride in 95 ml. of water and 15 ml. of methanol according to the method of Magnus and Levine.[1c] The cooled mixture was poured onto ice and made strongly basic with 30% sodium hydroxide solution. Extraction with four 50-ml. portions of chloroform followed by concentration of the chloroform solution after drying over magnesium sulfate left a residue which was vacuum distilled to give 2.43 g. (6.4%) of 2-(2-aminoethyl)pyridine,[1c] b.p. 88–89°/8 mm.

Anal. Calcd. for $C_7H_{10}N_2$: C, 68.80; H, 8.25; N, 22.94. Found: C, 68.73; H, 8.23; N, 22.70.

The main product was 18.40 g. (51.6%) of bis[2-(2-pyridyl)ethyl]amine,[3] b.p. 142°/0.1 mm.

Anal. Calcd. for $C_{14}H_{17}N_3$: C, 73.97; H, 7.54; N, 18.49. Found: C, 73.91; H, 7.71; N, 18.72.

(B). A solution of 80.25 g. (1.5 moles) of ammonium chloride in 200 ml. of water was treated with 52.57 g. (0.50 mole) of freshly distilled 2-vinylpyridine. Enough methanol (200 ml.) was added to make the mixture homogeneous. After being heated for 8 hr. under reflux, the mixture was cooled to room temperature, made basic with 30% sodium hydroxide solution and extracted with five 100-ml. portions of chloroform. The chloroform solution was dried over magnesium sulfate, concentrated and distilled to give 20.95 g. (34.4%) of 2-(2-aminoethyl)pyridine.

A similar experiment with 4-vinylpyridine gave 50.6% conversion to 4-(2-aminoethyl)pyridine,[1c] b.p. 104°/9 mm.

Anal. Calcd. for $C_7H_{10}N_2$: C, 68.80; H, 8.25; N, 22.94. Found: C, 69.01; H, 8.23; N, 22.80.

This compound formed a monopicrate, m.p. 152°, from 95% ethanol (Magnus and Levine report[1c] the dipicrate, m.p. 186–187°).

Anal. Calcd. for $C_{13}H_{13}N_5O_7$: C, 44.44; H, 3.73; N, 19.94; O, 31.88. Found: C, 44.34; H, 3.51; N, 20.26; O, 31.51.

2-(2-Isopropylaminoethyl)pyridine. A solution of 21.03 g. (0.20 mole) of freshly distilled 2-vinylpyridine and 11.82 g. (0.20 mole) of isopropylamine in 80 ml. of methanol was treated with 12.01 g. (0.20 mole) of glacial acetic acid then heated under reflux for 8 hr. The mixture was evaporated to dryness and the residue was dissolved in a few milliliters of water, made strongly basic with 10% sodium hydroxide solution, and extracted with three 75-ml. portions of ether. The ethereal solution was dried over magnesium sulfate, concentrated, and distilled to give 5.19 g. (15.8%) of product, b.p. 91–92°/7 mm.

Anal. Calcd. for $C_{10}H_{16}N_2$: C, 73.14; H, 9.82; N, 17.06. Found: C, 72.78; H, 9.64; N, 17.04.

2-(2-Dibenzylaminoethyl)pyridine. A solution of 24.58 g. (0.234 mole) of freshly distilled 2-vinylpyridine and 46.20 g. (0.234 mole) of dibenzylamine in 100 ml. of methanol was treated with 28.0 g. (0.468 mole) of glacial acetic acid then heated under reflux for 15 hr. The mixture was evaporated and the residue dissolved in 50 ml. of water. This solution was made strongly basic with 30% sodium hydroxide solution and extracted with four 75-ml. portions of chloroform. The chloroform solution was dried over magnesium sulfate, concentrated, and distilled to give 31.1 g. (44.0%) of product, b.p. 179°/0.1 mm.

Anal. Calcd. for $C_{21}H_{22}N_2$: C, 83.40; H, 7.33; N, 9.27. Found: C, 83.62; H, 7.37; N, 9.24.

4-(2-Aminoethyl)piperidine. A solution of 12.8 g. (0.1 mole) of 4-(2-aminoethyl)pyridine in 100 ml. of methanol with 13 ml. (0.2 mole) of glacial acetic acid was shaken at room temperature under 2.5 atm. of hydrogen pressure in the presence of 2.4 g. of 5% rhodium on alumina catalyst. The hydrogen uptake was 12.5% after 8 hr. The solution was filtered and rehydrogenated in the presence of 3.0 g. of fresh catalyst. Hydrogen uptake was complete in 24 hr. After filtration, the solution was treated with 0.2 mole of ethanolic hydrogen chloride and evaporated to dryness. The residue was washed with acetone and recrystallized from absolute ethanol, yield 10.7 g. (53%) of the dihydrochloride, m.p. 243°.

Anal. Calcd. for $C_7H_{16}N_2 \cdot 2HCl$: C, 41.79; H, 9.01; N, 13.93. Found: C, 41.86; H, 8.81; N, 13.92.

Bis[2-(2-piperidyl)ethyl]amine. A solution of 13.6 g. (0.06 mole) of bis[2-(2-pyridyl)ethyl]amine in 50 ml. of methanol was shaken at room temperature under 2.5 atm. of hydrogen pressure in the presence of 2.72 g. of 5% rhodium on alumina. Hydrogen consumption was 60% of theory after 18 hr. Filtration of the solution and further hydrogenation with 5.4 g. of fresh catalyst for 8 hr. was necessary to complete the reaction. The mixture was filtered, concentrated, and distilled to give 10.3 g. (72%) of product, b.p. 145°/0.5 mm.

Anal. Calcd. for $C_{14}H_{29}N_3$: C, 70.23; H, 12.21; N, 17.55. Found: C, 70.37; H, 12.38; N, 17.14.

2-(2-Isopropylaminoethyl)piperidine. A solution of 2-(2-isopropylaminoethyl)pyridine (5.19 g.; 0.0316 mole) in 100 ml. of 95% ethanol containing 4.0 ml. (0.063 mole) of glacial acetic acid was hydrogenated under 2.0 atm. pressure with 1.0 g. of 5% rhodium on alumina. Hydrogen uptake was complete after 3 hr. The solution was filtered, treated with 0.063 mole of ethanolic hydrogen chloride, and evaporated to dryness. The residue was recrystallized from ethanol-ether to give 6.4 g. (91%) of material, m.p. 296–300°.

Anal. Calcd. for $C_{10}H_{22}N_2 \cdot 2HCl$: C, 49.58; H, 9.98; N, 11.57. Found: C, 49.75; H, 10.15; N, 11.73.

2-(2-Cyclohexylaminoethyl)piperidine. A solution of 5.23 g. (0.0256 mole) of 2-(2-cyclohexylaminoethyl)pyridine[1b] in 150 ml. of glacial acetic acid was shaken under 2 atm. of hydrogen pressure at room temperature with 0.175 g. of platinum oxide. At the end of 24 hr., uptake was 60%. Filtration, addition of 0.5 g. of fresh catalyst and further hydrogenation (2 atm.; 60°) for 15 hr. led to complete reduction. The mixture was filtered, treated with 0.0513 mole of ethanolic hydrogen chloride, and evaporated to dryness. The residue was washed with acetone and recrystallized from ethanolic hydrogen chloride solution by addition of ether to yield 6.30 g. (87.6%) of the dihydrochloride, m.p. 305°.

Anal. Calcd. for $C_{13}H_{26}N_2 \cdot 2HCl$: C, 55.31; H, 9.99; N, 9.92. Found: C, 55.32; H, 10.02; N, 9.83.

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(2) All melting and boiling points are uncorrected.

(3) K. Loffler, *Chem. Ber.*, **37**, 161 (1904).

4,6-Dimethoxy-2,2-dimethyl-3[2*H*]benzofuranone and Its Halogenated Derivatives

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The antifungal antibiotic griseofulvin[1,2,3] has the structure I which is a derivative of 2,2-disubsti-

(1) For a review of the chemistry of griseofulvin, see W. B. Walley, *Progress in Organic Chemistry*, Vol. 4, J. W. Cook, ed., Academic Press Inc., New York, 1958, p. 98.