Experimental[5]

2-Ethyl-3-hydroxy-4-methyl-5-hydroxymethylpyridine Hydrochloride (III).—2-Ethyl-3-nitro-4-methoxymethyl-5-cyano-6-chloropyridine (I, 25.6 g.) was shaken with palladium-Darco and hydrogen in a solution containing hydrochloric acid under 2–3 atmospheres of pressure until 6 moles of hydrogen had been absorbed. The reduction was finished in 21 hours. After removal of the catalyst, the solution was concentrated under reduced pressure to a thick oil. This oil was heated with 400 ml. of 40–42% hydrobromic acid, and about 250 ml. distilled at atmospheric pressure. The black color was removed with Darco. The solution, after further concentration under reduced pressure, was diluted with alcohol, which caused crystallization of 27.1 g. of crude 2-ethyl-3-amino-4-bromomethyl-5-aminomethylpyridine dihydrobromide (II); m.p. 217–220° dec. Concentration of the filtrate left an oil which was again subjected to the hydrobromic acid treatment. Another 3.8 g. of product brought the yield to 76%.

A solution of 18.0 g. of this material in 600 ml. of water was shaken with 3 g. of 5% palladium chloride on Darco catalyst under 2–3 atmospheres of hydrogen. There was almost no hydrogen uptake for about an hour; then one mole was rapidly absorbed. The catalyst was removed by filtering, and the solution, combined with the reduction product of another 12 g. of bromomethyl compound II, was concentrated under reduced pressure to about 100 ml., and then shaken with 48 g. of silver chloride for several hours. The solid material was removed by filtering. The resulting solution containing 2-ethyl-3-amino-4-methyl-5-aminomethylpyridine dihydrochloride was diluted to 450 ml. and heated to 85°. A solution of 11.2 g. of sodium nitrite in 150 ml. of water, and 15 ml. of 12 *N* hydrochloric acid were added simultaneously over a period of 20 minutes. After an additional 10 minutes of stirring at 85°, the solution contained no nitrous acid, and was decolorized with Darco and concentrated to dryness under reduced pressure.

The residue, dissolved in a minimum amount of warm water, was treated with an excess of sodium bicarbonate and extracted continuously with chloroform for two days. After removal of the chloroform under reduced pressure, the residue was dissolved in alcohol and treated with an excess of alcoholic hydrogen chloride. 2-Ethyl-3-hydroxy-4-methyl-5-hydroxymethylpyridine hydrochloride (III) was obtained in a yield of 5.2 g. (35%, based on 30 g. of crude 2-ethyl-3-amino-4-bromomethyl-5-aminomethylpyridine dihydrobromide); after two recrystallizations from alcohol the m.p. was 174–176°.

Anal. Calcd. for $C_9H_{14}NO_2Cl$: C, 53.07; H, 6.93; N, 6.88. Found: C, 52.81; H, 6.64; N, 7.13.

2-Ethyl-3-hydroxy-4-methyl-5-hydroxymethylpyridine Hydrochloride (III) by Hydrogenolysis of 2-Ethyl-3-hydroxy-4,5-bis-(hydroxymethyl)-pyridine Hydrochloride.—A mixture of 1.0 g. of 2-ethyl-3-hydroxy-4,5-bis-(hydroxymethyl)-pyridine hydrochloride,[2] 1 ml. of 6 *N* hydrochloric acid, 1 g. of 5% palladium on Darco catalyst and 125 ml. of water was shaken under 2–3 atmospheres of hydrogen for one hour. Approximately one mole of hydrogen was absorbed. After removal of the catalyst, the solution was concentrated to 3 ml., treated with an excess of sodium bicarbonate, and extracted continuously with chloroform for 17 hours. 2-Ethyl-3-hydroxy-4-methyl-5-hydroxymethylpyridine hydrochloride (0.19 g., 21%) was isolated as described in the preceding experiment; the m.p., 178–179°, was not lowered when this material was mixed with a sample prepared by the method described above.

2-Isobutyl-3-hydroxy-4-methyl-5-hydroxymethylpyridine Hydrochloride (III).—2-Isobutyl-3-nitro-4-methoxymethyl-5-cyano-6-chloropyridine[3] (I, 13.4 g.) was hydrogenated in the manner described for the ethyl homolog. The reduction required 5 hours. The gummy residue, after concentration of the filtrate, was treated with 200 ml. of 40–42% hydrobromic acid. After removal of one third of the solution by distillation at atmospheric pressure, the dark color was removed by treatment with Darco, and the resulting solution concentrated under reduced pressure to 25 ml. Crystalline 2-isobutyl-3-amino-4-bromomethyl-5-aminomethylpyridine dihydrobromide (II), m.p. 211–213° dec., was obtained in a yield of 6.73 g. The yield was increased to 14.3 g. (69%) after further concentration of the filtrate.

(5) We are indebted to Mr. Richard Boos and his associates for the microanalyses.

A mixture of 6.7 g. of this material, 1.5 g. of 10% palladium on Darco and 125 ml. of water was shaken with hydrogen under 2–3 atmospheres of pressure. One mole of hydrogen was consumed in several minutes. After removal of the catalyst, the solution was concentrated to dryness under reduced pressure. The white, crystalline residue was slurried with alcohol and collected on a filter. Two fractions, totaling 4.8 g., of 2-isobutyl-3-amino-4-methyl-5-aminomethylpyridine dihydrobromide were obtained. A solution of this material in 78 ml. of water was heated to 85° and treated simultaneously with 5.2 ml. of 6 *N* hydrochloric acid, and 1.95 g. of sodium nitrite dissolved in 26 ml. of water. The additions required 10 minutes and were followed by 10 minutes of stirring at 85°. After decolorization with Darco, the solution was concentrated to dryness under reduced pressure. The residue, dissolved in a small amount of water, was treated with an excess of sodium bicarbonate and extracted continuously with chloroform for 19 hours. The product, 2-isobutyl-3-hydroxy-4-methyl-5-hydroxymethylpyridine hydrochloride, was isolated and purified as described above for the ethyl homolog; yield 1.00 g. (28%, based on 6.7 g. of 2-isobutyl-3-amino-4-bromomethyl-5-aminomethylpyridine dihydrobromide); m.p. 163–165°.

Anal. Calcd. for $C_{11}H_{18}NO_2Cl$: C, 57.01; H, 7.83; N, 6.05. Found: C, 56.85; H, 7.79; N, 6.13.

2-Isobutyl-3-hydroxy-4-methyl-5-hydroxymethylpyridine Hydrochloride by Hydrogenolysis of 2-Isobutyl-3-hydroxy-4,5-bis-(hydroxymethyl)-pyridine Hydrochloride.—The hydrogenolysis was carried out on 3.0 g. of material exactly as described for the ethyl homolog, with the exception that the mixture was shaken with hydrogen for 2.5 hours. 2-Isobutyl-3-hydroxy-4-methyl-5-hydroxymethylpyridine hydrochloride, m.p. 160–162°, was obtained in a yield of 0.77 g. (27%) after isolation as described for the ethyl homolog.

2-*n*-Amyl-3-hydroxy-4-methyl-5-hydroxymethylpyridine Hydrochloride (III).—2-*n*-Amyl-3-nitro-4-methoxymethyl-5-cyano-6-chloropyridine (I, 29.8 g.) was hydrogenated and heated with hydrobromic acid as described for the ethyl homolog. 2-*n*-Amyl-3-amino-4-bromomethyl-5-aminomethylpyridine dihydrobromide (II), m.p. 215–218°, was obtained in a yield of 5.0 g. Concentration of the filtrate and further treatment with hydrobromic acid yielded another 11.4 g. raising the yield to 37%.

This material (5.0 g.) was subjected to hydrogenation and diazotization as described for the ethyl homolog, and the product was isolated in the same manner. 2-*n*-Amyl-3-hydroxy-4-methyl-5-hydroxymethylpyridine hydrochloride was obtained in a yield of 1.46 g. (53%, based on 5.0 g. of 2-*n*-amyl-3-amino-4-bromomethyl-5-aminomethylpyridine dihydrobromide). After one recrystallization from alcohol, the material had a m.p. of 125.0–125.5°.

Anal. Calcd. for $C_{12}H_{20}NO_2Cl$: C, 58.64; H, 8.20; N, 5.70. Found: C, 58.72; H, 8.13; N, 5.95.

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Chloro-substituted Alkenyl Dithiocarbamates

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RECEIVED APRIL 13, 1953

Although a number of alkyl esters of substituted dithiocarbamic acids have been prepared, no reference to the preparation of chloro-substituted alkenyl dithiocarbamates has been found.[1–7] The purpose of this investigation was the synthesis of compounds of this type.

The compounds were prepared by treating either sodium dimethyldithiocarbamate, sodium diethyl-

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TABLE I

CHLORO-SUBSTITUTED ALKENYL DITHIOCARBAMATES

R = $CH_2CH{=}CClCH_3$, R′ = $CH_2CCl{=}CH_2$, R″ = $CH_2CH{=}CHCl$

Derivatives	Yield, % crude	B.p., °C., 1 mm. or m.p.	$n^{25}D$	Empirical formula	Nitrogen Calcd.	Nitrogen Found	Sulfur Calcd.	Sulfur Found	Chlorine Calcd.	Chlorine Found
$(CH_3)_2NCSSR$	87.5	27–28[a]	....	$C_7H_{12}ClNS_2$	6.68	6.90	30.57	30.60	16.90	17.00
$(CH_3)_2NCSSR'$	88.1	35–37[a]	....	$C_6H_{10}ClNS_2$	7.16	7.34	32.76	32.80	18.11	18.07
$(CH_3)_2NCSSR''$	94.5	Dec.[b]	1.6135	$C_6H_{10}ClNS_2$	7.16	7.04	32.76	32.60	18.11	18.05
$(C_2H_5)_2NCSSR$	84.4	158–160[b] (2 mm.)	1.5800	$C_9H_{16}ClNS_2$	5.89	5.82	26.96	26.86	14.91	14.65
$(C_2H_5)_2NCSSR'$	89.0	128–130[b]	1.5822	$C_8H_{14}ClNS_2$	6.26	6.18	28.65	28.57	15.84	15.74
$(C_2H_5)_2NCSSR''$	85.0	Dec.[b]	1.5891	$C_8H_{14}ClNS_2$	6.26	6.22	28.65	28.41	15.84	15.84
H_2NCSSR	83.0	25–27[a]	....	$C_5H_8ClNS_2$	7.71	7.93	35.29	34.96	19.51	19.84
$(CH_2{=}CHCH_2)_2NCSSR$	95.1	Dec.[b]	1.5881	$C_{11}H_{16}ClNS_2$	5.35	5.50	24.49	24.42	13.54	13.33
$(CH_2{=}CHCH_2)_2NCSSR'$	82.9	145–146[b]	1.5882	$C_{10}H_{14}ClNS_2$	5.65	5.39	25.87	26.00	14.31	14.60
$C_4H_8NO—CSSR''$[c]	91.8	−10[a]	1.6261	$C_8H_{12}ClNOS_2$	5.89	5.91	26.97	27.22	14.91	15.20
$C_4H_8NO—CSSR$[c]	95.5	56–57[a]	....	$C_9H_{14}ClNOS_2$	5.56	5.71	25.46	25.56	14.08	14.04
$C_4H_8NO—CSSR'$[c]	95.0	73–74[a]	....	$C_8H_{12}ClNOS_2$	5.89	6.06	26.97	26.90	14.91	15.29
$C_6H_{12}N_2—(CSSR')_2$[d]	97.0	124–125[e]	....	$C_{14}H_{20}Cl_2N_2S_4$	6.74	6.76	30.87	31.30	17.07	16.69
$C_6H_{12}N_2—(CSSR)_2$[d]	95.0	102–103[e]	....	$C_{16}H_{24}Cl_2N_2S_4$	6.32	6.33	28.91	28.88	15.99	15.59
$(HOCH_2CH_2)_2NCSSR$	91.7	Dec.[b]	....	$C_9H_{16}ClNO_2S_2$	5.19	5.17	23.77	23.36	13.14	12.90
$(HOCH_2CH_2)_2NCSSR'$	93.4	Dec.[b]	....	$C_8H_{14}ClNO_2S_2$	5.48	5.23	25.07	25.27	13.86	13.68
$(HOCH_2CH_2)_2NCSSR''$	87.8	Dec.[b]	....	$C_8H_{14}ClNO_2S_2$	5.48	5.47	25.07	24.83	13.86	13.45

[a] M.p. [b] B.p. [c] C_4H_8NO = morphinyl. [d] $C_6H_{12}N_2$ = 2,5-dimethylpiperazine group. [e] M.p. recrystallization from ethyl alcohol.

dithiocarbamate, sodium diallyldithiocarbamate, ammonium dithiocarbamate, sodium 4-morpholinecarbodithioic acid, sodium bis-(2-hydroxyethyl)-dithiocarbamate, or disodium 2,5-dimethyl-1,4-piperazinedicarbodithioate with the following unsaturated chloro compounds: 1,3-dichloro-2-butene, 2,3-dichloro-1-propene and 1,3-dichloropropene. The reaction may be represented as follows: RSNa + R′Cl → RSR′ + NaCl where R is a thiocarbamyl group and R′ is a chloro-substituted alkenyl group. Reaction of sodium 3-chloro-2-butenyl trithiocarbonate dihydrate with N,N-diethylthiocarbamyl chloride did not yield the expected product, 3-chloro-2-butenyl N,N-diethyltrithiocarbamyl trithiocarbonate but gave instead 3-chloro-2-butenyl diethyldithiocarbamate. The former presumably was unstable, decomposing to form the latter and carbon disulfide. The reaction may be represented as

$$(C_2H_5)_2NCSCl + NaSCSCH_2CH{=}CClCH_3 \longrightarrow$$

$$(C_2H_5)_2NCSCSCH_2CH{=}CClCH_3 \longrightarrow$$

$$(C_2H_5)_2NCSSCH_2CH{=}CClCH_3 + CS_2$$

Physical data are listed in Table I.

Experimental[8]

Chloro-substituted Alkenyl Dithiocarbamates. General Procedure.—To one mole of 15–27% aqueous solution of sodium dimethyldithiocarbamate, sodium diethyldithiocarbamate, sodium bis-(2-hydroxyethyl)-dithiocarbamate, ammonium dithiocarbamate, sodium 4-morpholinecarbodithioic acid, sodium diallyldithiocarbamate and (0.5 mole) of disodium 2,5-dimethyl-1,4-piperazine dicarbodithioate containing a few drops of dodecylbenzene sulfonate was added one mole of either 1,3-dichloro-2-butene,[9] 2,3-dichloro-1-propene or 1,3-dichloropropene.[10] An exothermic reaction set in, the temperature rising 5–16° over a period of 20 minutes. The reaction mixture was stirred for six hours. For compounds possessing a melting point below 56° the organic layer was dissolved in 400 ml. of ethyl ether, the ether solution washed with water until the washings were neutral to litmus, dried over sodium sulfate and the solvent removed *in vacuo*. For compounds melting above 55°, the solid was recovered by filtration, washed with water until the wash water was neutral to litmus and air-dried at room temperature.

3-Chloro-2-butenyl Diethyldithiocarbamate. Alternate Method.—To an agitated suspension of 80 g. (0.31 mole) of sodium 3-chloro-2-butenyl trithiocarbamate dihydrate in 500 ml. of acetone, was added a solution containing 47.5 g. (0.31 mole) of N,N-diethylthiocarbamyl chloride[11] in 300 ml. of acetone. An exothermic reaction set in, the temperature rising from 21 to 29° within 20 minutes. The reaction mixture was stirred for one day. The sodium chloride was removed by filtration, the acetone recovered by distillation and the residue dried over sodium sulfate. A yield of 65 g. (88.6%) of an amber oily product was obtained.

Anal. Calcd. for $C_9H_{16}ClNS_2$: Cl, 14.91; N, 5.89. Found: Cl, 15.03; N, 5.71.

Acknowledgment.—Grateful acknowledgment is made for the analyses rendered by Mr. Edward Null and to the Monsanto Chemical Company for permission to publish this work.

(8) All melting points were taken upon a Fisher–Johns block and are uncorrected.

(9) Kindly supplied by E. I. du Pont de Nemours and Company, Wilmington, Delaware.

(10) Kindly supplied by Shell Chemicals Corporation, Emeryville, California.

(11) Kindly supplied by Sharples Chemicals Inc., Philadelphia, Pennsylvania.

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Vanadium Oxide Hydrogenation Catalyst. IV.[1] The Action of Vanadium Oxide Catalyst on Cyclohexene

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RECEIVED APRIL 2, 1953

The work presented in this article has been undertaken in order to find additional information of the difference in mechanism between metal and

(1) For paper III of this series see V. I. Komarewsky and E. A. Knaggs, *Ind. Eng. Chem.*, **43**, 1414 (1951).