salts, the citrate and the phosphate appear to be the most stable.

Experimental[6]

2-Diethylaminoethylisothiouronium Chloride Hydrochloride.—To a refluxing solution of 156.5 g. of thiourea in 500 ml. of alcohol a solution of 352.2 g. of 2-chlorotriethylamine hydrochloride (m. p. 205–209°) in 1000 ml. of alcohol was added in a thin stream during one-half hour. The resulting clear solution was refluxed for six hours, cooled, and diluted with a mixture of two liters of ethyl acetate and 500 ml. of ligroin. The white precipitate was filtered and air-dried, yielding 444 g. of product. An additional 38 g. was recovered by working up the mother liquor. One crystallization from absolute alcohol–ether gave pure material, m. p. 194–195°, with but little loss; total yield, 94.5%.

Anal.[7] Calcd. for $C_7H_{19}N_3Cl_2S$: N, 16.93. Found: N, 17.08.

2-Diethylaminoethanethiol.—To a suspension of 248 g. of 2-diethylaminoethylisothiouronium chloride hydrochloride in 400 ml. of water was added a warm solution of 81.2 g. of 98.5% sodium hydroxide in 300 ml. of water. There was an immediate separation of a pink upper oily layer. The mixture was saturated with salt and extracted with three 100-ml. portions of ether. After thorough drying of the combined extracts over anhydrous sodium sulfate, the ether was distilled in a current of nitrogen through an efficient fractionating column. (The compound readily co-distills with ether.) Distillation of the residual oil *in vacuo* gave 103 g. (77.5%) of colorless product; mobile liquid with a nauseating odor, b. p. 65–66° at 23 mm. The pure compound boiled at 74.0° at 32.0 mm.,[8] $n^{20}D$ 1.4670.

Anal. Calcd. for $C_6H_{15}NS$: C, 54.08; H, 11.35. Found: C, 54.40; H, 11.46.

The **hydrochloride** formed long slender white needles (from absolute alcohol–ligroin), m. p. 172–173°.[8]

Anal. Calcd. for $C_6H_{15}NS \cdot HCl$: N, 8.25. Found: N. 8.73.

2-Diethylaminoethanethiol was also prepared from 2-chlorotriethylamine and thiourea by the above method using a one-half hour reflux period. The intermediate **2-diethylaminoethylisothiouronium chloride** was obtained in 85% yield: rosets of long slender white needles, m. p. 192–194° (dec.).

Anal. Calcd. for $C_7H_{18}N_3ClS$: N, 19.84. Found: N, 19.72.

Hydrolysis by the above method gave a 76.3% yield of the thiol.

The addition of 2-chlorotriethylamine to an excess of alcoholic sodium hydrosulfide solution under reflux in an atmosphere of hydrogen sulfide gave a 40% yield of the thiol. A large proportion of the 2-chlorotriethylamine was converted to the piperazinium salt.[9] The thiol was always accompanied by a higher boiling fraction, which could be made the major product (up to 80% yield) by using an excess of 2-chlorotriethylamine and conducting the reaction below 25°. This material proved to be **2-diethylaminoethylsulfide**, a colorless mobile liquid, boiling at 64.0° at 0.4 mm., $n^{20}D$ 1.4740. It rapidly absorbed carbon dioxide from the air and became semi-solid.

Anal. Calcd. for $C_{12}H_{28}N_2S$: C, 62.01; H, 12.14. Found: C, 62.15; H, 12.37.

The **dihydrochloride** melted at 252–254° (dec.), (lit.[5] m. p. 245.5–247.5°).

Anal. Calcd. for $C_{12}H_{28}N_2S \cdot 2HCl$: C, 47.20; H, 9.90; N, 9.18. Found: C, 46.90; H, 9.66; N, 9.00.

2-Diethylaminoethyl *p*-Nitrothiolbenzoate Hydrochloride.—2-Diethylaminoethanethiol was treated with *p*-nitrobenzoyl chloride in cold dry benzene; yield 87.8%, m. p. 163–165°. A small portion crystallized from absolute alcohol–petroleum ether formed small prisms with a light yellow color in bulk, m. p. 166–168°.

Anal. Calcd. for $C_{13}H_{19}O_3N_2ClS$: C, 48.97; H, 6.01; N, 8.79. Found: C, 49.03; H, 6.03; N, 8.72.

2-Diethylaminoethyl *p*-Aminothiolbenzoate (Thiocaine).—2-Diethylaminoethyl *p*-nitrothiolbenzoate hydrochloride was reduced with iron powder essentially by the method of Hansen and Fosdick.[1] However, no additional hydrogen chloride over that present in the salt was used; yield 55.6%, m. p. 74–75°. Recrystallization from benzene–petroleum ether gave long slender white needles, m. p. 74.0–75.5°

Anal. Calcd. for $C_{13}H_{20}ON_2S$: C, 61.87; H, 7.99; N, 11.10. Found: C, 61.64; H, 7.90; N, 11.26.

The free base is stable if protected from air and moisture; in the presence of these latter it slowly turns yellow over a period of a few weeks.

2-Diethylaminoethyl *p*-Aminothiolbenzoate Salts.—The salts listed below, with the exception of the dihydrochloride, were prepared by admixture of warm solutions of equimolecular amounts of the components in absolute alcohol. The dihydrochloride was prepared by the addition of an excess of anhydrous hydrogen chloride in absolute alcohol to an absolute alcohol solution of the base. The salts were crystallized from absolute alcohol with Nuchar treatment; one crystallization sufficed to render them pure. The yields were nearly quantitative except in the case of the tartrate.

Dihydrochloride.—Light yellow hygroscopic needles, m. p. 173–175°. A 0.5% aqueous solution had a *p*H of 2.15 at 25°.[10]

Anal. Calcd. for $C_{13}H_{20}ON_2S \cdot 2HCl$: N, 8.61. Found: N, 8.78.

Phosphate.—White needles or blunt prisms, m. p. 170.0–170.5°. A 0.5% aqueous solution had a *p*H of 4.85 at 25°.

Anal. Calcd. for $C_{13}H_{20}ON_2S \cdot H_3PO_4$: N, 8.00. Found: N, 7.93.

Citrate.—Rosets of small white prisms, m. p. 165–166° (dec.). A 0.3% aqueous solution had a *p*H of 3.90 at 25°.

Anal. Calcd. for $C_{13}H_{20}ON_2S \cdot C_6H_8O_7$: N, 6.30. Found: N, 6.31.

Tartrate.—Rosets of large white needles, m. p. 79–80°. A 0.5% aqueous solution had a *p*H of 3.68 at 25°.

Anal. Calcd. for $C_{13}H_{20}ON_2S \cdot C_4H_6O_6$: N, 6.96. Found: N, 6.96.

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[6] All melting points are uncorrected.

[7] We are indebted to the Misses Patricia Curran and Alice Rainey for the microanalyses.

[8] U. S. Patent 2,342,142 reports b. p. 160–170° for the thiol and m. p. 205° (dec.) for the thiol hydrochloride.

[9] Gough and King, *J. Chem. Soc.*, 2437 (1928); Eisleb, *Ber.*, **74**, 1433 (1941).

[10] We are indebted to Mr. George Bronell for these determinations.

RESEARCH LABORATORIES
WINTHROP CHEMICAL CO., INC.
RENSSELAER, NEW YORK
RECEIVED DECEMBER 14, 1944

The Purification of Phenothiazine

BY BRUCE E. BAKER AND LEO BRICKMAN

The discovery that phenothiazine is an excellent anthelmintic in sheep,[1] cattle[2] and poultry[3] as well as an effective insecticide[4] has renewed interest in this compound and its derivatives. The commercial material as usually obtained is a dark green powder melting 170–175°. The value set

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[1] Swales and Collier, *Can. J. Research*, **18D**, 279 (1940).

[2] Knipling, *J. Econ. Entomol.*, **31**, 315 (1938).

[3] Roberts, *Austral. Vet. J.*, **16**, 172 (1940).

[4] Campbell, Sullivan, Smith and Haller, *J. Econ. Entomol.*, **27**, 1176 (1934).

by the National Formulary[5] is 181–185° although Smith and Nelson[6] reported 185.1° for a carefully sublimed and purified sample.

Purification has usually been carried out by recrystallization from organic solvents.[7] Britton and Eiseman[8] treated the crude molten phenothiazine with a powdered metal melting in the range 200–1100° followed by vacuum distillation. We have found that distillation with superheated steam can replace the vacuum distillation and that iron powder (m. p. 1530°) can be substituted for the metals recommended by them. The method is both simple and rapid and avoids the mechanical difficulties such as bumping and clogging which we encountered with the vacuum distillation.

Experimental

The crude phenothiazine (100 g.) was placed in a distilling flask and heated to 300° by means of a sodium nitrate–potassium nitrate bath. Iron powder (2 g.) was stirred into the molten phenothiazine and after a few minutes, superheated steam was passed through the mixture at the rate of 6 g. a minute. The steam was kept at 300° using the apparatus described by Morton.[9] The receiver was a large round-bottomed flask cooled by means of cold running water. The phenothiazine sublimed into the receiver in the form of a pale yellow snow. The distillation required twenty-five to thirty minutes. The product weighed 91 g. and melted at 178–180°. The melting point could be raised to 181–183° by redistilling the product with superheated steam or by washing with carbon tetrachloride in which the phenothiazine is practically insoluble. Washing the twice-distilled product with carbon tetrachloride gave phenothiazine melting at 183–185°.

We wish to thank the Mallinckrodt Chemical Works, Ltd., for permission to publish this work.

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[5] United States National Formulary, Ed. VII, 1942, p. 323.

[6] Smith and Nelson, This Journal, **64**, 461 (1942).

[7] Belokrinitskii, *J. Applied Chem.* (U. S. S. R.), **14**, 187 (1941); Lannung, *Arch. Pharm. Chem.*, **48**, 141 (1941).

[8] Britton and Eiseman, U. S. Patent 2,295,074.

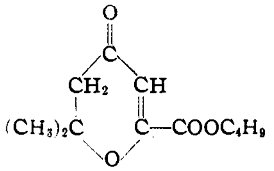
[9] Morton, "Laboratory Technique in Organic Chemistry," McGraw-Hill Book Co., New York, N. Y., 1938, p. 144.

RESEARCH LABORATORIES OF THE
MALLINCKRODT CHEMICAL WORKS, LTD.
LASALLE, QUEBEC, CANADA
RECEIVED MARCH 26, 1945

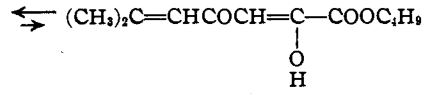
Photochemical Dimerization of *n*-Butyl Mesityl Oxide Oxalate[1]

BY S. A. HALL, R. K. ADAMS, JR., AND H. L. HALLER

The *n*-butyl ester of mesityl oxide oxalic acid, patented under the trade name "Indalone,"[2] is used as an insect repellent to protect against the bites of mosquitoes and flies. The commercial product is a yellow to reddish-brown, high-boiling liquid of characteristic odor. It exists largely as the butyl ester of 2,2-dimethyl-6-carboxydihydro-4-pyrone in equilibrium with the open-chain enol form.



Dihydropyrone form



$$\rightleftarrows (CH_3)_2C{=}CHCOCH{=}\underset{\substack{|\\ O\\ H}}{C}{-}COOC_4H_9$$

Enol form

We have found that exposure to ultraviolet light of a thin film of Indalone causes irreversible and quantitative polymerization of the liquid ester to a crystalline solid, m. p. 106–107°, which we have identified as a dimer of Indalone. That this dimerization will take place completely in three and one-half hours on exposure of a thin layer to March sunlight, or in one hour on exposure to an ultraviolet lamp, is of especial interest because of the loss in insect-repellent properties involved after dimerization. Federlin[3] has described dimers of the methyl, ethyl, propyl and amyl esters of mesityl oxide oxalic acid which he obtained by exposure of 20% solutions of the respective esters in methanol to diffuse daylight from eight days to five months. His attempts to saponify the dimeric ethyl ester to the dimeric acid were unsuccessful. This and other aspects of the reaction are being further investigated.

Experimental

_n_-Butyl Mesityl Oxide Oxalate Dimer.—Redistilled commercial **Indalone** (1.2 g.) was placed in a 9-cm. Petri dish and covered tightly with a cellophane cover. The dish was placed upon a sheet of polished aluminum and irradiated with ultraviolet light from a 100-watt mercury-vapor spotlight, type CH-4. After forty-five minutes crystallization of the dimer had spread through two-thirds of the liquid film. Further exposure for fifteen minutes produced complete solidification to the dimer. There was no loss in weight.

A similar experiment was conducted outdoors on March 13 in midday sunlight except that no aluminum reflector was placed under the Petri dish. At a temperature of 13–14° in the sun, the film of **Indalone** was about half solidified after two and one-fourth hours and completely solidified to the dimer after three and one-half hours. The dimer recrystallized from dilute alcohol in prisms, m. p. 106–107° (cor.), which sublimed without decomposition at 0.4 mm. pressure at an oil-bath temperature of 155–180°. The sublimed crystals melted at 106.5–107.5° (cor.).

Anal. Calcd. for $(C_{12}H_{18}O_4)_2$: C, 63.70; H, 8.02; neut. equiv. (4 equivs. per mole), 113; mol. wt., 452. Found: C, 63.59; H, 8.07; neut. equiv., 108; mol. wt., 445 (in benzene), 443 (in camphor).

No color was obtained with alcoholic ferric chloride reagent which indicates that the dimer is not enolized. The monomeric ester with this reagent gives a deep red color which is attributed to the presence of the enol form. With tetranitromethane reagent the dimer gave a negative test for unsaturation; the monomer gave a positive test.

Semicarbazone of Dimeric _n_-Butyl Mesityl Oxide Oxalate.—The semicarbazone crystallized from methanol as very fine white crystals, m. p. 233.0–233.5° (dec.) (cor.).

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[1] This work was done under a transfer of funds, recommended by the Committee on Medical Research, from the Office of Scientific Research and Development to the Bureau of Entomology and Plant Quarantine.

[2] U. S. Patent 2,138,540, issued Nov. 29, 1938; assigned to Ford, Kilgore Development Corp.

[3] Federlin, *Ann.*, **356**, 261 (1907).