EXPERIMENTAL[5]

1,2,4-Triphenylbenzene. Preparation from 3,4-diphenylthiophene-1,1-dioxide. A mixture of 1.0 g. (0.0037 mole) 3,4-diphenylthiophene-1,1-dioxide[6] and 1.0 g. (0.0098 mole) of phenylacetylene was slowly heated to 135°, at which point a sudden vigorous evolution of sulfur dioxide occurred. After 1 hr. at 140–150° excess phenylacetylene was removed under reduced pressure, the residue dissolved in 1:1 benzene–petroleum ether (b.p. 30–60°) and passed through a column of activated alumina. Solvent was removed, the product dissolved in petroleum ether, chromatographed on alumina, and eluted with 1:4 benzene–petroleum ether The oily product was taken up in a small quantity of petroleum ether, from which it crystallized very slowly. After 19 days, 71.5 mg. (6.3%) of white granules, m.p. 97.5–98.5°, were collected. After two recrystallizations from methanol, fine white needles were obtained, m.p. 99.1–99.6°.

A very low yield of the same compound was obtained by refluxing 1.07 g. (0.0040 mole) 3,4-diphenylthiophene-1,1. dioxide and 0.71 g. (0.0044 mole) α-acetoxystyrene[7] in 5 ml. xylene for 4 hr., acidification, and repeated chromatographic purification.

1,2,4-Triphenylbenzene. Preparation from 2,5-diphenylthiophene-1,1-dioxide. A mixture of 0.461 g. (0.00172 mole) 2,5-diphenylthiophene-1,1-dioxide,[8] and 1.06 g. (0.0104 mole) phenylacetylene were heated in a xylene vapor bath for 11 hr.; sulfur dioxide was evolved. The solution was diluted with petroleum ether, chromatographed on alumina and eluted with 1:4 benzene–petroleum ether. Solvent removal left 0.238 g. (45.3%) of white needles, m.p. 100°.

The infrared spectra of these three materials, as well as those of a sample prepared from styrene and 3,4-diphenyl-4-hydroxy-2-cyclopentenone[1] and a sample of the 119° form supplied by Dr. A. Halleux, were identical. The principal absorption bands in carbon tetrachloride solution were at 3040, 3010, 1940(w), 1875(w), 1800(w), 1750(w), 1670(w), 1600, 1575(w), 1490, 1472(s), 1440, 1385, 1177(w), 1072, 1027, 1008, 911, 895, 837, and 698(vs) cm.$^{-1}$ A supercooled melt showed, in addition, bands at 779, 756, and 742 cm.$^{-1}$ The ultraviolet spectrum in cyclohexane showed a minimum at 229 mμ (log ε 4.31), λ_{max} 248 mμ (log ε 4.54), an inflection at 270 mμ (log ε 4.39), and very low absorbance beyond 320 mμ.

Phenylacetylene trimer (?) The procedure of Rose and Statham[1] gave the 109° material in 1.4% yield; chromatographic purification of the residues, using the same procedure as used for 1,2,4-triphenylbenzene, provided an additional 7.1%. The infrared spectrum showed all of the bands of 1,2,4-triphenylbenzene at somewhat lower absorbance, except for a stronger 1490 cm.$^{-1}$; in addition, it absorbed strongly at 952 and 689 cm.$^{-1}$ and had weak bands at 1298, 1260, 1098, and 981(vw) cm.$^{-1}$ The ultraviolet spectrum in cyclohexane showed λ_{max} 248 mμ (log ε 4.40),[9] 280 mμ (log ε 4.32), and 335 mμ (log ε 3.90), with minima at 232 mμ (log ε 4.28), 266 mμ (log ε 4.30), and 333 mμ (log ε 3.89) and an inflection at 315 mμ (log ε 4.11).

DEPARTMENT OF CHEMISTRY
POLYTECHNIC INSTITUTE OF BROOKLYN
BROOKLYN 1, N. Y.

(5) All melting points are corrected. Infrared spectra were determined on a Perkin-Elmer Model 21 instrument with sodium chloride prism and ultraviolet spectra on a Carey Recording Spectrophotometer, Model 11.

(6) H. J. Backer, C. C. Bolt, and W. Stevens, *Rec. trav. chim.* **56,** 1063 (1937), modified by use of peroxyacetic acid in place of peroxybenzoic acid.

(7) W. M. Quattlebaum and C. A. Noffsinger, Brit. Pat. **615,521,** Jan. 7, 1949.

(8) J. L. Melles and H. J. Backer, Rec. trav. chim., **72,** 319 (1953).

(9) Assuming molecular weight 306.

Pyrido[3,2-b][1,4]benzothiazine (1-Azaphenothiazine)

ALFONSO R. GENNARO[1]

Received February 16, 1959

Due to the importance of phenothiazine and its derivatives in medicinal chemistry it seemed of interest to synthesize the phenothiazine nucleus incorporating a nitrogen atom in one of the benzenoid rings. A recent publication by Yale and Sowinski[2] describes the preparation of 1-azaphenothiazine (I) by the Smiles rearrangement of 2′-(3-nitro-2-pyridylthio) acetanilide. Other 3- or 4-aza[3,4] and 4,6-diazaphenothiazines[5] are known. This paper is concerned with the direct thionation[6] of 2-anilinopyridine (II) to give I.

Heating II with sulfur in the presence of iodine catalyst affords a rapid method for obtaining I. Attempts to obtain I using other cyclization methods analogous to those reported for phenothiazine, such as: heating phenol and 2-aminopyridine with sulfur and iodine[7] or aluminum chloride; the thionation of II with aluminum chloride catalyst[8]; or directly with sulfuryl chloride[9] failed.

With picric acid I forms a *mono*picrate but a hydrochloride of definite composition could not be isolated. Oxidation of I with hydrogen peroxide in an attempt to form the 5-oxide or 5,5-dioxide regenerated II. Acylation with acetic anhydride gives the 10-acetyl derivative (III).

Preliminary attempts to alkylate I by the usual methods employed for phenothiazine (alkyl halide preceded by treatment with sodamide in a hydrocarbon solvent) were not successful. The only identifiable product obtained was II, which could arise by dethionation of I. Since dethionation of phenothiazine (with copper powder) leads to the formation of carbazole,[10] the product derived from I in such a case should be 9-pyrid[2,3-*b*]indole (α-carboline).[11] This compound was not identified in the reaction products of I with sodamide or copper. Raney nickel has been reported to remove the

(1) This study was initiated by a grant from the Institute for Muscle Research, New York, N.Y.

(2) H. L. Yale and F. Sowinski, *J. Am. Chem. Soc.*, **80,** 1651 (1958).

(3) T. Takahashi and E. Yoshi, *Pharm. Bull. (Tokyo)*, **2,** 382 (1954).

(4) (a) T. Takahashi and Y. Maki, *Yakugaku Zasshi*, **77,** 485 (1957); *Chem. Abstr.*, **51,** 14738a (1957). (b) V. A. Petrow and E. L. Rewald, *J. Chem. Soc.*, 591 (1945).

(5) Y. Maki, *Yakugaku Zasshi*, **77,** 862 (1957); *Chem. Abstr.*, **52,** 1174b (1958).

(6) A. Bernthsen, *Ann.* **230,** 73 (1885).

(7) Swiss patent **204,521**; *Chem. Abstr.*, **35,** 2338 (1941).

(8) F. Ackermann, D. R. P. **222,879**; *Chem. Abstr.*, **5,** 210 (1911).

(9) Kym, *Ber.*, **21,** 2807 (1888).

(10) A. Goske, *Ber.*, **20,** 232 (1887).

(11) R. Robinson, *J. Chem. Soc.*, 629 (1924).

sulfur of phenothiazine yielding the diarylamine.[12]

Subsequent attempts at alkylation of I using freshly prepared sodamide by the method of Yale did give the 10-alkyl derivative. Even in this instance some 2-anilinopyridine was recovered from the reaction mixture indicating partial reductive dethionation of I.

Thionation of *N*-phenyl-*N*-(2-pyridyl)-*N'*,*N'*-dimethyl ethylenediamine (IV), in an attempt to achieve ring closure with the 10-alkyl substituent (in this instance diethylaminoethyl) previously attached gave IV as the only isolable product.

As has been noted with phenothiazine, I changes color, developing a reddish crust on standing for a period of three years under normal conditions of light and temperature, with a subsequent lowering of the melting point. Recrystallization restores both color and melting point.

EXPERIMENTAL

Carbon and hydrogen analyses are by Clark Microanalytical Laboratory, Urbana, Ill. Nitrogen and sulfur analyses by Clark or this Laboratory. All melting points were determined using Anschutz, short scale thermometers, totally immersed in the heating bath.

1-Azaphenothiazine (I). A mixture of 12 g. (0.075 mole) of 2-anilinopyridine,[13] 4.8 g. of sulfur (0.15 g. atom) and 0.3 g. of iodine was intimately mixed in a mortar and heated under reflux at 160–180° (pot temperature) for 3 hr. The tarry mass was directly distilled from the reaction flask to give 6.3 g. (42%) of 1-azaphenothiazine (I), b.p. 178–184° at 3 mm., m.p. 109–112°. An analytical sample recrystallized from ethanol melted at 112.5–113.5° (yellow rosettes).

Anal. Calcd. for $C_{11}H_8N_2S$: N, 13.99; S, 16.00; Mol. wt. 200.3. Found: N, 14.07; S, 16.49, 16.20; Mol. wt. 196 (Rast). I gives the same color reactions used for the identification of phenothiazine.[14] A dilute alcoholic solution of I (0.05%) gives a green color with 1% aqueous ferric chloride and a red color with acidified hydrogen peroxide solution.

Reaction of I *with hydrochloric acid.* Mixing equimolar ethereal solutions of I and dry hydrogen chloride caused the precipitation of yellow crystals which, after recrystallization from absolute ethanol-ether, melted at 182–183° dec., and was only partially water soluble.

Anal. Calcd. for $C_{11}H_8N_2S.HCl$: Cl, 15.0; for $C_{11}H_8N_2S.2$ HCl: Cl, 26.7. Found: Cl, 16.65.

With concentrated hydrochloric acid I formed a clear yellow solution and gave yellow needles on spontaneous evaporation. Two recrystallizations from absolute ethanol-ether gave yellow needles melting at 167–170°, which also showed incomplete water solubility and inconclusive analytical results.

Oxidation of I. Two grams of I (0.01 mole) in 50 cc. of ethanol at 50° was treated with 10 cc. (0.09 mole) of 30% hydrogen peroxide to give a clear yellow solution which on dilution with 5 volumes of water yielded 2-anilinopyridine, m.p. and mixed m.p. 109–110°.

Reaction of I *with copper.* Freshly precipitated copper was prepared by immersion of aluminum rods into a concentrated solution of copper sulfate with agitation. The precipitated copper was filtered, washed well with water, alcohol, and ether, then dried at 40° for 0.5 hr. and used immediately. An intimate mixture of 1 g. of I and 5 g. of copper powder was heated at 130° for 1 hr. in a nitrogen atmosphere. The powdered residue was extracted with ether, the solvent evaporated, and the pale yellow residue recrystallized from ethanol to give 0.27 g. of II, m.p. and mixed m.p. 108–110°.

1-Azaphenothiazine picrate. Mixing of saturated alcoholic solutions of I and picric acid gives the *mono picrate*, m.p. 198–200° dec.

Anal. Calcd. for $C_{17}H_{11}N_5O_7S$: N, 16.31. Found: N, 16.29.

Alkylation of I. Alkylation with dimethylaminoethyl chloride and sodamide[2] proceeded smoothly using freshly prepared sodamide. After vacuum distillation of the 10-alkyl derivative the residue in the flask solidified. Several recrystallizations from ethanol gave white plates, m.p. 108–109° which did not depress the melting point of an authentic sample of 2-anilinopyridine.

10-Acetyl-1-azaphenothiazine (III). A mixture of 2 g. (0.01 mole) of I, 0.21 g. (0.0025 mole) of anhydrous sodium acetate and 15 cc. of acetic anhydride (16.2 g., 0.16 mole) was refluxed for 0.5 hr. then poured into 50 cc. of ice water with stirring. Recrystallization of the separated solid from ethanol gave 2 g. (83.5%) of 10-acetyl-1-azaphenothiazine melting at 167–8° (pale yellow plates).

Anal. Calcd. for $C_{13}H_{10}N_2OS$: C, 64.43; H, 4.16; N, 11.55. Found: C, 64.53; H, 4.18; N, 11.28.

Infrared spectral data.[15] (KBr pellet, wave length and % transmission).

I[16]; 3.08 (23), 3.12 (36), 3.25 (38), 6.23 (20), 6.36 (33), 6.55 (29), 6.70 (12), 6.90 (1), 7.58 (28), 7.24 (33), 7.33 (41), 8.09 (67), 8.62 (72), 8.85 (41), 9.19 (50), 9.53 (26), 9.63 (58), 10.79 (62), 11.07 (67), 11.81 (63), 12.87 (12), 13.29 (8), 13.50 (1).

III; 3.27 (48), 5.89 (12), 6.30 (22), 6.36 (40), 6.75 (34), 7.01 (4), 7.25 (6), 7.58 (11), 7.64 (1), 7.76 (21), 7.93 (1), 8.27 (10), 8.72 (24), 8.84 (49); 9.19 (34), 9.55 (43), 9.69 (52), 9.87 (19), 10.04 (76), 10.60 (67), 10.18 (79), 11.05 (80), 11.62 (56), 12.45 (1), 13.00 (38), 13.15 (9), 13.30 (12), 13.40 (2), 13.69 (37), 14.20 (63).

SCHOOL OF CHEMISTRY
PHILADELPHIA COLLEGE OF PHARMACY AND SCIENCE
PHILADELPHIA 4, PA.

(12) K. H. Shah and K. Venkataraman, *Proc. Indian Acad. Sci.*, **28A**, 142 (1948).

(13) The preparation of substituted anilinopyridines and quinolines for the attempted synthesis of substituted 1-azaphenothiazines and azabenzophenothiazines by the thionation method has led to some interesting observations which will be discussed in a future paper.

(14) *The National Formulary*, 10th edition, J. B. Lippincott Co., Philadelphia, Pa. 1955, p. 442.

(15) The infrared spectra were run on a Beckman IR-4 double beam recording spectrophotometer equipped with sodium chloride optics.

(16) The infrared spectrum of I is identical with that of a sample of 1-azaphenothiazine generously supplied by Dr. H. L. Yale, The Squibb Institute for Medical Research, New Brunswick, N. J.

Preparation of 2-Imino- and 2-Nitrimino-1,3-diazacycloalkanes

L. S. HAFNER AND ROBERT EVANS

Received February 16, 1959

In a previous publication[1] the isolation of 5,5-bis(hydroxymethyl)-2-nitrimino-1,3-diazacyclohexane and the salts of 5,5-bis(hydroxymethyl)-

(1) L. S. Hafner and Robert Evans, *J. Am. Chem. Soc.*, **79**, 3783 (1957).