

which was dried by azeotropic distillation with benzene and then purified by distillation. The procedure (including quantities of reactants) was in each case as described for the reaction with piperidine. Characteristics of the products were as follows: *N,N*-Diethylaniline: b.p. 62–66°/3 mm., n_D^{25} 1.5394 (lit.^{11,12} b.p. 70°/3 mm., n_D^{25} 1.5410). *N,N*-Diisopropylaniline: b.p. 95.5°/12 mm., n_D^{20} 1.5222 (lit.¹³ b.p. 98–100°/13 mm.). *N,N*-Di-*n*-butylaniline: b.p. 103.5–106° (3.5 mm.), n_D^{20} 1.5182. The picrate, crystallized from ether, had m.p. 124° (lit.¹⁴ m.p. 124°) not depressed on admixture with the picrate of authentic *N,N*-di-*n*-butylaniline. *N*-Phenylmorpholine: b.p. 87–92°/3–4 mm., m.p. 52–53° after crystallization from an ethanol-ether mixture (lit.¹⁵ m.p. 57–58°).

Reaction of bromobenzene with sodium amide and aniline. Bromobenzene (15.7 g., 0.1 mole), sodium amide (11.7 g., 0.3 mole) and 35 cc. of purified aniline were allowed to react by the procedure described for the reaction with piperidine. After water had been added to the reaction mixture, it was made acidic by addition of hydrochloric acid and then was extracted with five 150-cc. portions of benzene. The combined benzene washings were distilled until the boiling point reached 80° and then were treated with anhydrous hydrogen chloride. The purple solid which formed was collected on the suction filter and then was treated with sodium hydroxide solution. The resulting product was separated by steam distillation. Diphenylamine (4.3 g., 25.4%), m.p. 52–52.5°, not depressed on admixture with authentic diphenylamine, was so obtained. The benzene filtrate was distilled and two fractions of interest were obtained: a yellow oil, b.p. 100–106° (2–3 mm.), wt. 3.9 g., and a mushy solid, b.p. 106–161° (2–3 mm.), wt. 2.8 g. By trituration of the first fraction with petroleum ether (b.p. 30–60°), 1.1 g. of a sublimable white solid, m.p. 205–210° with decomposition, was obtained, but this product was not identified. Cooling the filtrate to –78° caused 0.61 g. of a sublimable solid, m.p. 33–35°, to separate; this was not identified. From the second fraction, 0.33 g. (4.4%) of triphenylamine, m.p. 126–127° not depressed on admixture with authentic triphenylamine, was obtained by crystallization from petroleum ether (b.p. 30–60°). A yellow oil, n_D^{18} 1.6431, remained on evaporation of the mother liquor from the triphenylamine crystallization.

Reaction of 2-bromomesitylene with sodium amide and piperidine. 2-Bromomesitylene (19.9 g., 0.1 mole), sodium amide (7.8 g., 0.2 mole) and 30 cc. of piperidine were allowed to react by the procedure described above for the bromobenzene-sodium amide-piperidine reaction. From the neutral product fraction, 6.4 g. (53.2%) of mesitylene, b.p. 75–78° (40 mm.), n_D^{24} 1.4987 (authentic mesitylene has b.p. 79.8°/40 mm., n_D^{18} 1.4954) and 4.8 g. (24.1% recovery) of 2-bromomesitylene, b.p. 106–109°/17 mm., n_D^{24} 1.5480 (authentic 2-bromomesitylene has b.p. 108–110°/17–18 mm., n_D^{24} 1.5484). No basic product could be isolated.

Reaction of bromobenzene with piperidine and sodium metal. Sodium metal (2.3 g., 0.1 mole) and piperidine (20 cc.) were combined and heated at reflux for 15 min. Bromobenzene (7.9 g., 0.05 mole) was then added through the condenser and the resulting mixture was refluxed for 2 hr. Water (25 cc.) was cautiously added to the cooled reaction mixture; there was little evidence of residual sodium. The neutral and basic product fractions were separated by common extraction procedures. The basic fraction yielded 5.2 g. (66.7%) of *N*-phenylpiperidine, b.p. 95–98° (5 mm.),

n_D^{25} 1.5590. The neutral fraction furnished 0.9 g. of an unidentified yellow oil b.p. 65–68° (40 mm.).

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Preparation of Tetramethylene Dibromide and Chlorobromide

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In the course of a synthetic study relatively large quantities of tetramethylene dibromide and chlorobromide were required, and an attempt was made to develop inexpensive methods for the preparation of these substances.

For the preparation of tetramethylene dibromide, the reaction of tetramethyleneglycol with hydrogen bromide (yield, 70%),¹ with hydrogen bromide in the presence of concentrated sulfuric acid,^{2,3} or with phosphorus tribromide (55–60%)⁴ has been described. Since tetrahydrofuran has become easily available, its reaction with hydrogen bromide (71%)^{5–7} or with hydrogen bromide and concentrated sulfuric acid (77–82%)^{8,9} has been suggested as an attractive alternative. A third method is the bromination of butane in the presence of zinc acetate (85%).¹⁰ It has now been found that the reaction of tetrahydrofuran with sodium bromide and concentrated sulfuric acid represents the easiest method. Under the conditions specified herein, this reaction gives a yield of 86%.

Most of the syntheses of tetramethylene chlorobromide have been based on tetrahydrofuran and consist of two steps, its transformation into tetramethylene chlorohydrin (50–60%) and the treatment of the latter with phosphorus tribromide

(1) A. Mueller, *Monatsh.*, **49**, 27 (1928).

(2) C. D. Nenitzescu and I. Nescioiu, *J. Am. Chem. Soc.*, **72**, 3483 (1950).

(3) C. C. Steele, *J. Am. Chem. Soc.*, **53**, 283 (1931).

(4) G. S. Kolesnikov and V. V. Korshak, *Izvest. Akad. Nauk S.S.S.R., Otdel. Khim. Nauk*, 761 (1951) [*Chem. Abstr.*, **46**, 7527 (1952)].

(5) S. Fried and R. D. Kleene, *J. Am. Chem. Soc.*, **62**, 3258 (1940); **63**, 2691 (1941).

(6) E. V. Whitehead, R. A. Dean, and F. A. Fidler, *J. Am. Chem. Soc.*, **73**, 3632 (1951).

(7) N. D. Scott, U. S. Patent 2,491,834 [*Chem. Abstr.*, **44**, 2542 (1950)].

(8) C. L. Wilson, *J. Chem. Soc.*, 48 (1945).

(9) K. V. Levshina and S. J. Sergievskaya, *Zhur. Obshchei Khim.*, **22**, 2189 (1952) [*Chem. Abstr.*, **48**, 584 (1954)].

(10) Gunshi Spinning Mills Co., Japanese Patent 154,417 [*Chem. Abstr.*, **44**, 3003 (1950)].

(11) Kahlbaum, *Z. physik. Chem.*, **26**, 606 (1898).

(12) Brühl, *Z. physik. Chem.*, **16**, 213 (1895).

(13) Rosser and Ritter, *J. Am. Chem. Soc.*, **59**, 2179 (1937).

(14) Reilly and Hickinbottom, *J. Chem. Soc.*, **113**, 99 (1918).

(15) Kamm and Waldo, *J. Am. Chem. Soc.*, **43**, 2223 (1921).

(98%).¹¹⁻¹⁴ A modification of this method is the procedure of Normant and Voreux,¹⁵ in which the intermediate is the acetate of tetramethylene chlorohydrin. Furthermore, the chlorination of *n*-butyl bromide with atomic chlorine or sulfonyl chloride has been suggested as a method for the preparation of tetramethylene chlorobromide; in this reaction a yield of 35% is obtained.¹⁶

Attempts have been made to improve the conversion of tetramethylene chlorohydrin into the chlorobromide. However, the use of sodium bromide and concentrated sulfuric acid, or the application of phosphorus and bromine to this step, did not give better overall yields (58%; 40%) for the conversion of tetrahydrofuran into tetramethylene chlorobromide. Eventually, it was found that the treatment of tetrahydrofuran with a mixture of sodium chloride, sodium bromide, and concentrated sulfuric acid gives in a single step a 44% yield of the desired substance, which is accompanied by a 10% yield of tetramethylene dibromide. In our experience, this represents the easiest method for the preparation of tetramethylene chlorobromide.

EXPERIMENTAL

Tetramethylene dibromide. To a solution of sodium bromide (500 g; 4.85 mole) in water (600 ml.), there were added tetrahydrofuran (144 g.; 2.0 mole) and, with efficient agitation, concentrated sulfuric acid (750 ml.). The temperature was kept at 70–72°. The mixture was heated on the steam bath for 8 hr., then the two liquid layers were decanted from the solid phase and separated. The aqueous layer and the solid phase were washed with benzene (500 ml.), and the benzene extract was combined with the organic layer. The combined product was washed with sodium carbonate solution, sodium bisulfite solution, and water, dried, and distilled. Thus, 71 g. (86%) of the dibromide, b.p. 194–196°, was obtained.

Tetramethylene chlorobromide. (1) To a solution of sodium bromide (65 g.; 0.64 mole) in water (150 ml.), tetramethylene chlorohydrin (54.3 g.; 0.5 mole) and concentrated sulfuric acid (190 ml.) were added successively with efficient agitation. The temperature rose to 60–70°. The mixture was heated for 3 hr. on the water bath with continued agitation and kept at room temperature for 12 hr. Benzene was added and the organic layer separated, washed with 5% sodium hydroxide solution, sodium sulfite solution, and water, and then dried. Distillation gave 63.6 g., boiling at 87–95° (35 mm.). Fractionation of the product gave 49.9 g. (58%) of tetramethylene chlorobromide, b.p. 173–177°, n_D^{20} 1.4870, and 9.5 g. (9%) of tetramethylene dibromide, b.p. 193–195° n_D^{20} 1.5162.

(2) To a mixture of crude tetramethylene chlorohydrin,

prepared from 228 g. (3.2 mole) of tetrahydrofuran¹⁷ and 33 g. (1.07 mole) of red phosphorus, bromine (240 g., 1.5 mole) was added within 3 hr., with cooling and agitation. The reaction product was poured into ice water and the organic layer separated, washed with sodium bicarbonate solution and water, and dried. Distillation under 30 mm pressure (b.p. 80–85°) and at atmospheric pressure (b.p. 172–176°) gave 221 g. (43%) of tetramethylene chlorobromide, n_D^{20} 1.4872.

(3) Sodium bromide (124 g., 1.2 mole) and sodium chloride (76 g.; 1.3 mole) were dissolved in water (400 ml.), and tetrahydrofuran (72 g.; 1.0 mole) and, with agitation, concentrated sulfuric acid (400 ml.) were added, the latter at such a rate that the temperature did not exceed 70°. The mixture was then heated for 3 hr. at 100°, kept for 12 hr. at room temperature, and extracted with benzene or ether (250 ml.), and the extract was washed with 5% sodium hydroxide solution, sodium bisulfite solution, and water, dried and distilled. The product which collected between 65 and 100° at 6 mm. pressure was washed again with 20% sodium hydroxide solution and fractionated: 173–177°, tetramethylene chlorobromide, n_D^{20} 1.4870, yield, 75.5 g. (44%); 193–195°, tetramethylene dibromide, n_D^{20} 1.5162, yield, 22.7 g. (10%).

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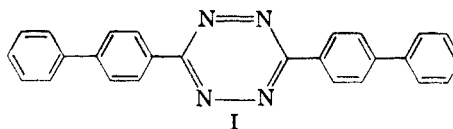
(17) D. Starr and R. M. Hixon, *Org. Syntheses, Coll. Vol. II*, 571 (1943).

Heterocyclic Analogs of Terphenyl: 3,6-Diaryl-1,2,4,5-Tetrazines

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As part of a study of the heterocyclic analogs of terphenyl and quaterphenyl, which are of interest as solutes in liquid scintillation counting systems, we have devised improved syntheses for two previously known 3,6-diaryl-1,2,4,5-tetrazines (3,6-diphenyl³ and 3,6-di-*m*-tolyl⁴) and synthesized for the first time 3,6-di-*p*-biphenyl-1,2,4,5-tetrazine (I) as well as the corresponding dihydrotetrazines.



The preparation of these compounds has been accomplished by a variation of the original Pinner synthesis in which the imido ester of an aromatic nitrile was reacted with hydrazine in an aqueous solution of either ammonium hydroxide or potassium hydroxide. Under these reaction conditions

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(3) A. Pinner, *Ber.*, **26**, 2128 (1893); **27**, 984 (1894).

(4) L. Müller, L. Herrdegen, *J. prakt. Chem.* [2], **102**, 144 (1921).

(11) D. Starr and R. M. Hixon, *J. Am. Chem. Soc.*, **56**, 1595 (1934).

(12) Y. K. Yur'ev, K. M. Minachev, and K. A. Samurshaya, *J. Gen. Chem. U.S.S.R.*, **9**, 1710 (1939) [*Chem. Abstr.* **34**, 3731 (1940)].

(13) M. S. Newman and J. H. Wotiz, *J. Am. Chem. Soc.*, **71**, 1292 (1949).

(14) E. Szarvasi, *Bull. soc. chim. France*, 463 (1950).

(15) H. Normant and G. Voreux, *Compt. rend.*, **231**, 703 (1950).

(16) D. C. Sayles and E. F. Degering, *J. Am. Chem. Soc.*, **71**, 3161 (1949).