A Publication
of Reliable Methods
for the Preparation
of Organic Compounds

Working with Hazardous Chemicals

The procedures in *Organic Syntheses* are intended for use only by persons with proper training in experimental organic chemistry. All hazardous materials should be handled using the standard procedures for work with chemicals described in references such as "Prudent Practices in the Laboratory" (The National Academies Press, Washington, D.C., 2011; the full text can be accessed free of charge at http://www.nap.edu/catalog.php?record_id=12654). All chemical waste should be disposed of in accordance with local regulations. For general guidelines for the management of chemical waste, see Chapter 8 of Prudent Practices.

In some articles in *Organic Syntheses*, chemical-specific hazards are highlighted in red "Caution Notes" within a procedure. It is important to recognize that the absence of a caution note does not imply that no significant hazards are associated with the chemicals involved in that procedure. Prior to performing a reaction, a thorough risk assessment should be carried out that includes a review of the potential hazards associated with each chemical and experimental operation on the scale that is planned for the procedure. Guidelines for carrying out a risk assessment and for analyzing the hazards associated with chemicals can be found in Chapter 4 of Prudent Practices.

The procedures described in *Organic Syntheses* are provided as published and are conducted at one's own risk. *Organic Syntheses, Inc.*, its Editors, and its Board of Directors do not warrant or guarantee the safety of individuals using these procedures and hereby disclaim any liability for any injuries or damages claimed to have resulted from or related in any way to the procedures herein.

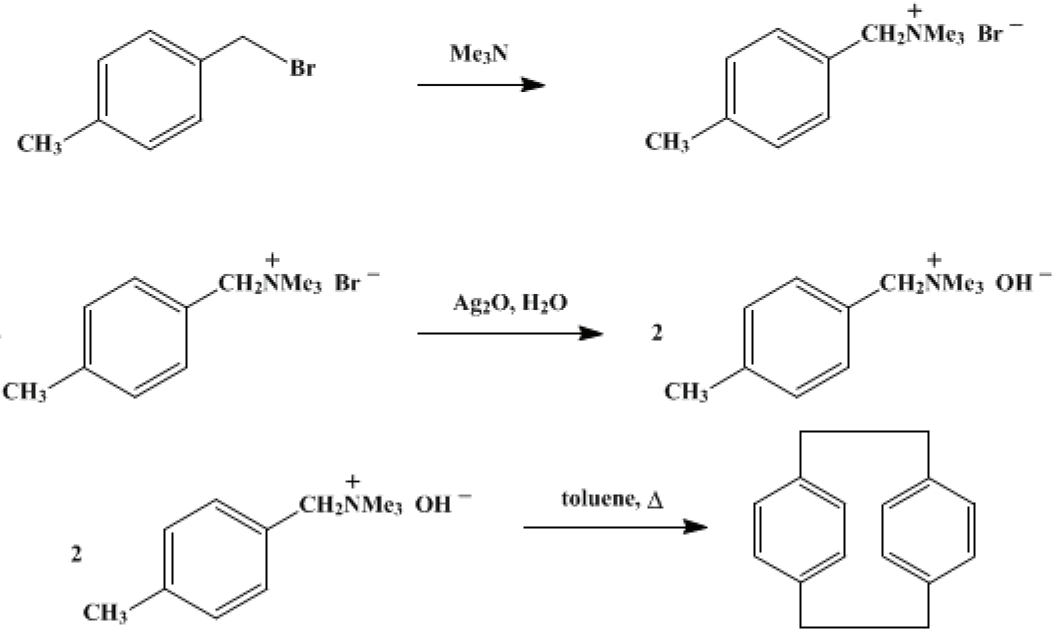
These paragraphs were added in September 2014. The statements above do not supersede any specific hazard caution notes and safety instructions included in the procedure.

DOI:10.15227/orgsyn.042.0083

Organic Syntheses, Coll. Vol. 5, p.883 (1973); Vol. 42, p.83 (1962).

[2.2]PARACYCLOPHANE

[Tricyclo[8.2.2.2^{4,7}]hexadeca-4,6,10,12,13,15-hexaene]



Submitted by H. E. Winberg and F. S. Fawcett[1].
Checked by William E. Parham, Wayland E. Noland, and Thomas A. Chamberlin.

1. Procedure

Caution! This preparation should be conducted in a hood to avoid exposure to trimethylamine and to α-bromo-p-xylene.

A. *p-Methylbenzyltrimethylammonium bromide*. In a 1-l. three-necked flask equipped with a stirrer, a reflux condenser provided with a Drierite drying tube, and a gas inlet tube about 1 cm. above the surface of the liquid are placed 600 ml. of dry ether and 100 g. (0.54 mole) of α-bromo-*p*-xylene (Note 1). The flask is cooled in an ice-water bath with stirring. A dry, weighed trap is cooled in a mush of Dry Ice-acetone, and 50 g. (0.85 mole) of liquid trimethylamine is condensed into the trap. A boiling chip is added to the cold trimethylamine, the trap is connected to the gas inlet tube and is then removed from the cooling bath. The trimethylamine is allowed to distil into the flask during a period of 2 hours, during which time *p*-methylbenzyltrimethylammonium bromide separates as a white solid (Note 2). The resulting pasty mixture is allowed to stand overnight at room temperature. The bromide is collected on a Büchner funnel, the transfer being aided by re-use of the filtrate. The bromide is washed on the filter with 200 ml. of dry ether and dried in air to give 125–130 g. (95–99%) of product (Note 3).

B. *[2.2]Paracyclophane*. *p*-Methylbenzyltrimethylammonium bromide (24.4 g., 0.10 mole) is dissolved in 75 ml. of water. Silver oxide (23 g.) (Note 4) is added, and the mixture is stirred at room temperature for 1.5 hours. The mixture is filtered, the solid is rinsed with 40 ml. of water, and the combined liquids are collected and then dried azeotropically as follows. A 500-ml. three-necked flask is equipped with a Tru-bore stirrer with a paddle of "Teflon" tetrafluoroethylene resin, a Dean-Stark water separator[2] attached to a reflux condenser, and a heating mantle. In the flask are placed 300 ml. of toluene, 0.5 g. of phenothiazine (Note 5), and the above aqueous solution containing the quaternary ammonium hydroxide. The mixture is stirred and heated under reflux during about 3 hours, the water being separated as it collects in the separator. When the water has been removed, decomposition occurs, as indicated by trimethylamine evolution and the separation of solid polymer. Heating and stirring are continued for 1.25 hours, after which time the evolution of trimethylamine has virtually ceased. The mixture is cooled, the solid is separated by filtration, and the somewhat gelatinous solid is extracted overnight in a Soxhlet apparatus (Note 6) employing the toluene used in the azeotropic drying step. After extraction there remains 5.7–6.7 g. of air-dried insoluble poly-*p*-xylylene. The toluene extract is concentrated to dryness under reduced pressure, and the solid residue is washed with three 10-ml. portions of acetone. Sublimation of the remaining solid at 0.5–1.0 mm. (temperature of oil bath 150–160°) gives a sublimate of 1.0–1.1 g. (10–11%; (Note 7)) of white, crystalline [2.2]paracyclophane, m.p. 284–287° (sealed capillary tube).

2. Notes

1. The α-bromo-*p*-xylene was obtained from Eastman Organic Chemicals; it melted at 35–36.5°.
2. A convenient, alternative procedure consists in slowly passing trimethylamine directly from a cylinder through a trap into the reaction mixture until an excess is present.
3. *p*-Methylbenzyltrimethylammonium bromide is not noticeably hygroscopic. The crude product, after it has been dried at 80° under reduced pressure over phosphorus pentoxide, melts at 197–199°. Recrystallization from absolute ethanol followed by similar drying gives crystals melting at 199–200°. Less thoroughly dried samples show lower and erratic melting points.
4. The silver oxide used may be the commercially available material or that freshly prepared by adding, with stirring, 8.8 g. of sodium hydroxide in 80 ml. of water to a solution of 34 g. of silver nitrate in 200 ml. of water. The precipitate is collected by filtration and washed with water to remove the bulk of the alkali. The wet cake is used directly for preparation of the quaternary hydroxide. The strongly basic quaternary hydroxide solution should be protected from excessive exposure to air because of carbon dioxide absorption.
5. The addition of a polymerization inhibitor appears to increase the amount of paracyclophane formed in the reaction.
6. The polymer is bulky when swollen by the toluene; a Soxhlet thimble 12 cm. long and 145 mm. in diameter is used. Additional toluene may be used in the extraction.
7. The checkers' yields are reported; the submitters report yields of 1.75–2.05 g. (17–19%).

3. Discussion

The above procedures are essentially those described by Winberg, Fawcett, Mochel, and Theobald.[3] Equally good results have been obtained starting with α-chloro-*p*-xylene, but the hygroscopic nature of *p*-methylbenzyltrimethylammonium chloride makes this intermediate less convenient to use than the bromide. [2.2]Paracyclophane has been isolated from the pyrolysis of *p*-xylene[4] and by dimerization of *p*-xylylene.[5] Paracyclophanes have been synthesized by intramolecular Wurtz reactions at high dilution.[6]

4. Merits of Preparation

This reaction, a 1,6-elimination of the Hofmann type, gives [2.2]paracyclophane from readily available starting materials without requiring complex equipment or manipulations, and, accordingly, it is probably the most convenient method of preparing [2.2]paracyclophane. This substance is of interest because of its unusual geometrical features.[6] The method is fairly general. Thus in addition to the hydrocarbon [2.2]paracyclophane, heterocyclophanes have been prepared by similar procedures.[3] The thiophene derivative, 5,5'-ethylene-1,2-bis-(2-thienyl)-ethane, has been made in 19% yield and the furan derivative, 5,5'-ethylene-1,2-bis-(2-furyl)-ethane, has been made in 72% yield. A monomeric intermediate, 2,5-dimethylene-2,5-dihydrofuran, was isolated in the latter case.

This preparation is referenced from:

- Org. Syn. Coll. Vol. 7, 485

References and Notes

1. Contribution No. 672 from the Central Research Department, Experimental Station, E. I. du Pont de Nemours and Company, Wilmington, Delaware.
2. S. Natelson and S. Gottfried, *Organic Syntheses*, Coll. Vol. **3**, 382, 1955.
3. H. E. Winberg, F. S. Fawcett, W. E. Mochel, and C. W. Theobald, *J. Am. Chem. Soc.*, **82**, 1428 (1960); J. L. Anderson and H. E. Winberg, U.S. pat. 2,876,216 (March 3, 1959); H. E. Winberg, U.S. pat. 2,904,540 (Sept. 15, 1959); F. S. Fawcett, U.S. pat. 2,757,146 (July 31, 1956); T. E. Young, U.S. pat. 2,999,820 (1961).
4. C. J. Brown and A. C. Farthing, *Nature*, **164**, 915 (1949); C. J. Brown, *J. Chem. Soc.*, 3265 (1953).
5. L. A. Errede, R. S. Gregorian, and J. M. Hoyt, *J. Am. Chem. Soc.*, **82**, 5218 (1960).
6. D. J. Cram and H. Steinberg, *J. Am. Chem. Soc.*, **73**, 5691 (1951).

Appendix
Chemical Abstracts Nomenclature (Collective Index Number);
(Registry Number)

[2.2]Paracyclophane

poly-p-xylylene

paracyclophane

ethanol (64-17-5)

ether (60-29-7)

sodium hydroxide (1310-73-2)

silver oxide (20667-12-3)

silver nitrate (7761-88-8)

carbon dioxide (124-38-9)

acetone (67-64-1)

toluene (108-88-3)

ammonium hydroxide (1336-21-6)

p-xylene (106-42-3)

Trimethylamine (75-50-3)

tetrafluoroethylene (9002-84-0)

α-bromo-p-xylene (104-81-4)

phenothiazine (92-84-2)

2,5-dimethylene-2,5-dihydrofuran

phosphorus pentoxide (1314-56-3)

α-chloro-p-xylene (104-82-5)

Tricyclo[8.2.2.2^{4,7}]hexadeca-4,6,10,12,13,15-hexaene (1633-22-3)

5,5'-ethylene-1,2-bis-(2-thienyl)-ethane

5,5'-ethylene-1,2-bis-(2-furyl)-ethane

p-methylbenzyltrimethylammonium bromide

p-methylbenzyltrimethylammonium chloride

p-xylylene