A Publication
of Reliable Methods
for the Preparation
of Organic Compounds

Working with Hazardous Chemicals

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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.

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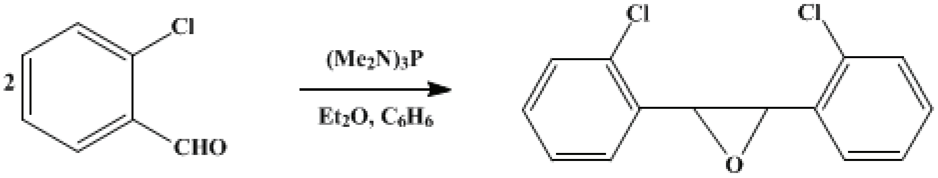
Organic Syntheses, Coll. Vol. 5, p.358 (1973); Vol. 46, p.31 (1966).

2,2'-DICHLORO-α,α'-EPOXYBIBENZYL

[Bibenzyl, α,α'-epoxy-, 2,2'-dichloro-]



Submitted by V. Mark[1]
Checked by G. A. Frank and W. D. Emmons.

1. Procedure

To a solution of *o*-chlorobenzaldehyde (56.2 g., 0.4 mole) (Note 1) in 50 ml. of benzene in a 250-ml. three-necked flask equipped with a stirrer, thermometer, dropping funnel, and reflux condenser, there is added a solution of hexamethylphosphorous triamide (37.9 g., 0.232 mole) in 20 ml. of dry ether[2] at such a rate that the temperature remains between 24° and 36°. The ensuing exothermic reaction is controlled readily by immersing the flask in a water bath (Note 2). After completion of the addition, which requires 30–50 minutes, the clear solution is maintained at 50° for 15 minutes. The solvent is removed on a rotary evaporator, and the oily residue is triturated with 100 ml. of water and then with 150 ml. of pentane. At this point only a small portion of the product is left undissolved (Note 3). The aqueous layer is extracted with 150 ml. of pentane (Note 4). The combined pentane solution is washed with two 100-ml. portions of water and concentrated to dryness to give 46–50 g. of a light yellow solid. Recrystallization from 100 ml. of methanol yields 37.5–43.1 g. of white crystals (71–81%), composed of a mixture of the *trans* epoxide (about 50–55%) and the *cis* epoxide (about 45–50%) (Note 5), (Note 6), (Note 7).

2. Notes

1. The commercial product was distilled before use. The checkers found the undistilled material equally satisfactory.
2. The solvent can be omitted, but more efficient cooling is then required to control the reaction.
3. Pentane dissolves the epoxide and water dissolves the co-product, hexamethylphosphoric triamide. The insoluble, thick, yellow syrup sometimes found is the betaine 1:1 adduct of the aldehyde and amide.[3] The checkers found no insoluble portion in their preparations.
4. Filtration through a sintered-glass funnel readily breaks up the emulsion which is formed occasionally.
5. The simplest and most accurate way to determine the composition of the product is by proton n.m.r. spectroscopy. The ratio of the oxirane hydrogen atoms (*cis* 4.48 p.p.m. and *trans* 3.97 p.p.m. downfield from internal tetramethylsilane reference, determined in carbon tetrachloride or deuteriochloroform solution)[3] gives directly the ratio of the isomers. Infrared spectroscopy, although it readily distinguishes between the isomers, gives a less accurate quantitative relationship.
6. Chromatography over silica gel (60–200 mesh), using benzene as eluent, yields pure *trans*-epoxide (m.p. 76–77°; δ 4.08) in the first fractions, and the *cis*-epoxide (m.p. 94–95°, after recrystallization from hexane; δ 4.56) in the last fractions. The assignment was also confirmed by analysis of the ^{13}C-satellite bands (*cis*, J(^{13}C-H) 181, J(H-H) 4.4, and *trans*, J(^{13}C-H) 182, J(H-H) 1.9 Hz.). In all of the cases studied the *trans* epoxide was eluted first and had lower δ and J(H-H) values than its *cis* isomer.
7. Hexaethylphosphorous triamide[2] may be substituted for the methyl homolog without adverse effect on the quality and yield of the product.

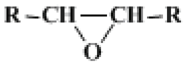
3. Discussion

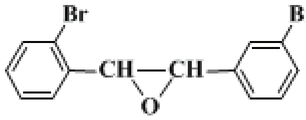
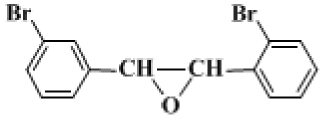
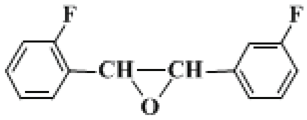
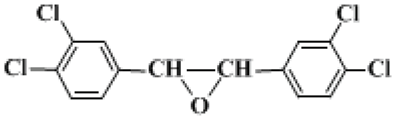
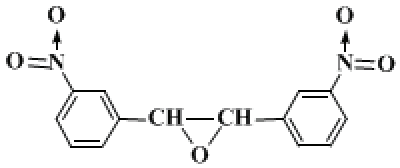
2,2'-Dichloro-α,α'-epoxybibenzyl has been prepared only by the present procedure.[3]

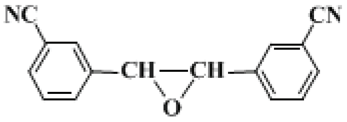
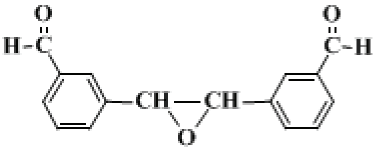
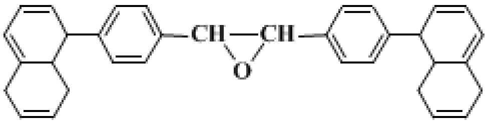
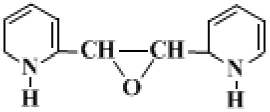
4. Merits of the Preparation

The reaction of aldehydes with hexaalkylphosphorous triamides to yield the corresponding epoxides is a synthetic procedure of considerable scope (Table I) and represents a new and simple, one-step method of forming symmetrical and unsymmetrical epoxides.[3] In contrast to the most widely used epoxide synthesis, *i.e.*, from olefins with peroxides or peracids, the present procedure may be used to obtain epoxides having structural features (*e.g.*, thiophene or pyridine rings) which would not survive the more drastic peroxide route. The procedure does not, however, afford stereochemically unique products. The yields of the epoxides from the corresponding aldehydes are usually high, and new members of the underpopulated class of aromatic and heterocyclic epoxides become readily accessible. Application of this method to certain aromatic dialdehydes yielded the first examples of cyclic aromatic epoxides.[4]

TABLE I SYNTHESIS OF SYMMETRICAL EXPOXIDES



R	%Yield	Composition %*trans*	%*cis*
 *o*-Bromophenyl	90–95	59	41
 *m*-Bromophenyl	45–50	72[a]	28
 *o*-Fluorophenyl	90–95	60	40
 3,4-Dichlorophenyl	88–95	60	40
 *m*-Nitrophenyl	75–80	74[b]	26

	90–95	57	43
p-Cyanophenyl			
	75–80	53	47
p-Formylphenyl			
	83–87	53	47
1-Naphthyl			
	60–65	53	47
2-Thienyl[c]			
	85–90	75[d]	25
2-Pyridyl			

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[a] M.p. 84–86°.

[b] M.p. 156–158°.

[c] Hexaethylphosphorous triamide was used.

[d] M.p. 95–97°.

This preparation is referenced from:

- Org. Syn. Coll. Vol. 5, 602

References and Notes

1. Hooker Chemical Corporation, Niagara Falls, New York.
2. V. Mark, this volume, p. 602.
3. V. Mark, *J. Am. Chem. Soc.*, **85**, 1884 (1963).
4. M. S. Newman and S. Blum, *J. Am. Chem. Soc.*, **86**, 5598 (1964).

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

Benzene (71-43-2)

methanol (67-56-1)

ether (60-29-7)

carbon tetrachloride (56-23-5)

Pentane (109-66-0)

hexane (110-54-3)

tetramethylsilane (75-76-3)

Hexamethylphosphorous triamide (1608-26-0)

hexamethylphosphoric triamide (680-31-9)

betaine (107-43-7)

deuteriochloroform (865-49-6)

Hexaethylphosphorous triamide (2283-11-6)

o-chlorobenzaldehyde (89-98-5)

2,2'-Dichloro-α,α'-epoxybibenzyl,
Bibenzyl, α,α'-epoxy-, 2,2'-dichloro- (53608-92-7)