Organic Syntheses

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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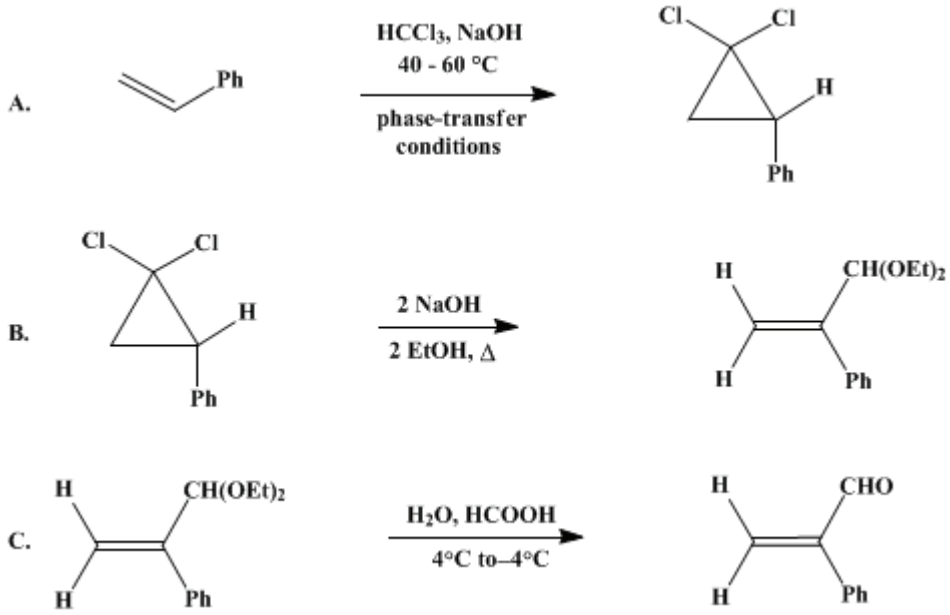
# ATROPALDEHYDE

## [Benzeneacetaldehyde, α-methylene]

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## 1. Procedure

A. *1,1-Dichloro-2-phenylcyclopropane.* In a 1-L, three-necked, round-bottomed "Morton" flask (Note 1) equipped with a mechanical stirrer, a thermometer, and a reflux condenser are placed 57 mL (0.50 mol) of styrene, 50 mL of chloroform, 2 g of triethylbenzylammonium chloride, 25 mL of methylene chloride, and a solution of 77 g of sodium hydroxide in 77 mL of water (Note 2). The mixture is stirred vigorously.

The temperature is allowed to rise to 40°C and then kept between 40 and 45°C by cooling with water (Note 3). After about an hour evolution of heat subsides, and the dark reaction mixture is heated to 55–60°C for an additional hour. The products are transferred to a 1-L separatory funnel with 250 mL of water and shaken. The organic layer is separated and the aqueous phase extracted with 25 mL of petroleum ether (Note 4). The organic fractions are combined, dried over anhydrous magnesium sulfate, filtered, concentrated in vacuo, and distilled through a 20-cm Vigreux column. A forerun at about 50°C (16 mm) consists mainly of styrene. Distillation of the remainder affords 80–82 g (86–88%) of dichlorophenylcyclopropane, bp 118–120°C (16 mm) (Note 5).

B. *Atropaldehyde diethyl acetal*. A mixture of 18.7 g (0.100 mol) of 1,1-dichloro-2-phenylcyclopropane, 16 g (0.40 mol) of sodium hydroxide, and 160 mL of ethanol is placed in a 250-mL flask fitted with a reflux condenser. The mixture is heated under reflux for 24 hr. Some bumping may occur. Water (200 mL) is added, and the mixture is extracted with three 30-mL portions of petroleum ether. The extracts are combined, dried as above with magnesium sulfate, concentrated in vacuo, and distilled through a 20-cm Vigreux column. The acetal begins to distill at about 70°C (0.5 mm), and the product (14–15 g) is collected until the temperature reaches about 100°C. Gas chromatographic analysis of the product shows it to be about 85% pure (yield 58–62%) (Note 6).

C. *Atropaldehyde*. The acetal (15 g), placed in a 100-mL flask fitted with a magnetic stirrer and a thermometer, is cooled to about 4°C in an ice bath. A mixture of 15 mL of formic acid and 4 mL of

water is similarly cooled and added in one lot with stirring to the acetal. The temperature drops to about −4°C. The homogenous mixture is stirred for 60 sec and then quenched by adding 15 mL of petroleum ether and 25 mL of water. The mixture is transferred to a separatory funnel and thoroughly shaken. The aqueous phase is extracted with two additional 15-mL portions of petroleum ether, and the combined extracts are dried as above with magnesium sulfate and concentrated in vacuo (Note 7). A mixture of 10 mL each of petroleum ether and diethyl ether is added to the crude aldehyde, and the solution is cooled to about −50°C. After 15 min the colorless crystals are filtered and washed with a few milliliters of the solvent cooled to 0°C. The yield of vacuum-dried product (Note 7) is 5.8–6.8 g (71–83%). Recrystallization from a mixture of 10 mL each of diethyl ether and petroleum ether as above gives 5–6 g, mp 38–40°C (Note 8) and (Note 9).

## 2. Notes

1. The checkers used a 1-L, three-necked "Morton" flask[2] containing deep vertical creases for more efficient mixing and temperature control. The sodium hydroxide solution was added to the stirred reaction mixture through the reflux condenser in one portion.
2. The submitters used Merck styrene 99%, stabilized with 4-tert-butylpyrocatechol. Triethylbenzylammonium chloride was prepared by refluxing equimolar amounts of triethylamine and benzyl chloride in ethanol for 2 hr and removing the solvent in vacuo. The salt is commercially available. The other reagents were technical grade.
3. The reaction is exothermic, and it may be a problem to keep the temperature low enough during the first 5 min. A bath with cold water must be kept ready below the flask. The methylene chloride may be added to moderate the reaction.
4. The organic layer is heavier than the aqueous phase. It may be necessary to allow the mixture to stand for an hour before the phases separate.
5. The product shows $^1$H NMR (60 MHz, $CCl_4$) δ: 1.87 (q, 2), 2.83 (triplet, 1), 7.20 (singlet, 5). The reported bp is 118–119°C (16 mm) or 114°C (13 mm).[3,4] Gas chromatographic analysis indicates the product to be 99% pure, $n_D^{23}$ 1.551.
6. The product shows $^1$H NMR (90 MHz, $CDCl_3$) δ: 1.18 (triplet J = 7 Hz, 6), 3.58 (multiplet, 4), 5.22 (singlet, 1), 5.54 (singlet, 2), 7.18–7.58 (multiplets, 5). Minor resonance signals near the foot of the triplet revealed the presence of 1-phenyl-2,2-diethoxycyclopropane as the major by-product. Gas chromatographic analyses on a 44-m SCOT column, 150–200°C, indicated that the crude product contained the ketal (10%), the starting material (2%), and an unidentified compound (2%). The submitters have not observed polymerization or other deterioration of the crude acetal when it was stored without special precautions in the laboratory for 2 months at ca. 20°C.
7. The aldehyde must be kept cold; see (Note 8). If the solution is cooled much below room temperature, crystallization of the aldehyde may take place and render some of the manipulations difficult. The crystals may be dissolved in diethyl ether.
8. The product shows $^1$H NMR (90 MHz, $CDCl_3$) δ: 6.11 (singlet, 1), 6.56 (singlet, 1), 7.36 (multiplet, 5), 9.72 (singlet, 1). Mass spectrum (70 eV, *m/e*, relative intensity): 132 ($M^+$, 51%), 104 (69%), 86 (100%), 78 (13%), 77 (35%). The crystalline aldehyde is unstable at room temperature. When kept for 24 hr in a vacuum-sealed ampoule at 20°C, the crystals slowly deliquesce. The aldehyde may, however, be kept at −6°C for 10 days without any observable deterioration.
9. Procedures B and C work well on a larger scale. Thus atropaldehyde was obtained in 20–26-g quantities from 0.5 mol of styrene (30–39%).

## 3. Discussion

The method presented here is a simple procedure for the preparation of pure atropaldehyde via its stable acetal, starting from inexpensive chemicals.

The described synthesis of 1,1-dichloro-2-phenylcyclopropane is a slightly modified version of published procedures.[3,4]

Syntheses of acetals of atropaldehyde have been reported previously, but all required either multistep sequences or difficultly accessible starting materials.[5,6] Thus the ethylene glycol acetal has been prepared from 2-phenylpropanal in a three-step procedure.[5] Ring openings of dihalocyclopropanes

to give acetals are well known.[7,8,9,10] The reaction of 1,1-dichloro-2-phenylcyclopropane with methanolic sodium methoxide has been shown to give 1-phenyl-2,2-dimethoxycyclopropane.[11]

The only described preparatively useful route to atropaldehyde is the hydrolysis of the ethylene glycol acetal mentioned above.[5] The present method is fast and affords labile aldehyde that is pure enough to allow crystallization. A cyclopropene is suggested to be an intermediate in the ring-opening reaction.[12] Nitro-substituted atropaldehydes have been prepared *via* a Mannich reaction.[13]

Formally the reactions amount to an α-formylation of styrene. The homologous aldehyde may be prepared from propenylbenzene.[10]

This preparation is referenced from:

- Org. Syn. Coll. Vol. 6, 10
- Org. Syn. Coll. Vol. 6, 187

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## References and Notes


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

petroleum ether

ethylene glycol acetal

Nitro-substituted atropaldehydes

ethanol (64-17-5)

diethyl ether (60-29-7)

sodium hydroxide (1310-73-2)

chloroform (67-66-3)

formic acid (64-18-6)

sodium methoxide (124-41-4)

benzyl chloride (100-44-7)

methylene chloride (75-09-2)

styrene (100-42-5)

propenylbenzene

magnesium sulfate (7487-88-9)

2-phenylpropanal (93-53-8)

triethylamine (121-44-8)

Cyclopropene (2781-85-3)

triethylbenzylammonium chloride (56-37-1)

Atropaldehyde,
Benzeneacetaldehyde, α-methylene (4432-63-7)

dichlorophenylcyclopropane

1,1-Dichloro-2-phenylcyclopropane (2415-80-7)

4-tert-butylpyrocatechol (98-29-3)

1-phenyl-2,2-diethoxycyclopropane

1-phenyl-2,2-dimethoxycyclopropane

Atropaldehyde diethyl acetal (80234-04-4)