



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.

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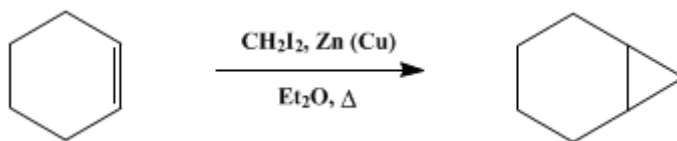
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These paragraphs were added in September 2014. The statements above do not supersede any specific hazard caution notes and safety instructions included in the procedure.

Organic Syntheses, Coll. Vol. 5, p.855 (1973); Vol. 41, p.72 (1961).

NORCARANE

[Bicyclo[4.1.0]heptane]



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1. Procedure

A. *Zinc-copper couple*. In a 500-ml. Erlenmeyer flask fitted with a magnetic stirrer are placed 49.2 g. (0.75 g. atom) of **zinc powder** (Note 1) and 40 ml. of 3% **hydrochloric acid**. The mixture is stirred rapidly for 1 minute, then the supernatant liquid is decanted. In a similar manner, the **zinc powder** is washed successively with three additional 40-ml. portions of 3% **hydrochloric acid**, five 100-ml. portions of distilled water, two 75-ml. portions of 2% aqueous **copper sulfate** solution, five 100-ml. portions of distilled water, four 100-ml. portions of absolute **ethanol**, and five 100-ml. portions of absolute **ether** (Note 2). The couple is finally transferred to a Büchner funnel, washed with additional anhydrous **ether**, covered tightly with a rubber dam, and suction-dried until it reaches room temperature. The zinc-copper couple is stored overnight in a vacuum desiccator over **phosphorus pentoxide** and is then ready for use in the preparation of **norcarane** (Note 3).

B. *Norcarane*. In a 500-ml. round-bottomed flask fitted with a magnetic stirrer and a reflux condenser protected by a drying tube filled with Drierite are placed 46.8 g. (0.72 g. atom) of zinc-copper couple and 250 ml. of anhydrous **ether**. A crystal of **iodine** is added, and the mixture is stirred until the brown color has disappeared (Note 4). A mixture of 53.3 g. (0.65 mole) of **cyclohexene** and 190 g. (0.71 mole) of **methylene iodide** is added in one portion (Note 5). The reaction mixture is then heated under gentle reflux with stirring. After 30–45 minutes, a mildly exothermic reaction occurs which may require cessation of external heating. After the exothermic reaction has subsided (approximately 30 minutes), the mixture is stirred under reflux for 15 hours. At the end of this time, most of the gray couple has been converted to finely divided **copper**. The **ether** solution is decanted (Note 6) from the **copper** and unreacted couple, which are then washed with two 30-ml. portions of **ether**. The washes are combined with the bulk of the solution and shaken with two 100-ml. portions of saturated **ammonium chloride** solution (Note 7), 100 ml. of saturated **sodium bicarbonate** solution, and 100 ml. of water. The **ether** solution is dried over anhydrous **magnesium sulfate** and filtered. The **ether** is distilled through a 20 × 2-cm. column packed with glass helices. The residue is distilled through a 45-cm. spinning-band column² to give 35–36 g. (56–58%) of **norcarane**, b.p. 116–117°, n_D^{25} 1.4546 (Note 8).

2. Notes

1. Mallinckrodt A. R. **zinc** dust was found satisfactory for this preparation. The checkers used Merck **zinc** dust but found it necessary to start with 51 g. of **zinc** in order to obtain sufficient couple for the next step.
2. The washings with **hydrochloric acid** should be done rapidly to avoid adsorption of bubbles of **hydrogen** on the **zinc** which make subsequent washings more difficult. The use of a magnetic stirrer greatly facilitates the washings. The absolute **ethanol** and absolute **ether** washings are decanted directly on a Büchner funnel to prevent loss of the couple.
3. This method of preparing zinc-copper couple is essentially that of Shank and Shechter.³ An equally active couple can be prepared by reduction of **cupric oxide** in the presence of **zinc powder**.⁴ Mallinckrodt A. R. wire-form **cupric oxide** (30 g.) is ground to a powder in a mortar and mixed with 240 g. of Mallinckrodt A. R. **zinc** dust. The mixture is placed in a Vycor combustion boat lined with copper foil, and a thermocouple is imbedded in the powder. The boat is placed in a Vycor tube heated

by a muffle furnace. A mixed gas (hydrogen, 65 l. per hour; nitrogen, 25 l. per hour) is passed through the tube while the temperature is raised to 500° during 4 hours. The mixture is kept at 500° for 30 minutes, and the tube is then allowed to cool to room temperature in a hydrogen atmosphere. The zinc-copper couple is obtained as dark gray lumps, which are ground to a fine powder in a mortar before use. In some instances, there is also found in the mixture a small amount of material which has apparently melted and agglomerated during heating. This shiny, metallic material is easily separated from the powdered couple and is not used in the preparation of norcarane.

4. The addition of iodine appears to promote the subsequent reaction of the zinc-copper couple with methylene iodide.

5. Commercial cyclohexene (Eastman Kodak) was distilled and passed over a column of activated alumina just before use. Methylene iodide (Matheson, Coleman and Bell) was distilled under reduced pressure, b.p. 50–51°/7 mm., and was stored in a brown bottle over iron wire.

6. The checkers filtered the solution because the finely divided copper and unreacted couple did not settle completely.

7. Care must be taken when adding the ammonium chloride solution to the ether solution since considerable heat is generated.

8. About 10–12 g. of cyclohexene, b.p. 82–84°, is recovered. The intermediate fraction, b.p. 84–116°, amounts to 1.5–2.5 g., and 10–12 g. of a dark residue remains in the still pot.

3. Discussion

This method is generally applicable to the stereospecific synthesis of cyclopropane derivatives from a large variety of substituted olefins.⁴

Three methods have been employed to generate iodomethylzinc iodide, the intermediate active in cyclopropanation: (1) reaction of methylene iodide with a zinc-copper couple in an ether solvent;⁴ (2) reaction of diazomethane with zinc iodide in an ether solvent;⁵ (3) reaction of methylene iodide with diethylzinc in ether or hydrocarbon solvents.⁶ Method (1) has been used more extensively to prepare cyclopropanes from olefins because it is generally the simplest, most convenient, and most economical variation when applicable.⁷ An active zinc-copper couple has been reported that is easily prepared and is recommended for the cyclopropanation reaction.⁸

Norcarane has been prepared by the reduction of 7,7-dichloronorcarane with sodium and alcohol,⁹ and by the light-catalyzed reaction of diazomethane with cyclohexene.⁹ The reaction of cyclohexene with methylene iodide and zinc-copper couple represents the most convenient preparation of norcarane which is of high purity.

This preparation is referenced from:

- Org. Syn. Coll. Vol. 6, 327
- Org. Syn. Coll. Vol. 8, 274

References and Notes

1. Contribution No. 622 from the Central Research Department, Experimental Station, E. I. du Pont de Nemours and Co., Wilmington, Del.
2. R. G. Nester, *Anal. Chem.*, **28**, 278 (1956).
3. R. S. Shank and H. Shechter, *J. Org. Chem.*, **24**, 1825 (1959).
4. H. E. Simmons and R. D. Smith, *J. Am. Chem. Soc.*, **81**, 4256 (1959).
5. G. Wittig and F. Winkler, *Ann.*, **656**, 18 (1962); *Ber.*, **97**, 2146 (1964).
6. J. Furukawa, N. Kawakata, and J. Mishimura, *Tetrahedron*, **24**, 53 (1968).
7. H. E. Simmons, T. L. Cairns, and C. M. Hoiness, *Org. Reactions*, in press.
8. E. LeGoff, *J. Org. Chem.*, **29**, 2048 (1964).
9. W. von E. Doering and A. K. Hoffman, *J. Am. Chem. Soc.*, **76**, 6162 (1954).

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

zinc-copper couple

ethanol (64-17-5)

hydrochloric acid (7647-01-0)

ether (60-29-7)

ammonium chloride (12125-02-9)

hydrogen (1333-74-0)

sodium bicarbonate (144-55-8)

Cyclohexene (110-83-8)

nitrogen (7727-37-9)

copper sulfate (7758-98-7)

copper (7440-50-8)

iodine (7553-56-2)

zinc,
zinc powder (7440-66-6)

sodium (13966-32-0)

cupric oxide (1317-38-0)

Methylene iodide (75-11-6)

diethylzinc (557-20-0)

cyclopropane (75-19-4)

magnesium sulfate (7487-88-9)

Diazomethane (334-88-3)

zinc iodide

Norcarane,
Bicyclo[4.1.0]heptane (286-08-8)

iodomethylzinc iodide

7,7-dichloronorcarane (823-69-8)

phosphorus pentoxide (1314-56-3)