



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.

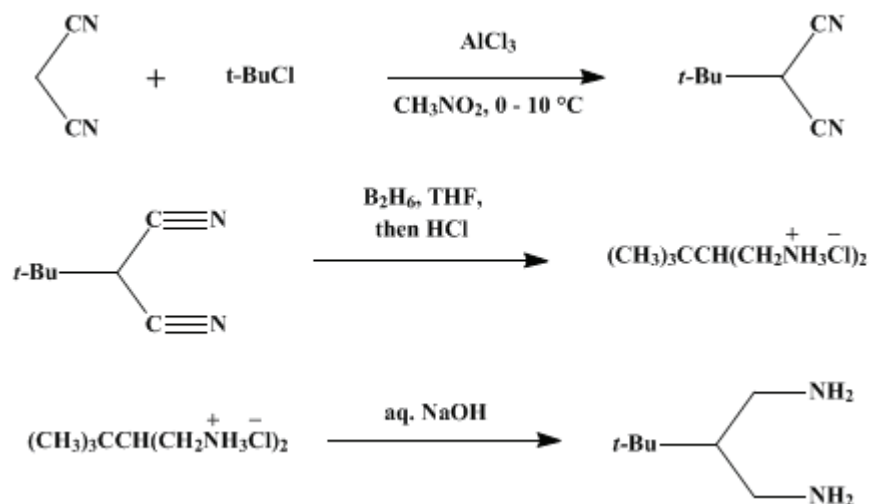
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These paragraphs were added in September 2014. The statements above do not supersede any specific hazard caution notes and safety instructions included in the procedure.

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2-*tert*-BUTYL-1,3-DIAMINOPROPANE

[1,3-Propanediamine, 2-(1,1-dimethylethyl)-]



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1. Procedure

A. *tert*-Butylmalononitrile. A dry, 2-l., three-necked flask equipped with a thermometer, mechanical stirrer, and a Claisen adapter fitted with a dropping funnel and condenser protected with a drying tube is charged with 200 ml. of nitromethane (Note 1). The flask is cooled to 0° in an ice-salt bath (Note 2), and anhydrous powdered aluminum chloride (90.0 g., 0.674 mole) is added, with slow stirring, through a powder funnel that temporarily replaces the thermometer. The temperature may rise to *ca.* 50° but quickly drops to 0°. A solution of 45.0 g. (0.682 mole) of malononitrile (Note 3) in 50 ml. of nitromethane is added through the dropping funnel at a rate such that the temperature is kept below 10° (approximately one hour). This is followed by slow, dropwise addition of a solution of 150 g. (1.62 moles) of *tert*-butyl chloride in 50 ml. of nitromethane at a rate such that the temperature is maintained below 10° (approximately 3–4 hours). The reaction mixture is stirred at 0–5° for 10 hours before 1 l. of saturated sodium hydrogen carbonate (*ca.* 80 g. in 1000 ml. of water) is added slowly and cautiously (still in the cold), keeping the temperature below 10°. The mixture is poured into a 3 or 4 l. beaker and solid sodium hydrogen carbonate (*ca.* 100 g.) is added in *small* portions, with stirring. The organic phase is separated, and the aqueous layer extracted with three half-volume portions of dichloromethane, which are concentrated on a rotary evaporator, combined with the organic phase, and concentrated further. The resultant brown oil is subjected to steam distillation. The first fraction is collected using a cold water condenser until solidification is observed in the condenser, at which time warm water is passed through the condenser and the receiver is changed (Note 5). The product is collected until occasional passage of cold water through the condenser no longer causes apparent solidification. At this point, the receiver is changed again, and a third fraction (*ca.* 500 ml.) is collected. The middle fraction is cooled in ice and filtered with vacuum through a medium fritted glass funnel, yielding 48–50 g. of light-yellow product. Extraction of the filtrate with two half-volumes of diethyl ether followed by evaporation gives an additional small amount (*ca.* 2 g.) of product. Another small crop of product may be gleaned from the first and third steam distillation fractions by separating any organic phase, removing distillable material on a rotary evaporator, cooling, and filtering the resulting solid. The total combined yield of crude product is 54–58 g. (65–70%). Further purification is accomplished by careful sublimation at 80–90 mm. (*ca.* 85°), giving 52–56.5 g. (63–68%) of white, waxy dinitrile, m.p. 76–79° with softening at 71°.

B. *2-tert-Butyl-1,3-diaminopropane*. A dry, 500-ml., three-necked flask fitted with a magnetic stirrer, nitrogen inlet, dropping funnel, and condenser attached to an acetone gas trap (Note 6) is flushed with dry nitrogen for 30 minutes and charged with purified *tert*-butylmalononitrile (30.5 g., 0.250 mole), sodium borohydride (17.5 g., 98% assay, 0.453 mole), and 150 ml. of dry tetrahydrofuran (Note 1). A dry nitrogen atmosphere is maintained while boron trifluoride diethyl etherate (85.3 g., 0.600 mole) (Note 7) in 50 ml. of dry tetrahydrofuran is added dropwise, with slow magnetic stirring, at a rate that permits gentle reflux. The addition takes about 4 hours (Note 8). The mixture is stirred for an additional 90 minutes, hydrolyzed by the very cautious dropwise addition of 30 ml. of concentrated hydrochloric acid, and transferred to a 1-l. flask, with rinsing by 100 ml. of tetrahydrofuran. The solution is evaporated to dryness on a rotary evaporator, yielding a dry, white, solid mass, to which is added a small portion (*ca.* 10 ml.) of 125 ml. of aqueous 40% (w/w) sodium hydroxide. The mixture is triturated with a glass rod and warmed on a steam bath until a reaction begins; heat is generated, and white smoke is evolved. The reaction is controlled by cooling in an ice bath. When the reaction appears to have subsided at room temperature, the trituration is repeated cautiously until all 125 ml. of the hydroxide solution is added. The resulting mixture is warmed for 30 minutes on a steam bath, with occasional stirring, cooled, and filtered with vacuum. The solid material is washed with ten 20-ml. portions of ether. The filtrate is separated, and the aqueous phase is extracted with three 100-ml. portions of ether. The combined ethereal extracts and organic phase are dried over anhydrous sodium sulfate. The drying agent is filtered and washed with ether, and the filtrate concentrated on a rotary evaporator. The residue is fractionally distilled at reduced pressure through a short Vigreux column. After removal of residual solvent and collection of a small forerun, 11.5–15.5 g. (36–48%) of product is obtained, b.p. 92.5–95° (21 mm.), 96–98° (27 mm.), n_D^{28} 1.4570–1.4585. Analysis of the product by GC (OV-1 column) indicated the purity to be *ca.* 95% (Note 9).

2. Notes

1. Fisher Scientific Company certified reagent grade was used without further purification from a freshly opened bottle.
2. As a convenience, the reaction may be conducted in a refrigerated room, in which case it will be unnecessary to replenish the ice during the course of the reaction.
3. Malononitrile was obtained from Eastman Organic Chemicals and distilled prior to use, b.p. 80–82° (3 mm.).
4. The commercial material was distilled prior to use, b.p. 50–51°.
5. Passing warm water through the condenser prevents blockage by solid product; otherwise, pressure may build and force the joints apart. As an alternative, steam may be passed through the condenser periodically.
6. Impure diborane is a hazardous material and may combust explosively on contact with air. Therefore, precautions must be taken to prevent escape from the reaction.
7. The commercial material was distilled prior to use, b.p. 59–60° (20 mm.). The material employed should not be more than a few days old.
8. The duration of the reaction is important and should not be curtailed. For example, if one is operating on a one-tenth scale, the reaction should be heated at gentle reflux for an additional 3.5 hours after the addition (25 minutes).
9. A sample of the compound, collected by GC, gave the correct analyses for carbon, hydrogen, and nitrogen. Two solid derivatives were prepared in good yield and both gave correct analyses.

3. Discussion

This preparation illustrates the alkylation of malononitrile under acid-catalyzed conditions, and the use of diborane for the reduction of a dinitrile to a diamine. The procedure for the preparation of *tert*-butylmalononitrile has been outlined briefly by Boldt and co-workers.² The generation of diborane *in situ* and the general method for nitrile reduction is that described by Brown and co-workers.³ Attempts to reduce the dinitrile to the diamine by other methods including catalytic hydrogenation (5% rhodium on alumina, 5 atm.), lithium aluminum hydride, and lithium aluminum hydride–aluminum chloride were singularly unsuccessful.

References and Notes

1. Department of Chemistry, Drexel University, Philadelphia, Pennsylvania, 19104.
 2. P. Boldt and W. Thielecke, *Angew. Chem. Int. Ed. Engl.*, **5**, 1044 (1966); P. Boldt and L. Schulz, Ger. Pat. 1,200,298 (1965) [*Chem. Abstr.*, **63**, 16221e (1965)]; P. Boldt and L. Schulz, *Naturwissenschaften*, **51**, 288 (1964).
 3. H. C. Brown and B. C. Subba Rao, *J. Am. Chem. Soc.*, **82**, 681 (1960); and more recently, H. C. Brown, P. Heim, and N. M. Yoon, *J. Am. Chem. Soc.*, **92**, 1637 (1970).
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Appendix Chemical Abstracts Nomenclature (Collective Index Number); (Registry Number)

diborane

hydrochloric acid (7647-01-0)

ether,
diethyl ether (60-29-7)

hydrogen (1333-74-0)

sodium hydroxide (1310-73-2)

sodium hydrogen carbonate (144-55-8)

sodium sulfate (7757-82-6)

nitrogen (7727-37-9)

carbon (7782-42-5)

aluminum chloride (3495-54-3)

tert-Butyl chloride (507-20-0)

hydroxide (14280-30-9)

Nitromethane (75-52-5)

dichloromethane (75-09-2)

Malononitrile (109-77-3)

Tetrahydrofuran (109-99-9)

lithium aluminum hydride (16853-85-3)

boron trifluoride diethyl etherate (109-63-7)

sodium borohydride (16940-66-2)

rhodium (7440-16-6)

1,3-Propanediamine, 2-(1,1-dimethylethyl)-,
2-tert-Butyl-1,3-diaminopropane (56041-82-8)

tert-Butylmalononitrile (4210-60-0)