



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.

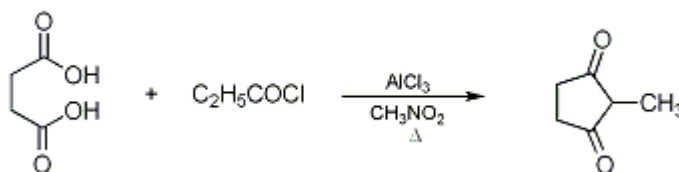
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September 2014: The paragraphs above replace the section "Handling and Disposal of Hazardous Chemicals" in the originally published version of this article. The statements above do not supersede any specific hazard caution notes and safety instructions included in the procedure.

Organic Syntheses, Coll. Vol. 9, p.570 (1998); Vol. 70, p.226 (1992).

2-METHYL-1,3-CYCLOPENTANEDIONE

[1,3-Cyclopentanedione, 2-methyl-]



Submitted by Philip G. Meister, Matthew R. Sivik, and Leo A. Paquette¹.
Checked by David L. Coffen

1. Procedure

CAUTION! These operations result in the evolution of considerable amounts of hydrogen chloride and should therefore be performed in a well-ventilated hood

A dry, 5-L, three-necked, round-bottomed flask equipped with a nitrogen inlet, mechanical stirrer (Note 1), and an efficient reflux condenser (Note 2) is charged with 500 mL of dry nitromethane (Note 3). Stirring is begun and 1000 g (7.50 mol) of anhydrous aluminum chloride (Note 4) is added, followed by an additional 500 mL of dry nitromethane. After the reaction mixture cools to room temperature, the gas inlet is replaced with a Gooch tube attached to a 500-mL filter flask containing 295 g (2.5 mol) of powdered succinic acid (Note 5). The nitrogen line is now attached to the sidearm of this flask. The succinic acid is introduced in portions during 1.5 hr (*CAUTION: This process evolves a large volume of hydrogen chloride gas which may cause the mixture to foam. Small quantities of the acid should be added at a time and the foaming should be allowed to subside prior to introduction of the next amount*). The mixture is stirred for 2 hr and the Gooch tube is replaced by a 500-mL pressure-equalizing addition funnel equipped with a nitrogen inlet. Propionyl chloride (650 mL, 694 g, 7.5 mol) (Note 6) is added dropwise during 30 min and the reaction mixture is brought to reflux for 2 hr, cooled, and poured onto 4 L of crushed ice. After the precipitated brown solid is cooled in an ice bath, it is separated by filtration (Note 7) and washed with 250 mL of brine and 250 mL of cold (0°C) toluene. The material is dissolved in 7 L of boiling water containing 20 g of decolorizing carbon, then filtered while still hot (Note 8). The filtrate is concentrated to a volume of 5 L, then cooled in an ice bath. The crystals are collected by suction filtration and air-dried to give 157–171 g (56–61%) of 2-methyl-1,3-cyclopentanedione (Note 9). The mother liquors are concentrated to approximately 1.5 L by rotary evaporation. The solution is boiled until crystals form, cooled in ice, and filtered to give an additional 20–23 g (7–8%) of product (63–69% overall yield).

2. Notes

- Efficient stirring is mandatory.
- The top of the condenser is equipped with a gas outlet leading via an oil bubbler into a large alkali bath or to a water aspirator. A steady stream of nitrogen should be maintained at all times.
- Commercial nitromethane was dried over calcium chloride, filtered, and distilled. The forerun was discarded. The checker used 96% spectrophotometric grade as received from Aldrich Chemical Company, Inc.
- Aluminum chloride, which was obtained from Fluka Chemical Corporation, generates heat during dissolution.
- Succinic acid was obtained in powdered form from Fluka Chemical Corporation. If granular succinic acid is to be used, it should be pulverized to aid in dissolution.
- Propionyl chloride was purchased from Fluka Chemical Corporation and Aldrich Chemical Company, Inc.

7. Two 17-cm Büchner funnels should be used simultaneously. However, if left to digest overnight, the mixture can be conveniently filtered using a 3-L sintered glass funnel.
8. Use of a 17-cm Büchner funnel preheated with hot tap water has proven most convenient for this purpose. The checker used an oven-heated, 3-L sintered glass funnel layered with Celite.
9. The crystals are off-white to tan, mp 211–212°C. It appears to exist in the enol form: ¹H NMR (200 MHz, CDCl₃/d₆-DMSO) δ: 1.05 (s, 3 H), 2.0 (s, 4 H), 10.7 (s, 1 H).

Waste Disposal Information

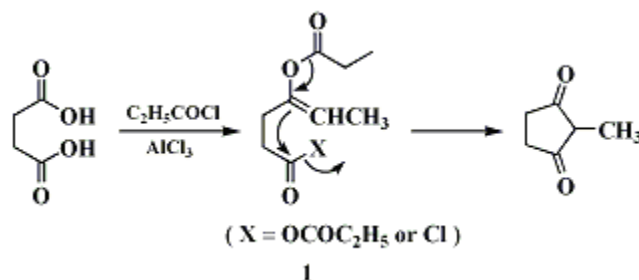
All toxic materials were disposed of in accordance with "Prudent Practices in the Laboratory"; National Academy Press; Washington, DC, 1995.

3. Discussion

A variety of methods have been published to achieve the preparation of 2-methyl-1,3-cyclopentanedione.^{2,3,4,5,6} The present method, which was first reported by Schick, Lehmann, and Hilgetag,⁴ provides for the acquisition of large amounts of the product in a single step from inexpensive starting materials. The alternative multistep procedures are appreciably more laborious and costly.

The importance of the title compound as an intermediate in organic synthesis goes unquestioned, having been produced on an industrial scale. The syntheses and reactions of this class of compounds have recently been summarized in an extensive review of the subject.⁷

The success of the present process appears to rest on the facility with which intermediate **1** is produced and its capacity for ready intramolecular cyclization.⁴



References and Notes

1. Department of Chemistry, The Ohio State University, Columbus, OH 43210.
 2. Orchin, M.; Butz, L. W. *J. Am. Chem. Soc.* **1943**, *65*, 2296.
 3. Grenda, V. J.; Lindberg, G. W.; Wendler, N. L.; Pines, S. H. *J. Org. Chem.* **1967**, *32*, 1236.
 4. Schick, H.; Lehmann, G.; Hilgetag, G. *Chem. Ber.* **1969**, *102*, 3238.
 5. John, J. P.; Swaminathan, S.; Venkataramani, P. S. *Org. Synth., Coll. Vol. V* **1973**, 747.
 6. Hengartner, U.; Chu, V. *Org. Synth., Coll. Vol. VI* **1988**, 774.
 7. Schick, H.; Eichhorn, I. *Synthesis* **1989**, 477.
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Appendix

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

brine

calcium chloride (10043-52-4)

hydrogen chloride (7647-01-0)

nitrogen (7727-37-9)

Succinic acid (110-15-6)

carbon (7782-42-5)

aluminum chloride (3495-54-3)

toluene (108-88-3)

Nitromethane (75-52-5)

propionyl chloride (79-03-8)

1,3-Cyclopentanedione, 2-methyl-,
2-Methyl-1,3-cyclopentanedione (765-69-5)