Organic Syntheses

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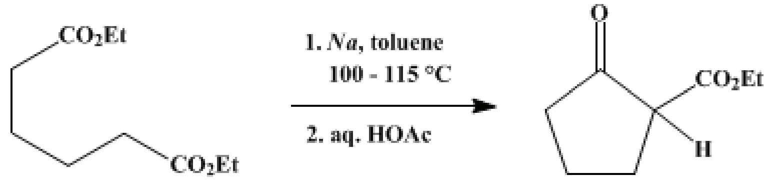
*These paragraphs were added in September 2014. The statements above do not supersede any specific hazard caution notes and safety instructions included in the procedure.*

DOI:10.15227/orgsyn.017.0030

*Organic Syntheses, Coll. Vol. 2, p.116 (1943); Vol. 17, p.30 (1937).*

# 2-CARBETHOXYCYCLOPENTANONE

## [Cyclopentanecarboxylic acid, 2-oxo-, ethyl ester]



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Checked by Louis F. Fieser and T. L. Jacobs.

## 1. Procedure

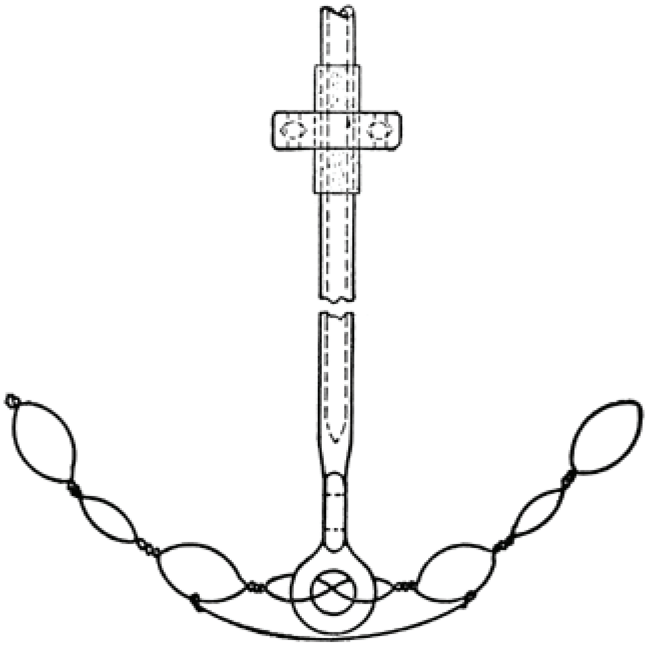
A 3-l. three-necked, round-bottomed flask is fitted with a mercury-sealed mechanical stirrer (Note 1), a 250-cc. dropping funnel, and a reflux condenser protected from the air by means of a calcium chloride tube. In the flask are placed 23 g. (1 gram atom) of sodium and 250 cc. of dry toluene (Note 2). The stirrer is started, and 202 g. (1 mole) of ethyl adipate (p. 264) is added from the dropping funnel at such a rate that the addition is complete in about two hours. The reaction usually starts immediately on addition of the ethyl adipate. The temperature of the oil bath is maintained at 100–115° during the addition and for about five hours longer. Dry toluene is added through the condenser from time to time in order to keep the reaction mixture fluid enough for efficient stirring (Note 3). Between 750 cc. and 1 l. of toluene is added in this manner.

The reaction mixture is cooled in an ice bath and slowly poured into 1 l. of 10 per cent acetic acid cooled to 0° (ice-salt mixture). The toluene layer is separated, washed once with water, twice with cooled 7 per cent sodium carbonate solution, and again with water. The toluene is removed by distillation at ordinary pressure, and the residue is distilled under reduced pressure. The yield is 115–127 g. (74–81 per cent of the theoretical amount) of a product boiling at 83–88°/5 mm. or 79–84°/3 mm. (Note 4) and (Note 5).

## 2. Notes

1. The Hershberg[1] stirrer, shown in part in Fig. 4, provides very efficient agitation of this or other pasty mixtures. Two glass rings are sealed to the end of a stirrer shaft at right angles to one another, and each is threaded with B. and S. No. 18 Chromel or Nichrome wire (in the drawing the wire is shown only for the lower ring; the upper wire is not provided with a cross brace). The stirrer is easily introduced and removed through a narrow opening, and in operation it follows the contour of the flask. It is convenient to use glass tubing for the stirrer shaft and to provide it with a pair of small ball bearings slipped on over short sections of rubber tubing (one of these bearings is shown in the drawing).

**Fig. 4**



The yields reported were obtained using this stirrer; with various other stirrers it was seldom possible to duplicate the results.

2. The toluene is dried by distillation from sodium.

3. If the reaction mixture is allowed to become too thick for efficient stirring, or if the temperature of the oil bath is raised above 115–120°, the solid sodium derivative will cake on the sides of the flask. This makes the complete removal of the reaction mixture from the flask and the decomposition of the sodium derivative more difficult.

4. According to the literature,[2], [3] the product obtained in this manner may contain ethyl adipate. To remove this, the product is cooled to 0° and run slowly into 600 cc. of 10 per cent potassium hydroxide solution maintained at 0° with ice-salt. Water is added until the salt which separates has dissolved, and the cold alkaline solution is extracted twice with 200-cc. portions of ether. The alkaline solution, kept at 0°, is run slowly into 900 cc. of 10 per cent acetic acid solution with stirring, the temperature remaining below 1° (ice-salt). The oil which separates is taken up in 400 cc. of ether, and the aqueous solution is extracted with four 250-cc. portions of ether. The ether extract is washed twice with cold 7 per cent sodium carbonate solution and dried over sodium sulfate. After removal of the ether the residue is distilled, b.p. 79–81°/3 mm. The recovery is only 80–85 per cent, and in a well-conducted preparation the ethyl adipate eliminated amounts to less than 1 per cent of the total product. Unless the preparation has proceeded poorly the tedious purification ordinarily is best omitted.

If material free from all traces of ethyl adipate is desired, time and material can be saved by omitting the first distillation (observation of the checkers). The toluene solution of the crude 2-carbethoxycyclopentanone is cooled to 0° and added slowly with stirring to 300 cc. of 10 per cent potassium hydroxide solution maintained below 1°. Cold water is added until the slightly soluble potassium salt has dissolved. The toluene layer is then separated and washed twice with 150-cc. portions of cold, 10 per cent potassium hydroxide solution. After each washing, cold water is added to dissolve any solid which separates. The toluene solution, now very light yellow in color, is finally washed twice with 150-cc. portions of cold water. The aqueous solutions are combined, extracted with 250 cc. of ether, and treated as described for the alkaline solution above. The yield is 100–115 g. (64–74 per cent).

5. The following procedure gives slightly better yields.

A 3-l. round-bottomed flask, which contains 50 g. of "molecular" sodium, is fitted with a reflux condenser protected from the air by means of a calcium chloride tube, and 1250 cc. of benzene, dried by distilling over sodium, is added. Three hundred and three grams (1.5 moles) of ethyl adipate is then added, in one lot, followed by 3 cc. of absolute alcohol. The flask is warmed on the steam bath until, after a few minutes, a vigorous reaction commences and a cake of the sodio-compound begins to separate. During this stage the flask is kept well shaken by hand. After the spontaneous reaction has abated, the mixture is refluxed on the steam bath overnight, then cooled in ice. The product is decomposed with ice and 6 *N* hydrochloric acid, the acid being added until Congo red paper is turned blue. The benzene layer is separated, and the aqueous layer is extracted once with 200 cc. of benzene. The united extract is washed with 200 cc. of 5 per cent sodium carbonate solution and 300 cc. of water. The solution is placed in a 3-l. distilling flask and the benzene and water are removed by distillation under ordinary pressure. The residue is fractionated under reduced pressure. The yield is 185–192 g. (79–82 per cent of the theoretical amount) of a product boiling at 108–111°/15 mm. On redistillation the product boils at 102°/11 mm.

The significant features of this procedure are the addition of alcohol, which eliminates or greatly reduces the induction period, and the excess of sodium, which contributes to the completeness of the reaction. The benzene, used as a solvent, may be replaced by petroleum ether (b.p. 60–80°).

The once-distilled carbethoxycyclopentanone is sufficiently pure for ordinary synthetic purposes; it gives a 93 per cent yield of the Cmethyl derivative. (R. P. Linstead and E. M. Meade, private communication.[4] Checked by R. L. Shriner and N. S. Moon.)

## 3. Discussion

2-Carbethoxycyclopentanone has been prepared from ethyl adipate by the action of sodium,[5], [2], [3], [4] sodamide,[6] and sodium ethoxide.[7] The method in the above procedure is based upon the work of Cornubert and Borrel.[2]

This preparation is referenced from:

- Org. Syn. Coll. Vol. 2, 57
- Org. Syn. Coll. Vol. 2, 128
- Org. Syn. Coll. Vol. 2, 139
- Org. Syn. Coll. Vol. 2, 539
- Org. Syn. Coll. Vol. 3, 3
- Org. Syn. Coll. Vol. 3, 16
- Org. Syn. Coll. Vol. 3, 121
- Org. Syn. Coll. Vol. 4, 68
- Org. Syn. Coll. Vol. 4, 313
- Org. Syn. Coll. Vol. 4, 771
- Org. Syn. Coll. Vol. 4, 866
- Org. Syn. Coll. Vol. 5, 76
- Org. Syn. Coll. Vol. 5, 121
- Org. Syn. Coll. Vol. 5, 300
- Org. Syn. Coll. Vol. 5, 424
- Org. Syn. Coll. Vol. 5, 572
- Org. Syn. Coll. Vol. 5, 966
- Org. Syn. Coll. Vol. 8, 522

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## References and Notes

1. Hershberg, Ind. Eng. Chem., Anal. Ed. **8**, 313 (1936).
2. Cornubert and Borrel, Bull. soc. chim. (4) **47**, 301 (1930).
3. Bouveault, ibid. (3) **21**, 1019 (1899); Zelinsky and Ouchakoff, ibid. (4) **35**, 484 (1924).
4. Linstead and Meade, J. Chem. Soc. **1934**, 940.
5. van Rysselberge, Bull. acad. roy. Belg. (Sci.) [5] **12**, 171 (1926); (Chem. Zentr. **1926**, 11, 1846).
6. Bouveault and Locquin, Bull. soc. chim. (4) **3**, 440 (1908).
7. Wislicenus and Schwanhäusser, Ann. **297**, 112 (1897).

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

petroleum ether

alcohol (64-17-5)

hydrochloric acid (7647-01-0)

acetic acid (64-19-7)

Benzene (71-43-2)

ether (60-29-7)

Ethyl adipate (626-86-8)

sodium carbonate (497-19-8)

sodium sulfate (7757-82-6)

potassium hydroxide (1310-58-3)

toluene (108-88-3)

sodium (13966-32-0)

sodium ethoxide (141-52-6)

2-Carbethoxycyclopentanone,
Cyclopentanecarboxylic acid, 2-oxo-, ethyl ester,
carbethoxycyclopentanone (611-10-9)

sodamide (7782-92-5)