



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.

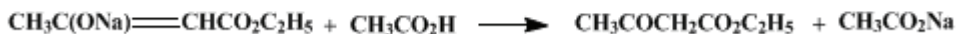
The procedures described in *Organic Syntheses* are provided as published and are conducted at one's own risk. *Organic Syntheses, Inc.*, its Editors, and its Board of Directors do not warrant or guarantee the safety of individuals using these procedures and hereby disclaim any liability for any injuries or damages claimed to have resulted from or related in any way to the procedures herein.

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. 1, p.235 (1941); Vol. 6, p.36 (1926).

ETHYL ACETOACETATE

[Acetoacetic acid, ethyl ester]



Submitted by J. K. H. Inglis and K. C. Roberts.

Checked by C. S. Marvel and F. E. Kendall.

1. Procedure

In a 2-l. round-bottomed flask, fitted with an efficient reflux condenser, are placed 500 g. (531 cc., 5.7 moles) of [ethyl acetate](#) ([Note 1](#)), and 50 g. (2.2 atoms) of clean [sodium](#) wire or finely sliced [sodium](#) ([Note 2](#)) is added. The reaction is at first quite slow, and must be started by warming on a water bath ([Note 3](#)). After the reaction is once started it proceeds vigorously and cooling is then necessary in order to avoid loss of material through the condenser. When the rapid reaction slows down, the reaction mixture is heated on a water bath until the [sodium](#) has completely dissolved. This usually requires about one and one-half hours. At this stage the reaction mixture should be a clear red liquid with a green fluorescence.

This solution is then cooled and made slightly acid by adding about 275 cc. of 50 per cent [acetic acid](#) ([Note 4](#)). Salt is added if necessary to cause the ester to separate. The ester layer is separated, dried over [calcium chloride](#), and fractionally distilled under reduced pressure from a modified Claisen flask (p. 130).

The yield of ester boiling at 76–80°/18 mm. is 105–110 g. (28–29 per cent of the theoretical amount based on the [ethyl acetate](#)) ([Note 5](#)).

2. Notes

1. The grade of [ethyl acetate](#) used is very important. It must be entirely free from water and should contain about 2–3 per cent of [alcohol](#). The absolute [ethyl acetate](#) of the U. S. Industrial Alcohol Company is satisfactory for use. If this grade is not available, ordinary [ethyl acetate](#) may be purified by washing it with twice its volume of water and drying over fused [potassium carbonate](#), from which it is decanted, and used directly. The [ethyl acetate](#) purified in this way contains enough [ethyl alcohol](#) to allow the reaction to run well. The [ethyl acetate](#) in the wash water may be recovered by distilling through a short column from a steam cone until the vapors reach a temperature of 72°. Dry [ethyl acetate](#) containing 2–3 per cent of [alcohol](#) has a boiling point range of 2 to 3°.

If the ester is dry enough to use in this reaction it will not give a gelatinous mass of [sodium hydroxide](#) when treated with a little [sodium](#).

2. [Sodium](#) wire and finely sliced [sodium](#) are equally good to use in this reaction. It is important to avoid exposure of the [sodium](#) to the air which converts part of it into [sodium hydroxide](#).

3. It is convenient to arrange the water bath so that it may be heated by passing in steam or cooled by running in cold water.

4. It is advisable to avoid a large excess of [acetic acid](#) since it increases the solubility of the ester in water.

5. When larger runs are made, the yields increase; thus 2000 g. of [ethyl acetate](#) and 200 g. of [sodium](#) give 515–568 g. of [ethyl acetoacetate](#). From a run of this size it is possible to recover about 700 cc. of [ethyl acetate](#). An approximately proportional recovery is obtained in smaller runs.

The yield is based on [ethyl acetate](#) and not on [sodium](#), because it is uncertain whether one atom or two atoms of [sodium](#) react with one mole of [ethyl acetate](#).

3. Discussion

Ethyl acetoacetate can be prepared from ethyl acetate by the action of sodium,¹ sodium ethoxide,² sodamide,³ and calcium.⁴ When the condensation, using sodium ethoxide, is carried out in such a manner as to remove the alcohol formed, the yield is reported to be 80 per cent of the theoretical amount.⁵

This preparation is referenced from:

- Org. Syn. Coll. Vol. 1, 248
- Org. Syn. Coll. Vol. 1, 360
- Org. Syn. Coll. Vol. 2, 202
- Org. Syn. Coll. Vol. 2, 262
- Org. Syn. Coll. Vol. 2, 266
- Org. Syn. Coll. Vol. 2, 422

References and Notes

1. Geuther, Jahresber. 323 (1863); *ibid.* 302 (1865); Z. Chem. 5 (1866); Wislicenus, Ann. **186**, 214 (1877); Friessner, J. prakt. Chem. (2) **65**, 528 (1902); Claisen, Ber. **38**, 709 (1905); Tingle and Gorsline, Am. Chem. J. **40**, 76 (1908); J. Am. Chem. Soc. **30**, 1876 (1908); Backhaus, U.S. pat. 1,425,626 [C. A. **16**, 3314 (1922)]; Carter, U. S. pat. 1,472,324 [C. A. **18**, 400 (1924)]; Robert, J. Soc. Chem. Ind. **43**, 295T (1924).
2. Geuther, Z. Chem. 653 (1868); Michael, Ber. **33**, 3735 (1900); Claisen, Ber. **38**, 709 (1905); Higley, Am. Chem. J. **37**, 299 (1907); Snell and McElvain, J. Am. Chem. Soc. **53**, 2310 (1931); Alexander Wacker Ges. für elektrochemische Industrie, Ger. pat. 526,691 [C. A. **25**, 4891 (1931)].
3. Titherley, J. Chem. Soc. **81**, 1527 (1902); Freund and Speyer, Ber. **35**, 2321 (1902).
4. Perkin and Pratt, J. Chem. Soc. **95**, 161 (1909).
5. Roberts and McElvain, J. Am. Chem. Soc. **59**, 2007 (1937).

Appendix

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

ethyl alcohol,
alcohol (64-17-5)

calcium chloride (10043-52-4)

potassium carbonate (584-08-7)

acetic acid (64-19-7)

ethyl acetate (141-78-6)

sodium hydroxide (1310-73-2)

calcium (7440-70-2)

sodium (13966-32-0)

sodium ethoxide (141-52-6)

Ethyl acetoacetate,
Acetoacetic acid, ethyl ester (141-97-9)

Copyright © 1921-2005, Organic Syntheses, Inc. All Rights Reserved