



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](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.

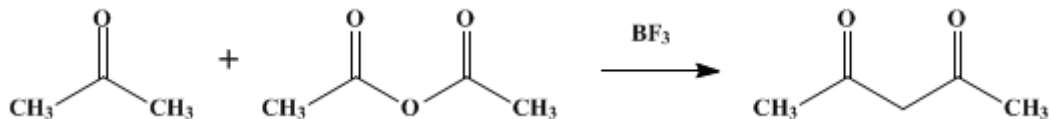
*These paragraphs were added in September 2014. The statements above do not supersede any specific hazard caution notes and safety instructions included in the procedure.*

*Organic Syntheses, Coll. Vol. 3, p.16 (1955); Vol. 20, p.6 (1940).*

## ACETYLACETONE

[Diacetylmethane; 2,4-pentanedione]

### [I. BORON TRIFLUORIDE METHOD]



Submitted by C. E. Denoon, Jr.

Checked by Homer Adkins and Ivan A. Wolff.

### 1. Procedure

One hundred and sixteen grams (2 moles) of acetone (Note 1) and 510 g. (5 moles) of reagent grade acetic anhydride are placed in a 2-l. three-necked flask and cooled in an ice-salt bath. One neck of the flask is stoppered; the second neck contains a tube for admitting boron trifluoride; and the third neck contains an outlet tube leading to an alkali trap to catch any unabsorbed boron trifluoride. Commercial grade boron trifluoride (Note 2) is passed through a Kjeldahl bulb, to prevent the reaction mixture from sucking back into the cylinder, and is then bubbled into the reaction mixture at such a rate that 500 g. is absorbed in about 5 hours (2 bubbles per second). The reaction mixture is poured into a solution of 800 g. of hydrated sodium acetate in 1.6 l. of water contained in a 5-l. flask. The mixture is then steam-distilled and the distillate collected in the following portions: 1 l., 500 ml., 500 ml., 400 ml.

A solution of reagent grade hydrated copper acetate is made by dissolving 240 g. of the salt in 3 l. of water at about 85° and filtering from any basic acetate. The copper salt of acetylacetone is then precipitated by adding 1.4 l. of the hot copper acetate solution to the first fraction of the acetylacetone, 700 ml. to the second, 500 ml. to the third, and 400 ml. to the fourth fraction. After standing for 3 hours, or better overnight, in a refrigerator the salt is filtered, washed once with water, and sucked dry. The salt is shaken in a separatory funnel with 800 ml. of 20% sulfuric acid and 800 ml. of ether, and the ether layer is removed. The aqueous layer is extracted with 400 ml. and then 200 ml. of ether. The combined extracts are dried with 250 g. of anhydrous sodium sulfate, and the ether is removed by distillation. The residue is distilled through a Widmer column (Note 3) and yields 160–170 g. of acetylacetone boiling at 134–136° (80–85% based on acetone).

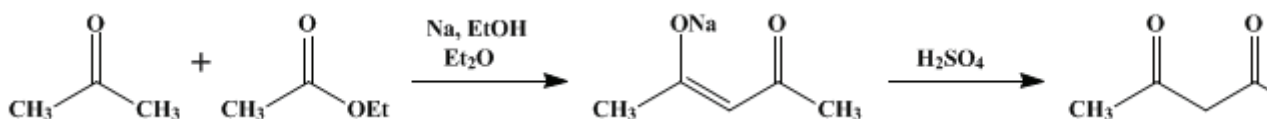
### 2. Notes

1. Acetone is preferably dried over anhydrous potassium carbonate or anhydrous calcium sulfate, followed by phosphorus pentoxide if a very dry product is required. Calcium chloride is commonly used (100–150 g. per liter), but this is less satisfactory since it combines chemically with acetone.<sup>1</sup> For this preparation the checkers used acetone that had been dried over calcium chloride, followed by distillation from phosphorus pentoxide.

2. Boron trifluoride may be purchased in cylinders from Harshaw Chemical Company, Cleveland, Ohio.

3. The Widmer column used contained a spiral 15 cm. in length, 13 mm. in diameter, with 15 turns of the helix.

### [II. SODIUM ETHOXIDE METHOD]



Submitted by Homer Adkins and James L. Rainey.

Checked by R. L. Shriner and Neil S. Moon.

## 1. Procedure

Sixty-nine grams (3 gram atoms) of **sodium**, from which all the oxide coating has been cut away, and 400 ml. of dry **xylene** (Note 1) are placed in a 1-l. round-bottomed flask and heated until the **sodium** is melted. The flask is closed with a rubber stopper (Note 2), and the **sodium** is finely powdered by vigorous shaking. The contents of the flask are transferred to a 3-l. three-necked flask, and the **xylene** decanted. The **sodium** is washed with two 100-ml. portions of anhydrous **ether** (Note 3) by decantation. One liter of anhydrous **ether** is added, and the flask is placed on a steam bath and fitted with a condenser, Hershberg stirrer (*Org. Syntheses*, 17, 31), and a 250-ml. dropping funnel. The condenser and dropping funnel are protected by drying tubes containing absorbent cotton (Note 4). One hundred and thirty-eight grams (175 ml., 3 moles) of anhydrous **ethanol** is placed in the dropping funnel, and the stirrer is started. The alcohol is dropped in over a period of 2–3 hours with gentle refluxing. The reaction mixture is refluxed with stirring for 6 hours (Note 5) after the addition of the alcohol. The stirrer is stopped, the condenser turned downward, and the **ether** distilled as completely as possible from the steam bath (Note 6).

The condenser is again arranged for refluxing, and 1.2 l. of **ethyl acetate** (Note 7) is added to the warm **sodium ethoxide** through the separatory funnel as rapidly as possible. The stirrer is started immediately, and 174 g. (220 ml., 3 moles) of **acetone** (Note 1, p. 17) is dropped in over a period of 15–20 minutes, refluxing being maintained by heating if necessary. Addition of the **acetone** must be started as soon as the **ethyl acetate** has been added. During the addition the solution becomes quite red, and then the mixture turns brown (Note 8). The mixture is refluxed for 1 hour; the stirrer is then stopped and the contents of the flask are allowed to stand at room temperature for 12 hours, during which time crystals of the **sodium** salt separate.

The liquid layer is decanted into a 5-l. flask, and the **sodium** salt of the diketone is dissolved and washed into the flask with 2.5 l. of ice water. After the salt is dissolved, the ester layer is separated as soon as possible (Note 9). The water layer is extracted twice with 300-ml. portions of **ether**, and the **ether** extract is discarded. To the water solution is added ice-cold dilute **sulfuric acid** (150 g. of concentrated **sulfuric acid** and 400 g. of cracked ice) until the solution is just acid to litmus. The diketone is extracted from the solution with four 300-ml. portions of **ether**. The combined **ether** extracts are dried for 24 hours over 60 g. of anhydrous **sodium sulfate** in the icebox. The **ether** solution is decanted into a 2-l. round-bottomed flask, and the **sodium sulfate** is extracted with 100 ml. of anhydrous **ether**. This extract is added to the **ether** solution, and the **ether** is distilled by means of a steam bath. The residue is transferred to a 500-ml. flask, rinsing with a little **ether**, and distilled through a Widmer column, the portion boiling between 130° and 139° being collected. This fraction is dried over 5 g. of anhydrous **potassium carbonate** for 1 hour and, after the **carbonate** has been removed, is redistilled through the Widmer column. The portion boiling at 134–136° is collected; it amounts to 115–136 g. (38–45% based on **acetone**).

## 2. Notes

1. The **xylene** is dried by distillation from **sodium**.
2. Rubber stoppers should be used throughout, including the drying of reagents, as corks contain some moisture. The stoppers should be boiled in 10% **sodium hydroxide** solution for 2 hours, thoroughly washed with dilute **acetic acid**, and dried.
3. Commercial anhydrous **ethyl ether** and **ethanol** are satisfactory. If these are unavailable, the **ether** should be purified as for use in the Grignard reaction and the **ethanol** as described in *Org. Syntheses Coll. Vol. 1*, 249 (1941).
4. Absorbent cotton is an excellent drying agent and more convenient for drying tubes than anhydrous **calcium chloride**.<sup>2</sup> It is possible to keep **maleic anhydride** in a flask, closed only by a plug of absorbent cotton, for 3 weeks without appreciable change in the titration value (F. P. Pingert, private communication).
5. The period of heating varies somewhat with the size of the powdered **sodium**. Almost all the **sodium** should be used up before removal of the **ether**. However, a few small pieces do no harm.

6. The success of the reaction depends upon the quality of the [sodium ethoxide](#) used. The product at this point should be white and very finely divided. All moisture must be excluded during its preparation in order to avoid the formation of [sodium hydroxide](#), which markedly lowers the yield.
7. The [ethyl acetate](#) is allowed to stand over [calcium chloride](#) for 2 days, with occasional shaking. The [calcium chloride](#) is removed by filtration, and the ester is allowed to stand over [phosphorus pentoxide](#) several hours. It is then distilled directly from the [phosphorus pentoxide](#).
8. After about half of the [acetone](#) has been added, the mixture usually sets to a solid mass. The stirrer is turned by hand and the addition of [acetone](#) continued. In a few minutes the mass can again be stirred.
9. The [ethyl acetate](#) layer is washed with water, [sodium bisulfite](#) solution, saturated [calcium chloride](#) solution, and again with water. It is further purified as in (Note 6), giving 316–400 g. of recovered ester. The amount of recovered ester depends somewhat upon the length of time the two layers are allowed to remain in contact before separating.

### 3. Discussion

[Acetylacetone](#) has been prepared by the reaction of [acetyl chloride](#) with [aluminum chloride](#), followed by hydrolysis;<sup>3</sup> by the condensation of [acetone](#) with [ethyl acetate](#) in the presence of [sodium](#),<sup>4</sup> [sodium amide](#),<sup>5,6</sup> [sodium ethoxide](#),<sup>5,7,8</sup> and alkali or alkaline-earth hydrides;<sup>9</sup> by the reaction of [acetone](#) and [acetic anhydride](#) in the presence of [boron trifluoride](#);<sup>10</sup> by the pyrolysis of [isopropenyl acetate](#);<sup>11,12,13</sup> by the reaction of [ethyl acetoacetate](#) and [acetic anhydride](#) in the presence of [magnesium](#) at 140°;<sup>11</sup> from methyl or ethyl diacetylacetate by treatment with acids;<sup>14</sup> and by the dehydrogenation of [4-pentanol-2-one](#) in the presence of [Raney nickel](#).<sup>15</sup>

This preparation is referenced from:

- [Org. Syn. Coll. Vol. 3, 251](#)
- [Org. Syn. Coll. Vol. 3, 829](#)

---

### References and Notes

1. Bagster, *J. Chem. Soc.*, **1917**, 494.
2. Obermiller and Goertz, *Z. physik. Chem.*, **109**, 162 (1924)
3. Combes, *Ann. chim. et phys.*, (6) **12**, 207 (1887).
4. Claisen, *Ann.*, **277**, 168 (1893).
5. Claisen, *Ber.*, **38**, 695 (1905).
6. Adams and Hauser, *J. Am. Chem. Soc.*, **66**, 1220 (1944).
7. Claisen and Ehrhardt, *Ber.*, **22**, 1010 (1889).
8. Sprague, Beckham, and Adkins, *J. Am. Chem. Soc.*, **56**, 2665 (1934).
9. U. S. pat. 2,158,071 [*C. A.*, **33**, 6342 (1939)].
10. Meerwein and Vossen, *J. prakt. Chem.*, **141**, 149 (1934).
11. U. S. pat. 2,395,800 [*C. A.*, **40**, 3130 (1946)].
12. Brit. pat. 615,523 [*C. A.*, **43**, 7954 (1949)].
13. Hagemeyer and Hull, *Ind. Eng. Chem.*, **41**, 2920 (1949).
14. U. S. pat. 2,395,012 [*C. A.*, **40**, 3130 (1946)].
15. DuBois, *Compt. rend.*, **224**, 1734 (1947).

---

### Appendix

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

copper salt of acetylacetone

condenser

Hershberg stirrer

methyl or ethyl diacetylacetate

ethanol (64-17-5)

calcium chloride (10043-52-4)

potassium carbonate (584-08-7)

sulfuric acid (7664-93-9)

acetic acid (64-19-7)

ethyl acetate (141-78-6)

ether,

ethyl ether (60-29-7)

acetic anhydride (108-24-7)

sodium acetate (127-09-3)

sodium hydroxide (1310-73-2)

acetyl chloride (75-36-5)

magnesium (7439-95-4)

carbonate (3812-32-6)

sodium sulfate (7757-82-6)

sodium bisulfite (7631-90-5)

calcium sulfate (7778-18-9)

Raney nickel (7440-02-0)

acetone (67-64-1)

aluminum chloride (3495-54-3)

sodium (13966-32-0)

sodium ethoxide (141-52-6)

copper acetate (142-71-2)

xylene (106-42-3)

Ethyl acetoacetate (141-97-9)

boron trifluoride (7637-07-2)

Acetylacetone,  
Diacetylmethane,  
2,4-pentanedione (123-54-6)

maleic anhydride (108-31-6)

isopropenyl acetate (108-22-5)

4-pentanol-2-one

phosphorus pentoxide (1314-56-3)