



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.

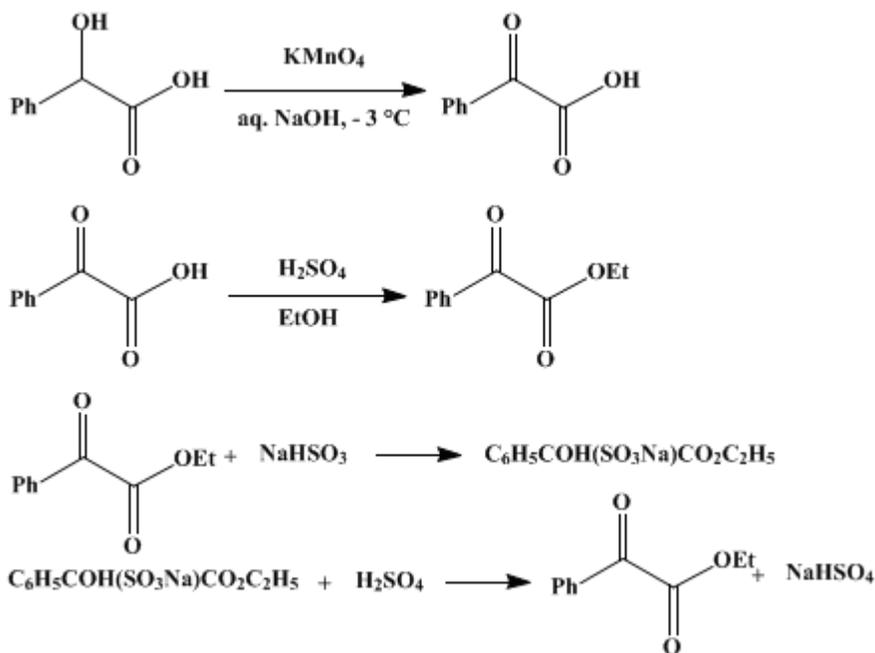
The procedures described in *Organic Syntheses* are provided as published and are conducted at one's own risk. *Organic Syntheses, Inc.*, its Editors, and its Board of Directors do not warrant or guarantee the safety of individuals using these procedures and hereby disclaim any liability for any injuries 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. 1, p.241 (1941); Vol. 8, p.68 (1928).*

## ETHYL BENZOYLFORMATE

[Glyoxylic acid, phenyl-, ethyl ester]



Submitted by B. B. Corson, Ruth A. Dodge, S. A. Harris, and R. K. Hazen.  
Checked by C. S. Marvel and F. E. Kendall.

### 1. Procedure

In a 12-l. earthenware crock equipped with an efficient stirrer and a strong motor are placed 375 g. (2.5 moles) of [mandelic acid](#) (p. 336) and 500 cc. of water. The stirrer is started, and a cool solution of 110 g. (2.8 moles) of [sodium hydroxide](#) (or 115 g. of technical [sodium hydroxide](#)) in 500 cc. of water is added. This is followed by the addition of 2000 g. of cracked ice and then after a few minutes by 275 g. (1.74 moles) of finely ground u.s.p. [potassium permanganate](#) in portions over a period of one-half hour. The mixture is stirred for one and one-half hours, the temperature being maintained at  $-2^\circ$  to  $-4^\circ$ . About 5 kg. of ice is necessary. At the end of one and one-half hours the mixture is tested for excess permanganate by placing a drop on a piece of filter paper; a black or brown center of [manganese dioxide](#) is formed, a greenish ring around this, and an outer ring which is colorless in the absence and pink in the presence of excess permanganate. Any excess is removed by adding [ethyl alcohol](#), generally about 200–300 cc.

When the permanganate has been destroyed, the stirrer is stopped and the [manganese dioxide](#) allowed to coagulate for one hour. The mixture is filtered through two 20-cm. Büchner funnels; the filter cakes are washed with 1000 cc. of water ([Note 1](#)) and sucked dry again ([Note 2](#)). The filtrate is evaporated to 800–1000 cc. over a free flame. While the volume of solution is large, two 30-cm. evaporating dishes are used, but toward the end the two solutions are combined in one dish. The evaporation requires two to three hours. Sometimes a little [manganese dioxide](#) will be coagulated during the evaporation; this should be removed by filtration.

The yellowish solution is transferred to a 3-l. round-bottomed, wide-necked flask and cooled with running water while 300 cc. of concentrated [sulfuric acid](#) is added slowly from a separatory funnel. This acidification process requires thirty minutes, during which time the temperature should not rise much above  $25^\circ$ . The liquid froths and about 30 g. of [benzoic acid](#) separates but it is not filtered. Extraction of the reaction mixture with 200-cc. portions of [ether](#) until 1500 cc. of extract has been collected is now

carried out in a separatory funnel. The ether is distilled on a steam bath from a 1-l. round-bottomed, wide-necked flask connected with a water condenser, the extract being added from a separatory funnel as fast as the ether distils. After most of the ether has been removed, the heating is continued for an additional one-half hour.

The crude liquid acid (about 300 g.) is cooled with running water, and 15 cc. of concentrated sulfuric acid is added; the clear yellow oil becomes cloudy. The acid is esterified by passing the vapor of ethyl alcohol into the hot solution as in the preparation of ethyl fumarate in Org. Syn. 10, 48, or by the method described for ethyl cyanoacetate in Org. Syn. 3, 54, with the following changes: all three flasks, the alcohol flask, the trap, and the esterification flask are 1-l. round-bottomed, wide-necked flasks. The alcohol flask and the trap are set on adjacent steam baths. The esterification flask is placed in an oil bath which is heated by a free flame. A safety tube leads from the alcohol flask and dips under 7.5 cm. of mercury contained in a side-arm tube. This mercury safety valve avoids all dangers which might result from the development of excess pressure within the system (Note 3). The temperature of the esterification mixture is kept at 105–110° and ethyl alcohol vapor is passed through until 500 cc. of distillate has been collected. This requires about three hours. The distillate consists of alcohol, water, and a little ether.

The crude ester is cooled, an equal volume of benzene is added, then the free acid is neutralized by shaking with about 250 cc. of a 10 per cent solution of sodium carbonate (Note 4). The benzene solution is poured into 1300 cc. of a saturated solution of sodium bisulfite (about 60 g. of technical sodium bisulfite per 100 cc.), contained in a wide-necked bottle equipped with an efficient stirrer, and the mixture stirred for two and one-half hours. The mixture soon warms up a little and becomes semi-solid. It is filtered through a 20-cm. Büchner funnel and carefully washed, first with 200 cc. of a saturated solution of sodium bisulfite, finally with two 150-cc. portions of benzene (Note 5) and (Note 6). The white pearly flakes of the sodium bisulfite addition product are transferred to a 3-l. round-bottomed, wide-necked flask equipped with a mechanical stirrer and containing 700 cc. of water, 175 cc. of concentrated sulfuric acid, and 500 cc. of benzene. The flask is heated on a steam bath under a hood, the temperature being kept at 55°, and the mixture is stirred for thirty minutes (Note 7).

The solution is then poured into a separatory funnel, the benzene separated, and the water layer extracted with a 200-cc. portion of benzene. The combined benzene solution is shaken with excess of 10 per cent sodium carbonate solution to remove free acid and sulfur dioxide (Note 8). The benzene is washed with a little water and then dried over anhydrous potassium carbonate (Note 9). The benzene is distilled at ordinary pressure over a free flame from a 500-cc. Claisen flask, the solution being added from a separatory funnel as fast as the benzene distils. It is advisable to distil the ester under reduced pressure although it can be done under ordinary pressure. The fraction distilling around 118°/5 mm., 130°/10 mm., 138°/15 mm., 148°/25 mm., 155°/35 mm., or 254°/760 mm. is collected. The yield of ethyl benzoylformate is 155–175 g. (35–40 per cent of the theoretical amount) (Note 10) and (Note 11).

## 2. Notes

1. In order to wash the manganese dioxide cake it must be removed from the funnel and stirred into a thin paste with water.
2. It is advisable not to stop the experiment until after filtration since manganese dioxide slowly oxidizes benzoylformic acid to benzoic acid.
3. If it is necessary to generate the steam from a can or similar contrivance, the steam generator should be connected with a safety tube dipping under 20–25 cm. of mercury.
4. The sodium carbonate solution contains 8–15 g. of unesterified acid which can be easily recovered by acidification with concentrated hydrochloric acid followed by extraction with ether.
5. The benzene contains 80 g. of impure ethyl benzoate boiling at 180–260° and containing about 20 per cent of ethyl benzoylformate. In the preparation of the methyl ester the benzene contains 60 g. of impure methyl benzoate, boiling at 170–250°, and containing about 20 per cent of methyl benzoylformate.
6. If the stirring is not very efficient the benzene layer should be stirred with the bisulfite solution a second time.
7. Longer contact with acid tends to hydrolyze the ester. The reaction should be performed under a hood since considerable sulfur dioxide is generated. A gas-absorption trap (Fig. 7 on p. 97) may be used.

8. This [sodium carbonate](#) solution contains about 4 g. of impure [benzoylformic acid](#).
9. The [potassium carbonate](#) holds some ester which may be recovered by adding water and separating the ester layer.
10. The methyl ester is easily made by substituting [methyl](#) for [ethyl alcohol](#). It boils at 250–255°/760 mm. The yield is about 175 g. (43 per cent of the theoretical amount).
11. By a slight modification of the procedure, crystalline [benzoylformic acid](#) ([phenylglyoxylic acid](#)) can be isolated. The oxidation of 375 g. (2.5 moles) of [mandelic acid](#) by cold alkaline [potassium permanganate](#) is performed exactly as described in the first paragraph (p. 241). After removal of the [manganese dioxide](#), the combined filtrates are evaporated to 2500–3000 cc. and acidified carefully, so as to precipitate only [benzoic acid](#), by the addition of 100 cc. (190 g.) of concentrated [sulfuric acid](#) (sp. gr. 1.84) previously diluted with an equal volume of water and cooled. The [benzoic acid](#) (25–30 g.) which separates is removed by filtration. The filtrate is made alkaline with 75 g. of [sodium hydroxide](#) and concentrated to 800–1000 cc. The subsequent acidification, with 280–300 cc. of concentrated [sulfuric acid](#), and [ether](#) extraction are performed as described in the third paragraph (p. 242). After the [ether](#) is removed, about 280 g. of crude, liquid [benzoylformic acid](#) remains. Since, at this stage, enough water is present to render the acid immiscible with [carbon disulfide](#), the liquid residue is dried by placing it in a distilling flask with 70–90 cc. of [toluene](#) and distilling off the water and [toluene](#) (preferably under slightly reduced pressure). The dried liquid residue is taken up in an equal volume of [carbon disulfide](#); with adequate precautions to exclude moisture, the solution is cooled thoroughly in an ice-salt mixture. The yield of product melting at 58–61° is 190–250 g. (50–67 per cent of the theoretical amount). (Charles D. Hurd and R. W. McNamee, private communication. Checked by Reynold C. Fuson and W. E. Ross.)
12. This work was done with the aid of a grant to the submitters from the Cyrus M. Warren fund of the American Academy of Arts and Sciences.

### 3. Discussion

[Benzoylformic acid](#) can be prepared by the hydrolysis of [benzoyl cyanide](#),<sup>1</sup> and the oxidation of [acetophenone](#)<sup>2</sup> and of [mandelic acid](#).<sup>3</sup> The ester can be prepared from the acid by direct esterification.<sup>4</sup>

This preparation is referenced from:

- [Org. Syn. Coll. Vol. 3, 114](#)

---

### References and Notes

1. Claisen, Ber. **10**, 429, 844 (1877); **12**, 626 (1879); Buchka, Ber. **20**, 395 (1887); Simon, Ann. chim. phys. (7) **9**, 508 (1896).
2. Glücksmann, Monatsh. **11**, 248 (1890); Claus and Neukranz, J. prakt. Chem. (2) **44**, 80 (1891).
3. Hunaeus and Zincke, Ber. **10**, 1489 (1877); Acree, Am. Chem. J. **50**, 391 (1913).
4. Claisen, Ber. **10**, 846 (1877); Acree, Am. Chem. J. **50**, 392, 393 (1913).

---

### Appendix

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

Gloxylic acid, phenyl-, ethyl ester

[ethyl alcohol](#) (64-17-5)

[potassium carbonate](#) (584-08-7)

sulfuric acid (7664-93-9)  
hydrochloric acid (7647-01-0)  
Benzene (71-43-2)  
methanol (67-56-1)  
ether (60-29-7)  
sodium hydroxide (1310-73-2)  
Mandelic acid (90-64-2)  
potassium permanganate (7722-64-7)  
sodium carbonate (497-19-8)  
sulfur dioxide (7446-09-5)  
Benzoic acid (65-85-0)  
sodium bisulfite (7631-90-5)  
Acetophenone (98-86-2)  
toluene (108-88-3)  
carbon disulfide (75-15-0)  
manganese dioxide (1313-13-9)  
Ethyl cyanoacetate (105-56-6)  
ethyl benzoate (93-89-0)  
Ethyl benzoylformate (1603-79-8)  
ethyl fumarate (2459-05-4)  
Benzoylformic acid,  
phenylglyoxylic acid (611-73-4)  
methyl benzoate (93-58-3)  
Methyl benzoylformate (15206-55-0)  
Benzoyl cyanide (613-90-1)