



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.258 (1941); Vol. 5, p.55 (1925).

ETHYL ORTHOFORMATE

[Orthoformic acid, triethyl ester]



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1. Procedure

In a 5-l. round-bottomed flask, fitted with an 80-cm. reflux condenser, are placed 3 l. of absolute alcohol (Note 1) and 490 g. (327 cc., 4.1 moles) of chloroform (Note 2). The flask is arranged for outside cooling by running water. To the solution, 207 g. (9 atoms) of clean sodium cut into pieces which will conveniently drop through the condenser is added during the course of about two hours. In order to add the sodium at this rate, the flask must be cooled during the addition. When the sodium is entirely reacted and the mixture has been cooled to room temperature, the sodium chloride which has separated is removed by suction filtration with the use of thoroughly dry apparatus (Note 3). The salt is washed on the filter with 200 cc. of absolute alcohol, and the washings are allowed to run into the main filtrate.

The solution is placed in a 3-l. flask fitted with an 80-cm. fractionating column (Note 4), and the excess chloroform and most of the alcohol are distilled off on a steam or water bath. The distillate is caught in a 2-l. suction flask protected from moisture by a drying tube. This distillation requires five or six hours. A mixture of chloroform and alcohol, weighing about 2000 g., is recovered and saved for the next run (Note 3). The liquid remaining in the flask is decanted from the small amount of salt which has separated, into a Claisen flask with a 30-cm. fractionating column (Note 5). The mixture is distilled at atmospheric pressure. The fraction boiling below 85° is mainly alcohol and is discarded. An intermediate fraction of about 100 g., boiling at 85–140°, contains about one-fourth of the total yield. This may be fractionated but is best added to a subsequent run. The orthoformic ester is collected at 140–146° and weighs 120–140 g. (27–31 per cent of the theoretical amount). There is practically no higher-boiling material. Another distillation gives almost all the material boiling over a 2° range.

After the first run, 400 g. of chloroform and enough absolute alcohol (800–1000 cc.) are added to the recovered chloroform-alcohol mixture to give a total volume of 3 l. The sodium is then added as before. After the excess of chloroform and alcohol has been distilled through the fractionating column, the intermediate fraction from the previous run is added before fractionating. The yield from such a run is about 200 g. (45 per cent of the theoretical amount) (Note 6) and (Note 7).

2. Notes

1. *Absolute Alcohol.*—Good absolute alcohol is essential. The use of alcohol of about 98 per cent gives only about two-thirds the yields obtained with absolute alcohol. Alcohol dried over lime usually runs about 98.5–99.5 per cent. A good method of obtaining a higher grade of absolute alcohol is to treat this alcohol with a little sodium. When the sodium has dissolved, the alcohol is distilled from a steam bath. Under these conditions, any trace of water that may be present on account of the equilibrium



remains in the concentrated solution of sodium ethoxide and sodium hydroxide. See, also, p. 249 and, Note 1, on p. 251.

2. Sufficient chloroform must be used to keep the solution from being alkaline at the end of the reaction.

3. If care is taken to prevent moisture from getting into the recovered alcohol-chloroform mixture, this mixture may be used repeatedly. After it has been used four or five times, the yield begins to fall.

4. The long fractionating column used by Clarke and Rahrs¹ is satisfactory. If such a column is not

available, an 80-cm. reflux condenser without any water in it, may be used, connecting it at the top by means of a wide, bent glass tube to a condenser set downward for distillation.

5. A satisfactory type of flask for the distillation is that illustrated on p. 130.

6. The present method is better than that which uses dry ether as a solvent.

7. Yields equally good as those mentioned in the above procedure are obtained by first preparing a sodium ethoxide solution, taking the quantities given above and adding this to an alcohol-chloroform solution. One decided disadvantage in this alternative procedure is that, unless a great deal more alcohol is employed, the sodium ethoxide solution tends to become semi-solid and cannot be introduced easily into the chloroform-alcohol solution. If one attempts to use recovered alcohol, containing chloroform, the sodium chloride which separates as soon as sodium is added increases the tendency to become semi-solid.

The reaction is carried out best without stirring, thus allowing the sodium to float on top. In this way, the hydrogen escapes rapidly and little reduction of the chloroform takes place.

3. Discussion

Orthoformic ester can be prepared by the treatment of a mixture of chloroform and alcohol with sodium;² by the action of dry sodium ethoxide on chloroform³ or on an ether solution of chloroform;⁴ by the action of alcoholic sodium hydroxide on chloroform;⁵ and by the action of alcoholic hydrochloric acid on ethyl formimido ester⁶ or its mercuric chloride double salt.⁷ A method⁸ has been published for the preparation of orthoformic ester, in which sodium and chloroform are added alternately to the absolute alcohol. A few runs were made according to its directions but the results were not so satisfactory as those obtained by the procedure described.

This preparation is referenced from:

- Org. Syn. Coll. Vol. 1, 237
- Org. Syn. Coll. Vol. 1, 248
- Org. Syn. Coll. Vol. 1, 272
- Org. Syn. Coll. Vol. 2, 126
- Org. Syn. Coll. Vol. 2, 137
- Org. Syn. Coll. Vol. 2, 262
- Org. Syn. Coll. Vol. 2, 287
- Org. Syn. Coll. Vol. 2, 323
- Org. Syn. Coll. Vol. 4, 291
- Org. Syn. Coll. Vol. 4, 630

References and Notes

1. Clarke and Rahrs, *Ind. Eng. Chem.* **15**, 349 (1923).
 2. Sawitsch, *Jahresber.* 391 (1860); Ladenburg and Wichelhaus, *Ann.* **152**, 164 (1869); Deutsch, *Ber.* **12**, 116 (1879); Wood and Comley, *J. Soc. Chem. Ind.* **42**, 430 T (1923).
 3. Williamson, *Ann.* **92**, 346 (1854); Stapaff, *Z. Chem.* 186 (1871).
 4. Arnhold, *Ann.* **240**, 193 (1887).
 5. Walter, *J. prakt. Chem.* (2) **48**, 231 (1893).
 6. Pinner, *Ber.* **16**, 356 (1883); Claisen, *Ber.* **31**, 1010 (1898).
 7. Hill and Black, *Am. Chem. J.* **31**, 209 (1904).
 8. Wood and Comley, *J. Soc. Chem. Ind.* **42**, 430 T (1923).
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Appendix

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

orthoformic ester

alcohol-chloroform

mercuric chloride double salt

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

[hydrochloric acid \(7647-01-0\)](#)

[ether \(60-29-7\)](#)

[hydrogen \(1333-74-0\)](#)

[sodium hydroxide \(1310-73-2\)](#)

[chloroform \(67-66-3\)](#)

[sodium chloride \(7647-14-5\)](#)

[sodium \(13966-32-0\)](#)

[sodium ethoxide \(141-52-6\)](#)

[Ethyl orthoformate](#)

[Orthoformic acid, triethyl ester \(122-51-0\)](#)

[chloroform-alcohol](#)