



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.

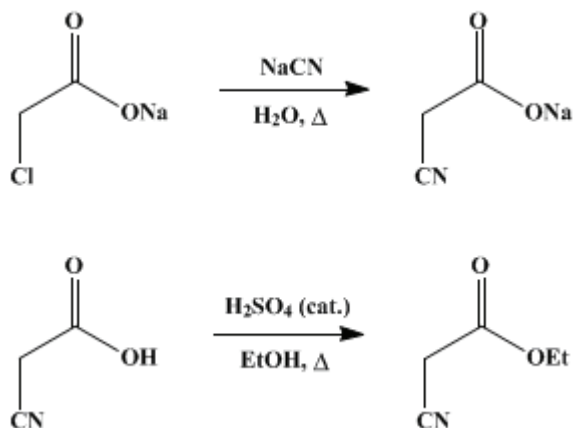
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These paragraphs were added in September 2014. The statements above do not supersede any specific hazard caution notes and safety instructions included in the procedure.

Organic Syntheses, Coll. Vol. 1, p.254 (1941); Vol. 8, p.74 (1928).

ETHYL CYANOACETATE

[Acetic acid, cyano-, ethyl ester]



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1. Procedure

In a 5-l. round-bottomed flask, 500 g. (5.3 moles) of chloroacetic acid is dissolved in 700 cc. of water. The solution is warmed to 50° and neutralized with anhydrous sodium carbonate of which about 290 g. (2.7 moles) is required (a slight excess of sodium carbonate is not disadvantageous). Meanwhile 294 g. (5.8 moles) of sodium cyanide (97 per cent) is dissolved in 750 cc. of water warmed to 55°. The sodium cyanide solution is then added to the sodium chloroacetate solution, which has been cooled to room temperature, with rapid mixing of the two solutions and cooling under the water tap. The temperature rapidly rises; when it reaches 95° the solution should be cooled by adding 200 cc. of cold water and this repeated, if necessary, until the temperature no longer rises (Note 1). The solution is heated to the boiling point and boiled for five minutes (Note 2), and finally cooled with running water for one-half hour.

The solution is filtered if not clear, and the cyanoacetic acid is set free (Hood) by adding with thorough stirring 694 g. (600 cc., 5.8 moles) (a slight excess) of commercial hydrochloric acid (sp. gr. 1.156). The solution is evaporated on a water bath at 60–70° (Note 3) under a pressure of 20–30 mm. and the evaporation continued until practically no more distillate (Note 4) comes over. To the residue is added 600 cc. of 95 per cent alcohol. The solution is filtered (Note 5) from the sodium chloride, and the residue is washed with another 500-cc. portion of alcohol.

On evaporating the alcoholic solution under reduced pressure from a water bath held at 50–60° (Note 6) the residue weighs about 540 g. A mixture of 600 cc. of absolute alcohol (p. 249) and 10 cc. of concentrated sulfuric acid (Note 7) is then added. The mixture is then heated on the water bath under a reflux condenser for three hours. The excess of alcohol and some of the water formed are removed by distillation under reduced pressure and the residue again heated for two hours with 300 cc. of absolute alcohol and an additional 4 cc. of concentrated sulfuric acid. The alcohol is removed by distillation under reduced pressure, and when the ester has cooled to room temperature, the sulfuric acid is neutralized with a concentrated solution of sodium carbonate; the ester (upper layer) is separated, and the aqueous solution extracted with ether, or preferably benzene; about one-tenth of the yield is in the extract. The combined products are placed in a 1-l. distilling flask and distilled under reduced pressure after the solvent and alcohol and water have been removed. The ester is collected at 94–99°, chiefly at 97–98°/16 mm. (Note 8). The yield of a product analyzing about 97–98 per cent ethyl cyanoacetate amounts to 474–492 g. (77–80 per cent of the theoretical amount) (Note 9) and (Note 10).

2. Notes

1. If the reaction between the cyanide and chloroacetate becomes too vigorous, [hydrogen cyanide](#) is set free and partly changed to brown material and a corresponding amount of glycolate is formed.
2. The color at this stage should be yellow or a light brown.
3. If the mixture is heated to a higher temperature there is a considerable loss due to decomposition of the [cyanoacetic acid](#).
4. Toward the end of the distillation, [hydrochloric acid](#) should be present in the distillate if excess was added in the first place. During the addition of the [hydrochloric acid](#) the excess of cyanide is decomposed, giving off [hydrogen cyanide](#).
5. It is much easier to remove the salt by means of a centrifuge. If this method is used the salt should be washed first with 500 cc. and then with 250 cc. of [alcohol](#).
6. The solution containing mineral acid must not be evaporated at a high temperature or [diethyl malonate](#) will be formed.
7. The addition of [sulfuric acid](#) will probably produce a slight precipitate, but this may be ignored if the original treatment with [hydrochloric acid](#) was properly carried out.
8. [Ethyl cyanoacetate](#) boils at 97°/16 mm.; 101°/19 mm.; and 107°/27 mm.
9. The product was analyzed for [nitrogen](#) by the Kjeldahl method.
10. The procedure described in *Org. Syn.* **10**, 48, for the esterification of [fumaric acid](#) can probably be used for the preparation of the methyl and the ethyl esters of cyanoacetic acid.

3. Discussion

[Ethyl cyanoacetate](#) can be prepared by the action of [sodium](#)¹ or [potassium cyanide](#)² on [ethyl chloroacetate](#), and by the action of [sodium cyanide](#) on [sodium chloroacetate](#), followed by esterification.³ The procedure described differs from that given in *Org. Syn.* **3**, 53, mainly in the use of [hydrochloric acid](#) in place of [sulfuric acid](#) in the liberation of the [cyanoacetic acid](#) from the [sodium](#) salt, and in the simplified esterification process. These are slight but very important differences and make the procedure much easier to carry out in the laboratory. Moreover, the yields are higher. The preparation from [ethyl chloroacetate](#) and [potassium cyanide](#) in methyl alcoholic solution⁴ gives a mixture of methyl and ethyl esters.⁵

This preparation is referenced from:

- [Org. Syn. Coll. Vol. 1, 179](#)

References and Notes

1. Stephens, *J. Soc. Chem. Ind.* **43**, 313 T, 327 T (1924).
2. Finkelstein, *Ann.* **133**, 339 (1865); van't Hoff, *Jahresber.* 561 (1874); Henry, *Bull. soc. chim.* **46**, 62 (1886); Noyes, *J. Am. Chem. Soc.* **26**, 1545 (1904); Scarborough, *Proc. Chem. Soc.* **30**, 307 (1914).
3. Kohler and Allen, *Org. Syn.* **3**, 53 (1923); Phelps and Tillotson, *Am. J. Sci.* **26**, 264, 275 (1908); Stephens, *J. Soc. Chem. Ind.* **43**, 313 T, 327 T (1924).
4. Noyes, *J. Am. Chem. Soc.* **26**, 1545 (1904).
5. Urushibara, *Bull. Chem. Soc. Japan*, **2**, 143 (1927) [*C. A.* **21**, 2879 (1927)].

Appendix

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

methyl and the ethyl esters of cyanoacetic acid

alcohol (64-17-5)

sulfuric acid (7664-93-9)

hydrochloric acid (7647-01-0)

Benzene (71-43-2)

ether (60-29-7)

sodium cyanide (143-33-9)

sodium chloride (7647-14-5)

hydrogen cyanide (74-90-8)

sodium carbonate (497-19-8)

nitrogen (7727-37-9)

potassium cyanide (151-50-8)

chloroacetic acid (79-11-8)

sodium chloroacetate (3926-62-3)

sodium (13966-32-0)

Ethyl chloroacetate (105-39-5)

Ethyl cyanoacetate,
Acetic acid, cyano-, ethyl ester (105-56-6)

cyanoacetic acid (372-09-8)

diethyl malonate (105-53-3)

Fumaric acid (110-17-8)