



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.

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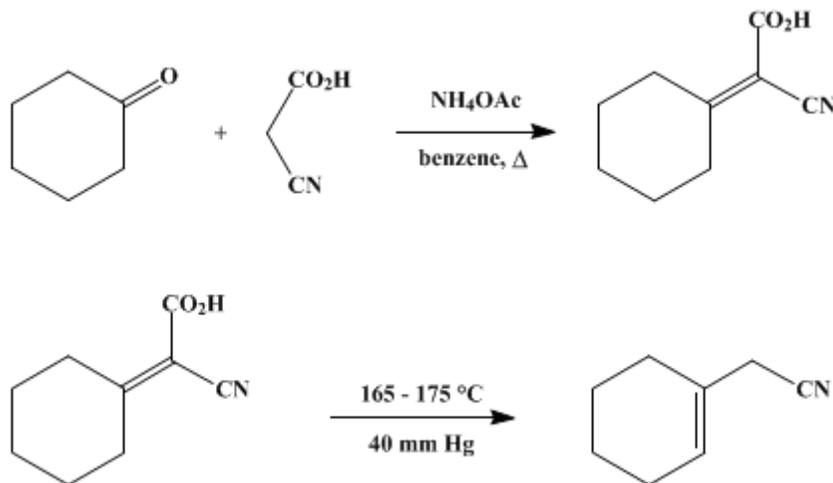
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*These paragraphs were added in September 2014. The statements above do not supersede any specific hazard caution notes and safety instructions included in the procedure.*

*Organic Syntheses, Coll. Vol. 4, p.234 (1963); Vol. 31, p.25 (1951).*

## CYCLOHEXYLIDENECYANOACETIC ACID AND 1-CYCLOHEXYNYLACETONITRILE

[ $\Delta^{1,\alpha}$ -Cyclohexaneacetic acid,  $\alpha$ -cyano-, and 1-Cyclohexene-1-acetonitrile]



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### 1. Procedure

In a 500-ml. round-bottomed flask equipped with a side arm through which a capillary tube is inserted (Note 1) are placed 108 g. (1.1 moles) of cyclohexanone (Note 2), 85 g. (1.0 mole) of cyanoacetic acid (Note 3), 3.0 g. (0.04 mole) of ammonium acetate (Note 4), and 75 ml. of benzene. The flask is attached to a modified Dean and Stark constant water separator,<sup>2,3</sup> which in turn is attached to an efficient reflux condenser. The mixture is heated in an oil bath at  $160-165^\circ$  so that a vigorous reflux is maintained, and the water that collects in the separator is removed at intervals. The theoretical amount of water (18 ml.) is collected in the course of 2 hours, and the mixture is heated under reflux for an additional 1 hour. At this point, Part A is followed for the isolation of cyclohexylidencyanoacetic acid, or Part B for the preparation of 1-cyclohexenylacetonitrile.

A. *Cyclohexylidencyanoacetic acid*. The benzene solution is diluted with an additional 100 ml. of hot benzene and transferred to a 1-l. separatory funnel. The solution is allowed to cool until it is slightly above room temperature, and then 200 ml. of ether is added, small portions being used to rinse the reaction flask. After the solution has cooled to room temperature, it is washed with two 50-ml. portions of cold water (Note 5). The emulsion which normally forms at this point is broken by slow filtration through a Büchner funnel. The ether is removed, and the benzene solution is concentrated to approximately 300 ml. by distillation under reduced pressure. The solution is allowed to cool slowly to room temperature and then is cooled to about  $10^\circ$  in a refrigerator (Note 6). Cyclohexylidencyanoacetic acid crystallizes as colorless prisms (Note 7). It is collected on a Büchner funnel, washed with two 100-ml. portions of cold benzene ( $10^\circ$ ), and dried in a vacuum desiccator to constant weight (88–92 g.). The filtrate and washings are concentrated by distillation under reduced pressure to about 150 ml. and cooled as in the first crystallization. The second crop of crystals is separated by filtration, washed with two 50-ml. portions of cold benzene ( $10^\circ$ ), and dried in a vacuum desiccator to constant weight (21–25 g.). Further concentration of the mother liquor and washings to a volume of about 75 ml. followed by cooling, filtering, washing with two 10-ml. portions of cold benzene, and drying yields an additional 2–5 g. The total yield of cyclohexylidencyanoacetic acid, m.p.  $110-110.5^\circ$ , is 108–126 g. (65–76%).

B. *1-Cyclohexenylacetonitrile*. The benzene solution is allowed to cool to about 50°, and the flask is attached to a Vigreux column. The benzene is removed under reduced pressure, whereupon the residual cyclohexylidenecyanoacetic acid solidifies. The flask is then heated slowly in an oil bath to 165–175° while the system is evacuated with a water pump to a pressure of 35–45 mm. (not lower). The acid melts, decarboxylation occurs very rapidly, and the crude 1-cyclohexenylacetonitrile distils at 100–120°/35–45 mm.

The crude product is diluted with 50 ml. of ether, washed with 10 ml. of 5% sodium carbonate solution then with 10 ml. of water, and dried over anhydrous sodium sulfate. The ether is removed by distillation, and the residue is distilled under reduced pressure. 1-Cyclohexenylacetonitrile is collected as a colorless liquid, b.p. 74–75°/4 mm. (110–112°/25 mm.),  $n_D^{25}$  1.4769, in a yield of 92–110 g. (76–91%).

## 2. Notes

1. The capillary aids ebullition in the distillation under reduced pressure in Part B and may be omitted if cyclohexylidenecyanoacetic acid is to be prepared according to Part A.
2. Commercial cyclohexanone obtained from the Barrett Division of the Allied Chemical and Dye Corporation was used.
3. Good quality commercial cyanoacetic acid was used. It may be purchased from the Benzol Products Company, Newark, New Jersey.
4. The amount of ammonium acetate specified permits completion of the condensation in a relatively short reaction period.
5. The product is washed with water to remove small amounts of ammonium acetate and acetamide which are formed from the ammonium acetate during the condensation.
6. If the rate of cooling is too fast at this point, very small crystals difficult to wash are formed. The rate and time of cooling also control the proportions of product found in the three fractions.
7. The solvated crystals effloresce upon drying, leaving a white solid which is easily powdered.

## 3. Discussion

Cyclohexylidenecyanoacetic acid has been prepared by the condensation of cyclohexanone and cyanoacetic acid in the presence of piperidine<sup>4,5</sup> or basic ion-exchange resins,<sup>6</sup> and by the hydrolysis of ethyl cyclohexylidenecyanoacetate.<sup>4</sup>

1-Cyclohexenylacetonitrile has been prepared by the decarboxylation of cyclohexylidenecyanoacetic acid;<sup>4,5</sup> by the dehydration of 1-cyclohexenylacetamide;<sup>5</sup> by the condensation of cyclohexanone and cyanoacetic acid in the presence of piperidine;<sup>7</sup> by the condensation of cyclohexanone and ethyl cyanoacetate in the presence of sodium ethoxide;<sup>4,8</sup> and by the condensation of cyclohexanone and cyanoacetic acid in the presence of ammonium acetate followed by decarboxylation.<sup>9</sup> Ammonium acetate also has been used as a catalyst for the condensation of ketones with ethyl cyanoacetate.<sup>3,10</sup>

In a number of instances the decarboxylation of  $\alpha,\beta$ -unsaturated (conjugated) cyanoacetic acids has been found to yield  $\beta,\gamma$ -unsaturated (unconjugated) nitriles.<sup>5,11</sup>

This preparation is referenced from:

- Org. Syn. Coll. Vol. 7, 108

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## References and Notes

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3. Cope, Hofmann, Wyckoff, and Hardenbergh, *J. Am. Chem. Soc.*, **63**, 3452 (1941).
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  6. Astle and Gergel, *J. Org. Chem.*, **21**, 493 (1956).
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  8. Birch and Kon, *J. Chem. Soc.*, **123**, 2444 (1923).
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**Appendix**  
**Chemical Abstracts Nomenclature (Collective Index Number);**  
**(Registry Number)**

$\Delta^{1,\alpha}$ -Cyclohexaneacetic acid,  $\alpha$ -cyano-

Acetamide (60-35-5)

Benzene (71-43-2)

ether (60-29-7)

ammonium acetate (631-61-8)

Cyclohexanone (108-94-1)

sodium carbonate (497-19-8)

sodium sulfate (7757-82-6)

piperidine (110-89-4)

sodium ethoxide (141-52-6)

Ethyl cyanoacetate (105-56-6)

cyanoacetic acid (372-09-8)

Cyclohexylidenecyanoacetic acid (37107-50-9)

1-Cyclohexenylacetonitrile,  
1-Cyclohexene-1-acetonitrile (6975-71-9)

ethyl cyclohexylidenecyanoacetate

1-cyclohexenylacetamide