Organic Syntheses

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.

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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.

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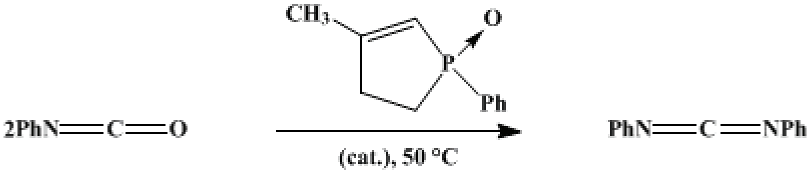
DIPHENYLCARBODIIMIDE

[Carbodiimide, diphenyl-
Method I]



Submitted by T. W. Campbell[1] and J. J. Monagle.
Checked by W. S. Wadsworth and W. D. Emmons.

1. Procedure

A 250-ml. four-necked flask is fitted with a sealed mechanical stirrer, a condenser protected by a drying tube, a thermometer, and a gas inlet. The flask is swept with a slow stream of nitrogen (Note 1) and dried by flaming. One hundred milliliters (108 g., 0.91 mole) of phenyl isocyanate (Note 2) is pipetted into the flask. One gram (0.052 mole) of 3-methyl-1-phenylphospholene 1-oxide[2] is added (Note 3), and the reaction mixture is heated at 50° under nitrogen for 2.5 hours (Note 4); at this point only a faint test for carbon dioxide is obtained when the off-gas is passed through saturated calcium hydroxide solution. The reaction mixture is cooled and rapidly transferred to a Claisen flask. Distillation yields 72–82 g. (82–93%) of diphenylcarbodiimide, obtained as a clear water-white oil, b.p. 110–112°/0.2 mm., n_D^{25} 1.6360–1.6362 (Note 5).

2. Notes

1. Commercial nitrogen is dried by passage through concentrated sulfuric acid.
2. Best results were obtained with material obtained from Eastman Kodak Company. Either freshly distilled material or material from a freshly opened bottle may be used. Material obtained from several other sources gave variable results even after redistillation.
3. Since the phosphine oxides are very hygroscopic and the reaction rate is sensitive to traces of moisture, the catalyst can be conveniently stored and added to the reaction mixture in long-necked, thin-walled glass ampoules. The catalyst may be dried by distillation (b.p. 168–170°/1.4 mm.) into a receiver containing the inverted ampoules. When sufficient catalyst has distilled to fill the ampoules, nitrogen is bled into the receiver, forcing the catalyst into the ampoules. An ampoule about 15 mm. in diameter will hold about 1 g. of catalyst. A small air space should be left to facilitate crushing the ampoule.
4. Use of more catalyst or higher temperature leads to an increasingly vigorous evolution of carbon dioxide.
5. Diphenylcarbodiimide can be stored for several weeks at 0°. At room temperature it gradually solidifies to a mixture of trimer and polymer. The monomer can be separated from the solid by vacuum distillation.

3. Discussion

Carbodiimides have been prepared by desulfurization of thioureas by metal oxides,[3] by sodium hypochlorite,[4] or by ethyl chloroformate in the presence of a tertiary amine;[5] by halogenation of ureas or thioureas followed by dehydrohalogenation of the N,N'-disubstituted carbamic chloride;[6] and by dehydration of disubstituted ureas using *p*-toluenesulfonyl chloride and pyridine.[7] The method described above is a modification of that of Campbell and Verbanc.[8]

This method may be applied to the synthesis of a variety of aryl and alkyl carbodiimides.[9] Other catalysts may also be used,[10] but the especially active one described here is the one most easily obtained.

The method is superior to other methods reported in that it provides pure products under very simple and mild conditions, allows the use of readily available isocyanates with or without the use of solvent, and offers extremely easy work-up.

This preparation is referenced from:

- Org. Syn. Coll. Vol. 5, 504

References and Notes

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

phosphine oxides

tertiary amine

sulfuric acid (7664-93-9)

nitrogen (7727-37-9)

carbon dioxide (124-38-9)

pyridine (110-86-1)

calcium hydroxide

sodium hypochlorite (7681-52-9)

ethyl chloroformate (541-41-3)

phenyl isocyanate (103-71-9)

carbamic chloride

Diphenylcarbodiimide,

Carbodiimide, diphenyl- (622-16-2)

3-Methyl-1-phenylphospholene 1-oxide (707-61-9)

p-Toluenesulfonyl chloride (98-59-9)

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