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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CHLORODIISOPROPYLPHOSPHINE

[Phosphinous chloride, diisopropyl-]

$$2\ i\text{-PrMgCl} \xrightarrow{PCl_3,\ Et_2O} (i\text{-Pr})_2PCl$$

Submitted by W. Voskuil and J. F. Arens[1].
Checked by Hugh D. Olmstead, James E. Oliver, and Herbert O. House.

1. Procedure

Caution! Because of the sensitivity of the reagents and product to moisture and oxygen, all manipulations must be performed in an anhydrous, inert atmosphere (Note 1).

A 500-ml., four-necked, round-bottomed flask is equipped with an efficient stirrer, a reflux condenser, a 250-ml. dropping funnel, and a low-temperature thermometer (Note 2). In the flask are placed 34.4 g. (21.8 ml., 0.25 mole) of phosphorus trichloride (Note 3) and 150 ml. of anhydrous ether. A solution of 0.50 mole of isopropylmagnesium chloride in about 150 ml. of ether (Note 4) and (Note 5) is placed in the dropping funnel.

The flask is cooled in a dry ice-acetone bath, and the Grignard reagent solution is added dropwise with rapid stirring at such a rate that the temperature of the reaction mixture remains between −25° and −30° with a bath temperature of −45°; this addition requires about 1.5 hours. After the addition has been completed, the cooling bath is removed, and the mixture is allowed to warm to room temperature. Finally, the reaction mixture is heated to reflux with continuous stirring for 30 minutes.

After the reaction mixture has cooled to room temperature, it is filtered with suction (Note 6) and (Note 7), and the residual salts are washed thoroughly with three 100-ml. portions of anhydrous ether. The combined ethereal filtrates are concentrated under reduced pressure at room temperature, and the residual liquid is fractionally distilled through a 15-cm. Vigreux column. After a small forerun has been collected, the product is obtained as a clear, colorless liquid, b.p. 46–47° (10 mm.), n^{20}D 1.4752 (Note 8). The yield is 21–23 g. (55–60%); practically no residue remains in the distillation pot.

2. Notes

1. The submitters used nitrogen purified by passage through B.T.S. catalyst (B.A.S.F., Ludwigshafen, Germany). The checkers used commercial prepurified nitrogen without further treatment.
2. The checkers used a three-necked flask, one neck of which was fitted with an adapter to accommodate the thermometer. They also used a pressure-equalizing dropping funnel so that a static nitrogen atmosphere several millimeters above atmospheric pressure could be maintained in the flask.
3. The submitters used Merck reagent grade phosphorus trichloride. The checkers used material from Baker and Adamson.
4. It is essential to use the Grignard reagent prepared from isopropyl chloride. From phosphorus trichloride and isopropylmagnesium bromide, bromodiisopropylphosphine is obtained because of a halogen exchange reaction between the initially formed chlorophosphine and magnesium bromide. The checkers used both the Grignard reagent prepared from isopropyl chloride and a commercial solution of isopropylmagnesium chloride available from Matheson, Coleman and Bell.
5. The concentration of the Grignard reagent should be estimated by titration. If an excess or less than the stoichiometric amount of the organometallic reagent is added, the yield is lower and the product is less pure. The checkers found the titration procedure of Watson and Eastham[2] to be most convenient. In a typical titration, performed under a nitrogen atmosphere, a 5.00-ml. aliquot of the Grignard reagent was added to a solution of about 2 mg. of *o*-phenanthroline in 10 ml. of anhydrous benzene. The resulting purple solution was titrated with a standard solution (0.999*M*) of *sec*-butyl alcohol in xylene

until the purple color of the *o*-phenanthroline-Grignard reagent charge transfer complex was just discharged. In this procedure the number of millimoles of *sec*-butyl alcohol added is equal to the number of millimoles of alkylmagnesium chloride present in the aliquot of Grignard reagent.

6. The checkers performed this filtration and subsequent washing of the precipitate by replacing the dropping funnel in the reaction flask by a sintered-glass filter stick. A slight positive nitrogen pressure was applied in the reaction flask, and the pressure was reduced in the flask that served as a receiver for the filtrate passing through the sintered-glass filter.

7. The checkers found it necessary to dislodge and break up the cake of magnesium salts that formed on the walls of the reaction flask. If this precaution was not observed, a substantial amount of product occluded in the salt cake was not recovered during the washing process.

8. The checkers verified the absence of dichloroalkylphosphine and trialkylphosphine contaminants in this product by obtaining acceptable elemental analytical results and by measuring the mass spectrum of the product, which exhibits a molecular ion peak at m/e 152 (^{35}Cl) with abundant fragment peaks at m/e 110, 43, and 41.

3. Discussion

Chlorodiisopropylphosphine has been prepared by the reduction of the diisopropyltrichlorophosphorus-aluminum chloride complex with antimony;[3,4] this is a general method and the reduction can be performed with other reagents.[5] Other general methods for the preparation of chlorodialkylphosphines are reaction of dialkylphosphines with phosgene[6,7] and the cleavage of N,N-dialkylaminodialkylphosphines with hydrogen chloride[8,9,10] or phosphorus trichloride.[11]

4. Merits of the Preparation

Chlorodialkylphosphines are important synthetic intermediates in organophosphorus chemistry. In the chemical literature there is a widespread view that the simple one-step Grignard method is not suitable for the preparation of these compounds because of dominant trisubstitution and the formation of difficultly separable mixtures.[12] Although this is true for the *n*-alkyl compounds, the present preparation demonstrates that in the case of branched primary alkyl compounds and secondary and tertiary alkyl compounds the method can be very convenient and can give pure products. The submitters have prepared[13] chlorodiisobutylphosphine (45–50%), chlorodi-*sec*-butylphosphine (75–80%), chlorodi-*t*-butylphosphine (65–70%), and chlorodicyclohexylphosphine (60–65%) in analogous manner.

With *t*-butylmagnesium chloride the substitution of only one chlorine atom of the phosphorus trichloride is possible, giving dichloro-*t*-butylphosphine (65–70%).

This preparation is referenced from:

- Org. Syn. Coll. Vol. 5, 775
- Org. Syn. Coll. Vol. 6, 762
- Org. Syn. Coll. Vol. 6, 901
- Org. Syn. Coll. Vol. 7, 200

References and Notes

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

diisopropyltrichlorophosphorus-aluminum chloride complex

hydrogen chloride (7647-01-0)

Benzene (71-43-2)

ether (60-29-7)

oxygen (7782-44-7)

nitrogen (7727-37-9)

chlorine (7782-50-5)

phosgene (75-44-5)

phosphorus trichloride (7719-12-2)

magnesium bromide (7789-48-2)

xylene (106-42-3)

antimony (7440-36-0)

isopropylmagnesium bromide (920-39-8)

isopropylmagnesium chloride (1068-55-9)

Chlorodiisopropylphosphine,
Phosphinous chloride, diisopropyl- (40244-90-4)

isopropyl chloride (75-29-6)

bromodiisopropylphosphine

chlorophosphine

phenanthroline

chlorodiisobutylphosphine

chlorodicyclohexylphosphine (16523-54-9)

sec-butyl alcohol (78-92-2)

chlorodi-sec-butylphosphine

chlorodi-t-butylphosphine (13716-10-4)

dichloro-t-butylphosphine (25979-07-1)

t-butylmagnesium chloride (677-22-5)