



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.

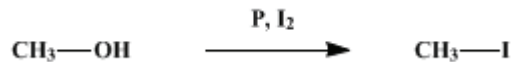
These paragraphs were added in September 2014. The statements above do not supersede any specific hazard caution notes and safety instructions included in the procedure.

Organic Syntheses, Coll. Vol. 2, p.399 (1943); Vol. 13, p.60 (1933).

METHYL IODIDE

[Methane, iodo-]

[(A) (*From Methyl Alcohol*)]



Submitted by Harold S. King

Checked by Louis F. Fieser

1. Procedure

Iodine is slowly washed by means of condensed liquid into a mixture of methyl alcohol and phosphorus. The apparatus employed by the submitter, Fig. 14, is rendered more flexible by the use of a three-necked flask, as shown in Fig. 15, and a further improvement is in the provision of a side tube for the addition of iodine to the separatory funnel, A (Note 1). In the following description reference is made to the simpler apparatus, Fig. 14; the changes required for the modified assembly will be obvious.

Fig. 14

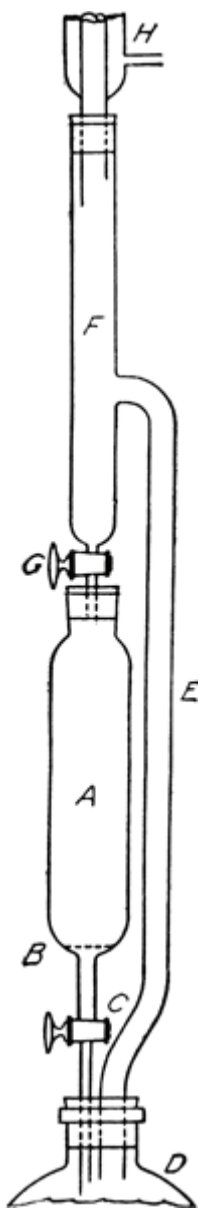
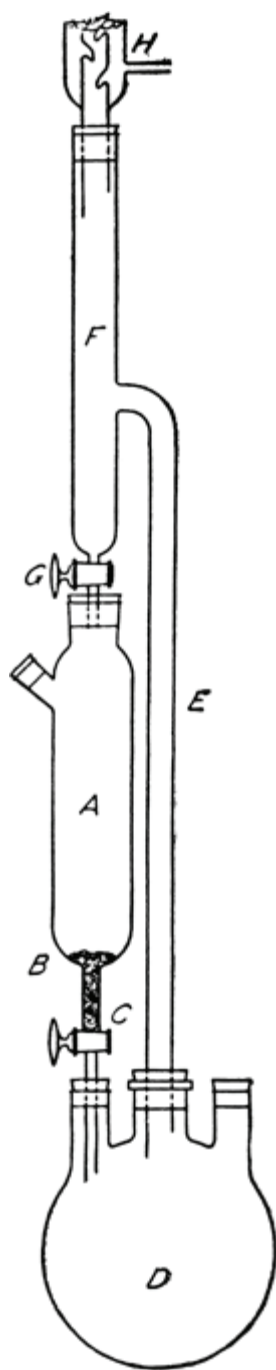


Fig. 15



The cylindrical separatory funnel A has a volume of 1.2 l. and holds 2 kg. (15.75 gram atoms) of iodine crystals (Note 2). A piece of perforated platinum foil B, or a loose plug of glass wool, is placed in the bottom to prevent clogging of the stopcock by iodine crystals or solid impurities. Stopcock C is as large as 5 mm. in bore as a further precaution. For producing up to 4 kg. of methyl iodide, a 5-l. round-bottomed Pyrex flask D is used (Note 3). It is partly submerged in a water bath. Tube E, fitted into the reaction flask by a rubber stopper, is at least 2.5 cm. in internal diameter in order to allow the vapor to rise without interrupting the return of the excess distillate. Tube F is 4 cm. in diameter to allow for preliminary condensation. A space (13 cm.) is left above stopcock G as a reservoir for the distillate. Stopcock G has a bore of 2 or 3 mm. (Note 4). The bottom of the tube from this stopcock is flush with the bottom of the rubber stopper to the iodine container, so that the liquid will flow down the sides of the container instead of forming a channel through the middle of the iodine. Condenser H, 2.5 cm. in diameter and at least 200 cm. long, is attached by a rubber stopper and is well cooled with a strong

stream of water (Note 5) and (Note 6).

In container A is placed 2 kg. of iodine, no crystals being allowed to fall below the platinum foil or glass wool. The iodine is covered with part of 2 l. (50 moles) of methanol (Note 7), the rest of which is added to 200 g. each of red and yellow phosphorus (12.8 gram atoms) in reaction flask D. The apparatus is assembled as illustrated in Fig. 14. The water bath is heated to 70–75°; stopcock G is opened wide and stopcock C part way to allow the solution of iodine to flow slowly into the reaction flask. By the time all the alcohol has been added, enough methyl iodide will have been formed to start the refluxing. Stopcock C is then opened wide and stopcock G partly closed so that only a small stream of methyl iodide flows through the iodine container. The temperature is adjusted so that little of the reflux flows back through tube E. This will require the progressive lowering of the temperature of the water bath as the reaction proceeds (Note 8); a temperature of about 55° is sufficient to promote even boiling after the first portion of iodine has been introduced. If for any reason refluxing becomes too violent, both stopcocks are closed. When the reaction has been brought under control, stopcock G is partly opened and then stopcock C part way, until any liquid in A has run out, after which C is opened wide. When all the iodine has been extracted (about two and one-half hours) both stopcocks are closed, the separatory funnel is lowered with a rotary motion, filled with a second charge of 2 kg. (15.75 gram atoms) of iodine, and raised to its former position. Stopcock C is opened wide and stopcock G part way as before.

After the extraction of this second charge of iodine, the flask is cooled, and a condenser arranged for downward distillation is fitted in place of the special apparatus. To the lower end of the condenser is tightly attached an adapter dipping under a slush of ice and water. When all the methyl iodide has distilled (b.p. 40–42.5°) (Note 9), it is separated from the water, dried by shaking with anhydrous calcium chloride, filtered through glass wool, stored for use in a sealed flask or tubes, and kept in the dark (Note 10). The yield is 4150–4250 g. (93–95 per cent of the theoretical amount based on iodine), and the crude product is colorless and sufficiently pure for many purposes. Redistillation gives, with a 95 per cent recovery, a product boiling at 41.0–42.0°. Because of the high vapor pressure of methyl iodide, special precautions should be taken to prevent loss of material. Two different devices that have been found satisfactory are described in (Note 11) and (Note 12).

The discoloration of purified methyl iodide is greatly retarded by the addition of a drop of mercury, and traces of iodine in an old sample may be removed by shaking with mercury (Note 13). A very highly colored product is best washed with very dilute sodium thiosulfate, then with water, before drying.

With minor modifications, this method is suitable for the preparation of ethyl, *n*-propyl, *n*-butyl, *n*-amyl, isobutyl, and isoamyl iodides with yields of more than 90 per cent. A somewhat lower yield is obtained in the preparation of *sec.*-butyl iodide owing to the formation of hydrogen iodide.

2. Notes

1. The upper opening of the funnel A (Fig. 15) should be the same size as that of tube F, so that the funnel may be used as a receiver in the distillation described below (Note 12).
2. A funnel of this volume and shape is not essential but has been found convenient. Even if a globular separatory funnel is used, the liquid flowing through it has been found to wet the walls.
3. For larger quantities a flask up to 12 l. in capacity may be substituted.
4. The stopcock from a small, broken, separatory funnel serves the purpose.
5. In hot weather there is usually some loss of methyl iodide through the condenser. This can be recovered by a trap made by bending the mouth end of a 50-cc. pipet into a U, which is stoppered into the end of the condenser, the delivery end being just below the surface of a slush of ice and water.
6. In place of the very long condenser, the checker used a modified West condenser with staggered indentures, as shown in Fig. 15. The jacket was 90 cm. in length, the inner tube was 2.2 cm. i.d., the opening at the top was 3.3 cm. i.d. At the top of this condenser was attached a 30-cm. bulb condenser which could be cooled with ice water. With the tap water at 5°, there was no difficulty in effecting complete condensation, and the trap described in (Note 5) was not required. In warm weather it will probably be necessary to run the water to each condenser through a large bottle of ice.
7. The methanol need not be absolute. In one experiment it was diluted with 10 per cent of its weight of water. The yield of methyl iodide was identical with that of a check run in which absolute methanol was

used.

The refluxing starts more smoothly if the iodine crystals are covered with methanol. The alcoholic solution of iodine forms sufficient methyl iodide to start the refluxing at a lower temperature than would otherwise be necessary.

8. The increased speed of the reaction is largely due to the fact that iodine is more soluble in methyl iodide than in methanol and is therefore more rapidly introduced as the reaction progresses. The reaction is exothermic.

9. It has been pointed out that this distillate is probably the constant-boiling mixture of methyl iodide and methyl alcohol which is composed of 93 per cent by weight of methyl iodide and boils at 39°. The procedure given for recovering the methyl iodide from the water-ice mixture is adequate. (Robert A. Dinerstein, private communication.)

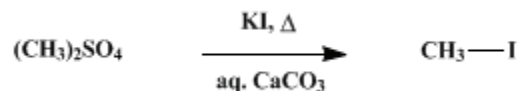
10. Caution is necessary in disposing of the residues left in the reaction flask because they contain yellow phosphorus. They should be covered at once with water.

11. One end of a coil of 2-mm. glass tubing is sealed to the end of the inner tube of the condenser. The other end of the coil is sealed to a tube leading through the stopper of the collecting vessel, which also carries a Bunsen valve to prevent the entrance of moisture from the air. Both the coil and the collecting vessel are cooled with ice and salt, or with carbon dioxide snow.

12. Another convenient assembly for the distillation is furnished by using the condenser shown in Fig. 15, together with the separatory funnel, A. The methyl iodide is distilled from a 3-l. flask through an inverted U-tube (22 mm.); this brings the vapor down into the condenser, which is also clamped in a vertical position. The separatory funnel serves as the receiver and permits the easy removal of fractions. The side opening is equipped with a small condenser carrying a calcium chloride tube. A simple and adequate method of recording the boiling temperature is to insert in the U-tube in an inverted position a long thermometer with its head imbedded in a small cork, which rests on the bottom of the flask.

13. *Caution.* Methyl iodide in contact with mercury when exposed to the sunlight readily forms methylmercuric iodide, which is exceedingly poisonous.

[(B) (From Methyl Sulfate)]



Submitted by W. W. Hartman

Checked by John R. Johnson and H. J. Passino.

1. Procedure

A 3-l. three-necked flask is fitted with a thermometer, a separatory funnel, a liquid-sealed mechanical stirrer, and a small fractionating column connected with an efficient condenser set for downward distillation. The condenser leads to a receiving vessel cooled in ice water (Note 1). A solution of 800 g. (4.8 moles) of u.s.p. potassium iodide in 430 cc. of water is placed in the flask, 60 g. of calcium carbonate is added, and the mixture is heated to 60–65°, with stirring.

The temperature is kept at 60–65°, and 630 g. (473 cc., 5 moles) of "practical" methyl sulfate (Note 2) is added gradually through the separatory funnel. The rate of addition is such that the methyl iodide distils briskly; the addition requires about two hours.

After all the methyl sulfate has been added, the temperature is raised to 65–70° for about forty minutes to complete the distillation of the methyl iodide. The product is separated from a small amount of water, dried thoroughly over anhydrous calcium chloride, and decanted into a dry distilling flask. A few crystals of potassium iodide are added, and the material is distilled from a water bath. The yield of methyl iodide, boiling at 41–43°, is 615–640 g. (90–94 per cent of the theoretical amount) (Note 3).

2. Notes

1. It is important to avoid loss of the volatile methyl iodide. The notes to Procedure (A) can be read with

profit on this point.

2. [Methyl sulfate](#) is extremely toxic. Contact with the liquid or inhaling the vapor should be avoided. [Ammonia](#) is a specific antidote.
3. Similar percentage yields are obtained with quantities of material up to ten times as large as those specified in the procedure.

3. Discussion

[Methyl iodide](#) has been prepared by the action of [methyl sulfate](#) on an aqueous solution of [potassium iodide](#);¹ by the slow distillation of a mixture of [methanol](#) with a large excess of constant-boiling [hydriodic acid](#);² by the electrolysis of an aqueous solution of [potassium acetate](#) in the presence of [iodine](#) or [potassium iodide](#);³ by the action of an aqueous solution of [potassium iodide](#) on [methyl p-toluenesulfonate](#);⁴ and by the action of [methanol](#) on a solution of [phosphorus pentaiodide](#) in [methyl iodide](#).⁵ The most generally employed method of preparing [methyl iodide](#) has been the interaction of [methanol](#) and [phosphorus triiodide](#) (or a mixture of [iodine](#) and [phosphorus](#), red, yellow, or both).⁶ Many modifications of this method have been proposed and certain variants have been suggested for the preparation of the higher alkyl iodides which are applicable to the preparation of [methyl iodide](#).⁷

The procedure described in (A) is a modification of Walker's method.⁸ The method of introducing a soluble substance gradually into a reaction flask, described above, is applicable to other reactions, such as the preparation of mercury dialkyls.⁹

The procedure described in (B) can also be employed successfully with [iodoform](#) as the iodine-containing starting material, if the [iodoform](#) is first heated with alcoholic alkali.¹⁰

This preparation is referenced from:

- [Org. Syn. Coll. Vol. 4, 325](#)
- [Org. Syn. Coll. Vol. 6, 830](#)

References and Notes

1. Weinland and Schmid, *Ber.* **38**, 2327 (1905); Ger. pat. 175,209 [*Frld.* **8**, 17 (1905-07)].
 2. Norris, *Am. Chem. J.* **38**, 639 (1907).
 3. Kaufler and Herzog, *Ber.* **42**, 3860 (1909).
 4. Peacock and Menon, *Quart. J. Indian Chem. Soc.* **2**, 240 (1925); Rodionow, *Bull. soc. chim.* (4) **39**, 323 (1926).
 5. Walker and Johnson, *J. Chem. Soc.* **87**, 1595 (1905).
 6. Dumas and Peligot, *Ann.* **15**, 20 (1835); Ipatiew, *J. Russ. Phys.-Chem. Soc.* **27**, I, 364 (1895) [*Ber.* **29** (R) 90 (1896)]; *J. prakt. Chem.* (2) **53**, 275 (1896); Crismer, *Ber.* **17**, 652 (1884); Walker and Johnson, *J. Chem. Soc.* **87**, 1592 (1905); Haywood, *ibid.* **121**, 1911 (1922).
 7. Hunt, *ibid.* **117**, 1592 (1920); Bogert and Slocum, *J. Am. Chem. Soc.* **46**, 763 (1924).
 8. Walker, *J. Chem. Soc.* **61**, 717 (1892); Nagai, *J. Pharm. Soc. Japan* **1916**, No. 407, 1 [*C. A.* **10**, 987 (1916)]; Adams and Voorhees, *J. Am. Chem. Soc.* **41**, 796 (1919); Adams, Kamm, and Marvel, *Organic Chemical Reagents I*, *Univ. Illinois Bull.* **16** (43) 19 (1919); Reynolds and Adkins, *J. Am. Chem. Soc.* **51**, 280 (1929); King, *Proc. Trans. Nova Scotian Inst. Sci.* **16** [2] 87 (1924).
 9. Gilman and Brown, *J. Am. Chem. Soc.* **51**, 928 (1929).
 10. Kimball, *J. Chem. Education* **10**, 747 (1933).
-

Appendix Chemical Abstracts Nomenclature (Collective Index Number);

(Registry Number)

yellow phosphorus

methyl alcohol and phosphorus

red and yellow phosphorus

ethyl, n-propyl, n-butyl, n-amyl, isobutyl, and isoamyl iodides

calcium chloride (10043-52-4)

ammonia (7664-41-7)

methyl alcohol,
methanol (67-56-1)

PHOSPHORUS (7723-14-0)

potassium iodide (7681-11-0)

sodium thiosulfate (7772-98-7)

mercury (7439-97-6)

calcium carbonate (471-34-1)

iodine (7553-56-2)

hydriodic acid,
hydrogen iodide (10034-85-2)

Methyl iodide,
Methane, iodo- (74-88-4)

methyl sulfate (75-93-4)

iodoform (75-47-8)

potassium acetate (127-08-2)

methylmercuric iodide

phosphorus pentaiodide

phosphorus triiodide (13455-01-1)

Methyl p-toluenesulfonate (80-48-8)

sec.-butyl iodide (513-48-4)

