



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.

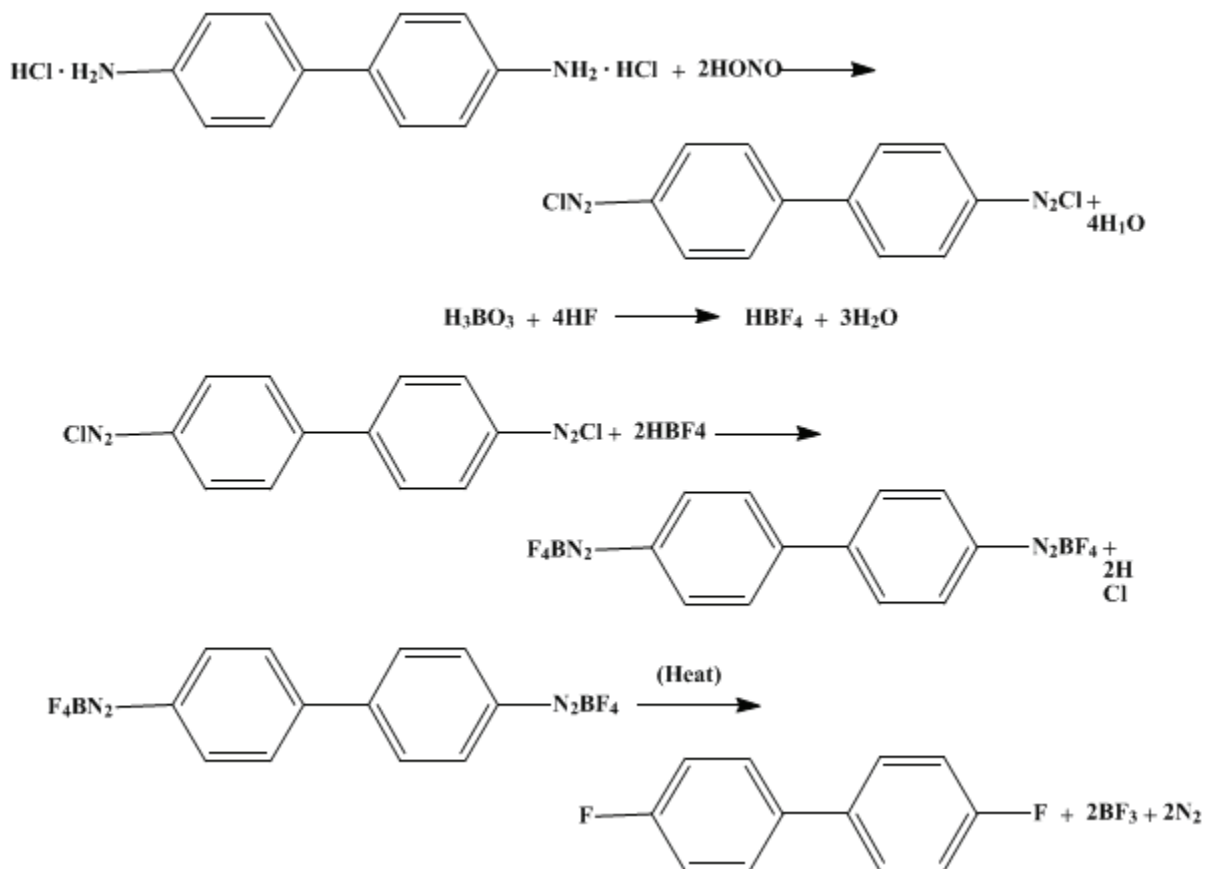
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These paragraphs were added in September 2014. The statements above do not supersede any specific hazard caution notes and safety instructions included in the procedure.

Organic Syntheses, Coll. Vol. 2, p.188 (1943); Vol. 18, p.20 (1938).

4,4'-DIFLUOROBIPHENYL

[Biphenyl, 4,4'-difluoro-]



Submitted by G. Schiemann and W. Winkelmüller.

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1. Procedure

A mixture of 280 g. (1.5 moles) of commercial [benzidine](#) and 880 cc. (10.2 moles) of concentrated [hydrochloric acid](#) (sp. gr. 1.18) is placed in a 5-l. round-bottomed flask and warmed on a steam bath for one to two hours, with occasional shaking, to form the dihydrochloride. The flask is then equipped with a mechanical stirrer and a dropping funnel, and cooled, with stirring, to -10° in an ice-salt bath. When this temperature has been reached, the [benzidine dihydrochloride](#) is tetrazotized over a period of two hours with a solution of 232 g. (3.2 moles) of 95 per cent [sodium nitrite](#) in 800 cc. of water, until a faint test for [nitrous acid](#) with starch-iodide paper is obtained after twenty minutes. During this reaction, the temperature is kept below -5° .

Concurrently with the tetrazotization, 104 g. (1.68 moles) of [boric acid](#) is dissolved in 222 g. (6.66 moles) of 60 per cent [hydrofluoric acid](#). The solution is made in a 1-l. beaker, which has been coated inside with paraffin, and is cooled in an ice bath. The [boric acid](#) is added slowly in small portions, and the mixture is stirred with a lead rod. It is necessary to keep the temperature below $20-25^\circ$ in order that the heat of solution may not melt the paraffin from the walls of the beaker ([Note 1](#)).

The ice-cold fluoboric acid solution is added rather rapidly, with stirring, to the finished tetrazo solution, the temperature being kept below 10° . A thick paste of 4,4'-biphenylene-bis-diazonium borofluoride forms. The mixture is stirred at 10° for twenty to thirty minutes. It is then collected on a

19-cm. Büchner funnel and washed consecutively with about 200 cc. of cold water, 200 cc. of cold commercial [methyl alcohol](#), and 200 cc. of commercial [ether](#); the cake is sucked as dry as possible between washings. It is then dried in a vacuum desiccator over concentrated [sulfuric acid](#) (sp. gr. 1.84). The yield of the dry solid is 393–400 g. (68–69 per cent of the theoretical amount). The product decomposes at 135–137°.

A 1-l. distilling flask with a wide side arm may be used for the decomposition of the [tetrazonium borofluoride](#). A 500-cc. distilling flask is fastened directly to the side arm of the decomposition flask and cooled with running water. To the side arm of the receiver is connected a rubber tube which is placed over 2 l. of water in a 5-l. flask ([Note 2](#)). The solid to be decomposed ([Note 3](#)) is placed in the decomposition flask and heated at the upper edge with a Bunsen burner. When white fumes begin to be evolved, the burner is removed and the decomposition permitted to continue spontaneously. More heat is applied as needed. Finally vigorous heating is employed to ensure complete decomposition. Some [4,4'-difluorobiphenyl](#) is collected in the receiver, but the larger portion remains in the decomposition flask, from which it is recovered by steam-distilling the black residue. A second steam distillation gives a pure white compound melting at 88–89°, after drying in an oven at 60–70°. When 153 g. of the [tetrazonium borofluoride](#) is decomposed in this manner, 61–62 g. of [4,4'-difluorobiphenyl](#) is obtained (80–81.5 per cent of the theoretical amount, based on the [tetrazonium borofluoride](#); 54–56 per cent based on the [benzidine](#) used).

2. Notes

1. A small lead jar is excellent for preparing the solution. By means of a lead stirrer of the usual shape, mechanical stirring may be used. The stirrer should be thrust through a hole in a lead cover of sufficient size to prevent splashing of the [hydrofluoric acid](#).

Hydrofluoric acid produces extremely painful burns. Exposed parts of the body must be protected when working with this material. Compare, [Note 3](#), p. 297. Instead of preparing fluoboric acid, 355.5 g. of commercial 40 per cent fluoboric acid may be used.

2. A convenient apparatus is made by connecting a 1-l. round-bottomed flask by means of a bent tube of large diameter (2 cm.) to a second 1-l. round-bottomed flask containing 500 cc. of water. The second flask is equipped with an exit tube, and the gases which do not dissolve in the water are led into a hood.

3. It is very necessary that the [tetrazonium borofluoride](#) be dried completely. If the solid is wet, the decomposition proceeds very vigorously. There is formed at the same time a product of higher melting point (160°) as well as some tar. These products, although not volatile with steam, lower the yield of the [4,4'-difluorobiphenyl](#) very materially.

3. Discussion

[4,4'-Difluorobiphenyl](#) has been prepared from [4,4'-biphenyl-bis-diazonium piperidide](#) (by diazotizing [benzidine](#) and coupling with [piperidine](#)) and concentrated [hydrofluoric acid](#);¹ by the action of sodium on [p-fluorobromobenzene](#) in [ether](#);² from [benzidine](#) by tetrazotization and decomposing the biphenyl-bis-diazonium salt with concentrated [hydrofluoric acid](#);³ by the above method in the presence of [ferric chloride](#);⁴ and by the prolonged contact of the vapors of [fluorobenzene](#) with a red-hot wire.⁵ The method described here is the most satisfactory for use in the laboratory and is an improvement on the method of Balz and Schiemann.⁶

References and Notes

1. Wallach, *Ann.* **235**, 271 (1886).
2. Wallach and Heusler, *ibid.* **243**, 244 (1888).
3. Valentiner and Schwarz, *Ger. pat.* 96, 153 [*Frdl.* **5**, 910 (1897–1900)].
4. Valentiner and Schwarz, *Ger. pat.* 186,005 [*Frdl.* **8**, 1237 (1905–07)].
5. Meyer and Hofmann, *Monatsh.* **38**, 149 (1917).
6. Balz and Schiemann, *Ber.* **60**, 1189 (1927).

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

fluoboric acid

4,4'-biphenylene-bis-diazonium borofluoride

sulfuric acid (7664-93-9)

hydrochloric acid (7647-01-0)

methyl alcohol (67-56-1)

ether (60-29-7)

sodium nitrite (7632-00-0)

nitrous acid (7782-77-6)

hydrofluoric acid (7664-39-3)

sodium (13966-32-0)

piperidine (110-89-4)

ferric chloride (7705-08-0)

boric acid (10043-35-3)

benzidine (92-87-5)

benzidine dihydrochloride

tetrazonium borofluoride

Fluorobenzene (462-06-6)

p-fluorobromobenzene (460-00-4)

4,4'-DIFLUOROBIPHENYL,
Biphenyl, 4,4'-difluoro- (398-23-2)

4,4'-biphenyl-bis-diazonium piperidide