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of Reliable Methods
for the Preparation
of Organic Compounds

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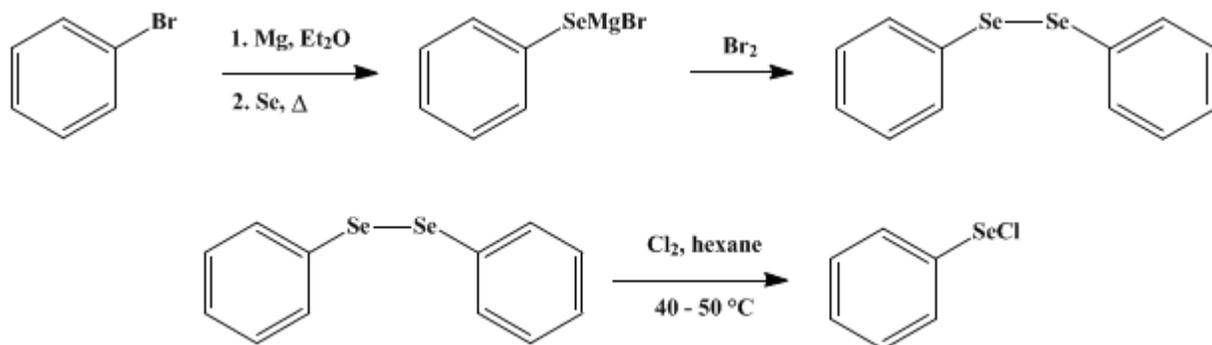
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These paragraphs were added in September 2014. The statements above do not supersede any specific hazard caution notes and safety instructions included in the procedure.

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REAGENTS FOR SYNTHESIS OF ORGANOSELENIUM COMPOUNDS: **DIPHENYL DISELENIDE AND BENZENESELENYL CHLORIDE**



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1. Procedure

Caution! Most selenium compounds are toxic; care should be exercised to avoid contact with skin. All operations in this procedure should be conducted in a well-ventilated hood.

A. *Diphenyl diselenide*. A 2-l., three-necked, round-bottomed flask is equipped with a mechanical stirrer, a pressure-equalizing dropping funnel, and an efficient reflux condenser mounted with a combined inlet-outlet assembly connected to a **nitrogen** source and a bubbler. The apparatus is flamed dry while a slow stream of **nitrogen** is passed through the system. In the cooled flask a solution of **phenylmagnesium bromide** is prepared from 160 g. (1.02 mole) of **bromobenzene**, 24.0 g. (0.988 g.-atom) of **magnesium**, and 550 ml. of anhydrous **diethyl ether**. The dropping funnel is removed, and an Erlenmeyer flask containing 70 g. (0.89 g.-atom) of **selenium** (Note 1) is attached to the neck of the flask with a section of nylon tubing (Note 2). The **selenium** is added in portions at a rate sufficient to maintain a vigorous reflux (Note 3). The addition requires 15–30 minutes, after which the mixture is stirred and heated at reflux for another 30 minutes. The Erlenmeyer flask and nylon tubing are removed, and 3 g. (0.2 mole) of water is added to hydrolyze any excess Grignard reagent. The mixture is stirred and cooled in an ice bath while 74.3 g. (23.8 ml., 0.465 mole) of **bromine** is added dropwise at a rate such that the **ether** does not reflux (Note 4). Cooling and stirring are continued as a solution of 53.5 g. (1.00 mole) of **ammonium chloride** in 140 ml. of water is added slowly. The mixture is filtered by gravity into a 1-l., round-bottomed flask, and the granular precipitate is washed thoroughly with three 100-ml. portions of **ether**. The combined filtrates are evaporated, the remaining solid is dissolved insofar as possible in 500 ml. of hot **hexane**, and a small amount of insoluble material is separated by gravity filtration. The filtrate is allowed to crystallize at room temperature and then at 6°. The yellow microcrystalline solid is collected, washed with 30 ml. of **pentane**, and dried in the air, 89–97 g. (64–70%) of **diphenyl diselenide**, m.p. 60–62° (Note 5) and (Note 6).

B. *Benzeneselenenyl chloride*. A 1-l., three-necked, round-bottomed flask equipped with a magnetic stirring bar, a thermometer, a gas-inlet tube, and a reflux condenser is charged with 50 g. (0.16 mole) of **diphenyl diselenide** and 350 ml. of **hexane** (Note 7). The mixture is warmed to 40–50°, dissolving the solid. The resulting solution is stirred while **chlorine** gas is passed through the gas-inlet tube into the flask 1 cm. above the surface of the liquid, at a rate sufficient to maintain the temperature between 40° and 50°. Chlorination is continued until 11.3 g. (0.159 mole) of the gas is absorbed (Note 8). The solution is heated to reflux, filtered by gravity, and allowed to cool slowly at room temperature, then at 6° (Note 9). The mother liquor is decanted, the large, deep-orange crystals are washed with 25 ml. of

pentane, and the residual solvent is evaporated by passing a slow stream of nitrogen over the crystals for 30 minutes, giving 51–54 g. (84–88%) of benzeneselenenyl chloride, m.p. 60–62° (Note 10).

2. Notes

1. The gray powdered form of selenium should be used. The submitters purchased this material from Research Organic/Inorganic Chemical Corporation, 11686 Sheldon Street, Sun Valley, California 91352, and from Var-lac-oid Chemical Company, 666 South Front Street, Elizabeth, New Jersey 07202.
2. Alternatively the flask may be equipped with a Y-shaped adapter bearing a straight condenser on its vertical branch and fitted with a nitrogen inlet in its lower branch. A slow stream of nitrogen is passed through the nitrogen inlet while the portions of selenium are added through the top of the condenser. The top of the condenser is stoppered between additions.
3. Careful exclusion of oxygen during this operation is important.
4. The addition of bromine requires about 30 minutes, after which the maintenance of a nitrogen atmosphere is no longer necessary.
5. The submitters have carried out this procedure on a 3-mole scale and obtained similar yields. A melting point of 63.5° is reported² for diphenyl diselenide.
6. The appearance of a red coloration in the product indicates the presence of excess selenium. Free selenium begins to separate when the product is contaminated by more than *ca.* 1% of diphenyl triselenide. Even material that crystallizes as a brick-red solid may contain only 5% excess selenium. The procedure described here gives diphenyl diselenide containing less than 0.5% free selenium. More of this contaminant will be present, however, if the formation of the Grignard reagent is incomplete, or if oxygen is allowed to enter the flask during the addition of selenium.
7. Technical grade hexane is adequate.
8. The amount of chlorine absorbed can be measured by the increased weight of the flask. The progress of the reaction can also be monitored in the following manner. A white ring of phenylselenium trichloride forms on the wall of the flask just above the surface of the liquid during the chlorination. If diphenyl diselenide remains in the solution, the solid dissolves when the flask is tipped slightly to immerse the phenylselenium trichloride below the surface of the solution. The solid no longer dissolves after the reaction is complete. The remaining ring of phenylselenium trichloride can be removed by adding another small portion of diphenyl diselenide.
9. The solution should not be cooled below 0°, since impurities, including diphenyl selenide dichloride, may also crystallize.
10. The submitters obtained 54–57 g. (88–93%) of product, m.p. 62–64° (lit.,³ m.p. 64–65°).

3. Discussion

Diphenyl diselenide has been prepared by disproportionation of phenyl selenocyanate in the presence of potassium hydroxide^{4,5} or ammonia,⁴ and by air oxidation of benzeneselenol.^{6,7} The preparation of benzeneselenol is described in an earlier volume in this series.⁸ In the present procedure phenylselenomagnesium bromide, formed from phenylmagnesium bromide and selenium,⁸ is oxidized directly to diphenyl diselenide with bromine.⁹ Thus, the liberation of the malodorous and toxic hydrogen selenide and benzeneselenol is avoided. Benzeneselenenyl chloride has been prepared by thermal elimination of ethyl chloride from ethyl phenyl selenide dichloride,^{3,10} by thermal elimination of chlorine from phenylselenium trichloride,¹¹ and by chlorinolysis of diphenyl diselenide with either sulfur chloride^{12,13} or chlorine.^{9,13}

Diphenyl diselenide and benzeneselenenyl chloride have been utilized as intermediates for the preparation of several phenyl-substituted organoselenium reagents (Table I).¹⁴ Benzeneselenenyl bromide is available by direct brominolysis of diphenyl diselenide.^{9,15} ¹⁶ The reaction of benzeneselenenyl halides with silver acetate and silver trifluoroacetate has been employed to generate benzeneselenenyl acetate¹³ and trifluoroacetate¹⁷ *in situ*. *N,N*-Dialkyl benzeneselenenamides have been isolated from the reaction of secondary amines with benzeneselenenyl chloride or bromide.¹⁸ Oxidation of benzeneselenenyl chloride and diphenyl diselenide with ozone affords benzeneselenenyl chloride and benzeneseleninic anhydride, respectively.^{9,19} The highly nucleophilic selenenylating reagent, selenophenoxide, is liberated in solution readily by reduction of diphenyl diselenide with sodium

borohydride in ethanol²⁰ or with other reducing agents.¹⁴ Solutions of selenophenol are conveniently prepared by reduction with hypophosphorous acid.²¹

TABLE I
ORGANOSELENIUM REAGENTS PREPARED FROM DIPHENYL
DISELENIDE OR BENZENESELENIENYL CHLORIDE

Organoselenium Reagent	M.p. or B.p. (°)	Reference(s)
C_6H_5SeBr	62	4,9,15,16
$C_6H_5SeOC(=O)CH_3$	<i>a</i>	13
$C_6H_5SeOC(=O)CF_3$	<i>a</i>	17
$C_6H_5SeN(CH_3)_2$	39–40(0.1 mm.)	18
$C_6H_5-Se(=O)-Cl$	75	9,19
$C_6H_5-Se(=O)-O-Se(=O)-C_6H_5$	120–122	19
C_6H_5SeNa	<i>a</i>	14,20,21
C_6H_5SeH	<i>a</i>	21

^a This reagent was generated in solution and used without isolation.

Diphenyl diselenide, benzeneselenenyl chloride, and organoselenium compounds derived from them have served as convenient reagents for introducing the phenylseleno group. The reaction of organolithium and Grignard reagents with diphenyl diselenide affords phenyl selenides.²² The phenylseleno group has been introduced into the α -position of aldehydes, ketones, esters, nitriles, sulfones, and related compounds by reaction of enol derivatives, enolate anions, or carbanions with diphenyl diselenide or benzeneselenenyl chloride.^{9,14,15} The addition of benzeneselenenyl halides,^{13,23} acetate,¹³ and trifluoroacetate¹⁷ to olefins affords alkyl phenyl selenides substituted in the β -position with halo, acetoxy, and trifluoroacetoxy groups.

This preparation is referenced from:

- *Org. Syn. Coll. Vol. 6, 23*

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

hypophosphorous acid

benzeneselenenyl chloride or bromide

C_6H_5SeNa

C_6H_5SeH

C_6H_5SeBr

ethanol (64-17-5)

ammonia (7664-41-7)

ether,
diethyl ether (60-29-7)

ammonium chloride (12125-02-9)

magnesium (7439-95-4)

bromine (7726-95-6)

oxygen (7782-44-7)

nitrogen (7727-37-9)

sulfuryl chloride (7791-25-5)

chlorine (7782-50-5)

potassium hydroxide (1310-58-3)

bromobenzene (108-86-1)

Phenylmagnesium bromide (100-58-3)

Pentane (109-66-0)

ozone (10028-15-6)

selenium

selenophenoxide

silver acetate (563-63-3)

hexane (110-54-3)

hydrogen selenide (7782-49-2)

Selenophenol

Benzeneselenol (645-96-5)

Diphenyl diselenide (1666-13-3)

ethyl chloride (75-00-3)

silver trifluoroacetate (2966-50-9)

sodium borohydride (16940-66-2)

Benzeneselenenyl chloride (5707-04-0)

benzeneselenenyl bromide (34837-55-3)

diphenyl triselenide

phenylselenium trichloride

diphenyl selenide dichloride (2217-81-4)

phenyl selenocyanate (2179-79-5)

phenylselenomagnesium bromide

ethyl phenyl selenide dichloride

benzeneselenenyl acetate

benzeneseleninyl chloride

benzeneseleninic anhydride (17697-12-0)