Organic Syntheses

A Publication
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of Organic Compounds

# Working with Hazardous Chemicals

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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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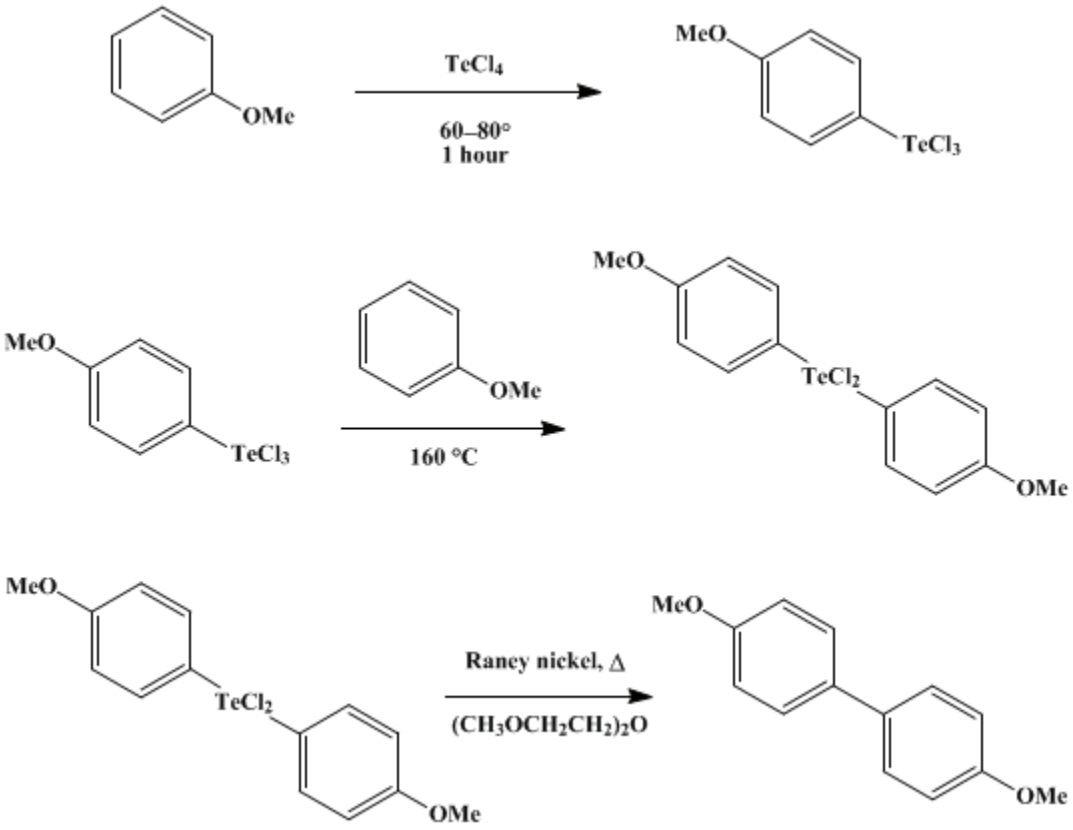
# BIARYLS FROM SIMPLE ARENES *via* ORGANOTELLURIUM INTERMEDIATES: 4,4'-DIMETHOXY-1,1'-BIPHENYL

**[1,1'-Biphenyl, 4,4'-dimethoxy-]**

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## 1. Procedure

*Caution! Because tellurium compounds have toxic effects similar to those of arsenic compounds,[2] care should be taken not to bring tellurium tetrachloride and its reaction products into contact with the skin. Avoid breathing fumes and dust of tellurium compounds. In addition, hydrogen chloride is evolved in Step A, and pyrophoric Raney nickel is used in Step B. Therefore all manipulations described in this procedure must be carried out in an efficient fume hood.*

*Benzene has been identified as a carcinogen; OSHA has issued emergency standards on its use. All procedures involving benzene should be carried out in a well-ventilated hood, and glove protection is required.*

A. *Bis(4-methoxyphenyl)tellurium dichloride.* A dry, 500-ml., three-necked, round-bottomed flask equipped with a thermometer and a reflux condenser fitted with a calcium chloride drying tube is charged with 27.0 g. (0. 100 mole) of tellurium tetrachloride (Note 1) and 64.8 g. (0.600 mole) of dry anisole (Note 2). The mixture is heated to 160° over a period of 30 minutes and maintained at this temperature for 6 hours. The reaction mixture is allowed to cool to room temperature, and the solvent is

removed with the aid of a vacuum pump. The crude solid (Note 3) is dissolved in *ca.* 250 ml. of boiling acetonitrile and filtered while hot (Note 4). Upon cooling to −25°, crystals deposit (Note 5), which weigh 35.5–38.5 g. (84–90%), m.p. 182–183° (Note 6).

B. 4,4'-*Dimethoxy*-1,1'-*biphenyl*. A 500-ml., three-necked, round-bottomed flask is equipped with a 500-ml. dropping funnel, a stopper, and a reflux condenser fitted with a two-way stopcock, one end of which is connected to an aspirator, and the other to a cylinder of dry, oxygen-free nitrogen. To this flask are added 60 g. of Raney nickel (Note 7) and 150 ml. of benzene. The system is flushed with nitrogen, and the solvent is evaporated under reduced pressure. The Raney nickel is then degassed behind an explosion shield (Note 8) in a hood by heating to 200° (2 mm.) for 2 hours.

The catalyst is allowed to cool under nitrogen, and 400 ml. of bis(2-methoxyethyl) ether is added from the dropping funnel. The stopper is then temporarily removed to add 20.6 g. (0.0497 mole) of bis (4-methoxyphenyl)tellurium dichloride. The mixture is refluxed for 8 hours and filtered while still hot. The filtrate is evaporated under reduced pressure (10–20 mm.), giving a residue which when recrystallized from ethanol yields 8.5–9.8 g. (78–90%) of the product, m.p. 175–176° (Note 9).

## 2. Notes

1. The submitters used tellurium tetrachloride available from E. Merck A G. The checkers purchased the reagent from Research Organic/Inorganic Chemical Corporation.
2. The checkers distilled anisole from calcium sulfate before use. This reagent functions not only as a reactant, but also as solvent. In some similar preparations the intermediate trichloride is rather insoluble, as in the case of bis(3-methyl-4-methoxyphenyl)tellurium dichloride. The addition of co-solvents such as bis(2-methoxyethyl) ether is beneficial.[3]
3. The crude product contains the 4,4'- and the 2,4'-isomers in the ratio 99.2/0.8. See (Note 5).
4. A small amount of tellurium (95 mg.) is formed during the preparation. The amount of tellurium increases slowly as the heating is prolonged. In a separate experiment pure bis(4-methoxyphenyl) tellurium dichloride was pyrolyzed at 250°. The main products were 1-chloro-4-methoxybenzene and tellurium.
5. Evaporation of the mother liquor gives a solid enriched in the 2,4'-isomer. Recrystallization of this solid from ethanol yields crystals containing 45% of the 2,4'-isomer.
6. The spectral details of the product are: $^1$H NMR (DMSO-$d_6$), δ (multiplicity, number of protons, assignment): 3.80 (s, 6H, OC$H_3$), 7.05–8.0 (q, 8H, $A_2B_2$ aryl); mass spectrum *m/e* (relative intensity > 10% for peaks with *m/e* above 150): 379 (16), 377 (14), 344 (39), 342 (35), 340 (22), 272 (36), 270 (31), 237 (18), 235 (17), 233 (10), 215 (15), 214 (99), 200 (14), 199 (100), 172 (21). No peaks corresponding to the parent ion could be detected.
7. The catalyst was prepared from a nickel–aluminum (50:50) alloy using the procedure in *Org. Synth.*, **Coll. Vol. 3**, 181 (1955). The catalyst is used in large excess. Reduced amounts of catalyst resulted in decreased yields, and the product is contaminated with detectable (GC) amounts of bis(4-methoxyphenyl)telluride.
8. This operation has been performed several times without incident. However, it should be noted that the W6 and W7 forms of Raney nickel have been reported to explode [*Org. Synth.*, **Coll. Vol. 5**, 102 (1973)]. No explosions have been reported with the W2 form used in this preparation.
9. 4,4'-Dimethoxybiphenyl can also be prepared by simply refluxing bis(4-methoxyphenyl)tellurium dichloride with degassed, commercial Raney nickel. The yields are, however, lower and less reproducible,[3] and the product may contain some bis(4-methoxyphenyl)telluride.

## 3. Discussion

Most synthetic methods for biaryl preparation, such as the Ullmann coupling and all variants of the Grignard coupling,[4,5,6] require halogen-substituted aromatic compounds as starting materials. Since these components are prepared by halogenation of the appropriate precursor, either directly or indirectly, it is evident that a direct coupling method offers obvious advantages. Such reactions may be effected electrochemically,[7] and by reagents such as palladium(II) acetate,[8,9] thallium(III) trifluoroacetone,[10] and vanadium tetrachloride.[11] The applicability of these reagents and the selectivity of the reactions are often restricted, when compared with the present procedure. For a recent review, see

reference [12].

Tellurium tetrachloride reacts as an electrophilic reagent with aromatic compounds bearing activating substituents, such as RO-, $R_2N$-, and RS- groups, providing first aryltellurium trichlorides, then diaryltellurium dichlorides, as one raises the reaction temperature. The second step should, in order to prevent formation of elemental tellurium and chlorinated aromatics, be performed at as low a temperature as possible (Note 4). This is especially important when highly reactive substrates such as 1,3-dimethoxybenzene are used. The addition of a Lewis acid to the reaction mixture brings about an acceleration of the reaction with less reactive reactants such as benzene and chlorobenzene.[3] The rate of acceleration is dramatically enhanced when the ratio of $AlCl_3/TeCl_4$ is more than 1:1. Thus, refluxing a mixture of 1 equivalent of $TeCl_3$ and 3 equivalents of $AlCl_3$ in benzene provided diphenyltellurium dichloride in 58.5% yield.[13]

The coupling reaction proceeds better when a rigorously degassed Raney nickel catalyst is used, but a nickel catalyst prepared by a much simplified procedure (Note 9) is also effective. The coupling may also be promoted by other elements, including copper and palladium.

## References and Notes


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

oxygen-free nitrogen

thallium(III) trifluoroacetone

ethanol (64-17-5)

hydrogen chloride (7647-01-0)

Benzene (71-43-2)

acetonitrile (75-05-8)

nitrogen (7727-37-9)

Anisole (100-66-3)

copper (7440-50-8)

calcium sulfate (7778-18-9)

nickel,
Raney nickel (7440-02-0)

chlorobenzene (108-90-7)

palladium (7440-05-3)

bis(2-methoxyethyl) ether (111-96-6)

1-chloro-4-methoxybenzene (623-12-1)

1,3-dimethoxybenzene (151-10-0)

tellurium

tellurium tetrachloride (10026-07-0)

Bis(4-methoxyphenyl)tellurium dichloride (4456-36-4)

bis(3-methyl-4-methoxyphenyl)tellurium dichloride

bis(4-methoxyphenyl)telluride

palladium(II) acetate (3375-31-3)

vanadium tetrachloride (7632-51-1)

diphenyltellurium dichloride

4,4'-dimethoxybiphenyl,
4,4'-Dimethoxy-1,1'-biphenyl,
1,1'-Biphenyl, 4,4'-dimethoxy- (2132-80-1)