

Simple Methods of Preparing Substituted Deuteriobenzenes and α -Deuteriotoluenes of High Isotopic Purity

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Deuteriobenzenes, $\text{XC}_6\text{H}_4\text{D}$ ($X = \text{H}$, *o*-, *m*-, or *p*-Me, *m*- or *p*-Cl, *m*- or *p*-OMe, *m*-CF₃, *p*-F, or *p*-Br), of better than 98% isotopic purity have been prepared by treatment of the appropriate aryltrimethylstannane, $\text{XC}_6\text{H}_4\cdot\text{SnMe}_3$, with *O*-deuterioacetic acid containing 10% (w/w) of deuterium oxide at 75°. The benzyl compound *m*-CF₃·C₆H₄·CH₂D has been correspondingly prepared by treatment of the compound *m*-CF₃·C₆H₄·CH₂·SiMe₃ with sodium deuterioxide in *O*-deuteriomethanol. The methods should have general application.

CLEAVAGES of aryl-MMe₃ bonds, where M = Si or Sn, by electrophilic reagents provide useful routes to aromatic compounds bearing functional groups in predetermined positions;^{1,2} thus the compounds $\text{XC}_6\text{H}_4\cdot\text{SiMe}_3$ or $\text{XC}_6\text{H}_4\cdot\text{SnMe}_3$, which are easily prepared in most cases, can be readily converted into the compounds $\text{XC}_6\text{H}_4\text{Y}$, here, for example, $\text{Y} = \text{I}$,³ SO₃H,⁴ NO₂,⁵ NO,⁶ CN,⁷ COR,⁸ or SO₂R.⁹ We have now used this approach with considerable success to obtain the compounds $\text{XC}_6\text{H}_4\text{D}$ of high isotopic purity.

The method consists of treating the compound $\text{XC}_6\text{H}_4\cdot\text{SnMe}_3$ at 75° with *O*-deuterioacetic acid containing 10% (w/w) of deuterium oxide. We used a standard reaction time of 24 h, but since the reaction was effectively complete in this time even with a strongly deactivating group present (*e.g.* $X = \text{m-CF}_3$), it is probable that much shorter times would suffice for most of the compounds, and certainly for those containing electron-supplying groups. The compound $\text{XC}_6\text{H}_4\text{D}$ is easily separated from the other product, trimethyltin acetate. Yields of 60–80% were obtained; the losses seem to be only those incurred in handling, especially fractionation, and substantially higher yields could undoubtedly be obtained in large-scale experiments. The products were all of greater than 98% isotopic purity, and a control experiment showed that no detectable isotopic exchange occurred with benzene under the reaction conditions used even in 48 h.

Normally the compounds $\text{XC}_6\text{H}_4\text{D}$ are made by hydrolysis of Grignard reagents, but this usually gives products

¹ C. Eaborn, *Pure Appl. Chem.*, 1969, **19**, 375.

² R. W. Bott and C. Eaborn in 'Organometallic Derivatives of the Group IV Elements,' ed. A. G. MacDiarmid, vol. 1, part 1, 1968, pp. 407–431.

³ C. Eaborn, A. A. Najam, and D. R. M. Walton, *J.C.S. Perkin I*, 1972, 2481.

⁴ R. W. Bott, C. Eaborn, and T. Hashimoto, *J. Organometallic Chem.*, 1965, **3**, 442.

⁵ Ref. 2, pp. 421–424; C. Eaborn, Z. Salih, and D. R. M. Walton, *J.C.S. Perkin II*, 1972, 172.

⁶ E. H. Bartlett, C. Eaborn, and D. R. M. Walton, *J. Chem. Soc. (C)*, 1970, 1717.

of low isotopic purity, although the effect of hydrogen abstraction from the solvent can be minimised by a complex procedure.¹⁰ The Grignard reagents ArMgHal can normally be readily converted into the tin compounds $\text{XC}_6\text{H}_4\cdot\text{SnMe}_3$, and use of the latter seems to be preferable to direct hydrolysis of the Grignard reagent if high isotopic purity is required. But the new method described here should be of even greater utility for cases in which the Grignard reagents, $\text{XC}_6\text{H}_4\text{MgHal}$, or organolithium compounds, $\text{XC}_6\text{H}_4\text{Li}$, cannot be prepared because of the presence of a reactive functional group X, but for which the relevant tin compounds, $\text{XC}_6\text{H}_4\cdot\text{SnMe}_3$, are available (*e.g.* $X = \text{NO}$, CN, NO₂, or COR). There is, moreover, no reason to doubt that the method could be readily extended to cover the use of certain silicon compounds, $\text{XC}_6\text{H}_4\cdot\text{SiMe}_3$, in association with a more acidic medium, such as deuteriotrifluoroacetic acid, if necessary containing added stronger acid, such as deuteriosulphuric acid, but the possibility of hydrogen exchange would place constraints on the nature of X.

A corresponding procedure, involving an alkaline cleavage medium, can be used to introduce deuterium into benzylic positions, but since (in contrast to the situation for acid cleavage of Ar-SiMe₃ and Ar-SnMe₃ bonds¹¹) there is little difference between the reactivities of corresponding ArCH₂-SiMe₃ and ArCH₂-SnMe₃ bonds,¹² it is more convenient in this case to use the even more readily available silicon compounds. For example, we treated the compound *m*-CF₃·C₆H₄·CH₂·SiMe₃ with methan[²H]ol containing sodium deuterioxide for

⁷ E. H. Bartlett, C. Eaborn, and D. R. M. Walton, *J. Organometallic Chem.*, 1972, **46**, 267; see also *U.S. Clearinghouse Fed. Sci. Tech. Inform., A.D.* (1969) 701102; (*Chem. Abs.*, 1970, **73**, 35473r).

⁸ K. Dey, C. Eaborn, and D. R. M. Walton, *Organometallics in Chem. Synth.*, 1970/72, **1**, 151.

⁹ S. N. Bhattacharya, C. Eaborn, and D. R. M. Walton *J. Chem. Soc. (C)*, 1969, 1367.

¹⁰ R. A. Caldwell, *J. Org. Chem.*, 1970, **35**, 1193.

¹¹ C. Eaborn and K. C. Pande, *J. Chem. Soc.*, 1960, 1566.

¹² R. W. Bott, C. Eaborn, and T. W. Swaddle, *J. Chem. Soc.*, 1963, 2342.

36 h at 50°, and obtained $m\text{-CF}_3\cdot\text{C}_6\text{H}_4\cdot\text{CH}_2\text{D}$ with an isotopic purity greater than 98%.

EXPERIMENTAL

Materials.—The deuterioacetic acid, methan[^2H]ol, and deuterium oxide were CIBA products of >99% isotopic purity. Sodium deuterioxide was made by dissolving sodium in deuterium oxide, with appropriate precautions, and removing the excess of the deuterium oxide under reduced pressure.

Aryltrimethylstannanes, $\text{XC}_6\text{H}_4\cdot\text{SnMe}_3$, were prepared from the appropriate Grignard or organolithium reagents in ether as previously described,¹³ and had the following physical constants: [X, b.p. (°C) at pressure (mmHg), n_{D}^{25}] H, 89—90 at 20, 1.5328; *o*-Me, 89 at 7.0, 1.5388; *m*-Me, 54 at 0.8, 1.5309; *p*-Me, 62—63 at 1.0, 1.5306; *m*-Cl, 86—87 at 2.5, 1.5491; *p*-Cl, 95 at 5.0, 1.5480; *m*-OMe, 96 at 4.5, 1.5392; *p*-OMe, 82—83 at 1.5, 1.5404; *m*-CF₃, 53 at 1.4, 1.4790; *p*-F, 45 at 1.0, 1.5149; *p*-Br, 64 at 0.2, 1.5669.

Preparation of Substituted Deuteriobenzenes, XC₆H₄D.—In a typical experiment, a mixture of *O*-deuterioacetic acid (4.0 g) and deuterium oxide (0.4 g) was added to trimethyl-(phenyl)stannane (9.6 g, 0.4 mol), and the mixture was kept at 75° under nitrogen for 24 h. It was then cooled, and the trimethyltin acetate which separated was filtered off and washed with ether (20 ml). The combined filtrates and washings were neutralized with aqueous sodium carbonate, and the organic products were extracted with ether (80 ml).

¹³ C. Eaborn and J. A. Waters, *J. Chem. Soc.*, 1961, 1131; C. Eaborn, H. L. Hornfeld, and D. R. M. Walton, *J. Organometallic Chem.*, 1967, **10**, 529; *J. Chem. Soc. (B)*, 1967, 1036.

The extract was dried (Na_2SO_4), and fractionally distilled to give deuteriobenzene (1.5 g, 60%), b.p. 80°, n_{D}^{25} 1.4976. The mass spectrum (MS9 instrument at 70 eV) showed the product to be >99% isotopically pure. Other $\text{XC}_6\text{H}_4\text{D}$ compounds, prepared analogously from the appropriate $\text{XC}_6\text{H}_4\cdot\text{SnMe}_3$ compounds, had physical constants as follows: [X, b.p. (°C), n_{D}^{25}] *o*-Me, 110, 1.4940; *m*-Me, 110, 1.4940; *p*-Me, 110, 1.4938; *m*-Cl, 132, 1.5220; *p*-Cl, 132, 1.5220; *m*-OMe, 154, 1.5140; *p*-OMe, 154, 1.5139; *m*-CF₃, 99, 1.4110; *p*-F, 85, 1.4650; *p*-Br, 156, 1.5575. In each case the mass spectrum showed the isotopic purity to be >98%.

Control Experiments with Benzene.—Benzene (4.0 g), *O*-deuterioacetic acid (1.0 g), and deuterium oxide (0.1 g) were heated together at 75° for 48 h, and the mixture was then worked up as just described. Mass spectral examination of the benzene recovered by fractional distillation showed that no deuterium had been incorporated. A similar experiment, but with trimethyltin acetate present, gave the same result.

*Preparation of α -Deuterio-*m*-trifluoromethyltoluene.*—A mixture of trimethyl-(*m*-trifluoromethylbenzyl)stannane (6.7 g, 0.030 mol),¹⁴ *O*-deuteriomethanol (8 ml), and sodium deuterioxide (0.5 g, 0.013 mol) was stirred under nitrogen for 3 h at 50°, then neutralized with dilute acid. Extraction with ether followed by the usual work-up, culminating in fractionation, gave pure α -deuterio-*m*-trifluoromethyltoluene (3.6 g, 80%), b.p. 123 °C, n_{D}^{25} 1.4420.

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¹⁴ R. W. Bott, C. Eaborn, and B. M. Rushton, *J. Organometallic Chem.*, 1965, **3**, 448.