The Copper(I) Iodide-assisted Reaction of Nonactivated Aryl Iodides with Some Alkali Metal Pseudohalides[1)]

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Synopsis. Copper(I) iodide dissolves into warm hexamethylphosphoric triamide to give a black solution, in which polymethylated iodobenzenes undergo nucleophilic attack by azide and selenocyanate ions, giving the corresponding aryl azides and selenocyanates in low to good yields. In the absence of copper(I) salt, however, the reaction does not take place. Cyanide, cyanate, thiocyanate, and fluoride ions bring about a decoloration of the reaction mixture and no displacement reactions ensue, while the tellurocyanate ion affords the corresponding aryl cyanides while liberating elemental tellurium.

The traditional methods for converting organic halides to the corresponding pseudohalides involve displacement reactions with alkali metal pseudohalides; these methods are unsatisfactory or even fail with most aryl halides. The most commonly employed procedures of preparing aryl pseudohalides are thus based on the reaction of diazotized aromatic amine with pseudohalide ions, preferably in the presence of an appropriate catalyst.[2)] However, these methods are often limited by the availability of the starting amines, especially in the case of polysubstituted systems.

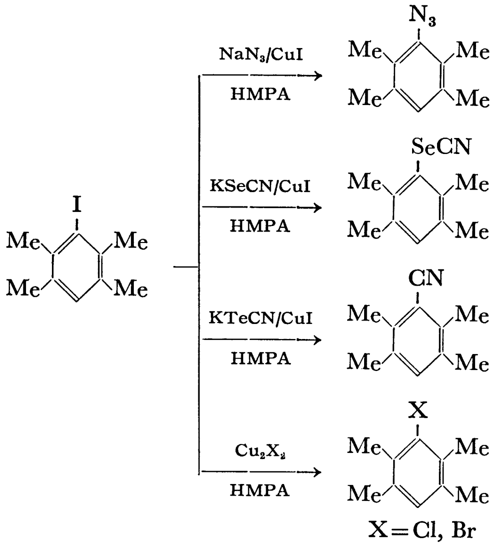
During the course of preparing some polyalkylbenzene derivatives, we have found that copper(I) iodide dissolved in hexamethylphosphoric triamide (HMPA) can induce the reaction of nonactivated aryl iodides with some pseudohalide ions, such as azide and selenocyanate ions. This reaction has not previously been reported in the literature, but it seems to have some potential as an alternative route to aryl azides and selenocyanates.[3,4)]

Copper(I) iodide dissolves into warm HMPA to give a black solution, in which polymethylated iodobenzenes are activated to such an extent as to undergo nucleophilic attack by azide and selenocyanate ions, giving the corresponding aryl azides or aryl selenocyanates in low to good yields. Curiously, the reaction does not proceed to completion even in the presence of a large excess of a nucleophilic reagent. Without copper(I) salt, no displacement reaction takes place. Moreover, when other dipolar aprotic solvent systems, including *N*,*N*-dimethylformamide, *N*,*N*-dimethylacetamide, and *N*-methylpyrrolidone, are used, the reaction fails to occur.

The replacement of copper(I) iodide by copper(I) chloride or bromide, as expected,[5)] leads to a facile halogen exchange, and the corresponding aryl chloride or bromide are obtained in nearly quantitative yields. Several attempts to accomplish similar reactions between aryl chloride and pseudohalide ions in the presence of copper(I) chloride have, however, been unsuccessful. With this combination, the characteristic coloration of the reaction mixture is not observed.

Of considerable interest is the finding that the addition of other pseudohalide ions, *i.e.*, cyanide, cyanate, or thiocyanate ions, to a black solution of aryl iodide and copper(I) iodide in HMPA results in a decoloration of the reaction mixture, and no displacement reactions ensue. These results are in contrast to those obtained from the reactions of aryl iodides with copper(I) cyanide and thiocyanate in warm HMPA, in which aryl cyanides[6)] and diaryl disulfides[7)] respectively are obtained in high yields. Alkali fluorides also produce decoloration.

In one procedure, potassium tellurocyanate[8)] is allowed to react with aryl iodides in a mixture of HMPA and dimethyl sulfoxide (DMSO). In the presence of copper(I) iodide, tellurocyanate undergoes immediate decomposition, with the deposition of a dark grey tellurium powder, and aryl cyanide is the sole identifiable product obtained. Since potassium cyanide does not react with aryl iodide, not even in the presence of copper(I) iodide, the copper(I) cyanide resulting from the decomposition of the initially formed copper(I) tellurocyanate seems to be responsible for the formation of aryl cyanide.[6)] The mechanism of the activation of polyalkylated aryl iodides by copper(I) iodide is not clear at present, although one may expect a possible role of the *in situ*-formed copper(I) azide or selenocyanate.



Scheme 1.

Experimental

The melting points were determined on a hot-stage apparatus and are uncorrected. The infrared spectra were run as Nujol mulls on a Hitachi 215 spectrophotometer; only prominent peaks were recorded. The ^{1}H-NMR spectra were measured in deuteriochloroform with a Varian T-60 spectrometer, using TMS as the internal standard, unless otherwise stated. The mass spectra were obtained on a Hitachi RMS-4 mass spectrometer with an ionizing potential of 70 eV, and selenium-containing peaks are reported for ^{80}Se.

The iodoarenes were prepared by the direct iodination of the corresponding arenes with iodine/periodic acid.[9] Hexamethylphosphoric triamide was dried over phosphorus pentaoxide and distilled prior to use. The alkali azide, cyanide, cyanate, thiocyanate, and selenocyanate were used as received. The potassium tellurocyanate was obtained by gently heating tellurium powder and potassium cyanide in dry DMSO and was used in solution.[8]

The mode of reaction is illustrated below by the representative preparations of pentamethylphenyl selenocyanate and 2,3,5,6-tetramethylphenyl azide. No effort was made to optimize the reaction.

Pentamethylphenyl Selenocyanate. A mixture of iodopentamethylbenzene (1.37 g; 5 mmol), copper(I) iodide (0.48 g; 2.5 mmol), and HMPA (7 ml) was heated with stirring at 100—110 °C until a black solution resulted, to which potassium selenocyanate (1.44 g; 10 mmol) was then added in one portion. The mixture was stirred for 7—12 h at this temperature and then poured into water. The milky solution gradually separated a precipitate, which was filtered off and extracted with hexane using a Soxhlet extractor. From the concentrated extract, the selenocyanate separated as pale yellow plates. Yield, 0.59—0.91 g (47—72%). Mp 123—124 °C. ^{1}H-NMR: δ 2.27 (s, 3Me) and 2.62 ppm (s, 2Me); IR: ν_{max} 2145, 1055, 1005, and 910 cm^{-1}. Found: C, 57.02; H, 6.00; N, 5.42%; M$^+$, 253. Calcd for $C_{12}H_{15}NSe$: C, 57.15; H, 5.99; N, 5.55%; M$^+$, 252.2.

In a similar fashion, 2,3,5,6-tetramethylphenyl selenocyanate was obtained from iododurene in 45—61% yields. Pale yellow plates; mp 88—89 °C. ^{1}H-NMR: δ 2.25 (s, 2Me), 2.52 (s, 2Me), and 7.02 ppm (s, 1H$_{arom}$); IR: ν_{max} 2150, 995, 875, and 790 cm^{-1}. Found: C, 55.39; H, 5.64; N, 5.66%; M$^+$, 239. Calcd for $C_{11}H_{13}NSe$: C, 55.47; H, 5.50; N, 5.88%; M$^+$, 238.2.

2,3,5,6-Tetramethylphenyl Azide. To a black homogenious solution of iododurene (0.68 g; 2.6 mmol) and copper(I) iodide (0.48 g; 2.5 mmol) in HMPA (5 ml), sodium azide (1.3 g; 20 mmol) was added in one portion. The deep red mixture was heated at 70—90 °C for 24 h and then quenched by the addition of water. Heating at higher temperatures led to the extensive decomposition of the azide formed. The product was extracted with ether, washed with water, and dried over sodium sulfate. The subsequent removal of the solvent gave a white crystalline mass, which showed a sharp IR band due to the azide group at 2100 cm^{-1}. Since the pure azide could not be obtained by fractional crystallization and chromatography over alumina, the product mixture was treated with an excess of lithium aluminum hydride in tetrahydrofuran; the resulting 2,3,5,6-tetramethylaniline was isolated and identified as an *N*-acetyl derivative. Mp 205—207 °C (lit,[10] 207 °C). The displacement reaction by the azide ion proceeded slowly, and the conversion, as calculated from the integration area of the ^{1}H-NMR peaks of the methyl groups, never exceeded 15% under the above conditions.

By a similar treatment, iodopentamethylbenzene was converted into the corresponding azide (10—15% conversion calculated from the ^{1}H-NMR peak area), which was reduced to pentamethylaniline and identified as an *N*-acetyl derivative. Mp 212—214 °C (lit,[11] 213 °C).

Reaction with Potassium Tellurocyanate. To a solution of iododurene (1.30 g; 5 mmol) and copper(I) iodide (0.48 g; 2.5 mmol) in HMPA (10 ml), a fresh solution of potassium tellurocyanate (1.92 g; 10 mmol) in DMSO (10 ml)[8] was added all at once. The mixture, which had turned dark brown with the liberated tellurium powder, was heated with stirring at 100—110 °C for 12 h and then poured into water. A dark grey precipitate was filtered off and extracted with hexane using a Soxhlet extractor. The extract was evaporated under reduced pressure, and the residue was recrystallized from ethanol to give white needles (0.08 g; 10%); it was identified as 2,3,5,6-tetramethylbenzonitrile by direct comparison with an authentic specimen. Mp 74—75 °C (lit,[12] 76—77 °C). ^{1}H-NMR: δ 2.22 (s, 2Me), 2.41 (s, 2Me), and 7.08 ppm (s, 1H$_{arom}$); IR (KBr): ν_{max} 2200, 1470, 1375, and 1000 cm^{-1}.

Reaction with Copper(I) Chloride. A mixture of iododurene (0.78 g; 3 mmol), copper(I) chloride (0.40 g; 4 mmol), and HMPA (6 ml) was kept at 90—100 °C for 4 h and then diluted with water. A grey precipitate was filtered off and extracted with hexane using a Soxhlet extractor. The extract was evaporated to give chlorodurene as a white mass (0.50 g; 99%) which, on recrystallization from aqueous ethanol, melted at 45—47 °C (lit,[13] 47.5—48 °C).

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