## AROMATIC POLYFLUORO-COMPOUNDS—XXX<sup>1</sup>

## NUCLEOPHILIC REPLACEMENT REACTIONS OF PENTA-NITROSOBENZENE

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Abstract—Sodium methoxide and dimethylamine react with pentafluoronitrosobenzene to replace mainly (>90%) the fluorine *para* to the nitroso-group. Methylamine *appears* to replace the *ortho* and *para* fluorines in the ratio 2:3.

IN GENERAL,<sup>2</sup> C<sub>6</sub>F<sub>5</sub>X compounds react at the same position with all nucleophiles; most compounds (e.g. X = H,  $CH_3$ ,  $CF_3$ , SMe, SO<sub>2</sub>Me, NMe<sub>3</sub>, Cl, Br, I) react mainly at the position para to X and a few either mainly meta<sup>3-5</sup> (X = OH, NH<sub>2</sub>) or approximately equal meta and para<sup>3.5</sup> (X = OMe, NHMe). Pentafluoronitrobenzene<sup>6</sup> and pentafluorobenzoic acid,<sup>1</sup> however, react mainly at the para position with sodium methoxide in methanol, but give high ortho replacement (>50% in some cases) with amines. The nitro-case resembles a number of other examples in the general nucleophilic aromatic substitution field where methoxide is more reactive towards halogens para to a nitro-group and amines are more reactive towards ortho-halogens.<sup>7</sup> This effect has been attributed<sup>6.7</sup> to hydrogen-bonding between the amines and the nitrogroup, although in view of our recent finding<sup>8</sup> that methoxide can also give high ortho-replacement (higher than some amines) in ether containing a little methanol, the whole picture cannot be as simple as this. We now report another example of a C<sub>8</sub>F<sub>5</sub>X compound, pentafluoronitrosobenzene, which appears to give a large amount of ortho-fluorine replacement in one case. This study of pentafluoronitrosobenzene was made very difficult by the great instability of all the nitroso-compounds encountered; they all decomposed to brown tars, which possibly contained azoxycompounds,<sup>9</sup> on being heated or even kept at room temperature in air for a few days. This renders some of our conclusions about isomer ratios suspect; in the methylamine reaction, for example, no pure products could be isolated even though PMR spectroscopy clearly indicated their presence.

- <sup>1</sup> Part XXIX. J. Burdon, W. B. Hollyhead and J. C. Tatlow, submitted to J. Chem. Soc.
- <sup>2</sup> J. C. Tatlow, *Endeavour* 22, 89 (1963).
- <sup>1</sup> J. Burdon, W. B. Hollyhead and J. C. Tatlow, submitted to J. Chem. Soc. (Part XXV).
- <sup>4</sup> L. A. Wall, W. J. Pummer, J. E. Fearn and J. M. Antonucci, J. Res. Nat. Bur. Stand. 67A, 481 (1963).
- <sup>b</sup> J. G. Allen, J. Burdon and J. C. Tatlow, submitted to J. Chem. Soc. (Part XXVII)
- <sup>6</sup> J. G. Allen, J. Burdon and J. C. Tatlow, J. Chem. Soc. 1045 (1965).
- <sup>7</sup> S. D. Ross, Progress in Physical Organic Chemistry 1, 31 (1963).
- <sup>8</sup> J. Burdon, D. Fisher, D. King and J. C. Tatlow, Chem. Comm. 65 (1965).
- <sup>9</sup> J. Burdon, C. J. Morton and D. F. Thomas, J. Chem. Soc. 2621 (1965).

Sodium methoxide in methanol gave a 76% yield of the 4-methoxynitrosocompound (I); PMR spectroscopy indicated that there was no (<10%) other isomer formed. Hydrogenation of I gave the known<sup>4.9</sup> tetrafluoro-*p*-anisidine, thus proving the structure (I).



Dimethylamine at  $-20^{\circ}$  under nitrogen gave a 45% yield of the 4-dimethylaminocompound (II); again PMR could detect no other isomer (<10%), but in view of the amount of decomposition which occurred, some may well have been formed. Hydrogenation of II, followed by acetylation, gave the diamine (III), which, as it was also produced from the known<sup>6</sup> tetrafluoro-N,N-dimethylnitroaniline in the same way, must have the amino-groups *para*-oriented; the structure of II must therefore be as shown.

With methylamine at  $-20^{\circ}$ , pentafluoronitrosobenzene gave a product which showed a triplet and a doublet in intensity ratio 3:2, together with some partially resolved peaks, in the NHMe region of its PMR spectrum. The triplet and doublet can be attributed<sup>10</sup> to *para*- and *ortho*-(methylamino)-tetrafluoronitrosobenzene respectively; unfortunately, however, all attempts to isolate pure compounds failed and therefore the formation of these compounds in the ratio 3:2 must be regarded as suspect.

Reaction of pentafluoronitrosobenzene with methyllithium at  $-50^{\circ}$  gave dark tars only, as did reaction with ammonia; pentafluoroaniline gave at least eleven products (as bands on a column of alumina).

From the temperatures at which the reactions of pentafluoronitrosobenzene occur, the nitroso-group is, as expected, activating the ring very powerfully towards nucleophilic attack.

Since the reactions of dimethylamine, methylamine and sodium methoxide with pentafluoronitrosobenzene, pentafluoronitrobenzene<sup>6</sup> and pentafluorobenzoic acid<sup>1</sup> were carried out, for practical reasons, at different temperatures and in slightly different solvent mixtures, it is not possible to compare the isomer ratios obtained in the three cases with any precision. In fact, pentafluoronitrobenzene, at room temperature, gave<sup>6</sup> 20% ortho-replacement with dimethylamine in 3% ethanol-ether, 70% ortho-replacement with methylamine in the same solvent, and 8% orthoreplacement with sodium methoxide in methanol, the remaining percentage in each case being the para-isomer; pentafluorobenzoic acid gave<sup>1</sup>, at 70°, 45% orthoreplacement with dimethylamine and 37% with methylamine, both in ethanol, again the remaining percentages were para-isomers. With refluxing sodium methoxide in methanol pentafluorobenzoic acid gave only the para-replacement product and no detectable ortho. Within the limitations of our results, therefore, we tentatively classify pentafluoronitrosobenzene with pentafluoronitrobenzene and pentafluorobenzoic acid in giving apparently anomalously high ortho-replacement with some amine nucleophiles.

<sup>10</sup> J. Burdon, *Tetrahedron* 21, 1101 (1965).

The nitroso-compounds (I and II) were both green in the solid state and therefore they exist largely as the monomers; pentafluoronitrosobenzene is also monomeric in the solid state.<sup>11</sup> 2,3,5,6-tetrafluoronitrosobenzene (i.e. hydrogen *para* to the nitroso-group), however, is a colourless solid<sup>9</sup> and therefore entirely dimeric.

## EXPERIMENTAL

Pentafluoronitrosobenzene and sodium methoxide. Sodium methoxide in MeOH (2.5 ml of 1 N) was added dropwise at room temp, with stirring, to a solution of pentafluoronitrosobenzene<sup>11</sup> (0.5 g) in MeOH (20 ml); the blue-green solution immediately became dark green. After 1 hr, the reaction mixture was poured into water and the crude product isolated by ether extraction. Sublimation at 60-70°/15 mm gave green crystals of tetrafluoro-4-methoxynitrosobenzene (I) (0.4 g), m.p. 59-61°, (Found: C, 39.9; H, 1.5. C<sub>7</sub>H<sub>3</sub>F<sub>4</sub>NO<sub>2</sub> requires: C, 40.2; H, 1.4%.)

Proton NMR of the crude product showed only a triplet (J = 2.5 c/s) at 4.31 ppm  $(OMe)^{10}$  (downfield from tetramethylsilane as internal reference).

Hydrogenation of I (0.3 g) at room temp and atm. press. over 10% Pd-C gave, after crystallization from light petroleum (b.p. 80–100°), tetrafluoro-*p*-anisidine (0.2 g), m.p. 72–75° (lit.,  $^{4}$  75–76.5°), identified by IR.<sup>9</sup>

Pentafluoronitrosobenzene and dimethylamine. Ethanolic dimethylamine (0.42 ml; 33% w/w) was added dropwise, with stirring, to a cooled (-20°) solution of pentafluoronitrosobenzene<sup>11</sup> (0.50 g) in EtOH (10 ml) (the reaction and all subsequent operations were conducted under N<sub>2</sub>). The solution immediately changed from blue-green to dark green and after 30 min, the reaction mixture was allowed to warm to room temp and then evaporated *in vacuo*. The residue, which showed only a triplet (J = 3.1 c/s) at 3.17 ppm (NMe<sub>2</sub>)<sup>10</sup> in its proton NMR spectrum, was sublimed *in vacuo* to give green crystals of 4-(*dimethylamino)-tetrafluoronitrosobenzene* (II; 0.25 g), m.p. 68-70°, (Found: C, 42.4; H, 2.9. C<sub>8</sub>H<sub>6</sub>F<sub>4</sub>N<sub>8</sub>O requires: C, 43.3; H, 2.7%) and a brown residue (0.3 g) which was not investigated. When the reaction was carried out at room temp much more tar (~80%) was produced.

Hydrogenation of II (0.2 g) over 10% Pd–C at room temp and atm. press., followed by acetylation of the crude product with acetic anhydride and conc.  $H_2SO_4$ , gave, after crystallization from light petroleum (b.p. 80–100°), N-acetyl tetrafluoro-N'N'-dimethyl-1,4-phenylenediamine (III; 0.07 g), m.p. 142.5–143°. (Found: C, 47.9; H, 4.1.  $C_{10}H_{10}F_4N_4O$  requires: C, 48.0; H, 4.0%.)

Hydrogenation and acetylation of tetrafluoro-N,N-dimethyl-4-nitroaniline<sup>4</sup> (1 g) in the same way gave the same N-acetyl compound (III; 1 g), m.p. and mixed m.p. 141-142°.

Pentafluoronitrosobenzene and methylamine. Ethanolic methylamine (0.47 ml; 33% w/w) in ether (10 ml) was added dropwise, with stirring, to a cooled (-20°) solution of pentafluoronitrosobenzene<sup>11</sup> (1 g) in ether (20 ml). An immediate reaction occurred and after 30 min at -20°, the dark green reaction mixture was evaporated to dryness *in vacuo*. The proton NMR spectrum of the brown residue showed a triplet (J = 2.7 c/s) at 3.30 ppm and a doublet (J = 1.5 c/s) at 3.18 ppm (NHMe)<sup>10</sup> in approximate intensity ratio 3:2, together with some partially resolved multiplets centered at ca. 3.25 ppm of about the same intensity as the doublet and triplet combined. Attempted sublimation of the residue *in vacuo* gave only a brown tarry material which was not investigated.

<sup>11</sup> G. M. Brooke, J. Burdon and J. C. Tatlow, Chem. & Ind. 832 (1961).