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## Iodination of Fluorenone by N-lodosuccinimide

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N-lodosuccinimide in sulphuric acid and a mixture of silver sulphate and iodine in sulphuric acid both convert fluorenone into 2-iodofluorenone and 2,7-di-iodofluorenone. The first method appears to be preferable.

N-HALOGENO-SUCCINIMIDES have been used to halogenate 1-4 aromatic compounds but the use of N-iodosuccinimide as an iodinating agent has in general been neglected, except by biochemists; Udenfriend and his co-workers<sup>5</sup> used it to convert tyrosine into 3,5-diiodotyrosine. In spite of the carbonyl groups, we found fluorenone to be easily mono- and di-iodinated with N-iodosuccinimide in sulphuric acid. Attempts to triiodinate gave a product, containing on average just over 2 atoms of iodine per molecule, which we were unable to purify.

The melting point of 2-iodofluorenone has been re-

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<sup>5</sup> G. Guroff, J. W. Daly, D. M. Jerina, J. Renson, B. Witkop, and S. Udenfriend, Science, 1967, 157, 1524.

ported  $^{6,7}$  as 143—144° and  $^8$  as 152°; we confirm the lower value. 2,7-Di-iodofluorene has m.p. 214° (lit.,9 156° for material probably impure in view of the reported iodine content). The mono- and di-iodination products were further characterised as their thiosemicarbazones.

To assess the utility of this iodination procedure further, fluorenone was iodinated by the method of Derbyshire and Waters,<sup>10</sup> *i.e.* reaction with iodine and silver sulphate in concentrated sulphuric acid. This probably involves attack by a positively charged species, which could be expected to give 2-iodofluorenone and

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  <sup>9</sup> P. S. Varma and V. S. Rao, J. Indian Chem. Soc., 1938, 15,
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  <sup>10</sup> D. H. Derbyshire and W. A. Waters, J. Chem. Soc., 1950, 3694.

2,7-di-iodofluorenone. The products were the same as those from *N*-iodosuccinimide but were obtained in poorer yield.

## EXPERIMENTAL

Iodination of Fluorenone with N-Iodosuccinimide.--(a) Monoiodofluorenone. N-Iodosuccinimide (1.2 g.) was added in portions to a well stirred solution of fluorenone (0.9 g.) in 90% sulphuric acid (25 ml.) maintained at 20-25°. The mixture was stirred for 30 min. and then poured on crushed ice. After filtration, washing with water, and drying a yellow product (1.35 g.), m.p. 110-115° was obtained. A solution of this material in ethanol was boiled with charcoal, filtered, and evaporated to dryness. The residue was extracted with light petroleum (b.p. 40-60°) (25 ml.). Two recrystallisations from ethanol gave a yellow product, m.p. 138-142°. Chromatography on alumina in ethanol gave small yellow needles (0.65 g.) of 2-iodofluorenone, m.p. 143-144° (Found: C, 51.0; H, 2.2; I, 41.4. Calc. for  $C_{13}H_7IO$ : C, 51.0; H, 2.3; I, 41.5%). It was not possible to raise the m.p. by further chromatography and recrystallisation (lit., m.p. 143-144°; lit., 152°). The product showed no depression of m.p. when mixed with a sample of 2-iodofluorenone obtained by diazotisation of 2-aminofluorenone.<sup>6</sup> The i.r. spectra of the two samples were identical.

(b) Di-iodination. N-Iodosuccinimide (4.5 g.) was added to a well stirred solution of fluorenone (1.8 g.) in 90% sulphuric acid (50 ml.) maintained at 40°. The mixture was stirred for 1 hr. then poured on crushed ice. The yellow product was filtered off, washed with water, dried, and dissolved in benzene. The solution was filtered through alumina (2 in.) to remove tarry material, then evaporated to dryness to give material (3.4 g.), m.p. 165—168°. Two recrystallisations from glacial acetic acid and one from ethanol gave fine orange yellow needles (2.5 g.) of 2,7-diiodofluorenone, m.p. 208° (Found: C, 36.2; H, 1.4; I, 58.8.  $C_{13}H_6OI_2$  requires C, 36.2; H, 1.4; I, 58.9%), identical (mixed m.p. and i.r. spectra) with a sample obtained by diazotisation of 2,7-diaminofluorenone.

2,7-Di-iodofluorene.--2,7-Di-iodofluorenone (0.43 g.) obtained by use of N-iodosuccinimide was dissolved in warm diethylene glycol (45 ml.), hydrazine hydrate (99-100%; 2 ml.) was added, and the mixture was maintained at 80-90° for 30 min. The excess of hydrazine hydrate and water were distilled off. The temperature was then raised to 200° and, after 2 hr. heating, the product was precipitated with water (100 ml.). Three recrystallisations from ethanol gave straw-coloured needles of 2,7-*di-iodofluorene* (>90%), m.p. 214° (Found: C, 37.5; H, 2.1; I, 60.6. C<sub>13</sub>H<sub>8</sub>I<sub>2</sub> requires C, 37.4; H, 1.9; I, 60.7%), identical (mixed m.p. and i.r. spectra) with a sample obtained by reducing 2,7-di-iodofluorenone produced by the diazotisation of 2,7-diaminofluorenone.

2,7-Di-iodofluorenone Thiosemicarbazone.—This was prepared from 2,7-di-iodofluorenone, obtained by use of Niodosuccinimide, as described for 2-iodofluorenone thiosemicarbazone. The product, which precipitated during the reaction, was recrystallised from 80% aqueous dimethylformamide to give a yellow *powder* which on heating began to turn red at  $260^{\circ}$  and finally melted with decomposition at 269° (Found: C, 33.5; H, 1.9; I, 50.4; N, 8.2; S, 6.4.  $C_{14}H_9I_2N_3S$  requires C, 33.3; H, 1.8; I, 50.3; N, 8.3; S, 6.3%).

2-Iodofluorenone Thiosemicarbazone.—Equimolecular quantities of the iodo-compound and thiosemicarbazide were heated under reflux for 30 min. in ethanol to which hydrochloric acid (2 drops) had been added. The thiosemicarbazone (ca. 98%) precipitated during the reaction and was filtered from the cooled solution. Two recrystallisations from glacial acetic acid gave fine yellow needles, m.p. 223— 225° (decomp.) (Found: C, 44·2; H, 2·6; I, 33·7; N, 11·00; S, 8·6.  $C_{14}H_{10}IN_3S$  requires C, 44·4; H, 2·6; I, 33·5; N, 11·1; S, 8·5%).

Iodination of Fluorenone by the Method of Derbyshire and Waters.—Fluorenone (1.8 g.), silver sulphate (1.6 g.), concentrated sulphuric acid (25 ml.), and water (5 drops) were heated, with stirring, on a boiling water bath. Finely powdered iodine (2.6 g.) was added in portions and after 30 min. the mixture was poured on ice. Excess of iodine was removed with sodium thiosulphate solution and the product was collected, washed, dried, and extracted with benzene. The extracts were filtered through alumina (1 in.) and evaporated to dryness to give material (1.6 g.), m.p. 125—132°. Fractional crystallisation from methanol gave yellow needles (0.8 g.) of 2-iodofluorenone, m.p. and mixed m.p. 144°. Di-iodofluorenone (150 mg.), m.p. 208°, was also isolated from the crude product.

When this experiment was repeated with twice the amount of iodine, 2,7-di-iodofluorenone (0.6 g.), m.p. and mixed m.p. 208° was obtained. Reduction of this material as before gave 2,7-di-iodofluorene, m.p. 214°.

Preparation of 2,7-Di-iodofluorenone via the Amine.-Fluorenone was nitrated with nitric acid in conc. sulphuric acid to give 2,7-dinitrofluorenone (30%), m.p. 290°, by the method of Schultz.<sup>11</sup> The product (3 g.), hydrated stannous chloride (24 g.), concentrated hydrochloric acid (30 ml.), and glacial acetic acid (150 ml.) were stirred for 30 min. on a boiling water bath. The cooled solution deposited the amine hydrochloride, which was collected, washed with water, and then stirred with 2N-sodium hydroxide solution (60 ml.) for 10 min. The solid was filtered off and gave dark violet needles (60%) of 2,7-diaminofluorenone, m.p. 288° (from ethanol) (lit.,<sup>8</sup> m.p. 288-289). The diamine (1 g.) was added to warm concentrated hydrochloric acid (5 ml.) and the base was precipitated in a finely divided state by addition of water (50 ml.) and cooling below  $10^{\circ}$ . The resultant suspension was diazotised with sodium nitrite (0.7 g.) in water (20 ml.). The mixture was stirred for 20 min. and excess of nitrous acid was destroyed with urea. The mixture was filtered and potassium iodide (2 g.) in water (15 ml.) was added. The solution was boiled for 5 min. then set aside for 12 hr. The product was collected, washed with N-sodium hydroxide solution and water, and then dried. After two recrystallisations from glacial acetic acid and chromatography on alumina, in ethanol, 2,7-diiodofluorenone (10%), m.p. 207-208°, was obtained.

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<sup>11</sup> G. Shultz, Annalen, 1880, 203, 95.