Additive Compounds as Possible Intermediates in Substitution Processes. Part I.

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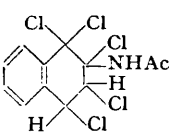
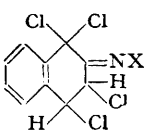
The chlorination of a number of aromatic bases and their derivatives has been examined to see whether additive compounds could be isolated. Positive results were obtained only with 5 : 6 : 7 : 8-tetrahydro-*N*-toluene-*p*-sulphonyl-2-naphthylamine.

Claus and Philipson (*J. pr. Chem.*, 1891, **43**, 58) by chlorination of *N*-acetyl-2-naphthylamine obtained the compound (I), and Bell (*J.*, 1953, 3035) by chlorination of various sulphonyl derivatives of β-naphthylamine obtained compounds of type (II). Durand and Huguenin A.G. (D.R.-P. 400,254) have described conditions under which many bases react with chlorine to give compounds of type (III). As a working hypothesis it is accepted that the intermediate formation of such compounds may be responsible for substitution products of abnormal orientation. Conversely, the isolation of an abnormal substitution product would encourage a search for intermediate additive compounds. Thus, the

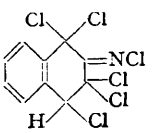


(I)

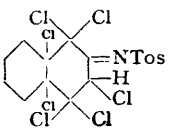


(II)

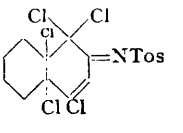
(X = SO_2·Ar)



(III)



(IV)



(V)

(Tos = SO_2·C_7H_7-*p*)

production of the 4-bromo-derivative from *N*-acetyl-5 : 6 : 7 : 8-tetrahydro-2-naphthylamine (Smith, *J.*, 1904, **85**, 728) suggests that in this reaction an addition–elimination mechanism may be involved. This is of particular interest because, whereas in the examples given above the addition has resulted in the conversion of a naphthalene derivative into a tetralin with one true aromatic nucleus, here addition involves the partial or complete

saturation of a benzene nucleus. The present investigation sought to ascertain whether additive compounds could be obtained from appropriate derivatives of tetralin, diphenyl, and fluorene on treatment with halogens.

First, it was found that *N*-acetyl-5 : 6 : 7 : 8-tetrahydro-1-naphthylamine on chlorination gave a monochloro-derivative and then the hydrochloride of a dichloro-derivative, whilst *N*-acetyl-5 : 6 : 7 : 8-tetrahydro-2-naphthylamine, under the same conditions, yielded uncrystallisable oils. Next, 5 : 6 : 7 : 8-tetrahydro-*N*-toluene-*p*-sulphonyl-1-naphthylamine gave on chlorination a dichloro-derivative and on bromination a mixture of the 4-bromo-derivative with a dibromo-derivative. In all these reactions no evidence was obtained for the formation of additive compounds.

On the other hand, 5 : 6 : 7 : 8-tetrahydro-*N*-toluene-*p*-sulphonyl-2-naphthylamine in chloroform with chlorine gave a mixture of two closely related compounds, probably (IV) and (V), together with toluene-*p*-sulphonamide. Compound (V) is readily produced from (IV) by dissolution in aniline, and either of these might by decomposition yield toluene-*p*-sulphonamide and a derivative of β-tetralone (or simpler breakdown products). Analogous additive compounds were not obtained on bromination; only substitution products were obtained, the nature depending on the solvent employed.

Chlorination of 2-aminodiphenyl under the conditions outlined in D.R.-P. 400,254 led only to 2-amino-3 : 5-dichlorodiphenyl in *ca.* 10% yield. 4-Aminodiphenyl and 2-aminofluorene, treated similarly, gave plastic masses. Chlorination of 2-toluene-*p*-sulphonamidodiphenyl under a variety of conditions led only to the 5-chloro-derivative. 4-Toluene-*p*-sulphonamidodiphenyl gave first the 3-chloro- and then the 3 : 4′-dichloro-derivative. 2-Toluene-*p*-sulphonamidofluorene and 2-acetamidofluorene gave dichloro-derivatives. No addition compounds were isolated in this series of experiments.

Experimental

Chlorination of 2-aminodiphenyl (25 g.) by the general method of D.R.-P. 400,254 led to the hydrochloride of the 3 : 5-dichloro-base (3·5 g.) and a dark, undistillable viscous mass. 3 : 5-Dichloro-2-aminodiphenyl could be recovered from hot acetic anhydride alone, but in the presence of a drop of sulphuric acid it gave the 2-*acetamido*-compound, which formed prisms, m. p. 162°, from ethanol (Found : Cl, 25·3. $C_{14}H_{11}ONCl_2$ requires Cl, 25·3%). With toluene-*p*-sulphonyl chloride in pyridine the dichloro-base reacted slowly and it was better to use slightly more than 2 mols. of the chloride and leave the mixture overnight. The product was freed from any ditoluene-*p*-sulphonamide by solution in warm piperidine and then crystallised from ethanol to give 3 : 5-*dichloro*-2-*toluene*-p-*sulphonamidodiphenyl* as needles, m. p. 159° (Found : Cl, 17·9. $C_{19}H_{15}O_2NCl_2S$ requires Cl, 18·1%).

Chlorination of 2-*Toluene*-p-*sulphonamidodiphenyl*.—Passage of chlorine (3 mols.) into a chloroform solution of the sulphonamide, or addition of sulphuryl chloride (1—3 mols.) to a similar solution, or treatment of the sulphonamide with excess of sulphuryl chloride all led to 5-*chloro*-2-*toluene*-p-*sulphonamidodiphenyl*, which crystallised from ethanol or benzene–light petroleum (b. p. 60—80°) in prisms, m. p. 110° (Found : Cl, 10·4. $C_{19}H_{16}O_2NClS$ requires Cl, 9·9%). This compound was unchanged after several hours in cold sulphuric acid. The structure was confirmed by its preparation from 2-amino-5-chlorodiphenyl (Scarborough and Waters, *J.*, 1927, 90).

Chlorination of 4-*Toluene*-p-*sulphonamidodiphenyl*.—(*a*) The sulphonamide was warmed until dissolved with excess of sulphuryl chloride, and the excess was then evaporated off. The residual light brown treacle was very soluble in acetic acid and in ethanol, but the solution in benzene slowly deposited prisms of 3 : 4′-*dichloro*-4-*toluene*-p-*sulphonamidodiphenyl*, m. p. 133° after recrystallisation from acetic acid (Found : Cl, 17·5. $C_{19}H_{15}O_2NCl_2S$ requires Cl, 18·1%). By dissolution in cold sulphuric acid this compound gave 4-*amino*-3 : 4′-*dichlorodiphenyl*, which crystallised from aqueous ethanol in plates, m. p. 100° (Found : C, 60·6; H, 3·5. $C_{12}H_9NCl_2$ requires C, 60·5; H, 3·8%), and gave an acetyl derivative, m. p. 184° (Kenyon and Robinson, *J.*, 1926, 3053, give m. p. 184°). (*b*) Chlorine (1 mol.) was passed into a solution of the sulphonamide in chloroform, the solution concentrated, and light petroleum added. The first crop consisted of essentially unchanged material but the second crop was 3-*chloro*-4-*toluene*-p-*sulphonamidodiphenyl*, which formed large prisms, m. p. 107°, from ethanol (Found : Cl, 9·7. $C_{19}H_{16}O_2NClS$ requires Cl, 9·8%). This compound was unchanged after 2 hr. in sulphuric acid.

It was alternatively prepared from 4-amino-3-chlorodiphenyl (Scarborough and Waters, *J.*, 1926, 557). By interaction with sulphuryl chloride it gave the above described 3 : 4′-dichloro-compound, alternatively prepared from *4′-chloro-4-toluene*-p-*sulphonamidodiphenyl* (Found: C, 63·2; H, 4·6. $C_{19}H_{16}O_2NClS$ requires C, 63·8; H, 4·5%). The latter, obtained from 4-amino-4′-chlorodiphenyl, crystallised from ethanol in needles, m. p. 156°.

Chlorination of 2-*Toluene*-p-*sulphonamidofluorene*.—(*a*) On addition of the sulphonamide (Bell and Mulholland, *J.*, 1949, 2021) to sulphuryl chloride a brisk reaction set in with development of a violet colour. When reaction had ceased the excess of sulphuryl chloride was evaporated off, and the residue crystallised from chloroform or acetic acid to give 3(?) : 7-*dichloro*-2-*toluene*-p-*sulphonamidofluorene* as a cotton-wool-like mass of needles, m. p. 215° (Found: Cl, 17·7. $C_{20}H_{15}O_2NCl_2S$ requires Cl, 17·6%). On dissolution in cold sulphuric acid this gave 2-*amino*-3(?) : 7-*dichlorofluorene*, which formed needles, m. p. 161°, from aqueous ethanol (Found: C, 61·6; H, 3·7. $C_{13}H_9NCl_2$ requires C, 62·4; H, 3·6%). The *acetyl* derivative (by use of acetic anhydride) crystallised from acetic acid in needles, m. p. 261° (Found: Cl, 24·0. $C_{15}H_{12}ONCl$ requires Cl, 24·3%). (*b*) Chlorine (1 mol.) was passed into a solution of the sulphonamide in chloroform, and the solution concentrated and allowed to cool. The crystalline crop after recrystallisation from acetic acid gave 3(?)-*chloro*-2-*toluene*-p-*sulphonamidofluorene* in prisms, m. p. 151° (Found: Cl, 9·5. $C_{20}H_{16}O_2NClS$ requires Cl, 9·6%). It was converted into the above dichloro-compound by solution in sulphuryl chloride.

7-*Chloro*-2-*toluene*-p-*sulphonamidofluorene*, obtained from 2-amino-7-chlorofluorene (Gutmann and Francis, *J. Amer. Chem. Soc.*, 1951, **73**, 4033), crystallised from acetic acid in needles, m. p. 202° (Found: Cl, 10·4. $C_{20}H_{16}O_2NClS$ requires Cl, 9·6%). It gave the above dichloro-compound with sulphuryl chloride.

Chlorination of 2-*Acetamidofluorene*.—Chlorine (1 mol.) was passed into a solution of the compound in acetic acid (10 parts). The resulting precipitate was filtered off, warmed with aqueous ammonia, and dried. Extraction with hot chloroform left pure 2-acetamido-3(?) : 7-dichlorofluorene (above) and the filtrate on concentration gave a crude monochloro-derivative, m. p. 200° (Found: C, 67·9; H, 4·6. Calc. for $C_{15}H_{12}ONCl$: C, 69·9; H, 4·7%). A similar result was obtained by using chloroform as solvent.

5 : 6 : 7 : 8-*Tetrahydro*-N-*toluene*-p-*sulphonyl*-1-*naphthylamine*, from the base and toluene-*p*-sulphonyl chloride, crystallised from ethanol in prisms, m. p. 123° (Found: C, 68·1; H, 6·4. $C_{17}H_{19}O_2NS$ requires C, 67·8; H, 6·3%). Chlorine (3 mols.) was passed into a solution of this sulphonamide in cold chloroform, and the chloroform evaporated. The residue solidified when rubbed with acetic acid and was then purified by repeated recrystallisation from acetic acid to yield *dichloro*-5 : 6 : 7 : 8-*tetrahydro*-N-*toluene*-p-*sulphonyl*-1-*naphthylamine* as needles, m. p. 170° (Found: Cl, 18·7. $C_{17}H_{17}O_2NCl_2S$ requires Cl, 19·2%), hydrolysed in cold sulphuric acid to yield an oily base, which gave an acetyl derivative, m. p. 200° (below).

Bromination of 5 : 6 : 7 : 8-*Tetrahydro*-N-*toluene*-p-*sulphonyl*-1-*naphthylamine*.—Bromine (2 mols.) in chloroform was added to the sulphonamide in chloroform, and the mixture boiled to expel hydrogen bromide. On cooling there separated needles, m. p. 244°, of the hydrobromide of the dibromo-base, which with excess of aqueous ammonia gave a liquid base, converted by acetic anhydride into an acetyl derivative, which formed needles, m. p. 198—200°, from ethanol (Morgan, Micklethwait, and Winfield, *J.*, 1904, **85**, 736, give m. p. 198—199°). After evaporation of the chloroform there remained a viscous oil which yielded crystalline material, m. p. *ca.* 124°, after solution in hot ethanol. This material, after removal of impurities by solution in cold sulphuric acid and reprecipitation by water, gave 4-*bromo*-5 : 6 : 7 : 8-*tetrahydro*-N-*toluene*-p-*sulphonyl*-1-*naphthylamine* as prisms, m. p. 140°, after recrystallisation from acetic acid (Found: Br, 21·6. $C_{17}H_{18}O_2NBrS$ requires Br, 21·0%). It was alternatively prepared from 4-bromo-5 : 6 : 7 : 8-tetrahydro-1-naphthylamine (*idem*, *loc. cit.*).

Chlorination of 5 : 6 : 7 : 8-*Tetrahydro*-N-*toluene*-p-*sulphonyl*-2-*naphthylamine*.—Chlorine (3 mols.) was passed into a solution of the sulphonamide (Buu-Hoï and Jacquignon, *J.*, 1951, 2966) in chloroform, and the solution diluted with light petroleum. The first crop consisted of toluene-*p*-sulphonamide. The second, after crystallisation from acetic acid in which it was sparingly soluble, formed needles, m. p. 163° (decomp.). The third was a sticky mass, which solidified completely when rubbed with acetic acid and, after recrystallisation from acetic acid, formed needles, m. p. 183° (decomp.). The compound, m. p. 163°, was unchanged after dissolution in pyridine but reacted briskly with aniline to give a highly coloured product from which only the compound, m. p. 183°, could be isolated in a pure condition. When compound, m. p. 163°, was kept at 170° until gas evolution ceased the residue was a dark, uncrystallisable oil. It is suggested that the compound, m. p. 163°, is 1 : 1 : 3 : 4 : 9 : 10-*hexachloro*-2-*toluene*-

p-*sulphonamidodecalin* (IV) (Found : Cl, 40·7. $C_{17}H_{17}O_2NCl_6S$ requires Cl, 41·6%) and the compound, m. p. 183°, formed from this by loss of hydrogen chloride, is 1 : 1 : 4 : 9 : 10-*pentachloro*-2-*toluene*-p-*sulphonimido*-Δ^3-*octalin* (V) (Found : Cl, 37·3. $C_{17}H_{16}O_2NCl_5S$ requires Cl, 37·3%).

The same two compounds were obtained by chlorination of the sulphonamide in acetic acid solution; chlorination by dissolution in sulphuryl chloride gave the compound, m. p. 163°, in very small yield together with an uncrystallisable oil.

Bromination of 5 : 6 : 7 : 8-*Tetrahydro*-N-*toluene*-p-*sulphonyl*-2-*naphthylamine*.—(*a*) Bromine (1 mol.) in chloroform was added to the compound dissolved in chloroform. After the brisk reaction the solution was warmed to expel hydrogen bromide and then filtered from a deposit of the hydrobromide of 1-bromo-5 : 6 : 7 : 8-tetrahydro-2-naphthylamine (acetyl derivative, m. p. 126°; Sandin and Evans, *J. Amer. Chem. Soc.*, 1939, **61**, 2916, give m. p. 126—127°). On removal of the chloroform there remained a thick oil which after solution in either ethanol or acetic acid gave material, m. p. 100—115°, which could not be purified. It was redissolved in chloroform and treated with bromine (1 mol.). This led to the deposition of the hydrobromide of 1 : 3-dibromo-5 : 6 : 7 : 8-tetrahydro-2-naphthylamine (below). On evaporation of the chloroform there remained a viscous oil from which crystalline material was not obtained. (*b*) Bromine (2 mols.) was added to the sulphonamide dissolved in cold pyridine, and after 2 hr. the mixture was decomposed with dilute hydrochloric acid. The resultant solid on crystallisation from acetic acid gave 1 : 3-*dibromo*-5 : 6 : 7 : 8-*tetrahydro*-N-*toluene*-p-*sulphonyl*-2-*naphthylamine* as needles, m. p. 195°, in almost theoretical yield (Found : Br, 34·9. $C_{17}H_{17}O_2NBr_2S$ requires Br, 34·8%). By solution in cold sulphuric acid it gave 1 : 3-*dibromo*-5 : 6 : 7 : 8-*tetrahydro*-2-*naphthylamine*, which crystallised from methanol in needles, m. p. 65° (Found : C, 38·8; H, 3·4. $C_{10}H_{11}NBr_2$ requires C, 39·4; H, 3·6%). The position of the bromine atoms is assigned by analogy with the results obtained from the bromination of other sulphonamides in pyridine (see, *e.g.*, Bell, *J.*, 1931, 2340; 1932, 2732; Consden and Kenyon, *J.*, 1935, 1593; Hodgson and Dean, *J.*, 1950, 821) and also the known 1 : 3-dibromination of 5 : 6 : 7 : 8-tetrahydro-2-naphthol and the 1 : 3-dinitration of 5 : 6 : 7 : 8-tetrahydro-2-acetonaphthalide (Schroeter, *Annalen*, 1922, **426**, 39).

1- and 4-Bromo-5 : 6 : 7 : 8-tetrahydro-2-naphthylamines were prepared by Smith's method (*loc. cit.*) and yielded, respectively, 1-*bromo*-, prisms, m. p. 127°, from ethanol (Found : C, 53·2; H, 4·5. $C_{17}H_{18}O_2NBrS$ requires C, 53·7; H, 4·7%), and 4-*bromo*-5 : 6 : 7 : 8-*tetrahydro*-N-*toluene*-p-*sulphonyl*-2-*naphthylamine*, prisms, m. p. 133°, from ethanol (Found : C, 53·7; H, 4·9%). A mixture of the isomerides had m. p. <120°.

Chlorination of N-*Acetyl*-5 : 6 : 7 : 8-*Tetrahydro*-1-*naphthylamine*.—Chlorine (1 mol.) was passed into a chloroform solution of the compound and most of the chloroform removed. The crystalline crop after recrystallisation from ethanol gave N-*acetyl* 4(?)-*chloro*-5 : 6 : 7 : 8-*tetrahydro*-1-*naphthylamine* in white needles, m. p. 184° (Found : Cl, 16·1. $C_{12}H_{14}ONCl$ requires Cl, 15·9%); yield, 2·9 g. from 5 g. This chloro-derivative in chloroform was treated with excess of chlorine. On cooling, there separated needles, m. p. 188° (decomp.) of the *hydrochloride* of *N*-acetyl-2 : 4(?)-dichloro-5 : 6 : 7 : 8-tetrahydro-1-naphthylamine (Found : Cl, 35·8. $C_{12}H_{13}ONCl_2,HCl$ requires Cl, 36·2%). When heated above its m. p. or dissolved in pyridine, this gave N-*acetyl*-2 : 4(?)-*dichloro*-5 : 6 : 7 : 8-*tetrahydro*-1-*naphthylamine*, which crystallised from acetic acid in needles, m. p. 199—200° (Found : C, 54·9; H, 4·9. $C_{12}H_{13}ONCl_2$ requires C, 55·8; H, 5·0%).

The introduction of chlorine (1 mol.) into *N*-acetyl-5 : 6 : 7 : 8-tetrahydro-2-naphthylamine in chloroform led only to a viscous mass.

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