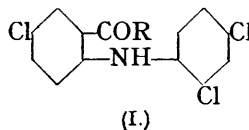


### 246. The Action of Phosphorus Pentachloride on Derivatives of Diphenylamine.

By ROBERT R. GOODALL and WILLIAM O. KERMACK.

THE cyclisation of certain derivatives of diphenylamine-2-carboxylic acid may be readily effected by refluxing with an excess of phosphorus oxychloride (cf. Magidson and Grigorowski, *Ber.*, 1933, **66**, 866), the resulting acridone being usually converted at the same time (in whole or in part) into the corresponding 5-chloroacridine. In certain cases, the same reaction may be effected by phosphorus pentachloride in chlorobenzene. In this way, for example, 4-methoxy- and 4-chloro-diphenylamine-2-carboxylic acids are readily converted, in good yield, into 5-chloro-3-methoxy- and 3 : 5-dichloro-acridine. When this method was applied to 2 : 4-dichlorodiphenylamine-2'-carboxylic acid, the yellow crystalline product, m. p. 188°, which separated from the chlorobenzene, did not show the properties of a derivative of 5-chloroacridine. Analysis indicated that it had the formula  $C_{13}H_7ONCl_4$ . Treatment with potassium methoxide gave a potassium salt, from which the acid  $C_{13}H_7NCl_3 \cdot CO_2H$ , m. p. 270°, could be liberated, and methyl alcohol and potassium phenoxide afforded the corresponding *esters*. The original compound contained no immediately ionisable chlorine, but after 2 hours' boiling with 25% nitric acid, one chlorine atom was liberated. These observations indicate that the compound  $C_{13}H_7ONCl_4$  is probably 2 : 4 : 4'-trichlorodiphenylamine-2'-carboxylic acid chloride (I, R = Cl), the extra chlorine atom being inserted in position 4', as this is the position most likely to be reactive. This conclusion was confirmed by the synthesis of the corresponding *acid* (I, R = OH) from 2 : 4-dichloroaniline and potassium 2 : 5-dichlorobenzoate in amyl alcohol, in presence of a trace of copper; it had m. p. 269—270°, undepressed on admixture with the foregoing acid.



When 2-bromo-4-methyldiphenylamine-2'-carboxylic acid is treated in boiling chlorobenzene with phosphorus pentachloride, the reaction proceeds analogously, the product being the 4'-chloro-acid chloride; from this was obtained the free *acid*, the constitution of which was confirmed (m. p. and mixed m. p.) by its synthesis from 3-bromo-

*p*-toluidine and potassium 2:5-dichlorobenzoate. Similar treatment of 2:5-dichlorodiphenylamine-2'-carboxylic acid afforded a crystalline yellow product, but this could not be obtained in a pure form, even after repeated recrystallisation. Analysis showed, however, that it was a trichlorodiphenylamine-2'-carboxylic acid chloride. 2:5:4'-*Trichlorodiphenylamine-2'-carboxylic acid* was prepared from 2:5-dichloroaniline and 2:5-dichlorobenzoic acid, and the *acid chloride*, m. p. 125—126°, prepared from this by the action of thionyl chloride gave no depression of the m. p. with a fraction, m. p. 113—117°, of the above impure acid chloride, which appears therefore to be a mixture of the 2:5:4'- with (probably) the 2:4:5-isomeride. For comparison, 2:5-dichlorodiphenylamine-2'-carboxylic acid chloride, m. p. 148—151°, was also prepared.

In three cases described above the phosphorus pentachloride appears to effect further substitution before ring closure can take place, and it is apparently the 2-halogeno-substituent which thus retards cyclisation. The chlorinating action of phosphorus pentachloride, which presumably depends on its dissociation into phosphorus trichloride and free chlorine, has been recorded in relation to aliphatic compounds (cf. Kauder, *J. pr. Chem.*, 1885, **31**, 3: Colson and Gautier, *Compt. rend.*, 1886, **102**, 1075) and to aliphatic side chains in aromatic compounds (cf. *idem, ibid.*, 1885, **101**, 1064; 1886, **102**, 689), but cases of direct nuclear chlorination by this reagent do not seem to be on record.

#### EXPERIMENTAL.

*Action of Phosphorus Pentachloride on 4-Methoxydiphenylamine-2'-carboxylic Acid.*—Phosphorus pentachloride (40 g.) was added to the crude acid (cf. Borsche *et al.*, *Ber.*, 1933, **66**, 1316) (45 g.) suspended in chlorobenzene (180 c.c.) and the mixture refluxed for 1 hour in an oil-bath at 130°. Hydrogen chloride was evolved, and the green solution changed to brown; then a yellow solid separated, which partly redissolved. After cooling, the solid product was filtered off, thoroughly washed with ether (about 50 c.c.) to remove chlorobenzene and phosphorus oxychloride, and the residue, presumably the hydrochloride of 5-chloro-3-methoxyacridine, converted into the free base by suspending it in alcohol (100 c.c.), and gradually adding ammonia in the cold, till slightly alkaline. The base was filtered off and crystallised from alcohol; yield 25 g., m. p. 148—149° (Found: C, 69.1; H, 3.9. Calc. for C<sub>14</sub>H<sub>10</sub>ONCl: C, 69.0; H, 4.1%). Magidson and Grigorowski (*Ber.*, 1936, **69**, 404) give m. p. 152—153°.

*Action of Phosphorus Pentachloride on 4-Chlorodiphenylamine-2'-carboxylic Acid.*—The crude acid (cf. Ullmann, *Annalen*, 1907, **355**, 399) (9 g.) in chlorobenzene (15 c.c.) was treated with phosphorus pentachloride (9 g.) and the product worked up as above; the pale green voluminous precipitate obtained on treatment with ammonia was filtered off, washed with ether, and dried. 3:5-Dichloroacridine crystallises from alcohol as pale green micro-needles, m. p. 196—198°, soluble in benzene, ligroin, and chloroform, and sparingly soluble in ether and acetone. The base dissolves in dilute hydrochloric acid, but on boiling, 3-chloroacridone, m. p. 398° (Ullmann, *ibid.*, gives m. p. over 360°), is immediately obtained. When 3:5-dichloroacridine was heated in phenol (7.5 g.) containing potassium hydroxide (0.8 g.) for 2 hours at 100°, it was converted into 3-chloro-5-phenoxyacridine, isolated by dissolving the phenol in excess of 10% sodium hydroxide solution, and recrystallising the well-washed residue from ligroin. The pale yellow rectangular prisms (m. p. 144—145°) obtained closely resemble 3:5-dichloroacridine in properties (Found: C, 74.4; H, 4.0. C<sub>18</sub>H<sub>12</sub>ONCl requires C, 74.7; H, 3.9%).

*Action of Phosphorus Pentachloride on 2:4-Dichlorodiphenylamine-2'-carboxylic Acid.*—This acid (cf. Ullmann, *loc. cit.*) (20.4 g.), phosphorus pentachloride (36 g.), and chlorobenzene (40 c.c.) were heated under reflux in an oil-bath at 120° for 1 hour. On cooling, the green solution afforded bright yellow crystals, which were filtered off and washed with ether; yield 13.5 g. 2:4:4'-*Trichlorodiphenylamine-2'-carboxylic acid chloride* (I; R = Cl) crystallises from toluene as canary-yellow needles, m. p. 188—189° [Found: C, 46.2; H, 2.5; N, 4.8; Cl (total), 41.8; Cl (ionisable), 10.3. C<sub>13</sub>H<sub>7</sub>ONCl<sub>4</sub> requires C, 46.6; H, 2.1; N, 4.2; Cl (total), 42.4; Cl (ionisable), 10.6%]; it is very soluble in chloroform, slightly soluble in benzene, toluene, ligroin, and acetone, and insoluble in cold dilute sodium hydroxide.

When this acid chloride (0.5 g.) was boiled under reflux with 10% methyl-alcoholic potash (5 c.c.), the bright yellow colour disappeared, and a pale green solution was gradually formed. After about 15 minutes, a voluminous precipitate separated. Boiling was continued for 2 hours, the whole was filtered hot, and the pale yellow residue washed with a little methyl alcohol, dissolved in hot water, and acidified with hydrochloric acid, the white precipitate of the *acid* being

filtered off and washed; it recrystallised from alcohol as pale yellow micro-needles, m. p. 270° (Found: C, 49.6; H, 2.6.  $C_{13}H_8O_2NCl_3$  requires C, 49.2; H, 2.5%).

The same acid was formed when potassium 2:5-dichlorobenzoate (2.1 g.), 2:4-dichloroaniline (2 g.), and amyl alcohol (5 c.c.) containing a trace of copper-bronze were refluxed in an oil-bath at 150° for 6 hours. The purple product was made alkaline, and the amyl alcohol and excess 2:4-dichloroaniline removed by steam-distillation. By boiling with charcoal, filtering hot, and acidifying, the acid separated as a grey precipitate, from which any unchanged 2:5-dichlorobenzoic acid was removed by extraction with boiling water. Recrystallisation from alcohol gave grey micro-needles, m. p. 269—270°, not depressed on admixture with the above acid. Further, the action of thionyl chloride (30 minutes' refluxing) afforded an acid chloride which, recrystallised from toluene, had m. p. 188—189°, and was identical in all respects with that described above.

When the acid chloride (0.5 g.) was refluxed with methyl alcohol (15 c.c.) for 1 hour and cooled, it afforded the *methyl* ester, which, recrystallised from ligroin, formed pale yellow micro-needles, m. p. 124° (Found: C, 51.0; H, 3.4; Cl, 32.9.  $C_{14}H_{10}O_2NCl_3$  requires C, 50.7; H, 3.0; Cl, 32.3%).

The *phenyl* ester resulted when the acid chloride was heated for 2 hours on the water-bath with potassium hydroxide (0.33 g.) in phenol (5.0 g.), and the melt stirred into 10% aqueous sodium hydroxide (50 c.c.). The solid was washed, dried, and recrystallised from ligroin, forming pale yellow micro-needles, m. p. 108—109° (Found: C, 57.6; H, 3.5.  $C_{15}H_{12}O_2NCl_3$  requires C, 58.1; H, 3.1%).

*2-Bromo-4-methyldiphenylamine-2'-carboxylic acid.*—Potassium *o*-chlorobenzoate (19.4 g.), 3-bromo-*p*-toluidine (19.4 g.), copper-bronze (0.4 g.), and amyl alcohol (30 c.c.) were refluxed in an oil-bath at 150° for 4 hours. The product was worked up as described for 2:4:4'-trichlorodiphenylamine-2'-carboxylic acid; yield 18.2 g. Recrystallised from benzene, the acid formed white silky needles, m. p. 191°, soluble in alcohol, benzene, acetone, ether, and chloroform (Found: C, 55.1; H, 4.1.  $C_{14}H_{12}O_2NBr$  requires C, 54.9; H, 3.9%).

*Action of Phosphorus Pentachloride on 2-Bromo-4-methyldiphenylamine-2'-carboxylic Acid.*—When this acid (10 g.) and phosphorus pentachloride (16 g.) in chlorobenzene (40 c.c.) were refluxed for 1 hour, the resulting dirty green solution deposited yellow needles on cooling; these were washed with ether (yield 5 g.) and recrystallised from ligroin, bright canary-yellow needles of 4'-chloro-2-bromo-4-methyldiphenylamine-2'-carboxylic acid chloride, m. p. 175°, being obtained (Found: C, 46.7; H, 3.1.  $C_{14}H_{10}ONCl_2Br$  requires C, 46.8; H, 2.8%); it is moderately soluble in alcohol, benzene, chloroform, and acetone, slightly soluble in ether and ligroin, insoluble in cold dilute caustic soda.

This acid chloride (0.5 g.) was heated on the water-bath with 0.2*M*-aqueous sodium carbonate (1 equiv.) for 4 hours, and the pale yellow crystalline product was filtered off, washed free from alkali, and dried. Recrystallisation from benzene yielded micro-needles, m. p. 235—237° (Found: C, 49.1; H, 3.2.  $C_{14}H_{11}O_2NBrCl$  requires C, 49.3; H, 3.2%). The same acid (m. p. and mixed m. p. 236—238°) was obtained when potassium 2:5-dichlorobenzoate (1 g.) and 3-bromo-*p*-toluidine (1 g.), in amyl alcohol (5 c.c.) containing a trace of copper-bronze, were refluxed for 4 hours, and then worked up in the usual way, being crystallised from benzene.

*Action of Phosphorus Pentachloride on 2:5-Dichlorodiphenylamine-2'-carboxylic Acid.*—When this acid (5 g.), phosphorus pentachloride (9 g.), and chlorobenzene (10 c.c.) were refluxed for 1 hour, the dark brown solution obtained yielded only a very small quantity of solid on cooling. This was separated, the filtrate concentrated in a vacuum, and the solid obtained on cooling was crystallised from ligroin, but repeated fractional recrystallisations failed to purify the yellow needles, m. p. 104—112° (Found: C, 46.8; H, 2.5.  $C_{13}H_7ONCl_4$  requires C, 46.6; H, 2.1%).

Potassium 2:5-dichlorobenzoate (1 g.) and 2:5-dichloroaniline (1 g.) in amyl alcohol (2.5 c.c.) containing a trace of copper-bronze were refluxed over-night, and the product worked up in the usual way. After drying, the resulting crude pale green 2:5:4'-trichlorodiphenylamine-2'-carboxylic acid (m. p. 254—255°, from toluene) was refluxed with a large excess of thionyl chloride for 30 minutes, the latter removed in a vacuum, and the residue washed with light petroleum. Recrystallisation from ligroin yielded pale yellow plates of the acid chloride, m. p. 125—126°, which showed no depression of m. p. when mixed with a fraction, m. p. 113—118°, separated mechanically from the product obtained as above.

*2:5-Dichlorodiphenylamine-2'-carboxylic Acid Chloride.*—2:5-Dichlorodiphenylamine-2'-carboxylic acid (cf. Nisbet, J., 1933, 1372) (2 g.) was refluxed with thionyl chloride (3 c.c.) for 30 minutes. The cooled dark brown solution deposited light green rhombic prisms of the

corresponding *acid chloride*, which were filtered off, washed with light petroleum, and recrystallised from ligroin, m. p. 150—152° (Found : C, 52.1; H, 2.8.  $C_{13}H_9ONCl_3$  requires C, 52.0; H, 2.6%).

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