

393. *Substitution in Compounds containing Two or More Phenyl Groups. Part III. Nitration and Bromination of 2:4:6-Trimethyldiphenyl.*

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THE work of Carnelley (J., 1876, 29, 20) and of Gomberg and Pernert (*J. Amer. Chem. Soc.*, 1926, 48, 1372) on the nitration and bromination of 4-methyldiphenyl indicates that the substitution takes place mainly in the non-methylated nucleus. These results would appear to be in disagreement with the general tendency of the methyl group to promote substitution in the nucleus to which it is attached, unless the Ph and *p*-Me-C₆H₄ groups also promote substitution in the same way. A more detailed study of the nitration of 4- and of 3-methyldiphenyl (this vol., pp. 1888, 2245), however, has shown that in the former case, in which the *op*-directive effects of the two hydrocarbon radicals Me and Ph are acting in opposition, the product consists of some 45% of 4-nitro-4'-methyldiphenyl, the remainder consisting mainly of 2-nitro-4'-methyl- together with 2-nitro-4'-methyl-diphenyl. On the other hand, with 3-methyldiphenyl, in which the *op*-directive effects of the hydrocarbon radicals are acting together, predominating homonuclear substitution at the 4-position takes place. These results, which constitute the first direct comparison of the orienting powers of the phenyl group with those of an alkyl group, show that, like the methyl group, the Ph and the *p*-Me-C₆H₄ group also promote increased reactivity, thus confirming Vorländer's view (*Ber.*, 1925, 58, 1893) that the phenyl group behaves in the same manner as any other hydrocarbon radical, when attached to an aromatic nucleus. The fact that the two essentially different

radicals, phenyl and methyl, should thus appear to act in the same manner is rendered possible in diphenyl owing to the presence of the two aromatic rings, one only of which at any moment can behave in this manner with reference to the second nucleus. The reactivity gained by the one nucleus must be lost by the other, and this indicates a condition of dissymmetry which, as emphasised by Turner (*Rec. trav. chim.*, 1929, **48**, 821), is a characteristic of compounds of this class.

It has already been shown that the introduction of one methyl group at the 4-position in diphenyl is far from sufficient to promote exclusive homonuclear substitution, and a study was therefore made of the substitution reactions of 2 : 4 : 6-trimethyldiphenyl in order to find out if the activation in the methylated nucleus was sufficient to overcome the tendency towards substitution at the 4-position in the non-methylated nucleus.

When 2 : 4 : 6-trimethyldiphenyl was (1) warmed slightly with fuming nitric acid in glacial acetic acid solution, (2) heated on the water-bath with concentrated nitric acid, or (3) treated with a mixture of concentrated nitric and sulphuric acid at 0°, only one nitration product could be isolated, viz., 3 : 5 : 4'-trinitro-2 : 4 : 6-trimethyldiphenyl. If, however, the hydrocarbon was treated as in (1) but at room temperature, some 3 : 4'-dinitro-2 : 4 : 6-trimethyldiphenyl was obtained, although it was difficult to stop the reaction sharply at this stage. In no case could a mono-nitration product be obtained, the use of weaker solutions of nitric acid resulting in the formation of alkali-soluble products due to oxidation and/or side-chain nitration. In similar manner, bromination of 2 : 4 : 6-trimethyldiphenyl in glacial acetic acid solution at room temperature gave 3 : 5 : 4'-tribromo-2 : 4 : 6-trimethyldiphenyl.

In order to establish the positions occupied by the nitro-groups in the nitration products, utilisation was made of the different susceptibilities of the two nuclei towards oxidation by chromic acid, for, whereas the introduction of a nitro-group stabilises the ring to which it is attached, the presence of several methyl groups weakens it; e.g., nitrobenzene is almost unaffected by chromic anhydride in boiling acetic acid solution, but mesitylene is attacked instantly. Similarly, it was found that, whereas trinitromesitylene is largely recovered unchanged after 4 hours' boiling with the same reagents, yet dinitromesitylene, under similar treatment, is largely destroyed, a small quantity being converted into 2 : 4-dinitromesitylenic acid. When the trinitro- and also the dinitro-trimethyldiphenyl were treated in this manner, both gave *p*-nitrobenzoic acid, which proves that in both products there is only one nitro-group in the non-methylated nucleus, and that this must be at

the 4-position. The dinitrotrimethyldiphenyl underwent further nitration to the trinitro-compound.

Reduction of 3 : 5 : 4'-trinitro-2 : 4 : 6-trimethyldiphenyl with stannous chloride gave 3 : 5 : 4'-*triamino*-2 : 4 : 6-*trimethyldiphenyl*, which was oxidised abnormally to an indefinite acidic product by potassium bromate and bromide in acid solution (cf. also Francis, *J. Amer. Chem. Soc.*, 1926, **48**, 1631; Grieve and Hey, this vol., p. 2246). On the other hand, reduction of the trinitro-compound with sodium sulphide gave 5-nitro-3 : 4'-*diamino*-2 : 4 : 6-*trimethyldiphenyl*, which reacted quantitatively and normally with bromide-bromate to give 3' : 5'-*dibromo*-5-nitro-3 : 4'-*diamino*-2 : 4 : 6-*trimethyldiphenyl*.

EXPERIMENTAL.

2 : 4 : 6-*Trimethyldiphenyl*.—Four methods were employed for the prep. of this hydrocarbon : (a) from diazotised NH_2Ph and mesitylene in the presence of aq. alkali (cf. Gomberg and Bachmann, *J. Amer. Chem. Soc.*, 1924, **46**, 2339; Gomberg and Pernert, *ibid.*, 1926, **48**, 1372); (b) from diazotised mesidine and benzene according to method (a); (c) from nitrosoacetanilide and mesitylene (cf. Bamberger, *Ber.*, 1897, **30**, 366); and (d) from nitrosoacetomesidine and benzene according to method (c). Of these, the most successful were (a) and (c) (which gave yields of 10—15%, calc. on the wt. of NH_2Ph or nitrosoacetanilide), since in methods (b) and (d) side reactions take place involving the formation of indazole derivatives.

Method (a). A solution of PhN_2Cl was gradually added to a well-stirred mixture of mesitylene (130 g.) and 40% aq. NaOH (52 c.c.) at 0°. After 5 hrs., the temp. was allowed to rise gradually, and the mixture was acidified and extracted with C_6H_6 . Distillation of the extract gave unchanged mesitylene and a yellow oil, b. p. 240—290°, which was freed from N compounds by shaking with HFeCl_4 aq. (see Robinson, *J.*, 1925, **127**, 768). After having been washed with H_2O and dried over CaCl_2 , the main bulk distilled between 270° and 285°. Further distillation gave 2 : 4 : 6-*trimethyldiphenyl* as a pale yellow oil, b. p. 275—277° (Found: C, 90.8; H, 8.3. $\text{C}_{15}\text{H}_{16}$ requires C, 91.8; H, 8.2%).

Method (b). A paste of mesidine hydrochloride [from 68 g. mesidine, 118 c.c. HCl (d 1.16), and 50 c.c. H_2O] was diazotised with aq. NaNO_2 at 0—5° and added to C_6H_6 (500 c.c.) and $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ (50 g.). Into this cooled and well-stirred mixture, 40% aq. NaOH (136 c.c.) was dropped gradually. After 4—5 hrs., the mixture was distilled with superheated steam, and unchanged C_6H_6 , trimethyldiphenyl, and some 5 : 7-dimethylindazole were collected. The distillate was treated as in (a). The residue from the steam distillation contained 3-mesityleneazo-5 : 7-dimethylindazole (Bamberger, *Annalen*, 1899, **305**, 316). The reverse order of addition (diazotised mesidine to C_6H_6 and aq. NaOH) gave similar results.

Method (c). Nitrosoacetanilide (40 g.) was added gradually to dry mesitylene (150 c.c.) in dry Et_2O (50 c.c.). The solution darkened, and a brisk evolution of N_2 ensued with slight rise in temp.; it was cooled to room temp. until all action had subsided, and then a further portion of nitrosoacetanilide (40 g.) was added as before. After 12 hrs., H_2O was added, and the mixture

steam distilled. $\text{CH}_3\cdot\text{CHO}$ and unchanged mesitylene were first collected, and the temp. was then raised to $160\text{--}170^\circ$ in an oil-bath, and distillation continued for 8 hrs. with superheated steam. The yellow oil in the distillate was extracted with C_6H_6 and treated as in (a).

Method (d). Nitrosoacetomesidide (25 g.) and dry C_6H_6 (70 c.c.) were used as in (c). The fraction collected between 220° and 280° partly solidified on cooling, and crystn. of a portion from aq. EtOH gave some 5 : 7-dimethylindazole. The main portion was treated as in (a).

In all four methods the reaction product may be either extracted with C_6H_6 and distilled directly, or first distilled from tarry matter by means of superheated steam, but in both cases subsequent treatment with HFeCl_4 is essential.

Nitration of 2 : 4 : 6-Trimethyldiphenyl.—(a) A mixture of HNO_3 (*d* 1.52; 5 c.c.) and AcOH (5 c.c.) was added to 2 : 4 : 6-trimethyldiphenyl (1 g.) in AcOH (10 c.c.), and after standing for 1 hr. at $40\text{--}50^\circ$ it was poured on ice. The yellow solid which separated was crystallised from C_7H_8 and gave 3 : 5 : 4'-trinitro-2 : 4 : 6-trimethyldiphenyl, pale yellow prisms, m. p. 216° (Found : C, 54.8; H, 4.0; N, 12.6. $\text{C}_{15}\text{H}_{13}\text{O}_6\text{N}_3$ requires C, 54.4; H, 3.9; N, 12.7%). A similar result was obtained by using HNO_3 (*d* 1.42) in AcOH at $70\text{--}80^\circ$ or conc. HNO_3 and conc. H_2SO_4 (1 : 1 by vol.) at 0° . In no case was quantitative trinitration effected, the highest yields of the trinitro-compound (*viz.*, 55—60%) being obtained by the last method. The remainder of the product consisted of a viscous non-crystallisable residue, which was mostly sol. in warm aq. NaOH.

(b) A mixture of HNO_3 (*d* 1.52; 10 c.c.) and AcOH (10 c.c.), added to 2 : 4 : 6-trimethyldiphenyl (1 g.) in AcOH (10 c.c.), was kept at room temp. over-night, poured on ice, neutralised, and extracted with Et_2O . The viscous residue obtained on evaporation was dissolved in light petroleum—EtOH and kept at -10° for a long time. A solid gradually separated, which after several crystns. from EtOH gave 3 : 4'-dinitro-2 : 4 : 6-trimethyldiphenyl in pale yellow plates, m. p. 120° (Found : C, 61.5, 61.3; H, 4.4, 4.4. $\text{C}_{15}\text{H}_{14}\text{O}_4\text{N}_2$ requires C, 62.9; H, 4.9%). A very small quantity of the less sol. trinitration product was also obtained, and traces of it, which could not be removed by repeated crystn., contaminated the dinitro-compound. The latter, on treatment with conc. HNO_3 and conc. H_2SO_4 at 0° , was converted into the trinitro-compound.

Attempts to effect nitration by employing more dil. HNO_3 at various temps. resulted generally in an increased proportion of alkali-sol. products, together with mixtures of the dinitro-compound with either unchanged hydrocarbon or trinitro-compound. The presence of the first in these mixtures was shown by reduction and acetylation (see p. 2640).

Oxidation of 3 : 4'-Dinitro- and of 3 : 5 : 4'-Trinitro-2 : 4 : 6-trimethyldiphenyl.—The di- or tri-nitrotrimethyldiphenyl (0.2 g.) in AcOH (5 c.c.) was refluxed for 4—5 hrs. with CrO_3 (5 g.) in AcOH (10 c.c.) and a few drops of water. The solution was then poured into H_2O and extracted with Et_2O , evaporation of which gave, in both cases, *p*-nitrobenzoic acid, m. p. and mixed m. p. $236\text{--}237^\circ$.

Bromination of 2 : 4 : 6-Trimethyldiphenyl.—To the hydrocarbon (1 g.) in AcOH (5 c.c.) was gradually added a 10% solution of Br in AcOH at room temp. (in diffused light). The solid which separated (together with that separating on addition of aq. alkali) was washed with hot EtOH; and crystn.

from C_7H_8 -light petroleum (b. p. 80—100°) gave 3 : 5 : 4'-tribromo-2 : 4 : 6-trimethyldiphenyl, white plates, m. p. 223° (Found : Br, 55.5. $C_{15}H_{13}Br_3$ requires Br, 55.4%).

Reduction of 3 : 4'-Dinitro-2 : 4 : 6-trimethyldiphenyl.—A solution of $SnCl_2$ in hot conc. HCl was added to the dinitro-compound in hot EtOH. After evaporation of the EtOH on the water-bath, the solution was made strongly alk., extracted with Et_2O , dried (KOH), and the Et_2O evaporated. The solid residue, with Ac_2O , gave 3 : 4'-diacetoamido-2 : 4 : 6-trimethyldiphenyl, m. p. 293—294°; microscopic needles from EtOH (Found : C, 73.0; H, 7.0. $C_{19}H_{22}O_2N_2$ requires C, 73.55; H, 7.1%).

Reduction of 3 : 5 : 4'-Trinitro-2 : 4 : 6-trimethyldiphenyl.—(a) *With* $SnCl_2$. A suspension of the trinitro-compound in hot EtOH was reduced with $SnCl_2$ as described above. The solid thus obtained, on recrystn. from hot EtOH, gave 3 : 5 : 4'-triamino-2 : 4 : 6-trimethyldiphenyl in pale yellow prisms, m. p. 248° (Found : C, 75.0; H, 7.6; N, 17.6. $C_{15}H_{19}N_3$ requires C, 74.7; H, 7.9; N, 17.4%).

(b) *With* Na_2S . The trinitro-compound in alc. suspension was refluxed with the gradual addition of sat. aq. Na_2S . After 2 hrs., the EtOH was evaporated, and H_2O added. An orange-yellow ppt. separated, which, on crystn. first from EtOH and then from light petroleum—EtOH, gave 5-nitro-3 : 4'-diamino-2 : 4 : 6-trimethyldiphenyl in orange-yellow needles, m. p. 194° (Found : C, 66.7; H, 6.3; N, 15.6. $C_{15}H_{17}O_2N_3$ requires C, 66.4; H, 6.3; N, 15.5%).

Bromination of 5-Nitro-3 : 4'-diamino-2 : 4 : 6-trimethyldiphenyl.—5-Nitro-3 : 4'-diamino-2 : 4 : 6-trimethyldiphenyl (0.517 g.), suspended in 200 c.c. of H_2O , 25 c.c. of conc. HCl, and 10 c.c. of 20% aq. KBr, required 38.2 c.c. of 0.2N-KBrO₃ for bromination at room temp. (starch-KI paper gave a sharp end-point) (calc. for dibromination, 38.16 c.c.). The mixture was then made just alk., and the pale yellow solid filtered off; crystn. from hot EtOH gave 3' : 5'-dibromo-5-nitro-3 : 4'-diamino-2 : 4 : 6-trimethyldiphenyl in deep yellow flakes, m. p. 238° (Found : C, 42.2; H, 3.9; Br, 37.6. $C_{15}H_{15}O_2N_3Br_2$ requires C, 42.0; H, 3.5; Br, 37.3%).

Under similar conditions, 3 : 5 : 4'-triamino-2 : 4 : 6-trimethyldiphenyl gave indefinite results, and excess of bromine afforded a pale yellow ppt., sol. in alkalis and reprecipitated by acids; this was not further examined.

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