## CCCXXI.—*Investigations in the Diphenyl Series. Part X. The Bromination of* 4-p-*Toluenesulphonamidodiphenyl.*

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IN previous papers (J., 1928, 2770; 1930, 1071) it has been shown that the *p*-toluenesulphonamido-group has a high orienting power compared with the acetamido-group in all nitration experiments. It would be anticipated that the same relative behaviour would be shown in halogenations, but the quantitative measurements of Orton and Bradfield (J., 1927, 986) and of Bradfield and Jones (J., 1928, 3073) do not bear out this expectation. These authors have deter-

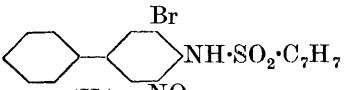
mined the velocity coefficient of chlorination of certain anilides in acetic acid solution under standard conditions and the comparative numbers are: acetanilide, 66·5; *p*-toluenesulphonanilide, 65·11; benzenesulphonanilide, 41·2. Instead of the values for the sulphonanilides being very considerably higher than that for acetanilide, they are actually lower. This result can only be interpreted as indicating a difference in the mechanisms of nitration and halogenation or that the normal character of the acetamido-group is modified by salt formation in the presence of mineral acid, with consequent lowering of its orienting power relative to that of the sulphonamido-group. It is significant that "the amount of hydrochloric acid employed produces an appreciable effect on the velocity of chlorination, the effect on acetanilide being a decrease in speed as the hydrochloric acid is increased, although with benzenesulphonanilide this effect is reversed" (Orton and Bradfield, *loc. cit.*). The same effect is revealed in the substitution of 2-acetamidodiphenyl, which on nitration in acetic acid gives the 5-nitro-derivative but in the presence of sulphuric acid the 4′-derivative (the orienting power of the acetamido-group having been rendered very small) (Scarborough and Waters, J., 1927, 89).

The difference which exists between the nitration and the bromination of 4-acetamidodiphenyl (Kenyon and P. H. Robinson, J., 1926, 3050) cannot, however, be explained in this way. Substitution in the 3-position (nitration) is directly controlled by the group in position 4, whilst entry in position 4′ (bromination) is controlled by the substituted phenyl group, conjugative effects between the nuclei being discredited (Le Fèvre and Turner, J., 1928, 245). Steric factors cannot be of great importance, for 3 : 5-dibromoaminodiphenyl can be acetylated and diacetylated with the utmost ease. If the possibility of indirect substitution *via* the acetamido-group can be left out of account (Orton, Soper, and Williams, J., 1928, 998), it appears that the acetamido-group is more effective in nitration than in brominations.

It appeared of interest to see whether a similar difference between nitration and bromination was shown by *p*-toluenesulphonamides. 4-*p*-Toluenesulphonamidodiphenyl underwent nitration quantitatively in the 3-position, but bromination of the compound led to so many products that great stress could not be laid on the absence of the 4′-derivative. 3-Nitro-4-*p*-toluenesulphonamidodiphenyl proved unsuitable for use because, although nitration proceeded cleanly to the 3 : 5-dinitro-derivative, bromination in acetic acid was accompanied by much hydrolysis and formation of 5 : 4′-dibromo-3-nitro-4-aminodiphenyl. However, 3-bromo-4-*p*-toluenesulphonamidodiphenyl on bromination gave quite a good yield of the 3 : 4′-

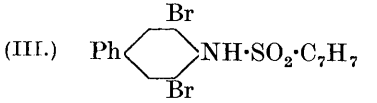
dibromo-compound (I), whereas on nitration 3-*bromo*-5-*nitro*-4-p-*toluenesulphonamidodiphenyl* (II) was obtained.

(I.)

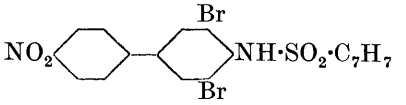


(II.)

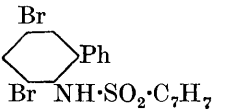
It appears, therefore, that the nature of the entering group must be taken into account as a factor not entirely over-ruled by conditions of substitution and strength of orienting group. Lapworth and Robinson (*Mem. Manchester Phil. Soc.*, 1927, **72**, 43) have emphasised the distinction between degree and frequency of activation of a nuclear carbon atom. It might be suggested that position 4′ in 4-acetamidodiphenyl has a lower degree but a higher frequency of activation than position 3, and bromine, a more energetic kationoid reagent, enters position 4′. Since 4-hydroxydiphenyl is brominated in positions 3 : 5 without formation of the 3 : 4′-derivative (Bell and P. H. Robinson, J., 1927, 1128), it appears that when the activation in positions 3 and 5 is sufficiently high, so that every tentative union proceeds to completion, the higher frequency of activation of position 4′ is more than counterbalanced. The activating power of a *p*-toluenesulphonamido-group can be increased by removal of its incipiently ionised hydrogen atoms by salt formation, and therefore the bromination of 4-*p*-toluenesulphonamidodiphenyl in pyridine solution was examined. It gave the 3 : 5-derivative (III) in good yield. Similarly 4′-bromo-4-*p*-toluenesulphonamidodiphenyl gave the 3 : 5 : 4′-*tribromo*-derivative, 4′-*nitro*-4-p-*toluenesulphonamidodiphenyl* the 3 : 5-*dibromo*-derivative (IV), 3-nitro-4-*p*-toluenesulphonamidodiphenyl the 5-*bromo*-derivative, and 5-bromo-2-*p*-toluenesulphonamidodiphenyl the 3-bromo-derivative (V). Without the exceptionally high activation caused by salt formation,



(III.)



(IV.)



(V.)

bromine in cold pyridine is of no value as a brominating agent. 3 : 5-Dibromo-4-*p*-toluenesulphonamidodiphenyl, 3 : 5-*dibromo*-2-p-*toluenesulphonamidodiphenyl*, 3- and 4′-bromo-4-methoxydiphenyls, 3 : 5-dinitro-4-*p*-toluenesulphonamidodiphenyl, 4′-bromo-4-acetamidodiphenyl, and even 4-acetamidodiphenyl were recovered in

quite good amount after treatment with 1—2 molecules of bromine in this way.

The conclusion is drawn that directing groups may not appear in the same sequence in substitutions of different types. Salt formation with the media and consequent establishment of real poles is of the utmost importance, and the degree of activity of the substituting reagent in part determines the positions in the molecule which are open to attack.

## EXPERIMENTAL.

*Bromination of* 4-p-*Toluenesulphonamidodiphenyl.*—(*a*) Bromine (4 g.) was added to 4 g., dissolved in pyridine, and the solution, after standing over-night, was poured into water. The product was warmed with alcohol, and the residue (4·7 g.; m. p. *ca.* 190°) crystallised from acetic acid. Pure 3 : 5-dibromo-4-*p*-toluenesulphonamidodiphenyl, m. p. 196°, was obtained (Bell, this vol., p. 615). This compound was unchanged after introduction into cold fuming nitric acid, and after being warmed with bromine in acetic acid solution.

(*b*) Bromination in chloroform solution gives the 3 : 4′-dibromo-derivative (Bell, J., 1930, 1076). 3 : 4′-Dibromo-4-*p*-toluenesulphonamidodiphenyl on bromination in pyridine solution as described above gave a quantitative yield of 3 : 5 : 4′-*tribromo*-4-p-*toluenesulphonamidodiphenyl.* This compound crystallised from acetic acid in needles, m. p. 218° (Found : Br, 42·4. $C_{19}H_{14}O_2NBr_3S$ requires Br, 42·9%), and reacted readily with *p*-toluenesulphonyl chloride in pyridine solution to give 3 : 5 : 4′-*tribromo*-4-*di*-p-*toluenesulphonamidodiphenyl.* The latter, which was the only compound which could be isolated from the product of interaction of 3 : 5 : 4′-tribromo-4-aminodiphenyl with *p*-toluenesulphonyl chloride, crystallised from alcoholic pyridine in needles, m. p. 274° (Found : Br, 33·4. $C_{26}H_{20}O_4NBr_3S_2$ requires Br, 33·6%). Nitric acid (*d* 1·5; 1 c.c.) in acetic acid (1 c.c.) was added to a warm solution of 3 : 4′-dibromo-4-*p*-toluenesulphonamidodiphenyl (1·25 g.) in acetic acid (7 c.c.). 3 : 4′-*Dibromo*-5-*nitro*-4-p-*toluenesulphonamidodiphenyl* separated immediately; it formed pale yellow needles, m. p. 229°, after recrystallisation from acetic acid (Found : C, 43·5; H, 2·9. $C_{19}H_{14}O_4N_2Br_2S$ requires C, 43·4; H, 2·7%). It dissolved slowly in cold sulphuric acid, and when the solution was poured into water 3 : 4′-dibromo-5-nitro-4-aminodiphenyl was precipitated.

*Bromination of* 3-*Nitro*-4-p-*toluenesulphonamidodiphenyl.*—(*a*) A solution of this compound and bromine (1 mol.) in acetic acid was kept warm for 1 hour. On cooling, 5 : 4′-dibromo-3-nitro-4-aminodiphenyl separated and no other product was isolated in a pure condition.

(*b*) Bromine (3 g.) was added drop by drop to 6·8 g., dissolved in pyridine, and the solution was left over-night and poured into water. The viscous mass obtained was dissolved in boiling acetic acid; on cooling, 3-*bromo*-5-*nitro*-4-p-*toluenesulphonamidodiphenyl* (6·3 g.) separated. This was alternatively prepared as follows. Nitric acid (*d* 1·5; 3 c.c.) in acetic acid (3 c.c.) was added to a warm solution of 3-bromo-4-*p*-toluenesulphonamidodiphenyl (3 g.) in acetic acid (30 c.c.), and the mixture allowed to cool. 3-Bromo-5-nitro-4-*p*-toluenesulphonamidodiphenyl separated; it formed long needles, m. p. 191°, after recrystallisation from acetic acid (Found: Br, 18·1. $C_{19}H_{15}O_4N_2BrS$ requires Br, 17·9%). This compound dissolved almost immediately in cold sulphuric acid and when the solution was poured into water and neutralised with aqueous ammonia 3-bromo-5-nitro-4-aminodiphenyl (Scarborough and Waters, J., 1927, 1138; Hinkel and Hey, J., 1928, 1838) was precipitated, the constitution of which was further confirmed by preparation of the acetyl derivative (Bell, this vol., p. 2227). 3-Bromo-5-nitro-4-*p*-toluenesulphonamidodiphenyl was recovered unchanged after introduction into cold fuming nitric acid, after warming in a steam-bath with concentrated nitric acid, and after warming with bromine in acetic acid solution.

*Bromination of* 4′-*Nitro*-4-p-*toluenesulphonamidodiphenyl*—4′-*Nitro*-4-p-*toluenesulphonamidodiphenyl*, prepared by interaction of 4′-nitro-4-aminodiphenyl with *p*-toluenesulphonyl chloride in pyridine solution, formed small prisms, m. p. 144° after recrystallisation from acetic acid (Found: C, 61·7; H, 4·4. $C_{19}H_{16}O_4N_2S$ requires C, 61·9; H, 4·4%).

(*a*) 3 G. in warm acetic acid (15 c.c.) were treated with bromine (1·3 g.) in acetic acid (4 c.c.), and the mixture kept over-night. Crystals (1·7 g., m. p. *ca.* 130°) separated and the mother-liquor on dilution furnished similar material (1·6 g.). Recrystallisation from acetic acid gave large prisms, m. p. 130—133°, which must have contained unchanged material (Br, 14·0%), but recrystallisation from alcohol soon gave 3-*bromo*-4′-*nitro*-4-p-*toluenesulphonamidodiphenyl* in lustrous needles, m. p. 144° (Found: Br, 17·6. $C_{19}H_{15}O_4N_2BrS$ requires Br, 17·9%). On addition of nitric acid (*d* 1·5; 1 c.c.) to this compound (1 g.) in acetic acid, there separated immediately needle crystals of 3-*bromo*-5:4′-*dinitro*-4-p-*toluenesulphonamidodiphenyl*, m. p. 250° (Found: Br, 16·3. $C_{19}H_{14}O_6N_3BrS$ requires Br, 16·3%).

(*b*) Bromine (3·3 g.) was added to the compound (3 g.) in pyridine, and the solution, after standing over-night, poured into water. The product (4·4 g.) after crystallisation from pyridine gave pure 3:5-*dibromo*-4′-*nitro*-4-p-*toluenesulphonamidodiphenyl* in needles, m. p. 274° (Found: Br, 30·2. $C_{19}H_{14}O_4N_2Br_2S$ requires Br, 30·4%).

*Bromination of* 2-p-*Toluenesulphonamidodiphenyl.*—2-*p*-Toluenesulphonamidodiphenyl, treated with bromine (2·5 mols.) in pyridine in the usual way, gave 3 : 5-*dibromo*-2-p-*toluenesulphonamidodiphenyl*, which crystallised from alcohol in large prisms, m. p. 118° (Found : Br, 32·8. $C_{19}H_{15}O_2NBr_2S$ requires Br, 33·3%). 2 G. were left with sulphuric acid (5 c.c.) over-night and the solution was poured into aqueous sodium acetate. The resultant precipitate after crystallisation from alcohol had m. p. 53°, alone or mixed with 3 : 5-dibromo-2-aminodiphenyl (Scarborough and Waters, J., 1927, 94).

4′-*Bromo*-3 : 5-*dinitro*-4-p-*toluenesulphonamidodiphenyl*, prepared by addition of nitric acid (*d* 1·5; 2 c.c.) in acetic acid (2 c.c.) to 4′-bromo-4-*p*-toluenesulphonamidodiphenyl (2 g.) in acetic acid (15 c.c.), crystallised from acetic acid in long needles, m. p. 233° (Found : Br, 16·1. $C_{19}H_{14}O_6N_3BrS$ requires Br, 16·3%).

In conclusion, the author wishes to express his thanks to Dr. J. Kenyon for criticism of this paper.

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