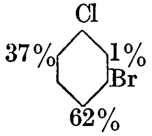
XCIII.—*The Nitration of Mixed* m-*Dihalogenobenzenes.*

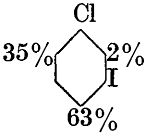
By Horace Alfred Mayes and Eustace Ebenezer Turner.

When this investigation was begun, it was hoped to make a complete study of the mononitration of the *m*- and *p*- mixed dihalogenobenzenes, but experiments on the nitration of *p*-halogenoiodobenzenes carried out in conjunction with Mr. C. R. Pinnell have shown that a direct comparison of such compounds is impracticable, owing to the readiness with which the iodine is expelled. This part of our work has been confirmed by van Hove (*Bull. Acad. roy. Belg.*, 1926, **12**, 801, 823).

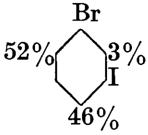
We have, however, made a thorough investigation of the mononitration of three mixed dihalogenobenzenes, with the results indicated by (I), (II) and (III) :



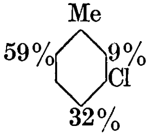
(I.)



(II.)



(III.)



(IV.)

These results are interesting in comparison with those of Holleman and his co-workers (*Rec. trav. chim.*, 1900, **19**, 188, 364; 1905, **24**, 146; 1913, **32**, 134). Holleman showed that, under similar conditions, chloro-, bromo-, and iodo-benzene gave 69·9% and 29·8%, 62·1% and 37·6%, and 58·7% and 41·1% of *p*- and *o*-nitro-derivatives, respectively. The ratio of ortho to para nitration for chlorine, bromine, and iodine in these compounds is therefore 0·43, 0·61 and 0·70, or roughly 6 : 9 : 10. Our nitrations fall fairly well into line with Holleman's results. For instance, when *m*-bromoiodobenzene is nitrated, since both halogens have an approximately equal ortho-para directive ratio, nitration occurs to almost the same extent in positions 4 and 6 (III). The nitration of the other two compounds (I and II) illustrates the same point, for bromine and iodine produce almost precisely the same effect when present in the meta-position to a chlorine atom.

It should be noted that the para-selecting volume effect of the iodine atom must be quite small. This follows equally from Holleman's results and from our own.

Our mononitro-mixtures were analysed by means of the mixed-freezing-point curves and we resorted to common practice to overcome the difficulties due to the presence of a small amount of the 2-nitro-compound. The mononitration of *m*-dichloro- and of *m*-dibromo-benzene produces 4% and 4·6%, respectively, of the 2-nitro-compound (Holleman and Reiding, *Rec. trav. chim.*, 1904, **23**, 359; Holleman, *ibid.*, 1906, **25**, 187).

Wibaut (*ibid.*, 1913, **32**, 244) obtained results for the mononitration of *m*-chlorotoluene as shown in (IV). Now Holleman (*Proc. K. Wetensch. Amsterdam*, 1908, **11**, 248; *Rec. trav. chim.*, 1909, **28**, 408) showed that the ratio of ortho to para nitration of toluene (under conditions similar to those used by Wibaut and by ourselves) was 56·0 : 40·9, *i.e.*, 1·37 : 1. Comparing (IV) with (III), it is perhaps surprising that only 59% nitration occurs in position 6.

We have discovered a minor point which is somewhat difficult to explain. Körner, the only other worker to describe the nitration of mixed *m*-dihalogenobenzenes, found that 1-chloro-3-bromobenzene yielded the 4- and 6-nitro-derivatives and that 1-chloro-3-iodobenzene yielded the 4-derivative and another, undefined compound (*Gazzetta*, 1874, **4**, 379). On the other hand, he stated that 1-bromo-3-iodobenzene on nitration gave two mononitro-derivatives, one of which (no m. p. given) he thought might be the 2-nitro-compound. The second compound, m. p. 126·8°, he regarded as 1-bromo-3-iodo-6-nitrobenzene, and described it as being convertible by alcoholic ammonia into 5-iodo-2-nitroaniline, also obtained by the action of the same reagent on 1 : 3-di-iodo-4-nitrobenzene. We have shown conclusively, however, that Körner's compound, m. p. 126·8°, must be 1-bromo-3-iodo-4 : 6-dinitrobenzene, and that authentic 1-*bromo*-3-*iodo*-6-*nitrobenzene* melts at 76—76·5°.

EXPERIMENTAL.

Preparation of Materials required for plotting the Freezing-point Curves of the Mixtures.—The three *m*-dihalogenobenzenes were prepared from *m*-chloro- and *m*-bromo-aniline and had the b. p.'s given in the literature.

3-Chloro-6-nitroaniline was prepared from *m*-chloroacetanilide by sulphonation, nitration, and removal of the sulpho-group according to D.R.-P. 206,345. A similar method was used successfully for the preparation of 3-bromo-6-nitroaniline.

3-Chloro-4-nitroaniline was prepared by the direct nitration of *m*-chloroacetanilide: under the conditions recorded by Beilstein and Kurbatow (*Annalen*, 1876, **182**, 94), the nitration mixture occasionally ignited, and even when it did not it gave only a poor yield of the nitro-compound. The following method proved suitable : A solution of *m*-chloroacetanilide (33 g.) in 30 c.c. of glacial acetic acid and 55 c.c. of concentrated sulphuric acid was kept at 10° while 20 c.c. of nitric acid (*d* 1·5) were slowly added, and after 1 hour the mixture was poured on ice. The separated nitro-compound was heated for 1 hour at 100° with excess of 60% sulphuric acid, and the mixture then poured into water; on distillation with steam, 3-chloro-6-nitroaniline passed over (10 g.), leaving a residue (16·5 g.) of almost pure 3-chloro-4-nitroaniline (total yield of mononitro-compounds, 80%).

m-Bromoacetanilide (70 g.) was similarly converted into 17 g. of 3-bromo-6-nitroaniline and 34 g. of 3-bromo-4-nitroaniline.

1-Chloro-3-bromo-6-nitrobenzene was prepared by the Sandmeyer process from 3-bromo-6-nitroaniline. It had setting point 43·4° and m. p. 44·5° (Körner gives 42·4°). 1-Chloro-3-bromo-4-nitrobenzene, from 3-chloro-6-nitroaniline, had setting point 48·4° and melted at 49·5° as stated by Körner.

1-*Chloro*-3-*iodo*-6-*nitrobenzene*, from 3-chloro-4-nitroaniline, had setting point 61·8° and m. p. 63°. Körner probably obtained this compound when he nitrated *m*-chloroiodobenzene, but he gave no m. p. 1-Chloro-3-iodo-4-nitrobenzene, from 3-chloro-6-nitroaniline (obtained by more than one process), had setting point 60·3°; it melted at 61·5° even after repeated crystallisation (Körner gives m. p. 63·4°).

1-*Bromo*-3-*iodo*-6-*nitrobenzene*, from 3-bromo-4-nitroaniline, had setting point 74·4° and melted at 76—76·5° (Found : AgBr + AgI, 0·2544 g.; *M*, in camphor, 322. $C_6H_3O_2NBrI$ requires AgBr + AgI, 0·2531 g.; *M*, 328). Since Körner gave m. p. 126·8°, two check experiments were made as follows : (*a*) a sample of the 3-bromo-4-nitroaniline used for the preparation was converted into 1-chloro-3-bromo-4-nitrobenzene, identical with the product obtained above from 3-chloro-6-nitroaniline. (*b*) *m*-Bromoiodobenzene was warmed with excess of nitric acid (*d* 1·5) and concentrated sulphuric acid, the cooled solution poured on ice, and the solid so obtained crystallised from alcohol; it melted at 125—127°, and was clearly 1-*bromo*-3-*iodo*-4 : 6-*dinitrobenzene* (Found : AgBr + AgI, 0·2444 g.; *M*, in camphor, 378. $C_6H_2O_4N_2BrI$ requires AgBr + AgI, 0·2430 g.; *M*, 373). When warmed with piperidine, the substance was quantitatively converted into dinitrodipiperidinobenzene, m. p. 130°, identical with a specimen obtained from 1 : 3-dichloro-4 : 6-dinitrobenzene.

1-Bromo-3-iodo-4-nitrobenzene, from 3-bromo-6-nitroaniline, had the m. p. recorded by Körner (83·5°), and setting point 82·1°.

Nitration of the Dihalogenobenzenes.—The halogen compound was slowly added to well-stirred nitric acid (*d* 1·5), kept at — 5°, stirring was continued for $\frac{1}{4}$ hour, and the solution was then poured on ice. The precipitate was washed and dried in the usual manner. Molecular-weight determinations and analyses were carried out in order to make sure that dinitro-compounds were absent.

Sufficient nitric acid was used to effect complete solution in each case. 5 G. of chlorobromo-, chloroiodo-, and bromoiodo-benzene dissolved respectively in 10·5, 13·3, and 15·5 g. of nitric acid. The bromoiodo-compound dissolves rather slowly, and the fact that Körner warmed the mixture to effect solution no doubt accounts for his obtaining a dinitro-compound.

Freezing Points.—These were determined by means of a standard thermometer graduated in fifths of a degree and capable of being read to tenths. The mixtures of isomerides were melted in a test-tube, which was then immersed in a well-stirred bath kept at a suitable temperature.

Determination of the Compositions of Mixtures of the Nitro-compounds.—Freezing-point curves were determined for a number of known mixtures of the two isomerides produced in each nitration. The curves obtained for the chlorobromo- and chloroiodo-nitro-compounds each showed one well-defined minimum point but no other appreciable inflexion. The curve for the bromoiodonitro-compounds was almost flat in the region corresponding to 75—45% of 1-bromo-3-iodo-6-nitrobenzene. The actual f. p.'s of various mixtures were as follows :

1-Chloro-3-bromo-6-nitrobenzene (A) and 1-chloro-3-bromo-4-nitrobenzene (B).

A, %	100	92·74	85·57	79·53	72·74	67·42
F. p.	43·4°	41·9°	39·9°	38·3°	37·0°	36·1°
A, %	62·25	57·79	54·00			
F. p.	36·8°	37·5°	38·2°			

B, %	100	95·01	89·31	84·26	79·9	76·27
F. p.	48·4°	47·4°	46·2°	45·2°	44·5°	43·7°
B, %	68·12	64·64	61·0	57·42	54·68	
F. p.	42·2°	41·5°	40·6°	39·9°	39·3°	

1-Chloro-3-iodo-6-nitrobenzene (A) and 1-chloro-3-iodo-4-nitrobenzene (B).

A, %	100	95·03	90·9	82·39	76·41	70·9
F. p.	61·8°	58·7°	56·4°	51·2°	47·3°	43·5°
A, %	60·59	53·99	49·87	47·64		
F. p.	37·2°	31·3°	30·6°	30·4°		

B, %	100	94·47	90·14	84·42	78·22	71·83
F. p.	60·3°	57·3°	54·8°	51·8°	47·8°	43·3°
B, %	64·64	57·82				
F. p.	38·1°	33·0°				

1-Bromo-3-iodo-6-nitrobenzene (A) and 1-bromo-3-iodo-4-nitrobenzene (B).

A, %	100	94·83	89·14	82·92	77·23	72·26
F. p.	74·4°	73·4°	71·8°	70·1°	69·3°	68·9°
A, %	67·78	64·14	60·28	56·46	52·83	
F. p.	68·8°	68·8°	68·7°	68·5°	68·4°	

B, %	100	93·80	89·26	85·62	81·92	78·71
F. p.	82·1°	80·0°	78·4°	77·4°	75·8°	74·7°
B, %	75·19	71·33	67·6	64·2	59·06	
F. p.	73·5°	72·2°	71·1°	70·0°	68·9°	

The freezing point of each crude, dry nitration product was determined. A known quantity of one of the isomerides was added, and the f. p. again determined. In every case, the second point conformed to the curve constructed with the above figures. In the case of the chlorobromo- and chloroiodo-compounds (experiments IV and V with the former, and III, IV, and V with the latter) sufficient of one isomeride was added to give a f. p. on the other arm of the curve. This gave a second figure with which to calculate the original composition. In both series the composition of the original product corresponded to a point on the arm of the curve plotted when A was added to B, so that the first f. p. gave the amount of B present and the second point gave the amount of A present in the new mixture (*i.e.*, after addition of a known amount of A). Taking the mean of the values obtained, we find that the sum A + B is somewhat less than 100%, indicating almost certainly the presence of a little of the 2-nitro-derivative.

The composition of the nitration product of *m*-bromoiodobenzene corresponded to a point on the flat portion of the curve. Both A and B were therefore added in two different experiments, so as to obtain two freezing points, one on each side of the curve. The f. p. of the original nitro-compound always lay slightly below the lowest point on the curve, indicating the presence of a little of the 2-nitro-derivative. This was confirmed by the values obtained for the proportion of A and B present.

In this method of calculation, the assumption is made that a small quantity of the 2-nitro-derivative causes the same depression of f. p. as an equal quantity of A or of B. The results obtained are as follows :

Nitration of m-*chlorobromobenzene. Experiment* I. F. p. of product, 40·9° (Found : AgCl + AgBr, 0·2870 g.; *M*, in camphor, 235. Calc. for mononitro-mixture : AgCl + AgBr, 0·2854 g.; *M*, 236·5). Addition of A lowered f. p., and therefore the mixture contained 62·0% of B. When 0·2032 g. of A was added to 2·6020 g. of mixture, the new mixture had f. p. 40·1°, corresponding to 57·5% of B.

Experiment II. F. p. of product, 41·2°, corresponding to 63·5% of B. On addition of 0·1556 g. of B to 1·9492 g. of mixture, the f. p. became 41·8°, corresponding to 66·2% of B. Further addition of B (0·1781 g.) to 2·1048 g. of the second mixture gave a third mixture with f. p. 42·3°, corresponding to 68·9% of B.

Experiment III. F. p. of product, 40·6°, corresponding to 61·0% of B. 0·2075 G. of B added to 1·6656 g. of product. New f. p., 41·6°, corresponding to 65·4% of B.

Experiment IV. F. p. of product, 40·8°, corresponding to 61·5% of B. 0·4690 G. of A added to 0·3025 g. of product. New f. p., 37·6°, corresponding to 75·5% of A in new mixture, *i.e.*, to 37·6% of A in original mixture.

Experiment V. F. p. of product, 40·7°, corresponding to 61·3% of B. 0·5352 G. of A added to 0·5130 g. of product. New f. p., 36·5°, corresponding to 70·0% of A, so that the original mixture contained 36·3% of A.

Mean % of A found : 37·0. Mean % of B found : 61·9. Probably 1% of 2-nitro-derivative.

Nitration of m-*chloroiodobenzene. Experiment* I. F. p. of product, 36·4° (Found : AgCl + AgI, 0·2857 g.; *M*, in camphor, 288. Calc. for mononitro-mixture : AgCl + AgI, 0·2865 g.; *M*, 283·5). Addition of B raised f. p., so that mixture contained 62·5% of B. 0·0522 G. of B added to 0·9310 g. of product. New f. p., 37·7°, corresponding to 64·5% of B.

Experiment II. F. p. of product 36·1°, corresponding to 62·2% of B. 0·1456 G. of B added to 3·075 g. of product. New f. p., 37·3°, corresponding to 64·0% of B.

Experiment III. F. p. of product, 37·2°, corresponding to 63·5% of B. 0·4020 G. of A added to 0·6805 g. of product. New f. p., 35·8°, corresponding to 59·0% of A. Original mixture therefore contained 34·8% of A.

Experiment IV. F. p. of product, 37·2°, corresponding to 63·5% of B. 0·2978 G. of A added to 0·6202 g. of product. New f. p., 33·6°, corresponding to 56·5% of A. Original mixture therefore contained 35·6% of A.

Experiment V. F. p. of product, 36·6°, corresponding to 62·7% of B. 1·3670 G. of A added to 2·3755 g. of product. New f. p., 35·8°, corresponding to 59·0% of A. Original mixture therefore contained 35·3% of A.

Mean % of A found : 35·2. Mean % of B found : 62·9. Probably 2% of 2-nitro-derivative.

Nitration of m-*bromoiodobenzene. Experiment* I. F. p. of product, 68·2° (Found : AgBr + AgI, 0·2635 g.; *M*, in camphor, 320. Calc. for mononitro-mixture : AgBr + AgI, 0·2628 g.; *M*, 328). 1·5896 G. of A added to 1·7300 g. of product. New f. p., 69·1°, corresponding to 75·3% of A. Original mixture therefore contained 52·6% of A.

Experiment II. F. p. of product, 68·0°. 1·0012 G. of B. added to 0·9254 g. of product. New f. p., 73·0°, corresponding to 73·6% of B. Original mixture therefore contained 45·1% of B.

Experiment III. F. p. of product, 68·1°. 1·2375 G. of B added to 0·3745 g. of product. New f. p., 77·8°, corresponding to 87·5% of B. Original mixture therefore contained 46·1% of B.

Experiment IV. F. p. of product, 67·9°. 1·3080 G. of A added to 0·4150 g. of product. New f. p., 71·4°, corresponding to 88·1% of A. Original mixture therefore contained 50·6% of A.

Experiment V. 1·5005 G. of the mixture prepared in experiment III (87·5% of B) was added to 1·5390 g. of the mixture from experiment IV (88·1% of A). New mixture had f. p. 68·2°, and contained 50·8% of A.

Mean % of A found : 51·6. Mean % of B found : 45·6. Probably 3% of 2-nitro-derivative.

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EAST LONDON COLLEGE,
UNIVERSITY OF LONDON.

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