131. *The Nitration of Anisole.*

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No quantitative studies of the nitration of anisole are recorded in the literature, although Hoeflake (*Rec. trav. chim.*, 1916, **36**, 24) refers to certain preliminary experiments of Holleman and van der Linden, which appear to have been abandoned owing to the difficulty of obtaining a product free from dinitroanisole (compare Holleman, " Substituenten," p. 164). Qualitatively, *p*-nitroanisole has usually been isolated in major quantity (Holleman, *op. cit.*), but Francis (*Ber.*, 1906, **39**, 3801) states that nitration by means of benzoyl nitrate results in an almost theoretical yield of the *o*-isomeride.

In the present work, mononitration was secured by using molecular quantities of the reagents and allowing the reaction to proceed only until about 70% of the anisole had disappeared; 99% of this was recoverable as mononitroanisoles when acetyl or benzoyl nitrate was used as nitrating reagent, but nitric acid, either alone or with sulphuric acid, gave only 30% yields owing to loss as nitroso-compounds or tarry matter. The acyl nitrates

gave a high proportion (some 70%) of *o*-nitroanisole, but this isomeride was not formed exclusively, as suggested by Francis (*loc. cit.*). With nitric acid, however, the percentage of the *o*-isomeride did not exceed 45, and in presence of sulphuric acid was as low as 30. The use of an acyl nitrate has been found, in some cases, to favour *o*-substitution (Francis, *loc. cit.*; J., 1906, **89**, 1; Pictet and Khotinsky, *Compt. rend.*, 1907, **144**, 210; Holleman, Hartog, and van der Linden, *Ber.*, 1911, **44**, 717; Arnall, *J. Soc. Chem. Ind.*, 1929, **48**, 159T; Oxford, J., 1926, 2004), but in others the product is identical with that yielded by nitric acid (Holleman, *Rec. trav. chim.*, 1914, **33**, 11; Flürscheim and Holmes, J., 1928, 1612). In the present instance the difference in the *o/p* ratio is probably a real one, and not due to selective decomposition of the *o*-isomeride by the nitric acid, since such decomposition does not occur on heating for 3 hours on the water-bath.

A study of the m. p. curves of *o*- and *p*-nitroanisoles and of the mononitration product, proved (by control experiments on synthetic mixtures; see below) to be free from unnitrated or dinitrated material, disclosed the formation of a small quantity of the *m*-isomeride, and from the effect of this isomeride in lowering the *o-p* eutectic, this proportion is estimated at 2%. Our observations thus provide some confirmation of Arnall's results (J., 1924, **125**, 811), indicating a small quantity of the *m*-isomeride in the products of nitration of phenol.

EXPERIMENTAL.

Nitroanisoles.—These were prepared by methylation of the corresponding nitrophenols with methyl sulphate, the product being steam-distilled from slightly alkaline solution and finally purified by crystallisation from 50% alcohol (*m*- and *p*-) or vacuum distillation (*o*-). The m. p.'s of the pure isomerides were determined in an apparatus of the usual Beckmann type with a thermometer graduated in 0·1°. Several concordant determinations gave the following m. p.'s : *o*- 10·45°, *m*- 35·5°, *p*- 52·1° (± 0·05°); Cowley and Partington (J., 1933, 1257) give 10·3°, 35·7°, and 52·0° respectively.

o-p Fusion Curve.—The m. p.'s of various mixtures of *o*- and *p*-nitroanisoles are as follows :

% *o*-	0·0	1·4	2·9	5·6	10·8	16·6	21·2	27·8	33·7	37·7	43·6	47·8
M. p.	52·1°	51·2°	50·4°	48·85°	45·9°	42·15°	39·4°	35·05°	30·6°	28·0°	23·1°	19·55°

% *o*-	52·9	56·5	60·2	64·0	67·0	67·8	70·0	75·8	87·3	94·5	100·0
M. p.	14·6°	11·2°	6·7°	1·9°	−2·3°	−3·5°	−6·5°	−3·3°	3·7°	7·8°	10·45°

The fusion curve is of the simple binary type, and a number of determinations of the eutectic gave − 7·2° (± 0·05°).

Effect of m-*Nitroanisole upon the* o-p *Eutectic.*

m-Nitroanisole added, %	0	1·08	2·22	2·96	3·46
Eutectic	−7·2°	−7·5°	−7·9°	−8·2°	−8·45°

Effect of Dinitroanisole upon the Eutectic and upon the Nitro-content.—2 : 4-Dinitroanisole was prepared as directed by Meldola and Woolcot (J., 1896, **69**, 1330). A mixture of 2 : 4- and 2 : 6-dinitroanisoles was obtained by nitration of *o*-nitroanisole (Holleman, *Rec. trav. chim.*, 1903, **22**, 263). An examination of the effect of these upon the *o-p* eutectic and upon the total nitro-content (determined by titanous chloride, accuracy of method ± 0·5%, and calculated as mononitroanisole) gave the following results :

		2 : 4-Dinitro-.		2 : 4 + 2 : 6-Dinitro-.
Dinitroanisole, %	0	1·92	3·00	2·00
Eutectic	−7·2°	−7·75°	−8·1°	−7·8°
Mononitroanisole, % (apparent)	99·8	100·9	101·3	101·2

These experiments show that a quantity of dinitroanisole sufficient to cause the observed lowering of the eutectic from the actual nitrations would have been detected in the determination of the nitro-compounds by titanous chloride.

A mixture of *o*- and *p*-nitroanisoles containing 1% of anisole and 1% of mixed dinitroanisoles was distilled at 10 mm. Anisole distilled at 50°, and nitroanisoles at about 130—132°. A small quantity of liquid remained at 190°. A titanous chloride determination on the " mononitro " fraction gave 102%, indicating decomposition of the dinitroanisole, which was confirmed by the appearance of a yellow colour when the distillate was shaken with *N*-sodium hydroxide. The nitration products never showed these characteristics.

Nitrations.—The anisole was washed with alkali and then with water, extracted with ether, dried, and fractionated. In Expts. 1—9 (below), nitric acid (1 mol.) was dissolved in the particular medium employed, and mixed with anisole (100 g., also in solution for Expts. 5—9), the mixture being stirred mechanically. Preliminary experiments indicated the time necessary for approximately 70% of the anisole to react, and also the most suitable temperature. The product was made slightly alkaline, steam-distilled, extracted with ether, the extract dried, the ether evaporated, and the residue fractionated under reduced pressure, the unchanged anisole thus being removed completely (see below). The nitro-content was then determined by titanous chloride (standardised by pure nitrophenol or nitroanisole), and the mixture of nitro-anisoles subjected to thermal analysis. Nitrations 1—6 led to the formation of much tar, and also of a green colour (nitroso-compounds) which turned brown on addition of alkali (compare Baeyer and Knorr, *Ber.*, 1902, **35**, 3034). For Expt. 10, the benzoyl nitrate was prepared from silver nitrate and benzoyl chloride (Francis, *loc. cit.*), dissolved in carbon tetrachloride, and added to excess of anisole in the same solvent. The pasty mass (containing benzoic acid) was treated as above.

The efficiency of the process adopted for the isolation of the nitration product was demonstrated as follows : 10 g. of anisole were added to 50 g. of the eutectic mixture of *o*- and *p*-nitroanisoles, and the whole fractionated under reduced pressure. The resulting mixture gave a eutectic at $-7\cdot2°$, and the correct nitro-content (by titanous chloride) for mononitroanisole. Complete removal of anisole had therefore occurred, with no decomposition of nitroanisoles.

Thermal Analysis of Nitration Product.—This was conducted as in the case of the synthetic mixtures. In Expts. 7—10, the composition of the product of nitration was very close to that of the eutectic mixture, and it was necessary to add a weighed quantity of one isomeride before determining the m. p. Control experiments indicated the accuracy of this procedure.

(1) *Nitration by nitric acid.*

Expt. No.	Nitrating agent.	Temp.	Time (hrs.).	Nitro-anisole in pro-duct, %.	M. p.	Eutectic.	Composition of pro-duct (%).		
							o.	*m.*	*p.*
1	HNO₃ (*d* 1·42)	45°	4·5	100·3	24·8°	−7·6°	39·6	1·4	59·0
2				100·2	23·9	−7·55	41·2	1·3	57·5
3	HNO₃ (*d* 1·42) +	45	4·5	99·7	30·9	−7·7	31·3	1·7	67·0
4	H₂SO₄ (equal vols.)			99·5	31·6	−7·7	30·8	1·7	67·5
5	25% (w/v) HNO₃ in	65	3	99·4	20·6	−7·65	45·0	1·5	53·5
6	acetic acid			100·2	21·9	−7·65	43·5	1·5	55·0

(2) *Nitration by an acyl nitrate.*

The following reagents were used : (7) 10% HNO₃ (*d* 1·5) in Ac₂O; (8) and (9) 15% HNO₃ (*d* 1·42) in Ac₂O, the % in each case referring to w/v of actual HNO₃; (10) benzoyl nitrate in CCl₄.

Expt. No.	Temp.	Time (hrs.).	Nitro-anisole in pro-duct, %.	Wt. taken, g.	Wt. of *p*- added, g.	M. p.	Eutectic.	Composition of pro-duct (%).		
								o.	*m.*	*p.*
7	10°	1	99·8	6·632	2·215	12·4°	−7·92°	71·1	2·3	26·6
8	10	0·75	100·2	6·118	2·469	15·15	−7·88	71·5	2·2	26·3
9	10	0·75	99·5	5·786	2·412	17·1	−7·90	69·4	2·2	28·4
10	0	3	99·9	5·816	2·414	13·5	−7·78	63·5	1·9	34·6