SHORT PAPER

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Reactions of 1,2- and 1,3-dimethoxy- and 1,3,5-trimethoxybenzene with nitrogen dioxide/dinitrogen tetraoxide in dichloromethane[†]

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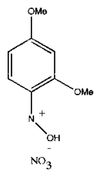
The products of reaction of nitrogen dioxide/dinitrogen tetraoxide with dichloromethane solutions of three different methoxybenzenes are studied and interpreted in terms of initial nitrosation followed by oxidation with nitrogen dioxide.

The reaction of nitrogen dioxide/dinitrogen tetraoxide with anisole and 1,3- and 1,4- dimethoxybenzene in non-aqueous media has been reported.[1–4] With a 6:1 excess of nitrogen dioxide/dinitrogen tetraoxide in carbon tetrachloride at –10 °C anisole gave both 2- and 4-nitroanisole together with anisole-4-diazoniumnitrate;[1] the last product suggesting the formation of 4-nitrosoanisole followed by reaction with nitric oxide. Similarly 1,3-dimethoxybenzene[2] gave 1,3-dimethoxy-4-nitrobenzene and 1,3-dimethoxy-4-nitro-6-benzenediazonium nitrate. Reaction of 1,4-dimethoxybenzene with a slight excess of nitrogen dioxide/dinitrogen tetraoxide in carbon tetrachloride gave 1,4-dimethoxy-2-nitrobenzene.[3] Reaction of anisole in either chloroform or nitromethane at 25 °C gave both 2- and 4-nitroanisole.[4] In some of these papers, the initial formation of a nitroso compound, followed by nitrogen dioxide oxidation to the nitro compound, has been proposed and this led us to carry out kinetic studies of such reactions for a number of aromatic[5] and aliphatic[6] nitrosocompounds. Mononitration of acetonitrile solutions of the three dimethoxybenzenes using nitrogen monoxide-molecular dioxygen mixed gas has been reported;[7] under nitrogen dioxide/dinitrogen tetraoxide 1,2-dimethoxybenzene produces 1,2-dimethoxy-4,5-dinitrobenzene in addition to 1,2-dimethoxy-4-nitrobenzene. To the best of our knowledge no studies of the reaction of nitrogen dioxide/dinitrogen tetraoxide with 1,3,5-trimethoxybenzene have been reported.

Results

The reaction of 1,2-dimethoxybenzene with nitrogen dioxide/dinitrogen tetraoxide in the molar ratio 2:1 (*i.e.* 2 mol dimethoxybenzene: 1 mol N_2O_4 in dichloromethane) gave only one product in 97% yield. NMR, IR and m.p. were identical with literature values for 1,2-dimethoxy-4-nitrobenzene. [For convenience the term nitrogen dioxide is used hereafter for the N_2O_4/NO_2 equilibrium mixture in dichloromethane].

The reaction of 1,3-dimethoxybenzene was more complex in that the addition of nitrogen dioxide was followed by the immediate formation of an intense green colour which disappeared with time. After standing for 48 h the colour had gone from green to red. TLC analysis indicated that there were two initial products of reaction, but after standing at room temperature for 20 h a further six, very minor, products could be detected. NMR indicated the presence of a major product (~ 80%) and a minor product (~ 15%). The minor product was isolated from the crude reaction products by CCl_4 extraction and recrystallised from aqueous methanol, giving pale orange, needle-like crystals, m.p. 75˚C. NMR, IR and CHN analysis agreed with 1,3-dimethoxy-4-nitrobenzene. After removal of this nitrocompound, the major product was isolated from the reaction mixture by recrystallisation from methylene chloride/light petroleum (40–60). It had m.p. 65–66°C, λ_{max} (CH_3OH)/nm 630 ε/ $dm^3 mol^{-1} cm^{-1}$ 2550. TLC analysis showed no movement of this product from the base line even when polar solvents such as ethyl acetate were used. On dissolution in water the solution was acidic. NMR analysis showed the presence of two different methoxy group environments in the ratio 1:1, the splitting pattern in the aromatic region being characteristic of a 1,3,4 substituted compound with two electron donating groups in the 1,3 positions. IR spectroscopy showed strong C–H out of plane bending vibration at 830 cm^{-1}, and a sharp peak at 1385 cm^{-1} which agrees with that expected for a nitrate ion. Dissolution in water of this major product gave a red solid, **3**, m.p. 164–65 °C, in 100% yield. Detailed analysis of **3** was carried out to obtain the most probable structure for the major product for which the available evidence suggested either **1** or **2**



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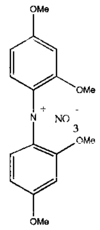

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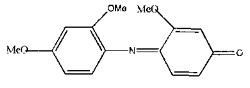

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NMR analysis of **3** indicated the presence of three different methoxy groups, the ratio of aromatic hydrogens to methoxy hydrogens being 6:9. CHN analysis agreed with the formula $C_{15}H_{15}NO_4$ and MS gave M^+ at *m/e* 273. IR showed strong absorption at 1600 cm^{-1} characteristic of anilquinones. These properties are compatible with 2,4-dimethoxyanilino-*p*-(2-methoxy)quinone, **3** suggesting that the isolated major product has the structure **2** *i.e.* bis(2,4-dimethoxyphenyl) anil nitrate. Confirmation by CHN analysis was not possible due to the instability of this compound. When the reaction of 1,3-dimethoxybenzene with nitrogen dioxide was carried out under Horner's conditions[2] (*i.e.* 6:1 excess of nitrogen dioxide) TLC analysis indicated the formation of at least 10 products. Using a similar work up technique to his 1,3-dimethoxy-4-nitrobenzene and 1,3-dimethoxy-4-nitro-6-benzenediazonium nitrate were isolated. The former of these was identified by Horner and also appears as a product under our stoichiometric conditions, but under Horner's conditions there is no indication of the formation of the product of structure **2**. The latter was identified by the product of coupling with ß-naphthol.

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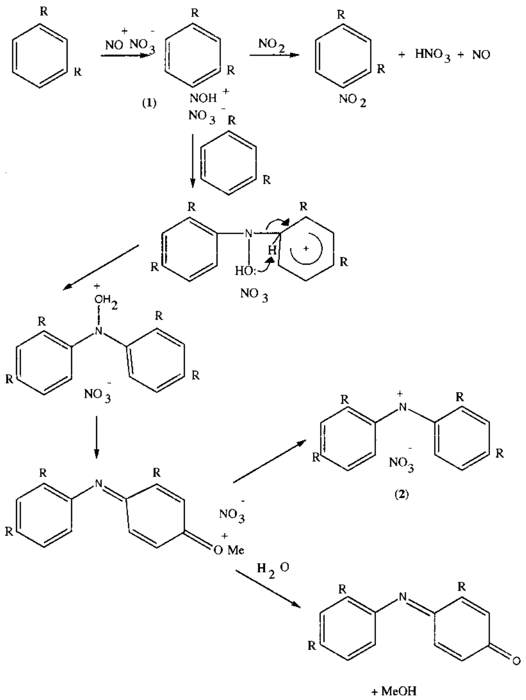
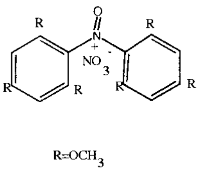
[†] This is a Short Paper, there is therefore no corresponding material in *J Chem. Research (M).*



Scheme 1 (R = OMe)

On addition of nitrogen dioxide to 1,3,5-trimethoxybenzene an intense blue colouration resulted. Following work up, TLC analysis indicated only one product and recrystallisation from dichloromethane/ light petroleum (40–60) gave a deep blue coloured salt, m.p. 147–148 °C; IR (KBr)/cm^{-1} 1605, 1560, 1490, 1440, 1420, 1385, 1340, 1250, 1230, 1165, 1130, 1000; λ_{max} (CH_3OH)/nm 610 ε/ mol dm^{-3} cm^{-1} 5400. CHN analysis: found C 50.80%, H 5.30%, N 6.58%, $C_{18}H_{22}N_2O_{10}$.requires C 50.70%, H 5.20%, N 6.57%. NMR analysis showed the presence of two different methoxy group environments in the ratio of 2:1 compatible with **4**.



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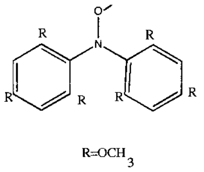

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NMR analysis demonstrated that 1 mol dinitrogen tetraoxide reacted with 1 mol 1,3,5-trimethoxybenzene to give only one organic product in 100% yield.

In order to obtain evidence for reactive intermediates, an ESR spectroscopic study was conducted; to a degassed chloroform solution of the trimethoxybenzene a small amount of nitrogen dioxide was added by vacuum distillation and the room temperature ESR spectrum obtained. A strong triplet signal (a_N = 34.0 G, a_H = 2.9 G, g = 2.0036) resulted. No radical intermediates were observed when the nitrogen dioxide was present in more than the stoichiometric quantity. In addition the ESR spectrum of the aminoxyl radical **5** prepared by Reppe's method[8] was also measured (a_N = 11.6 G, a_H = 0.7 G) in agreement with Kalashnikova *et al.*[9]

From these results we propose that 1,2-dimethoxy-4-nitrobenzene, the sole reaction product for the case of 1,2-dimethoxybenzene, is probably formed by initial nitrosation (1) followed by rapid oxidation (2) of the intermediate nitroso-compound as suggested by Bonner[3] and Underwood[4], the initial nitrosation step being ionic. The single reaction product for this aryl ether is in marked contrast with those obtained for 1,3-dimethoxybenzene where the expected 1,3-dimethoxy-4-nitrobenzene is only 15% of the total products of reaction, the major product (80%) being bis(2,4-dimethoxybenzene) anil nitrate **2** together with 5% of minor products including a diazonium salt. We suggest an initial nitrosation step followed by oxidation to the nitro-compound followed by a further reaction with 1,3-dimethoxybenzene leading to the anil nitrate (Scheme 1). Nitrosation of the 1,3-dimethoxy-4-nitrobenzene in the 6-position followed by reaction with nitric oxide to give the diazonium nitrate[10] is also suggested. The hydrolysis of the anil nitrate results in the formation of a phenolic OH group and then rearrangement to the quinone 3 occurs (Scheme 1).

$$RH + N_2O_4 \longrightarrow RNO + HNO_3 \qquad (1)$$

$$RNO + NO_2 \longrightarrow RNO_2 + NO \qquad (2)$$

We consider that the deep blue product, bis(2,4, 6-trimethoxyphenyl)nitrosonium nitrate, obtained from reaction of nitrogen dioxide with 1,3,5-trimethoxybenzene also results from an initial nitrosation step followed by further reactions. This product has also been observed in the reaction products from nitric acid and 1,3,5-trimethoxybenzene.[8,11]

Experimental

1,2- and 1,3-Dimethoxy- and 1,3,5-trimethoxybenzene were commercial products. Commercial nitrogen dioxide and dichloromethane were purified and stored as before,[5] this solvent being preferred to carbon tetrachloride because the latter did not give a homogeneous solution for the reaction of 1,3-dimethoxybenzene with nitrogen dioxide. 50 cm^3 0.2M N_2O_4 in CH_2Cl_2 were added to 50 cm^3 0.4M in CH_2Cl_2 of the methoxybenzene at 0 °C with stirring over a period of 30 min (dimethoxybenzenes) or 1 h (trimethoxybenzene), followed by vacuum distillation to leave the reaction products as a residue. In addition to this, Horner's conditions[2] were reproduced for 1,3-dimethoxybenzene using 100 cm^3 6M N_2O_4 in CH_2Cl_2 added dropwise with stirring to 200 cm^3 0.5M 1,3-dimethoxybenzene over a period of 15 min at –10°C followed by allowing the reaction mixture to stand for 12 h with subsequent vacuum distillation of solvent and excess reactant, prior to residue treatment as given by Horner.[2]

Analyses: ^{1}H NMR spectra were measured at 60 MHz, ESR spectra were measured using a JEOL JES-PE1-X spectrometer, mass spectra were recorded on an AEI MS30 double beam mass spectrometer and electronic absorption spectra were recorded with a Pye-Unicam SP 1800 spectrophotometer.

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References

1 L. Horner and F. Hübenett, *Chem. Ber.,* 1952, **85**, 804.
2 L. Horner and F. Hübenett, *Liebigs Annalen*, 1953, **579**, 193.
3 T.G. Bonner, R.A. Hancock, G. Yousif and F.R. Rolle, *J. Chem. Soc., B.,* 1969, 1237.
4 G.R. Underwood, R.S. Silverman and A. Vanderwalde, *J. Chem. Soc., Perkin Trans. 2,* 1973, 1177.
5 B.G. Gowenlock, J. Pfab and V. M. Young, *J. Chem. Soc., Perkin Trans. 2,* 1997, 1793.
6 B.G. Gowenlock, B. King, J. Pfab and M. Witanowski, *J. Chem. Soc., Perkin Trans. 2,* 1998, 483.
7 K. Mizuno, T. Tamai. I. Hashida, Y. Otsuji and H. Inoue, *J. Chem. Research (S),* 1995, 284.
8 K.H. Meyer and W. Reppe, *Ber. Dtsch. Chem. Gesell.,* 1921, **54**, 327.
9 L.A. Kalashnikova, M.B. Neiman, E. G. Rozantsev and L.A. Skripko, *Zh. Org. Khim.,* 1967, **2**, 1529.
10 E. Bamberger, *Ber. Dtsch. Chem. Gesell.,* 1897, **30**, 512.
11 K.H. Meyer and W.E. Elbers, *Ber. Dtsch. Chem. Gesell.,* 1921, **54**, 337.