Keten. Part 16.[1] The Reaction of Diketen with Dimethylaniline *N*-Oxide

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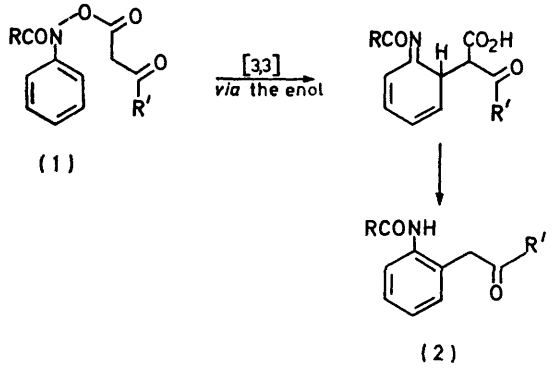
The title reaction gives dimethylaniline, (2-dimethylaminophenyl)propan-2-one, (4-dimethylaminophenyl)propan-2-one, and *N*-methyl-*N*-phenyl-3-oxobutanamide as the major products. The observation of a CIDNP effect is evidence for participation of a radical mechanism.

DURING a study of the complex mixture of compounds obtained by the reaction of keten with dimethylaniline *N*-oxide it appeared that some of the products may have arisen *via* initial dimerisation of the keten followed by further reaction of the diketen so formed. Accordingly the reaction of diketen with dimethylaniline *N*-oxide was investigated and this paper reports the results.

Diketen reacted vigorously with the *N*-oxide in dichloromethane at room temperature with evolution of a gas, which, in the light of subsequent results, is presumed to be carbon dioxide. Separation of the reaction mixture by standard procedures gave a neutral compound identified as *N*-methyl-*N*-phenyl-3-oxobutanamide and a mixture of basic compounds which were separated by fractional distillation. The major components of this mixture were *NN*-dimethylaniline and *o*- and *p*-(dimethylaminophenyl)propan-2-one (5) and (6). A small amount of higher boiling material was not further investigated. The two ketones (5) and (6) were identified by spectroscopic data (given in the Experimental section) and by Wolff–Kishner reduction to the corresponding dimethylaminophenylpropanes, which were synthesised by standard methods from 1-phenylpropane.

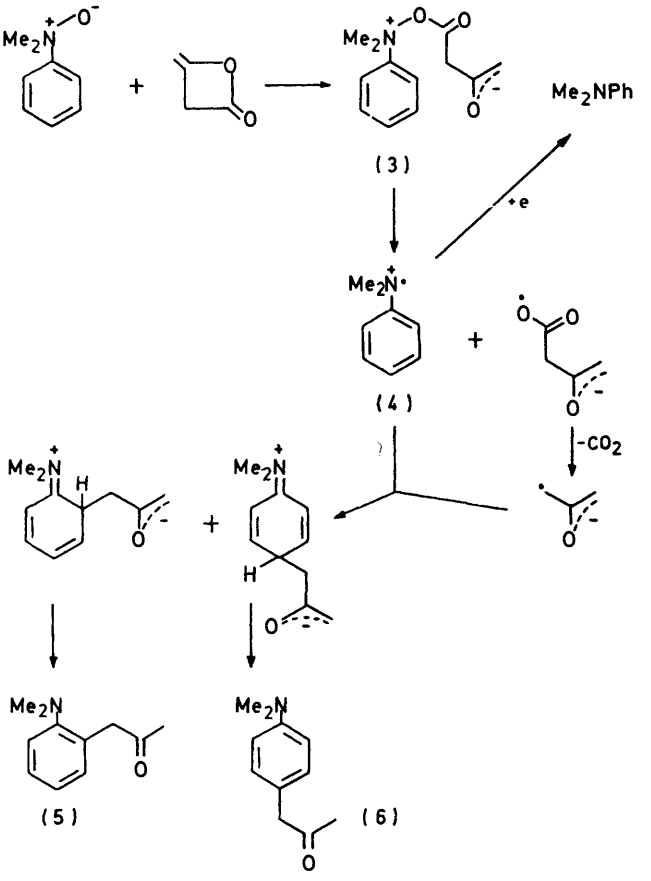
The diversity of products indicates that a number of processes compete in the reaction. A recent communication [2] describes the thermal rearrangement of compounds of type (1) into (2) for which the intramolecular mechanism shown is proposed. An analogous process starting from the zwitterion (3) formed by nucleophilic attack of the *N*-oxide on diketen could account for the formation of (5). However, formation of the *para*-substituted isomer (6) requires a different mechanism. A



(1) (2)

radical process seemed a more promising explanation and the Scheme is proposed.

The formation of dimethylaniline could be explained by electron capture by the radical cation (4). *N*-Methyl-



SCHEME

N-phenyl-3-oxobutanamide presumably arises from the reaction of diketen with *N*-methylaniline. Demethylation of dimethylaniline, presumably *via* the radical cation (4), is known to occur during electrochemical cyanation of dimethylaniline,[3] suggesting that (4) may also be the precursor of the oxobutanamide.

Confirmation of radical involvement in the process was sought by following the reaction by n.m.r. spectroscopy. A reaction mixture prepared at −80° was allowed to warm up in the spectrometer and the reaction followed by repeated scanning of the ^1H n.m.r. spectrum with the spectrometer operating in the Fourier transform mode. A CIDNP effect was observed with a very strong emission at δ 2.90 coinciding approximately with the proton

absorption of the dimethylamino group in (6). Clearly a part of the reaction process involves radicals, but although the Scheme provides an explanation for the formation of all the observed products, the simultaneous formation of (5) by intramolecular rearrangement of (3) is not excluded.

EXPERIMENTAL

^{1}H N.m.r. spectra were measured with a Varian HA100 spectrometer. ^{13}C N.m.r. spectra were measured on a JEOL PTF-100 spectrometer. I.r. spectra were measured on a Perkin-Elmer PE 180 spectrometer. U.v. spectra were measured on a Cary 14 spectrometer.

Reaction of Diketen with Dimethylaniline N-Oxide.—A solution of diketen (27 ml, 29.5 g) in dichloromethane (80 ml) was added slowly with stirring to a solution of dimethylaniline *N*-oxide (46 g) in dichloromethane (300 ml) at 0° and the mixture was allowed to warm to room temperature. The reaction mixture was extracted several times with dilute hydrochloric acid (total 700 ml) and the organic layer was washed with water and dried. Evaporation of the solvent left an oil (7 g, 11%), b.p. 96—100° at 0.1 mmHg, identified as *N*-methyl-*N*-phenyl-3-oxobutanamide by i.r. comparison with an authentic sample, b.p. 100° at 0.1 mmHg (lit.,[4] 130—132° at 4 mmHg).

The acidic aqueous extract was neutralised with an excess of sodium carbonate causing the formation of a small amount of tarry, insoluble material. Repeated extraction with ether followed by normal work-up gave an oil (43.7 g) which was separated by fractional distillation into three fractions and a small amount of high boiling tarry residue.

Fraction 1, b.p. 76—116° at 11 mmHg, was identified as dimethylaniline (7.4 g, 18%) by i.r. comparison with an authentic sample.

Fraction 2, b.p. 120—132° at 12 mmHg, 80° at 0.3 mmHg, was (*2-dimethylaminophenyl)propan-2-one* (5) (22.5 g, 38%) (Found: N, 7.9. $C_{11}H_{15}NO$ requires N, 7.9%), $\lambda_{max.}$(EtOH 245 and 346 nm (log ε 3.72 and 2.53); $\nu_{max.}$(film) 1 710 cm^{-1}, δ_H ($CDCl_3$) 2.04 (3 H, s), 2.58 (6 H, s), 3.70 (2 H, s), and 6.9—7.4 (4 H, m); δ_C ($CDCl_3$) 28.5 (q), 44.3 (q), 47.2 (t), 120.2 (d), 123.8 (d), 128.1 (d), 131.0 (d), 131.2 (s), 152.6 (s), and 206.6 (s). The *picrate* was prepared, m.p. 151—152° (from methanol) (Found: C, 50.3; H, 4.6; N, 13.9. $C_{11}H_{15}NO,C_6H_3N_3O_7$ requires C, 50.2; H, 4.4; N, 13.8%).

Fraction 3, b.p. 135—180° at 12 mmHg, 80—90° at 0.02 mmHg, was identified as a mixture of (5) and (4-dimethylaminophenyl)propan-2-one (6) (total 5.1 g, 9%) (lit.,[5] 120—125° at 2—3 mmHg), from the n.m.r. spectrum, δ($CDCl_3$) 2.05 (3 H, s), 2.87 (6 H, s), 3.51 (2 H, s), and 6.5—7.2 (4 H, A_2B_2) with other minor peaks attributable to (5), $\nu_{max.}$(film) 1 715 cm^{-1}.

Reduction of (2-dimethylaminophenyl)propan-2-one with sodium borohydride in boiling propan-2-ol gave 1-(*2-dimethylaminophenyl)propan-2-ol* (88%), b.p. 126—130° at 9 mmHg (Found: N, 7.7. $C_{11}H_{17}NO$ requires N, 7.8%), $\nu_{max.}$(film) 3 350 cm^{-1}; δ_H ($CDCl_3$) 1.15 (3 H, d, *J* 6 Hz), 2.64 (6 H, s), 2.85 (2 H, d, *J* 6 Hz), 3.96 (1 H, m), 6.12br (1 H, removed by D_2O treatment), and 6.9—7.3 (4 H, m). The *picrate* was prepared, m.p. 129—130° (from methanol) (Found: C, 49.4; H, 4.9; N, 13.5. $C_{11}H_{17}NO,C_6H_3N_3O_7$ requires C, 50.0; H, 4.9; N, 13.7%).

Reduction of the ketone (5) with amalgamated zinc and hydrochloric acid gave an identical product.

Wolff–Kishner Reduction of the Ketones (5) *and* (6).—The ketone (1 g) was heated at 100° with hydrazine hydrate (1 ml, 100%) in ethanediol (5 ml) for 1 h. Potassium hydroxide (2 g) and ethanediol (5 ml) were added and the mixture boiled under nitrogen for ½ h and then slowly distilled under nitrogen until the b.p. had reached 200°. The combined distillate and residue was diluted with water and extracted repeatedly with ether. The ether extract was dried (KOH) and evaporated and the oily residue was distilled.

Ketone (5) (fraction 2) gave 1-(2-dimethylaminophenyl)-propane (0.75 g), b.p. 92—94° at 13 mmHg (lit.,[6] 87—90° at 15 mmHg), δ_H ($CDCl_3$) 0.94 (3 H, t, *J* 7 Hz), 1.64 (2 H, sextet, *J* 7 Hz), 2.62 (7 H, s + m), and 6.8—7.3 (4 H, m). G.l.c. comparison (on Carbowax + KOH) showed this to be identical with a synthetic sample of 1-(2-dimethylaminophenyl)propane. The picrate was prepared, m.p. and mixed m.p. 176—177° (from methanol) (lit.,[6] 176—178°) (Found: C, 52.2; H, 5.2; N, 14.1. Calc. for $C_{11}H_{17}N,C_6H_3N_3O_7$: C, 52.0; H, 5.1; N, 14.3%).

Ketone (6) (fraction 3) gave an oil (0.9 g) which g.l.c. showed to contain one major component, identified as 1-(4-dimethylaminophenyl)propane from the n.m.r. spectrum, δ_H ($CDCl_3$) 0.91 (3 H, t, *J* 7 Hz), 1.59 (2 H, sextet, *J* 7 Hz), 2.49 (2 H, t, *J* 7 Hz), 2.86 (6 H, s), and 6.5—7.2 (4 H, A_2B_2) with some minor peaks attributable to the *ortho*-isomer. G.l.c. comparison (on Carbowax + KOH) showed this major component to be identical with a synthetic sample of 1-(4-dimethylaminophenyl)propane.

Synthesis of Isomeric (Dimethylaminophenyl)propanes.—Nitration of 1-phenylpropane in acetic acid at 0° with a mixture of fuming nitric acid and acetic anhydride gave a mixture of isomers which was separated by distillation at 0.1 mmHg into a number of fractions.[7] The lower b.p. fractions were shown by g.l.c. to contain predominantly the *o*-nitro derivative and the later fractions were mainly the *p*-nitro derivative, confirmed by the aromatic proton absorptions in the n.m.r. spectrum. The crude nitro compounds were reduced to the corresponding amines (Sn–HCl) which were fully methylated with formaldehyde and sodium cyanoborohydride following published procedures.[8] The products obtained were 1-(2-dimethylaminophenyl)propane, b.p. 94—96° at 13 mmHg, n.m.r. spectrum identical with that described above, picrate, m.p. 175—176° (from methanol); and 1-(4-dimethylaminophenyl)propane, b.p. 116—118° at 13 mmHg (lit.,[9] 116—118° at 16 mmHg), n.m.r. spectrum identical with that described above, *picrate*, m.p. 119—120° (from methanol) (Found: C, 51.8; H, 4.9; N, 14.1. $C_{11}H_{17}N,C_6H_3N_3O_7$ requires C, 52.0; H, 5.1; N, 14.3%).

Observation of a CIDNP Effect.—Solutions of dimethylaniline *N*-oxide (0.5 g) and diketen (0.5 ml) in dichlorodideuteriomethane (1 ml each) were separately cooled to −80° and then mixed. A portion of the mixture was allowed to warm to room temperature in a 5 mm tube in a JEOL PFT-100 n.m.r. spectrometer operating in the Fourier transform mode. The ^{1}H spectrum was scanned every 2.3 s and individual free induction decays were stored on a Diabolo backing disc. A strong emission signal was observed at δ 2.90, which reached maximum intensity after 11.5 s.

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[1] Part 15, A. F. Gettins, D. P. Stokes, G. A. Taylor, and C. B. Judge, *J.C.S. Perkin I*, 1977, 1849.
[2] R. M. Coates and I. M. Said, *J. Amer. Chem. Soc.*, 1977, **99**, 2355.
[3] S. Andreades and E. W. Zahnow, *J. Amer. Chem. Soc.*, 1969, **91**, 4181; N. L. Weinberg ' Techniques of Electro-organic Synthesis ' Wiley, New York, 1974, p. 665.
[4] C. E. Kaslow and D. J. Cook, *J. Amer. Chem. Soc.*, 1945, **67**, 1969.
[5] J. Finkelstein, J. A. Romano, E. Chiang, and J. Lee, *J. Medicin. Chem.*, 1963, **6**, 153.
[6] H. Booth, F. E. King, and J. Parrick, *J. Chem. Soc.*, 1958, 2302.
[7] G. Baddeley and J. Kenner, *J. Chem. Soc.*, 1935, 303.
[8] R. F. Borch and A. I. Hassid, *J. Org. Chem.*, 1972, **37**, 1673.
[9] W. C. Davies and F. L. Hulbert, *J. Soc. Chem. Ind. Transactions*, 1938, **57**. 349.