297. *Aliphatic Nitro-compounds. Part XVIII. Interaction of Ketones and Nitro-paraffins.*

By A. Lambert and A. Lowe.

Interaction of acetone and nitromethane in presence of sodium methoxide, sodium hydroxide, quaternary ammonium hydroxides, or triethylamine gives chiefly nitro-*tert.*-butyl alcohol; with secondary amines as catalysts, 1 : 3-dinitro-2 : 2-dimethylpropane is the main product, and this is formed from both nitro-*tert.*-butyl alcohol and 1-nitro-2-methylprop-1-ene with nitromethane. The products obtained from other nitro-paraffins and other ketones are briefly discussed and a reaction mechanism is proposed.

The literature on the products formed by interaction of ketones and nitro-paraffins, though not extensive, is extremely confusing. According to Fraser and Kon (*J.*, 1934, 604), condensation of acetone and some homologous ketones with nitromethane in the presence of sodium ethoxide, piperidine, pyridine, methylamine, or molecular sodium gives 1 : 3-dinitro-paraffins of the type $RR'C(CH_2{\cdot}NO_2)_2$ in 15—25% yield. Nitromethane and *cyclo*hexanone with piperidine as a catalyst give 1-nitromethyl*cyclo*hexene and a little 1-nitromethyl*cyclo*hexanol, and the latter becomes the main product if sodium ethoxide is used as condensing agent. Since completion of the present work, Hass and co-workers (U.S.PP. 2,343,256; 2,383,603; cf. *Chem. Reviews*, 1943, **32**, 383; *Ind. Eng. Chem.*, 1943, **35**, 115) have described improved yields of 1 : 3-dinitro-paraffins from nitromethane and aliphatic or alicyclic ketones by using aliphatic amines as catalysts. They also report failure to duplicate Fraser and Kon's work, saying (U.S.P. 2,343,256) " this disclosure is inoperative and does not enable one skilled in the art to obtain the compounds described ".

In addition to the dinitro-paraffins, Hass also obtains from acetone and nitromethane some 1-nitro-2 : 2-dimethylpentan-4-one in yields which vary with the relative proportions of the reactants; with methyl ethyl ketone, some 1-nitro-2-ethylbut-2-ene is produced.

We have now found that, with sodium methoxide as catalyst, nitromethane and aliphatic ketones give only nitro-tertiary alcohols.

$$RR'CO + CH_3{\cdot}NO_2 \longrightarrow RR'C(OH){\cdot}CH_2{\cdot}NO_2$$

e.g., acetone and nitromethane gave nitro-*tert.*-butyl alcohol in 62% yield. Similar results were obtained with sodium hydroxide, quaternary ammonium hydroxides, or triethylamine as catalyst. However, by using secondary amines (diethylamine or piperidine), 68% of

1 : 3-dinitro-2 : 2-dimethylpropane was formed, but with *n*-amylamine the main product was again nitro-*tert*.-butyl alcohol.

Nitromethane and methyl ethyl ketone in the presence of piperidine have given a mixture of 1-nitro-2-methylbut-1-ene, 1-nitro-2-methylbutan-2-ol, and 2 : 2-di(nitromethyl)butane. The isolation of these compounds from one experiment, together with the formation of 1 : 3-dinitro-2 : 2-dimethylpropane from both nitro-*tert*.-butyl alcohol and 1-nitro-2-methylprop-1-ene with nitromethane, indicates that the reaction proceeds as follows :

$$RR'CO + CH_3{\cdot}NO_2 \rightleftarrows RR'C(OH){\cdot}CH_2{\cdot}NO_2 \longrightarrow RR'C{=}CH{\cdot}NO_2 \longrightarrow RR'C(CH_2{\cdot}NO_2)_2$$

Hass *et al.* (*loc. cit.*) put forward this mechanism but were unable to isolate any nitro-tertiary alcohol. It is unlikely that 1-nitro-2-diethylamino-2-methylpropane (formed from diethylamine and the nitro-olefin; see this series, Part VII) is an important intermediate product, since on reaction with nitromethane this substance gives only small yields of 1 : 3-dinitro-2 : 2-dimethylpropane.

When *cyclo*hexanone and nitromethane were brought into reaction in the presence of diethylamine, 1-nitromethyl*cyclo*hexane, 1-nitromethyl*cyclo*hexanol and a small amount of 1 : 1-di(nitromethyl)*cyclo*hexane were formed (cf. Fraser and Kon, *loc. cit.*), together with an unidentified *product*, m. p. 270—271° (*acetyl* derivative, m. p. 128—129°). The analyses of these agreed with an empirical formula, $C_{14}H_{20}O_3N_2$, but the apparent molecular weight varied with the method used for the determination.

EXPERIMENTAL.

Nitro-tert.-*butyl Alcohol*.—A mixture of sodium methoxide solution [from sodium (2 g.) and methyl alcohol (50 c.c.)], nitromethane (122 g.), and acetone (600 c.c.) was stirred for 3 days at 20°. After neutralisation (10N-hydrochloric acid) and filtration from salt, fractionation gave unchanged nitromethane (62 g.) and *nitro*-tert.-*butyl alcohol* (71·4 g.) as a colourless oil, b. p. 76—77°/10 mm. (Found : C, 40·7; H, 7·5; N, 11·85. $C_4H_9O_3N$ requires C, 40·3; H, 7·55; N, 11·75%). *Nitro*-tert.-*butyl acetate*, prepared from the alcohol by boiling it with acetic anhydride, is a colourless liquid, b. p. 86—88°/13 mm. (Found : N, 8·75. $C_6H_{11}O_4N$ requires N, 8·7%).

1-*Nitro*-2-*methylprop*-1-*ene*.—Nitro-*tert*.-butyl acetate (7·7 g.) was heated with sodium acetate (0·035 g.) at 110° for 30 minutes, and the mixture then distilled under reduced pressure. The distillate, b. p. 45—65°/12 mm., was diluted with ether, washed with water, dried, and fractionated, giving 1-nitro-2-methylprop-1-ene (4 g.) as a pale yellow liquid, b. p. 54—56°/11 mm. (cf. Levy and Scaife, in the press).

1 : 3-*Dinitro*-2 : 2-*dimethylpropane*.—(a) *From acetone and nitromethane.* A mixture of nitromethane (61 g.), acetone (58 g.), and diethylamine (21·5 g.) was kept at 20° for 28 days, poured into water, acidified (2N-hydrochloric acid), and extracted with chloroform. Fractionation of the dried extract gave 1 : 3-*dinitro*-2 : 2-*dimethylpropane* (55·5 g.) as an almost colourless liquid, b. p. 130—132°/10 mm., rapidly solidifying to an amorphous mass, m. p. 75—80° (Found : C, 37·2; H, 6·3; N, 17·5. $C_5H_{10}O_4N_2$ requires C, 37·0; H, 6·2; N, 17·3%).

The same substance was obtained in equal yield using piperidine in place of diethylamine; with *n*-amylamine as catalyst, only 2·5% of the dinitro-compound was formed, together with 10% of nitro-*tert*.-butyl alcohol.

(b) *From nitro*-tert.-*butyl alcohol and nitromethane.* A mixture of nitro-*tert*.-butyl alcohol (38 g.), nitromethane (20 g.), and piperidine (3 g.) was kept at 20° for 14 days. After working up in the usual way, nitro-*tert*.-butyl alcohol (2 g.) and 1 : 3-dinitro-2 : 2-dimethylpropane (19·8 g.) were obtained. Use of *n*-amylamine in place of piperidine reduced the yield of dinitro-paraffin to 8·2 g., 20 g. of the nitro-alcohol being recovered unchanged.

(c) *From nitro*-tert.-*butyl alcohol.* A mixture of nitro-*tert*.-butyl alcohol (24 g.) and diethylamine (20 g.) was kept at 20° for 6 days. After acidification (2N-hydrochloric acid), the mixture was extracted with ether and the extract fractionated, giving 1-nitro-2-methylprop-1-ene (2 g.), b. p. 54—56°/11 mm., nitro-*tert*.-butyl alcohol (3·4 g.), b. p. 75—76°/10 mm., and 1 : 3-dinitro-2 : 2-dimethylpropane (8·6 g.), b. p. 130—132°/10 mm.

(d) *From* 1-*nitro*-2-*methylprop*-1-*ene and nitromethane.* A mixture of 1-nitro-2-methylprop-1-ene (20 g.), nitromethane (12 g.), and diethylamine (3 g.), after 14 days at 20° and working up in the usual way, yielded unchanged nitro-olefin (7·8 g.) and 1 : 3-dinitro-2 : 2-dimethylpropane (6 g.), b. p. 130—132°/10 mm.

(e) *From* 1-*nitro*-2-*diethylamino*isobutane *and nitromethane.* The nitro-amine was prepared by interaction of 1-nitro-2-methylprop-1-ene (5·05 g.) and diethylamine (3·7 g.) in dry ether (15 c.c.) at 0° for 1 hour. Evaporation of the ether gave an almost completely crystalline mass of 1-nitro-2-diethylamino*iso*butane, which separated from ether on strong cooling as yellow needles, m. p. 76°. Yield, 48%. The nitro-amine decomposed rapidly on keeping and could not be analysed.

A mixture of the nitro-amine (14 g.) and nitromethane (6 g.) in ether (15 c.c.) was kept at 20° for 15 days. The yellow nitro-amine dissolved after 24 hours and the smell of diethylamine became apparent. After acidification, extraction with ether, and distillation, 1 : 3-dinitro-2 : 2-dimethylpropane (1·8 g.), b. p. 130—132°/10 mm., was obtained.

(f) *From nitro*-tert.-*butyl acetate and nitromethane.* A mixture of nitro-*tert*.-butyl acetate (14 g.), nitromethane (6 c.c.), and piperidine (2 c.c.) was kept at 20° for 16 days and worked up in the usual way. 1 : 3-Dinitro-2 : 2-dimethylpropane (5·1 g.), b. p. 134—135°/10 mm., was obtained.

1-*Nitro*-2-*methylbutan*-2-*ol*.—A mixture of nitromethane (61 g.), methyl ethyl ketone (150 c.c.), and methyltriethylammonium hydroxide (3 c.c. of 40% aqueous solution) was kept at 20° for 5 days. The mixture was acidified (10N-hydrochloric acid) and distilled; nitromethane (45 g.) was recovered, followed by 1-*nitro*-2-*methylbutan*-2-*ol* (12 g.) as a colourless oil, b. p. 96—97°/18 mm. (Found : C, 44·8; H, 8·0; N, 10·8. $C_5H_{11}O_3N$ requires C, 45·1; H, 8·3; N, 10·5%).

1-*Nitro*-2-*methylbut*-1-*ene*.—(a) *From methyl ethyl ketone and nitromethane.* A mixture of nitromethane (100 c.c.), methyl ethyl ketone (100 c.c.), and piperidine (8 c.c.) was kept at 20° for 9 days. The solution was acidified (2N-hydrochloric acid), extracted with ether, and the extract, after being washed successively with dilute sodium hydrogen carbonate and water, was dried and fractionated, giving 1-nitro-2-methylbut-1-ene (7 g.), b. p. 62°/11 mm. (Found : C, 52·3; H, 7·55; N, 12·2. $C_5H_9O_2N$ requires C, 52·2; H, 7·8; N, 12·2%), 1-nitro-2-methylbutan-2-ol (4·4 g.), b. p. 90—91°/11 mm., and 2 : 2-di(nitromethyl)butane (11·4 g.), b. p. 92°/0·05 mm. (Fraser and Kon, *loc. cit.*, give b. p. 135—138°/9 mm.).

(b) *From* 1-*nitro*-2-*methylbutan*-2-*ol and nitromethane.* A mixture of 1-nitro-2-methylbutan-2-ol (13·3 g.), nitromethane (6·1 g.), and piperidine (3 c.c.) was kept at 20° for 14 days and worked up in the usual way. 2 : 2-Di(nitromethyl)butane (12·7 g.), b. p. 106—108°/1 mm., was obtained.

3-*Nitro*-2-*methylbutan*-2-*ol*.—A solution of sodium methoxide [from sodium (3 g.) and methyl alcohol (60 c.c.)] was mixed with nitroethane (225 g.) and acetone (935 c.c.) and the mixture stirred at 20° for 5 days. After acidification (10N-hydrochloric acid), filtration from salt and fractionation, nitroethane (170 g.) was recovered and 3-*nitro*-2-*methylbutan*-2-*ol* (51 g.) was obtained as a colourless oil, b. p. 85—86°/14 mm. (Found : C, 45·4; H, 8·0; N, 10·7. $C_5H_{11}O_3N$ requires C, 45·1; H, 8·3; N, 10·5%).

1 : 3-*Dinitro*-2 : 2-*dimethylbutane*.—A mixture of nitro-*tert.*-butyl alcohol (60 g.), nitroethane (32·5 g.) and piperidine (10 c.c.) was kept at room temperature for 3 months. After neutralisation and fractionation, 1 : 3-*dinitro*-2 : 2-*dimethylbutane* (1 g.), b. p. 128—132°/9 mm., was obtained (Found : N, 15·9. $C_6H_{12}O_4N_2$ requires N, 15·9%).

1 : 1-*Di*(*nitromethyl*)cyclo*hexane*.—(a) *From* cyclo*hexanone and nitromethane.* A mixture of *cyclo*hexanone (50 c.c.), nitromethane (30 c.c.), and diethylamine (35 c.c.) was refluxed for 10 hours. The solution was acidified (2N-hydrochloric acid) and extracted with ether. A colourless solid (12 g.) separated at this point, and was collected and crystallised from 2-ethoxyethyl alcohol, giving colourless prisms of a *substance*, m. p. 270—271° [Found : C, 63·9; H, 7·3; N, 10·8; *M* (by *X*-ray determination), 259. $C_{14}H_{20}O_3N_2$ requires C, 63·9; H, 7·2; N, 10·65%; *M*, 263]; the *acetate* had m. p. 128—129° [Found : C, 61·5; H, 6·8; N, 8·05; *M* (by *X*-ray determination), 347. $C_{18}H_{24}O_5N_2$ requires C, 62·0; H, 6·9; N, 8·05%; *M*, 348]. The constitution of this substance is unknown.

Fractionation of the ethereal solution gave 1-nitromethyl*cyclo*hexene, 1-nitromethyl*cyclo*hexanol, and 1 : 1-*di*(*nitromethyl*)cyclo*hexane* (3 g.) as a colourless oil, b. p. 105°/0·1 mm., $n_D^{20^\circ}$ 1·4963 (Found : N, 14·2. $C_8H_{14}O_4N_2$ requires N, 13·9%).

(b) *From nitromethyl*cyclo*hexanol and nitromethane.* 1-Nitromethyl*cyclo*hexanol (30 g.; Fraser and Kon, *loc. cit.*), nitromethane (15 c.c.), and diethylamine (5 c.c.) were refluxed for 12 hours. After acidification and extraction with ether [some solid, m. p. 270—271° (1·9 g.), separated here; see above], fractionation of the dried extract afforded 1 : 1-di(nitromethyl)*cyclo*hexane, b. p. 110°/0·2 mm. (Found : N, 13·6%).

3-*Amino*-2-*methylbutan*-2-*ol*.—3-Nitro-2-methylbutan-2-ol (48 g.) in methyl alcohol (900 c.c.) was hydrogenated using Raney nickel at 20°/85 atms. (initial pressure). Fractionation of the filtered solution afforded 3-*amino*-2-*methylbutan*-2-*ol* as a colourless oil, b. p. 65—67°/17 mm. (Found : C, 58·6; H, 12·35; N, 13·9. $C_5H_{13}ON$ requires C, 58·2; H, 12·7; N, 13·6%).

1 : 3-*Diamino*-2 : 2-*dimethylpropane*.—Hydrogenation of 1 : 3-dinitro-2 : 2-dimethylpropane (25 g.) in methyl alcohol (500 c.c.) with Raney nickel (10 g.) at 20°/42 atms. (initial pressure) gave an oil, b. p. 146—156°, which on redistillation from solid potassium hydroxide yielded 1 : 3-diamino-2 : 2-dimethylpropane (11·2 g.) as a colourless oil, b. p. 154—156° (Found : C, 58·4; H, 13·6; N, 27·0. Calc. for $C_5H_{14}N_2$: C, 58·8; H, 13·7; N, 27·4%). The dihydrochloride formed prisms from alcohol, m. p. 259°; the dibenzoyl derivative, leaflets from aqueous methyl alcohol, m. p. 152° alone and in admixture with an authentic specimen prepared according to Part XII of this series.

1 : 1-*Di*(*aminomethyl*)cyclo*hexane*.—Reduction of 1 : 1-di(nitromethyl)*cyclo*hexane (5·5 g.) as described above gave 1 : 1-*di*(*aminomethyl*)cyclo*hexane* (2·6 g.) as a colourless liquid, b. p. 106—108°/10 mm. (Found : C, 67·5; H, 12·3. $C_8H_{18}N_2$ requires C, 67·6; H, 12·7%). The *dibenzoyl* derivative had m. p. 210° (Found : C, 75·3; H, 7·5; N, 8·0. $C_{22}H_{26}O_2N_2$ requires C, 75·4; H, 7·4; N, 8·0%).

The authors wish to thank Dr. H. A. Piggott and Mr. J. D. Rose for advice and interest in this work.

IMPERIAL CHEMICAL INDUSTRIES LIMITED, RESEARCH LABORATORIES,
HEXAGON HOUSE, BLACKLEY, MANCHESTER, 9.
[*Received, January 23rd, 1947.*]