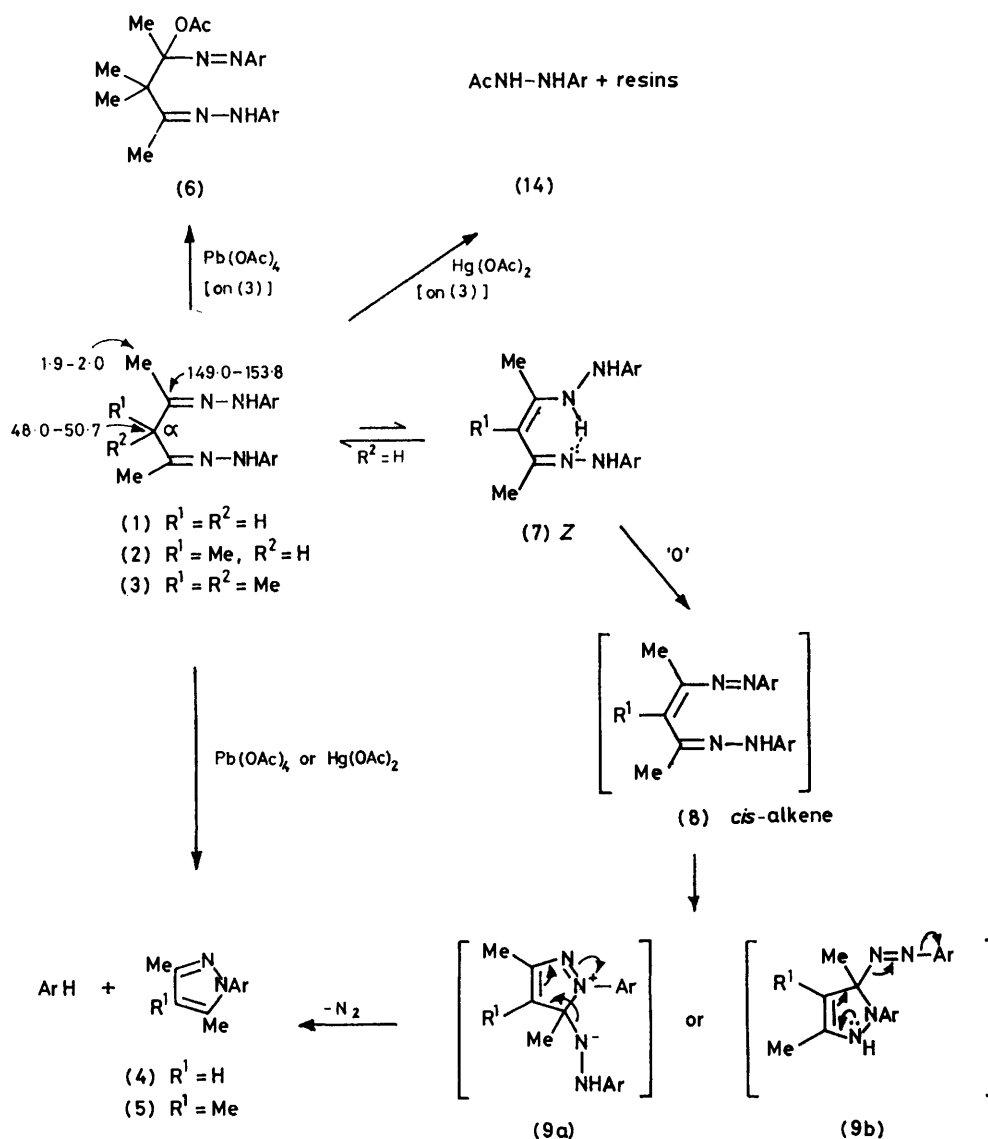


## Reactions of Mercury(II) Acetate with Nitrogen Compounds. Part 9.1 Oxidations of the Bis-(4-nitrophenylhydrazone)s of Some 1,3-Diketones with Mercury(II) Acetate and Lead(IV) Acetate

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Oxidation of bis-(4-nitrophenylhydrazones) of 1,3-diketones containing an  $\alpha$ -CH between the hydrazone chains resulted in cyclisation with fragmentation, giving pyrazoles. The reaction is considered to involve dehydrogenation of the conjugated tautomeric enamine form of the bis-hydrazone, giving a *cis*-azo-hydrazone-alkene intermediate. When the postulated azo-hydrazone-alkene intermediate had *trans*-stereochemistry, unfavourable for cyclisation, as in the oxidation of cyclohexa-1,3-dione bis-(4-nitrophenylhydrazone), the azo-alkene was stable and was the main product. When the conjugated enamine tautomeric form of the 1,3-bis-hydrazone could not exist, as with 3,3-dimethylpentane-2,4-dione bis-(4-nitrophenylhydrazone), pyrazoles were not formed and the hydrazone chains behaved as isolated monohydrazones.

OUR studies of the behaviour of 1,2-bis-hydrazones ( $RC=N-NH-X$ )<sub>2</sub> in oxidation reactions with Pb<sup>IV</sup> and Hg<sup>II</sup> acetates showed that the reactions depend on the stereochemistry of the substrate and the nature of the amino-substituent X.<sup>2,3</sup> When X was a good leaving group, fragmentation of one of the hydrazone chains to a



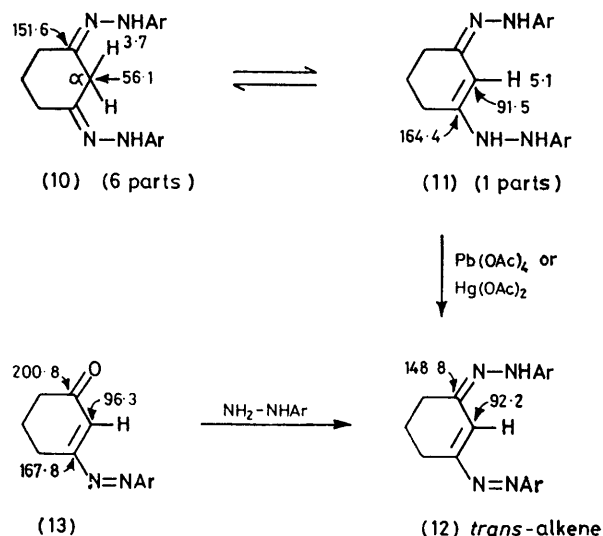
SCHEME 1 Ar = 4-NO<sub>2</sub>C<sub>6</sub>H<sub>4</sub>; <sup>1</sup>H and <sup>13</sup>C δ values are given in p.p.m. for selected atoms

diazo-species gave rise to 1-substituted amino-1,2,3-triazoles.<sup>2,3</sup> When X was a poor leaving group, the oxidation involved dehydrogenations to bis-azo-ethylenes, and these could cyclise subsequently to 1,2,3-triazoles if the stereochemistry was appropriate.<sup>4</sup> We were interested in the effect of the distance between the hydrazone chains on the oxidations of bis-hydrazone systems and accordingly have examined the reactions of some 1,3-bis-hydrazones.

When the bis-(4-nitrophenylhydrazone) of pentane-2,4-dione (1) and 3-methylpentane-2,4-dione (2) were treated with lead tetra-acetate or mercury(II) acetate at 25–30 °C in acetic acid, the corresponding known<sup>5</sup> pyrazoles (4) and (5) were formed in high yields (*ca.* 90%). Each substrate [(1) or (2)] contains an enolizable  $\alpha$ -hydrogen atom (Scheme 1). Oxidation of the 1,3-bis-hydrazone (3), containing two  $\alpha$ -methyl groups, with  $\text{Pb}(\text{OAc})_4$  gave the purple azo-acetate (6) in 60% yield along with some decomposition products. In this case, with no central  $\alpha$ -hydrogen atom present, the hydrazone chains cannot become conjugated *via* an enamine form, and therefore behave independently. An azo-acetate is the normal product<sup>6</sup> of oxidation of an unconjugated monohydrazone moiety with  $\text{Pb}(\text{OAc})_4$ . Treatment of compound (3) with  $\text{Hg}(\text{OAc})_2$  under reflux in acetic acid gave only intractable resins and *N*-acetyl-*N'*-4-nitrophenylhydrazine (14), in a different reaction. Although the enamine form (7) could not be detected in  $^1\text{H}$  and  $^{13}\text{C}$  n.m.r. spectra of compounds (1) and (2), this form is likely to exist in low equilibrium concentrations. There are a number of possible forms for the enamine structure resulting from geometrical isomerism of the alkene and imine bonds, but the extra stability arising from favoured intramolecular hydrogen bonding<sup>4</sup> should ensure the presence of the *Z*-form (7). A dehydrogenation of this to the *cis*-azo-hydrazone-alkene intermediate (8) would allow cyclisation to the pyrazole (4) or (5) *via* a 6 $\pi$ -heteroelectrocyclisation<sup>7</sup> or a 5-exo-trig<sup>8</sup> type reaction [see (9a) and (9b) in Scheme 1].

This sequence of enamine formation and oxidative dehydrogenation to a conjugated azo-alkene was readily observed with a substrate where the alkene was *trans* and therefore cyclisation was not favoured. The bis-(4-nitrophenylhydrazone) of cyclohexane-1,3-dione (10) exists as an equilibrium mixture of the bis-hydrazone form (10) and the enamine form (11) in the ratio 6 : 1; both are readily detected by  $^1\text{H}$  and  $^{13}\text{C}$  n.m.r. spectra (Scheme 2). Monophenylhydrazones of cyclohexane-1,3-dione exist exclusively in the enamine form.<sup>9</sup> Oxidation of compound (10) with either  $\text{Pb}(\text{OAc})_4$  or  $\text{Hg}(\text{OAc})_2$  resulted in dehydrogenation to the *trans*-conjugated alkene (12), which was isolated in 87–90% yield. The structure of this compound was confirmed by its spectra and by comparison with material synthesised from the conjugated azo-vinyl ketone (13) by coupling with 4-nitrophenylhydrazine (Scheme 2). The oxidation of compound (10) to (12) supports the route to the pyrazoles suggested in Scheme 1. The similarity in the reactions with the two oxidants suggests that the 1,3-bis-hydra-

zones are being oxidised through a highly reactive form since  $\text{Pb}(\text{OAc})_4$  and  $\text{Hg}(\text{OAc})_2$  usually behave quite differently towards normal hydrazone substrates.<sup>1</sup> This is further supported by the fact that compound (3), which cannot give a conjugated enamine form, did not react with the weaker oxidising agent  $\text{Hg}(\text{OAc})_2$  at room temperature, and when it was heated under reflux only decomposition products were encountered.



SCHEME 2 Ar = 4- $\text{NO}_2\text{C}_6\text{H}_4$ ;  $^1\text{H}$  and  $^{13}\text{C}$   $\delta$  values are given in p.p.m. for selected atoms

In these oxidations with  $\text{Hg}^{\text{II}}$  and  $\text{Pb}^{\text{IV}}$  the behaviour of the 1,3-bis-hydrazone system differs from that observed in recently reported<sup>10</sup> oxidations with  $\text{SeO}_2$  and  $\text{TeO}_2$  where fused seleno- and telluro-azapentalenes were the products, probably arising from reaction *via* the *E*-form of structure (7).

#### EXPERIMENTAL

M.p.s were measured with an Electrothermal apparatus. I.r. spectra were measured for KBr discs or mulls with Perkin-Elmer 377 and 457 spectrophotometers. N.m.r. spectra ( $^1\text{H}$  and  $^{13}\text{C}$ ) were measured for solutions in  $(\text{CD}_3)_2\text{SO}$  with JEOL JNM-MH-100 and FX-60 spectrometers. 3-Methyl- and 3,3-dimethyl-pentane-2,4-dione were prepared by a modification of a literature<sup>11</sup> alkylation of pentane-2,4-dione. Thus pentane-2,4-dione (25 g) was added to a slurry of sodium hydride (6 g) and dimethyl sulphoxide (150 ml), and after 30 min the solution was treated with methyl iodide (40 g). After a further 30 min the mixture was treated with more NaH (6 g), and more MeI (40 g) was added 15 min later. The mixture was stirred for 12 h, then extracted with ether (150 ml), and the insoluble salts were leached with ether ( $2 \times 75$  ml). The combined ethereal solution was washed with water, dried, and distilled. The fraction of b.p. 165–172 °C was a 4 : 1 mixture of the dimethyl- and monomethyl-pentane-2,4-diones, which was separated by mixing with *m*-NaOH (40 ml) and subsequent extraction of the dimethyl compound (43%) with ether. The monomethyl compound (16%) was obtained by acidification of the sodium hydroxide solution and subsequent extraction with ether.

The bis-hydrazones were prepared by slowly adding the diketone (*ca.* 1 g) to a solution of 4-nitrophenylhydrazine (2 mol equiv.) in absolute ethanol at ambient temperature followed by brief (10–20 min) heating under reflux. The bis-hydrazone separated as yellow crystals from the hot solution. The bis-(4-nitrophenylhydrazone) of pentane-2,4-dione (1) had m.p. 205–207°; that of 3-methylpentane-2,4-dione (2) at m.p. 218 °C; that of 3,3-dimethylpentane-2,4-dione (3) had m.p. 221–223 °C; that of cyclohexane-1,3-dione (10) had m.p. 196–198 °C. All the compounds gave satisfactory microanalytical figures and showed the expected <sup>1</sup>H and <sup>13</sup>C n.m.r. signals (Schemes 1 and 2).

**Oxidation Reactions.**—The following are typical examples.

(a) Pentane-2,4-dione bis-(4-nitrophenylhydrazone) (1) (500 mg) in acetic acid (25 ml) containing acetic anhydride (0.25 ml) was treated with Pb(OAc)<sub>4</sub> (650 mg) and stirred at 25–30 °C for 4 h. The orange-red solution was treated with water (50 ml), filtered, and extracted with ether (2 × 75 ml). The combined extracts contained 1-(4-nitrophenyl)-3,5-dimethylpyrazole (4) (90%), m.p. 100–101° (lit.,<sup>5</sup> 100–101°). Similar results were obtained by using a mixture of dichloromethane (50 ml) and triethylamine (2 ml) as solvent, and also by using Hg(OAc)<sub>2</sub> in acetic acid as oxidant in a reaction of 40 h duration, after which the pyrazole was extracted into light petroleum (b.p. 40–60 °C).

Similar oxidations of the bis-(4-nitrophenylhydrazone) of 3-methylpentane-2,4-dione (2) gave 1-(4-nitrophenyl)-3,4,5-trimethylpyrazole (5) (85%), m.p. 112–114° (from absolute ethanol) (lit.,<sup>5</sup> 116°). The pyrazoles were identified by comparison (<sup>1</sup>H n.m.r. and i.r. spectra, mixed m.p.) with authentic samples.

(b) 3,3-Dimethylpentane-2,4-dione bis-(4-nitrophenylhydrazone) (3) (500 mg) in dichloromethane (50 ml) was treated with Pb(OAc)<sub>4</sub> (570 mg) and stirred at ambient temperature for 40 h. Insoluble salts were removed; evaporation left a gummy residue from which 4-acetoxy-4-(4-nitrophenylazo)-3,3-dimethylpentan-2-one 4-nitrophenylhydrazone (6), m.p. 116–118° (from CHCl<sub>3</sub>) was obtained by extraction with chloroform (yield 350 mg, 60%) (Found: C, 55.5; H, 5.1; N, 18.8. C<sub>21</sub>H<sub>24</sub>N<sub>6</sub>O<sub>6</sub> requires C, 55.25; H, 5.25; N, 18.4%);  $\nu_{\max}$  3 320 (N–H), 1 720 (ester C=O) and 1 100 cm<sup>-1</sup> (–C–O–C);  $\lambda_{\max}$  260 nm (log  $\epsilon$  4.164) (Ar–N=N–);  $\delta$ (CDCl<sub>3</sub>) 1.0 (s, 3 H, MeC), 1.2 (s, 6 H, Me<sub>2</sub>C), 1.7 (s, 3 H, MeC=N), 2.0 (s, 3 H, OAc), 7.40 and 8.0 (A<sub>2</sub>B<sub>2</sub>, –N=N–Ar,  $J_{AB}$  8 Hz), and 6.8 and 7.8 (A<sub>2</sub>B<sub>2</sub>, –NH–Ar,  $J_{AB}$  8 Hz). A similar reaction in acetic acid gave the same product in 57% yield along with intractable resins. When the bis-hydrazone (3) was treated with Hg(OAc)<sub>2</sub> in acetic acid for

prolonged periods at room temperature, it was recovered unchanged; when this reaction was carried out at reflux temperature for 2 h intractable resins and the hydrazine (14) were encountered.

(c) A solution of cyclohexane-1,3-dione bis-(4-nitrophenylhydrazone) (10) in acetic acid (25 ml) containing acetic anhydride (0.25 ml) was treated with Pb(OAc)<sub>4</sub> (640 mg) and stirred at ambient temperature for 30 h. The dark purple product, 3-(4-nitrophenylazo)cyclohex-2-enone (4-nitrophenylhydrazone) (12) (87%), m.p. 230–232 °C (from dimethyl sulphoxide–water), was filtered off (Found: C, 56.8; H, 4.2; N, 22.1. C<sub>18</sub>H<sub>16</sub>N<sub>2</sub>O<sub>4</sub> requires C, 56.85; H, 4.4; N, 21.8%);  $\nu_{\max}$  3 300 (NH) and 1 600 cm<sup>-1</sup> (C=N);  $\lambda_{\max}$  483 (log  $\epsilon$  4.5) and 320 nm (3.97);  $\delta$  7.0–7.3 (overlapping A<sub>2</sub>B<sub>2</sub>, 8 H, two Ar,  $J_{AB}$  8 Hz) and 10.2 (br, NH) (some <sup>13</sup>C shifts are given in Scheme 2). The compound was also obtained by coupling the ketone (13)<sup>9</sup> with 1 mol equiv. of 4-nitrophenylhydrazine and from a comparable oxidation of compound (10) with Hg(OAc)<sub>2</sub>.

When the bis-hydrazone substrates were treated under conditions identical with those of the oxidation reactions described but with the oxidant Pb(OAc)<sub>4</sub> or Hg(OAc)<sub>2</sub> absent, they were recovered in high yields, and no pyrazoles or azo-compounds were formed.

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