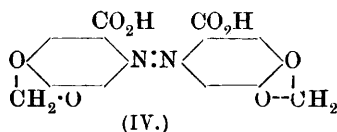
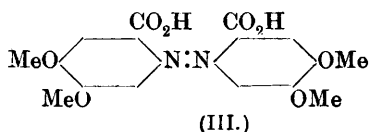
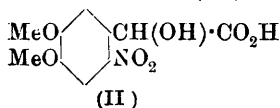
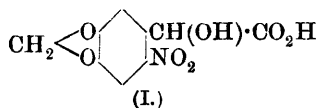


CXC.—*A Decomposition of Certain o-Nitromandelic Acids.*

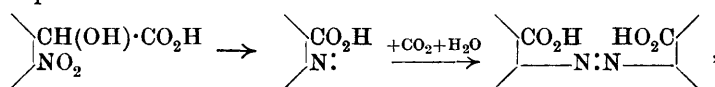
By GERTRUDE MAUD ROBINSON and ROBERT ROBINSON.

In a previous communication (T., 1914, **105**, 1466) the authors described a convenient procedure for the preparation of 6-nitro-3:4-methylenedioxymandelic acid (I), and noted that this substance, on boiling with nitrobenzene, suffered decomposition, with loss of carbon dioxide, water, and nitrogen, and the production of a chocolate-coloured compound, which crystallised from the nitrobenzene and appeared to possess the composition  $C_{32}H_{20}O_{16}N_2$ . This formula was deduced from a number of concordant analyses of different specimens, but as we were unable to assign a structure to the substance, it was considered desirable to institute further experiments, and, in the first place, the analogous decomposition of 6-nitro-3:4-dimethoxymandelic acid (II, p. 1755) by heat was investigated. On boiling the nitrobenzene solution of this acid, a vigorous reaction ensued, and again water and carbon dioxide (but no nitrogen) were produced, along with a bright red, crystalline substance, the investigation of which proved it to be 4:5:4':5'-tetramethoxyazobenzene-2:2'-dicarboxylic acid (III).

Ultimately a method was devised by the use of which we were able to isolate from the chocolate-coloured mixture, already mentioned, a brick-red acid, which consists of pure 4:5:4':5'-dimethylenetetraoxyazobenzene-2:2'-dicarboxylic acid (IV).



The reactions involved in the production of these azo-acids may be represented as follows:

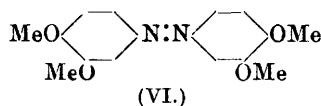
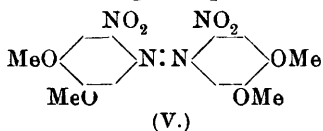


and the facility with which the process may be accomplished is doubtless due to the fact that the nitro-group supplies precisely the correct amount of oxygen to oxidise the side-chain to carboxyl.

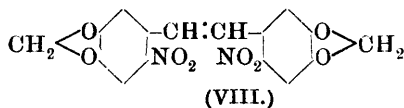
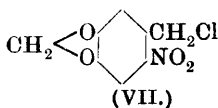
When the acid III (IV behaves similarly) is allowed to react

with concentrated nitric acid, the carboxyl groups are displaced by nitro-groups, with the production of the neutral 2:2'-dinitro-4:5:4':5'-tetramethoxyazobenzene (V), and the latter, in its turn, on reduction in acid solution, furnishes 4:5-diaminoveratrole, isolated in the form of its condensation product with phenanthraquinone. In a quantitative experiment, the dimethoxyphenanthraquinone of correct melting point was obtained in a yield of 65 per cent. of the theoretical amount, calculated on the assumption that each molecule of the supposed dinitroazo-compound gives rise to two molecules of the azine derivative. Taken in conjunction with the analytical data, these facts demonstrate the constitution of the original acid III.

On nitration in acetic acid solution, azoveratrole (VI) yields a dinitro-derivative, which is changed by reduction processes into 4:5-diaminoveratrole only, and to which, therefore, the formula V must be ascribed. This dinitroazoveratrole should accordingly be identical with the product of nitration of the acid III, and, so far as our observations go, the two substances are identical in every respect except colour, specimens obtained from the acid crystallising from nitrobenzene in deep red needles, whilst, when obtained from azoveratrole, the compound separates from the same solvent in orange needles. The streaks on paper are distinct and the separate colours are preserved after the two substances are dissolved in sulphuric acid, recovered by dilution with water, and recrystallised. In view of the fact, however, that the two specimens melt alone, or when intimately mixed, at the same temperature, we regard them as consisting of the same substance, and the anomalous colour of one of them as due to a small proportion of a probably isomorphous impurity. There is a possibility of *cis-trans*-isomerism, but, in this case, such isomerides would become identical in sulphuric acid solution, owing to one of the catechol nuclei assuming the quinonoid or other more labile condition.



6-Nitrohomopiperonyl chloride (VII) is changed in boiling nitrobenzene to the azo-acid (IV) and hydrogen chloride, whilst, with alcoholic potassium hydroxide, it is changed to the stilbene derivative VIII.



## EXPERIMENTAL.

*6-Nitro-3:4-dimethoxymandelic Acid (II).*

6-Nitroveratraldehyde (44 grams) was mixed with acetic acid (350 c.c.), and powdered potassium cyanide (50 grams) gradually added, with careful cooling. The mixture was allowed to remain at the room temperature during three days, in the course of which the aldehyde passed into solution and the cyanohydrin separated in colourless prisms. Water was added, the pale yellow, crystalline precipitate collected and heated on the steam-bath with concentrated hydrochloric acid (200 c.c.) until complete solution resulted. After the addition of two volumes of water, the cooled liquid deposited green crystals, which, after drying in the air in the dark, weighed 36 grams. For purposes of analysis, a specimen was recrystallised several times from water and obtained in pale yellow needles, melting and decomposing at 169—172°:

0.1205 gave 0.2067  $\text{CO}_2$  and 0.0443  $\text{H}_2\text{O}$ .  $\text{C}=46.8$ ;  $\text{H}=4.1$ .

$\text{C}_{10}\text{H}_{11}\text{O}_7\text{N}$  requires  $\text{C}=46.7$ ;  $\text{H}=4.3$  per cent.

The acid is sparingly soluble in benzene, chloroform, ether, or ethyl acetate, but dissolves more readily in acetic acid, alcohol, or water.

*4:5:4':5'-Tetramethoxyazobenzene-2:2'-dicarboxylic Acid (III).*

A mixture of the foregoing nitrodimethoxymandelic acid (10 grams) and nitrobenzene (50 c.c.) was heated until the vigorous reaction commenced, and this was then allowed to proceed without further heating. The crystalline product separated while the liquid was hot, and a semi-solid mass resulted. The product was collected, washed with alcohol, and boiled with a relatively large volume of acetic acid. The greater portion of the substance remained undissolved, and was sufficiently pure for most experiments, but the filtered solution deposited, on cooling, glistening leaflets resembling hæmatite in lustre and colour. These were collected, washed, and dried at 100°:

0.1244 gave 0.2540  $\text{CO}_2$  and 0.0528  $\text{H}_2\text{O}$ .  $\text{C}=55.7$ ;  $\text{H}=4.7$ .

0.1295 „ 9.0 c.c.  $\text{N}_2$  at 25° and 758 mm.  $\text{N}=7.6$ .

$\text{C}_{18}\text{H}_{18}\text{O}_8\text{N}_2$  requires  $\text{C}=55.4$ ;  $\text{H}=4.6$ ;  $\text{N}=7.2$  per cent.

0.2679 Dissolved in 30 c.c. of  $N/10$ -sodium hydroxide required the addition of 17.4 c.c. of  $N/10$ -hydrochloric acid to produce a permanent precipitate. This was redissolved by the addition of 1.1 c.c. of  $N/10$ -sodium hydroxide, so that 0.0548  $\text{NaOH}$  was required for neutralisation. This amount of a dibasic acid,  $\text{C}_{18}\text{H}_{18}\text{O}_8\text{N}_2$ , requires 0.0550  $\text{NaOH}$  for neutralisation.

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The substance melts and decomposes at  $274^{\circ}$ , and dissolves readily in aqueous sodium carbonate to a brownish-yellow solution. It is very sparingly soluble in organic solvents, with the exception of hot nitrobenzene. The smallest visible amount of the compound dissolved in concentrated sulphuric acid yields a fine royal blue solution.

*Azoveratrole (VI).*

This substance was prepared by a modification of Kauffmann and Kugel's method (*Ber.*, 1911, **44**, 2388), who state that the substance melts at  $163^{\circ}$ . In our experience, the product of approximately this melting point is contaminated with nitroveratrole, and does not give satisfactory figures on analysis. The compound was obtained in a pure condition by recrystallisation from ethyl acetate, and occurs as glistening orange prisms, melting at  $182^{\circ}$ :

0.1251 gave 0.2897  $\text{CO}_2$  and 0.0667  $\text{H}_2\text{O}$ .  $\text{C}=63.2$ ;  $\text{H}=5.9$ .

$\text{C}_{16}\text{H}_{18}\text{O}_4\text{N}_2$  requires  $\text{C}=63.6$ ;  $\text{H}=5.9$  per cent.

*2:2'-Dinitro-4:5:4':5'-tetramethoxyazobenzene (V).*

A. Azoveratrole (5 grams) in acetic acid (50 c.c.) was nitrated by the addition of nitric acid (15 c.c., D 1.42) dissolved in acetic acid (50 c.c.), the mixture being cooled if necessary. The magenta solution at first produced soon disappeared, and a greenish-yellow, crystalline precipitate was obtained. This was collected and washed with alcohol, which changed its colour to orange, and after drying it was recrystallised from nitrobenzene, separating in orange needles, melting at  $283^{\circ}$ . Further crystallisation raised the melting point to  $315^{\circ}$ , the substance also decomposing at this temperature:

0.1228 gave 0.2214  $\text{CO}_2$  and 0.0484  $\text{H}_2\text{O}$ .  $\text{C}=49.2$ ;  $\text{H}=4.3$ .

$\text{C}_{16}\text{H}_{16}\text{O}_8\text{N}_4$  requires  $\text{C}=49.0$ ;  $\text{H}=4.1$  per cent.

B. 4:5:4':5'-Tetramethoxyazobenzene-2:2'-dicarboxylic acid was triturated with ten times its weight of nitric acid (D 1.45). The purple colour at first produced gradually faded, the acid disappeared, and a red substance separated. After leaving overnight, water was added, and the precipitate collected, washed with a solution of sodium carbonate, then water, dried at  $100^{\circ}$ , and crystallised from nitrobenzene.

The brilliant red needles resemble a good specimen of sublimed alizarin, and melt and decompose at  $315^{\circ}$ :

0.1065 gave 0.1906  $\text{CO}_2$  and 0.0393  $\text{H}_2\text{O}$ .  $\text{C}=49.0$ ;  $\text{H}=4.1$ .

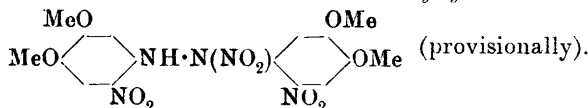
The substances obtained as under A and B differ only in regard to colour. They dissolve in sulphuric acid to the same intense

blue solution, and a mixture of them melts and decomposes at  $315^{\circ}$ . So far as a superficial examination is able to show, the two specimens have the same crystalline form and behave similarly under the polarising microscope. The reduction experiment which follows immediately was made with both the orange and red crystals with almost identical results.

*2:3-Dimethoxyphenanthraphenazine from 2:2'-Dinitro-  
4:5:4':5'-tetramethoxyazobenzene.*

One gram of the finely powdered orange crystals obtained by the direct nitration of azoveratrole was mixed with crystallised stannous chloride (5 grams), metallic tin (5 grams), and concentrated hydrochloric acid (15 c.c.). After shaking for a few days reduction was complete, and a colourless solution resulted, which was diluted to 150 c.c. with water, and the tin eliminated by means of hydrogen sulphide, after which the excess of hydrogen sulphide was exactly removed by the addition of just sufficient of a saturated solution of lead acetate. The filtered liquid was mixed with sodium acetate (50 grams) and a solution of phenanthraquinone (2 grams) in water (50 c.c.) and sodium hydrogen sulphite (10 grams). The mixture was heated on the steam-bath, when a gelatinous precipitate filled the liquid, and the heating was then continued until the jelly had become crystalline. The substance was collected, washed, dried, and crystallised from a mixture of nitrobenzene and alcohol, when 1.15 grams of the substance were obtained, a yield of 66 per cent. of the theoretical. The red crystals (1.0 gram) in the same process gave rise to 1.06 grams of the condensation product, a divergence from the previous result which is considered to be well within the experimental error. The two quantities of the phenanthraphenazine were fractionally crystallised from xylene, and found to be homogeneous. The substance melts at  $259-261^{\circ}$ , and at the same temperature when mixed with 2:3-dimethoxyphenanthraphenazine obtained as described by Moureu (*Compt. rend.*, 1896, **123**, 33) from 4:5-diaminoveratrole. This azine dissolves in sulphuric acid to a rich magenta solution. Moureu describes the solution as having a violet colour, and states that the substance melts at  $255^{\circ}$ . In benzene or alcohol solution the derivative exhibits intense violet fluorescence.

N-2:2'-Trinitro-4:5:4':5'-tetramethoxyhydrazobenzene,



This compound was obtained by nitrating azoveratrole under the following conditions:

Nitric acid (D 1.52; 40 c.c.) was added to azoveratrole (3 grams) suspended in acetic acid (10 c.c.). The greenish-yellow precipitate at first produced afterwards redissolved to a red solution, and on the addition of water a yellow substance separated, which was collected and crystallised from acetic acid. The reaction was accompanied by copious evolution of nitrous fumes.

The substance is sparingly soluble in most solvents, and was obtained in yellow needles, which melt at 228°:

0.1097 gave 0.1752 CO<sub>2</sub> and 0.0397 H<sub>2</sub>O. C=43.5; H=4.0.

0.1103 „ 15.2 c.c. N<sub>2</sub> at 16° and 767 mm. N=16.1.

C<sub>16</sub>H<sub>17</sub>O<sub>10</sub>N<sub>5</sub> requires C=43.7; H=3.9; N=15.9 per cent.

The substance does not readily dissolve in sulphuric acid in the cold; on gently warming, however, an olive green solution, rapidly changing to intense blue, is produced. On reduction by means of zinc in alcoholic hydrochloric acid suspension, 4:5-diamino-veratrole is formed, and was easily recognised by the formation of 2:3-dimethoxyphenanthraphenazine, melting at 259°. This reaction is opposed to the idea that this peculiar compound is merely trinitroazoveratrole. The phenanthraphenazine is entirely free from any diazotisable amine, which we have found is not the case in the azine prepared from the reduction products of a mixture of dinitro- and trinitro-veratrole. Furthermore, the addition of potassium nitrate to the blue solution of dinitroazoveratrole in sulphuric acid produces a characteristic red colour. Water precipitates a substance which is evidently a tri- or tetra-nitroazoveratrole; this dissolves in sulphuric acid to a red solution, and is quite different from the product which is the subject of this section.

#### *6-Nitrohomopiperonyl Chloride (VII).*

A solution of homopiperonyl alcohol (20 grams) in acetic acid (100 c.c.) was saturated at 0° with hydrogen chloride, and then gradually treated with nitric acid (30 c.c.; D 1.42), the whole being well cooled. After fifteen minutes, the mixture was added to water; the precipitated oil quickly solidified, and was collected and crystallised from methyl alcohol, from which it separated in pale salmon-coloured leaflets, melting at 86°. Ten recrystallisations

did not remove the salmon tint, but pale yellow crystals were obtained by the recrystallisation of the substance produced from the first methyl alcohol mother liquor:

0.1290 gave 0.0867 AgCl. Cl=16.5.

$C_8H_6O_4NCl$  requires Cl=16.4 per cent.

The substance is rather readily soluble in organic solvents, and resembles *o*-nitrobenzyl chloride in powerfully irritating the skin and in causing a sensation of burning. Nevertheless, the chlorine atom in this compound is more firmly bound than in the parent homopiperonyl chloride, since the nitro-derivative is comparatively stable in the presence of water and under conditions which, if applied to homopiperonyl chloride, would cause its hydrolysis.

When the solution of the nitro-chloride in nitrobenzene was boiled it became orange, then brown, and hydrogen chloride was evolved. On cooling, the azo-acid (IV) separated as a chocolate-brown, crystalline precipitate, and was purified and identified as described below. The melting point of the acid so obtained was 265—270° (decomp.), but the yield by this process was unsatisfactory.

*2:2'-Dinitro-4:5:4':5'-dimethylenetetraoxystilbene* (VIII).

This compound was obtained by the action of cold methyl-alcoholic potassium hydroxide on 6-nitrohomopiperonyl chloride. After the addition of water, the yellow precipitate was collected, washed, dried, and crystallised from nitrobenzene. On warming with the solvent, the yellow substance became orange, and the crystals obtained were brownish-red needles, very sparingly soluble in solvents. The compound darkens at 280°, but does not melt at 350°:

0.1136 gave 0.2258 CO<sub>2</sub> and 0.0335 H<sub>2</sub>O. C=54.2; H=3.3.

$C_{16}H_{10}O_8N_2$  requires C=53.6; H=2.8 per cent.

*4:5:4':5'-Dimethylenetetraoxyazobenzene-2:2'-dicarboxylic Acid* (IV).

The method employed for the decomposition of 6-nitro-3:4-methylenedioxymandelic acid \* was the same as that described

\* The following experiment made by Mr. D. A. Pritchard shows that this substance may be resolved although it is not claimed that the resolution is complete:—

The acid (15 grams) was suspended in water (600 c.c.) and nearly neutralised by the addition of *N*-potassium hydroxide solution (60 c.c.). The filtered liquid was mixed with sufficient of an aqueous solution of brucine hydrochloride (10 grams in 100 c.c.) to cause a slight milkiness and then allowed to remain overnight in the ice-chest. A crystalline crust separated, and the

above for the corresponding dimethoxy-derivative. In contradistinction from the latter case, however, nitrogen was now evolved, and in one experiment 0.58 of the acid gave 1.8 c.c.  $N_2$  at  $17^\circ$  and 764 mm., the yield of the chocolate-coloured reaction product being 0.31. Analyses made on this substance and on the same product after crystallisation from nitrobenzene gave:

C=55.0, 55.4; H=3.1, 2.9; N=4.4, 4.3.

$C_{32}H_{20}O_{16}N_2$  requires C=55.8; H=2.9; N=4.1 per cent.

On treatment with nitric acid as described for the pure compound in the next section, a scarlet substance was obtained and crystallised from much acetic acid.

Found, C=49.0, 49.2; H=2.7, 2.6; N=9.9, 9.7.

Bearing in mind the evolution of nitrogen, these figures indicate the nature of the impurity present in some quantity in the chocolate-coloured specimens, since  $C_{32}H_{20}O_{16}N_2 = C_{16}H_{10}O_8N_2$  (formula of the azo-acid) +  $C_{16}H_{10}O_8$ . A compound of the formula  $C_{16}H_{10}O_8$  would be the diphenic acid of the piper series, possibly produced by loss of nitrogen from the azobenzenedicarboxylic acid. The neutral nitro-derivatives produced by displacement of the carboxyl by nitro-groups corresponding with  $C_{16}H_{10}O_8N_2$  and  $C_{16}H_{10}O_8$  are  $C_{14}H_8O_8N_4$  and  $C_{14}H_8O_8N_2$  respectively. A mixture of 25 per cent. of the former and 75 per cent. of the latter requires C=49.6; H=2.4; N=10.2, in approximate agreement with the analyses quoted above.

We have been able to isolate in a pure condition only the azo-constituents of these mixtures, and to this end have employed the following process. Ten grams of the dried substance were dissolved, as far as possible, in sodium carbonate solution (10 grams in 500 c.c. of water). The small, dark brown residue is doubtless responsible for the chocolate colour of the crude product. The filtered solution was evaporated to 50 c.c., and then allowed to cool and crystallise. The glistening, yellow leaflets of the sodium salt were collected, thoroughly drained, and dried in the air, and then dissolved in a litre of boiling alcohol containing 20 c.c. of water. The liquid was filtered and acidified while hot with boiling dilute alcoholic acetic acid. A brick-red, microcrystalline precipitate separated in a few seconds, and was collected, washed, and

rest of the brucine solution was cautiously added during a fortnight, the mixture being kept all the time in the ice-chest. The brucine salt was collected and decomposed with dilute hydrochloric acid in the presence of ether, the ethereal solution separated, dried with anhydrous sodium sulphate, and evaporated. The residue was crystallised from dilute hydrochloric acid with the aid of a little animal charcoal. The substance was so obtained in colourless needles melting at  $180^\circ$  with slight previous decomposition.

1.0285 made up to 25 c.c. with acetic acid gave  $\alpha - 2.61$ , whence  $(\alpha)_D - 63.4$ .



dried at 100°. The crystals formed opaque masses of needles, and melted and decomposed at 270°:

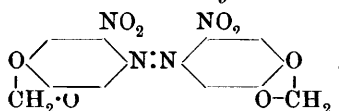
0.1047 gave 0.2061 CO<sub>2</sub> and 0.0287 H<sub>2</sub>O. C=53.7; H=3.0.

0.1211 „ 8.4 c.c. N<sub>2</sub> at 18° and 764 mm. N=8.0.

C<sub>16</sub>H<sub>10</sub>O<sub>8</sub>N<sub>2</sub> requires C=53.6; H=2.8; N=7.8 per cent.

This acid dissolves in sulphuric acid to a pure blue solution, which is opaque unless a mere trace is employed. Its sodium salt is readily soluble in water, and yields insoluble precipitates with salts of the heavy metals. Most of these are yellow, but the copper salt is ochre-brown.

*2:2'-Dinitro-4:5:4':5'-dimethylenetetraoxyazobenzene,*



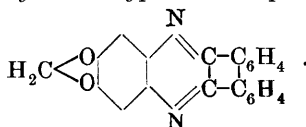
The pure acid, obtained as described in the last section, was ground in a mortar with an excess of nitric acid (D 1.45), when the original purple liquid soon lost its colour and a dark red precipitate was obtained. After the addition of water, the substance was collected, washed with alkali, dried, and crystallised from nitrobenzene, the only solvent in which the substance is at all readily soluble. Crimson needles were obtained, which darken at 295° and melt and decompose suddenly at 305°:

0.1163 gave 0.1996 CO<sub>2</sub> and 0.0248 H<sub>2</sub>O. C=46.8; H=2.4.

C<sub>14</sub>H<sub>8</sub>O<sub>8</sub>N<sub>4</sub> requires C=46.7; H=2.2 per cent.

This substance dissolves in sulphuric acid to produce the usual intense blue solution.

*2:3-Methylenedioxyphenanthrazine,*



This phenazine derivative was obtained from dinitrodimethylenetetraoxyazobenzene by an application of the process already described in connexion with the corresponding veratrole derivative (see p. 1756). It was also obtained from 4:5-dinitromethylenedioxybenzene by a similar method, and the substance so formed was found by the method of mixed melting points to be identical with that obtained from the azo-compound. The substance may

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be crystallised from xylene or acetic acid, and occurs as pale yellow needles, melting at  $305^{\circ}$ :

0.1154 gave 0.3301  $\text{CO}_2$  and 0.0412  $\text{H}_2\text{O}$ .  $\text{C}=78.0$ ;  $\text{H}=3.9$ .

$\text{C}_{21}\text{H}_{12}\text{O}_2\text{N}_2$  requires  $\text{C}=77.8$ ;  $\text{H}=3.7$  per cent.

The azine dissolves in sulphuric acid to a magenta solution, and its benzene solution exhibits a bluish-violet fluorescence.

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