CLV.—*The Action of Nitrogen Sulphide on Organic Substances. Part II.*

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FURTHER investigation of the action of nitrogen sulphide on anisaldehyde has confirmed our suspicion (this vol., p. 261) that tri-*p*-methoxyphenylcyanidine was a product of this condensation, being produced in somewhat larger proportion than we had previously supposed. Another product, anisamidine sulphate, which was contaminated with small quantities of ammonium sulphate, was separated by taking advantage of its solubility in hot water, and characterised by the preparation of the corresponding chloride, nitrate, and platinichloride. We were not, however, able to isolate pure anisamidine from its salts, for the base we obtained, although readily soluble in water and having the strongly basic properties characteristic of the amidines, had a melting point 6—7° higher than that given by Lossen, and, moreover, it gave unsatisfactory analytical data. But as its aqueous solution gave rise to anisamide and ammonia, the reaction occurring slowly in the cold and immediately on warming, this fact was sufficient proof that the substance under examination was actually anisamidine, although in an impure state. The unexpected and singular formation of an anisamidine salt when nitrogen sulphide acts on the aldehyde led to the supposition that such derivatives might be intermediate products in the formation of the cyanidines, since, on heating, the amidines lose ammonia and are converted into the corresponding polymerised nitriles, which in this case are cyanidines. Thus benzamidine begins to evolve ammonia at 115°, forming triphenylcyanidine,

$$3C_6H_5{\cdot}C(NH_2){:}NH = 3NH_3 + C_3N_3(C_6H_5)_3.$$

Consequently we again tried the action of nitrogen sulphide on benzaldehyde under varying conditions, but up to the present we have obtained no indication of the formation of a benzamidine salt. It seems, however, quite probable that the small amount of substance obtained in this reaction and described as being soluble in water and melting at 128° was benzamide (see this vol., p. 262). We have since found that it evolves ammonia on warming with caustic potash, the solution giving rise on acidification to a substance having the properties of benzoic acid. This amide may have been formed by the action of benzamidine on water :

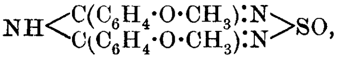
$$C_6H_5{\cdot}C(NH_2){:}NH + H_2O = NH_3 + C_6H_5{\cdot}CO{\cdot}NH_2.$$

But if this suggestion is correct, the amount of benzamide obtained was so small that only very little benzamidine could have been formed in the reaction. Moreover, the amount of ammonia obtained as ammonium sulphate in the experiments with either benzaldehyde or anisaldehyde is much less than would be expected had the formation of the cyanidine derivatives proceeded on the lines indicated. We are as yet unable to explain the oxidation that obviously takes place in this reaction. Sulphur dioxide is evolved, but, both with benzaldehyde and anisaldehyde, ammonium sulphate is formed to a greater extent in the former than the latter. Moreover, in the case of anisaldehyde, anisamidine sulphate is also produced. It is hoped that further investigation will elucidate this point.

An insoluble, definitely crystalline compound containing both nitrogen and sulphur, which was also obtained by the interaction of nitrogen sulphide and anisaldehyde, was easily separated from the other products by its insolubility in the ordinary solvents; it is readily soluble and stable in dilute solutions of the alkalis, and although the resulting salts could not be obtained in a state of purity from their aqueous or alcoholic solutions, yet the original substance was precipitated unchanged on neutralisation with acids. On the other hand, strong acids easily decompose the substance, when the whole of the sulphur present is eliminated as sulphur dioxide, while a part of the nitrogen is removed as ammonia and a good yield of anisoylanisamidine obtained. The composition of the latter substance was ascertained by its transformation into dianisamide on warming with dilute acids :

$$CH_3{\cdot}O{\cdot}C_6H_4{\cdot}C(NH){\cdot}NH{\cdot}CO{\cdot}C_6H_4{\cdot}O{\cdot}CH_3 + H_2O = (CH_3{\cdot}O{\cdot}C_6H_4{\cdot}CO)_2NH + NH_3.$$

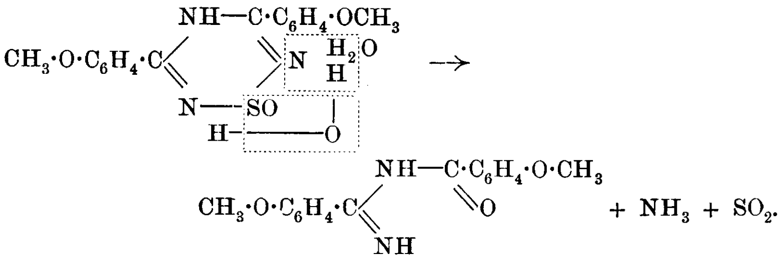
The formation of anisoylanisamidine suggested that, in all probability, the substance under investigation was an anisamidine derivative having the following constitution :



$$NH{<}\begin{matrix}C(C_6H_4{\cdot}O{\cdot}CH_3){:}N\\C(C_6H_4{\cdot}O{\cdot}CH_3){:}N\end{matrix}{>}SO,$$

I

and that the action of acids on it is represented by the equation :



The imidic hydrogen atom in the amidines can be replaced by silver, as, for instance, silver benzamidine, $C_6H_5{\cdot}C(NH_2){:}NAg$. If the constitution of the substance in question is correctly indicated by the foregoing formula, its formation might be accounted for in the following manner. Firstly, two molecules of anisamidine lose ammonia:

$$2CH_3{\cdot}O{\cdot}C_6H_4{\cdot}C(NH_2){:}NH = NH_3 + CH_3{\cdot}O{\cdot}C_6H_4{\cdot}C(NH){\cdot}NH{\cdot}C(NH){\cdot}C_6H_4{\cdot}O{\cdot}CH_3,$$

and secondly, the resulting substance forms a closed ring with sulphur dioxide, the sulphur becoming attached to the imidic nitrogen atom as indicated in formula I.

EXPERIMENTAL.

The action of nitrogen sulphide on anisaldehyde was carried out at 100°, as previously described. Sulphur dioxide was evolved, and a rather better yield was obtained by the addition of either benzene or toluene towards the end of the reaction, because, after heating for some time, the mass became semi-solid, and consequently the reaction was completed very slowly unless one of these solvents be employed. It was found that 20 grams of nitrogen sulphide and about 50 grams of anisaldehyde gave 10 grams of tri-*p*-methoxyphenylcyanidine, 12 grams of anisamidine sulphate, 11 grams of the insoluble sulphur derivative, very much smaller quantities of free sulphur, and about 1 gram of ammonium sulphate. These substances are easily separated; first, by repeatedly washing with boiling benzene, which extracts the cyanidine derivative together with free sulphur, then by extracting the insoluble residue with a large quantity of boiling water, which dissolves out the anisamidine sulphate and the ammonium salt, leaving behind the third chief product as a colourless, crystalline powder.

I. *Tri-*p*-methoxyphenylcyanidine.*—When the benzene solution is allowed to cool, this substance, contaminated with small quantities of sulphur, separates out in small, white plates; it is easily purified by several crystallisations from benzene, and, as previously described, melts at 217°, dissolves only sparingly in alcohol, and, like the majority of these cyanidine compounds, is stable at high temperatures; the following analytical data were obtained: C = 72·47; H = 5·56; whereas $C_3N_3(C_6H_4{\cdot}O{\cdot}CH_3)_3$ requires C = 72·18; H = 5·26 per cent. A molecular weight determination by the ebullioscopic method, using benzene as solvent, gave 422 and 437, the theoretical molecular weight being 399.

II. *Anisamidine Sulphate.*—When the aqueous solution of this salt is evaporated to about one-fourth of its bulk, large, well-formed, colourless prisms and pyramids separate out on cooling, leaving the ammonium sulphate in solution. This substance is insoluble in the ordinary organic solvents, is easily purified by recrystallisation from water, and melts above 270°; the following results were obtained on analysis: C = 48·50; H = 5·22; N = 14·4; H_2SO_4 = 24·59; whereas $[CH_3{\cdot}O{\cdot}C_6H_4{\cdot}C(NH_2){:}NH]_2,H_2SO_4$ requires C = 48·24; H = 5·52; N = 14·06; H_2SO_4 = 24·60 per cent.

On double decomposition with barium chloride, the corresponding hydrochloride was obtained; this, on recrystallisation from alcohol, melted at 217° (Lossen, *Annalen*, 1897, **297**, 385, gives the melting point as 220°). On analysis, it gave HCl = 19·0, whereas anisamidine hydrochloride, $CH_3O{\cdot}C_6H_4{\cdot}C(NH_2){:}NH,HCl$, requires HCl = 19·5 per cent.

The platinichloride, obtained by the addition of platinic chloride to an aqueous solution of the hydrochloride, crystallises well from water, and gave the following data on analysis: Pt = (I) 27·1 and (II) 27·3; $(C_8H_9ON_2)_2,H_2PtCl_6$ requires Pt = 27·4 per cent.

The nitrate obtained from the sulphate by double decomposition with barium nitrate crystallises in long needles fusing at 182—183°, whereas Lossen gives 181°.

The properties of anisamidine and its salts have been described by Tafel and Enoch (*Ber.*, 1890, **23**, 103) and by Lossen (*loc. cit.*). Briefly, it is a powerful base, having an alkaline reaction, but it is so easily decomposed by water that it is impossible to investigate its properties in solution. The sulphate, hydrochloride, and nitrate are neutral to litmus in aqueous solution. The molecular conductivity of solutions of the hydrochloride, determined by Mr. F. L. Usher, attain a maximum value at moderate dilutions, the salt behaving similarly to the chlorides of the alkali metals.

v litres	10	50	250	500	∞
μ	87·8	101·0	109·0	112·2	113·0

Tafel and Enoch do not give the melting point of the free base, but Lossen states that it is 112°. We made several attempts to isolate anisamidine from the sulphate by rapidly treating a well-cooled solution of the latter with caustic potash and extracting with ether, but only succeeded in obtaining a substance melting at 119°; this product, which crystallises well from benzene, is readily and completely soluble in water, giving an intensely alkaline solution. The aqueous solution slowly deposits crystals of anisamide, a reaction which takes place immediately on warming. The anisamide thus obtained melted at 165°, whereas it is usually stated to fuse at 163°, but an analysis left no doubt as to its identity: $C = 63{\cdot}26$; $H = 6{\cdot}06$; $N = 9{\cdot}80$; $CH_3{\cdot}O{\cdot}C_6H_4{\cdot}CO{\cdot}NH_2$ requiring $C = 63{\cdot}57$; $H = 5{\cdot}96$; $N = 9{\cdot}27$ per cent. Moreover, when heated with caustic alkalis and subsequently treated with acids, the amide gave anisic acid melting at 181° Although our product had the properties and characteristics of anisamidine, yet analysis showed that it was far from pure. Several attempts were made to prepare the pure base by using its hydrochloride, as Tafel had done, instead of the sulphate, but without success; the resulting substance either melted at about 119° and contained about 3 per cent. less nitrogen than is required for anisamidine, or was so contaminated with anisamide that further purification was impossible.

III. The insoluble crystalline powder left on dissolving out the anisamidine sulphate melted and decomposed at 200—205°, and is only freed with difficulty from the last traces of the cyanidine compound by washing with large quantities of boiling benzene. It is only very slightly soluble in the ordinary organic solvents, but may be recrystallised from hot nitrobenzene, when it is obtained in small, well-formed plates fusing sharply and decomposing at 205°, the melting point remaining constant on recrystallisation from amyl alcohol.

The substance is readily soluble in dilute aqueous caustic potash or soda, and is precipitated unchanged from these solutions by acids and even by carbon dioxide. If concentrated solutions are employed, the substance is at once converted on warming into an oil which is not affected by prolonged boiling, but at once passes into solution on the addition of sufficient water. In the case of caustic potash, if the oil is separated, it slowly sets to a solid mass soluble in alcohol, which contains 14·4 per cent. of potassium, but as the substance could not be recrystallised or otherwise purified, this analytical result merely serves to indicate that we are dealing with the potassium salt of the original substance. This salt is readily soluble in water, and, although a neutral solution could not be obtained, it gave white precipitates with silver nitrate and with lead acetate, and a light blue one with copper sulphate. The silver salt was readily soluble in ammonia and on boiling separated out in masses resembling cotton-wool; the lead salt showed no signs of darkening on prolonged boiling. These results led to the conclusion that, in all probability, the metal was not attached to sulphur. Powerful reducing agents such as hydriodic acid or phenylhydrazine liberate the sulphur as sulphuretted hydrogen. On gently warming with concentrated hydrochloric acid or, preferably, sulphuric acid, the whole of the sulphur was eliminated as sulphur dioxide, and when the solution was poured on to ice and neutralised with caustic soda, ammonia was evolved and anisoylanisamidine separated out as a white, crystalline mass; this product was soluble in the ordinary organic solvents, and when crystallised from benzene gave the following analytical data: C = 67·32, 67·55; H = 6·03, 5·98; N = 10·26; $C_{16}H_{16}O_3N_2$ requires C = 67·60; H = 5·63; N = 9·85 per cent.

A methoxyl determination by Zeisel's method gave OCH_3 = 21·26 per cent., the calculated value being 21·83 per cent.

A molecular weight determination by the ebullioscopic method, using benzene as solvent, gave 309 and 303, the theoretical molecular magnitude being 284.

The platinichloride, which separates slowly as a definitely crystalline substance on adding platinic chloride to a dilute solution of the base in acetone, water, and hydrochloric acid, is almost insoluble in water and alcohol and melts and decomposes at 239°. Pt = 19·82; $(C_{16}H_{16}N_2O_3)_2,H_2PtCl_6$ requires Pt = 19·86 per cent.

That the substance was actually anisoylanisamidine was fully confirmed by dissolving it in dilute hydrochloric acid and heating for some time at 70—80°, when well-formed needles of dianisamide slowly separated. This product, which is preferably recrystallised from benzene, is moderately soluble in hot alcohol; it dissolves in caustic potash solution and is reprecipitated by acids. It melts at 170° and on analysis gave the following data: C = 67·21; H = 5·49; N = 5·15; $(CH_3{\cdot}O{\cdot}C_6H_4{\cdot}CO)_2NH$ requires C = 67·37; H = 5·26; N = 4·91 per cent.

Having now proved that the insoluble substance, resulting from the interaction of nitrogen sulphide and anisaldehyde, gives rise to anisoylanisamidine on treatment with acids, and that the yield obtained, 3·4 from 5 grams, showed that it was the main product of the reaction, we considered that an important clue to the composition of the original compound had been obtained. We found that the analysis, which was again repeated, agrees fairly well, considering the difficulty experienced in the combustion, with a substance having the empirical formula $C_{16}H_{15}N_3O_3S$: C = 59·12, 59·27; H = 5·09, 4·98; N = 12·72; S = 10·78, 10·51; $C_{16}H_{15}N_3O_3S$ requires C = 58·35; H = 4·56; N = 12·76; S = 9·72 per cent. An estimation of sulphur, liberated as sulphur dioxide on treating the substance with hydrochloric acid, gave S = 9·42 per cent.

A Zeisel determination of the methoxyl groups gave CH_3O = 17·2, whereas the foregoing formula requires CH_3O = 18·8 per cent.; but the determination was hardly expected to be accurate owing to the difficulty experienced with the sulphuretted hydrogen liberated by the hydriodic acid employed and to the fact that substances containing sulphur seldom give reliable data.

An analysis of the silver salt gave Ag = 23·58, the theoretical value for $C_{16}H_{14}O_3N_3SAg$ being Ag = 24·77 per cent. Unfortunately, owing to its insolubility, it was not found possible to determine its molecular magnitude. Although the foregoing analyses differ somewhat considerably from the calculated values, we think, however, they leave but little doubt that the substance has the empirical formula we have assigned to it, and that its stability towards alkalis, and especially the formation of anisoylanisamidine on treatment with acids, points clearly to the constitutional formula given on p. 1537.

We have made several attempts to obtain ethyl and benzoyl derivatives, but so far without success; we hope, however, to continue the investigation of this interesting substance.

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