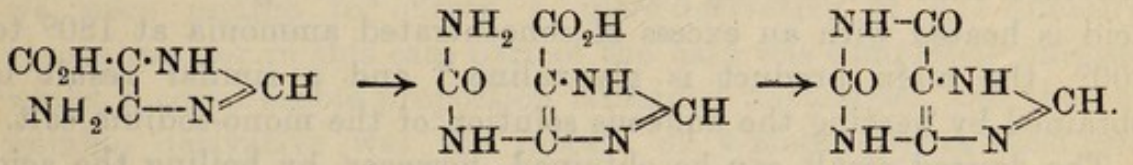
Nitro-, arylazo-, and amino-glyoxalines / by Robert George Fargher and Frank Lee Pyman.

XXVI.—*Nitro-, Arylazo-, and Amino-glyoxalines.*

By Robert George Fargher and Frank Lee Pyman.

This investigation was begun with the object of effecting the synthesis of purine derivatives by a method complementary to those which have been employed hitherto. In these, the pyrimidine nucleus is first built up and the glyoxaline ring closed subsequently. We proposed to prepare 4-aminoglyoxaline-5-carboxylic acid,* condense it with cyanic acid, and eliminate water with the production of xanthine.



Such a synthesis would be of interest in view of the suggestion that purine derivatives originate from histidine in the animal body (compare Hopkins, T., 1916, **109**, 629).

Although the starting material for the proposed synthesis, 4-aminoglyoxaline-5-carboxylic acid, was unknown, we did not anticipate that its preparation would offer any serious difficulty. We have, however, so far failed to obtain this substance, and now give an account of our attempts to prepare this and other amino-substituted glyoxalines.

An account of the investigation may be subdivided under three headings: first, the preparation of the glyoxalines and their carboxylic acids, which were required as starting materials; second, the preparation and properties of nitroglyoxalines; and last, the preparation and properties of arylazoglyoxalines.

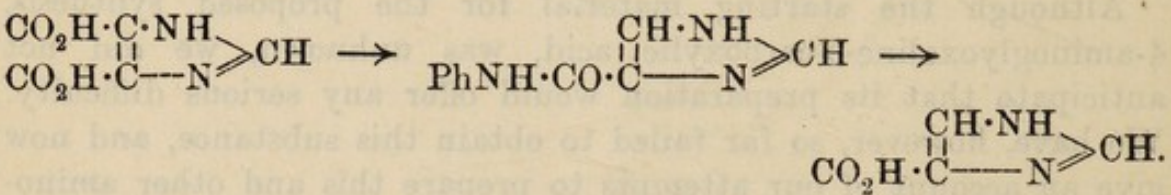
(1) *The Preparation of Glyoxalines and their Carboxylic Acids.*—For the purpose of this investigation, it was necessary to prepare considerable quantities of glyoxaline-4:5-dicarboxylic acid, the most convenient source of glyoxaline. This acid was first prepared by Maquenne (*Ann. chim. phys.*, 1891, [vi], **24**, 525), by mixing aqueous solutions of nitrotartaric acid and hexamethylenetetramine, adding ammonia, and allowing the mixture to become hot, and subsequently by Dedichen (*Ber.*, 1906, **39**, 1835), who replaced the hexamethylenetetramine by formaldehyde. We have carried out a large number of experiments on the best conditions for the pre-

* In glyoxalines containing a free imino-group, the 4- and 5-positions are equivalent.

paration of this acid, and find that to obtain a good yield it is essential that the reaction mixture should be kept cold.

A number of experiments were carried out with the object of effecting the partial decarboxylation of glyoxaline-4:5-dicarboxylic acid, and thus producing glyoxaline-4-carboxylic acid by a more convenient and economical process than that previously employed, where six operations are required in its synthesis from citric acid through 4-hydroxymethylglyoxaline (T., 1911, **99**, 668; 1916, **109**, 186). When the acid is heated with water, 10 per cent. hydrochloric acid, or concentrated hydrochloric acid, little decarboxylation takes place below 180°, but above this temperature, the action proceeds more readily, glyoxaline being the main product, whilst a small proportion of glyoxaline-4-carboxylic acid can be isolated provided that the heating has not been too prolonged. When the acid is heated with an excess of concentrated ammonia at 180° to 200°, the main product is glyoxaline,* and a similar result is obtained by heating the aqueous solution of the mono-sodium salt.

The desired result can be obtained, however, by boiling the acid with aniline, when the *anilide* of glyoxaline-4-carboxylic acid is formed in a yield amounting to 45 per cent. of the theoretical. From this, the acid is readily prepared by hydrolysis.



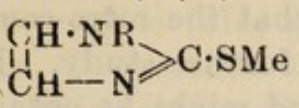
For the purpose of orientation, it was necessary to prepare glyoxalines substituted in the 2-, 4:5-, and 2:4:5-positions. The 2-alkylglyoxalines were prepared by suitable modifications of Maquenne's methods. From 2-methylglyoxaline-4:5-dicarboxylic acid, *2-methylglyoxaline-4-carboxylic acid* was obtained through its *anilide*.

As representatives of 4:5- and 2:4:5-substituted glyoxalines, 4:5-dimethylglyoxaline and 2:4:5-trimethylglyoxaline were prepared by modification of known methods.

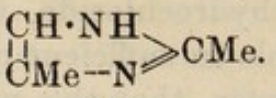
(2) *Nitroglyoxalines.*—The nitration of various glyoxalines has led to the formation of mononitroglyoxalines in the hands of several observers. In some cases the nitro-group evidently enters the 4-(or 5-)position, since no other position is vacant; for instance, in the nitration of 2-methylthiol-1-phenyl(and 1-methyl)glyoxaline

* We were unable to find any evidence of the formation of the imide of glyoxaline-4:5-dicarboxylic acid, from which the desired 5-aminoglyoxaline-4-carboxylic acid might have been obtained by the action of hypobromous acid.

(I) (Wohl and Marckwald, *Ber.*, 1888, **22**, 568, 1353) and 2:4-dimethylglyoxaline (II) (Windaus, *Ber.*, 1909, **42**, 758):



(I.)



(II.)

The orientation of the nitro-group in nitroglyoxaline itself (Rung and M. Behrend, *Annalen*, 1892, **271**, 28; R. Behrend and Schmitz, *ibid.*, 1893, **277**, 338) and in nitro-4-methylglyoxaline has not been determined previously, but an indication that the latter contains the nitro-group in the 5-position is afforded by Windaus's observation (*loc. cit.*) of its close similarity to 5-nitro-2:4-dimethylglyoxaline.

Moreover, whilst 4-*nitro*-2-*methylglyoxaline* is readily prepared, we were unable to obtain a nitro-derivative of 4:5-dimethylglyoxaline, for in this case part of the base was completely oxidised, whilst a considerable proportion remained unchanged, and the only isolable derivative was the nitrate of 4-methylglyoxaline-5-carboxylic acid, which has been described by Gerngross (*Ber.*, 1912, **45**, 509).

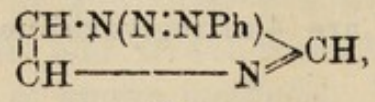
The inability of a glyoxaline substituted in both the 4- and 5-positions to form a nitro-derivative indicates that the nitroglyoxalines contain the substituent in the 4-(or 5-)position. This view is confirmed by their behaviour on reduction. Wohl and Marckwald (*loc. cit.*) attempted to reduce the 4-(or 5-)nitro-2-methylthiol-1-phenyl-(and 1-methyl)glyoxalines to the corresponding amines, but obtained only decomposition products, including methyl mercaptan. Similarly, we find that 4-nitro-2-methylglyoxaline undergoes fission on reduction with tin and hydrochloric acid, two of the three atoms of nitrogen in the molecule appearing in the form of ammonia.* Since precisely the same result is obtained with nitroglyoxaline and nitro-4-methylglyoxaline, whilst it is shown below that 2-aminoglyoxalines are stable, it is clear that these nitro-derivatives are 4-nitroglyoxaline and 5-nitro-4-methylglyoxaline respectively.

Before we had arrived at this conclusion, we were anxious to prepare some of the nitroglyoxaline-4-carboxylic acid, which Windaus and Opitz (*Ber.*, 1911, **44**, 1721) obtained by the action of boiling 25 per cent. nitric acid on 4-β-hydroxyethylglyoxaline.

* The first stage in the disintegration of the 4-aminoglyoxalines is probably the elimination of the amino-group as ammonia, with the formation of a glyoxalone, for certain members of the purine group—also derivatives of 4-aminoglyoxaline—have been shown to undergo hydrolysis in this manner (compare, for instance, Tafel and Mayer, *Ber.*, 1908, **41**, 2546; Biltz, *Ber.*, 1910, **43**, 1589).

These authors state that the yield of 4-β-hydroxyethylglyoxaline, obtained by the action of barium nitrite on 4-β-aminoethylglyoxaline hydrochloride, was so poor that the nitro-compound was not available in sufficient quantity for further study. It appeared to us, however, that this nitro-compound might be obtained by the action of nitric acid on other more readily accessible derivatives of glyoxaline containing a side-chain of carbon atoms in the 4-position, and in the first place we employed compounds containing two carbon atoms in the side-chains, like Windaus's starting material. The results were disappointing; 4-β-aminoethylglyoxaline, when boiled with 50 per cent. nitric acid for nine hours, was mainly recovered unchanged, whilst 4-cyanomethylglyoxaline was converted under the same conditions almost quantitatively into glyoxaline-4-acetic acid. Attempts to nitrate glyoxaline-4-carboxylic acid and glyoxaline-4:5-dicarboxylic acid were likewise unsuccessful. The prospect of nitrating 4-hydroxymethylglyoxaline was not hopeful, for it has been shown previously (T., 1916, **109**, 186) that hot concentrated nitric acid converts it into glyoxaline-4-formaldehyde and glyoxaline-4-carboxylic acid. It has now been found that the alcohol gives the same products when digested on the water-bath with fuming nitric acid, whilst it can be recovered almost quantitatively after boiling with ten parts of 25 per cent. nitric acid for four hours. On the other hand, the nitration of 4-hydroxymethylglyoxaline with nitric and sulphuric acids gave rise to a product which was not obtained in crystalline form, but further study of this was omitted in view of the peculiar behaviour of the simple nitroglyoxalines on reduction.

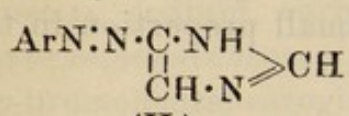
(3) *Arylazoglyoxalines.*—The constitution of the arylazo-derivatives of simple glyoxalines has not been settled hitherto. Rung and Behrend (*Annalen*, 1892, **271**, 28), who first isolated benzeneazoglyoxaline, considered it to be a diazoimino-compound (I), because boiling acids decomposed it with the formation of nitrogen



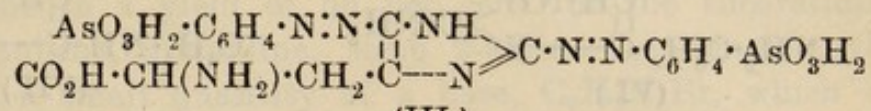
(I.)

and glyoxaline. Burian (*Ber.*, 1904, **37**, 696), who prepared many arylazoglyoxalines from diazobenzene-*p*-sulphonic acid and various glyoxalines, adopted the same view of the constitution of these compounds on other grounds, namely, because all the glyoxalines substituted in some or all of the 2-, 4-, and 5-positions which he examined coupled with the diazonium salt, whilst 1-substituted glyoxalines did not. Pauly (*Zeitsch. physiol. Chem.*, 1904, **42**, 508), however, pointed out the possibility that the arylazo-

glyoxalines were true *C*-azo-compounds (II) similar to those obtained from pyrrole, and later (*ibid.*, 1915, **94**, 284) attributed the probable formula (III) given below to the compound obtained by the action of diazotised arsanilic acid on histidine, owing to its stability towards acids. Whilst in the case of these simple



(II.)



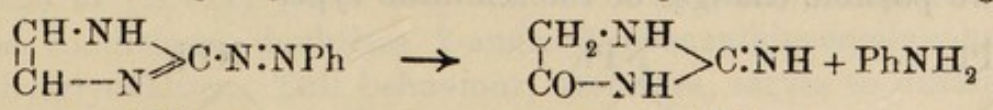
(III.)

glyoxalines the orientation of the arylazo-group is uncertain, the constitution of the arylazopurines is known, for Hans Fischer (*Zeitsch. physiol. Chem.*, 1909, **60**, 69) has shown that the arylazo-group enters the 8-position of the purine nucleus—the 2-position of its glyoxaline ring—by reducing arylazopurines to 8-aminopurines.

In view of this result, it appeared to us probable that the arylazo-derivatives of simple glyoxalines were also *C*-azo-compounds, as Pauly suggested, and it was of interest to determine whether the arylazo-group entered the 2- or the 4-position, and the nature of the products obtained on reduction.

The benzeneazoglyoxaline of Rung and Behrend was first examined. By the method of these workers, it is obtained in poor yield, but by the action of benzenediazonium chloride on one molecular proportion of glyoxaline in an excess of aqueous sodium carbonate, it is readily obtained mixed with a little 2:4:5-*tris-benzeneazoglyoxaline*. 2-Benzeneazoglyoxaline melts at 190° (corr.), and it is therefore evident that the specimen prepared by Rung and Behrend, melting at 177—178°, was impure. The pure substance is reasonably stable towards boiling 10 per cent. hydrochloric acid, for a considerable proportion can be recovered unchanged after two hours.

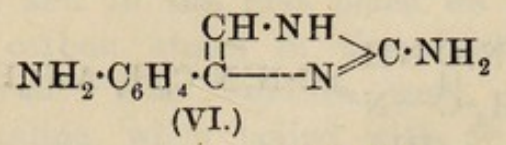
The constitution of 2-benzeneazoglyoxaline (IV) was proved by reduction. With zinc dust and hot acetic acid, it yields aniline and glycocyamidine* (V), the formation of the latter showing that the benzeneazo-group is attached to the 2-position of the ring.



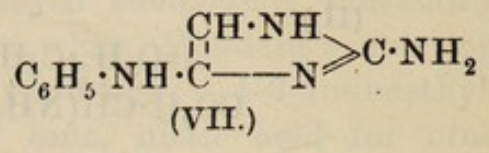
(IV.) (V.)

* The conversion of glyoxaline into glycocyamidine and 2-aminoglyoxaline, both derivatives of guanidine, is of biochemical interest, firstly, because creatinine is the *N*-methyl derivative of glycocyamidine, and secondly, on account of the similar behaviour of histidine and arginine in purine metabolism (compare Hopkins, *loc. cit.*).

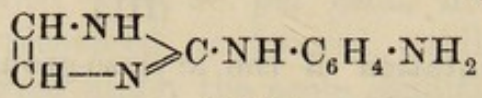
This result is confirmed by the formation of a small amount of guanidine on the reduction of 2-benzeneazoglyoxaline with stannous chloride. In this reduction, a small quantity of 2-*aminoglyoxaline* is formed and some aniline, but the main product is 2-*amino*-4-p-*aminophenylglyoxaline* (VI), a compound resulting from a change of the benzidine type. It is also formed in small proportion in the reduction with zinc dust and acetic acid.



(VI.)

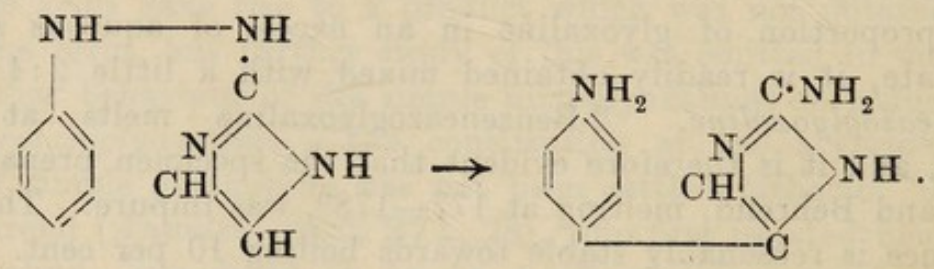


(VII.)

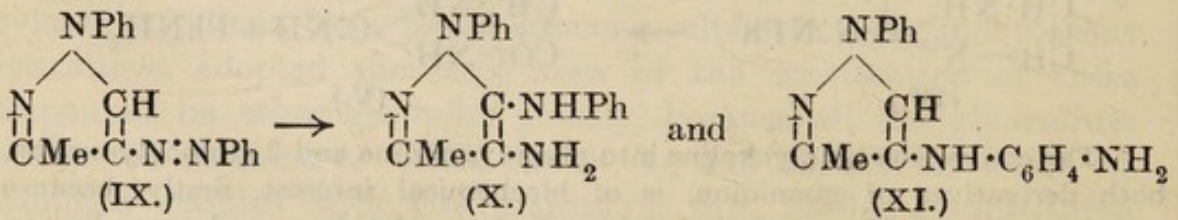


(VIII.)

Its constitution was proved by the oxidation of its diacetyl derivative with potassium permanganate, when *p*-acetylaminobenzoic acid was formed. This result eliminated the possibility that the compound had one of the two formulæ (VII) or (VIII), representing substances formed by a change of the semidine type. The occurrence of a rearrangement of the benzidine type in a five-membered heterocyclic nucleus seems remarkable at first sight, but a closer inspection of the formula shows that the conjugated system connecting the 2- and 5-carbon atoms of the glyoxaline ring is similar to that existing in the benzene nucleus.



Whilst no other case of the benzidine type of change in a heterocyclic nucleus has been observed previously, so far as we are aware, Michaelis and Schäfer (*Annalen*, 1915, **407**, 229) have obtained by the reduction of 1-phenyl-3-methyl-4-benzeneazopyrazole (IX) the two isomerides (X) and (XI) which result from the two possible changes of the semidine type.



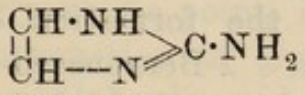
(IX.) (X.) (XI.)

Owing to the formation of 2-amino-4-*p*-aminophenylglyoxaline in the reduction of 2-benzeneazoglyoxaline, the yield of 2-amino-

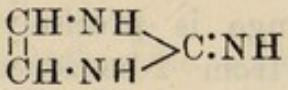
glyoxaline is small, so for the preparation of this substance the reduction of an arylazoglyoxaline containing a substituent in the para-position of the benzene nucleus was undertaken.

2-p-*Bromobenzeneazoglyoxaline* is the main product of the interaction of *p*-bromobenzenediazonium chloride and glyoxaline in aqueous sodium carbonate, only a very small proportion of 4-p-*bromobenzeneazoglyoxaline* being formed. The reduction of 2-*p*-bromobenzeneazoglyoxaline with stannous chloride gave 2-aminoglyoxaline in a yield of 56 per cent. of the theoretical, together with aniline, guanidine, some 2-amino-4-*p*-aminophenylglyoxaline, and a small quantity of a base, $C_9H_9N_4Br$, which is probably 2-5′-*bromo*-2′-*aminoanilinoglyoxaline* (compare p. 246).

2-Aminoglyoxaline is a monacidic base yielding crystalline salts, but the free base has not been obtained in a crystalline form.



(XII.)



(XIII.)

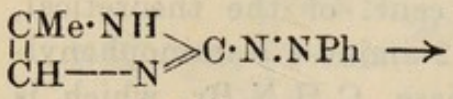
For this compound, the tautomeric formulæ (XII) and (XIII) are possible. The first is supported by the production of a red colour when the substance is mixed with sodium diazobenzene-*p*-sulphonate, and by the fact that, after treatment with nitrous acid, it couples with phenols. An indication that it can also react according to the formula (XIII)—which represents an unsaturated compound no longer containing the glyoxaline ring—is given by its behaviour towards permanganate, for 2-aminoglyoxaline and all the substituted 2-aminoglyoxalines described in this paper reduce cold aqueous acid potassium permanganate, and in this respect resemble the 2-thiolglyoxalines (compare T., 1911, **99**, 2173), whereas glyoxaline and its homologues are stable to this reagent, although they reduce alkaline permanganate, giving green solutions.

2-Aminoglyoxaline yields a *monoacetyl* and a *monobenzoyl* derivative, which are stable to cold aqueous acid permanganate.

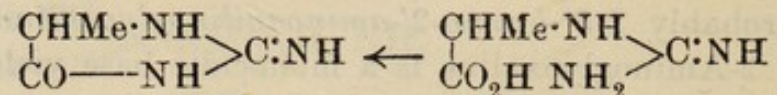
2-Aminoglyoxaline does not combine with benzaldehyde in acetic acid solution. Moreover, 2-amino-5-*p*-aminophenyl-4-methylglyoxaline (XVII) yields only a monobenzylidene compound under these conditions, doubtless 2-amino-5-*p*-benzylideneaminophenyl-4-methylglyoxaline. This behaviour, therefore, serves to differentiate between 2-aminoglyoxalines and homologues of aniline, and is employed later in the determination of constitution.

The action of benzenediazonium chloride on 4-methylglyoxaline proceeded quite differently from its action on glyoxaline. Instead of the 2-substituted arylazo-compound being formed predominantly,

nearly equal quantities of 2-*benzeneazo*-4-*methylglyoxaline*, 5-*benzeneazo*-4-*methylglyoxaline*, and 2:5-*bisbenzeneazo*-4-*methylglyoxaline* were obtained. The constitution of 2-benzeneazo-4-methylglyoxaline (XIV) follows from the fact that it yields, on reduction with zinc dust and acetic acid, alacreatinine (XV), a compound previously synthesised by Baumann (*Annalen*, 1873, **167**, 83) by the elimination of water from α-guanidinopropionic acid (XVI).

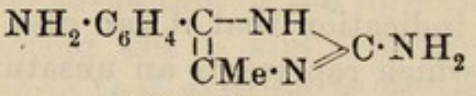


(XIV.)

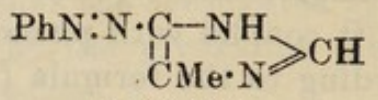


(XV.) (XVI.)

This change is precisely similar to the formation of glycocyamidine from 2-benzeneazoglyoxaline. 2-Benzeneazo-4-methylglyoxaline behaves in the same way as 2-benzeneazoglyoxaline on reduction with stannous chloride, the principal product of the reaction being 2-*amino*-5-p-*aminophenyl*-4-*methylglyoxaline* (XVII), a compound having similar properties to 2-amino-4-*p*-aminophenylglyoxaline.



(XVII.)



(XVIII.)

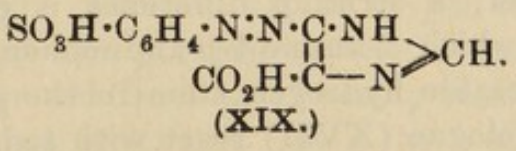
The constitution of 5-benzeneazo-4-methylglyoxaline (XVIII) could not be proved directly as in the case of the 2-isomeride. On reduction, aniline and a considerable amount of ammonia were formed, together with other products, which included a base, $C_9H_{10}ON_2$ (p. 254), when stannous chloride was employed as the reducing agent, and a base, $C_{10}H_{11}ON_3$ (p. 255), when zinc dust and acetic acid were used. The disintegration of the molecule indicated by the formation of ammonia is similar to that occurring in the reduction of the 4-nitroglyoxalines, and affords evidence that the constitution of the compound is represented correctly by the formula of 5-benzeneazo-4-methylglyoxaline. The formula is supported by the fact that the compound is soluble in dilute aqueous sodium hydroxide, which indicates that the imino-group is unsubstituted. Moreover, it is fairly stable towards boiling dilute acids. Its properties are not therefore in accord with those of a compound represented by the alternative formula, 1-benzeneazo-4-methylglyoxaline.

That aryldiazonium salts are capable of substituting the 4-position of the glyoxaline ring follows from the reduction of 2-*phenyl*-

4-p-*bromobenzeneazoglyoxaline*, $C_{15}H_{11}N_4Br$, for a *compound*, $C_{15}H_{13}N_4Br$, is produced, which is evidently derived from the corresponding hydrazo-compound by a change of the semidine or benzidine type (compare p. 257).

The polyarylazoglyoxalines—2 : 4 : 5-trisbenzeneazoglyoxaline and 2 : 5-bisbenzeneazo-4-methylglyoxaline—are insoluble in dilute mineral acids, and are decomposed on boiling with 10 per cent. hydrochloric acid. Nevertheless, we regard them as *C*-azo-compounds, because they are soluble to some extent in aqueous sodium hydroxide. In the case of the second compound, we have established the fact that it is precipitated unchanged from its solution in aqueous sodium hydroxide by means of acetic acid. The fact that the number of arylazo-groups in the polyarylazo-compounds corresponds with the number of nuclear methine groups in the parent glyoxaline points in the same direction.

The interaction of glyoxaline-4 : 5-dicarboxylic acid and diazobenzene-*p*-sulphonic acid was studied by Burian (*loc. cit.*), who found that carbon dioxide was liberated, and described a product forming yellow needles or red, microscopic prisms which gave on analysis results indicating that it was a compound derived from one molecular proportion of diazobenzene-*p*-sulphonic acid and one of glyoxaline-4-carboxylic acid, $SO_3H{\cdot}C_6H_4{\cdot}N{:}N{\cdot}C_3H_2N_2{\cdot}CO_2H$. Burian regarded this as a 1-substituted arylazoglyoxaline, but we thought it more probable that the arylazo-group had displaced a carboxyl group in the 4-(or 5-)position, and that the compound was 5-*p*-sulphobenzeneazoglyoxaline-4-carboxylic acid (XIX).

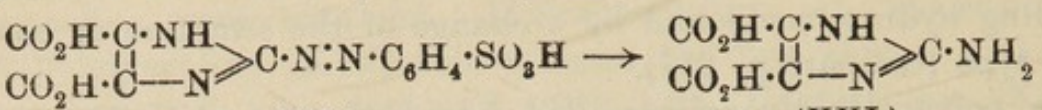


(XIX.)

This compound would yield 5-aminoglyoxaline-4-carboxylic acid if a suitable method of reduction could be found, and we therefore attempted to repeat its preparation, but were unable to do so. We can confirm Burian's statement that carbon dioxide is liberated in the reaction, but find the yield of this to be only about 40 per cent. of the theoretical, much less than he states. Moreover, we have isolated in a yield of about 30 per cent. of the theoretical the condensation product of diazobenzene-*p*-sulphonic acid and glyoxaline-4 : 5-dicarboxylic acid, namely, 2-p-*sulphobenzeneazoglyoxaline*-4 : 5-*dicarboxylic acid* (XX). No other definite compound could be isolated from the reaction mixture, and it appears to us that the compound described by Burian was probably a mixture of our acid with its sodium salt.

2-*p*-Sulphobenzeneazoglyoxaline-4 : 5-dicarboxylic acid yields on

reduction with sodium hyposulphite, sulphanilic acid and 2-*amino-glyoxaline*-4 : 5-*dicarboxylic acid* (XXI).

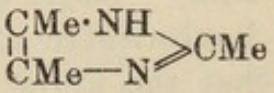


(XX.) (XXI.)

With the object of eliminating the elements of carbon dioxide, this acid was heated with water for twelve hours at 170°, when carbon dioxide and approximately one molecular proportion of ammonia were liberated, but no other fission product could be identified. On the other hand, when boiled with aniline for six hours, it gave a quantity of 2-aminoglyoxaline.

Whilst we were unable to isolate 5-*p*-sulphobenzeneazo-glyoxaline-4-carboxylic acid (XIX) from the products of the interaction of diazobenzene-*p*-sulphonic acid and glyoxaline-4 : 5-dicarboxylic acid, the liberation of carbon dioxide indicates that substitution in the 4-(or 5-)position takes place to some extent. Moreover, we can confirm the fact that 2-methylglyoxaline-4 : 5-dicarboxylic acid couples with sodium diazobenzene-*p*-sulphonate in aqueous sodium carbonate.

On the other hand, 2 : 4 : 5-trimethylglyoxaline (XXII), which contains a free imino-group but no other hydrogen atom attached



(XXII.)

to the nucleus, does not couple with sodium diazobenzene-*p*-sulphonate. Further, a striking difference is exhibited between the facilities with which 2-amino-4-*p*-aminophenylglyoxaline (VI) containing a displaceable hydrogen atom in the glyoxaline nucleus and its methyl homologue (XVII) react with sodium diazobenzene-*p*-sulphonate in aqueous sodium carbonate. The first gives the characteristic intense cherry-red colour immediately, whilst the second gives a pale orange colour which deepens on keeping, and is probably due to the participation of the aminophenyl group.

On reviewing these results and those of previous investigators, it appears to us that glyoxalines, in order to be capable of coupling, must contain a free imino-group and also a hydrogen atom, or some other displaceable group, such as the carboxyl group, in one of the 2-, 4-, or 5-positions, and that the arylazoglyoxalines hitherto prepared are *C*-azo-compounds.

The literature of the arylazoglyoxalines contains one possible exception to this generalisation—the compound (orange needles melting at 120—122°) described by Burian (*loc. cit.*) as having been obtained by the action of diazotised benzidine on 2-thiol-4 : 5-

diphenylglyoxaline. Since we found that 2-thiol-4:5-dimethylglyoxaline and 2-thiol-4:5-diphenylglyoxaline only gave pale orange colorations with sodium diazobenzene-*p*-sulphonate, we repeated Burian's preparation. We failed, however, to confirm his results, but isolated from the product, as main constituents, much unchanged 2-thiol-4:5-diphenylglyoxaline and a reddish-brown, amorphous compound, melting and decomposing above 200°, which from its low nitrogen content (5·5 per cent.) and the ratio of nitrogen to sulphur (2:1) could not have been an arylazo-derivative derived from 2-thiol-4:5-diphenylglyoxaline.

Experimental.

Part I. Glyoxalines and their Carboxylic Acids.

Preparation of Glyoxaline-4:5-dicarboxylic Acid.

Twenty-five grams of finely powdered tartaric acid are dissolved in 108 c.c. of nitric acid (D 1·5), and 125 c.c. of sulphuric acid are added. The mixture, which attains a temperature of about 40°, soon begins to deposit crystals, and is kept for three to four hours in a cool place. The nitrotartaric acid is collected, washed with 50 per cent. sulphuric acid, drained on porous porcelain, and stirred immediately with 150 grams of powdered ice until dissolved, when the temperature falls to −5°.

The liquid is immersed in a freezing mixture, and 100 c.c. of aqueous ammonia (D 0·880) are added gradually, the temperature being kept below 0°. Then 50 c.c. of 40 per cent. aqueous formaldehyde are added slowly, keeping the temperature below 10°. The product is removed from the freezing mixture after three to four hours, and kept overnight. It is then mixed with a little alcohol and acidified with hydrochloric acid, when 15·5 to 16·0 grams of glyoxaline-4:5-dicarboxylic acid separate, that is, about 60 per cent. of the theoretical yield calculated on the quantity of tartaric acid employed.

Glyoxaline-4:5-dicarboxylic acid melts and effervesces at 288° (corr.). It is soluble in about 800 parts of boiling water and in about 2000 parts of cold water. It is practically insoluble in the usual organic solvents, but dissolves sparingly in pyridine. It is soluble in concentrated mineral acids, but is precipitated unchanged on dilution with water. The *monosodium* salt, which crystallises from water as a felted mass of feathery needles containing $1H_2O$ (Found: $H_2O=9·4$; in dried salt, Na = 12·8. Calc.: $H_2O=9·2$; Na = 12·9 per cent.), is sparingly soluble in water but readily so in aqueous sodium hydr-

oxide, probably owing to the formation of a disodium salt in solution. Moreover, the addition of alcohol to a solution of the acid in sufficient aqueous sodium hydroxide to form the disodium salt causes the precipitation of a granular deposit approximating in composition to the disodium salt. (Found, in salt dried at 110°, Na = 21·2. $C_5H_2O_4N_2Na_2$ requires Na = 23·0 per cent.)

The acid is very stable towards nitric acid; after boiling it with ten times its weight of concentrated nitric acid for twenty-four hours, more than 90 per cent. was recovered unchanged, whilst similar results were obtained in a sealed tube at 130°, and when the acid was boiled with equal parts of nitric and sulphuric acids.

The acid is very resistant to esterification, for, after boiling with alcoholic sulphuric acid for twenty-four hours, 95 per cent. was recovered unchanged.

The Preparation of Glyoxaline.

One hundred grams of glyoxaline-4:5-dicarboxylic acid were distilled, under normal pressure, in quantities of 4 grams from a small flask into a long, wide air condenser. The distillate, which had solidified in the condenser, was crystallised from benzene, and gave a 92 per cent. yield of the pure base.

Glyoxaline picrate crystallises from water in long, fine, yellow needles, which become orange on drying at 100°, and then melt at 212° (corr.), after sintering from 208°. It contains rather more than $1H_2O$ (Found, loss at 100° = 7·2; in substance dried at 100°, N = 23·3. $C_3H_4N_2,C_6H_3O_7N_3$ [297·1] requires N = 23·6 per cent.).

Glyoxaline hydrogen tartrate crystallises from water in fine prisms of characteristic trapezoidal shape, which are anhydrous and melt at 202° (corr.). It is readily soluble in cold water, and is best crystallised from 50 per cent. alcohol (Found: N = 12·8. $C_3H_4N_2,C_4H_6O_6$ [218·1] requires N = 12·8 per cent.).

Glyoxaline hydrogen oxalate crystallises from water as a felted mass of prismatic needles, which are anhydrous and melt at 232° (corr.) after sintering from 230°. It is soluble in five or six parts of boiling water, but much less so in cold water (Found: N = 17·8. Calc.: N = 17·7 per cent.).

Action of Boiling Aniline on Glyoxaline-4:5-dicarboxylic Acid: Formation of Glyoxaline-4-carboxyanilide and Glyoxaline.

Five grams of glyoxaline-4:5-dicarboxylic acid were boiled with 50 c.c. of aniline for nine hours under a reflux condenser, when

the acid gradually passed into solution. The product was mixed with water and subjected to distillation with steam until the excess of aniline had been removed. The residual aqueous solution was filtered from a small quantity of resinous matter whilst still hot, when the filtrate at once began to deposit the anilide as a felted mass of fine needles. The first crop amounted to 2·6 grams, and a further quantity of 0·1 gram was obtained on concentrating the mother liquor. The filtrate from this gave on acidification 0·1 gram of glyoxaline-4:5-dicarboxylic acid, but no glyoxaline-4-carboxylic acid was found. The final mother liquor when mixed with sodium carbonate, evaporated to dryness, and extracted with benzene gave 0·9 gram of glyoxaline.

Glyoxaline-4-carboxyanilide crystallises from boiling water in fine, colourless needles, which are anhydrous and melt at 227—228° (corr.). It is fairly readily soluble in alcohol, but only sparingly so in boiling water and the other usual organic solvents.

Found: C = 64·2; H = 5·1; N = 22·6.
$C_{10}H_9ON_3$ (187·15) requires C = 64·2; H = 4·9; N = 22·5 per cent.

Hydrolysis of the Anilide.—The anilide is only slowly hydrolysed by 10 per cent. hydrochloric acid at 100°, but more readily at 130°.

One gram of the anilide was heated with 10 c.c. of 10 per cent. hydrochloric acid at 130° for three hours. The resulting solution was evaporated to dryness to remove the excess of acid, the residue dissolved in water, basified with sodium carbonate, and extracted with ether to remove aniline. Sufficient hydrochloric acid was added to render the solution faintly acid to methyl-orange, when crystallisation set in almost immediately, and 0·42 gram of glyoxaline-4-carboxylic acid was isolated The properties of the acid and its hydrochloride, nitrate, and picrate agreed with those previously given (T., 1916, **109**, 199) for the acid prepared by the oxidation of 4-hydroxymethylglyoxaline, and the melting points of mixtures of the compounds from the two sources were not depressed.

2-*Methylglyoxaline*-4:5-*dicarboxylic Acid.*

This acid was prepared in an analogous manner to its lower homologue, employing a solution of 15 c.c. of freshly distilled acetaldehyde dissolved in 50 c.c. of ice-water in the place of the aqueous formaldehyde. The yield of 2-methylglyoxaline-4:5-dicarboxylic acid, containing $1H_2O$, obtained from 25 grams of tartaric acid was 22 grams, that is, 67 per cent. of the theoretical.

Maquenne (*loc. cit.*) obtained 50 grams of the product from 100 grams of tartaric acid, that is, 38 per cent. of the theoretical.

Generally, the properties of this acid are very similar to those of glyoxaline-4:5-dicarboxylic acid, and it behaves similarly on acid and alkaline hydrolysis.

With sodium diazobenzene-*p*-sulphonate in aqueous sodium carbonate, it gives a faint red colour which deepens on keeping, whilst glyoxaline-4:5-dicarboxylic acid gives a deeper red colour in the first instance.

Action of Boiling Aniline on 2-Methylglyoxaline-4:5-dicarboxylic Acid.

Twenty grams of hydrated 2-methylglyoxaline-4:5-dicarboxylic acid, when treated with boiling aniline under the same conditions as its lower homologue, gave 11 grams of the hydrated anilide of 2-methylglyoxaline-4-carboxylic acid and 3·8 grams of 2-methylglyoxaline.

2-Methylglyoxaline-4-carboxyanilide crystallises from boiling water as a felted mass of colourless, silky needles, which contain rather less than $1H_2O$. It is sparingly soluble in boiling water, but readily so in alcohol. After drying at 110°, it melts at 208° (corr.).

Found, loss at 110° in three samples = 6·9, 7·0, 7·2.

$C_{11}H_{11}ON_3,H_2O$ requires H_2O = 8·2 per cent.

Found, in substance dried at 110°, C = 65·1, 65·6; H = 5·7, 5·6; N = 20·9.

$C_{11}H_{11}ON_3$ (201·2) requires C = 65·6; H = 5·5; N = 20·9 per cent.

2-Methylglyoxaline-4-carboxylic acid is obtained in nearly the theoretical yield by the hydrolysis of its anilide under similar conditions to those already described for glyoxaline-4-carboxylic acid. When placed in a bath at 250°, it melts and effervesces at 262° (corr.). It crystallises from water in clusters of prismatic needles containing $1H_2O$. It is soluble in about twenty parts of boiling water, but is practically insoluble in the usual organic solvents.

Found, loss at 110° = 12·9.

$C_5H_6O_2N_2,H_2O$ requires H_2O = 12·5 per cent.

Found, in the substance dried at 110°, C = 47·3; H = 4·8; N = 21·9.

$C_5H_6O_2N_2$ (126·1) requires C = 47·6; H = 4·8; N = 22·2 per cent.

With sodium diazobenzene-*p*-sulphonate it gives a red colour in sodium carbonate solution.

The *hydrochloride* crystallises from water, in which it is readily

soluble, in minute, flattened, rhombic prisms, which are anhydrous. It melts and effervesces at 268° (corr.).

Found: N = 16·9; Cl = 21·5.
$C_5H_6O_2N_2,HCl$ (162·6) requires N = 17·2; Cl = 21·8 per cent.

The *nitrate* crystallises from water, in which it is very readily soluble, in minute rhombic prisms, which melt and effervesce at 190° (corr.), resolidify, and on further heating gradually darken, melting at about 240°.

Found: C = 31·7; H = 4·1.
$C_5H_6O_2N_2,HNO_3$ (189·1) requires C = 31·7; H = 3·7 per cent.

The *picrate* crystallises from water in minute cubes containing $2H_2O$, which is lost at 100° (Found: H_2O = 9·4. Calc. for $2H_2O$, 9·2 per cent.). It melts to a turbid liquid at 200° (corr.), which does not become clear until 224°, at which temperature effervescence begins.

Found, in salt dried at 100°, N = 19·4.
$C_5H_6O_2N_2,C_6H_3O_7N_3$ (355·2) requires N = 19·7 per cent.

2-*Methylglyoxaline picrate* crystallises from boiling water in fine needles, which are anhydrous and melt at 213° (corr.).

Found: N = 22·3.
$C_4H_6N_2,C_6H_3O_7N_3$ (311·2) requires N = 22·5 per cent.

2-*Methylglyoxaline hydrogen oxalate* crystallises from water in large, rhombic prisms which contain $2H_2O$ (Found: H_2O = 17·6. Calc. for $2H_2O$: H_2O = 17·3 per cent.). After drying at 100°, it melts at 160° (corr.), and effervesces on further heating. It is much more readily soluble in water than the corresponding glyoxaline salt.

Found, in dried salt: N = 16·1.
$C_4H_6N_2,C_2H_2O_4$ (172·1) requires N = 16·3 per cent.

2-*Ethylglyoxaline*-4:5-*dicarboxylic Acid.*

This acid was prepared in the same way as the methyl substituted acid. From 32 c.c. of propaldehyde, and the nitrotartaric acid obtained from 50 grams of tartaric acid, 43 grams of hydrated 2-ethylglyoxaline-4:5-dicarboxylic acid were obtained, that is, 64 per cent. of the theoretical yield; Maquenne obtained 30 per cent. 2-Ethylglyoxaline-4:5-dicarboxylic acid melts and effervesces at 259° (corr.).

2-Phenylglyoxaline-4:5-dicarboxylic Acid.

The nitrotartaric acid from 25 grams of tartaric acid was treated with 100 c.c. of aqueous ammonia in the manner previously described. Then 20 grams of benzaldehyde were added, with stirring, below 0°, and the stirring was continued for seven hours, the temperature of the mixture being gradually allowed to approach that of the room. After keeping overnight, 17·1 grams of 2-phenylglyoxaline-4:5-dicarboxylic acid were isolated, that is, 48 per cent. of the theoretical yield, whereas Maquenne's yield was only 8 per cent. 2-Phenylglyoxaline-4:5-dicarboxylic acid melts and effervesces at 271° (corr.).

When distilled under the conditions previously described in the case of glyoxaline-4:5-dicarboxylic acid, it gives 2-phenylglyoxaline in a yield of more than 80 per cent. of the theoretical.

2-Phenylglyoxaline crystallises from water in small, prismatic needles, which melt at 148—149° (corr.) and are anhydrous.

2-Phenylglyoxaline nitrate is readily soluble in water, but less so in alcohol, from which it separates in leaflets containing $\frac{3}{4}H_2O$, which is lost at 60° in a vacuum. The dried salt melts at 135° (corr.).

Found, in air-dried salt, $H_2O = 6·1$; in dried salt, $N = 20·0$.

$C_9H_8N_2,HNO_3$ (207·1) requires $N = 20·3$ per cent.

The *hydrogen oxalate* crystallises from water in flattened needles, which melt and effervesce at 219° (corr.), and are anhydrous. It is readily soluble in hot water, but less so in cold.

Found: $N = 12·0$.

$C_9H_8N_2,C_2H_2O_4$ (234·1) requires $N = 12·0$ per cent.

The *picrate* is sparingly soluble even in boiling water, from which it crystallises in fine needles which melt at 238° (corr.), and are anhydrous.

Found: $N = 18·6$.

$C_9H_8N_2,C_6H_3O_7N_3$ (373·2) requires $N = 18·8$ per cent.

4:5-Dimethyl- and 2:4:5-Trimethyl-glyoxaline.

When 4:5-dimethylglyoxaline is prepared by Windaus' method (*Ber.*, 1909, **42**, 758), it is contaminated with 2:4:5-trimethylglyoxaline, which results from the interaction of diacetyl and ammonia (von Pechmann, *Ber.*, 1888, **21**, 1414).

8·6 Grams of diacetyl were dissolved in 50 c.c. of water, 50 c.c. of 40 per cent. aqueous formaldehyde added, the mixture cooled to 0°, and 80 c.c. of concentrated ammonia solution gradually

added, the reaction mixture being stirred and kept below 0°. After the addition was ended, the mixture was allowed to remain in a cool place overnight, then evaporated to a low bulk, saturated with anhydrous potassium carbonate, and the oil which separated extracted by ether. The crude extract, which was contaminated with hexamine, amounted to 5·9 grams. After destruction of the hexamethylenetetramine by boiling dilute hydrochloric acid, the picrates of the constituent bases were fractionated from water, when 5·7 grams of 4:5-dimethylglyoxaline picrate (17·5 per cent. of the theoretical yield) were obtained first, and then 3·5 grams of 2:4:5-trimethylglyoxaline picrate.

2:4:5-*Trimethylglyoxaline picrate* sinters from 160° and melts at 163° (corr.). It crystallises from water in well-defined prisms, which are often serrated.

Found: N = 20·6.

$C_6H_{10}N_2,C_6H_3O_7N_3$ requires N = 20·6 per cent.

The hydrochloride, previously prepared by von Pechmann, crystallises from alcohol in fine needles, which are anhydrous and melt at 316° (corr.) (Found: N = 19·0; Cl = 24·2. Calc.: N = 19·1; Cl = 24·2 per cent.).

4:5-*Dimethylglyoxaline hydrochloride* crystallises from alcohol in well-defined, rhombic prisms which melt and decompose at 305° (corr).

Found: N = 21·1; Cl = 26·4.

$C_5H_8N_2,HCl$ requires N = 21·1; Cl = 26·7 per cent.

4:5-Dimethylglyoxaline was also prepared by a modification of Künne's method (*Ber.*, 1895, **28**, 2039; compare also Jowett, T., 1905, **87**, 407). Nine grams of methyl α-*iso*nitrosoethyl ketone were reduced with stannous chloride, as described by Künne, but the temperature of the reaction mixture was maintained at 15°, and, after the removal of the tin, the evaporation of the liquor was conducted entirely under diminished pressure. By these means, a yield of 10 grams of crude, crystalline methyl α-aminoethyl ketone hydrochloride was obtained, as against 4·2 grams of syrup obtained by Künne. When this product was heated on the water-bath for four hours with 10 grams of potassium thiocyanate and 40 c.c. of water, 5·2 grams of 2-thiol-4:5-dimethylglyoxaline separated, and this gave 4:5-dimethylglyoxaline picrate in a yield of 85 per cent. of the theoretical when oxidised with the calculated quantity of ferric chloride.* The yield of 4:5-dimethylglyoxaline from methyl ethyl ketone is thus 23·8 per cent. of the theoretical.

* The method of oxidising thiolglyoxalines to glyoxalines by means of ferric chloride has been described by one of us (T., 1911, **99**, 2175) in the case of

Part II. Nitroglyoxalines.

4-*Nitroglyoxaline.*

Rung and Behrend (*loc. cit.*) prepared 4-nitroglyoxaline in a yield of 36 per cent. of the theoretical by boiling glyoxaline with a mixture of nitric and sulphuric acids. The yield can be improved greatly by the method given below. Eight grams of glyoxaline were dissolved in 16 c.c. of nitric acid (D 1·4), cooled, and 16 c.c. of sulphuric acid cautiously added. A vigorous reaction ensued, and when this had subsided the mixture was boiled gently for two hours, allowed to cool, and then poured into ice-water, when 7·85 grams of 4-nitroglyoxaline separated. The mother liquors yielded a further 0·5 gram of 4-nitroglyoxaline identical with the above, but no glyoxaline and merely a trace of other crystalline material. The total yield of 4-nitroglyoxaline thus amounted to 63 per cent. of the theoretical. 4-Nitroglyoxaline crystallises from boiling acetic acid or from alcohol in stout, rhombic prisms, which are anhydrous and melt at 312—313° (corr.) (Found: N = 36·8. Calc.: N = 37·1 per cent.). It is only very sparingly soluble in boiling water. Although it dissolves in strong mineral acids, it is precipitated unchanged on the addition of water, and is recovered unchanged when crystallised from aqueous picric acid.

4-*Nitro*-2-*methylglyoxaline* was similarly prepared. It crystallises from water in fine needles, which are anhydrous and melt at 254° (corr.), sintering from 251°.

Found: N = 33·0.

$C_4H_5O_2N_3$ (127·1) requires N = 33·1 per cent.

5-*Nitro*-4-*methylglyoxaline* was prepared by Windaus (*loc. cit.*) in a 60 per cent. yield by warming 4-methylglyoxaline with fuming nitric acid at 80°. Using this method, we found the main product to be 4-methylglyoxaline nitrate. Proceeding according to the method described for 4-nitro-2-methylglyoxaline, 5 grams of 4-methylglyoxaline gave 7 grams of 5-nitro-4-methylglyoxaline (Found: N = 32·8. Calc.: N = 33·1 per cent.) melting at 248° (corr.), that is, 90 per cent. of the theoretical yield.

2-thiol-4-aminomethylglyoxaline. The low yield of 4-aminomethylglyoxaline recorded (56 per cent. of the theoretical) was due to the fact that insufficient ferric chloride had been employed. When the calculated quantity (16·2 grams) of this reagent is used, the product is obtained in a yield of 90 per cent. of the theoretical.

Attempted Nitration of 4:5-Dimethylglyoxaline.

To five grams of 4:5-dimethylglyoxaline dissolved in 15 c.c. of nitric acid (D 1·4), 15 c.c. of sulphuric acid were added. The first vigorous reaction was controlled by cooling, and after it had ended the mixture was heated for two hours on the water-bath. From the reaction product, 1·7 grams of 4:5-dimethylglyoxaline were recovered, together with 0·3 gram of the nitrate of 4-methylglyoxaline-5-carboxylic acid (Found: C = 32·1; H = 4·0; N = 21·7. Calc.: C = 31·6; H = 3·7; N = 22·1 per cent.), which deposited the corresponding acid, melting and effervescing at 222°, on the addition of the calculated quantity of sodium hydroxide. From the pure acid, the hydrochloride, which melted and decomposed at 231°, and the nitrate, which decomposed at 189°, were prepared. The melting points of the acid and its salts are in agreement with those found by Gerngross (*loc. cit.*) for 4-methylglyoxaline-5-carboxylic acid.

Reduction of Nitroglyoxalines with Tin and Hydrochloric Acid.

When 4-nitroglyoxaline, 4-nitro-2-methylglyoxaline, or 5-nitro-4-methylglyoxaline is reduced with tin and hydrochloric acid, and the product mixed with sodium hydroxide and distilled into standard acid, two of the three atoms of nitrogen present in the molecule are eliminated in the form of ammonia:

0·5609 of 4-nitroglyoxaline gave 0·1746 NH_3; calc. as above, 0·1688.

0·4292 of 4-nitro-2-methylglyoxaline gave 0·118 NH_3; calc. as above, 0·115.

0·4931 of 5-nitro-4-methylglyoxaline gave 0·1378 NH_3; calc. as above, 0·1320.

That the greater part of the ammonia is actually produced during the reduction, and not by the subsequent action of the alkali, is shown in the case of 4-nitroglyoxaline by the following experiment.

Twelve grams of 4-nitroglyoxaline were reduced by means of tin and hydrochloric acid in the usual manner. The reduced liquors were freed from tin and then evaporated to dryness, then moistened with alcohol, and again evaporated to remove water as far as possible. The crude product was extracted with alcohol and left 9 grams of a crystalline solid, which proved to be ammonium chloride (Found: N = 25·9; Cl = 66·0. Calc.: N = 26·2;

Cl = 66·3 per cent.). The residue of the purple alcoholic solution gave 5 grams of an insoluble phosphotungstate after the removal of ammonia. This product has not yet been investigated.

Reduction of Nitroglyoxalines with Sodium Hyposulphite.

Behrend and Schmitz (*loc. cit.*) observed that 4-nitroglyoxaline gave a beautiful blue dye when treated with alkaline reducing agents. We can confirm this result, but find that ammonia is also produced in an amount corresponding with the loss of two atoms of nitrogen in this form from three molecules of 4-nitroglyoxaline when this compound is reduced with sodium hyposulphite in aqueous sodium hydroxide:

0·5148 of 4-nitroglyoxaline gave 0·0521 NH_3; calc. as above, 0·0516.

The liquors remaining from the distillation gradually acquired a dark blue colour on exposure to the air, and on acidification with acetic acid deposited rather less than 0·1 gram of a blue compound which did not melt below 300°.

The reduction of 5-nitro-4-methylglyoxaline with alkaline sodium hyposulphite led to the same result as in the case of 4-nitroglyoxaline, two molecules of ammonia being produced from three molecules of the nitro-compound (0·5311 gave 0·0487 NH_3; calc. as above, 0·0474). The reduced solution gradually acquired a rose colour on exposure to air, but gave no precipitate with acetic acid.

4-Nitro-2-methylglyoxaline behaved differently from the above compounds on reduction with alkaline sodium hyposulphite, yielding one molecule of ammonia from three molecules of the nitro-compound (0·5084 gave 0·0230 NH_3; calc. as above, 0·0227).

Part III. Arylazoglyoxalines.

2-Benzeneazoglyoxaline (IV, p. 221).

23·25 Grams of aniline were dissolved in 62·5 c.c. of hydrochloric acid and 187·5 c.c. of water, and diazotised with 18 grams of sodium nitrite dissolved in 100 c.c. of water. The solution was run slowly into a well-stirred solution of 17 grams of glyoxaline and 40 grams of anhydrous sodium carbonate in 1250 c.c. of water, previously cooled to 5°, and kept overnight. The insoluble orange powder was collected, washed well with water, and extracted successively with 250, 125, and 125 c.c. of cold 2·5 per cent. hydrochloric acid. (Extract = *A*.) The insoluble material amounted to 4·4

grams, and after crystallisation from alcohol gave 2:4:5-*trisbenzeneazoglyoxaline*, of which only 0·5 gram was obtained in a pure state. This compound decomposes at about 200° and effervesces at 208° (corr.). When pure, it is only sparingly soluble even in boiling alcohol, from which it crystallises slowly in dark brown clusters of crystals of indeterminate shape. (0·84 required 60 c.c. of boiling alcohol.)

Found: C = 66·0; H = 4·6; N = 29·0.

$C_{21}H_{16}N_8$ (380·3) requires C = 66·3; H = 4·2; N = 29·5 per cent.

Trisbenzeneazoglyoxaline is insoluble in cold dilute hydrochloric acid, and is decomposed when boiled with this reagent. It dissolves to some extent in aqueous sodium hydroxide.

The hydrochloric acid extract (*A*) was diluted with water and basified with sodium carbonate, when crude 2-benzeneazoglyoxaline was obtained as a yellow, crystalline precipitate, which, after thorough washing with cold water and drying, amounted to 34 grams. On crystallisation from 150 c.c. of alcohol, 31 grams of the pure base were obtained, that is, 74 per cent. of the theoretical. No other definite compound could be isolated from the mother liquor.

2-*Benzeneazoglyoxaline* crystallises from alcohol in large, orange tablets resembling potassium dichromate in appearance. It melts at 190° (corr.) to a reddish-black liquid.

Found: C = 62·7, 62·7; H = 4·8, 4·9; N = 32·3

$C_9H_8N_4$ (172·1) requires C = 62·8; H = 4·7; N = 32·6 per cent.

Rung and Behrend's Method.—By this method, in which benzenediazonium chloride is allowed to react with glyoxaline without the addition of alkali, 5 grams of glyoxaline gave 3·3 grams of crude precipitate insoluble in water. Of this, 2·2 grams were separated into 0·7 gram of insoluble resin, which appeared to evolve gas on keeping, and 1·45 grams soluble in acid, which gave pure 2-benzeneazoglyoxaline on crystallisation from alcohol. The crude precipitate was less readily purified by direct crystallisation from alcohol.

General Properties of Arylazoglyoxalines.—To avoid repetition, it will be convenient to describe the general properties of the monoarylazoglyoxalines at this point. 2-Benzeneazoglyoxaline and 2-benzeneazo-4-methylglyoxaline are fairly readily soluble in alcohol, ethyl acetate, or acetone, sparingly so in ether, chloroform, or benzene. 5-Benzeneazo-4-methylglyoxaline, 2-*p*-bromobenzeneazoglyoxaline, and 4-*p*-bromobenzeneazo-2-methylglyoxaline are sparingly soluble in the first three solvents and very sparingly so in the last three.

These compounds are almost insoluble in cold water or in dilute aqueous ammonia or sodium carbonate, but dissolve to some extent in dilute aqueous sodium hydroxide. The benzeneazo-compounds dissolve readily in dilute hydrochloric acid, and the solutions yield crystalline hydrochlorides on concentration; the hydrochlorides of the *p*-bromobenzeneazo-compounds are sparingly soluble in water.

The stability of a 2- and a 4-substituted member of the group towards boiling dilute hydrochloric acid was examined. When 0·5 gram of 2-benzeneazoglyoxaline was boiled with 20 c.c. of 10 per cent. aqueous hydrochloric acid for two hours under a reflux condenser, 0·35 gram was recovered little changed on the addition of ammonia, and readily gave the starting material in a pure state on crystallisation from alcohol.

When 5-benzeneazo-4-methylglyoxaline was boiled with an excess of 10 per cent. aqueous hydrochloric acid for a few minutes, it was recovered unchanged after the addition of ammonia, but after boiling for one hour it was mainly decomposed, with the formation of resinous compounds.

The arylazoglyoxalines dissolve in concentrated sulphuric acid, giving bright-coloured solutions. The monoarylazo-derivatives yield mainly orange or magenta solutions, the 2-substituted derivatives being more intensely coloured than the 4-substituted compounds, whilst the solutions of bis- and tris-arylazoglyoxalines are green and still more intense than those of the 2-monoarylazo-derivatives.

Reduction of 2-Benzeneazoglyoxaline with Stannous Chloride: Isolation of 2-Amino-4-p-aminophenylglyoxaline, 2-Aminoglyoxaline, Guanidine, and Aniline.

Twenty grams of 2-benzeneazoglyoxaline were dissolved in 200 c.c. of boiling 2·5 per cent. hydrochloric acid and mixed with 120 c.c. of stannous chloride solution.* The solution was immediately decolorised, and when mixed with 200 c.c. of hydrochloric acid deposited a crystalline tin salt (*A*). This was collected, and the mother liquor was evaporated to dryness, dissolved in hot water, and freed from tin. It was then evaporated to low bulk, mixed with sodium carbonate, and extracted with ether, which removed 3·0 grams of crude aniline. The alkaline liquor was acidified faintly with hydrochloric acid, evaporated to dryness, and extracted with alcohol, when 3·1 grams of extract were obtained. This was

* The stannous chloride solution employed throughout this investigation was made by mixing 40 grams of "tin salt" with sufficient hydrochloric acid to make 100 c.c. of solution.

mixed with stannic chloride, and deposited, first, 2·2 grams of pure 2-*aminoglyoxaline stannichloride*, then crops of the crude salt, from which a further quantity of 1·0 gram of the pure salt was obtained, the total yield amounting to 11 per cent. of the theoretical. The final stannichloride mother liquors were deprived of tin by means of hydrogen sulphide and mixed with picric acid. After crystallisation from water, the first crop of picrate, which melted at 325°, was decomposed by sulphuric acid, the picric acid being removed by means of ether. The solution of sulphates was deprived of sulphuric acid by barium hydroxide, and from excess of this reagent by carbon dioxide. The resulting solution was neutralised with aqueous oxalic acid, mixed with as much more aqueous oxalic acid, and concentrated, when crude guanidine hydrogen oxalate separated. After recrystallisation from water, this amounted to 0·07 gram, melting and effervescing at 172—173° (corr.) alone or when mixed with pure guanidine hydrogen oxalate.

The crystalline tin salt (*A*) was dissolved in water, treated with hydrogen sulphide, filtered from tin sulphide, and concentrated, when 18·55 grams of 2-*amino*-4-p-*aminophenylglyoxaline dihydrochloride* separated, that is, 64·6 per cent. of the theoretical yield.

2-*Amino*-4-p-*aminophenylglyoxaline*, $C_9H_{10}N_4$ (VI, p. 222).

When the dihydrochloride is mixed with an equivalent quantity of sodium carbonate, a colourless oil separates which solidifies on keeping. This is a carbonate, for it effervesces on treatment with acid, and when dissolved in boiling water disengages carbon dioxide vigorously on the addition of animal charcoal, leaving a solution of the free base, which crystallises on keeping. This solution becomes brown at the top owing to oxidation in the air, whilst the laminæ become mauve where exposed to the light.

To 5·0 grams of the dihydrochloride in 50 c.c. of boiling water, 30 c.c. of hot 10 per cent. aqueous sodium carbonate and a pinch of animal charcoal were added. The solution was boiled for five minutes, filtered, and kept, when 3·1 grams of the base separated and were recrystallised from water. This base crystallises from water in glistening leaflets which melt and effervesce at 148° (corr.). It contains $1H_2O$, which is not lost in a vacuum or on heating at 100°.

Found: C = 56·3; H = 6·4; N = 29·5, 29·2.
$C_9H_{10}N_4,H_2O$ (192·2) requires C = 56·2; H = 6·3; N = 29·2 per cent.

It is sparingly soluble in cold, fairly readily so in hot water; fairly readily soluble in cold, readily in hot alcohol, and very sparingly so in chloroform or ether.

An aqueous solution of the base gives, with silver nitrate, a white precipitate, which blackens at once on the addition of ammonia; with Fehling's solution, a nearly black precipitate—presumably a copper salt—which is unchanged on boiling the solution; with cold permanganate, instant reduction; with sodium diazobenzene-*p*-sulphonate in aqueous sodium carbonate, an immediate cherry-red colour. When the base is dissolved in an excess of hydrochloric acid and mixed with sodium nitrite, a yellow solution is obtained, which yields with a solution of β-naphthol in aqueous sodium hydroxide a sparingly soluble purple dye. On the addition of sodium hydroxide to a solution containing 2-amino-4-*p*-aminophenylglyoxaline hydrochloride and sodium nitroprusside, a green coloration changing to chestnut-brown is produced.

On the addition of dilute sulphuric acid to an aqueous solution of the base or its hydrochloride, the very sparingly soluble sulphate crystallises in woolly needles.

The *dihydrochloride* crystallises from dilute hydrochloric acid in colourless prisms, which do not melt below 300°. It is readily soluble in cold, very readily so in hot water.

Found: Cl = 28·6; N = 22·5.

$C_9H_{10}N_4,2HCl$ (247·1) requires Cl = 28·7; N = 22·7 per cent.

The *dipicrate* forms yellow, silky needles, which darken at 245° and decompose at 250° (corr.). It is very sparingly soluble even in boiling water.

The benzylidene derivative of 2-amino-4-*p*-aminophenylglyoxaline was not obtained in a crystalline form.

2-*Acetylamino*-4-p-*acetylaminophenylglyoxaline*.

10·6 Grams of 2-amino-4-*p*-aminophenylglyoxaline were boiled with 50 c.c. of acetic anhydride for one hour under a reflux condenser and mixed with aqueous sodium carbonate, when 13·9 grams of the diacetyl derivative were obtained, that is, 98 per cent. of the theoretical yield. The base forms a colourless, crystalline powder which does not melt below 300°.

Found: N = 21·2.

$C_{13}H_{14}O_2N_4$ (258·2) requires N = 21·7 per cent.

It dissolves in dilute hydrochloric acid, but the hydrochloride crystallises almost at once. It appears to be changed by prolonged boiling with hydrochloric acid.

The *hydrochloride* was consequently prepared by triturating the base with an excess of 10 per cent. aqueous hydrochloric acid, draining the insoluble salt, and crystallising it from water, when it

formed colourless, prismatic needles, which did not melt below 300°. It is sparingly soluble in cold, fairly readily so in hot water.

Found, in air-dried salt, loss at 110° = 11·1.

$C_{13}H_{14}O_2N_4,HCl,2H_2O$ (330·7) requires $2H_2O$ = 10·9 per cent.

Found, in salt dried at 110°, C = 53·1; H = 5·3; N = 18·7; Cl = 11·6.

$C_{13}H_{14}O_2N_4,HCl$ (294·7) requires C = 53·0; H = 5·1; N = 19·0; Cl = 12·0 per cent.

Oxidation.—Ten grams of 2-acetylamino-4-*p*-acetylaminophenylglyoxaline were suspended in 150 c.c. of cold water and mixed with 4 grams of 50 per cent. aqueous sulphuric acid, when a suspension of the sulphate resulted. To this, cold 4 per cent. aqueous potassium permanganate was added until a test portion of the product remained pink for a few seconds, about 240 c.c. being required. The liquor was then filtered from manganese hydroxide, acidified with hydrochloric acid, and extracted with ether. The ethereal extract amounted to 1·5 grams, and after digestion with a little warm water left 1·0 gram of *p*-acetylaminobenzoic acid, which melted at 260° (corr.). After recrystallisation from boiling water, the acid formed glistening needles having the same melting point. A specimen of the pure acid from another source and a mixture of the two melted at the same temperature. The identification was confirmed by analysis (Found: C = 59·9; H = 5·2; N = 7·8. Calc.: C = 60·3; H = 5·1; N = 7·8 per cent.) and by hydrolysis to *p*-aminobenzoic acid, which melted at 190° (corr.) alone or mixed with the acid resulting from the reduction of *p*-nitrobenzoic acid.

Reduction of 2-Benzeneazoglyoxaline with Zinc Dust and Acetic Acid: Isolation of Glycocyamidine, Aniline, and 2-Amino-4-p-aminophenylglyoxaline.

To a boiling solution of 17·2 grams of 2-benzeneazoglyoxaline in 100 c.c. of glacial acetic acid and 300 c.c. of water, 45 grams of zinc dust were added gradually in the course of twenty minutes without further heating. The excess of zinc was removed, the liquor diluted with 2 litres of water, giving an indigo-coloured solution, and treated with hydrogen sulphide. After collecting the zinc sulphide—which had carried down the colouring matter—the liquor was mixed with 20 c.c. of hydrochloric acid and evaporated to dryness. The residue was dissolved in a little water, mixed with sodium carbonate, and extracted with ether, when 2·7 grams of insoluble, black material were deposited; this contained zinc

carbonate and the carbonate of 2-amino-4-*p*-aminophenylglyoxaline. The ethereal extract left on evaporation 7·0 grams of practically pure aniline. The alkaline liquor was acidified faintly with hydrochloric acid, mixed with a solution of 23 grams of picric acid in 1 litre of boiling water, and stirred, when 2·6 grams of 2-amino-4-*p*-aminophenylglyoxaline dipicrate separated immediately as a brownish-yellow, crystalline powder which melted at 240°; for the identification of this substance, the hydrochloride and base were prepared and found to have the properties recorded above.

The filtrate from this salt was kept overnight, when 21·5 grams of a granular, crystalline picrate, melting at 196°, separated, and on concentrating the mother liquor a further 4·8 grams, melting at 180°, were obtained. These crops were mixed, converted into the hydrochloride, and crystallised from alcohol, when eventually 5·9 grams of pure glycocyamidine hydrochloride were obtained, that is, 43 per cent. of the theoretical yield. It formed clusters of prismatic needles, which began to darken and sinter at 205° and melted at 211—213° (corr.). E. Schmidt (*Arch. Pharm.*, 1913, **251**, 557) states that it begins to discolour at 200° and melts at 208—210° (Found: C=26·5; H=4·4; N=30·6; Cl=26·3. $C_3H_5ON_3$,HCl (135·6) requires C=26·6; H=4·5; N=31·0; Cl=26·2 per cent.).

To complete the identification of this compound, the base and some other salts were prepared. The base crystallised from water in colourless, prismatic needles, which began to darken slowly from about 220° and quickly from about 250°, without melting even at 300°. It was anhydrous. (Found: C=36·4; H=4·8; N=42·3. $C_3H_5ON_3$ (99·1) requires C=36·3; H=5·1; N=42·4 per cent.) E. Schmidt (*loc. cit.*) states that glycocyamidine darkens from 220°, but does not melt at 250°. It gave with sodium nitroprusside and sodium hydroxide an orange solution, which became Burgundy-red on the addition of acetic acid (Weyl's reaction). It is stable towards cold aqueous permanganate in acid solution, but reduces cold alkaline permanganate, yielding a green solution.

The platinichloride was obtained on spontaneous evaporation of an aqueous solution in large, transparent, quadrilateral tablets having the composition $C_3H_5ON_3,H_2PtCl_6,2H_2O$. It begins to darken at 220°, gradually sinters, and is quite black by 260° without actually melting even at 300°. E. Schmidt (*loc. cit.*) found that glycocyamidine platinichloride had this composition and did not melt at 260°, but sintered and blackened earlier.

The platinichloride was also obtained in an anhydrous form by crystallisation from a hot concentrated solution, when it formed clusters of prisms.

The additive compound with gold chloride, $C_3H_5ON_3,AuCl_3$, melted at 157—158° (corr.). Korndörfer (*Arch. Pharm.*, 1904, **242**, 633) found that glycocyamidine gold chloride had this composition, and melted at 153—154°.

The picrate crystallised from water in glistening, striated, yellow leaflets (flat needles) which melted at 215—216° (corr.). Jaffé (*Zeitsch. physiol. Chem.*, 1906, **48**, 430) describes glycocyamidine picrate as forming needles, which melt at 210°.

2- *and* 4-p-*Bromobenzeneazoglyoxaline.*

34·4 Grams of *p*-bromoaniline in 200 c.c. of hydrochloric acid and 600 c.c. of water were diazotised at −2° to 0° by a solution of 14·4 grams of sodium nitrite in 72 c.c. of water. The solution was kept for twenty minutes and poured in a slow stream into a solution of 13·6 grams of glyoxaline and 300 grams of sodium carbonate crystals in 2 litres of water, previously cooled to 5°. After adding a little more aqueous sodium carbonate, the mixture was kept overnight, and the insoluble, yellow powder collected and washed with water. It amounted to 48·7 grams after drying in the air, decomposed at 245°, and was almost completely soluble in dilute hydrochloric acid. After fractional crystallisation from alcohol, there were obtained 37·5 grams of pure 2-p-*bromobenzeneazoglyoxaline* and 5·1 grams scarcely less pure, whilst the final mother liquors deposited a mixture of this compound with dark brown warts, which were separated mechanically, and amounted to about 2·5 grams, melting at about 175°. These were dissolved in dilute hydrochloric acid, and the solution was filtered from a little dark brown, insoluble matter and mixed with ammonia, when a yellow, gelatinous precipitate was formed, which readily became crystalline on warming and stirring. This base was collected and crystallised several times from alcohol, when 4-p-*bromobenzeneazoglyoxaline* was obtained in a pure state.

2-p-*Bromobenzeneazoglyoxaline* crystallises from alcohol in chestnut-brown, prismatic needles, which melt and decompose at 253° (corr.).

Found: C = 42·9; H = 3·1; N = 22·1.

$C_9H_7N_4Br$ (251·1) requires C = 43·0; H = 2·8; N = 22·3 per cent.

4-p-*Bromobenzeneazoglyoxaline* crystallises from alcohol in clusters of brownish-yellow prisms which melt and decompose at 191° (corr.).

Found: C = 43·2; H = 3·1; N = 21·9.

$C_9H_7N_4Br$ (251·1) requires C = 43·0; H = 2·8; N = 22·3 per cent.

On reducing this base (0·26 gram) with stannous chloride and distilling the resulting solution with an excess of sodium hydroxide, the volatile products consisted of *p*-bromoaniline (0·18 gram) and ammonia, which gave 0·05 gram of ammonium chloride.

Reduction of 2-p-*Bromobenzeneazoglyoxaline with Stannous Chloride: Isolation of* 2-*Aminoglyoxaline*, p-*Bromoaniline*, *Guanidine*, 2-*Amino*-4-p-*aminophenylglyoxaline*, *and a Base*, $C_9H_9N_4Br$.

To 78 grams of 2-*p*-bromobenzeneazoglyoxaline suspended in 40 c.c. of hydrochloric acid and 1 litre of boiling water, 400 c.c. of stannous chloride solution were added. The solution immediately became decolorised, and, after the removal of 0·5 gram of brown, insoluble matter, was concentrated under diminished pressure. The tin salts which separated were collected from time to time and combined, so that the product was obtained in two fractions, consisting of the crystalline tin salts and the syrupy residue.

The crystalline tin salts were dissolved in water and deprived of tin by hydrogen sulphide. The solution of hydrochlorides was evaporated to dryness, dissolved in a little water, and mixed with aqueous sodium carbonate, when 39·6 grams of *p*-bromoaniline separated. The filtrate from this gave a further 1·1 grams of the same compound on extraction with ether, and was next acidified with hydrochloric acid, evaporated to dryness, and extracted with absolute alcohol. (Insoluble material = *A*.) On distilling the alcohol, a brown syrup remained, which quickly crystallised and became a rock-like mass of 2-aminoglyoxaline hydrochloride, amounting to 15·8 grams and melting at 135—140°.

The syrupy tin salts were also dissolved in water and deprived of tin. The resulting solution was evaporated to dryness, dissolved in a little water, mixed with sodium carbonate, and extracted with ether. This, on concentration, deposited 0·9 gram of colourless needles, melting at 178° (corr.), which proved to be a *base* having the composition $C_9H_9N_4Br$ (compare p. 245). The ethereal mother liquor on evaporation left 2·5 grams of dark brown syrup which gradually crystallised, and consisted largely of *p*-bromoaniline.

The alkaline liquor was acidified with hydrochloric acid, evaporated to dryness under diminished pressure, and extracted with absolute alcohol. The insoluble salts, consisting mainly of sodium chloride, were combined with those obtained previously (*A*), dissolved in water, and mixed with aqueous picric acid, when 2·7 grams of 2-amino-4-*p*-aminophenylglyoxaline dipicrate, melt-

ing at 240°, separated; the identity of this salt was confirmed by its conversion into the hydrochloride and base. The alcoholic extract was evaporated under diminished pressure, and left 13·0 grams of brown syrup, which crystallised only partly on seeding with 2-aminoglyoxaline hydrochloride. It was converted into the stannichloride and crystallised fractionally from 10 per cent. hydrochloric acid, when 10·2 grams of 2-aminoglyoxaline stannichloride melting at 280° (corr.) were obtained. This is equivalent to 4·9 grams of 2-aminoglyoxaline hydrochloride, the total yield of which was therefore 20·7 grams, that is, 56 per cent. of the theoretical.

The remaining stannichlorides were not readily purified by fractional crystallisation, and were reconverted into hydrochlorides, which amounted to about 3 grams. This material was mixed with sodium carbonate, evaporated until nearly dry, and extracted with hot alcohol.* The extract was distilled and the residue mixed with an excess of 10 per cent. aqueous oxalic acid, when 1·6 grams of guanidine hydrogen oxalate separated in large crystals. After recrystallisation from water, this salt formed colourless spears, which melted at 173—174° (corr.) after drying at 100°, and was sparingly soluble in water.

It had the composition $CH_5N_3,C_2H_2O_4,H_2O$ previously recorded by Strecker (*Annalen*, 1861, **118**, 160). (Found: $H_2O=10·3$. Calc.: $H_2O=10·8$. Found, in dried salt, C = 24·0; H = 4·9; N = 28·0. Calc.: C = 24·1; H = 4·7; N = 28·2 per cent.) The melting point of a specimen of guanidine hydrogen oxalate prepared synthetically and that of a mixture of the two preparations was the same. The identification was confirmed by the preparation of the nitrate and picrate, which had the properties previously recorded.

The *base*, melting at 178° (corr.), obtained as a by-product in the above reaction (compare p. 244), forms colourless needles from alcohol or ether. It contains halogen. It is sparingly soluble in water, readily so in cold, and very easily soluble in hot alcohol, but sparingly so in ether. Its alcoholic solution gradually becomes purple when exposed to the air.

Found: C = 43·0; H = 3·9; N = 21·9.
$C_9H_9N_4Br$ (253·1) requires C = 42·7; H = 3·6; N = 22·1 per cent.

0·122 Gram mixed with an excess of hydrochloric acid and evaporated to dryness gave 0·153 gram of salt, which is therefore

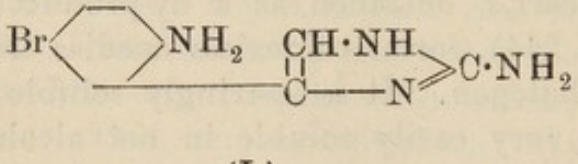
* The method employed for the extraction of guanidine carbonate is unsuitable, and it is probable that a considerable proportion remained behind with the sodium carbonate.

a *dihydrochloride* (calc. yield, 0·157 gram). This salt crystallised from water in elongated leaflets, which, after drying at 100°, melted and decomposed at 245° (corr.) after sintering earlier. The *(di)picrate* crystallises from water in woolly needles, which melt at 225° (corr.), and are sparingly soluble in hot, very sparingly so in cold water.

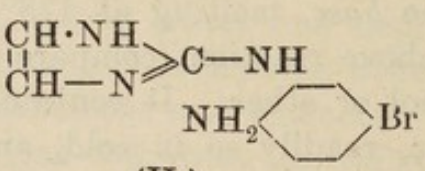
The base decolorises potassium permanganate instantly in cold dilute sulphuric acid solution, and gives a Burgundy-red coloration with sodium diazobenzene-*p*-sulphonate in aqueous sodium carbonate. When dissolved in dilute hydrochloric acid and mixed with sodium nitrite, it yields a colourless, crystalline precipitate, but the product—crystals and mother liquor—when poured into alkaline β-naphthol gives no coloration.

When an aqueous solution of the hydrochloride is mixed with sodium acetate and benzaldehyde, a turbid, yellow solution is produced—evidently owing to the formation of a benzylidene compound.

The composition and mode of formation of the base indicate that it is 2-*p*-bromobenzenehydrazoglyoxaline, or a substance resulting from this by the benzidine or semidine change. The formation of a dihydrochloride and a benzylidene derivative rule out the first suggestion, whilst the formation of the latter compound also eliminates the semidine-type formula III given below. This formula and the benzidine-type formula I are also incompatible with the behaviour of the compound on treatment with nitrous acid and sodium β-naphthoxide, but the semidine-type formula II, representing 2-5′-*bromo*-2′-*aminoanilinoglyoxaline*, admits the possibility of *o*-diazoimine formation with nitrous acid, and is in harmony with all the observed properties of the compound (compare p. 223).



(I.)



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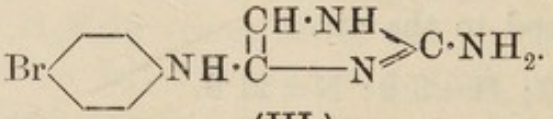


(III.)

2-Aminoglyoxaline (XII, p. 223).

For the purification of 2-aminoglyoxaline, crystallisation of the stannichloride and hydrogen oxalate has proved to be useful.

The free *base* can be obtained (1) from the hydrochloride by the

addition of an equivalent quantity of sodium carbonate, evaporation to dryness, and extraction with alcohol, and (2) from the hydrogen oxalate by treatment with aqueous barium hydroxide, removal of the excess of this by carbon dioxide, and evaporation of the solution under diminished pressure. In either case, it is obtained as a nearly colourless syrup which gradually turns brown on keeping. It is miscible with water and alcohol, sparingly soluble in chloroform, but hardly soluble in ether or benzene.

The *hydrochloride* crystallises from absolute alcohol in long, colourless plates which melt at 152° (corr.). It is deliquescent, and readily soluble in cold, very readily so in hot absolute alcohol. Its aqueous solution reacts neutral to litmus.

Found: C = 30·2; H = 5·2; N = 34·7; Cl = 29·9.
$C_3H_5N_3,HCl$ (119·5) requires C = 30·1; H = 5·1; N = 35·1; Cl = 29·7 per cent.

The *stannichloride* crystallises from two to two and a-half times its weight of 10 per cent. hydrochloric acid in prismatic needles, which are anhydrous and melt at 286° (corr.). It is readily soluble in water.

Found: Cl = 42·4.
$(C_3H_5N_3)_2,H_2SnCl_6$ (499·6) requires Cl = 42·6 per cent.

The *nitrate* separates from water in large, transparent tablets, which are anhydrous, and, after drying at 100°, sinter from about 125° and melt at 135—136° (corr.).

Found: N = 38·2.
$C_3H_5N_3,HNO_3$ (146·1) requires N = 38·4 per cent.

The *hydrogen oxalate* crystallises from water in large, colourless tablets, which are anhydrous and melt and effervesce at 211° (corr.). It is sparingly soluble in cold, readily so in hot water.

Found: N = 24·0.
$C_3H_5N_3,C_2H_2O_4$ (173·1) requires N = 24·3 per cent.

The *picrate* separates from water in long, glistening, silky needles, or in short, prismatic needles, both melting at 236° (corr.) after drying at 100°. It is sparingly soluble in cold, fairly readily so in hot water.

Reactions of 2-Aminoglyoxaline.—2-Aminoglyoxaline hydrochloride dissolved in dilute aqueous copper sulphate gives on the addition of sodium hydroxide a green precipitate, which rapidly darkens and becomes purple-brown. The same precipitate—evidently a copper salt—is obtained eventually with Fehling's solution; no reduction of this solution takes place even on boiling. 2-Aminoglyoxaline nitrate in aqueous silver nitrate gives a white

precipitate on the addition of ammonia; this precipitate is soluble in excess of ammonia, and the solution deposits metallic silver on heating.

2-Aminoglyoxaline hydrochloride in aqueous solution decolorises aqueous potassium permanganate instantly; with ferric chloride, it gives no coloration. With sodium diazobenzene-*p*-sulphonate in aqueous sodium carbonate, it gives a deep red colour. On the addition of sodium nitrite to aqueous 2-aminoglyoxaline hydrochloride, a clear, yellow solution is produced which gives a soluble, brownish cherry-coloured dye with β-naphthol in aqueous sodium hydroxide. An aqueous solution of 2-aminoglyoxaline hydrochloride mixed with dilute aqueous sodium nitroprusside gives, on the addition of sodium hydroxide, a deep blue colour, which slowly changes to a bright chestnut on keeping.

2-Aminoglyoxaline is very stable towards hot acids and alkalis. When boiled with 10 per cent. aqueous sodium hydroxide, no ammonia is evolved, and it can be recovered unchanged from the solution. It can be recovered mainly unchanged after heating with concentrated hydrochloric acid for three hours at 170°, and even after three hours at 200° a small proportion can be recovered, together with ammonium chloride and other unidentified products.

An aqueous solution of 2-aminoglyoxaline hydrochloride containing an excess of sodium acetate gives no coloration or other evidence of the formation of a benzylidene derivative when mixed with benzaldehyde.

2-*Acetylaminoglyoxaline* was prepared by boiling 2-aminoglyoxaline hydrochloride with anhydrous sodium acetate and acetic anhydride for one hour, and mixing the product with aqueous sodium carbonate. It crystallises from water in small prisms which melt to a brown liquid at 287° (corr.), after sintering and darkening from about 270°. It is anhydrous and sparingly soluble in cold water, but fairly readily so in hot water.

Found: C = 47·7; H = 5·7; N = 33·4.
$C_5H_7ON_3$ (125·1) requires C = 48·0; H = 5·6; N = 33·6 per cent.

The reactions of this substance are described with those of the next compound.

2-*Benzoylaminoglyoxaline* was prepared by the Schotten-Baumann method. The crude product collected from the reaction liquor appears to be a di- or tri-benzoylaminoglyoxaline. After washing with ether to remove benzoic anhydride, it formed a nearly colourless, crystalline powder, which contained only a trace of chloride, but gave an odour of benzoyl chloride when boiled with dilute hydrochloric acid. When treated with a little hot alcohol,

it dissolved, and 2-benzoylaminoglyoxaline crystallised from the hot liquor, whilst the mother liquor from this left an oil—apparently ethyl benzoate—on distillation. 2-Benzoylaminoglyoxaline was purified by crystallisation from alcohol, from which it separates in glistening leaflets, melting at 227° (corr.) after sintering earlier. It is sparingly soluble even in hot alcohol, and almost insoluble in boiling water.

Found: C = 63·9; H = 4·9; N = 22·4.
$C_{10}H_9ON_3$ (187·1) requires C = 64·1; H = 4·9; N = 22·5 per cent.

2-Acetylaminoglyoxaline and 2-benzoylaminoglyoxaline are soluble in dilute hydrochloric acid and in aqueous sodium hydroxide, but not in aqueous sodium carbonate. They give cherry-red solutions with sodium diazobenzene-*p*-sulphonate in sodium carbonate, but do not give colorations with sodium nitroprusside and sodium hydroxide. They do not change the colour of cold aqueous acid permanganate, but give green solutions with cold aqueous permanganate in sodium hydroxide solution. When mixed with hydrochloric acid and sodium nitrite, they do not couple with β-naphthol in aqueous sodium hydroxide.

The Benzeneazo-4-methylglyoxalines.

37·2 Grams of aniline in 100 c.c. of hydrochloric acid and 300 c.c. of water were diazotised with 28·8 grams of sodium nitrite in 150 c.c. of water. The solution was run slowly into a solution of 32·8 grams of 4-methylglyoxaline and 100 grams of sodium hydrogen carbonate in 2 litres of water at 10° and kept overnight. The orange precipitate was collected, washed well with water (filtrate *F*), and triturated successively with 500, 250, and 250 c.c. of 2·5 per cent. aqueous hydrochloric acid. The insoluble fraction formed a dark red powder, which amounted to 23·2 grams, and decomposed at 175° after sintering from 160°. On crystallisation from 300 c.c. of alcohol, it gave 17·3 grams of pure 2:5-*bisbenzeneazo-4-methylglyoxaline*, the remainder of the material forming a black resin.

The hydrochloric acid extract was basified with sodium carbonate, and gave 40·4 grams of a yellow, crystalline powder, which sintered from 160° and decomposed at 195°. On crystallisation from 400 c.c. of alcohol, it gave, successively, 13·1 grams melting at 235°, 3·9 grams melting at 232°, which both gave 5-*benzeneazo-4-methylglyoxaline* on recrystallisation, then 7·4 grams melting at 175°, which gave 2-*benzeneazo-4-methylglyoxaline* on recrystallisation, then 12·4 grams of a mixture of the two compounds.

Owing to the formation of the bis-compound in the above reaction, the benzenediazonium chloride employed was insufficient to combine with the whole of the methylglyoxaline present, and it was calculated that 10·5 grams of this remained in the filtrate *F*. This was accordingly treated with a diazo-solution prepared from 11·9 grams of aniline, and gave further quantities of the substances described above, 5·3 grams of the bis-compound and 5·6 grams of 5-benzeneazo-4-methylglyoxaline being obtained in a nearly pure state.

2-*Benzeneazo*-4-*methylglyoxaline* (XIV, p. 224) crystallises from alcohol in orange prisms, which melt at 185° (corr.).

Found: C = 64·8; H = 5·6; N = 30·1.

$C_{10}H_{10}N_4$ (185·2) requires C = 64·5; H = 5·4; N = 30·1 per cent.

5-*Benzeneazo*-4-*methylglyoxaline* (XVIII, p. 224) crystallises from alcohol in flat, glistening, copper-coloured needles, which melt and decompose at 240° (corr.).

Found: C = 64·5; H = 5·6; N = 30·0.

$C_{10}H_{10}N_4$ (185·2) requires C = 64·5; H = 5·4; N = 30·1 per cent.

2:5-*Bisbenzeneazo*-4-*methylglyoxaline* separates from alcohol in prismatic needles and from ethyl acetate in cubes. Both forms are garnet-red in colour and melt and decompose at 206° (corr.).

Found: C = 66·0, 65·9; H = 5·1, 5·1; N = 28·8, 28·8.

$C_{16}H_{14}N_6$ (290·2) requires C = 66·2; H = 4·9; N = 29·0 per cent.

This substance is readily soluble in alcohol, ethyl acetate, or acetone, fairly readily so in chloroform, but sparingly so in ether or benzene.

It is soluble in aqueous sodium hydroxide, and is reprecipitated unchanged on the addition of acetic acid. It is only very sparingly soluble in dilute hydrochloric acid. When boiled with 10 per cent. aqueous hydrochloric acid, it is quickly resinified with effervescence, doubtless due to nitrogen, and the production of an odour of phenol.

Reduction of 2-Benzeneazo-4-methylglyoxaline with Stannous Chloride.

1·5 Grams of 2-benzeneazo-4-methylglyoxaline gave 1·4 grams of 2-amino-5-*p*-aminophenyl-4-methylglyoxaline dihydrochloride when reduced with stannous chloride in the manner previously described for the lower homologue (p. 238).

2-*Amino*-5-p-*aminophenyl*-4-*methylglyoxaline dihydrochloride* crystallises from water in diamond-shaped plates, which are anhydrous and do not melt below 300°. It is readily soluble in cold, very readily so in hot water.

Found: C=46·0, 45·9; H=5·5, 5·5.

$C_{10}H_{12}N_4,2HCl$ (201·0) requires C=46·0; H=5·4 per cent.

When boiled with an excess of aqueous sodium carbonate and animal charcoal, it yields the *monohydrochloride*, unlike the lower homologue, which yields the corresponding base under this treatment.

The *monohydrochloride* crystallises from alcohol in flat needles which sinter at about 80°, become discoloured rapidly about 240°, and melt at 260° (corr.). It is readily soluble in hot water or alcohol, less so in these solvents when cold.

Found, in air-dried base, loss at 60° in a vacuum, 13·2, 13·3.

$C_{10}H_{12}N_4,HCl,2\frac{1}{2}H_2O$ requires loss of $2H_2O$=13·4 per cent.

Found, in base so dried: C=51·5; H=5·6; N=24·0, 24·0; Cl=14·9.

$C_{10}H_{12}N_4,HCl,\frac{1}{2}H_2O$ (233·7) requires C=51·4; H=6·0; N=24·0; Cl=15·2 per cent.

The *dipicrate* forms glistening yellow needles, which melt and decompose at 255° (corr.) after darkening earlier. It is very sparingly soluble even in boiling water.

An aqueous solution of the hydrochloride reduces cold ammoniacal silver nitrate. It gives, with Fehling's solution, a greyish-green precipitate, which becomes pale brown on boiling the liquor; with cold aqueous acid permanganate, instant reduction; with sodium diazobenzene-*p*-sulphonate, a pale orange colour, which deepens on keeping; with hydrochloric acid and sodium nitrite, an orange-yellow solution, which yields a sparingly soluble claret dye when added to a solution of β-naphthol in aqueous sodium hydroxide. On the addition of sodium hydroxide to an aqueous solution of the hydrochloride and sodium nitroprusside, an orange colour is produced, which changes to green on the addition of acetic acid.

The *diacetyl* derivative was prepared by the action of sodium acetate and acetic anhydride on the dihydrochloride, and was purified by crystallisation of the hydrochloride.

2-*Acetylamino*-5-p-*acetylaminophenyl*-4-*methylglyoxaline hydrochloride* crystallises from water in felted, silky needles, which are sparingly soluble in cold water, contain $4H_2O$, and, after drying at 100°, melt and decompose at 303° (corr.).

Found, in air-dried salt, loss at 100°=19·0.

$C_{14}H_{16}O_2N_4,HCl,4H_2O$ requires H_2O=18·9 per cent

Found, in salt dried at 100°, Cl=11·4.

$C_{14}H_{16}O_2N_4,HCl$ (308·7) requires Cl=11·5 per cent.

On adding ammonia to an aqueous solution of the hydrochloride, the base was precipitated in minute, glistening needles, which, after drying at 100°, melted to a red liquid at 280° (corr.).

Monobenzylidene Derivative.—To 0·5 gram of the dihydrochloride in 5 c.c. of water there were added, first, 0·55 gram of sodium acetate in 5 c.c. of water, and then 0·5 c.c. of benzaldehyde, and the mixture was stirred. A yellow colour was developed, and the aqueous liquor became turbid and gradually deposited crystals. On adding a few drops of acetic acid and ether, the quantity of crystals was increased. They were collected and washed with water and ether, when there remained 0·5 gram of a pale yellow, crystalline powder, which proved to be the *acetate* of 2-*amino*-5-*p*-*benzylideneaminophenyl*-4-*methylglyoxaline*. When dried at 100°, it melts and decomposes at 208° (corr.), after sintering and darkening earlier.

Found, in substance dried in a vacuum, C=67·2; H=6·2; N=16·2.*

$C_{17}H_{16}N_4,C_2H_4O_2$ (336·3) requires C=67·8; H=6·0; N=16·7 per cent.

This salt is very sparingly soluble in cold water, but slightly so in boiling water, with which, however, it gives an odour of benzaldehyde, and thus appears to suffer hydrolysis. When mixed with aqueous sodium carbonate, it yields the base as a deep yellow, insoluble gum, which could not be obtained in crystalline form. When the acetate is moistenel with 10 per cent. aqueous hydrochloric acid, it turns red, but does not dissolve until the mixture is warmed, when the red colour disappears.

Reduction of 2-Benzeneazo-4-methylglyoxaline with Zinc Dust and Acetic Acid.

Two grams of the azo-compound were reduced by the method applied to the lower homologue (p. 241) and worked up in the same manner as far as the removal of the aniline by extraction with ether. The solvent removed 0·65 gram of crude aniline. The alkaline liquor remaining was acidified with hydrochloric acid, evaporated to dryness, and extracted with absolute alcohol, when 1·4 grams of brown syrup were removed. This, when dissolved in a little absolute alcohol and kept, deposited 0·7 gram of nearly pure alacreatinine hydrochloride.

This was converted into the picrate, when a very small quantity of 2-amino-5-*p*-aminophenyl-4-methylglyoxaline dipicrate separated

* The substance left a trace of ash on combustion.

from the hot solution, whilst, on cooling, alacreatinine picrate crystallised out. After recrystallisation, the salt was obtained in a pure state, and was converted into the base and hydrochloride by the usual methods.

Alacreatinine crystallises from water in stout, elongated prisms which resemble carbamide, and contain $1H_2O$, as previously stated by Baumann (*Annalen*, 1873, **167**, 83). After drying at 100°, it melts at 222—223° (corr.). (Found, in air-dried salt, $H_2O = 13{\cdot}6$. Calc.: 13·7. Found, in dried salt, C = 42·4; H = 6·3; N = 36·9. Calc.: C = 42·5; H = 6·2; N = 37·1 per cent.)

It does not give Weyl's reaction, and does not reduce cold aqueous acid permanganate, but gives a green solution with cold alkaline permanganate.

The *hydrochloride* crystallises from absolute alcohol in clusters of prisms, which are anhydrous and melt at 202—203° (corr.). It is very readily soluble in water, sparingly soluble in cold, fairly readily so in hot alcohol.

Found: Cl = 23·6.

$C_4H_7ON_3,HCl$ (149·6) requires Cl = 23·7 per cent.

The *picrate* separates from water in yellow, prismatic needles, which are anhydrous and melt and decompose at 212° (corr.) after sintering from about 200°. It is sparingly soluble in cold, fairly readily so in hot water.

Found: N = 24·5.

$C_4H_7ON_3,C_6H_3O_7N_3$ (342·2) requires N = 24·6 per cent.

Reduction of 5-Benzeneazo-4-methylglyoxaline with Stannous Chloride.

Fourteen grams of the azo-compound were dissolved in a boiling mixture of 70 c.c. of 10 per cent. aqueous hydrochloric acid and 140 c.c. of water, and mixed with 80 c.c. of stannous chloride solution. The crystalline and residual tin salts were separated as in the experiments described earlier, and decomposed separately by hydrogen sulphide. The crystalline salts gave a solution of hydrochlorides, which, when evaporated nearly to dryness and mixed with alcohol, left 6·1 grams of ammonium chloride undissolved. (Alcoholic mother liquor = *A*.) The residual salts gave a solution of hydrochlorides, which on concentration deposited 1·7 + 0·5 grams of the *hydrochloride*, $C_9H_{10}ON_2,HCl$, described below, and on further concentration and addition of alcohol gave 1·5 grams of ammonium chloride. The alcoholic mother liquor was combined

with *A*, and gave 4·7 grams of aniline, together with 3·8 grams of a brown, gummy, hydrochloride. This was a mixture from which only very small quantities of crystalline compounds were isolated by various methods of treatment.

The *hydrochloride*, $C_9H_{10}ON_2,HCl$, crystallises from water in colourless, transparent, rectangular tablets, which melt and effervesce at 308° (corr.) after sintering and darkening earlier. It is readily soluble in hot, less so in cold water, giving a solution which is strongly acid to litmus.

Found, in air-dried salt, loss at 110° = 1·7.

Found, in salt dried at 110°: C = 54·8, 54·8, 55·0; H = 5·9, 5·0, 5·2; N = 13·5; Cl = 17·2.

$C_9H_{10}ON_2,HCl$ (198·6) requires C = 54·4; H = 5·6; N = 14·1; Cl = 17·8 per cent.

The corresponding *base* is obtained by adding ammonia to a concentrated aqueous solution of the hydrochloride. It crystallises from water in brilliant, elongated prisms, which are anhydrous and melt at 185° (corr.).

Found: C = 66·6, 66·1; H = 6·2, 6·1; N = 17·8, 17·2.

$C_9H_{10}ON_2$ (162·1) requires C = 66·6; H = 6·2; N = 17·3 per cent.

The base is more readily soluble in dilute aqueous sodium hydroxide than in water. With silver nitrate it yields a white precipitate, which dissolves on the addition of ammonia; on boiling this solution, no reduction takes place. The base does not reduce Fehling's solution on boiling.

It is stable towards cold aqueous acid potassium permanganate, but slowly reduces cold alkaline permanganate, giving a green solution. It gives no coloration with sodium diazobenzene-*p*-sulphonate in aqueous sodium carbonate. When dissolved in hydrochloric acid and mixed with sodium nitrite, it fails to couple with β-naphthol in aqueous sodium hydroxide. The hydrochloride is recovered slightly charred, but otherwise unchanged, after the action of concentrated hydrochloric acid at 170° for two and a-half hours.

The quantity of this compound available was insufficient for the determination of its constitution, and we are consequently unable to offer any suggestion as to how one of the carbon atoms of the starting material has been eliminated. It is perhaps worth recording that the formula $C_9H_{10}ON_2$ is that of a phenyldihydroglyoxalone.

Reduction of 5-Benzeneazo-4-methylglyoxaline with Zinc Dust and Acetic Acid.

Ten grams of the azo-compound were dissolved in 150 c.c. of boiling 50 per cent. acetic acid and reduced by adding gradually 16 grams of zinc dust. After removing the zinc as sulphide, the liquor was mixed with 20 c.c. of hydrochloric acid, evaporated to a syrup, and mixed with alcohol, when 1·3 grams of ammonium chloride were collected. The alcoholic mother liquor was deprived of the solvent, dissolved in water, mixed with sodium carbonate, and shaken with ether, when 1·6 grams of the base, $C_{10}H_{11}ON_3$, described below, separated as a nearly colourless, insoluble, crystalline powder. The ethereal solution left on evaporation 3·3 grams of aniline. From the alkaline liquor, 5·5 grams of a mauve varnish were obtained, from which only small quantities of crystalline substances could be isolated by various methods of treatment.

The *base*, $C_{10}H_{11}ON_3$, crystallises from water in small, colourless, glistening, rhomboidal plates, which are anhydrous and melt at 265° (corr.). It is very sparingly soluble in cold water, rather more readily in boiling water.

Found: C = 63·7; H = 6·2; N = 22·0.
$C_{10}H_{11}ON_3$ (189·2) requires C = 63·5; H = 5·9; N = 22·2 per cent.

The *hydrochloride* crystallises from absolute alcohol in transparent, oblong plates which melt at 206—208° (corr.). It is readily soluble in water, concentrated hydrochloric acid, or hot alcohol. Its aqueous solution reacts strongly acid to litmus.

The base dissolves slowly in cold 10 per cent. aqueous sodium hydroxide, readily on warming, and a well-crystallised sodium salt separates from the solution in prismatic needles. This salt is decomposed by carbon dioxide with the regeneration of the base. A solution of the base in aqueous sodium hydroxide gives with Fehling's solution no change in the cold, but a green precipitate on boiling. A solution of the base in nitric acid gives no precipitate with silver nitrate, but on the addition of ammonia a white precipitate, which dissolves on heating the solution, reappears on cooling, and is soluble in excess of ammonia. An aqueous solution of potassium permanganate is unaffected by a solution of the base in sulphuric acid, but turns green with a solution of the base in aqueous sodium hydroxide. The base does not couple with sodium diazobenzene-*p*-sulphonate in aqueous sodium carbonate, and when dissolved in hydrochloric acid and mixed with sodium nitrite does not couple with sodium β-naphthoxide.

When the hydrochloride is heated with concentrated hydrochloric

acid for two and a-half hours at 170°, it is decomposed, with the formation of ammonium chloride and a hydrochloride, which crystallises from alcohol in plates, melting and decomposing at about 280° (corr.).

4-Benzeneazo-2-methylglyoxaline.

This was prepared by the action of benzenediazonium chloride on 2-methylglyoxaline in aqueous sodium carbonate. The crude product readily resinified when boiled with alcohol, and only a small proportion was obtained in a pure state. It forms brick-red prisms, which melt at 158° (corr.) and are very readily soluble in alcohol.

Found: C = 64·3; H = 5·7; N = 30·0.
$C_{10}H_{10}N_4$ (186·2) requires C = 64·5; H = 5·4; N = 30·1 per cent.

4-p-Bromobenzeneazo-2-methylglyoxaline.

This was prepared in good yield by the action of *p*-bromobenzenediazonium chloride on 2-methylglyoxaline in aqueous sodium carbonate. It crystallises from absolute alcohol in red, rhomboidal prisms, which are anhydrous and melt and decompose at 200° (corr.).

Found: N = 21·0.
$C_{10}H_9N_4Br$ (265·1) requires N = 21·1 per cent.

From ordinary alcohol, it separates in elongated prisms, which lose 2·2 per cent. of water at 60° in a vacuum. This hydrated form melts at about 135° when heated quickly, and softens at this temperature when heated slowly, finally melting at about 190°. It can be dehydrated by crystallisation from absolute alcohol.

The reduction of this compound with either stannous chloride or zinc dust and acetic acid led to mixtures of products, from which no crystalline compounds except *p*-bromoaniline and ammonium chloride could be isolated.

2-Phenyl-4-p-bromobenzeneazoglyoxaline.

8·6 Grams of *p*-bromoaniline were diazotised and the liquor added to 7·2 grams of 2-phenylglyoxaline and 70 grams of hydrated sodium carbonate in 4 litres of water at 8°, the solution being vigorously stirred during the addition. Separation of an orange

precipitate began at once, but was not complete until forty-eight hours had elapsed. The crude product was crystallised from alcohol, and gave 13 grams of the pure azo-compound.

2-*Phenyl*-4-p-*bromobenzeneazoglyoxaline* crystallises from alcohol in clusters of fine, orange needles, which melt at 201° (corr.), and are anhydrous.

Found: N = 16·9.

$C_{15}H_{11}N_4Br$ (327·1) requires N = 17·1 per cent.

Reduction of 2-Phenyl-4-p-bromobenzeneazoglyoxaline with Stannous Chloride: Formation of a Base, $C_{15}H_{13}N_4Br$.

Two grams of the azo-compound were suspended in 20 c.c. of boiling 5 per cent. aqueous hydrochloric acid and mixed with 10 c.c. of stannous chloride solution. The solution was filtered quickly from a little resinous matter and mixed with 20 c.c. of concentrated hydrochloric acid, when a crystalline tin salt separated. This was deprived of tin, and the filtrate was evaporated to a small volume, when 0·85 gram of a crystalline hydrochloride separated.

This *hydrochloride* crystallises from dilute hydrochloric acid in nearly colourless needles, which, after drying in a vacuum, melt and decompose at 255° (corr.).

Found: C = 45·0; H = 3·8; N = 13·7.

$C_{15}H_{13}N_4Br,2HCl$ (402·0) requires C = 44·8; H = 3·8; N = 13·9 per cent.

0·1530 gave, by Carius's method, 0·1750 AgCl + AgBr. Calc., 0·1806.

It is sparingly soluble in cold water, more readily so in hot water. The aqueous solution gradually acquires a purple colour in the air or on the addition of acidified aqueous potassium permanganate. In the presence of an excess of hydrochloric acid, aqueous solutions are stable in the air. Sodium carbonate or ammonia precipitate the base as a grey, flocculent precipitate which is soluble in ether, the ethereal solution rapidly assuming a purple colour. On the addition of sodium hydroxide to an aqueous solution of the hydrochloride, a pale purple solution results. On adding sodium diazobenzene-*p*-sulphonate to a dilute solution of the compound in the presence of sodium carbonate, a dull purple colour is produced. An aqueous solution of the hydrochloride containing an excess of hydrochloric acid gives on the addition of

sodium nitrite a deep orange solution, which yields a sparingly soluble purple dye with sodium β-naphthoxide. On mixing a solution of the hydrochloride in dilute acetic acid with sodium acetate and benzaldehyde, there is evidence of the formation of a benzylidene derivative. When an aqueous solution of the hydrochloride is mixed with sodium nitroprusside, a pale buff precipitate is formed, which dissolves in sodium hydroxide, giving a deep red solution.

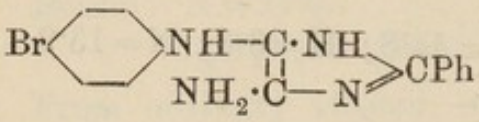
The *triacetyl* derivative was obtained by heating the hydrochloride for one hour on the water-bath with an excess of acetic anhydride and anhydrous sodium acetate. On heating the product with aqueous sodium carbonate, it separated as a slate-grey, crystalline powder, which did not melt at 300°.

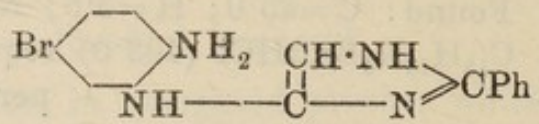
Found: C=55·2; H=4·1; N=12·6, 12·7; Br=17·3.

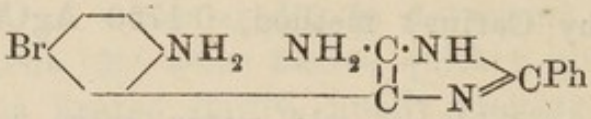
$C_{21}H_{19}O_3N_4Br$ (455·2) requires C=55·4; H=4·2; N=12·3; Br=17·6 per cent.

It is almost insoluble in boiling water or alcohol, and does not dissolve in dilute acids or in aqueous sodium hydroxide.

From its mode of formation, composition, and properties, it is clear that the hydrochloride, $C_{15}H_{13}N_4Br,2HCl$, arises from 2-phenyl-4-*p*-bromobenzenehydrazoglyoxaline by a change of the semidine or benzidine type, but it is not possible to decide definitely without further evidence which of the three formulæ given below represents its constitution.







2-p-*Sulphobenzeneazoglyoxaline*-4:5-*dicarboxylic Acid* (XX, p. 226).

20·8 Grams of sulphanilic acid were converted into diazobenzene-*p*-sulphonic acid, and the moist crystals (representing about 20 grams of dry substance) were added to a cold solution of 16 grams of glyoxaline-4:5-dicarboxylic acid in 240 c.c. of 10 per cent. aqueous sodium hydroxide. After keeping for one and a-half hours, the liquor was mixed with sufficient glacial acetic acid (36 c.c.) to neutralise the alkali, cooled, and kept for half an hour, when a mass of silky, yellow needles—the disodium salt of the new

acid, separated. These were recrystallised twice from 200 c.c. of water, and finally dissolved in 150 c.c. of hot water and mixed with 50 c.c. of hydrochloric acid, when 12 grams of 2-*p*-sulphobenzeneazoglyoxaline-4:5-dicarboxylic acid separated in red, microscopic prisms mixed with some smaller crystals of glyoxaline-4:5-dicarboxylic acid, from which it was purified by fractional crystallisation from water.

The acid separates from water with $2H_2O$, which is lost at 130° in a vacuum, but not at 100—110° under normal pressure.

Found, in air-dried substance, loss at 130° in a vacuum = 10·0; C = 35·5; H = 3·3; N = 15·1; S = 8·2.

$C_{11}H_8O_7N_4S,2H_2O$ (376·2) requires H_2O = 9·6; C = 35·1; H = 3·3; N = 14·9; S = 8·5 per cent.

It is sparingly soluble in cold water, but readily so in hot. It is soluble in aqueous alkalis, but not more soluble in dilute aqueous mineral acids than in water.

The *disodium* salt separates in yellow, silky needles, which contain $3H_2O$, when the acid is dissolved in aqueous sodium hydroxide and sufficient acetic acid is added to combine with the alkali. It is readily soluble in hot water, somewhat sparingly so in cold.

Found, in air-dried salt, loss at 100° = 11·6, 12·6.

$C_{11}H_6O_7N_4SNa_2,3H_2O$ (438·2) requires $3H_2O$ = 12·3 per cent.

Found, in salt dried at 100°, S = 8·2; N = 11·7.

$C_{11}H_6O_7N_4SNa_2$ (384·2) requires S = 8·4; N = 12·0 per cent.

Reduction of 2-p-Sulphobenzeneazoglyoxaline-4:5-dicarboxylic Acid: Formation of 2-Aminoglyoxaline-4:5-dicarboxylic Acid (XXI, p. 226).

6·2 Grams of the disodium salt were dissolved in 60 c.c. of 10 per cent. aqueous sodium hydroxide, mixed with 12 grams of sodium hyposulphite (80 per cent.), and boiled. The nearly colourless solution was kept overnight, acidified with hydrochloric acid, boiled, and filtered hot, when 1·6 grams of crude 2-aminoglyoxaline-4:5-dicarboxylic acid separated. This was purified by solution in aqueous sodium hydroxide, filtration, and reprecipitation with hydrochloric acid, and finally crystallised from about 500 c.c. of dilute hydrochloric acid.

2-Aminoglyoxaline-4:5-dicarboxylic acid forms minute, pale buff needles, which effervesce at 245° (corr.) and then melt. It is very sparingly soluble in cold water, a little more readily in hot.

Found, in substance dried at 110°, C = 34·6; H = 3·2; N = 24·6. $C_5H_5O_4N_3$ (171·1) requires C = 35·1; H = 3·0; N = 24·6 per cent.

It is soluble in aqueous alkalis, but not appreciably more soluble in dilute acids than in water. An aqueous solution, acidified with sulphuric acid, decolorises cold aqueous permanganate instantly. When treated with hydrochloric acid and sodium nitrite and poured into a solution of β-naphthol in aqueous sodium hydroxide, it gives a reddish-brown colour. With sodium diazobenzene-*p*-sulphonate in aqueous sodium carbonate, it gives a reddish-brown colour. It does not give any characteristic colour with sodium nitroprusside and sodium hydroxide.

Action of Water at 170°.—After a preliminary experiment, in which it was found that the product contained ammonium carbonate, 1·33 grams of the acid and 30 c.c. of water were heated in a sealed tube for twelve hours at 170°, when a dark brown deposit formed. After adding alkali and distilling into standard acid, 0·157 gram of ammonia was found, whereas 0·132 gram represents the liberation of one molecular proportion. From the residue of the distillation, small quantities of a crystalline picrate were isolated, but in insufficient amount for characterisation.

Action of Boiling Aniline.—0·9 Gram of the acid was boiled with 10 c.c. of aniline for six hours under a reflux condenser, in which a small quantity of ammonium carbonate collected. The product was distilled with steam to remove aniline, and left a pale brown, aqueous liquor containing some resinous matter. The liquor was cooled, filtered, and mixed with cold saturated aqueous picric acid, when 1·0 gram of a crystalline picrate, melting at about 215°, was obtained. After crystallising this from water twice, it gave 0·4 gram of 2-aminoglyoxaline picrate, melting at 234° (corr.), the pure substance melting at 236°, and a mixture of the two at 234° in the same bath. From the picrate, the hydrochloride and stannichloride were prepared, and identified as the salts of 2-aminoglyoxaline previously described.

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[*Received, February 7th,* 1919.]