CIII.—*Studies in the Malonic Acid Series.*

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THE halogen derivatives of malonic acid have been frequently subjected to close investigation, especially by Conrad and his pupils; this study led to the synthesis of polybasic acids and of a number of other interesting compounds. The readiness with which the bromine

* Pavy ('Physiology of the Carbohydrates,' p. 68) strongly recommends potash instead of soda. See also Moritz and Morris ('Text Book of the Science of Brewing,' "Fehling's Solution," p. 517).

in the bromo-derivatives of malonic acid is displaced by other groups is also shown by some observations which we have made on dibromomalonamide. The action of nitric acid on malonamide resembles that of the halogens, in that it gives rise to the formation of nitromalonamide, and this can readily be transformed into amidomalonic acid which A. Baeyer (*Annalen*, **131**, 291) discovered in the course of his investigations in the uric series. An account of the above indicated research is contained in this communication, together with the result of our experiments on the action of hydrazine hydrate on ethylic ethoxymethylenemalonate; the latter was undertaken with a view of ascertaining whether hydrazine behaves towards this derivative of malonic acid in the same way as phenylhydrazine does (Claisen and Haase, *Ber.*, 1895, **28**, 35), yielding ethylic pyrazolonecarboxylate, which one of us obtained from ethylic dicarboxyglutaconate (*Ber.*, 1894, **27**, 1658).

Diamidomalonamide.—On allowing dibromomalonamide, prepared according to Freund's directions (*Ber.*, 1884, **17**, 782), to remain in contact with a concentrated aqueous solution of ammonia for several days at the ordinary temperature, it is completely transformed into diamidomalonamide. The product, when collected and washed with alcohol, is free from bromine, and shows the characters of the compound which Conrad and Brückner (*Ber.*, 1891, **24**, 3002) obtained from ethylic dibromomalonate.* Its composition was verified by analysis of the product dried in a vacuum over sulphuric acid.

0.2158 gave 79.5 c.c. moist nitrogen at 16° and 746 mm. N = 42.13.

$C_3H_5O_2N_4$ requires N = 42.42 per cent.

Hydrazone of Mesoxalamide.—Hydrazine hydrate removes the halogen from dibromomalonamide, as does ammonia, with formation of the hydrazone of mesoxalamide. On adding the base to the dry amide, the action is so violent that it is advisable to dilute with alcohol; the action is completed by warming for a short time on the water bath. As the solution cools, it deposits long, colourless needles, which are somewhat soluble in cold but readily in boiling water, from which they can be recrystallised. The substance melts at 175°, gas being evolved. On analysis it gave numbers corresponding to the formula $(CONH_2)_2C:N:NH_2$.

0.2240 gave 0.2300 CO_2 and 0.0912 H_2O . C = 27.84; H = 4.52.

0.2010 „ 75 c.c. moist nitrogen at 20° and 767 mm. N = 43.08.

$C_3H_5N_4O_2$ requires C = 27.70; H = 4.61; N = 43.07 per cent.

The *phenylhydrazone of mesoxalamide* is formed by heating an

* We observed that the ethereal salt boils at 135–137° under a pressure of 13 mm., whilst, according to Conrad and Brückner, it distils at 145–155° under a pressure of 25 mm.

alcoholic solution of dibromomalonamide with the required quantity of phenylhydrazine on the water bath for about half an hour. The solution, on cooling, deposits long, yellow needles which are slightly soluble in cold and somewhat more readily in boiling alcohol. Glacial acetic acid, also, dissolves the substance, especially when boiling. It melts at 232—233°. A nitrogen determination agreed with the formula $(\text{CO}\cdot\text{NH}_2)_2\text{C}\cdot\text{N}\cdot\text{NH}\cdot\text{C}_6\text{H}_5$.

0.1970 gave 45 c.c. moist nitrogen at 15° and 764 mm. $\text{N} = 27.19$.

$\text{C}_9\text{H}_{10}\text{N}_4\text{O}_2$ requires $\text{N} = 27.18$ per cent.

Bromine and nitric acid act on the phenylhydrazone of mesoxalamide, forming bromo- and nitro-derivatives. The former is obtained by adding an excess of bromine gradually to the hydrazone dissolved in warm glacial acetic acid; the yellowish-brown precipitate which separates is collected, washed with alcohol, and dissolved in boiling glacial acetic acid; canary-yellow needles, which melt at 240°, crystallise from it. The following analyses lead to the formula

0.2950 gave 0.1973 AgBr. $\text{Br} = 28.44$.

0.2008 „ 34 c.c. moist nitrogen at 22° and 764 mm. $\text{N} = 19.27$.

0.1946 „ 33.8 c.c. „ 26° and 763 mm. $\text{N} = 19.34$.

$\text{C}_9\text{H}_9\text{BrN}_4\text{O}_2$ requires $\text{Br} = 28.07$; $\text{N} = 19.64$ per cent.

The nitrophenylhydrazone of mesoxalamide,

is prepared by adding fuming nitric acid carefully to a cold solution of the phenylhydrazone in glacial acetic acid; the deep yellow solution is poured on to ice, and the yellow precipitate produced, after being washed with water, is recrystallised from glacial acetic acid. It crystallises in yellow needles which decompose at 235°. On analysis the following numbers were obtained.

0.1988 gave 0.3126 CO_2 and 0.0682 H_2O . $\text{C} = 42.88$; $\text{H} = 3.81$.

0.2078 „ 50 c.c. moist nitrogen at 25° and 757 mm. $\text{N} = 26.71$.

0.1504 „ 36 c.c. „ 21° and 758 mm. $\text{N} = 27.17$.*

$\text{C}_9\text{H}_9\text{N}_5\text{O}_4$ requires $\text{C} = 43.02$; $\text{H} = 3.59$; $\text{N} = 27.88$ per cent.

The nitrophenylhydrazone of the mesoxalamide is readily decomposed by potash, producing a deep red solution, from which, on the addition of hydrochloric acid, a yellow substance is precipitated; this dissolves in glacial acetic acid, and separates from the solution in yellow needles, which decompose at 245°. This compound is most probably the phenylhydrazone of mesoxalic acid, formed by hydrolysis of the amide.

* The percentage of nitrogen found by analysis in substances of this class is always lower than that required by the formula.

Nitromalonamide.—Franchimont and Klobbie (*Rec. Trav. Chim.*, 8, 283) have, in the course of their researches on the action of nitric acid on organic compounds, obtained the nitro-derivatives of methylic and ethylic malonate. We have found that the nitro-group can be introduced into malonamide with the same readiness as bromine. The nitromalonamide is prepared by very gradually adding one part of malonamide to eight parts of fuming nitric acid. During the addition of the malonamide to the acid, the mixture must be kept cold by ice and well stirred. The separation of the nitromalonamide begins before the whole of the malonamide is introduced. The product is poured on to ice; the nitromalonamide is collected and washed thoroughly with cold water, in which it is almost insoluble. The amide thus obtained dissolves in boiling water, and, on cooling, separates in six-sided prisms, which decompose at 172° . Analysis confirms the formula $\text{CH}(\text{NO}_2)(\text{CONH}_2)_2$.

0.2104 gave 0.1874 CO_2 and 0.0672 H_2O . $\text{C} = 24.29$; $\text{H} = 3.54$.

0.1758 „ 44.5 c.c. moist nitrogen at 25° and 768 mm. $\text{N} = 28.54$.

$\text{C}_3\text{H}_5\text{N}_3\text{O}_4$ requires $\text{C} = 24.48$. $\text{H} = 3.40$. $\text{N} = 28.57$ per cent.

Nitromalonamide has acid properties, as have the ethereal salts of nitromalonic acid (Franchimont and Klobbie, *loc. cit.*). The potassium derivative is prepared by dissolving the nitromalonamide in pure dilute potash, and is precipitated from the solution on adding absolute alcohol, in the form of colourless needles which dissolve readily in water forming a yellow solution. For analysis, the salt was dried in a vacuum over sulphuric acid and finally at 100° .

0.3126 gave 0.1442 K_2SO_4 . $\text{K} = 20.68$.

0.3098 „ 0.1436 K_2SO_4 . $\text{K} = 20.78$.

$\text{C}_3\text{H}_4\text{KN}_3\text{O}_4$ requires $\text{K} = 21.08$ per cent.

The silver derivative is prepared from the aqueous solution of the potassium compound by adding silver nitrate; it gradually separates in colourless prisms which dissolve in boiling water. It was dried in a vacuum over sulphuric acid, and then at 100° .

0.3778 gave 0.1604 Ag . $\text{Ag} = 42.45$.

$\text{C}_3\text{H}_4\text{AgN}_3\text{O}_4$ requires $\text{Ag} = 42.52$ per cent.

The lead salt is deposited in yellow, rhombic crystals on mixing solutions of the potassium salt and lead acetate.

0.3176 gave 0.1920 PbSO_4 . $\text{Pb} = 41.30$.

$(\text{C}_3\text{H}_4\text{N}_3\text{O}_4)_2\text{Pb}$ requires $\text{Pb} = 41.48$ per cent.

Nitromalonamide dissolves readily in ammonia, and the salt is precipitated from the aqueous solution by alcohol in colourless needles.

An attempt was made to prepare methylnitromalonamide from the silver salt. Methyl iodide does not act on the silver salt when they are heated together on the water-bath; an action, however, takes place on digesting it with methyl iodide in the presence of methyl alcohol in a sealed tube at 100° for two or three hours. A gas escaped on opening the tube; the latter contained, besides silver iodide, colourless crystals suspended in the liquid. The solid was collected and extracted with boiling water, which, on cooling, deposited colourless plates melting at $173\text{--}174^{\circ}$. The melting point and crystalline form of this substance as well as a nitrogen determination proved it to be nitromalonamide.

0.1604 gave 40 c.c. moist nitrogen at 21° and 759 mm. $N = 28.34$.

$C_3H_5N_3O_4$ requires $N = 28.57$ per cent.

The formation of nitromalonamide from the silver salt is most probably explained by assuming an interaction to occur between the methyl iodide and methyl alcohol which produces methyl ether and hydrogen iodide, the latter decomposing the silver salt.

Action of Aniline on Nitromalonamide.

When nitromalonamide is warmed with excess of potash or baryta, decomposition immediately takes place, and ammonia is evolved. The salts of nitromalonic acid, however, were not obtained, for on boiling until ammonia ceased to come off, it was found that decomposition had taken place, potassium or barium carbonate having been formed.

Nitromalonamide is also decomposed on heating it with aniline; on boiling the amide with the base in a flask fitted with a reflux condenser, it enters into solution, ammonia is evolved, and the contents of the flask darken; when cold, the liquid solidifies almost completely to a mass of coloured crystals, which dissolve in hot alcohol and crystallise from the decolorised solution in colourless needles. The melting point (235°) and the chemical behaviour characterise this compound as diphenylcarbamide. A nitrogen determination gave the following result.

0.1792 gave 21 c.c. moist nitrogen at 22° and 758 mm. $N = 13.23$.

$C_{13}H_{12}N_2O$ requires $N = 13.21$ per cent.

Amidomalonic acid.—Amidomalonic acid was discovered by Baeyer (*Annalen*, **131**, 291), who obtained it by reducing nitrosomalonic acid, the product of the action of potash on violuric acid (nitrosobarbituric acid). Since nitromalonamide can be so readily prepared from malonic acid, it seemed to be of interest to subject this nitro-derivative to the action of reducing agents with a view of obtaining

amidomalonic acid. The reduction is effected in the following manner:—Nitromalonamide is suspended in water and the calculated quantity of sodium amalgam, containing $2\frac{1}{2}$ per cent. of sodium, is gradually introduced, the mixture being cooled with ice. The yellow colour of the solution of the sodium nitromalonamide slowly disappears, and the reduction is completed by adding a slight excess of sodium amalgam and heating on the water bath for half an hour. The alkaline solution is poured off from the mercury and boiled until ammonia, which first appeared during the reduction, ceases to be evolved. The cooled liquid is filtered and acidified with acetic acid; and, following Baeyer's directions, the amidomalonic acid is precipitated as lead salt by the addition of lead acetate. The acid is prepared by decomposing the lead salt, suspended in water, by hydrogen sulphide, filtering, and evaporating the filtrate from the lead sulphide in a vacuum over sulphuric acid, or by distilling it in a vacuum at a temperature of $50-55^{\circ}$. The colourless transparent prisms thus obtained melt at 109° , evolving carbon dioxide. A nitrogen determination of an air-dried specimen gave the following result.

0.2340 gave 21.5 c.c. moist nitrogen at 24° and 755 mm. $N = 10.23$.

$C_3H_5NO_4 \cdot H_2O$ requires $N = 10.21$ per cent.

The water of crystallisation is only very slowly given off in a vacuum over sulphuric acid.

Several salts of this acid have been prepared and analysed. The lead salt is obtained as described above, and, on analysis, gave numbers corresponding to the formula previously established by Baeyer, $[C_3H_2(NH_2)O_4]_2Pb$.

0.3824 gave 0.2624 $PbSO_4$. $Pb = 46.88$.

0.2236 „ 0.1534 $PbSO_4$. $Pb = 46.87$.

$C_6H_8N_2O_8Pb$ requires $Pb = 46.72$ per cent.

The silver salt precipitated on adding silver nitrate to the ammoniacal solution of the acid darkens under the influence of light. For analysis it was washed with alcohol, and dried in a vacuum.

0.2014 gave 0.1304 Ag . $Ag = 64.75$.

$C_3H_3Ag_2NO_4$ requires $Ag = 64.86$ per cent.

The ammonium salt is precipitated by alcohol from its aqueous solution in colourless crystals; it is most probably the normal salt which, however, on drying at 100° , loses ammonia and yields the acid ammonium salt.

0.1616 gave 29 c.c. moist nitrogen at 22° and 757 mm. $N = 20.22$.

0.1752 „ 31.5 c.c. „ „ 21° and 756 mm. $N = 20.34$.

$C_3H_2(NH_2)O_4 \cdot NH_4$ requires $N = 20.58$ per cent.

In connection with the experiments described above, we may here record the result of an investigation, in continuation of a research on the action of bases on ethylic dicarboxyglutaconate. It has already been shown by one of us, that ammonia and primary monamines and diamines of both the fatty and aromatic series act on the ethereal salt, forming ethylic amidoethylenedicarboxylate (ethylic amido-methylenemalonate) or its derivatives on the one hand, and the amide of malonic acid or the substituted amides on the other. It seemed to us of interest to subject ethylic dicarboxyglutaconate to the action of guanidine, in order to ascertain if, in this case also, a similar change would take place. We found, however, to our surprise, that such is not the case, but that it leads only to the formation of the guanidine salt of ethylic dicarboxyglutaconate.

On warming the ethereal salt with guanidine carbonate, dissolved in water, a solid is obtained, which is most probably a compound of both substances. This, on boiling with water, dissolves with evolution of carbon dioxide, and, on cooling, yellow prisms crystallise out; these melt and decompose at 163°. The fact that this compound is decomposed by hydrochloric acid with the formation of ethylic dicarboxyglutaconate and guanidine hydrochloride, shows it to be the guanidine salt of ethylic dicarboxyglutaconate, as does the analysis, which gives results corresponding with the formula

0.2092 gave 0.3790 CO₂ and 0.1304 H₂O. C = 49.40; H = 6.92.

0.2040 „ 19.5 c.c. moist nitrogen at 20° and 755 mm. N = 10.86.

C₁₆H₂₇N₃O₈ requires C = 49.36; H = 6.94; N = 10.80 per cent.

The same salt is formed when guanidine itself is used instead of the carbonate. The base is obtained by dissolving guanidine hydrochloride in absolute alcohol, and adding the calculated quantity of sodium dissolved in alcohol; the filtrate from the sodium chloride is evaporated in a vacuum, and the remaining guanidine mixed with ethylic dicarboxyglutaconate. Combination takes place immediately with evolution of heat, and the mixture solidifies to a mass of yellow crystals, which are identical with the product formed when guanidine carbonate is used.

Action of Hydrazine Hydrate on Ethylic Ethoxymethylenemalonate.

Ethylic dicarboxyglutaconate suffers, under the influence of phenylhydrazine, a decomposition similar to that which takes place with ammonia (Ruhemann and Morrell, *Trans.*, 1892, **61**, 793). This

reaction gives rise to the formation of ethylic 1-phenyl-5-pyrazolone-4-carboxylate, and is represented by the equation

Claisen and Haase (*Ber.*, 1895, **28**, 35) have found lately that the same compound is also formed by the action of phenylhydrazine on ethylic ethoxymethylenemalonate. They concluded from the chemical behaviour of the phenylpyrazolone, formed from the ethylic pyrazolonecarboxylate, that it has the formula

and not the tautomeric formula which follows from its synthesis.

The action of hydrazine hydrate on ethylic dicarboxylglutaconate is like that of phenylhydrazine, yielding, as one of us has shown, ethylic pyrazolonecarboxylate, the constitution of which, in the light of Claisen and Haase's work, is to be represented by the formula

So close is the analogy between the mode of formation of this compound and its phenyl derivative, and also between the chemical behaviour of these substances, that it was scarcely to be expected that objections would be raised against the above formula. Such objections, however, have been brought forward by v. Rothenburg (*J. pr. Chem.*, 1894, **50**, 230), who has expressed the view that the action of hydrazine hydrate on ethylic dicarboxylglutaconate does not produce a pyrazolone derivative, but gives rise to a compound of double the molecular weight.

S. Ruhemann and R. S. Morrell (*Ber.*, 1895, **28**, 988) have shown that the molecular weight corresponds with that required by ethylic pyrazolonecarboxylate, $\text{C}_6\text{H}_5\text{N}_2\text{O}_3$. This formula is further supported by the following experiments which we were enabled to carry out by the kindness* of Professor Claisen, who allowed us to study the action of hydrazine hydrate on ethylic ethoxymethylenemalonate.

* I take this opportunity of expressing my thanks to Professor Claisen for not

Hydrazine hydrate acts on ethylic ethoxymethylenemalonate as readily as phenylhydrazine does. The two substances, in molecular proportion, are gradually mixed in a flask, cooled by ice. They interact, and heat is evolved, a thick, yellow oil being formed, which solidifies slowly on standing; on washing the solid with dilute hydrochloric acid, it loses its yellow colour. The product readily dissolves in alcohol and ether, and crystallises from dilute spirit in colourless, rhombic prisms; it melts at 82° to a colourless oil, which only very slowly solidifies again. Analysis of the substance, dried in a vacuum over sulphuric acid, leads to the formula

0.2106 gave 0.3984 CO₂ and 0.1220 H₂O. C = 51.59; H = 6.41.

0.2152 „ 14 c.c. moist nitrogen at 17° and 770 mm. N = 7.75.

C₁₆H₂₄N₂O₈ requires C = 51.61; H = 6.45; N = 7.52 per cent.

The action of hydrazine hydrate on ethylic ethoxymethylenemalonate differs, therefore, from that of phenylhydrazine (Claisen and Haase, *loc. cit.*), yielding a compound, which may be regarded as the ethereal salt of hydrazodimethylenedimalonic acid. This view of the constitution is confirmed by its behaviour towards boiling hydrochloric acid. On heating the hydrazo-compound with the acid, it dissolves, and on evaporating the solution on the water bath, a crystalline residue is left, consisting of malonic acid and hydrazine hydrochloride. Their separation may be effected by means of ether, which dissolves the acid; on evaporating, and recrystallising the malonic acid from water, it melts at 132°. The part insoluble in ether was proved to be hydrazine hydrochloride by its chemical behaviour. The decomposition, which the hydrazo-compound suffers under the influence of hydrochloric acid may, therefore, be represented by the equation

The hydrazo-compound has acid properties, and, with alkalis, forms yellow salts. The sodium salt is readily obtained in the form of yellow needles by mixing alcoholic solutions of sodium ethoxide and the ethereal salt; the solution of the salt in water is strongly alkaline to litmus paper. For analysis, it was washed with alcohol, in which it is fairly soluble, and dried first in a vacuum over sulphuric acid, and finally at 100°.

only allowing me to study this action, but also for furnishing me with the exact details of the preparation of ethylic ethoxymethylenemalonate.—S. R.

0.2062 gave 0.0680 Na_2SO_4 . $\text{Na} = 10.93$.

0.2214 „ 0.0748 Na_2SO_4 . $\text{Na} = 10.94$.

$\text{C}_{16}\text{H}_{22}\text{Na}_2\text{N}_2\text{O}_8$ requires $\text{Na} = 11.05$ per cent.

The sodium salt is, no doubt, formed by the displacement of the imido-hydrogen atoms, and its constitution may be represented by the

This constitution is in agreement with the behaviour of the hydrazo-compound towards hydrazine hydrate and ammonia. Under the influence of these agents, it suffers a remarkable decomposition, yielding ethylic pyrazolonecarboxylate.

Action of Hydrazine Hydrate on Ethylic Hydrazodimethylenedimalonate.

On adding an excess of hydrazine hydrate to the hydrazo-compound, heat is evolved, and a yellow solid is obtained, which is, no doubt, the hydrazine salt of ethylic hydrazodimethylenedimalonate; this is decomposed on warming on the water bath for a short time, yielding a colourless substance, which enters into solution. Hydrochloric acid precipitates from this solution colourless needles, which, after recrystallisation from water, melt at 180° ; the properties of this product fully characterise it as ethylic pyrazolonecarboxylate, which has been obtained by the action of hydrazine hydrate on ethylic dicarboxyglutaconate (Ruhemann, *Ber.*, 1894, **27**, 1659), and on ethylic amidoethylenedicarboxylate (Ruhemann and Morrell, *Ber.*, 1894, **27**, 2747). The formula, $\text{C}_6\text{H}_8\text{N}_2\text{O}_3$, was, moreover, verified by a nitrogen determination of the substance dried at 100° .

0.2102 gave 33.5 c.c. of moist nitrogen at 25° and 764 mm. $\text{N} = 17.86$.

$\text{C}_6\text{H}_8\text{N}_2\text{O}_3$ requires $\text{N} = 17.94$ per cent.

The formation of the pyrazolone derivative in the above action may be explained by assuming that, under the influence of hydrazine hydrate, the hydrazo-compound undergoes a decomposition similar to that which takes place in the case of ethylic dicarboxyglutaconate. The transformation may be represented by the following equation.

The ethereal salt of hydrazomethylenemalonic acid then loses alcohol and yields ethylic pyrazolonecarboxylate, which combines with hydrazine to form a salt. This salt has been obtained (Ruhemann, *Ber.*, 1894, **27**, 1659) from the product of the action of hydrazine on ethylic dicarboxyglutaconate. On adding hydrochloric acid, it is converted into ethylic pyrazolonecarboxylate.

cerning the constitution of the compound formed from hydrazine and ethylic dicarboxyglutaconate, namely, that it is ethylic pyrazolonecarboxylate. These experiments suffice to prove that the objections raised by v. Rothenburg are unfounded; a further discussion of his remarks appears to be unnecessary and undesirable. What is the relation of the result of the investigation recorded above to v. Rothenburg's pyrazolone? V. Rothenburg has put this question (*J. pr. Chem.*, 1894, **50**, 230); it is to be hoped that he will give a satisfactory answer.

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