CXXV.—*Methyl Dicarboxyaconitate.*

By SIEGFRIED RUHEMANN.

THE observation that ethyl dicarboxyglutaconate, on treatment with ammonia, decomposes according to the equation

(Ruhemann and Morrell, *Trans.*, 1891, **69**, 743) has been the starting point of a series of experiments on the reaction between the ester and primary and secondary organic bases. In several later papers it has been shown that those bases behave towards the ester in a manner similar to ammonia and yield alkyl and aryl derivatives of ethyl aminomethylenemalonate, which in certain cases condense to heterocyclic compounds. In this way the synthesis of 5-pyrazolone and

* I take this opportunity of mentioning that I studied, some time ago, the action of potassium cyanate on ethyl aminomethylenemalonate, and obtained ethyl uramidomethylenemalonate, $\text{NH}_2\cdot\text{CO}\cdot\text{NH}\cdot\text{CH}:\text{C}(\text{CO}_2\text{Et})_2$, which Wheeler, Johnson, and Johns (*Amer. Chem. Journ.*, 1907, **37**, 392) recently detected as a by-product in the condensation of ethyl ethoxymethylenemalonate with ethyl- ψ -thiocarbamide hydrobromide. I have prepared the compound by mixing the solution of ethyl aminomethylenemalonate (3 grams) in about 70 c.c. of hot water with potassium cyanate (3 grams), dissolved in a little water, and digesting the mixture on the water-bath for an hour. On adding hydrochloric acid to the cold solution, a solid separates in the course of two days. This is readily soluble in hot alcohol, sparingly so, however, in boiling water, and, on cooling, crystallises in colourless plates which melt at 205° with evolution of gas:

0.2010 gave 0.3450 CO_2 and 0.1112 H_2O . $\text{C}=46.81$; $\text{H}=6.14$.

0.2220 „ 23.4 c.c. moist nitrogen at 17° and 762 mm. $\text{N}=12.26$.

$\text{C}_9\text{H}_{14}\text{O}_5\text{N}_2$ requires $\text{C}=46.95$; $\text{H}=6.09$; $\text{N}=12.17$ per cent.

I had intended to study this ester in a similar manner to that used by the above named chemists, but I have been unable to do so owing to the small yield of the compound which I have obtained.

several of its derivatives, as well as the formation of substances belonging to the pyrimidine series, has been effected.

The fact that ethyl dicarboxyglutaconate, under the influence of ammonia and organic bases, decomposes in the manner indicated by the above equation, and that the disruption of the ester takes place at the single carbon-linking, has led to a closer investigation of the reaction. Guthzeit (*Ber.*, 1897, **30**, 1757) has found that the ester forms with aniline an additive product, ethyl anilindicarboxyglutarate, which, however, is unstable, and readily decomposes into ethyl anilino-methylenemalonate and ethyl malonate:

This experiment tends to show that the disruption of ethyl dicarboxyglutaconate is preceded by the formation of additive compounds of the ester with bases. This conclusion is supported by the results which the study of the behaviour of organic bases towards unsaturated compounds has furnished. Ruhemann and Browning (*Trans.*, 1898, **73**, 723) have shown that piperidine readily unites with esters of olefinic acids, such as fumaric, citraconic, and aconitic acids. These, however, are very stable; they can be distilled under diminished pressure, and form stable hydrochlorides. We have stated, also, that the ester of the acetylenic acid, ethyl phenylpropiolate, unites with piperidine to yield ethyl phenylpiperidylcinnamate. This, as has been pointed out, behaves differently from the corresponding compounds which are formed from the esters of olefinic acids, as it reacts with hydrogen chloride to yield a pasty product. We had assumed (*loc. cit.*) that this was the hydrochloride of the additive product, but Moureu and Lazennec (*Compt. rend.*, 1906, **143**, 596) have shown recently that the products of the union of organic bases with ethyl phenylpropiolate, as well as the esters of other acetylenic acids, on treatment with hydrogen chloride yield the hydrochlorides of the bases and β -ketonic esters.

Different, however, is the behaviour of organic bases towards olefinic ketonic compounds. Ruhemann and Watson (*Trans.*, 1904, **85**, 466, 1170) have shown that in this case additive products are formed; benzylideneacetylacetone, for instance, unites with aniline, but the substance which is produced, on heating at 100° , decomposes into benzylideneaniline and acetylacetone, thus:

These reactions closely resemble the decomposition which ethyl dicarboxyglutaconate undergoes on treatment with ammonia or organic bases.

The results of this work on ethyl dicarboxyglutaconate induced me to examine whether compounds in which the hydrogen of chloroform is replaced by hydrocarbon or acid groups would react with ethyl sodiomalonate in the same way as chloroform. The substances which were supposed to be formed might be expected to behave towards bases in a similar manner as ethyl dicarboxyglutaconate. Experiments in this direction, which were undertaken some time ago, were unsuccessful, because, as has been stated (*Ber.*, 1896, 29, 1016), *aaa*-trichloroethane has no action on the sodium derivative of ethyl malonate, nor, as I have found since, does benzotrichloride react with it. Ethyl trichloroacetate, as I have also shown (*loc. cit.*), on treatment with a mixture of alcoholic sodium ethoxide and ethyl malonate, does not yield ethyl dicarboxyaconitate. This result, most probably, is due to the decomposition of ethyl trichloroacetate and the action of the resulting chloroform on the malonic ester. With the object of proving the correctness of this view I have now repeated the experiment, using, however, the sodium derivative of methyl malonate, which was prepared by the action of metallic sodium on the solution of the ester in absolute ether, but hardly any change takes place on digesting it with methyl trichloroacetate for several days. Methyl dicarboxyaconitate, $(\text{CO}_2\text{Me})_2\text{CH}\cdot\text{C}(\text{CO}_2\text{Me})\cdot\text{C}(\text{CO}_2\text{Me})_2$, as Anschütz (*Annalen*, 1903, 327, 233) has shown, is formed by the action of the dimethyl ester of dichloroglycollic acid (methyl dichloro-oxalate) on methyl sodiomalonate, suspended in dry ether. I have prepared this ester according to the directions of Anschütz and Deschauer (*Annalen*, 1906, 347, 3) in order to study it in a similar manner to ethyl dicarboxyglutaconate. This investigation has led to the following results.

Phenylhydrazine reacts with the solution of the ester in dry ether to yield an additive product. The fact that this is colourless points to the formula $\text{CO}_2\text{Me}\cdot\text{C}(\text{NH}\cdot\text{NH}\cdot\text{C}_6\text{H}_5)[\text{CH}(\text{CO}_2\text{Me})_2]_2$, according to which it is to be regarded as methyl phenylhydrazinodicarboxytricarballylate. The compound is fairly stable, and in this respect differs from the corresponding substance which may be supposed to be, first, formed from ethyl dicarboxyglutaconate and phenylhydrazine. Whilst the latter product decomposes in the course of the reaction to furnish ethyl malonate and ethyl 1-phenyl-5-pyrazolone-4-carboxylate, the additive compound of the hydrazine with methyl dicarboxyaconitate does not suffer a similar change until it is digested with dilute aqueous potassium hydroxide or boiled with sodium carbonate. Dimethyl 1-phenyl-5-pyrazolone-3-4-dicarboxylate, which undoubtedly is first formed along with malonic acid, is, however, partially hydrolysed, and yields the monomethyl ester of the pyrazolone-dicarboxylic acid. This, *a priori*, may be expressed either by the formula

the fact, however, that 5-pyrazolone-4-carboxylic acid and its 1-phenyl derivative are very unstable and lose carbon dioxide below 100°, whereas the substance which is formed from methyl dicarboxyaconitate melts and decomposes at 200°, points to formula (I). The hydrolysis of this compound, which is effected by boiling it with concentrated aqueous potassium hydroxide, is accompanied by the loss of carbon dioxide, and yields 1-phenyl-5-pyrazolone-3-carboxylic acid,

Different from the behaviour of phenylhydrazine towards methyl dicarboxyaconitate at the ordinary temperature, is the interaction of the two substances at 100°. The ester decomposes and yields methyl malonate besides a colourless compound having the formula $\text{C}_{24}\text{H}_{24}\text{O}_4\text{N}_6$. This is characterised as a phenylhydrazine salt, because its solution reacts with hydrochloric acid, thus:

The product $\text{C}_{18}\text{H}_{16}\text{O}_4\text{N}_4$ on treatment with sodium carbonate readily loses phenylhydrazine; it is therefore to be regarded as the phenylhydraze of monomethyl phenylpyrazolonedicarboxylate. With regard to its constitution there remains the choice between the formulæ

Aniline, like phenylhydrazine, decomposes methyl dicarboxyaconitate if the mixture of the two reagents is heated on the water-bath. The ester, $\text{CO}_2\text{Me} \cdot \text{C}(\text{NH} \cdot \text{C}_6\text{H}_5) : \text{C}(\text{CO}_2\text{Me})_2$, which, besides methyl malonate, may be expected to be produced, does not make its appearance, but is transformed into methyl carboxyanilinomethylenemalonanil,

The behaviour of methyl dicarboxyaconitate towards ammonia and hydroxylamine is still under examination, and will form the subject of a subsequent communication.

EXPERIMENTAL.

*Action of Phenylhydrazine on Methyl Dicarboxyaconitate at the Ordinary Temperature.**Methyl Phenylhydrazinodicarboxytricarballylate,*

$$\text{CH}_3 \cdot \text{CO}_2 \cdot \text{C}(\text{NH} \cdot \text{NH} \cdot \text{C}_6\text{H}_5)[\text{CH}(\text{CO}_2 \cdot \text{CH}_3)_2]_2.$$

This compound is readily formed on adding phenylhydrazine to methyl dicarboxyaconitate dissolved in dry ether. In the course of a few hours, beautiful colourless prisms separate which, on standing overnight, increase in quantity; the yield is more than 90 per cent. of the theoretical.

The substance after being washed with ether melts at 135° :

0.2005 gave 0.3795 CO_2 and 0.1000 H_2O . $\text{C} = 51.62$; $\text{H} = 5.54$.

0.2260 „ 12.4 c.c. moist nitrogen at 17° and 779 mm. $\text{N} = 6.52$.

$\text{C}_{19}\text{H}_{24}\text{O}_{10}\text{N}_2$ requires $\text{C} = 51.81$; $\text{H} = 5.45$; $\text{N} = 6.36$ per cent.

Dilute alkali hydroxides or carbonates decompose the additive product, thus:

$$\text{C}_{19}\text{H}_{24}\text{O}_{10}\text{N}_2 + 3\text{H}_2\text{O} = \text{C}_{12}\text{H}_{10}\text{O}_5\text{N}_2 + \text{CH}_2(\text{CO}_2\text{H})_2 + 4\text{CH}_3 \cdot \text{OH},$$

and yield

4-Monomethyl 1-Phenyl-5-pyrazolone-3-4-dicarboxylate,

On using dilute aqueous potassium hydroxide, the compound $\text{C}_{19}\text{H}_{24}\text{O}_{10}\text{N}_2$ dissolves after short digestion, and the yellow solution which is formed gives with hydrochloric acid a white precipitate. This crystallises from dilute alcohol in colourless prisms which soften at 195° and melt at 201 — 202° with evolution of gas:

0.2024 gave 0.4085 CO_2 and 0.0735 H_2O . $\text{C} = 55.04$; $\text{H} = 4.03$.

0.1671 „ 0.3360 CO_2 and 0.0585 H_2O . $\text{C} = 54.83$; $\text{H} = 3.88$.

0.2470 „ 22.5 c.c. moist nitrogen at 14° and 763 mm. $\text{N} = 10.76$.

$\text{C}_{12}\text{H}_{10}\text{O}_5\text{N}_2$ requires $\text{C} = 54.96$; $\text{H} = 3.81$; $\text{N} = 10.69$ per cent.

The pyrazolone derivative is only sparingly soluble in boiling water, but dissolves readily in alcohol, and the alcoholic solution gives a deep red coloration with ferric chloride; it dissolves with great ease in sodium carbonate or ammonia, and the ammoniacal solution yields with silver nitrate a gelatinous, white precipitate which, on boiling, becomes curdy.

The same decomposition of the additive product takes place on heating it with sodium carbonate; after about an hour's boiling, the whole is dissolved, and the yellow solution, on treatment with

hydrochloric acid, furnishes monomethyl phenylpyrazolonedicarboxylate. The filtrate from this compound contains malonic acid. It was isolated by evaporating the acid solution to dryness, extracting the residue with ether, decolorising the ethereal solution by means of animal charcoal, and distilling off the ether. The solid which is left behind was identified as malonic acid by the melting point (131—132°) and the following analysis:

0.1717 gave 0.2185 CO₂ and 0.0610 H₂O. C = 34.70; H = 3.94.

C₃H₄O₄ requires C = 34.61; H = 3.84 per cent.

On boiling monomethyl phenylpyrazolonedicarboxylate with concentrated aqueous potassium hydroxide (50 per cent.) for an hour, hydrolysis, accompanied by the loss of carbon dioxide, takes place, and there is formed

This substance is precipitated as a white solid on adding hydrochloric acid to the alkaline solution. It dissolves readily in alcohol, but only sparingly in boiling water, and crystallises from either solution in colourless needles which melt at about 261° with evolution of gas. The identity of this substance with the known 1-phenyl-5-pyrazolone-3-carboxylic acid was verified by the following analysis:

0.1615 gave 0.3488 CO₂ and 0.0593 H₂O. C = 58.90; H = 4.07.

0.1736 „ 20.4 c.c. moist nitrogen at 15° and 759 mm. N = 13.74.

C₁₀H₈O₃N₂ requires C = 58.82; H = 3.92; N = 13.72 per cent.

Action of Phenylhydrazine on Methyl Dicarboxyaconitate at 100°.

On heating equal weights of phenylhydrazine and methyl dicarboxyaconitate on the water-bath for an hour, the whole sets to a semi-solid. This is washed with methyl alcohol, when a colourless substance is left behind which melts at 224° with evolution of gas and turns yellow in the course of a week:

0.1990 gave 0.4558 CO₂ and 0.0953 H₂O. C = 62.47; H = 5.32.

0.1705 „ 27.2 c.c. moist nitrogen at 15° and 744 mm. N = 18.28.

C₂₄H₂₄O₄N₆ requires C = 62.62; H = 5.21; N = 18.26 per cent.

This substance, as has been pointed out (p. 1362), is a phenylhydrazine salt. As such it is characterised by the fact that its solution in dilute alcohol, on treatment with hydrochloric acid, yields phenylhydrazine hydrochloride; at the same time a precipitate is formed, which is the *phenylhydrazide* of monomethyl phenylpyrazolonedicarboxylate. Its constitution is to be represented by one of the two formulæ given before (*loc. cit.*). The compound is sparingly soluble in cold, but readily in

boiling alcohol, and, on cooling, crystallises in clusters of colourless, curved needles which, when heated, darken, but do not melt, above 250° :

0.2016 gave 0.4520 CO_2 and 0.0863 H_2O . $\text{C} = 61.14$; $\text{H} = 4.75$.

0.2262 „ 30.0 c.c. moist nitrogen at 15° and 779 mm. $\text{N} = 15.92$.

$\text{C}_{18}\text{H}_{16}\text{O}_4\text{N}_4$ requires $\text{C} = 61.36$; $\text{H} = 4.54$; $\text{N} = 15.91$ per cent.

The phenylhydrazide develops the odour of phenylhydrazine when agitated with cold sodium carbonate.

Action of Aniline on Methyl Dicarboxyaconitate.

Methyl Carboxyanilinomethylenemalonanil,

A mixture of equal weights of aniline and methyl dicarboxyaconitate, when heated on the water-bath for two to three hours, yields a red oil from which, on being kept overnight, a yellow solid separates. This gradually crystallises from its solution in methyl alcohol in canary-yellow prisms which melt at 194° :

0.1820 gave 0.4471 CO_2 and 0.0730 H_2O . $\text{C} = 67.0$; $\text{H} = 4.45$.

0.1696 „ 12.9 c.c. moist nitrogen at 18° and 753 mm. $\text{N} = 8.77$.

$\text{C}_{18}\text{H}_{14}\text{O}_4\text{N}_2$ requires $\text{C} = 67.08$; $\text{H} = 4.35$; $\text{N} = 8.69$ per cent.

This compound is somewhat soluble in cold alcohol, benzene, or chloroform, but dissolves readily in the boiling solvents.

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