

ON THE SO-CALLED DIETHYL DICYANOGLUTACONATE AND
SOME OF ITS DERIVATIVES. II.

By Yoshiyuki URUSHIBARA.

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In the previous paper⁽²⁾ on the same subject the author pointed out the incorrectness of the view hitherto held on the composition and constitution of the so-called diethyl dicyanoglutaconate and described some of its derivatives. The results which were not referred to then, and those obtained further by the continued investigation will be noted in this paper.

The starting substance of the investigation on the diethyl dicyanoglutaconate, the cyanacetic ester, has been always prepared by Noyes' method.⁽³⁾ That this method produces the mixture of methyl and ethyl esters, and that this fact has no direct effect upon the results, were explained in a separate paper.⁽⁴⁾

In order to distinguish the so-called diethyl dicyanoglutaconate from the real diethyl dicyanoglutaconate, which is not known in its free state, the former is followed by the word "semihydrate" according to the composition, but it must be remembered that the half molecule of water can not be removed.

(2) This journal, 2 (1927), 26.

(3) *J. Am. Chem. Soc.*, 26 (1904), 1545.

(4) This journal, 2 (1927) 143.

The mechanism of the formation and the yield of the diethyl sodio-dicyanoglutaconate. In the condensation of ethyl cyanacetate, chloroform, and sodium ethylate, the reaction producing the diethyl sodio-dicyanoglutaconate, the mixture is brought to violent boiling when it is heated on the water bath, whereby apparently causing the escape of chloroform and diminishing the yield of the product. In fact, if the reaction is moderated by avoiding violent boiling, the yield of purified sodium compound is better (60% of the theoretical amount) than that attained by Errera (40%).⁽¹⁾ But the yield is not improved, even if the less volatile iodoform is used. Addition of chloroform in excess seems also to be of no use. The calculated amount of chloroform is sufficient to bring the mass nearly to neutral reaction, and the quantity of separated sodium chloride is not too small. Hence, it is probable that a side reaction occurs between chloroform and sodium ethylate, yielding the orthoformic ester, which the more prevails over the desired reaction, when the more rapidly heat is applied.

On the other hand, that the orthoformic ester is at first produced from chloroform and three-fourth of the sodium ethylate, and then it is condensed with cyanacetic ester by the action of remaining sodium ethylate, seems to be suggested by the following facts: Chloroform, carbon tetrachloride, and ethyl trichloracetate, give all the same compound, triethyl orthoformate, by the action of sodium ethylate, while all these three substances give the same diethyl sodio-dicyanoglutaconate by the action of ethyl cyanacetate and sodium ethylate.⁽²⁾

An experiment was carried out on the condensation of orthoformic ester and cyanacetic ester by means of sodium ethylate, but such did not take place. Hence, in the condensation of chloroform, sodium ethylate, and cyanacetic ester, the portion changed into orthoformic ester is lost, the corresponding amount of cyanacetic ester taking no part in the reaction. By the use of excess of chloroform and sodium ethylate, the amount of excess being in the proportion of one molecule to three, an increased yield of diethyl sodio-dicyanoglutaconate referred to the amount of the cyanacetic ester was obtained (70% of the theoretical amount.)

The formation of the diethyl sodio-dicyanoglutaconate by the condensation of ethyl cyanacetate and ethyl trichloracetate by means of sodium ethylate. The condensation of diethyl malonate and ethyl trichloracetate by means of sodium ethylate gives the tetraethyl sodio-dicarboxylglutaconate,⁽³⁾ the same compound that is formed by using chloroform instead of ethyl trichloracetate. With a somewhat hopeless

(1) *Ber.*, 31 (1898), 1241.

(2) *Ber.*, 35 (1902), 2881; and see under.

(1) Ruheman, *Ber.*, 29 (1896), 1017.

expectation of obtaining the triethyl dicyanoaconitate, the condensation of ethyl cyanacetate and trichloracetate was tried. But the experiment showed that the product was nothing but the diethyl sodio-dicyanoglutaconate. 0.4570 Gr. of the substance decreased in weight by 0.0557 gr. after dehydration at 120° . (Found: $\text{H}_2\text{O}=12.2$. $\text{C}_{11}\text{H}_{11}\text{O}_4\text{N}_2\text{Na}\cdot 2\text{H}_2\text{O}$ requires $\text{H}_2\text{O}=12.24\%$.) 0.2024 Gr. of the dehydrated substance gave 0.0528 gr. of Na_2SO_4 . (Found: $\text{Na}=8.5$. The formula requires $\text{Na}=8.9\%$.)

The triethyl sodio-dicyanoaconitate has the formula $\text{C}_{11}\text{H}_{11}\text{O}_4\text{N}_2\text{Na}\cdot \frac{1}{3}\text{H}_2\text{O}$, which requires $\text{H}_2\text{O}=2.65$; $\text{Na}=6.79\%$.)

Colour of the diethyl sodio-dicyanoglutaconate. In the previous paper it was shown that this substance was obtained in colourless state from iodoform. But sometimes the same reaction produced a dark reddish substance which was not easily freed from the colouring matter. The specimen prepared from ethyl trichloracetate was greenish yellow. At any rate this sodium compound accompanies some impurities in varying colours according to the condition of the reaction. And it is difficult to remove entirely these colouring matters by repeated recrystallisation. But when the sodium compound was recrystallised by using animal charcoal several times, it became nearly colourless.

Metallic derivatives of the diethyl dicyanoglutaconate. Various metallic derivatives are known, but as all of them were prepared from yellow sodium derivative, and the yellow colour is not characteristic of this compound, the colours of other metallic derivatives have been investigated.

Silver derivative. When a cold aqueous solution of silver nitrate is added to a cold aqueous solution of the sodium derivative, a gelatinous precipitate is formed, which on heating changes into have been powder.

Copper derivative. Freshly precipitated copper derivative is a pink-red voluminous substance, which soon changes into reddish brown powder. When ammonia is added to the well-washed reddish brown copper derivative, it changes into white precipitate, the supernatant liquid being slightly blueish.

Ammonium derivative. The double decomposition of the silver derivative of the diethyl dicyanoglutaconate and ammonium chloride gave an ammonium derivative with properties similar to those of the sodium derivative. This ammonium derivative precipitates the diethyl dicyanoglutaconate semihydrate on acidifying its aqueous solution. It possesses the formula $\text{C}_{11}\text{H}_{11}\text{O}_4\text{N}_2\cdot \text{NH}_3\cdot 2\text{H}_2\text{O}$, but loses one molecule of water on heating at 130° .

0.1388 Gr. of the substance dried in the desiccator gave 16.9 c.c. of N_2 at 9° and 756 mm. (Found: $\text{N}=14.50$. $\text{C}_{11}\text{H}_{12}\text{O}_4\text{N}_2\cdot \text{NH}_3\cdot 2\text{H}_2\text{O}$ requires $\text{N}=14.53\%$.) 0.1452 Gr. of the substance dehydrated at 130° gave 19.2 c.c. of N_2

at 13° and 760 mm. (Found: N=15.55. $C_{11}H_{12}O_4N_2 \cdot NH_3 \cdot H_2O$ requires N=15.50%.) This substance decomposed when heated at a higher temperature.

Ruhemann⁽¹⁾ obtained an ammonium derivative by dissolving the diethyl dicyanoglutaconate semihydrate in aqueous ammonia. His compound has the composition $C_{11}H_{12}O_4N_2 \cdot NH_3 \cdot \frac{1}{2}H_2O$ and melts and decomposes at 162–163°. This is probably the ammonium derivative of the diethyl dicyanoglutaconate *semihydrate*, and the half molecule of water comes from the mother substance.

Incomplete hydrolysis of the diethyl dicyanoglutaconate semihydrate. Complete hydrolysis gives the diethyl dihydroxy-dinicotinate (diethyl 2,6-dioxypyridine-3,5-dicarboxylate).⁽²⁾ The author obtained the hydrobromide and the picrate of diethyl dicarbamylglutaconate by the hydrolysis of the bromine addition compound of diethyl dicyanoglutaconate semihydrate, and transformed the hydrobromide into the diethyl dihydroxydinicotinate. The experiments show that this diamide is formed intermediately during the direct hydrolysis of diethyl dicyanoglutaconate semihydrate by dilute hydrochloric acid.

The semihydrate was hydrolysed by boiling in dilute hydrochloric acid and dissolved in it. Prolonged boiling produces the ultimate product, i.e., diethyl dihydroxydinicotinate, which separates out in white crystals from the boiling liquid. Before the appearance of this substance the boiling was stopped and the solution was cooled. A crystalline substance was obtained and it gave a picrate identical in melting point with the picrate of diethyl dicarbamylglutaconate (197°).

Trial of synthesizing the real diethyl dicyanoglutaconate. According to L. Claisen⁽³⁾ the diethyl diacetylglutaconate is formed in a moderate yield when orthoformic ester and acetic anhydride are heated with an excess of acetoacetic ester, and in a good yield when the ethoxymethylene-acetoacetic ester is introduced into the alcoholic solution of sodioacetoacetic ester. In the latter case the sodium derivative is formed, and from it the free ester is obtained by treating with acid.

The diethyl sodio-dicyanoglutaconate does not give the corresponding free ester, but the semihydrate. The mixture of ethyl cyanacetate, triethyl orthoformate, and acetic anhydride, in the proportion of 2 mols : 1 mol : 3 mols, was boiled for two hours and distilled in vacuo (ca. 20 mm.) until the temperature reached 120°. By treating the residue of the distillation with an alcoholic sodium ethylate solution, the diethyl sodio-dicyanoglutaconate was obtained, and on acidifying its aqueous solution the diethyl

(1) *J. Chem. Soc.*, 73 (1898), 233.

(2) *J. Chem. Soc.*, 73 (1898), 284.

(3) *Ann.*, 297 (1897), 1.

dicyanoglutaconate semihydrate was precipitated. The formation of the diethyl sodio-dicyanoglutaconate probably owed to the presence of the real diethyl dicyanoglutaconate. But as it is possible that the ethoxymethylene-cyanacetic ester and cyanacetic ester were present in the residue and they produced the diethyl sodio-dicyanoglutaconate by the action of sodium ethylate, the formation of the real diethyl dicyanoglutaconate can not be insisted on.

The condensation of ethyl ethoxymethylene-cyanacetate and ethyl sodiocyanacetate. Another method for synthesizing such methenyl compounds consists in the condensation of ethoxymethylene compounds, and the corresponding sodio-compounds. This method was applied to the synthesis of the diethyl sodio-dicyanoglutaconate. Soon after the addition of ethyl ethoxymethylenecyanacetate to ethyl sodiocyanacetate in absolute alcohol, a crystalline substance separated out. On acidifying the aqueous solution of this substance the diethyl dicyanoglutaconate semihydrate was precipitated, which was quite identical with the specimen synthesized from chloroform.

The application of Claisen's condensation has enabled the author to synthesize all of the nitrile-esters of the dicarboxyglutaconic acid and the details will be given in another paper.

Dimethyl sodio-dicyanoglutaconate and its derivatives.⁽¹⁾ By the condensation of methyl cyanacetate and chloroform by means of sodium methylate in methyl alcohol the corresponding methyl compound was formed. Recrystallised from methyl alcohol, it was obtained as nearly colourless glittering crystals, which has the composition $C_9H_7O_4N_2Na \cdot 2CH_3OH$, but easily loses a part of the alcohol of crystallisation. 0.5081 Gr. of the substance decreased by 0.1092 gr. on heating at 150–160°. (At a lower temperature the escape of the alcohol was incomplete.) (Found: $CH_3OH = 21.52$. $C_9H_7O_4N_2Na \cdot 2CH_3OH$ requires $CH_3OH = 21.77\%$.) 0.3319 Gr. of the substance freed from the alcohol of crystallisation gave 0.1159 gr. of Na_2SO_4 . (Found: $Na = 9.83$. $C_9H_7O_4N_2Na$ requires $Na = 10.00\%$.) When this sodium compound is recrystallised from water and dried in the desiccator it contains about one molecule of water. 0.3821 Gr. of this substance decreased by 0.0265 gr. on heating at 150–160°. (Found: $H_2O = 6.94$. $C_9H_7O_4N_2Na \cdot H_2O$ requires $H_2O = 7.26\%$.)

By acidifying the hot aqueous solution of the dimethyl sodio-dicyanoglutaconate, yellow crystals of dimethyl dicyanoglutaconate semihydrate $C_9H_8O_4N_2 \cdot \frac{1}{2}H_2O$ were precipitated.

0.2383 Gr. of the substance dried at 100–110° gave 26.3 c.c. of N_2 at 16.5°

(1) Cf. this journal, 2 (1927), 145.

and 761 mm. (Found: $N=12.85$. $C_9H_5O_4N_2 \cdot \frac{1}{2}H_2O$ requires $N=12.90\%$). This substance melts at 225° (corr.), is insoluble in absolute alcohol, methyl alcohol, benzene, and acetone even when boiled.

When bromine was added to the dimethyl dicyanoglutaconate semi-hydrate suspended in chloroform, the intermediate product was insoluble in this solvent and no distinct bromine addition compound was obtained. But the reaction proceeded in the same direction as in the case of the ethyl compound, which was ascertained as follows: After the addition of bromine the solid substance was collected and introduced into ether containing water. The white solid was dissolved in alcohol and the alcoholic solution of picric acid was added. At once a picrate precipitated, which proved to be the picrate of the dimethyl dicarbamylglutaconate.

0.1505 Gr. of substance gave 19.6 c.c. of N_2 at 15.5° and 751 mm. (Found: $N=14.96$. $C_9H_{12}O_6N_2 \cdot C_6H_2(OH)(NO_2)_3$ requires $N=14.80\%$.)

Chemical Institute, Faculty of Science,
Tokyo Imperial University.
