TARTRONIC ESTER DERIVATIVES

BY

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THESIS

Submitted in Partial Fulfillment of the Requirements for the

Degree of

MASTER OF ARTS

IN CHEMISTRY

IN

THE GRADUATE SCHOOL

OF THE

UNIVERSITY OF ILLINOIS

1909
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THE GRADUATE SCHOOL

May 29, 1907

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

F. Groe C. Spencer

ENTITLED Iatrotronic Ester Derivatives

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF M.A. in Chemistry

Richard Hinton

In Charge of Major Work

W = A. No7.

Head of Department

Recommendation concurred in:

Committee on Final Examination
M. Conrad and R. Reinbach carried on a series of reactions on the methyl anilinomalonate and its derivatives. They made the methyl anilinomalonate \( C_6H_5NH\ COOCH_3 \) by the action of one molecule of methyl brommalonate with two molecules of aniline, and studied its properties. They also made the methyl dianilinomalonate \( C_6H_5NH\ COOCH_3 \) from methyl dibrommalonate.

Anil glyoxyl which has the double bond between the nitrogen and carbon atoms was made by Iwan Ostromissensky, by the action of aniline on dic. oraceticester. There are several byproducts formed. Dianilinoaceticester breaks up into aniline and anil glyoxyl:

\[
\begin{align*}
\text{C}_6\text{H}_5\text{NH} & \quad \text{H} \quad \text{C}_6\text{H}_5\text{NH} \quad \text{H} \\
\text{C}_6\text{H}_5\text{NH} & \quad \text{COOH} \quad \rightarrow \quad \text{C}_6\text{H}_5\text{NH}_2 + \text{C}_6\text{H}_5\text{N} = \text{C} \quad \text{COOH} \\
\end{align*}
\]

This is again changed by aniline to dianilineaceticester Hofmann's rearrangement also occurs.

\[
\begin{align*}
\text{C}_6\text{H}_5\text{NH} & \quad \text{H} \quad \text{H}_2\text{NCO}_6\text{H}_4 + \text{H} \\
\text{C}_6\text{H}_5\text{NH} & \quad \text{COOH} \quad \rightarrow \quad \text{H}_2\text{NCO}_6\text{H}_4 \quad \text{COOH} \\
\end{align*}
\]


It was noticed by Curtis\(^1\) that mercuric oxide on ethyl anilinomalonate in the presence of dry ligroin gave ethyl dianilinomalonate, and the reaction was at that time explained according to the following theory:

Mercuric oxide and ethyl anilinomalonate might first form ethyl anilinotartronate and this by the action of water might form ethyl phenylinomalonate which in turn by the action of water might split off aniline and ethyl dihydroxymalonate. These two react to form ethyl dianilinomalonate as proved by experiment\(^2\).

We have attempted to prove the value of this theory. We have made the theoretic oxidation product of aniline malonic ester as follows:

\[
\begin{align*}
C_6H_5NH\text{-}COOCH_3 + HO\text{-}COOCH_3 & \rightarrow C_6H_5NH\text{-}COOCH_3 + HO\text{-}COOCH_3
\end{align*}
\]

and from it methyl phenylinomalonate was formed by the action of phosphorus pentoxide:

\[
\begin{align*}
C_6H_5NH\text{-}COOCH_3 + P_2O_5 & \rightarrow C_6H_5N\text{-}COOCH_3 + H_3PO_4
\end{align*}
\]

We have proved that the latter substance does give by the action of water, methyl dianilinomalonate.

\[
\begin{align*}
2C_6H_5N\text{-}COOCH_3 + H_2O & \rightarrow C_6H_5NH\text{-}COOCH_3 + HO\text{-}COOCH_3 + C_6H_5NH\text{-}COOCH_3 + HO\text{-}COOCH_3
\end{align*}
\]


We have also shown that in the last reaction, in case aniline and methyl mesoxalate are first formed by the action of water upon methyl phenyliminomalonate that these products do react to give methyl dianilinomalonate.

\[
2C_6H_5NH_2 + HO\text{COOCH}_3 = C_6H_5NH\text{COOCH}_3 + 2H_2O.
\]

We have attempted to determine whether or not in the initial oxidation of methyl anilinomalonate \(C_6H_5COOCH_3\), the malonyl hydrogen is oxidized, forming a tartronic ester of the formula \(C_6H_5\text{COOCH}_3\); and whether or not this latter substance dissociates into methyl phenylimalonate \(C_6H_5\text{COOCH}_3\), which we have shown, does give methyl dianilinomalonate by the further action of water. We find that methyl anilinomalonate reacts with water but slightly, at ordinary temperature. The dissociation of phenyliminomalonate in the presence of water appears therefore to take place in the following manner. By the direct addition of two atoms of hydrogen of a molecule of water on the nitrogen with simultaneous separation of the carbon and its union to the oxygen of the water.

\[
\begin{align*}
C_6H_5\text{N=C COOCH}_3 \\
C_6H_5\text{COOCH}_3
\end{align*}
\]

These products then react as shown by experiment:

\[
2C_6H_5NH_2 + HO\text{COOCH}_3 = C_6H_5NH\text{COOCH}_3 + 2H_2O.
\]
We have studied methyl anilinotartronate derivatives and a brief summary of the work will be given. Methyl anilinotartronate was made by the action of aniline on methyl oxomalonate as stated above; and when this substance is treated with phosphorus pentoxide the elements of water are withdrawn and methyl phenyliminomalinate is formed.

\[ \text{C}_6\text{H}_5\text{NHCOOCH}_3 + \text{P}_2\text{O}_5 = \text{C}_6\text{H}_5\text{NCOOCH}_3 + \text{H}_3\text{PO}_4 \]

This is a heavy yellow oil, which acts in many ways like phenyliso cyanate or carbanile, which is produced by treating carbanilic ester with phosphorus pentoxide.

\[ \text{CO} \leq \text{NH.C}_2\text{H}_5 + \text{P}_2\text{O}_5 = \text{C}_6\text{H}_5\text{N}=\text{CO} + \text{PO}(\text{OC}_2\text{H}_5)_3 \]

Carbanile reacting with water yields diphenyl urea:

\[ \text{C}_6\text{H}_5\text{N}=\text{CO} + \text{H}_2\text{O} = \text{C}_6\text{H}_5\text{NH} \]

Treated with aniline it yields the same product;

\[ \text{C}_6\text{H}_5\text{N}=\text{CO} + \text{C}_6\text{H}_5\text{NH}_2 = \text{C}_6\text{H}_5\text{NH} \]

and with alcohol, phenylurethane is formed,

\[ \text{C}_6\text{H}_5\text{N}=\text{CO} + \text{C}_2\text{H}_5\text{OH} = \text{C}_6\text{H}_5\text{NH} \]

(2) Ricter, Vol. 2, p. 89.
We have found that the action of aniline on methyl phenyliminomalonate gives methyl dianilinomalonate:

\[
\text{C}_6\text{H}_5\text{N}=\text{C}^{-}\text{COOCH}_3 + \text{C}_6\text{H}_5\text{NH}_2 = \text{C}_6\text{H}_5\text{NH}^{-}\text{C}^{-}\text{COOCH}_3 \text{C}_6\text{H}_5\text{NH}^{+}\text{COOCH}_3.
\]

The same product is formed along with methyl dihydroxymalonate by the action of water.

\[
2\text{C}_6\text{H}_5\text{N}=\text{C}^{-}\text{COOCH}_3 + \text{H}_2\text{O} = \text{C}_6\text{H}_5\text{NH}^{-}\text{C}^{-}\text{COOCH}_3 + \text{HO}^{-}\text{COOCH}_3.
\]

In addition to the methods stated above we have formed methyl dianilinomalonate by the following methods:

\[
2\text{C}_6\text{H}_5\text{NH}^{-}\text{COOCH}_3 + \text{HgO} = \text{C}_6\text{H}_5\text{NH}^{-}\text{C}^{-}\text{COOCH}_3 + \text{HO}^{-}\text{COOCH}_3.
\]

In the following reaction the products were not separated pure.

\[
3\text{C}_6\text{H}_5\text{NH}^{-}\text{COOCH}_3 + \text{HgO} = \text{C}_6\text{H}_5\text{NH}^{-}\text{C}^{-}\text{COOCH}_3 + \text{HO}^{-}\text{COOCH}_3 + \text{H}_2\text{O}.
\]

The actions of ethyl and methyl alcohol and hydrochloric acid gas were tried on methyl phenyliminomalonate; in each case a white crystalline product was formed, the formulas of which were not determined on account of lack of time. In each case the reaction took place very rapidly showing the methyl phenyliminomalonate to be a very reactive body. The fact that this golden yellow oil looses its color when acted on by other substances and forms white crystalline compounds is also very interesting in connection with the recent theory of isorropesis, or cause of color.
EXPERIMENTAL

REACTIONS OF ANILINO TARTRONIC ESTER.

(a) PHOSPHORUS PENTOXIDE ON METHYL ANILINOTARTRONATE: Ten grams of methyl anilinotartronate were thoroughly mixed with two and five-tenths grams of phosphorus pentoxide (mol. = 1.97 gr.) and allowed to stand at ordinary room temperature. At the end of two days it was a yellow sticky mass (Sometimes the reaction begins almost immediately on mixing, and in one case it stood two weeks before any change was noticed.) At the end of six days it had separated into a heavy yellow oil and a hard red and yellow solid. A portion of the oil was decanted and the remainder was dissolved in five times its volume of sodium dry ether. The solid mass was not soluble in ether. Analysis was made on both the decanted sample and that which had been extracted with ether (after evaporating the ether).

ANALYSIS:

Calculated for

\[ C_6H_5N=C(COOCH_3)_2 \]

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<tr>
<th></th>
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<th>Found</th>
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<tbody>
<tr>
<td>C</td>
<td>59.69</td>
<td>59.98</td>
</tr>
<tr>
<td>H</td>
<td>5.02</td>
<td>5.00</td>
</tr>
<tr>
<td>N</td>
<td>6.33</td>
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PROPERTIES; The methyl phenyliminomalonate is a heavy golden yellow oil, having a sharp biting taste. The presence of the double bond between the N=C gives it color and makes it an extremely reactive body. It combines with the moisture of the atmosphere when exposed to the air; adds on water, alcohols, acids, and amines; and in many ways suggests the reactivity of the cyanate RN=CO and isocyanate RN=C.
(b) WATER ON METHYL ANILINOTARTRONATE: About two grams of methyl anilinotartronate were thoroughly mixed with a small quantity of water. A strong odor of aniline was noticed. The mixture was allowed to stand for seven days, and then washed with water and dissolved in ether. The crystaline product obtained melted at 80 degrees, showing the presence of methyl dihydroxymalonate. This substance was recrystalized seven times and then melted at 110 degrees. This indicates the presence of something having a higher melting point than the methyl anilinomalonate (102 degrees). Not enough of the material remained to purify further. These melting points indicate the presence of methyl dihydroxymalonate, methyl anilinotartronate, and methyl dianilinomalonate, and proves that under ordinary conditions of temperature and pressure the methyl anilinotartronate does not act in the same way as the methyl phenyliminomalonate in the presence of water.

(c) HEAT ON METHYL ANILINOTARTRONATE: One gram of methyl anilinotartronate was heated in a metal bath for one hour. The temperature of the bath went as high as 200 degrees. The substance turned yellow and then went to a deep red color and moisture condensed on the sides of the flask. It was removed from the water bath and extracted with ether. Part of it remained behind as a hard insoluble residue. The solution was washed thoroughly with dilute hydrochloric acid and then with water, and dried with calcium chloride. A red powdery substance remained after the ether was evaporated. This was not analysed,
but it was probably an indol compound.

**OXIDIZATION OF METHYL ANILINOMALONATE:** One gram of methyl anilinomalonate (made by the action of aniline on methyl brommalonate), was mixed with 1.08 grams of freshly prepared mercuric oxide in dry ligroin solution. This mixture was heated on a water bath for fifteen hours. The action was very slow and the mercuric oxide was not completely reduced. When the liquid was removed from the water bath, it was grass green in color. The liquid was filtered off and evaporated, crystals formed in hexagonal plates, which suggested the dianilino body.

After recrystallizing five times the substance melted at 124 degrees. This reaction was very slow and only a small percent yield was obtained.

The oxidization of methyl anilinomalonate was tried again using xyline as a solvent, the mercuric oxide was reduced a little more rapidly, than when ligroin was used. It was also tried using hydrochloric acid as a catalyst and again using sodium hydroxide. The action went more rapidly when hydrochloric acid was present.
ACTION OF ANILINE ON METHYL PHENYLIMINOMALONATE: Three and two-tenths grams of methyl phenyliminomalonate were mixed with one and seventy-one hundredths grams of aniline. The temperature rose thirty-five degrees. Then the mixture turned to a thick glycerine lige syrup, which quickly changed to a colorless crystalline mass. It was recrystallized several times by dissolving in sodium dry ether and evaporating the solvent in a vacuum dessicator over sulphuric acid, then filtering and washing with cold ether. Attempts to concentrate the solvent on a water bath produced a yellow gummy mass, which was almost impossible to purify.

ANALYSIS:
Calculated for
\[
\begin{align*}
C_6H_5NH & - COOCH_3 \\
C_6H_5NH & - COOCH_3
\end{align*}
\]

\[
\begin{align*}
C &= 64.91 \\
H &= 5.78 \\
N &= 6.93
\end{align*}
\]

Found:
\[
\begin{align*}
C &= 64.94 \\
H &= 5.99 \\
N &= 8.73
\end{align*}
\]

PROPERTIES: The methyl dianilinomalonate is a white crystalline substance having a melting point between 124 and 125 degrees. Its crystals appear as hexagonal plates. It is easily soluble in acetone, benzene, and chloroform; fairly soluble in acetic ether, ether, absolute ethyl and methyl alcohols; and slightly soluble in ligroin; and insoluble in water. It becomes electrified on rubbing with a glass rod. These properties are identical with those of the product as made by M. Conrad referred to in the introduction of this paper.
ACTION OF WATER ON METHYL PHENYLIMINOMALONATE: Two grams of methyl phenyliminomalonate were mixed with one gram of water. The water immediately becomes milky and the oil turns to a lemon yellow color and becomes sticky and thick. The substance goes to a hard dry nearly colorless crystaline mass, on allowing it to stand for one day. It was then washed with seven c.c. of water, in order to wash out all the methyl mesoxalate crystals. The remaining crystals were then dissolved in six times their volume of ether and again washed with water. The crude crystals from the ether solution weighed 1.2 grams, and had a melting point of 112 degrees. It was recrystalized from ether and weighed 0.9 gram, and melted at 124 degrees.

ANALYSIS:
Calculated for                              Found.
\[
\begin{align*}
\text{C}_6\text{H}_5\text{NH} & \quad \text{COOCH}_3 \\
\text{C}_6\text{H}_5\text{NH} & \quad \text{COOCH}_3
\end{align*}
\]
\[
\begin{align*}
\text{C} = 64.91 & \quad \text{C} = 65.05 \\
\text{H} = 5.78 & \quad \text{H} = 5.61 \\
\text{N} = 8.93 & \quad \text{N} = 8.71
\end{align*}
\]

The properties of this substance are identical with those of the methyl dianilinomalonate as stated above.

All the water washes were put together and evaporated in a dessicator. The methyl dihydroxymalonate weighed 0.9 gram and melted at 78 degrees.

ANALYSIS:
Calculated for                              Found.
\[
\begin{align*}
\text{HO} & \quad \text{COOCH} \\
\text{HO} & \quad \text{COOCH}
\end{align*}
\]
\[
\begin{align*}
\text{C} = 36.57 & \quad \text{C} = 36.70 \\
\text{H} = 4.92 & \quad \text{H} = 5.94
\end{align*}
\]
The properties of this substance were found to be identical with those of methyl dihydroxymalonate.

When methyl phenyliminomalonate is exposed to the air for several days it takes up moisture from the atmosphere, loses its color and changes to a solid crystalline mass, which when analysed proved to be a mixture of methyl dianilinomalonate and methyl dihydroxymalonate.

**ACTION OF HYDROCHLORIC ACID GAS ON METHYL PHENYLIMINOMALONATE:** Hydrochloric acid gas was run into a small quantity of methyl phenyliminomalonate, which was kept in a freezing mixture, for fifteen minutes. Heat was generated, the yellow oil lost its color and a light yellow crystalline substance was formed. This product was filtered and washed with ether. It was a pure white crystalline mass, which melted at 150 degrees. It was but very slightly soluble in all the common organic solvents. It was not the aniline hydrochloride because it was insoluble in hydrochloric acid. This product was not studied further.

**ALCOHOL ON METHYL PHENYLIMINOMALONATE:** The action of both ethyl and methyl alcohol was tested on methyl phenyliminomalonate and in each case a white crystalline salt was formed. The reaction went on in a manner similar to that which took place when water was added to methyl phenyliminomalonate. The salts of the alcohol reactions were not purified and analysed.

**REDUCTION OF METHYL PHENYLIMINOMALONATE:** To five-tenths of a gram of methyl phenyliminomalonate and six c.c. of water, was added three c.c. of a ten percent hydrochloric acid solution and a small quantity of sodium amalgam; a slight amount of gas
given off when the acid was added. On shaking vigorously a green oil separated out and floated on the surface of the liquid. The solution was kept acid. The product was a dirty green mixture. It was decanted and dissolved in ether and dried with calcium chloride, washed with ether and recrystallized. It melted at 123 degrees.

This reaction is not due to the reduction of hydrogen but is due to the presence of water.

ANILINE ON METHYL DIHYDROXYMALONATE: Four and ninety-two hundredths grams of methyl dihydroxymalonate were mixed with five and fifty-eight hundredths grams of aniline and heated in a water bath for thirty minutes. At sixty-five degrees the action began, water formed on the sides of the flask, and the substance changed to a thick yellow oil. When removed from the water bath it was dark red in color. It was extracted with fifty C.c. of ether and the dark red solution was washed thoroughly with ten percent hydrochloric acid, and then with water to remove the excess of aniline. It was then dried with potassium carbonate, filtered and evaporated on a water bath. The melting point of the crystals was 112 degrees. They were recrystallized again from dry ether and melted at 124-125 degrees. The properties are analogous to those of methyl dianilino-malonate.

ANALYSIS:
Calculated for
\[
\begin{align*}
\text{C}_6\text{H}_5\text{NH}_2\text{COOCH}_3 \\
\text{C}_6\text{H}_5\text{NH}_2\text{COOCH}_3 \\
\text{C}_6\text{H}_5\text{NH}_2\text{COOCH}_3
\end{align*}
\]

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Laboratory of Organic Chemistry,

University of Illinois,

June 1st. 1909.

F. Grace C. Spencer,
in
Conjunction with
Dr. R. S. Curtiss.