

a good gel structure. The reactions of this base with ferric chloride and arsenic acid do not interfere. It may be objected that 2 cc. of water on the upper side of the membrane would allow hydrochloric acid to dialyze out in the usual manner even in the absence of a base. Evidently this is not a factor as in our experiment the volume of the colloid below the membrane was 10 cc.

A similar experiment was performed with a colloid volume of 15 cc. below and 2 cc. of water above the membrane, the upper vessel containing some solid calcium hydroxide as the base. A good gel formed in a week.

Finally we tried an experiment with 50 cc. of the same colloid below and 2 cc. of a saturated solution of sodium acetate above the membrane. Some solid sodium acetate was added to replace what dialyzed down through the goldbeater's skin. A good gel resulted in one week. Here the sodium acetate slowly repressed the ionization of the hydrochloric acid and, for gel-forming purposes, did the same work as the ammonium hydroxide or the calcium hydroxide.

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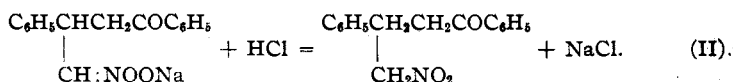
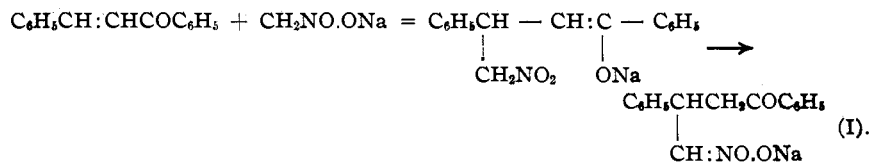
[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF HARVARD UNIVERSITY.]

THE ADDITION OF NITROMETHANE TO UNSATURATED ESTERS.

By E. P. KOHLER AND H. ENGELBRECHT.¹

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In an earlier paper² it was shown that sodium nitro-paraffins combine with α,β -unsaturated ketones and form metallic derivatives from which acids liberate γ -nitro ketones:



The reaction takes place so readily and smoothly that we anticipated little difficulty in extending it to α,β -unsaturated esters. We soon found,

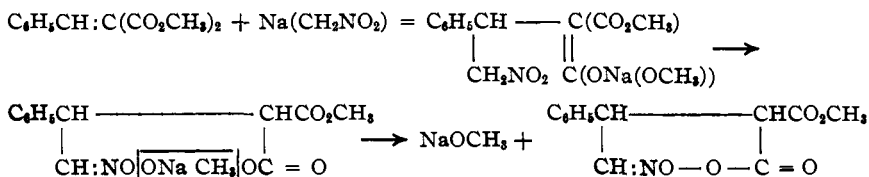
¹ This work was started with the intention of making cyclopropane derivatives containing nitro and carboxyl groups attached to the ring. It was interrupted when Mr. Engelbrecht joined the army and it is published in the present incomplete form because he died in the service.—E. P. K.

² THIS JOURNAL, 38, 889 (1916).

however, that no solid products can be obtained from the esters by the procedure that was so successfully used with the ketones. When sodium nitromethane was added to alcoholic solutions of a number of α,β -unsaturated esters it immediately produced an orange or red color in the solutions. The color increased as the reaction proceeded and became a deep blood red by the time one molecule of the nitro compound had been added. The solutions, on acidification, gave red oils which were uncrystallizable and which could not be purified by vacuum distillation.

The results were essentially the same when we attempted to condense the nitro compound and the ester in the presence of small quantities of sodium alcoholate, sodium amide, piperidine, potassium acetate, and other feebly basic condensing agents. By substituting benzene for alcohol as solvent and operating at temperatures just above the freezing point of the solutions it was possible, however, to get solid products with a few of the esters; and certain observations that were made while using this method, finally led to the development of a rational procedure.

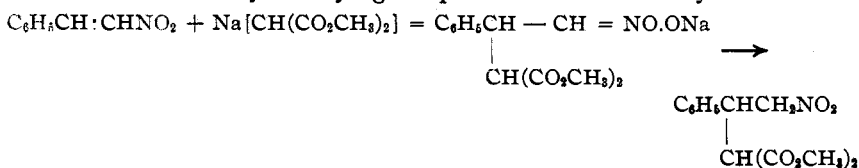
It was observed, for example, that in order to get solid products at all, it was necessary to acidify immediately after all of the nitro compound had been added. It was found, also, that by far the best yields of solid product were obtained in experiments with very small quantities. Thus the yield from 2 g. of benzoyl acrylic ester was 90%, while only 35% could be obtained from 25 g. of the same ester. These and similar observations led to the conclusion that sodium nitromethane combines with unsaturated esters as expected and that the red oils are secondary products. These red oils cannot be metallic derivatives because their color is not affected by addition of acid, and they cannot be due to simple hydrolysis of the esters because they are insoluble in sodium carbonate. It seemed probable, therefore, that they are heterocyclic compounds formed by loss of sodium alcoholate from the metallic derivatives:



Acting on this assumption we conducted the reaction in dry methyl alcohol neutralized with a little glacial acetic acid, and then saturated the solution with hydrogen chloride. This procedure gave uniformly good yields of solid nitro compounds and solved the problem of adding nitro-paraffins to unsaturated esters.

That the mode of addition to the esters is the same as that to unsaturated ketones could be shown neatly in the case of benzal-malonate. This gives a crystalline ester which melts at 63°. We have found that

sodium malonic ester readily combines with β -nitrostyrene and that the substance obtained by acidifying the product is the same crystalline ester.



Experimental Part.

Methyl β -Phenyl- γ -nitro-ethylmalonate, $\text{NO}_2\text{CH}_2\text{CH}(\text{C}_6\text{H}_5)\text{CH}(\text{CO}_2\text{CH}_3)_2$.—A suspension of sodium nitromethane was made by dissolving 1.5 g. of sodium in 30 cc. of dry methyl alcohol, adding 10 cc. of nitromethane, and shaking vigorously until the white, gelatinous mass was finely divided. A solution of 11 g. of methyl benzal-malonate in dry methyl alcohol was then added, and the mixture shaken until all the suspended solid had completely disappeared. The orange-colored solution was immediately acidified with a slight excess of glacial acetic acid, cooled in ice water, and saturated with hydrogen chloride. The color began to fade almost immediately, and as soon as the solution had become colorless it was poured into a suspension of cracked ice in sodium carbonate. This precipitated a colorless oil that solidified when rubbed with a glass rod. The solid was washed with water, dried, and crystallized from methyl alcohol, in which it is readily soluble and from which it separates very slowly in clusters of stout prisms that melt at 63° . The yield of recrystallized product was 13.5 g.

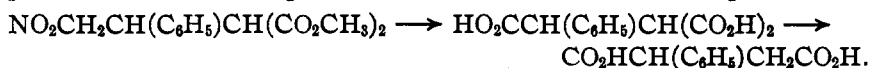
Calc. for $\text{C}_{18}\text{H}_{16}\text{O}_6\text{N}$: C, 55.5; H, 5.4. Found: C, 55.9; H, 5.4.

The nitro compound is readily soluble in all common organic solvents except ligroin. Its structure was established by the following synthesis from sodium methyl malonate and β -nitrostyrene:

A solution of sodium methyl malonate, made by adding one g. of sodium to a solution of 6 g. of methyl malonate in 30 cc. of dry methyl alcohol, was cooled in ice water, treated with 5 g. of finely powdered solid nitrostyrene, and shaken vigorously until all of the nitrostyrene had disappeared. The clear solution was immediately acidified with glacial acetic acid, then saturated with hydrogen chloride. The product was isolated as described in the previous experiment. The yield of recrystallized nitro compound was 7.5 g.

We did not succeed in hydrolyzing the ester. Alkalies, as expected, gave only oily decomposition products. Boiling hydrochloric acid slowly hydrolyzes the ester groups, but the nitro group is also lost in the process. Thus 5 g. of the ester was suspended in moderately concentrated acid and the mixture boiled for 15 hours during which all of it disappeared. The solution, on cooling, deposited a crystalline dibasic acid, which melted at 167° and had the formula $\text{C}_{10}\text{H}_{10}\text{O}_4$. By comparison with a specimen

on hand this was identified as phenylsuccinic acid. The yield—3 g. of pure acid—was almost quantitative, in accordance with the equation

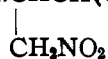


Methyl Bromophenylnitro-ethylmalonate.—The nitro ester reacts very slowly with bromine in carbon tetrachloride. The reaction stops with one molecule of bromine and it gives a monobromo derivative in calculated quantity. This was isolated in the usual way and purified by recrystallization from methyl alcohol. It separated in fine needles that melted at 158°.

Calc. for $\text{C}_{13}\text{H}_{14}\text{O}_6\text{NBr}$: Br, 22.6. Found: 22.2.

No attempt was made to locate the bromine atom; by analogy with the behavior of the corresponding nitro ketones, it would be expected to be in the α -position.

Addition to Dimethyl Cinnamylidenemalonate, $\text{C}_6\text{H}_5\text{CH}:\text{CH}.\text{CHCH}(\text{CO}-$



$\text{CH}_3)_2$.—Dimethyl-cinnamylidene malonate was the only unsaturated ester that gave fairly satisfactory results when the addition was carried out in benzene. A solution of 2.5 g. sodium in 65 cc. of dry methyl alcohol was added with constant shaking to a solution of 10 cc. of nitromethane in 200 cc. of dry benzene. This gave finely divided sodium nitromethane suspended in benzene. The suspension was cooled in ice water, treated with 26.5 g. of finely ground ester, and the mixture shaken vigorously until all the ester had disappeared. The resulting clear, red solution was acidified with 4 g. of hydrogen chloride in 50 cc. of methyl alcohol, the precipitated sodium chloride filtered off, and the red solution evaporated in a current of dry air. It deposited a crystalline solid which was purified by repeated recrystallization from methyl alcohol. The yield was 65% of pure, colorless product.

When the reaction was carried out in methyl alcohol as described under dimethyl-benzal malonate it gave a product that was pure after one recrystallization. The yield was 87% of pure substance.

Calc. for $\text{C}_{15}\text{H}_{17}\text{O}_6\text{N}$: C, 58.6; H, 5.6. Found: C, 58.8; H, 5.6.

The ester crystallizes in square plates that melt at 74–75°. It is readily soluble in chloroform and in benzene, moderately soluble in alcohol and in ether. It is readily oxidized by potassium permanganate in acetone, giving benzaldehyde as one of the products.

Addition of Sodium Nitromethane to the Methyl Ester of Benzoylacrylic Acid.—Benzoylacrylic acid has been little used in work on unsaturated compounds because it has been difficult to get it in sufficient quantities. All methods of preparation heretofore proposed have started with maleic acid. We have found it easy to prepare esters of the acid by brominating

the esters of benzoylpropionic acid and eliminating hydrobromic acid from the product. We have also succeeded in greatly increasing the yield of benzoylpropionic acid; it is now possible, therefore, to get esters of benzoylacrylic acid in any desired quantity.

Preparation of Benzoylpropionic Acid.—Seventy g. of dry succinic anhydride and 100 g. of powdered aluminum chloride are thoroughly ground together in a large, porcelain mortar. The anhydride must be free from acid and should be dried immediately before using. No reaction should take place during the grinding—which cannot be too thorough because the yield depends largely upon the intimacy of the mixture.

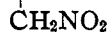
Dry benzene (350 g.) is added to the mixture in small quantities and with constant stirring. In the beginning each addition produces a vigorous reaction. When this no longer occurs, the remainder of the benzene is added and the brown paste stirred for another hour, and then allowed to stand at room temperature for 10–12 hours more. The aluminum compounds are then decomposed by pouring the paste into a mixture of finely cracked ice and hydrochloric acid, and the excess of benzene removed by distillation with steam. The residue is a red oil that solidifies on cooling. The red solid and the colorless crystals that separate from the aqueous layer are filtered off and the whole recrystallized from boiling water. The substance separates in long, white needles that melt at 116.5° . The maximum yield obtained was 75%, but most preparations gave 60–65%.

The methyl ester was made by dissolving the acid in dry methyl alcohol and saturating the cold solution with hydrogen chloride. The solution was allowed to stand overnight, then poured into a mixture of cracked ice and sodium carbonate. The oil was extracted with ether, the ethereal solution dried with anhydrous sodium sulfate, the ether removed, and the residue distilled under diminished pressure. The colorless ester boils at 187° under 30 mm. pressure, and solidifies at 18° . The yield was 85%, and 8% of the acid was recovered from the solution in sodium carbonate.

Preparation of Benzoylacrylic Ester.—The methyl ester of benzoylpropionic acid was brominated in chloroform in the usual way. The solution on evaporation under diminished pressure left a colorless oil. This was dissolved in dry methyl alcohol and the solution treated with twice the calculated quantity of potassium acetate. Potassium bromide began to separate at once. The mixture was allowed to remain at the ordinary temperature for several hours, then heated on a steam-bath for half an hour and poured into ice water. This precipitated a yellow oil which was dissolved in ether, washed with ice water, dried over sodium sulfate and distilled under diminished pressure. The yellow oil distilled at 191° under 40 mm. pressure, and the distillate solidified at 32° . The yield of pure ester was 92%.

Calc. for $C_{11}H_{10}O_3$: C, 69.5; H, 5.3. Found: C, 69.7; H, 5.4.

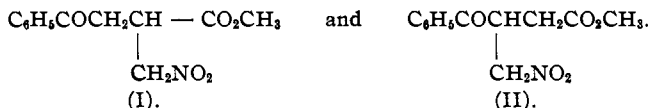
Methyl α -Phenacyl- β -nitro Propionate, $C_6H_5COCH_2CH - CO_2CH_3$.—



A solution of 26 g. of the ester in 30 cc. of methyl alcohol was added to a suspension of finely divided sodium nitromethane made by adding 20 cc. of nitromethane to a solution of 3.5 g. of sodium in 100 cc. of dry methyl alcohol. The mixture was kept cool with ice water and shaken vigorously until all of the precipitate had disappeared, then immediately acidified with 20 cc. of glacial acetic acid. This gave a bright red solution which was cooled in a freezing mixture, saturated with hydrochloric acid, and allowed to stand until colorless. The nitro compound separated as a solid when the colorless solution was poured into cracked ice and sodium carbonate. One recrystallization from methyl alcohol gave a perfectly pure product that melted at 57° . The yield was 92%.

Calc. for $C_{12}H_{13}O_5N$: C, 57.4; H, 5.2; N, 5.6. Found: C, 57.4; H, 5.2; N, 5.9.

Two formulas are possible for this substance because the ethylene linkage in benzoylacrylic ester is conjugated both with the carbonyl and the carboxyl groups.



We represent it by Formula I not only because unsaturated ketones combine with metallic derivatives more readily than do unsaturated esters, but also because work going on in this laboratory has shown that sodium malonic esters combine with benzoylacrylic ester in the manner indicated by this formula.

When the nitro compound was hydrolyzed by boiling with conc. hydrochloric acid it lost both carbon dioxide and the nitro group, and gave as sole product benzoylpropionic acid. On bromination in chloroform it formed two isomeric monobromo derivatives. These were easily separated because the higher melting compound is very sparingly soluble in cold methyl alcohol. It crystallizes in plates and melts at 125° , while the isomer crystallizes in needles and melts at 59° .

Calc. for $C_{12}H_{12}O_5NBr$: Br, 24.2. Found: 24.4, 24.6.

Summary.

1. The paper defines the conditions under which it is possible to get nitro esters by adding sodium nitromethane to α,β -unsaturated esters.

2. It shows that γ -nitro esters may also be obtained by adding metallic derivatives of malonic ester to β -nitrostyrene. This is a new reaction which promises to be quite as useful as the addition of nitroparaffins to unsaturated compounds.

3. It gives a series of reactions by which it is easy to prepare the esters of benzoylacrylic acid.

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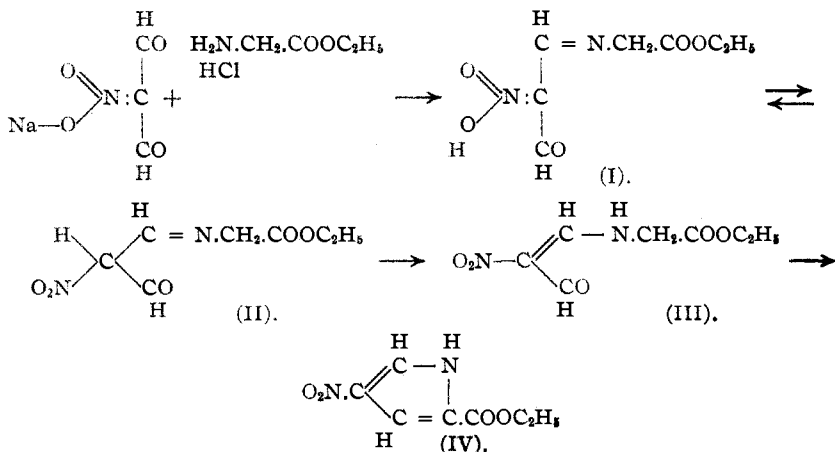
[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF THE UNIVERSITY OF MICHIGAN.]

THE CONDENSATION OF AMINO COMPOUNDS WITH NITROMALONIC ALDEHYDE.

BY WILLIAM J. HALE AND EDWARD M. HONAN.

Received February 15, 1919.

The condensation of aminoacetic esters with nitromalonic aldehyde has been shown by Hale and Hoyt¹ to yield carbopyrrolic esters. As an intermediate step in the production of this pyrrole these authors described briefly an aldehyde of the aliphatic series and assigned thereto the constitution as shown in Formula II. This intermediate product we now find possible of formation in dilute alkaline medium from which it separates readily. The presence of dilute alkali must certainly be expected to hold the isonitro group of nitromalonic aldehyde in its original form and make secure the constitution of Formula I for an alkaline salt of that compound produced in the first stage of the condensation; the free substance, however, actually precipitated from the alkaline solution is not a salt and consequently Formula II as a nitroparaffin, readily tautomeric with the isonitro form in the presence of alkali, cannot represent its constitution. The action of warm alkali easily effects the transformation of this intermediate product to a pyrrole derivative, in which the Hinsberg reaction and also the Liebermann nitrosamine reaction clearly indicated a secondary amine. By reason of the comparative stability of the intermediate product in dilute acid solution the Liebermann nitrosamine



¹ THIS JOURNAL, 37, 2538 (1915).