

2-Methyl-1-phenyl-1,3-pentanedione.—The above diketone (46 g., 0.25 mole) in dry ether (250 cc.) was added dropwise, with stirring, to a suspension of powdered sodium (6 g., 0.25 g. atom) in dry ether (80 cc.) at 0°. The mixture was stirred for three hours at 0°; ether was removed under reduced pressure and the residue was dissolved in dry acetone (300 cc.). The solution was stirred while methyl iodide (0.5 mole) was added dropwise; after addition was complete, the mixture was stirred for one and one-half hours and then allowed to stand overnight. Excess methyl iodide and acetone were removed by distillation under reduced pressure, water was added, and the whole was extracted with ether. The extract was dried (Drierite), ether was removed, and the residue was distilled. The product (35.1 g., 71%), a pale yellow liquid, boiled at 128–130° (5 mm.), and had n_D^{20} 1.5268, n_D^{25} 1.5261.

Anal. Calcd. for $C_{12}H_{14}O_2$: C, 75.76; H, 7.42. Found: C, 75.61; H, 7.69.

The diketone formed a copper enolate which, crystallized from methanol, was olive-green and melted at 173–175° (dec.), but there was always a small amount that remained unmelted and no feasible way was found to purify the substance.

3-Ethyl-4-methyl-5-phenylpyrazole.—Hydrazine hydrate (80%, 1.2 cc.) was added, with cooling and shaking, to the above diketone (2.4 g., 0.013 mole). Ethanol was added dropwise until the mixture became homogeneous; the solution was refluxed for five minutes, then cooled and diluted with water. The resulting heavy oil (2.1 g., 89%) solidified on standing in a refrigerator overnight. The product was crystallized three times from aqueous alcohol, when it melted at 100.5–101.5°, alone or when mixed with the pyrazole prepared from the diketone resulting from hydrolysis of V.

Anal. Calcd. for $C_{12}H_{14}N_2$: C, 77.38; H, 7.58. Found: C, 77.25; H, 7.72.

Summary

1. Two new nitrocyclopropyl ketones, each representing a new type of these substances, have been synthesized. One of these, 3,3-dimethyl-2-nitro-1-cyclopropyl phenyl ketone (I), has no hydrogen attached to the number 3 carbon atom of the ring; the other, 1,3-dimethyl-2-nitro-1-cyclopropyl phenyl ketone (II), has no hydrogen attached to the number 1 carbon atom of the ring.

2. Both of the new nitrocyclopropanes have been converted into 1,3-diketones by reaction with sodium methoxide; hence, if the reaction involves intermediate cyclopropenes formed by loss of the elements of nitrous acid, it is immaterial whether the double bond in the cyclopropene lies in the α,β - or β,γ - position to the carbonyl group. However, the precursors of the diketones, the methyl enol ethers, do differ in the two cases: from I, with no hydrogen attached to C-3 of the ring, the β -methoxy ketone is unsaturated at the α,β -position; from II, with no hydrogen attached to C-1 of the ring, the β -methoxy ketone is unsaturated at the β,γ - position.

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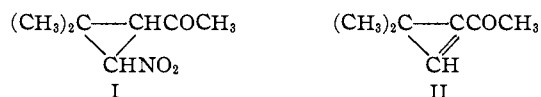
[CONTRIBUTION FROM THE SCHOOL OF CHEMISTRY OF THE UNIVERSITY OF MINNESOTA]

Cyclopropanes. II.¹ An Aliphatic 2-Nitro-1-cyclopropyl Ketone. Mechanism of the Reaction between Nitrocyclopropyl Ketones and Alkali

By LEE IRVIN SMITH AND VAUGHN A. ENGELHARDT²

In the previous paper,¹ it was shown that in the transformation of a nitrocyclopropyl ketone into a 1,3-diketone by action of alkali, the position of the double bond in the hypothetical cyclopropene intermediate was immaterial; whether the nitrocyclopropane was so constituted that the intermediate cyclopropenyl ketone possessed the double bond in the α,β - or β,γ -position to the carbonyl group, the ultimate product was a 1,3-diketone. In all the nitrocyclopropyl ketones previously studied, there was always at least one aromatic group present as a substituent and, in addition, the ring held directly a carbonyl or carbalkoxyl group. To explore the possible effects of these two groupings upon the reaction with alkali, a purely aliphatic nitrocyclopropyl ketone, I, has been prepared. This substance is of the type which could give only an α,β -cyclo-

propene ketone, II, by loss of the elements of nitrous acid.

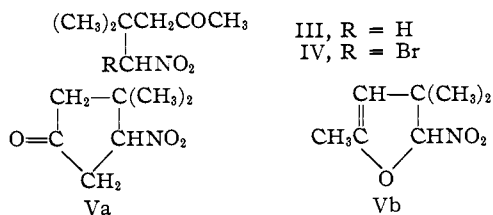


The preparation of I followed the conventional route established by Kohler and his students³; nitromethane was added to mesityl oxide to give the nitro ketone III, which, when brominated in alkaline solution, gave the liquid γ -bromo compound IV. When IV was subjected to the action of potassium acetate in methanol, the elements of hydrobromic acid were eliminated and a compound $C_7H_{11}O_3N$ resulted. In contrast with all the other γ -nitro ketones so far studied, III is a methyl ketone, and the possible compounds formed by ring closure of the bromo compound IV derived from III exceed in number those possible when the ketone is a phenyl- or *t*-butyl ketone. *A priori*, it cannot be taken for granted that bromination of III, even though in

(1) Paper I, Smith and Engelhardt, *THIS JOURNAL*, **71**, 2671 (1949).

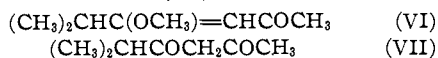
(2) Abstracted from a thesis presented to the Graduate Faculty of the University of Minnesota by Vaughn A. Engelhardt, in partial fulfillment of the requirements for the Ph.D. degree, August, 1948. Presented at the 115th meeting of the American Chemical Society, San Francisco, California, March 27–April 1, 1949.

(3) For example, Kohler and Smith, *THIS JOURNAL*, **44**, 624 (1922).



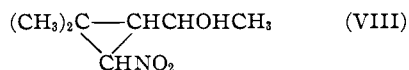
alkaline solution, would produce the γ -bromo compound IV; nor can it be taken for granted that cyclization of the bromo compound would produce I, for Va and Vb are also possible. The substance $\text{C}_7\text{H}_{11}\text{O}_3\text{N}$ readily formed a semicarbazone, and reacted with benzaldehyde to produce a monobenzal derivative. The substance was inert to the action of potassium permanganate, and gave, with ferrous sulfate and alkali, a precipitate of ferric hydroxide, showing the presence of a nitro group.⁴ Action of hydrobromic acid in acetic acid upon the compound produced exothermally an oil which could not be distilled. The compound gave no haloform reaction. However, the compound was converted, with loss of one carbon atom, into an acid via the pyridinium iodide, an elegant procedure developed by King.⁵

These facts serve to establish the structure of the compound as a nitrocyclopropyl ketone I; the acid derived from it is the first example of a nitro-cyclopropane monocarboxylic acid. When I was dissolved in methanol containing four equivalents of sodium methoxide, heat was evolved, sodium nitrite separated, and a liquid, 4-methoxy-5-methyl-3-hexen-2-one (VI) was isolated.



Ozonolysis of VI gave methyl isobutyrate, and action of dilute acid upon VI produced the diketone VII. Acetylisobutyrylmethane, prepared by condensation of ethyl isobutyrate with acetone, gave the same copper enolate as that obtained from VII. It follows, therefore, that the presence of aromatic or other tertiary groups is not necessary for conversion of a nitrocyclopropyl ketone such as I into a 1,3-diketone by action of alkali.

When reduced by action of aluminum isopropoxide, I gave two products—a crystalline solid and an oil. The solid was the alcohol VIII and the oil was a mixture of stereoisomers of VIII, for both oil and solid, when oxidized by action of sodium dichromate, were converted to the ketone I.



Both the oil and the solid gave positive tests for the nitro group with ferrous hydroxide, and the crystalline alcohol VIII gave a crystalline mono-

benzoate. The oil gave a crystalline *p*-nitrobenzoate, but this melted over a wide range and could not be brought to a sharp melting point in spite of the fact that it gave the correct analytical values.

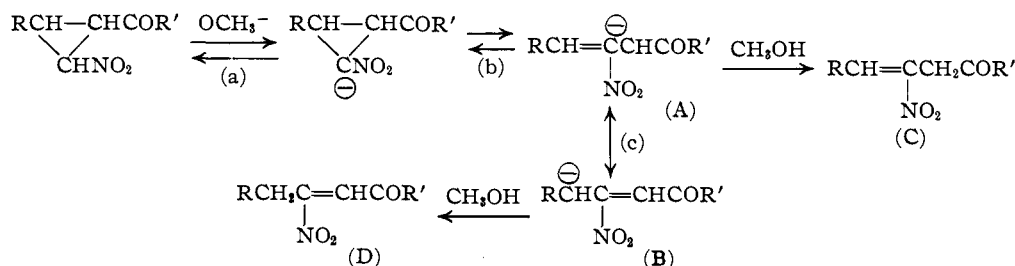
Neither the crystalline alcohol VIII, nor the oily mixture of stereoisomers of VIII, underwent any change when subjected to the action of sodium methoxide in methanol. It follows from this that the presence in position 1 of an electron attracting group, such as a carbonyl group, is a necessary condition for the reaction of 2-nitrocyclopropyl ketones with alkali to produce 1,3-diketones, and that this group in some way plays an essential role in the reaction. The mechanism proposed by Kohler and Smith³ does not assign any role whatever to this necessary electron attracting group. In the conversion of nitrocyclopropyl carbonyl compounds into 1,3-diketones, therefore: (a) an electron attracting group must be present in position 1, and (b) it is immaterial whether elimination of the elements of nitrous acid occurs so as to produce an α,β - or a β,γ -cyclopropene. One of the chief difficulties connected with the mechanism of Kohler and Smith³ has been the mode of transition of the hypothetical cyclopropene into the acetylenic ketone, assumed to be the immediate precursor of the 1,3-diketone. Although there is one example known in which a nitro cyclopropyl diester was transformed into a cyclopropene diester,⁶ the nitrocyclopropyl diester held on the number 2 carbon atom no hydrogen atom, but a phenyl group as well as the nitro group, and the resulting cyclopropene diester was not converted, in turn, into an acetylenic compound by action of alkali. All of these facts indicate that the reaction between alkali and those nitro cyclopropyl carbonyl compounds having one hydrogen atom as well as the nitro group in the 2-position begins with removal of a proton from the carbon atom holding the nitro group. This may be followed by an electron shift induced by the electron-attracting carbonyl group, to give a linear anion—a process analogous to the reversal of a Michael reaction—thus, the overall result of steps (a) and (b) is the withdrawal of the α -carbon atom of a ketone from the β -carbon atom of a nitro compound to give an α,β -unsaturated nitro compound. Step c shows two of the resonance forms of the open-chained nitro ketone: A is the anion of the β,γ -unsaturated ketone, and B is that of the α,β -unsaturated ketone. Addition of a proton to the anions A and B would give the nitro ketones C and D, respectively. From this point, the reaction involves merely the replacement of the nitro group by the methoxyl group, a reaction for which there are many precedents in the literature.⁷ So from C there

(6) Kohler and Darling, *ibid.*, **52**, 1174 (1930).

(4) Shriner and Fuson, "The Systematic Identification of Organic Compounds," 3d ed., John Wiley and Sons, Inc., New York, N. Y., 1948, p. 100.

(5) King, *THIS JOURNAL*, **66**, 894 (1944).

(7) (a) Wieland and Blümlich, *Ann.*, **424**, 102 (1921); (b) Meisenheimer and Connerade, *ibid.*, **330**, 145 (1904); (c) Laubenheimer, *Ber.*, **9**, 1828 (1876); **11**, 1155 (1878); (d) Lobry de Bruyn, *Rec. trav. chim.*, **2**, 236 (1883); **13**, 124 (1894).



would result E, and from D there would result F. Each of these methyl enol ethers would, by

action of acid, lead to the same 1,3-diketone $\text{RCH}_2\text{COCH}_2\text{COR}'$. There is reported in the literature one β -nitro- β,γ -unsaturated ketone of type C, the compound $\text{C}_8\text{H}_5\text{CH}=\text{C}(\text{NO}_2)\text{CH}_2\text{COC}(\text{CH}_3)_3$,⁸ derived from the cyclopropane $\text{C}_8\text{H}_5\text{CH}-\text{CHCOC}(\text{CH}_3)_3$ by successive action of

hydrobromic acid and potassium acetate. Following the directions of Kohler and Rao, this nitrocyclopropyl ketone and the unsaturated nitro compound were prepared; both compounds, subjected to the action of sodium methoxide, gave oils which did not form copper enolates by action of aqueous copper acetate. These oils—presumably unsaturated methoxy ketones—gave the same 1,3-diketone $\text{C}_8\text{H}_5\text{CH}_2\text{COCH}_2\text{COC}(\text{CH}_3)_3$ by action of dilute acid. Thus, an unsaturated, open-chained nitro compound can react with sodium methoxide to give sodium nitrite and an immediate precursor of a 1,3-diketone, a fact which supports the assumption that such unsaturated nitro compounds may be intermediates in the conversion of the nitrocyclopropyl ketones into 1,3-diketones by action of alkali.

The resonance involved between forms A and B of the anions of the unsaturated nitro ketone is important, for the nature of the methyl enol ether of the 1,3-diketone—E, F, or a mixture of the two—is determined by the relative importance of the two forms A and B. This relationship is the familiar one that exists between α,β - and β,γ -unsaturated carbonyl compounds; the available data⁹ indicate that the ratio of the two forms at equilibrium is profoundly influenced by the presence or absence of a hydrogen atom attached to the α -carbon atom in the α,β -form. When such a hydrogen atom is present, the equilibrium is greatly shifted toward the α,β -form; when an alkyl group is substituted for this hydrogen atom, the β,γ -form predominates, sometimes to the complete exclusion of the α,β -form. The mechanism proposed here leads to the β,γ -unsaturated nitro

compound as the first cleavage product, but it was shown in the previous paper¹ that nitrocyclopropyl ketone having a hydrogen atom on C-1, but none on C-3, gave a β -methoxy- α,β -unsaturated ketone, whereas the isomeric nitrocyclopropyl ketone, having a hydrogen atom on C-3, but none on C-1, gave a β -methoxy- β,γ -unsaturated ketone. The difference lies in the resonance shown in step c above, according to the manner in which this is affected by the presence or absence of the α -alkyl group. In this connection, it is significant that although the results of ozonolysis of the β -methoxy- β,γ -unsaturated ketone showed the presence of only this form, the absorption spectrum of this substance showed an intense band at $245\text{ m}\mu$ and a weak band at $315\text{ m}\mu$, indicating the presence of some of the α,β -form.

Experimental Part¹⁰

5-Nitro-4,4-dimethyl-2-pentanone (III).—A solution of mesityl oxide (410 g., 4.2 moles) and nitromethane (282 g., 4.6 moles) in dry ethanol (1500 cc.) was stirred and refluxed while a solution of sodium ethoxide (sodium, 9.8 g., dry ethanol, 200 cc.) was added. Refluxing was continued for twenty-one hours; the solution was then cooled, neutralized with acetic acid, and filtered. Most of the ethanol was removed under reduced pressure; the residue was mixed with an equal volume of water and extracted with ether. The combined extracts were dried (Drierite), ether and unchanged starting materials were removed by distillation (30 mm.), and the residual oil was fractionated. After a forerun (62.6 g.) boiling at $42\text{--}109^\circ$ (11 mm.), the main product (418 g., 63%) boiled at $109\text{--}110^\circ$ (11 mm.), and had n_D^{20} 1.4422.

Anal. Calcd. for $\text{C}_7\text{H}_{13}\text{O}_3\text{N}$: C, 52.81; H, 8.23. Found: C, 52.69; H, 8.23.

The nitroketone did not decolorize permanganate, and the iodoform test was negative. The semicarbazone, crystallized from alcohol, melted at $163\text{--}164^\circ$ (dec.). The experimental conditions outlined above must be followed rather closely in order to obtain the yield cited.¹¹

5-Bromo-5-nitro-4,4-dimethyl-2-pentanone (IV).—A solution of sodium methoxide (sodium, 23 g., dry methanol, 225 cc.) was added, with stirring, to the nitro ketone III (150 g., 0.95 mole) at $0\text{--}10^\circ$. This solution of the acinitro ketone was then added, with stirring and at $0\text{--}5^\circ$, to a solution of bromine (166 g., 1.04 moles) in dry chloroform (350 cc.). Cooling was discontinued, the mixture was stirred for thirty-five minutes, then washed successively with water, aqueous sodium bisulfite, aqueous sodium bicarbonate, and finally with water until neutral (litmus). The solution was dried (sodium sulfate), the

(10) Microanalyses by R. W. Amidon, J. Buckley, W. H. Hunter, and S. A. Sundet.

(11) After this synthesis was developed, Kloetzel, *THIS JOURNAL*, **69**, 2271 (1947), published a synthesis in which diethylamine was used as the catalyst. His product boiled at $112\text{--}113.5^\circ$ (14 mm.), and gave a semicarbazone melting at $164\text{--}165^\circ$ (dec.).

(8) Kohler and Rao, *THIS JOURNAL*, **41**, 1697 (1919).

(9) Kon and Leton, *J. Chem. Soc.*, 2496 (1931); Linstead and May, *ibid.*, 2565 (1927).

solvent was removed, and the residue was distilled. The product (187 g., 83%), a clear liquid, boiled at 110–112° (4 mm.); a sample, redistilled, boiled at 112–113° (4 mm.) and had n_D^{20} 1.4820.

Anal. Calcd. for $C_7H_9O_3NBr$: C, 35.31; H, 5.08. Found: C, 35.48; H, 5.03.

It is important that the substance be purified quickly and be free from acids when distilled; in one experiment, the chloroform solution was allowed to stand with the drying agent overnight, and an explosion resulted when about half the nitro ketone had distilled. Once purified, the substance appears to be quite stable. Isolation of the acini-nitro ketone before bromination gave a greatly decreased yield of IV.

3,3-Dimethyl-2-nitro-1-cyclopropyl Methyl Ketone (I).—The bromo compound IV (157 g., 0.66 mole) was dissolved in dry methanol (800 cc.) containing potassium acetate (217 g., freshly fused), and the solution was allowed to stand for eleven hours at room temperature. Potassium bromide was removed and the filtrate was refluxed for fifteen hours, cooled, and filtered. Methanol was removed from the filtrate under reduced pressure; the residue was diluted with water and extracted with benzene. The combined extracts were washed with aqueous sodium bicarbonate (5%) and then with water until neutral (litmus). The solution was dried (sodium sulfate), solvent was removed, and the residue was distilled. The product (87 g., 84%) formed a clear, straw-colored liquid boiling at 93–96° (8 mm.). A sample, redistilled, boiled at 107–108° (11 mm.), had n_D^{20} 1.4632, n_D^{20} 1.4642 and froze at 7.5–6.5°.

Anal. Calcd. for $C_7H_{11}O_3N$: C, 53.63; H, 7.03. Found: C, 53.72; H, 6.89.

The nitrocyclopropyl ketone did not decolorize permanganate, gave a negative iodoform reaction, and a positive reaction with ferrous hydroxide. When the ketone (1.8 g.) was refluxed with zinc dust (10 g.) and aqueous ethanol (80%, 80 cc.) for one and one-half hours,¹² there was isolated only starting material, identified as the semicarbazone, m. p. 192–193°. The nitrocyclopropyl ketone (9 g.) was added portionwise, with shaking, to acetic acid (35 cc.) which had been saturated with hydrogen bromide at 0°. The solution became warm; it was allowed to stand at room temperature for two hours, then diluted with water and extracted with benzene. The extract was washed successively with aqueous sodium bisulfite, aqueous sodium bicarbonate, and water until neutral, then dried (Drierite). Removal of the solvent under reduced pressure left a brown oil (13.4 g.) which could not be crystallized and which decomposed when attempts were made to distill it at 3 mm. The semicarbazone, recrystallized from aqueous ethanol (50%), melted at 193–194° (dec.).

Anal. Calcd. for $C_8H_{14}O_3N_4$: C, 44.85; H, 6.59. Found: C, 45.04; H, 6.35.

3,3-Dimethyl-2-nitro-1-cyclopropyl Styryl Ketone.—The nitro ketone I (1.6 g.), mixed with benzaldehyde (2.4 g.), was added to aqueous sodium hydroxide (10 cc., 10%) and ethanol (10 cc.), and the mixture was shaken for a short time. The product separated as an oil which soon solidified. Water was added, and the product was removed and crystallized from ethanol, when it melted at 95.5–96.5°.

Anal. Calcd. for $C_{14}H_{18}O_3N$: C, 68.55; H, 6.16. Found: C, 68.36; H, 6.36.

3,3-Dimethyl-2-nitro-1-cyclopropane Carboxylic Acid.—A solution of the nitrocyclopropyl ketone I (4.3 g., 0.027 mole) and iodine (6.9 g., 0.027 mole) in dry pyridine (8 cc.) was warmed on the steam-bath and then allowed to stand overnight. Ether (two volumes) was added, and the brown solid was removed and washed successively with ether and ethanol (10 cc.). The pyridinium iodide was added to water (150 cc.), solid sodium hydroxide (6 g., 0.15 mole) was added, and the solution was heated on the

steam-bath for one hour. Norit was added, the mixture was filtered, and the clear amber filtrate was acidified with sulfuric acid (50%) and extracted with ether. The extracts were dried (Drierite), the solvent was removed; the brown residue (1.8 g.) solidified on cooling. The substance was crystallized from water (Norit), when it formed colorless platelets (1.3 g., 25%) melting at 121–122°.

Anal. Calcd. for $C_6H_9O_4N$: C, 45.28; H, 5.70; neut. equiv. (one), 159. Found: C, 45.31; H, 5.48; neut. equiv., 158, 159.

4-Methoxy-5-methyl-3-hexen-2-one (VI).—The nitrocyclopropyl ketone I (62.8 g., 0.4 mole), when stirred with a solution of sodium methoxide (from sodium, 27.6 g., dry methanol, 300 cc.), gradually dissolved with evolution of heat (60°) and deposition of sodium nitrite. The solution was stirred for one hour, filtered, and about half of the methanol was removed from the filtrate under reduced pressure. The residue was mixed with water and extracted with ether. The extracts were washed with aqueous sodium bicarbonate (10%) and water until neutral (litmus) and dried (Drierite). Solvent was removed, and the residue was distilled. The fraction (30.7 g., 54%) boiling at 86–88° (24 mm.) was redistilled, when it boiled at 87.5–88° (24 mm.), was colorless, and had n_D^{20} 1.4634.

Anal. Calcd. for $C_8H_{14}O_2$: C, 67.57; H, 9.93. Found: C, 67.38; H, 9.85.

The substance decolorized permanganate in acetone; rapidly decolorized a solution (5%) of bromine in carbon tetrachloride with evolution of hydrobromic acid; and it also gave the iodoform test. The methoxy ketone VI (2.8 g., 0.02 mole) in ethyl bromide (70 cc.) was subjected, for two and one-half hours, to a current of ozonized oxygen (5%) at –20 to –30°. Ethyl bromide was removed in a current of dry air until the volume was reduced to 20 cc. (the ozonide exploded when attempts were made to remove ethyl bromide completely). The solution was stirred with water (60 cc.) at 0° for nineteen hours and was then distilled until all the ethyl bromide and 20 cc. of water were removed. The aqueous portion of the distillate was saturated with potassium carbonate and extracted with ether; these extracts were combined with the ethyl bromide from the distillate and the whole was dried (Drierite). Ether and ethyl bromide were removed and the residue, on distillation, gave material (0.9 g., 45%) boiling at 85–94° (760 mm.), having n_D^{20} 1.3835. The substance was identified as methyl isobutyrate by its physical constants and by hydrolysis to isobutyric acid, which in turn was identified as the *p*-phenylphenacyl ester, m. p. 88–89°, alone or when mixed with an authentic specimen.

5-Methylhexan-2,4-dione (VII).—The methoxy ketone VI (0.35 g.) was refluxed for five minutes with methanol (0.7 cc.) containing hydrochloric acid (0.2 cc.). Water was added, the mixture was extracted with ether and the extract was washed with water until neutral. The solvent was removed, hot aqueous cupric acetate (0.1 g. of salt) was added to the residual clear yellow oil. The solid was removed and crystallized from methanol, when it formed light blue needles melting at 170.5–171°.¹³

Anal. Calcd. for $C_{14}H_{22}O_4Cu$: C, 52.89; H, 6.98. Found: C, 53.05; H, 7.08.

The copper enolate was identical with that prepared from authentic 5-methyl-hexane-2,4-dione obtained by condensing ethyl isobutyrate with acetone in the presence of sodium amide, according to the procedure of Hauser, *et al.*¹⁴

α -(3,3-Dimethyl-2-nitro-1-cyclopropyl)-ethanol (VIII).—The nitrocyclopropyl ketone I (15.7 g., 0.1 mole) was dissolved in dry isopropyl alcohol (100 cc.) containing aluminum isopropoxide (10 g., 0.1 mole)¹⁵ in an apparatus arranged with a vertical condenser connected to a down-

(13) Conrad and Gast, *Ber.*, **31**, 1342 (1898), give the m. p. as 171°.

(14) Levine, Conroy, Adams and Hauser, *THIS JOURNAL*, **67**, 1510 (1945).

(15) B. p. 130–134° (10 mm.), prepared according to the directions given in Adams, *et al.*, "Organic Reactions," Vol. 2, John Wiley and Sons, Inc., New York, N. Y., 1944, pp. 198–203.

(12) Kohler and Williams, *THIS JOURNAL*, **41**, 1644 (1919).

ward condenser; water was circulated through the downward condenser, but the other one was not cooled. The solution was refluxed at such a rate that about 5 drops of liquid per minute was collected; after three and three-quarters hours, during which more isopropyl alcohol (20 cc.) was added, no more acetone could be detected (2,4-dinitrophenylhydrazine) in the distillate. Isopropyl alcohol was removed under reduced pressure; the residue was cooled, and hydrochloric acid (35 cc.) and water (175 cc.) were added. An oil separated; the whole was extracted with ether, the extracts were washed with aqueous sodium bicarbonate (5%), water, and dried (Drierite). Ether was removed and the residual oil, when distilled, gave a product (11.3 g.) boiling at 120–121° (7 mm.), which became partly solid on cooling. The product was dissolved in the minimum amount of boiling benzene, the solution was cooled, and petroleum ether (b. p., 60–68°) was added to cloudiness. On standing, a solid (7.6 g., 48%) separated; this melted at 56.5–57.5°.

Anal. Calcd. for $C_7H_{13}O_3N$: C, 52.81; H, 8.23. Found: C, 52.88; H, 8.22.

Evaporation of the mother liquors gave a liquid (3.5 g., 23%) which, when distilled, boiled at 115–116° (6 mm.) and had n_D^{20} 1.4722. This liquid was a mixture of stereoisomers of VIII; at –80°, the liquid froze to a glass, but it could not be crystallized.

Anal. Calcd. for $C_7H_{13}O_3N$: C, 52.81; H, 8.23. Found: C, 52.77; H, 8.16.

The alcohol VIII was soluble in benzene, ethanol, methanol, hot carbon tetrachloride and in water (about 0.1 g. per 3 cc.). It did not react with 2,4-dinitrophenylhydrazine nor with permanganate. The iodoform reaction was negative, but the test for the nitro group with ferrous hydroxide was positive. The benzoate, prepared from VIII, benzoyl chloride and pyridine, and crystallized from aqueous ethanol, melted at 72–72.5°.

Anal. Calcd. for $C_{14}H_{17}O_4N$: C, 63.86; H, 6.51. Found: C, 63.97; H, 6.57.

The liquid mixture of stereoisomers gave a liquid benzoate. However, the *p*-nitrobenzoate, although a solid and analytically pure, was a mixture which, despite repeated crystallization, melted at 101–113°.

Anal. Calcd. for $C_{14}H_{15}O_6N_2$: C, 54.54; H, 5.23. Found: C, 54.80; H, 5.32.

Oxidation of the solid form of VIII (1 g.) by action of sodium dichromate (1.3 g.) and sulfuric acid (0.6 cc.) in water (6.6 cc.) at 55°, followed by ether extraction, yielded the ketone I (0.6 g.) identified as the semicarbazone, m. p., and mixed m. p., 191.5–193.5° (dec.). Similarly, oxidation of the liquid form of VIII (1 g.) gave the ketone I (0.6 g.) identified as the semicarbazone, and as the benzal derivative, m. p., and mixed m. p., 95.5–96.5°. The solid form of VIII (4.8 g.) was added to a solution of sodium methoxide (from sodium, 2.8 g., and methanol 40 cc.). The solution was heated to 62°, then allowed to cool. No solid separated; after one and one-half hours, the solution was diluted with water, but no second phase separated. The solution was neutralized with acetic acid, filtered, concentrated to a volume of 8 cc. by evaporation under reduced pressure, and extracted with ether. From this extract there was isolated unchanged VIII (3.5 g.) melting at 52–55°; after crystallization from benzene-petroleum ether the substance melted at 55–57°, alone or when mixed with the starting material. Similarly, the liquid form of VIII (2.3 g.) was added to a solution of sodium methoxide (from sodium 1.3 g., dry methanol 13 cc.) and the solution was processed as above. The product, a brown oil, distilled at 97–102° (5 mm.), had n_D^{20} 1.4720, and weighed 1.7 g. It was identified as VIII by oxidation to the ketone I, as described above, and conversion of the ketone to the semicarbazone, m. p., and mixed m. p., 193–194°. The alcohol VIII (1 g.) was added to acetic acid (5 cc.) which had been saturated with hydrogen bromide at 0°. The solution was allowed to stand for one and one-half hours, then diluted with water. The oil was removed, dissolved in ether, and the solution was washed with aque-

ous sodium bicarbonate (5%) and water, and dried (Drierite). Removal of the solvent left a yellow oil (1.2 g.) which could not be crystallized, and which decomposed below 100° when attempts were made to distill it under 3 mm. pressure.

3-Phenyl-2-nitro-1-cyclopropyl *t*-butyl ketone (10 g., m. p., 93–94°) prepared from benzalpinacolone, was converted into 6-bromo-2,2-dimethyl-5-nitro-6-phenylhexane-3-one (11 g., m. p., 62.5–64.5°) by action of hydrobromic acid in acetic acid; the bromo compound (13.4 g.) by action of potassium acetate in methanol gave 6.5 g. (63%) of 2,2-dimethyl-5-nitro-6-phenyl-5-hexene-3-one, m. p., 53.5–54.5°, all according to the directions of Kohler and Rao.¹⁶

Anal. Calcd. for $C_{14}H_{17}O_3N$: C, 68.00; H, 6.93. Found: C, 68.26; H, 7.02.

A solution of sodium methoxide (from sodium, 0.6 g., and dry methanol, 6.5 cc.) was added portionwise and with shaking to a suspension of 3-phenyl-2-nitro-1-cyclopropyl *t*-butyl ketone (2 g.) in dry methanol (1.5 cc.) at 0°. The mixture was shaken for one hour at 0° and for thirty minutes at room temperature, and was then placed in a vacuum desiccator over sulfuric acid for twenty-five hours. The pasty residue was acidified with cold, dilute sulfuric acid and extracted with ether. The extracts were washed with aqueous sodium bicarbonate (5%), then with water, and dried (Drierite). Removal of the ether left an oil (1.3 g.) which gave no precipitate with aqueous copper acetate. A portion (0.9 g.) of this oil was refluxed in methanol (2 cc.) containing hydrochloric acid (2 drops). The product, isolated by dilution with water and ether extraction, was 5,5-dimethyl-1-phenylhexane-2,4-dione, identified as the copper enolate (0.5 g.) which after crystallization from methanol, melted at 105–106° (dec.).

Anal. Calcd. for $C_{28}H_{34}O_4Cu$: C, 67.51; H, 6.88. Found: C, 67.19; H, 7.12.

The copper enolate (0.6 g.) was shaken with sulfuric acid (6 cc., 10%) and ether (20 cc.) and the diketone (0.48 g., m. p., 42.5–43.5°) was isolated by ether extraction.¹⁷

The above unsaturated nitro ketone, m. p. 53–54°, (6.9 g.) was added to a solution of sodium methoxide (from sodium, 0.65 g., and dry methanol, 14 cc.) at 0°. The solution acquired an orange color, and sodium nitrite separated. The solution was stirred at 0° for two and one half hours, sodium nitrite was removed, and the filtrate was kept at 0° for ten hours. The deep red solution was diluted with ice-water, and extracted with ether; the extract was washed with water until neutral (litmus), and dried (Drierite). Ether was removed and the residual brown oil (3.8 g.), when distilled, gave a clear yellow distillate (1.6 g.) boiling at 132–136° (5 mm.). This material did not form a copper enolate. A portion (0.69 g.) was hydrolyzed to the diketone as described above, and the crude diketone was converted into the copper enolate of 5,5-dimethyl-1-phenylhexane-2,4-dione, m. p., and mixed m. p., 105–106° (dec.). The diketone, regenerated from the copper compound as described above, melted at 42.5–43.5°, alone or when mixed with the diketone obtained directly from the nitrocyclopropyl ketone.

Anal. Calcd. for $C_{14}H_{18}O_2$: C, 77.03; H, 8.31. Found: C, 77.38; H, 8.54.

Summary

1. A completely aliphatic nitrocyclopropyl ketone, 3,3-dimethyl-2-nitro-1-cyclopropyl methyl ketone (I) has been prepared. From this ketone, the corresponding nitrocyclopropane monocarboxylic acid, and the nitrocyclopropylcarbinol (VIII) have been prepared—the first representatives of these two classes of compounds.

2. It has been shown that the ketone I reacts

(16) Ref. 8. The m. p. of the unsaturated nitro ketone is given as 53–54° by these authors.

(17) Ref. 8. Kohler and Rao give the m. p. as 44°.

with sodium methoxide to give ultimately a 1,3-diketone (VII) via the methyl enol ether VI. On the other hand, the nitrocyclopropylcarbinol is unaffected by action of sodium methoxide. Hence, it has been established that an electron attracting group, such as a carbonyl group, in position 1, plays an essential role in the reaction whereby such 2-nitrocyclopropyl compounds are converted into 1,3-diketones, via the enol ethers, by reaction with sodium methoxide.

3. A mechanism for this transformation has been suggested; this mechanism involves an unsaturated nitro ketone as an intermediate. Such a nitro ketone has been synthesized and subjected to the action of sodium methoxide, and it is shown that, in harmony with the suggested mechanism, the product is a substance which, by action of dilute acid, gives a 1,3-diketone.

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[CONTRIBUTION FROM THE SANDERS LABORATORY OF CHEMISTRY, VASSAR COLLEGE]

The Reaction between Duroquinone and Phenyllithium¹

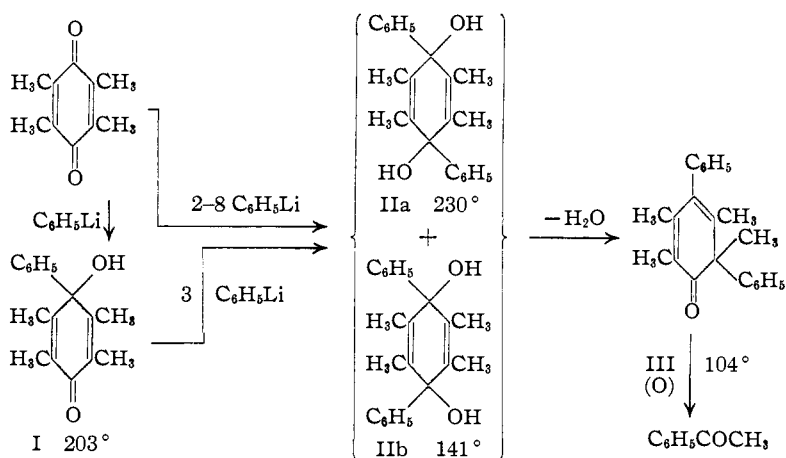
BY H. MARJORIE CRAWFORD AND MARJORIE McDONALD²

This paper continues the series of studies³ on the reactions of quinones with phenylmagnesium bromide and with phenyllithium. The first reaction studied, between duroquinone and phenylmagnesium bromide,^{3a} gave a great variety of mono- and di-addition products, reduction products and double compounds, which accounted for only 20% of the quinone used. In later studies on other quinones^{3c,e} it was shown that phenyllithium was useful because of its preferential addition to the carbonyl group, even in the presence of a conjugated system. In one case^{3c} over 90% of the 1,2-1,2-di-addition product was obtained. With this excellent yield in mind, it was decided to see whether the 1,2-addition products could be obtained from phenyllithium and duroquinone, since phenylmagnesium bromide and duroquinone gave mainly the 1,4-addition products.

The reaction between phenyllithium and duroquinone took place readily and either the mono- or the di-addition products resulted, depending on the relative amounts of the reactants. Biphenyl could be isolated by steam distillation of the reaction products. Variations of the conditions of the reaction, such as mode of addition of the reactants, length of time before decomposition, and heating, seemed to have little effect on the results. When the ratio of phenyllithium to quinone was 1:1 the product was the mono-addition compound. A ratio of 2-8:1 gave the di-addition

products. The mixture of di-addition products was also formed when an excess of phenyllithium (3:1) reacted with the mono-addition compound.

The relationships between the various compounds are shown in the chart.



The yields of I varied from 10-30%, while the best yield of this compound from phenylmagnesium bromide and duroquinone was 2.7%.^{3a} IIa and IIb were formed in about equal amounts; the total yield varied from 20-57% when starting with the quinone and was 90% when starting with I. IIa and IIb are apparently a pair of geometric isomers and the *cis* configuration is suggested for the one which is more soluble and has the lower melting point. Both of these substances lose water readily when warmed with Lucas reagent and give the same compound (III), which was shown, by oxidation, to have a phenyl and a methyl group on the same carbon atom. This behavior parallels that shown by similar 1,4-diols.^{3c,e}

In connection with this pair of isomers, it is interesting to remember that one of the products of the reaction between phenylmagnesium bromide and duroquinone also exists in stereoisomeric forms.⁴

(4) Crawford, *ibid.*, **56**, 1803 (1934).

(1) Abstract from a thesis by Marjorie McDonald, presented in partial fulfillment of the requirements for the degree of Master of Science at Vassar College in 1948.

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(3) (a) Smith and Crawford, *THIS JOURNAL*, **50**, 869 (1928); (b) Crawford, *ibid.*, **57**, 2000 (1935); (c) **61**, 3310 (1939); (d) **63**, 1070 (1941); (e) **70**, 1081 (1948).