radioactive aluminum chloride for 10 min. and then condensed with liquid air and shown to contain no hydrogen chloride. No color change occurred during this operation. Carbon tetrachloride at a pressure of 3 cm. was then allowed to exchange with the aluminum chloride for 10 min., following which benzene was admitted over a period of about 15 sec. until the total pressure was 6 cm. During the first 2 min. after admission of the benzene the surface turned deep brown and the pressure dropped from a total of 6 cm. to 5.2 cm. The reaction was allowed to proceed for 10 min. during which time the pressure did not change further. The gaseous products were then removed and counted. The fact that activity was found in the inorganic fraction (Table I) can only be explained if a Friedel–Crafts type reaction occurred. The reduction in pressure as the reaction proceeded is probably due to formation of essentially nonvolatile phenylchloromethanes which would cause the removal of more than one molecule of reactants from the gas phase for each molecule of gaseous hydrogen chloride formed. The brown film left in the reaction flask dissolved in ether turning green as it dissolved but forming a colorless solution.

Summary

A variety of gaseous organic chlorides have been found to exchange chlorine with solid aluminum chloride. Some of these undergo reactions on the surface with evolution of hydrogen chloride.

Gaseous carbon tetrachloride and benzene have been found to undergo a Friedel–Crafts type reaction on an aluminum chloride surface.

These observations are consistent with earlier work[1] which suggested that an aluminum chloride surface is necessary for exchange between liquid carbon tetrachloride and aluminum chloride.

MADISON, WISCONSIN RECEIVED MAY 12, 1950

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, UNIVERSITY OF MARYLAND]

Reactions of Naphthoquinones with Malonic Ester and its Analogs. I. Reactions with Malonic Ester[1]

BY ERNEST F. PRATT AND WERNER E. BOEHME

It has been found that 1,4-naphthoquinone and malonic ester in pyridine solution react to give a blue, crystalline solid (I). An improved synthesis (40% yield) of I from potassium 1,4-naphthoquinone-2-sulfonate and sodiomalonic ester has been developed. Compound I has been characterized by conversion in good yields to twelve different products to which structures have been assigned. A number of interrelations among these products have been established.

Products from the reaction of 1,4-benzoquinone with active methylene compounds have been well characterized in several instances.[2] Under the alkaline conditions usually employed the reactions were ordinarily of the Michael type proceeding *via* 1,4-addition. Evidence has accumulated that related reactions occur with 1,4-naphthoquinone but none of the products have been adequately characterized.[3]

Professor Louis F. Fieser and Dr. Yolanda Pratt observed that 1,4-naphthoquinone reacted with malonic ester in pyridine at room temperature to give a precipitate from which a low yield of dark blue needles could be obtained by extraction with and recrystallization from benzene.[4] The characterization of this product and a more practical synthesis are described in this paper.

The results of elementary analyses agreed satisfactorily with the values calculated for Ia. By using acetone in place of benzene for the isolation, the solvent-free compound (I) was obtained. Acetylation of I gave the orange diacetate (II) which was readily reduced by sodium hydrosulfite to the colorless bis-hydroquinone diacetate (III).

Oxidation of Ia with silver oxide in benzene gave green needles of the diquinone (VIIa). The oxidation equivalent calculated from the amount of metallic silver obtained agreed satisfactorily with the theoretical value. Oxidation with silver oxide in acetone or with chromic anhydride in acetic acid gave the solvent-free product (VII).

Reduction of either Ia or VII with sodium hydrosulfite gave the colorless bis-hydroquinone (IV) which rapidly turned blue upon exposure to the air. When a solution of the bis-hydroquinone (IV) was mixed with a solution of the diquinone (VII) at room temperature a dark blue precipitate appeared in only a few minutes. The results of elementary analyses and melting point and mixture melting point determinations indicated that disproportionation had occurred to give Ia.[5] The yield was nearly quantitative.

Acetylation of II or IV or reductive acetylation of Ia under rigorous conditions gave the tetraacetate (V). A diacetate different from II (see Experimental), but which could also be acetylated to V, was obtained by reductive acetylation of Ia under

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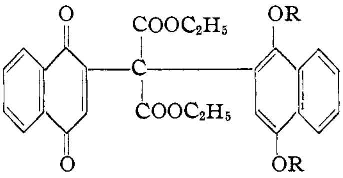
[1] From the Ph.D. thesis of W. E. Boehme, May, 1948.

[2] For a brief review see J. H. Wood, C. S. Colburn, Jr., L. Cox and H. C. Garland, THIS JOURNAL, **66**, 1540 (1944). Also see M. V. Ionescu, *Bull. soc. chim.*, **41**, 1094 (1927).

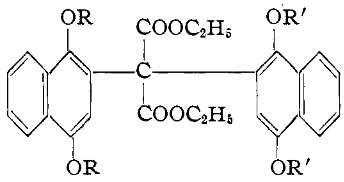
[3] R. Craven, *J. Chem. Soc.*, 1605 (1931); W. Kesting, *Z. angew. Chem.*, **41**, 358 (1928); *J. prakt. Chem.*, **138**, 215 (1933); C. Liebermann, *Ber.*, **33**, 566 (1900), and earlier papers. Liebermann, in his first paper (*ibid.*, **31**, 2093 (1898)) states without experimental confirmation that 1,4-naphthoquinone reacts with sodiomalonic ester in the same fashion as 2,3-dibromo-1,4-naphthoquinone which reacted in the orthodox manner cleaving out sodium bromide. His products, therefore, were quite different from the one obtained under our conditions.

[4] Personal communication. An oxidation product was also prepared but no structures were determined or further characterization done. We wish to thank these investigators for deferring to our interest in the problem.

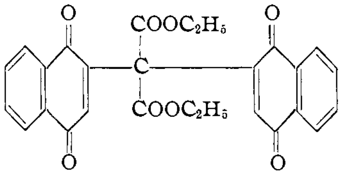
[5] We do not feel that the possibility that compound I (or Ia) is a quinhydrone formed from one molecule each of IV and VII has been definitely eliminated. We prefer, however, the interpretation given in the body of the paper chiefly because it more simply explains the reactions Ia → II → III → V.



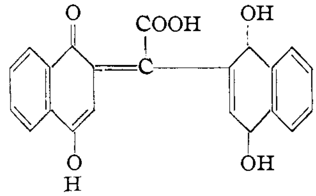
I, R = H
Ia, Cmpd. I plus $^1/_2C_6H_6$
II, R = $COCH_3$



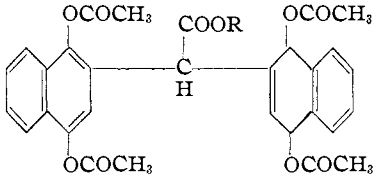
III, R = H; R′ = $COCH_3$
IV, R = R′ = H
V, R = R′ = $COCH_3$
VI, R = R′ = $COCH_2Cl$



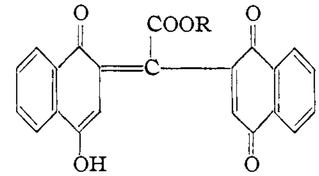
VII
VIIa, Cmpd. VII plus $^1/_2C_6H_6$



VIII



IX, R = H
X, R = C_2H_5



XI, R = H
XII, R = C_2H_5

mild conditions. The molecular weight of V as determined by the Rast method agreed fairly satisfactorily with the calculated value. A check on the number of ester groups present was obtained by preparing the tetrachloroacetate (VI) and determining its chlorine content.

Saponification of Ia followed by acidification gave the quinone–hydroquine (VIII) while similar treatment of VIIa gave the diquinone (XI). The quinone–hydroquinone (VIII) was reductively acetylated to IX.

It was interesting to find that treatment of the diquinone diester (VII) with concentrated sulfuric acid caused the loss of the elements of ethylene and carbon dioxide to form the monoester (XII). The *o*-quinonoid structures are favored for these compounds (VIII, XI and XII) because of their deep red color and because of the ultraviolet absorption characteristics of XII as compared to VII (Table I, Experimental). Hydrolysis of compound XII gave the corresponding acid (XI) and reductive acetylation gave a tetraacetate (X).

In spite of considerable effort to improve the process compound Ia was obtained in only 15% yield.[6] All of the other transformations were, however, carried out in good (usually 65 to 95%) yields. An improved synthesis of Ia (40% yield) was found in the reaction of potassium 1,4-naphthoquinone-2-sulfonate with sodiomalonic ester.[7]

Work is in progress in these laboratories on the reaction of analogs of malonic ester with naphthoquinones.

Acknowledgments.—It is a pleasure to acknowledge generous financial assistance by the Research Corporation and the National Institutes of Health which greatly aided the progress of this work.

Experimental[8,9]

Diethyl (1,4-Diketo-1,4-dihydronaphthyl-2)-(1,4-dihydroxynaphthyl-2)-malonate (I and Ia).—The results of many experiments under various conditions indicated the best procedure was the following: 1,4-Naphthoquinone (6.32 g.) was dissolved in 16 ml. of pyridine at 45°. Diethyl malonate (6.40 g.) was added and the solution was allowed to stand for 20 hours at room temperature. After the resulting dark brown mixture had been cooled in the refrigerator for several hours, it was filtered and the precipitate was washed with several small portions of ice-cold pyridine. The greenish-gray powder (1.94 g). was extracted with benzene in a Soxhlet apparatus and the extract was allowed to stand in the refrigerator overnight. Upon filtration there was obtained 0.78 g. (15%)[6] of fine dark blue needles which melted with decomposition at 259–260°. Considerable difficulty was encountered in the purification of this and many of the subsequent compounds because of their low solubility, instability and high melting points. Up to nine recrystallizations were required and even then certain of the analytical results were not entirely satisfactory. After six recrystallizations from benzene and drying at 100° at 1 mm. pressure this product (Ia) melted at 265.5–268° (dec., evac.).

Anal. Calcd. for $C_{27}H_{22}O_8 \cdot {}^1/_2C_6H_6$: C, 70.17; H, 4.91. Found: C, 70.13, 70.41; H, 4.40, 4.47.

When the greenish-gray material was extracted with acetone instead of benzene, dark blue needles were obtained in 12% yield. The product (I) was purified by recrystallizing it four times from acetone. Compound I was identical with Ia in appearance and decomposition point; a mixture of I and Ia decomposed at the same temperature.

Anal. Calcd. for $C_{27}H_{22}O_8$: C, 68.35; H, 4.68. Found: C, 68.84, 68.65; H, 4.64, 4.62.

The dull yellow powder (1.4 g.) which remained in the thimble after extraction with acetone or benzene was recrystallized eight times from nitrobenzene. The bright yellow prisms obtained did not melt below 360°. The analytical results agreed satisfactorily with those calculated for the triphthaloylbenzene of Pummerer and co-workers.[10]

Anal. Calcd. for $C_{30}H_{12}O_6$: C, 76.92; H, 2.58. Found: C, 76.65, 76.66; H, 2.82, 2.82.

The diacetate (II) was prepared by suspending 0.20 g. of Ia in a solution of 5 ml. of acetic anhydride and 10 ml. of pyridine. When the mixture was heated on the steam-bath for ten minutes the color changed from blue through black, green and yellow to a deep amber. After cooling to room temperature, the excess acetic anhydride was hydrolyzed by adding a little water. The mixture was then poured slowly with stirring into 75 ml. of ice-water. The yellow, flocculent precipitate was recrystallized from absolute alcohol. An 87% yield of diethyl (1,4-diketo-1,4-dihydronaphthyl-2)-(1,4-diacetoxynaphthyl-2)-malonate (II) which melted at 210–213° (dec.) was obtained. Three re-

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[6] This yield is calculated on the assumption that all the naphthoquinone needed in the reaction appears in the product (Ia); it is not improbable, however, that an additional molecule of the quinone must serve as an oxidizing agent.

[7] This is a modification of the reaction of 1,2-naphthoquinone-4-sulfonic acid of F. Sachs and M. Craveri, *Ber.*, **38**, 3685 (1905). See also L. F. Fieser and C. K. Bradsher, THIS JOURNAL, **61**, 417 (1939). It is noteworthy that with the *o*-quinone sulfonate only one of the active methylenic hydrogens was replaced while with the *p*-quinone sulfonate we found both hydrogens were replaced. This difference would seem to be a logical consequence of the fact that the *o*-quinone product probably tautomerizes to the *p*-quinone type of structure while the *p*-quinone product does not tautomerize so readily and hence the second methylenic hydrogen is available for replacement. In this connection see L. F. Fieser and M. Fieser, *ibid.*, **61**, 596 (1939).

[8] We wish to thank Dr. Eleanor Werble and Mrs. Mary Aldridge for carrying out the microanalyses.

[9] All melting points are corrected.

[10] R. Pummerer, *et al.*, *Ber.*, **71**, 2569 (1938).

crystallizations from absolute alcohol gave 91 mg. (42%) of orange prisms; m.p. 215.5–216.5° (dec.).

Anal. Calcd. for $C_{31}H_{26}O_{10}$: C, 66.66; H, 4.69. Found: C, 66.81, 67.05; H, 4.45, 4.44.

This diacetate (II) was reduced by shaking a suspension of 0.20 g. in 30 ml. of ether for 20 minutes with a solution of 1 g. of sodium hydrosulfite in 20 ml. of water. The colorless ether layer was filtered through anhydrous magnesium sulfate. Upon adding petroleum ether (30–60°) and cooling 0.17 g. (85%) of diethyl (1,4-dihydroxynaphthyl-2)-(1,4-diacetoxynaphthyl-2)-malonate (III) which melted at 222–224° (dec., evac.) was obtained. Two recrystallizations gave 0.14 g. (70%) of colorless plates; m.p. 223–226° (dec., evac.).

Anal. Calcd. for $C_{31}H_{28}O_{10}$: C, 66.42; H, 5.04. Found: C, 66.76, 66.92; H, 4.82, 4.82.

Diethyl Bis-(1,4-diketo-1,4-dihydronaphthyl-2)-malonate (VII and VIIa).—Two grams of Ia (recrystallized once from benzene) was suspended in 250 ml. of benzene and stirred for 1 hour with 2.00 g. of freshly prepared silver oxide. The color of the supernatant solution changed from pale blue to a light greenish-yellow during the course of the oxidation. The mixture was heated to boiling, filtered, and the filter cake was extracted with several small portions of boiling benzene. Bright greenish-yellow needles of VIIa crystallized when a solution obtained by concentrating the combined filtrates to a small volume was allowed to stand overnight in the refrigerator. The crystals, isolated by filtering and washing with cold benzene, weighed 1.95 g. (98%); m.p. 209–210° (dec.). A sample for analysis was recrystallized four times from benzene and dried at 100° at 1 mm. pressure. A 70% yield of VIIa which melted at 197–199° (dec.) was obtained.

Anal. Calcd. for $C_{27}H_{20}O_8 \cdot {}^1/_2C_6H_6$: C, 70.44; H, 4.53. Found: C, 70.20, 70.44; H, 4.27, 4.37.

The black filter cake from the oxidation, consisting of silver and silver oxide, was washed thoroughly with hot benzene to remove any organic matter and then with dilute ammonium hydroxide to remove the silver oxide. The residual silver after drying to constant weight at 100° weighed 0.880 g. On the assumption that one molecule of silver oxide is converted to metallic silver per molecule of Ia which is oxidized, a molecular weight of 490 is found; the calculated value for Ia is 514. Because of the deep blue color of Ia, attempts to determine its molecular weight by the Rast method were unsuccessful.

The diquinone (VII) free of solvent of crystallization was obtained as follows: Once crystallized Ia (0.70 g.) was added to 1 liter of acetic acid at 40°. A solution of 0.15 g. of chromic anhydride in 50 ml. of acetic acid was added dropwise with stirring over a period of one-half hour. After removal of the acetic acid under reduced pressure at 40–45° the residue was washed with dilute sodium bicarbonate solution and then with ether. The crude product (VII) weighed 0.38 g. (60%) and melted at 205–210° (dec.). A sample for analysis was recrystallized four times from acetic acid and water; m.p. 197–199° (dec., evac.). Compounds VII and VIIa appeared to be identical and no change in decomposition point was noted with a mixture of the two.

Anal. Calcd. for $C_{27}H_{20}O_8$: C, 68.64; H, 4.27. Found: C, 68.78, 68.50; H, 4.11, 4.36.

Analytically pure VII was also obtained in 80% yield by oxidizing I (crystallized from acetic acid) with silver oxide in acetone and recrystallizing the product from acetone.

Diethyl Bis-(1,4-dihydroxynaphthyl-2)-malonate (IV).—A suspension of 1.0 g. of finely powdered Ia in 25 ml. of ether was shaken for 20 minutes with a solution of 2.0 g. of sodium hydrosulfite in 20 ml. of water; during this process the blue color disappeared. The ether layer was separated and passed, in an atmosphere of nitrogen, through a layer of anhydrous magnesium sulfate. The solution was concentrated, under nitrogen, to a volume of 15 ml. and petroleum ether (30–60°) was added to incipient crystallization. Upon cooling in the refrigerator overnight a quantitative yield of crude bis-hydroquinone (IV) was obtained as colorless needles; m.p. 213–220° (dec., evac.). The purified product was obtained in 24% yield upon recrystallizing five times from peroxide-free ether and petroleum ether, m.p. 229.5–230.5° (dec., evac., Pyrex capillary). Since the product took on a blue tinge within a few minutes when exposed to the air it was necessary to store it in an evacuated and sealed Pyrex ampoule.

Anal. Calcd. for $C_{27}H_{24}O_8$: C, 68.04; H, 5.08. Found: C, 68.10, 67.81; H, 4.84, 4.82.

The same product was obtained pure in 86% yield when 0.10 g. of once crystallized diquinone (VII) was treated with sodium hydrosulfite as just described. The original greenish-yellow solution passed through an intense blue stage and then became colorless in a total period of 15 minutes.

Resynthesis of Ia from IV and VII.—When a solution of 50 mg. of the pure diquinone (VII) in 30 ml. of warm 95% alcohol was mixed with a solution of 50 mg. of the pure bis-hydroquinone (IV) in 10 ml. of alcohol, the mixture immediately turned deep blue and upon stirring for a few minutes a flocculent blue precipitate settled out. The product was obtained in 95% yield; m.p. 261.5–262.5° (dec., evac.). One recrystallization from benzene gave 75 mg. of fine, dark blue needles which appeared to be identical with the Ia synthesized by the other method and which melted at 264–266° (dec., evac.). No depression in decomposition point was observed with a mixture of this product and the product (Ia) obtained directly from 1,4-naphthoquinone and malonic ester.

Anal. Calcd. for $C_{27}H_{22}O_8 \cdot {}^1/_2C_6H_6$: C, 70.17; H, 4.91. Found: C, 70.25, 69.98; H, 4.70, 4.93.

Diethyl Bis-(1,4-diacetoxynaphthyl-2)-malonate (V).—A suspension of 50 mg. of the crude bis-hydroquinone (IV) in 1 ml. of pure dry pyridine was treated with 0.3 ml. of acetic anhydride. All of the solid dissolved when the mixture was stirred for 10 minutes at room temperature. The solution was then added dropwise with stirring to crushed ice and, after 1 hour, the resulting yellow precipitate was filtered off, washed with water and dried. An 89% yield (60 mg.) of crude product (V) which melted at 235–240° (dec.) was obtained. Six recrystallizations from absolute alcohol gave 40% (27 mg.) of colorless plates; m.p. 258–260° (dec.).

Anal. Calcd. for $C_{35}H_{32}O_{12}$: C, 65.21; H, 5.01. Found: C, 65.05, 65.27; H, 4.98, 5.03.

This tetraacetate (V) was also obtained upon further acetylation of the diacetate (II) in the same general fashion as just described for IV. Eighty milligrams of II, 1 ml. of acetic anhydride and 1 ml. of pyridine were used and the acetylation mixture was heated a few minutes on the steam-bath after it had been allowed to stand 1 hour at room temperature. The crude product, isolated as above, weighed 85 mg. (92%) and the recrystallized product weighed 55 mg. (60%); m.p. 258.5–260° (dec.).

A third route to this tetraacetate (V) was by reductive acetylation of the quinone-hydroquinone (Ia) under rigorous conditions. A suspension of 500 mg. of Ia in 10 ml. of pyridine and 10 ml. of acetic anhydride was heated under reflux for one-half hour during which time 1.0 g. of zinc dust was added in approximately 10-mg. portions. The reaction mixture was filtered and the pure product (V) was isolated as above. The yield of pure product was 59% and the m.p. was 257.5–260° (dec.).

Reductive acetylation of Ia under mild conditions gave a diacetate. A suspension of 0.10 g. of Ia in 2 ml. of acetic anhydride was treated with 0.10 g. of zinc dust and a drop of triethylamine. The mixture was warmed gently for a few minutes until the blue color was discharged. It was then filtered and the precipitate was washed with hot acetic acid. One-fifth ml. of water was added to the combined filtrates, the solution was heated to boiling and hot water was added to incipient precipitation. Upon cooling rapidly with stirring 0.104 g. (95%) of crystals formed; m.p. 234.5–235.5° (dec.). Recrystallization twice from dilute alcohol, once from acetone and twice from absolute alcohol gave 52 mg. (48%) of colorless needles; m.p. 239–240.5 (dec.).

Anal. Calcd. for $C_{31}H_{28}O_{10}$: C, 66.42; H, 5.04. Found: C, 66.89, 66.96; H, 5.24, 5.44.

A mixture of this product and the diacetate previously obtained (II, m.p. 223–226°) melted at 208–213° (dec.). Since this as well as the ultraviolet absorption characteristics (Table I) show that the two compounds are different and since the analytical results indicate that both are diacetates it is suggested that this second diacetate is diethyl bis-(1-hydroxy-4-acetoxynaphthyl-2)-malonate. The hydroxyl groups farther from the methylene bridge might acetylate preferentially since they are less hindered sterically. It is also conceivable, even though (see below) the same tetraacetate is obtained from both, that the two diacetates are geometrical isomers resulting from restricted rotation of the naphthalene moieties around the bonds of the malonic ester bridge.

This second diacetate (m.p. 239–240.5°) was further acetylated by treating 0.35 g. with 3.5 ml. of pyridine and 2 ml. of acetic anhydride as described above for IV except that stirring was continued for 1 hour. A quantitative yield of crude product (V) and a 40% yield of pure product which melted at 258.5–260° (dec.) was obtained.

It will be noted that the tetraacetate obtained *via* each of the four routes had the same melting point. The results of elementary analysis and mixture melting point determinations also indicated that a single compound was obtained. This product proved to be suitable for the determination of the molecular weight by the Rast method using camphor as a solvent. The average of several determinations was 574 as compared with a calculated value of 645.

Chloroacetylation was accomplished by treating a suspension of 0.50 g. of IV in 5 ml. of dry pyridine with 4 g. of redistilled chloroacetic anhydride. After 1 minute there resulted an amber solution which was poured onto crushed ice. Prolonged scratching of the gum which precipitated gave a granular yellow powder which was recrystallized from 1 l. of absolute alcohol. A 65% yield of diethyl bis-[1,4-di-(chloroacetoxy)-naphthyl-2]-malonate (VI) as tan plates which melted at 234.5–237.5° (dec.) was obtained. Four recrystallizations from 1:10 acetone–methanol gave 0.22 g. (27%) of ivory plates; m.p. 238.5–240° (dec.).

Anal. Calcd. for $C_{35}H_{28}O_{12}Cl_4$: C, 53.73; H, 3.61; Cl, 18.13. Found: C, 54.19, 54.20; H, 3.67, 3.62; Cl, 18.21, 18.01.

(1-Keto-4-hydroxy-1,2-dihydronaphthylidene-2)-(1,4-dihydroxynaphthyl-2)-acetic Acid (VIII).—One gram of pure Ia in 35 ml. of a 1 *N* solution of potassium hydroxide in diethylene glycol was heated at 130° for 3 minutes. The cooled solution was poured into 200 ml. of water and the mixture was acidified with hydrochloric acid, whereupon a brick-red precipitate appeared. The mixture was extracted with chloroform at about 50°, the extract was concentrated to about 50 ml. and 250 ml. of methanol was added. Red needles crystallized in 93% yield (0.68 g.). Recrystallization four times gave 0.48 g. (66%) of VIII which melted with decomposition at approximately 330° when introduced into the copper block just below this temperature.

Anal. Calcd. for $C_{22}H_{14}O_6$: C, 70.59; H, 3.77. Found: C, 70.90, 71.05; H, 3.87, 4.06.

Reductive acetylation to IX was accomplished by refluxing a suspension of 0.55 g. of once recrystallized VIII in 15 ml. of acetic anhydride and 5 ml. of pyridine for one-half hour while 1 g. of zinc dust was added in about 10-mg. portions. The cooled mixture was added dropwise to 100 ml. of ice-water. After prolonged stirring the tan gum became granular. The 0.74 g. (93%) of bis-(1,4-diacetoxynaphthyl-2)-acetic acid (IX) was recrystallized nine times from absolute alcohol to yield 0.14 g. (18%) of colorless crystals; m.p. 264.5–266° (dec.).

Anal. Calcd. for $C_{30}H_{24}O_{10}$: C, 66.17; H, 4.44. Found: C, 65.59; H, 4.77.

(1-Keto-4-hydroxy-1,2-dihydronaphthylidene-2)-(1,4-diketo-1,4-dihydronaphthyl-2)-acetic Acid (XI).—Two hundred mg. of once recrystallized diquinone (VIIa) was saponified as described above for Ia. A 76% yield (0.11 g.) of crude XI was obtained. Three recrystallizations from chloroform–methanol gave 80 mg. (55%) of ruby prisms which melted with decomposition at approximately 315° when introduced into the copper block slightly below this temperature.

Anal. Calcd. for $C_{22}H_{12}O_6$: C, 70.97; H, 3.25. Found: C, 70.64, 70.54; H, 3.53, 3.54.

Ethyl (1-Keto-4-hydroxy-1,2-dihydronaphthylidene-2)-(1,4-diketo-1,4-dihydronaphthyl-2)-acetate (XII).—Seventy-five mg. of the once recrystallized diquinone (VIIa) was added to 2 ml. of concentrated sulfuric acid at room temperature. Solution occurred with the development of an intense red color and the evolution of a gas which gave a precipitate when passed into aqueous calcium hydroxide solution. After 5 minutes the solution was poured into ice-water and the bright red precipitate was filtered off, washed until acid-free and dried; weight 59 mg. (100%). Recrystallization six times from chloroform–methanol gave 30 mg. (50%) of ruby prisms (XII) which melted at 305° (dec.).

Anal. Calcd. for $C_{24}H_{16}O_6$: C, 71.99; H, 4.01. Found: C, 72.07, 72.08; H, 3.89, 3.73.

This ester (XII) was hydrolyzed to XI by heating 0.10 g. of the crude product with 6 ml. of a 1 *N* solution of potassium hydroxide in diethylene glycol at 170°. After 3 minutes of stirring at this temperature all the solid had dissolved. The product was isolated and purified as described above for XI. Four recrystallizations of the crude product (57 mg.; 61%) gave 35 mg. of small red prisms. These were identical in appearance with compound XI obtained *via* saponification of VIIa. The products from the two sources melted with decomposition at the same temperature and no depression in decomposition point was observed with a mixture of the two.

The quinone ester (XII) was reductively acetylated by treating a suspension of 25 mg. of the crude product in 3 ml. of acetic anhydride with 50 mg. of zinc dust and one drop of triethylamine. The mixture was stirred for 5 minutes whereupon the color disappeared almost completely. After one-half hour ice was added, the mixture was heated to the boiling point, filtered, and hot water added to the filtrate to incipient precipitation. Upon rapid cooling, 23 mg. (64%) of crystalline ethyl bis-(1,4-diacetoxynaphthyl-2)-acetate (X) was obtained. Recrystallization three times from acetone–alcohol gave 11 mg. (31%) of colorless needles; m.p. 270–273° (dec.).

Anal. Calcd. for $C_{32}H_{28}O_{10}$: C, 67.12; H, 4.93. Found: C, 67.18, 67.31; H, 4.88, 4.81.

Synthesis of Ia from Potassium 1,4-Naphthoquinone-2-sulfonate Monohydrate.—A solution of 1.45 g. of this sulfonate[11] in 40 ml. of water was added to a mixture of 0.60 g. of diethyl malonate, 1.5 ml. of 10% aqueous sodium hydroxide and 8 ml. of alcohol. A blue color appeared which faded to a deep amber and within a few minutes a dark blue flocculent precipitate formed. This was filtered off and the filtrate (*p*H 6) was allowed to stand at room temperature for a week. Each day 40 to 90 mg. of blue precipitate was collected to give a total of 0.46 g. (40%) of product (I) which melted at 264.5–267° (dec.). For analysis the material was recrystallized five times from benzene; there was obtained 0.195 g. (17%) of Ia which melted at 264–266° (dec.) both alone and when mixed with the product obtained from the free 1,4-naphthoquinone.

Anal. Calcd. for $C_{27}H_{22}O_8 \cdot {}^1/_2C_6H_6$: C, 70.17; H, 4.91. Found: C, 70.24, 70.28; H, 4.62, 4.56.

This compound was converted to the tetraacetate (V) in 66% yield by reductive acetylation, as previously described. The product melted at 258–260° (dec.) both alone

TABLE I

Compound	Concn. moles per l. × 10^5	$\lambda_{max.}$, mμ	ε × 10^{-4}
I	2.26	271	3.33
		342	1.32
II	2.20	262	5.49
III	2.00	265	5.67
		342	1.32
		362	1.26
V	1.94	265	7.61
		320	1.84
		333	2.11
VII	2.29	244	2.65
		355	0.56
XII	2.23	285	2.68
		378	1.66
...[a]	1.90	268	7.36
		320	1.53
		333	1.74

[a] This is the diacetate for which the structure diethyl bis-(1-hydroxy-4-acetoxynaphthyl-2)-malonate was suggested (see above).

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(11) The preparation of this sulfonate is given by L. F. Fieser and M. Fieser, THIS JOURNAL, **57**, 491 (1935).

and when mixed with the tetraacetate made by acetylation of the bis-hydroquinone (IV).

Ultraviolet Absorption Data.—The ultraviolet absorption characteristics for seven of the compounds are summarized in Table I. A Beckman quartz spectrophotometer, model DU, with a hydrogen discharge lamp and 1 cm. quartz cells was used. The solvent was 95% ethanol in all cases.

The $\lambda_{max.}$ at 244 mμ ($\epsilon = 2.65 \times 10^4$) for the diquinone diester (VII) is in good agreement with the value of 250 mμ ($\epsilon = 1.95 \times 10^4$) found for 2-methyl-1,4-naphthoquinone.[12] The agreement with the value of 239 ± 5 mμ found to be characteristic of α,β-disubstituted-α,β-unsaturated ketones is also satisfactory.[13] With compound XII the absorption peak at 285 mμ agrees closely with value found for related cyclic β-diketones.[14] The monoester (XII) has considerably greater absorption than the diester (VII) suggesting that in XII the conjugation extends through both naphthalene moieties as in the structure shown. As previously pointed out it is apparent that the two diacetates (the third and last compounds tabulated) are not identical.

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[12] L. F. Fieser, D. M. Bowen, W. P. Campbell, E. M. Fry and M. D. Gates, Jr., THIS JOURNAL, **61**, 1927 (1939).

[13] R. B. Woodward, *ibid.*, **63**, 1123 (1941).

[14] E. R. Blout, V. W. Eager and D. C. Silverman, *ibid.*, **68**, 566 (1946).

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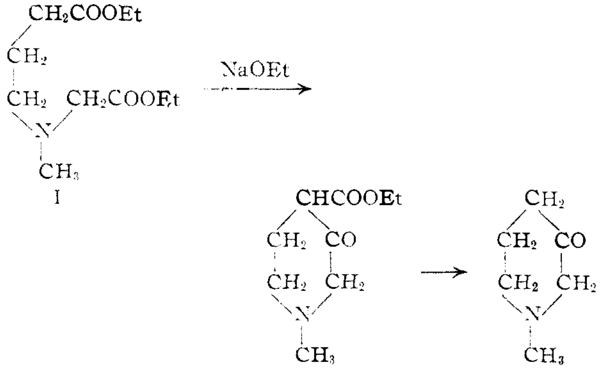
[CONTRIBUTION FROM THE LABORATORY OF ORGANIC CHEMISTRY OF THE UNIVERSITY OF WISCONSIN]

Piperidine Derivatives. XXIV. 1-Methyl-4-phenyl-3-piperidone and Related Products

BY S. M. McELVAIN AND PAUL M. LAUGHTON[1]

The Dieckmann cyclizations of the amino esters IV and V with dry sodium ethoxide yield the corresponding 2-carbethoxy-4-phenyl-3-piperidones, VI and VII, with the evolution of approximately two equivalents of ethyl alcohol. With IV the cyclization proceeds better with sodium hydride as the condensing agent. The decarbethoxylation of VI gives good yields of 1-methyl-4-phenyl-3-piperidone (VIII); however, a similar decarbethoxylation of VII gives very low yields of VIII because of extensive ring opening to produce the amino diacid corresponding to IV. The preparations of the amino esters IV and V from phenylmalonic ester, together with those of certain incidental compounds, are described.

In an earlier paper from this Laboratory the Dieckmann cyclization of the 3-azoheptanedioic ester I to a carbethoxy-3-piperidone, which yielded 1-methyl-3-piperidone (III) on decarbethoxylation, was reported.[2] The 4-carbethoxy structure (II) was assigned to the intermediate keto ester in preference to the isomeric 2-carboethoxy structure because of earlier observations that certain amino diesters, in which the methylene group involved in the reaction carried an amino substituent, reacted very sluggishly or not at all under the conditions of the Dieckmann cyclization. Later, however, the self-condensation of piperidinoacetic ester with dry sodium ethoxide to the corresponding diperidinoacetoacetic ester was effected[3] readily and in high yield, and the earlier failures to obtain reaction with this type of amino ester were ascribed to adverse surface or solubility effects or to the use of alkali metals, rather than to any inherent unreactivity of the α-aminomethylene group.



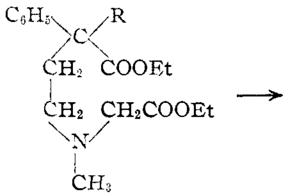
I

II

III

The present paper reports a study of the cyclization of the aminoesters IV and V. Aside from interest in the analgesic properties of the resulting products, a cyclization of either of these esters by sodium ethoxide would of necessity involve the amino methylene group of V and most probably that of IV, unless the hydrogen on the tertiary carbon of the latter ester is sufficiently activated by the phenyl and carbethoxy groups to react with the base to yield ethyl alcohol. If the cyclization of IV occurred in this latter manner the resulting keto ester would not be expected to form a sodium enolate. An alternative course of cyclization of V would involve the elimination of ethyl carbonate,[4] but the resulting keto ester would also be incapable of forming a sodium enolate.

The cyclizations of both IV and V were effected by either sodium ethoxide or sodium hydride. With the former base the course of the cyclization was followed by collecting the volatile material. From the diester IV only alcohol (94%) was evolved from the cyclization; from the triester V the volatile material was mainly alcohol (90%) with less than 5% of ethyl carbonate. This latter result was noteworthy in view of the previously noted facile cleavage of phenylmalonic esters to the corresponding acetic esters and ethyl carbonate by sodium ethoxide.[5] The cyclization of both IV and V yielded a sodium enolate which fixes the structure of the corresponding cyclic keto esters as VI and VII.



IV, R is H
V, R is COOEt

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[1] Wisconsin Alumni Research Foundation Research Assistant, 1947–1950.

[2] E. A. Prill and S. M. McElvain, THIS JOURNAL, **55**, 1233 (1933).

[3] W. B. Thomas and S. M. McElvain, *ibid.*, **56**, 1806 (1934).

[4] *Cf.* S. M. McElvain, *et al.*, *ibid.*, **57** (a) 1133, (b) 1443 (1935).

[5] A. C. Cope and S. M. McElvain, *ibid.*, **54**, 4319 (1932).