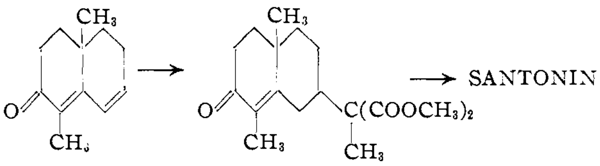
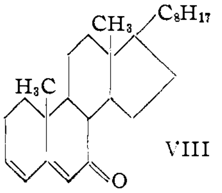
Michael adduct VII was transformed into santonin by reactions which do not affect the configurations



VI VII

of $C_{(6)}$ and $C_{(9)}$, the relative configurations at these carbon atoms are the same in the Michael adduct VII as in santonin. It is probable that the malonic ester substituent at $C_{(6)}$ and the angular methyl group at $C_{(9)}$ are *cis* in the Michael adduct (malonic ester group equatorial) because in the very closely analogous addition of malonic ester to cholesta-3,5-diene-7-one (VIII) the malonic ester substituent assumes the equatorial (β) orientation, *cis* to the angular methyl group.[10–12] The equatorial arrangement is the more stable one and would

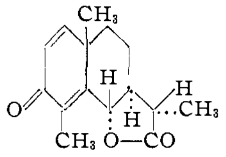


VIII

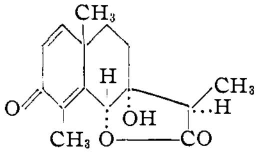
result either if the Michael addition proceeded to give the stable epimer more rapidly or if the addition were sufficiently rapidly reversible to allow equilibration.[13] There is, therefore, a good basis for formulating santonin as I or its mirror image.

Evidence for the absolute configuration of (−)-santonin can be deduced using the method of molecular rotation differences.[14] The molecular rotation difference between (−)-santonin (M_D -426[15]) and its 1,2-dihydroderivative (M_D $+187$[15]) is $+613°$ which is comparable to that between $\Delta^{1,4}$-cholesta-diene-3-one (M_D $+107$) and Δ^4-cholestenone (M_D $+342$), ΔM_D $+235°$. The ΔM_D value for santonin and either of its tetrahydroderivatives[15] (the two tetrahydroderivatives which are probably epimeric at C_{10} have approximately the same rotation) is *ca.* $+450°$ and that for $\Delta^{1,4}$-cholestadiene-3-one and cholestanone is $+245°$. The large positive values of ΔM_D in all cases indicates that (−)-santonin is related stereochemically to the steroids and, hence, is correctly represented by stereoformula I and *not* its mirror image.

On the basis of formula I for (−)-santonin and previously derived relationships,[9] it is now possible to assign formula IX to β-santonin and formula X to artemisin.



IX



X

Note added January 8.—Since the submission of this manuscript for publication, R. B. Woodward and P. Yates [*Chem. and Ind.*, 1319 (1954)] have proposed structure I for santonin on the basis of arguments similar to those presented herein.

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[10] J. W. Ralls, This Journal, **75**, 2123 (1953).

[11] C. W. Shoppee and R. J. Stephenson, *J. Chem. Soc.*, 2230 (1954).

[12] E. J. Corey and R. A. Sneen, This Journal, **75**, 6234 (1953). The assigned configuration given in this paper must be changed from α to β in view of the correction made in ref. 11 of the erroneous results [R. H. Baker and Q. R. Petersen, *ibid.*, **73**, 4080 (1951)] from which the α-assignment was derived.

[13] For another example in which the thermodynamically stable product is formed in a Michael reaction (with 4-phenylcyclohexenone) see E. D. Bergmann and J. Szmuszkovicz, *ibid.*, **75**, 3226 (1953).

[14] W. Klyne, *J. Chem. Soc.*, 2916 (1952); 3072 (1953).

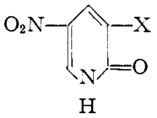
[15] J. Simonsen and D. H. R. Barton, "The Terpenes," 2nd edition, Cambridge University Press, Cambridge, 1952, Vol. 3, pp. 249–292.

The Condensation of Sodium Nitromalonaldehyde with Cyanoacetamide[1]

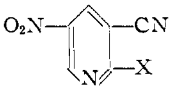
By Paul E. Fanta and Robert A. Stein

Received October 27, 1954

The condensation of sodium nitromalonaldehyde with cyanoacetamide in the presence of Triton B gave a 93% yield of 3-cyano-5-nitro-2-pyridone (I). This is the first reported synthesis of a nitropyridone by the use of sodium nitromalonaldehyde.



I, X = CN
II, X = CO$_2$H
III, X = H



IV, X = Cl
V, X = OC$_2$H$_5$

The cyanopyridone I was hydrolyzed in strong aqueous sulfuric acid to give the corresponding carboxylic acid II. Degradative evidence for the presence of the nitropyridone ring in I and II was provided by the decarboxylation of II to give the 5-nitro-2-pyridone (III) previously reported by Chichibabin.[2]

The pyridone I was converted in good yield to the chloropyridine (IV) by treatment with an excess of phosphorus pentachloride in phosphorus oxychloride solution. The ethoxypyridine V was obtained by treatment of IV with sodium ethoxide in ethanol. All attempts to hydrolyze the nitrile group of V resulted in the hydrolysis of both the nitrile and ethoxy group to give the pyridone II.

Experimental[3]

3-Cyano-5-nitro-2-pyridone (I).—To a solution of 31.4 g. (0.2 mole) of sodium nitromalonaldehyde and 16.4 g. (0.2 mole) of cyanoacetamide in 400 ml. of water at 20° was added 4 ml. of 40% aqueous Triton B (trimethylbenzylammonium hydroxide, technical). The solution became deep red and set to a mass of fine yellow needles as the temperature rose to 33° during the next 15 minutes. The reaction mixture was allowed to stand for another 5 minutes and

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[1] This work was supported by a grant from the Office of Ordnance Research. For the previous paper in the series, see P. E. Fanta, This Journal, **75**, 737 (1953).

[2] A. E. Chichibabin, *Ber.*, **58B**, 1707 (1925).

[3] All melting points are corrected. Analyses are by Micro-Tech Laboratories, Skokie, Ill.

then cooled to 5° in a salt-ice-bath. The crude yellow product was collected on a büchner funnel and dissolved in 200 ml. of water at 75°, and 20 ml. of concentrated hydrochloric acid was added with rapid stirring. The red solution became pale yellow, and a pale yellow precipitate began to separate in a few minutes. The mixture was cooled to 5° and the yellow solid was collected on a cold büchner funnel. After drying for three days in a vacuum desiccator over calcium chloride, the product weighed 30.6 g. (93% yield) and melted to an orange liquid at 258–263°, after slight previous sintering. By recrystallization from water, an analytical sample was obtained in the form of flat white needles which melted at 265–266°.

Anal. Calcd. for $C_6H_3N_3O_3$: C, 43.65; H, 1.83; N, 25.45. Found: C, 43.74; H, 2.10; N, 25.31.

5-Nitro-2-pyridone-3-carboxylic Acid (II).—A solution of 1.65 g. (0.01 mole) of the nitrile in a mixture of 20 g. of concentrated sulfuric acid and 10 ml. of water was refluxed for one and two-thirds hours. A crude product was obtained by diluting the reaction mixture with water, neutralizing the sulfuric acid with strong aqueous sodium hydroxide and cooling to 5°. Recrystallization from 50 ml. of water gave an analytically impure sample in the form of short, light tan needles which sintered at 246° and melted at 247–248°.

Anal. Calcd. for $C_6H_4N_2O_5$: C, 39.14; H, 2.19; N, 15.22. Found: C, 38.68; H, 2.35; N, 15.00; ash, 0.53.

A purer sample of II was obtained when the ethoxy derivative V was refluxed for 30 minutes with 50% aqueous sulfuric acid. Successive recrystallizations of the crude hydrolysis product from acetone-water and water gave short, thick, colorless needles which melted at 250–251°.

Anal. Calcd. for $C_6H_4N_2O_5$: C, 39.14; H, 2.19; N, 15.22. Found: C, 39.64; H, 2.12; N, 15.24.

Decarboxylation of 5-Nitro-2-pyridone-3-carboxylic Acid (II).—A 0.1-g. sample of the acid was heated in a side-arm test-tube at 330° and atmospheric pressure for three minutes, then sublimed to a cold finger at 60 mm. pressure. The crude yellow product was purified by another sublimation at 0.2 mm. and 180–200°, followed by two recrystallizations from water. The 5-nitro-2-pyridone obtained in this way melted at 182.5–184.5°. The previously reported value is 186°.[2]

2-Chloro-5-nitronicotinonitrile (IV).—A mixture of 16.51 g. (0.10 mole) of the pyridone (I), 41.6 g. (0.20 mole) of phosphorus pentachloride and 20 ml. of phosphorus oxychloride in an all-glass apparatus was refluxed by heating in an oil-bath at 130–140° for three hours and evaporated to dryness on the steam-bath at water aspirator pressure. One hundred ml. of cold water was added cautiously to the residue. The solid was crushed with a spatula and cold concentrated aqueous sodium hydroxide was added to bring the *p*H to 6. The crude product was collected on a büchner funnel and extracted in an erlenmeyer flask with two 200-ml. portions of boiling 95% alcohol. The combined extracts were diluted with 100 ml. of water and cooled overnight in the refrigerator, giving 15.30 g. (83% yield) of yellowish-brown crystalline product which sintered at 117–118° and melted at 118–120°. The analytical sample was prepared by sublimation at 0.1 mm. followed by crystallization from 50% aqueous alcohol, when it was obtained in the form of white platelets which melted at 121–122°.

Anal. Calcd. for $C_6H_2ClN_3O_2$: C, 39.26; H, 1.10; N, 22.89. Found: C, 39.65; H, 1.38; N, 22.50.

2-Ethoxy-5-nitronicotinonitrile (V).—To a solution of 1.38 g. (0.06 g. atom) of sodium in 60 ml. of absolute alcohol was added 10.98 g. (0.06 mole) of the chloropyridine IV. The reddish-brown solution was allowed to stand for one hour at room temperature, diluted with 60 ml. of water and cooled to −3°. A brown precipitate formed which was collected, dried and sublimed at 90° and 0.3 mm. pressure, giving 7.86 g. (67%) of nearly colorless product, m.p. 51–53°. After another sublimation and two recrystallizations from aqueous alcohol, an analytical sample was obtained in the form of fine, colorless, leaf-like crystals which melted at 62.5–63°.

Anal. Calcd. for $C_8H_7N_3O_3$: C, 49.74; H, 3.65. Found: C, 50.12; H, 3.62.

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2,7-Di-*t*-butyl-1,4-naphthoquinone and Related Compounds

BY H. MARJORIE CRAWFORD

RECEIVED OCTOBER 2, 1954

Two di-*t*-butylnaphthalenes, the 1,4-quinone corresponding to the higher melting hydrocarbon, and the diacetate made by the reductive acetylation of the quinone have been known for some time. Recently the 103° hydrocarbon was shown to be 2,7-di-*t*-butylnaphthalene[1] and the 146° hydrocarbon was shown to be 2,6-di-*t*-butylnaphthalene.[2] The latter paper also established the structure of the 86° quinone as 2,6-di-*t*-butyl-1,4-naphthoquinone and the corresponding 139° compound as the diacetate of 2,6-di-*t*-butyl-1,4-naphthalenediol.

To complete this series of compounds the quinone and diacetate corresponding to the 103° hydrocarbon have been prepared.

2,7-Di-*t*-butyl-1,4-naphthoquinone.—Half a mole (50 g.) of chromium trioxide dissolved in a mixture of 80 ml. of glacial acetic acid and 40 ml. of water was added slowly to a suspension of 0.1 mole (24 g.) of 2,7-di-*t*-butylnaphthalene in 200 ml. of glacial acetic acid. The solution became warm and the temperature was maintained at 40–50° by regulating the rate of addition of the chromium trioxide solution. After standing at room temperature for three hours the mixture was poured onto ice. The resulting gummy, yellow solid was collected and crystallized from ethanol. The yield was 18 g. (67%) and the melting point 55–57°.

Anal. Calcd. for $C_{18}H_{22}O_2$: C, 80.0; H, 8.2. Found: C, 80.6; H, 8.5.

Phenylhydrazone of 2,7-Di-*t*-butyl-1,4-naphthoquinone.—Five drops of glacial acetic acid was added to a solution of the quinone (3.5 g.) and phenylhydrazine (3 ml.) in 50 ml. of ethanol. The solution was allowed to stand for a few minutes after being heated to boiling. The resulting solid crystallized from ethanol as dark red needles with a greenish luster, d. 197–198°.

Anal. Calcd. for $C_{24}H_{28}ON_2$: C, 80.0; H, 7.8. Found: C, 80.3; H, 8.0.

The Diacetate of 2,7-Di-*t*-butyl-1,4-naphthalenediol.—Two grams of the quinone was refluxed for two hours with 5 g. of zinc, 1 g. of fused sodium acetate and 15 ml. of acetic anhydride. The addition of ice and water to the colorless solution gave a white precipitate which was collected and crystallized from ethanol. The yield was 2.2 g. (84%) and the melting point was 123–124°.

Anal. Calcd. for $C_{22}H_{28}O_4$: C, 74.1; H, 7.9. Found: C, 73.8; H, 7.9.

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(1) H. E. Nursten and A. T. Peters, *J. Chem. Soc.*, 729 (1950).

(2) H. M. Crawford and M. C. Glesmann, THIS JOURNAL, **76**, 1108 (1954).

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Copolymerization by Carbanion and Radical Mechanisms

BY RALPH L. DANNLEY AND EDWARD L. KAY[1,2]

RECEIVED DECEMBER 5, 1953

The copolymerization of several monomer pairs has been found[3] to be very susceptible to the nature

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(1) Standard Oil Company (Ohio) Fellow, 1953–1954. This paper is based on a portion of the thesis to be submitted by Edward L. Kay in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Graduate School of Western Reserve University.

(2) Presented at the New York City meeting of the American Chemical Society, September, 1954.

(3) C. Walling, E. R. Briggs, W. Cummings and F. R. Mayo, THIS JOURNAL, **72**, 48 (1950).