

Condensations of Carbonyl Compounds at the Methyl or α -Methylene Group of 6- or 4-Alkyl-3-cyano-2(1)-pyridones through Dianions¹

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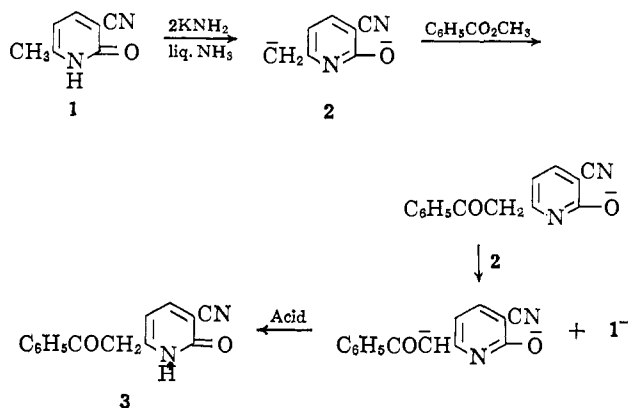
Contribution from the Chemistry Department, Duke University, Durham, North Carolina. Received July 6, 1965

Several types of condensations of carbonyl compounds at the methyl or methylene group of 6- or 4-alkyl-3-cyano-2(1)-pyridones were effected through dianions, which were prepared by means of 2 molecular equiv. of potassium amide in liquid ammonia. The types of condensations realized were arylation with methyl benzoate, acylation with ethyl oxalate, carbonyl addition with benzophenone or benzaldehyde, and conjugate addition with chalcone. One of the benzoyl derivatives was converted by polyphosphoric acid to the corresponding amide and another to a dihydroxy-2,7-naphthyridine. The carbonyl addition products were dehydrated or converted to another derivative. Consideration is given to possible extensions of the method.

A recent paper² has described alkylations at the methyl or α -methylene groups of 6- and 4-alkyl-3-cyano-2(1)-pyridones with alkyl halides. This novel mode of alkylation was effected through corresponding dianions, which were prepared by means of potassium amide in liquid ammonia.

The present paper describes some examples of several other types of condensations at the 6- and 4-methyl or -methylene groups of certain alkylcyanopyridones with carbonyl compounds.

Arylation and Acylation. Two 6-methyl- and one 4-methyl-3-cyano-2(1)-pyridones were aryolated with methyl benzoate through dianions, which were prepared by means of 2 molecular equiv. of potassium amide in liquid ammonia. Thus, dianion **2**, prepared from pyridone **1**, was benzoylated to form **3** in 80% yield. This reaction was effected with 2 molecular equiv. of dianion **2** to one of methyl benzoate, as half

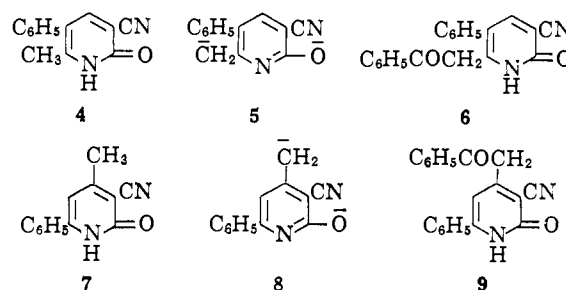


(1) This investigation was supported by Public Health Service Research Grant No. CA 04455-06 from the National Cancer Institute and by National Science Foundation Grant No. NSF GP 2274.

(2) S. Boatman, T. M. Harris, and C. R. Hauser, *J. Org. Chem.*, **30**, 3593 (1965).

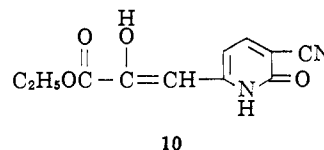
of **2** was probably neutralized in converting the mono-anion of the condensation product to its dianion.³

Similarly, cyanopyridones **4** and **7** were converted to dianions **5** and **8**, which were benzoylated in the presence of 1 molecular equiv. of potassium amide to give **6** and **9** in yields of 75 and 68%, respectively. In these cases, the monoanion of the condensation product apparently is converted to its dianion by the alkali amide.⁴



Structures **3**, **6**, and **9** were supported by absorption spectra (see Tables I and II). Their infrared spectra (KBr pellet) showed bands for the ketone carbonyl group, although this band in the spectrum of **6** appeared to be masked by that of the amide group carbonyl. Their ultraviolet spectra (in ethanol) exhibited maxima near the visible region, which might be attributed to enolized structures present in ethanolic solution; the two maxima characteristic of cyanopyridones were also observed. The n.m.r. spectrum of each compound (in trifluoroacetic acid) showed a singlet for the two methylene hydrogens. The singlets in the spectra of **3** and **6** were further downfield than that in the spectrum of **9** (see Table II). This may be due to the electron-withdrawing effect of the ring nitrogen. However, the methylene of **9** appeared abnormally far upfield. It should be noted that the three types of spectra, obtained in different media, probably represent three different structures for each compound.

Also, dianion **2** was acylated with ethyl oxalate by the second procedure mentioned above to afford **10** in 46% yield. Structure **10** was supported by absorption spectra. Its infrared spectrum showed absorption bands for the ester, ring-amide, and nitrile groups at 5.80, 6.05, and 4.46 μ , respectively. Its ultraviolet spectrum exhibited maxima at 420 m μ (log ϵ 4.25), 294 (3.73), and 277 (3.81).



(3) See R. J. Light and C. R. Hauser, *ibid.*, **25**, 538 (1960).

(4) See S. D. Work and C. R. Hauser, *ibid.*, **28**, 725 (1963).

Table I. Infrared and Ultraviolet Spectral Data for the Pyridones

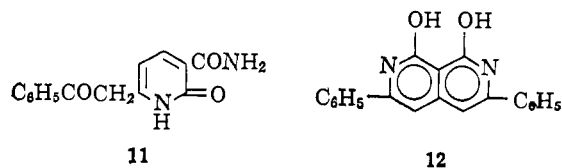
Pyridone	Infrared spectrum, μ			Ultraviolet spectrum	
	Ring amide	Nitrile	Other	λ_{\max} m μ	Log ϵ
	6.03, 6.14, 6.23	4.46	5.89 ^a		
3	6.00, 6.15, 6.22	4.46	5.85 ^a	435, 338, 242	3.64, 4.06, 4.23
6	6.03, 6.25, 6.41	4.50	...	448, 345, 245	3.69, 4.04, 4.38
9	6.08, 6.18, 6.33	4.49	5.95 ^a	405, ^b 359, 270	3.76, 4.22, 4.25
10	6.06	4.46	5.79 ^c	420, 294, ^b 277	4.25, 3.73, 3.81
13	6.05, 6.21, 6.36	4.47	2.94 ^d	338, 235	4.12, 4.04
14	6.00, 6.28, 6.41	4.48	...	338, 246, 237	4.28, 4.32, 4.30
15	6.08, 6.27,	354, 245	4.18, 4.48
17	6.00, 6.18, 6.37	4.48	2.92 ^d	338, 236	4.13, 3.92
18	6.00, 6.16, 6.37	4.48	5.73 ^c	380, 339, 235	3.38, 4.07, 3.95
19	6.08, 6.20, 6.33	4.52	2.86 ^d	351, 246	4.24, 4.40
20	6.09, 6.24, 6.36	4.50	...	385, 340, 276	4.16, 4.34, 4.25
21	6.01, 6.18, 6.36	4.49	5.94 ^a	339, 242	4.08, 4.23
22	6.10, 6.21, 6.34	4.55	5.95 ^a	356, 246, 226	4.21, 4.25, ...
26	6.03, 6.22, 6.37	4.55	5.93 ^a	351, 242	4.09, 4.28

^a Keto carbonyl. ^b Shoulder. ^c Ester carbonyl. ^d Hydroxyl group.

Table II. N.m.r. Data for the Cyanopyridones

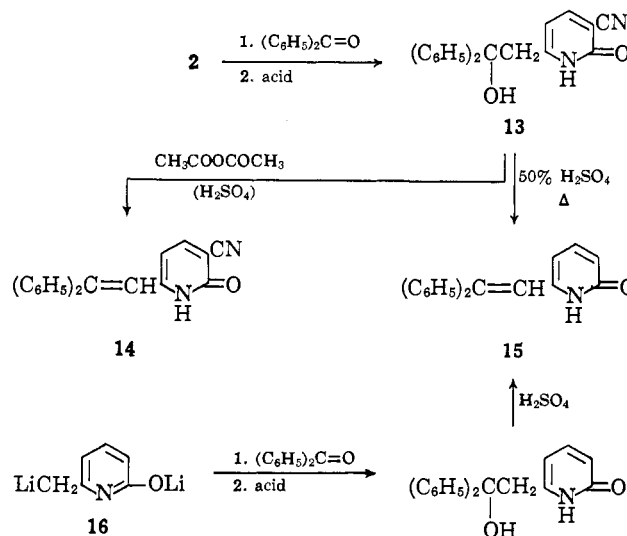
Cyano-pyridone	Type of hydrogen	Peak character	Peak center or over-all range, p.p.m.	No. of hydrogens (relative peak intensity)
3	Methylene	Singlet	4.92	2 (0.36)
	4 and 5 H of pyridone	Pair of doublets	6.65, 6.78	2 (0.36)
	Phenyl	Sharp peak with shoulders	7.66-8.54	5 (1.0)
6	Methylene	Singlet	4.56	2 (0.17)
	5 H of pyridone	Singlet	8.05	1 (0.09)
	Phenyl	Complex group	6.87-7.78	10 (1.0)
9	Methylene	Singlet	2.65	2 (0.20)
	4 H of pyridone	Doublet	7.04, 7.13	1 (0.12)
	Phenyl	Several peaks	7.23-8.14	10 (1.0)
21	CH ₂ CHCH ₂	Two complex groups	2.94-4.30	4 (0.43)
	4 and 5 H of pyridone	Several peaks	6.45-8.18	12 (1.0)
22	CH ₂ CHCH ₂	Two complex groups	3.16-4.06	5 (0.33)
	4 H of pyridone	Singlet	6.90	1 (0.06)
	Phenyl	Several peaks	7.23-8.23	15 (1.0)

Treatment of benzoyl derivatives **3** and **9** with polyphosphoric acid produced amide **11** and cyclic product **12** in yields of 91 and 65%, respectively. In the latter reaction, the corresponding amide was presumably an intermediate.



Structures **11** and **12** were supported by absorption spectra. The infrared spectrum of **11** showed amide carbonyl absorption at 5.96 μ and showed no nitrile band; a doublet for the hydrogens of NH₂ was present at about 3.1 μ . The ultraviolet spectrum exhibited maxima at 331 m μ (log ϵ 4.06) and 240 m μ (log ϵ 3.80). The infrared spectrum of **12** showed absorption at 6.10, 13.00, and 14.45 μ ; no absorption characteristic of nitrile or hydrogens of an amide NH₂ was observed. The ultraviolet spectrum exhibited maxima at 360 m μ (log ϵ 4.40) and 271 m μ (log ϵ 4.49).

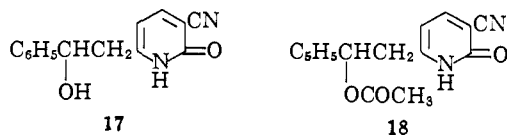
Carbonyl Addition. Dianion **2** (see preceding section) underwent an addition reaction with benzophenone to form **13** in 87% yield. Adduct **13** was dehydrated with acetic anhydride in the presence of a



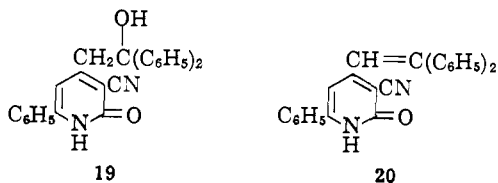
catalytic amount of concentrated sulfuric acid to give **14** in 99% yield. Product **14** was decyanated (probably through decarboxylation of the carboxylic acid) with refluxing 50% sulfuric acid to afford **15**, which was independently synthesized from 6-methyl-2(1)-pyridone through its dilithio salt **16**.⁵

The structures of these products were further supported by absorption spectra. Their ultraviolet spectra showed the expected maxima near 338 and 235 m μ for **13** and **14**, and 245 m μ for **14** and **15** (see Table I). The infrared spectrum of **13** showed an OH band which was missing in **14** and **15**. The infrared spectra of **13** and **14** showed CN absorption near 4.48 μ , which was missing in **15**.

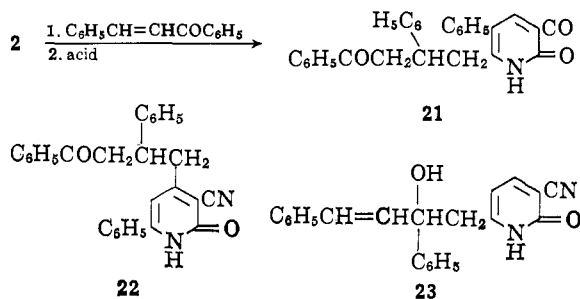
Similarly dianion **2** underwent an addition reaction with benzaldehyde to form **17** in 67% yield. Acetylation of **17** to form **18** was accomplished with acetic anhydride and a catalytic amount of sulfuric acid. The infrared spectrum of **17** showed an OH band at 2.92 μ , and that of **18** showed an ester peak at 5.73 μ . The ultraviolet spectra of both gave the expected maxima and extinction coefficients (see Table I).



Likewise dianion **8** (see previous section) underwent an addition reaction with benzophenone to give **19** in 80% yield; **19** was dehydrated with concentrated sulfuric acid to afford **20** in 91% yield. The structures were supported by infrared and ultraviolet spectra (see Table I).



Conjugate Addition. Dianions **2** and **8** (see arylation section) underwent conjugate addition with chalcone to form **21** and **22** in yields of 87 and 86%, respectively.

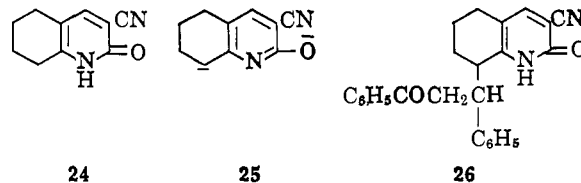


Structures **21** and **22** were supported by absorption spectra. Their infrared spectra showed bands for the ketone carbonyl group (see Table I), and their n.m.r. spectra exhibited complex peaks for one methinyl and four methylene hydrogens (see Table II). Their ultraviolet spectra showed the expected maxima and

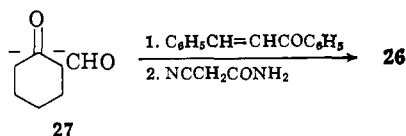
(5) This salt was prepared by means of two molecular equivalents of *n*-butyllithium in tetrahydrofuran; the details of this new method will be published soon.

extinction coefficients (see Table I). That the products were not the possible carbonyl addition adducts, for example **23**, was further indicated by the absence of a hydroxyl band in the infrared spectra, and by failure to undergo dehydration with cold, concentrated sulfuric acid.

Similarly pyridone **24** was converted to dianion **25**, which was condensed with chalcone to give **26** in 65% yield.



Structure **26** was supported by infrared and ultraviolet spectra (see Table I), and by independent synthesis from dianion **27** as described recently.⁶



Discussion

The scope of the carbonyl condensations illustrated above could presumably be extended considerably. Thus, not only should other 4- and 6-alkyl-3-cyano-2(1)-pyridones undergo such reactions, but other aromatic esters, aromatic ketones or aldehydes, and α,β -unsaturated carbonyl or related compounds should also be suitable for arylation, carbonyl additions, and conjugate additions, respectively. Extensions of the method to aliphatic esters and ketones seems possible by the use of dilithio salts of the cyano pyridones. As pointed out previously,² pyridones having an activating group other than CN might also be suitable for such condensations.

Experimental Section⁷

Pyridone Dianions. The starting cyanopyridones **1**, **4**, **7**, and **24** were prepared as reported previously.²

In a typical experiment, 0.05 mole of the pyridone was added to 0.108 mole of potassium amide, prepared from 0.108 g.-atom of potassium in commercial, anhydrous, liquid ammonia.⁸ Conversion to the dianion was assumed to be complete after the solution had stirred for 1 hr. Dianions **2** and **5** were red, and **8** and **25** were green.

Benzoylations. *A. Of 6-Methyl-3-cyano-2(1)-pyridone Dianion (2) to Form 3.* To a stirred solution of 0.118 mole of dianion **2** in 700 ml. of liquid ammonia was added 8.0 g. (0.059 mole) of methyl benzoate in

(6) T. M. Harris, S. Boatman, and C. R. Hauser, *J. Am. Chem. Soc.*, **87**, 3186 (1965).

(7) Melting points were taken on a Mel-Temp capillary melting point apparatus and are uncorrected. Infrared spectra were determined with Perkin-Elmer Infracorads, Models 137 and 237, with potassium bromide pellets or Nujol mulls. N.m.r. spectra were obtained with a Varian A-60 spectrometer using trifluoroacetic acid as solvent and tetramethylsilane as an external reference. Ultraviolet spectra were obtained with a Cary Model 14 spectrometer using solutions approximately 10^{-4} M in 95% ethanol. Elemental analyses were by Galbraith Laboratories, Knoxville, Tenn., Triangle Chemical Laboratories, Chapel Hill, N. C., and Janssen Pharmaceutica, Beerse, Belgium.

(8) See C. R. Hauser and T. M. Harris, *J. Am. Chem. Soc.*, **80**, 6360 (1958).

ether. The mixture was stirred for 40 min. before neutralization with ammonium chloride. The ammonia was evaporated, and the mixture was washed with dilute hydrochloric acid and filtered. The precipitate was washed with water and then stirred briefly with a solution of 6 g. of sodium hydroxide in 50 ml. of water. The remaining solid was collected and washed with water. Acidification of the combined washings and alkaline solution afforded 11.2 g. (80%) of the pale yellow 6-phenacyl-3-cyano-2(1)-pyridone (**3**), m.p. 199–205°. Recrystallization from ethanol gave two crystalline forms: on fast cooling, white needles, m.p. 209–211°, and on slow cooling, yellow rhomboids, m.p. 210–212°. Although their infrared spectra were slightly different (see Table I), their mixture melting point was undepressed.

Anal. Calcd. for $C_{14}H_{10}N_2O_2$: C, 70.58; H, 4.23; N, 11.76. Found: C, 70.71; H, 4.24; N, 11.84.

A 2-g. sample of **3** was heated with 20 g. of polyphosphoric acid at 150° for 1 hr. The solution was diluted with 150 g. of ice, and the resulting mixture was filtered. The solid was washed with saturated sodium bicarbonate solution and water and recrystallized from ethanol to give 1.9 g. (91%) of 6-phenacyl-2(1)-pyridone-3-carboxamide (**11**), m.p. 287–289°.

Anal. Calcd. for $C_{14}H_{12}N_2O_3$: C, 65.52; H, 4.72; N, 10.93. Found: C, 65.70; H, 4.73; N, 10.92.

B. Of 6-Methyl-5-phenyl-3-cyano-2(1)-pyridone Dianion (5) to Form 6. To a stirred solution of 0.05 mole of dianion **5** and an additional 0.06 mole of potassium amide (prepared from 0.06 mole of pyridone **4** and 0.15 mole of potassium amide) in 800 ml. of liquid ammonia was added 8.2 g. (0.06 mole) of methyl benzoate in 20 ml. of ether. The ammonia was allowed to evaporate,⁹ and the residue was dissolved in ether and cold water. The two layers were separated. The aqueous layer was acidified with 6 *M* hydrochloric acid. The solid was collected, washed with water, and recrystallized from ethanol (solution was deep yellow) to afford a mixture of pale yellow needles and orange platelets, m.p. 237–245°. Further recrystallization from ethanol afforded 4.9 g. (78%) of 6-phenacyl-5-phenyl-3-cyano-2(1)-pyridone (**6**), m.p. 247–248°.

Anal. Calcd. for $C_{20}H_{14}N_2O_2$: C, 76.42; H, 4.49; N, 8.91. Found: C, 76.43; H, 4.42; N, 8.80.

C. Of 4-Methyl-6-phenyl-3-cyano-2(1)-pyridone Dianion (8) to Form 9. The reaction was carried out as in **B**, using 0.05 mole of dianion **8**. One recrystallization of the product from ethanol afforded 10.3 g. (65%) of 4-phenacyl-6-phenyl-3-cyano-2(1)-pyridone (**9**), m.p. 248–250°.

Anal. Calcd. for $C_{20}H_{14}N_2O_2$: C, 76.42; H, 4.49; N, 8.91. Found: C, 76.19; H, 4.43; N, 8.93.

A 2-g. sample of **9** was heated with 20 g. of polyphosphoric acid at 150° for 1 hr. The solution was diluted with 150 g. of ice, and the resulting mixture was filtered. The solid was washed with saturated sodium bicarbonate solution and water and recrystallized from glacial acetic acid to give 1.2 g. (65%) of 1,8-dihydroxy-3,6-diphenyl-2,7-naphthyridine (**12**), m.p. 296–297°.

(9) This procedure, which is used also in (C), differs from that in (A), because the products of (B) and (C) could not be separated from their respective starting materials by stirring the mixture with aqueous base of varied concentrations.

Anal. Calcd. for $C_{20}H_{14}N_2O_2$: C, 76.42; H, 4.49; N, 8.91. Found: C, 76.50; H, 4.58; N, 8.65.

Acylation of Dianion 2 with Ethyl Oxalate. The reaction was carried out as in **B** above using 0.05 mole of dianion **2**, except that the ammonia was replaced by anhydrous ether, which was distilled and replaced until there was no detectable ammonia odor. A solution of 11.0 g. (0.075 mole) of ethyl oxalate in ether was added, and the mixture was refluxed for 8 hr. The work-up was carried out as in **B**. The product **10** was obtained in 46% yield (4.8 g.), m.p. 237–238° after recrystallization from ethanol. Compound **10** gave a green color with alcoholic ferric chloride.

Anal. Calcd. for $C_{11}H_{10}N_2O_4$: C, 56.41; H, 4.30; N, 11.96. Found: C, 56.34; H, 4.31; N, 11.92.

Carbonyl Additions. A. Of Dianion 2 with Benzophenone to Form 13. To a stirred solution of 0.025 mole of dianion **2** in 500 ml. of liquid ammonia was added 7.10 g. (0.039 mole) of benzophenone in ether. After 15 min. the green slurry was poured into a mixture of 5 g. of ammonium chloride and 200 ml. of liquid ammonia. The ammonia was evaporated and the residue was suspended in water. The mixture was filtered. The solid was washed with water and a little ether and dried to afford 6.9 g. (87%) of adduct 6-(2,2-diphenyl-2-hydroxyethyl)-3-cyano-2(1)-pyridone (**13**), m.p. 208–210°. Recrystallization from ethanol raised the melting point to 215–216°.

Anal. Calcd. for $C_{20}H_{16}N_2O_2$: C, 76.06; H, 5.07; N, 8.81. Found: C, 76.00; H, 5.12; N, 8.94.

Dehydration was effected by heating 3.0 g. of **13** with 20 ml. of acetic anhydride and about 0.1 ml. of sulfuric acid on the steam bath for 2 hr. Sodium carbonate (0.1 g.) was added, and the mixture was poured into water. After the acetic anhydride had been hydrolyzed, the precipitate was collected and dried to give 2.7 g. (99%) of 6-(2,2-diphenylvinyl)-3-cyano-2(1)-pyridone (**14**), m.p. 241–243° and 242.5–244° after recrystallization from ethanol.

Anal. Calcd. for $C_{20}H_{14}N_2O$: C, 80.51; H, 4.73; N, 9.39. Found: C, 80.46; H, 4.93; N, 9.48.

Decyanation was effected by heating 3.9 g. of **14** in a solution of 12 ml. of sulfuric acid and 12 ml. of water at 150° for 10 hr. The mixture was cooled and poured over ice. The precipitate was collected and was recrystallized from ethanol to afford 3.0 g. (84%) of 6-(2,2-diphenylvinyl)-2(1)-pyridone (**15**), m.p. 206–209° (211–213° after further recrystallization).

Anal. Calcd. for $C_{19}H_{15}NO$: C, 83.49; H, 5.53; N, 5.13. Found: C, 83.59; H, 5.58; N, 4.90.

Independent synthesis of **15** was accomplished by dehydration of the condensation product of benzophenone and dilithio-6-methyl-2(1)-pyridone (**16**).⁶ Samples of **15** prepared by the two routes were shown to be identical by mixture melting point and infrared spectra.

B. Of Dianion 2 with Benzaldehyde to Form 17. To a stirred solution of 0.025 mole of dianion **2** in 500 ml. of liquid ammonia was added 5.3 g. (0.05 mole) of benzaldehyde. The red color became dark green and then gradually brown. After 10 min., the solution was poured into a mixture of 6 g. of am-

monium chloride and 100 ml. of liquid ammonia. After evaporation of the ammonia, the sticky residue was filtered and washed with cold water. Crystallization from ethanol afforded 4.0 g. (67%) of 6-(2-phenyl-2-hydroxyethyl)-3-cyano-2(1)-pyridone (**17**), m.p. 195–196° (205–206° after recrystallization from ethanol).

Anal. Calcd. for $C_{14}H_{12}N_2O_2$: C, 70.47; H, 4.95; N, 11.47. Found: C, 70.50; H, 5.03; N, 11.65.

Acetylation was accomplished by dissolving 1.9 g. of **17** in 10 ml. of acetic anhydride and 1 drop of sulfuric acid. The mixture was warmed on the steam bath to effect solution and then allowed to stand at room temperature for 8 hr. A small amount of potassium carbonate was added, and the acetic anhydride and acetic acid were removed under reduced pressure. The residue was taken up in ethyl acetate, and the solution was filtered and evaporated. Recrystallization of the residue from ethanol afforded 1.75 g. (78%) of acetylation product **18**, which momentarily melted and then resolidified at about 200° and then melted again at 308–310° dec. The first transition may have reflected loss of acetic acid or the occurrence of some other chemical transformation.

Anal. Calcd. for $C_{16}H_{14}N_2O_3$: C, 68.07; H, 5.00; N, 9.93. Found: C, 68.28; H, 4.95; N, 10.02.

C. Of Dianion 8 with Benzophenone to Form 19. This reaction was carried out as in part A of this section, using 0.05 mole of dianion **8**, 9.1 g. (0.05 mole) of benzophenone, and 10 g. of ammonium chloride. Recrystallization of the product from ethanol afforded 15.8 g. (80%) of 4-(2,2-diphenyl-2-hydroxyethyl)-6-phenyl-3-cyano-2(1)-pyridone (**19**), m.p. 240–242°. Further recrystallization raised the melting point to 250–251.5°.

Anal. Calcd. for $C_{26}H_{20}N_2O_2$: C, 79.57; H, 5.14; N, 7.14. Found: C, 79.87; H, 5.18; N, 7.14.

Dehydration was accomplished by dissolving 2.5 g. of **19** in 25 ml. of concentrated sulfuric acid at about 5°, and then pouring the solution over 100 g. of ice. The resulting solid was collected, washed with sodium carbonate solution, and water, and recrystallized from ethanol to afford 2.0 g. (91%) of 4-(2,2-diphenylvinyl)-6-phenyl-3-cyano-2(1)-pyridone (**20**), m.p.

272–274°. Further recrystallization raised the melting point to 275–276°.

Anal. Calcd. for $C_{26}H_{18}N_2O$: C, 83.40; H, 4.85; N, 7.48. Found: C, 83.47; H, 4.86; N, 7.60.

Conjugate Additions. A. Of Dianion 2 to Form 21. To a stirred solution of 0.05 mole of dianion **2** in 700 ml. of liquid ammonia was added 11.0 g. (0.105 mole) of chalcone. After 1 hr. the ammonia was evaporated, and the residue was dissolved in ether, ice, and water. The aqueous layer was separated and acidified with 6 *M* hydrochloric acid. The resulting precipitate was collected, washed with water, and recrystallized from ethanol to afford 14.9 g. (87%) of 6-(2,4-diphenyl-4-oxobutyl)-3-cyano-2(1)-pyridone (**21**), m.p. 216–222° (227–228° after recrystallization from ethanol).

Anal. Calcd. for $C_{22}H_{18}N_2O_2$: C, 77.17; H, 5.30; N, 8.18. Found: C, 77.04; H, 5.11; N, 8.34.

A sample of **21** was recovered unchanged after treatment with cold, concentrated sulfuric acid.

B. Of Dianion 8 to Form 22. This reaction was carried out as in part A of this section, using 0.05 mole of dianion **8**. Recrystallization of the product from ethanol afforded 18.0 g. (86%) of 4-(2,4-diphenyl-4-oxobutyl)-6-phenyl-3-cyano-2(1)-pyridone (**22**), m.p. 252–255°; further recrystallization raised the melting point to 261.5–262°.

Anal. Calcd. for $C_{28}H_{22}N_2O_2$: C, 80.36; H, 5.29; N, 6.69. Found: C, 80.58; H, 5.33; N, 6.50.

This product was unchanged by treatment with cold, concentrated sulfuric acid.

C. Of Dianion 25 to Form 26. This reaction was carried out as in part A of this section, using 0.05 mole of dianion **25**. Recrystallization of the product from glacial acetic acid afforded 12.4 g. (65%) of 1,2,5,6,7,8-hexahydro-3-cyano-8-(1,3-diphenyl-3-oxopropyl)-2-quinolone (**26**), m.p. 259–260° (lit.⁶ m.p. 261–263°).

Independent synthesis of **26** was accomplished by addition of chalcone to the dianion of 2-formylcyclohexanone, followed by cyclization with cyanoacetamide. The identity of samples of **26** obtained by the two routes was established by mixture melting point and by infrared spectra.

The Kinetics of the Permanganate Oxidation of Acetone¹

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The kinetics of the permanganate oxidation of acetone were examined in basic aqueous solution. The data suggest that the enolate ion is an intermediate, and that it is oxidized by permanganate via an electron transfer rather than addition to the double bond. The rates of oxidation of the possible intermediates, and the products

(1) This work was supported by the U. S. Atomic Energy Commission.

of the oxidation were determined. The data indicate the nature of the reactions which occur.

One of the most common modes of oxidation of aliphatic aldehydes and ketones involves reaction at the α -position.² Our interest in the general subject of

(2) Cf. J. S. Littler, *J. Chem. Soc.*, 827, 832 (1962).