

A Novel Photo-Induced Substitution of Alkyl 2-Cyano-3-quinolinecarboxylates

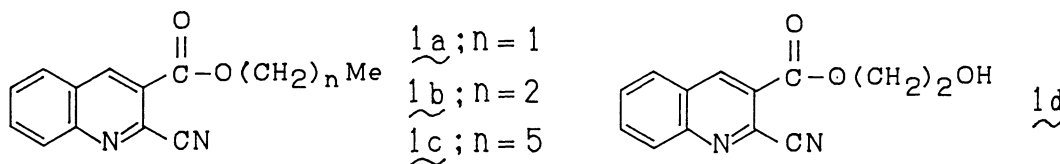
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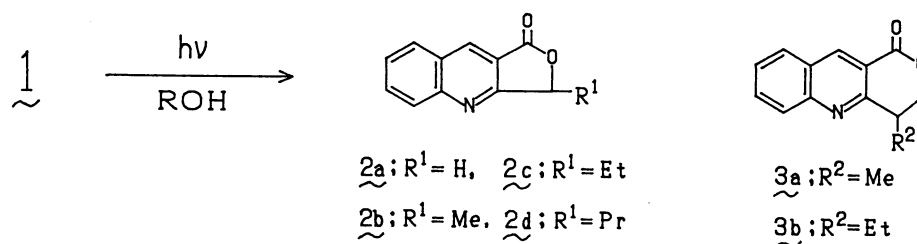
Irradiation of 2-quinolinecarbonitriles having an alkoxycarbonyl group at the 3-position afforded five-membered and/or six-membered lactones in normal alcohols depending on their alkyl-chain-length, whereas the irradiation in 2-propanol and t-butyl alcohol did not cause any cyclization, but instead decynated and methylated products were obtained, respectively.

Irradiation of 2-quinolinecarbonitriles in alcohols induces the replacement of a cyano group by a hydroxyalkyl group arising from the solvent alcohol.¹⁾ On the other hand, the photochemical reactions of ethoxycarbonyl-substituted quinolines give several types of photoproducts depending on the position of the substituent and the nature of the solvent used, but no photosubstitution of the ethoxycarbonyl group occurs.²⁾ In the present paper, we describe the photochemical studies of the quinolines having both substituents, namely alkyl 2-cyano-3-quinolinecarboxylates (1) in normal alcohols, 2-propanol, and t-butyl alcohol.



Irradiation was carried out in alcohols (70 cm³) containing 1 (100 mg) for 3 h with a 100 W high mercury lamp immersed in a Pyrex vessel. The reaction products were separated by either thin layer chromatography or column chromatography (SiO₂, Merck).

Photolysis in normal alcohols gave five-membered and/or six-membered lactones as shown in Table 1. Irradiations of 1a in methanol and ethanol gave the furano-[4,3-b]quinolin-1(2H)-ones (2a and 2b), respectively, as a main product, in rather high yields in an oxygen atmosphere. Photolyses in 1-propanol and 1-butanol yielded a small amount of the six-membered cyclic products, 3,4-dihydropyrano[4,3-b]quinolin-1(2H)-ones (3a and 3b) as well as five-membered cyclic products 2c and 2d, respectively. Other three alkyl 2-cyano-3-quinolinecarboxylates (1b-d) underwent similar photocyclizations, but irradiation of 1b in methanol gave exceptionally propyl 2-hydroxymethyl-3-quinolinecarboxylate (4a) instead of 2a. Such pho-

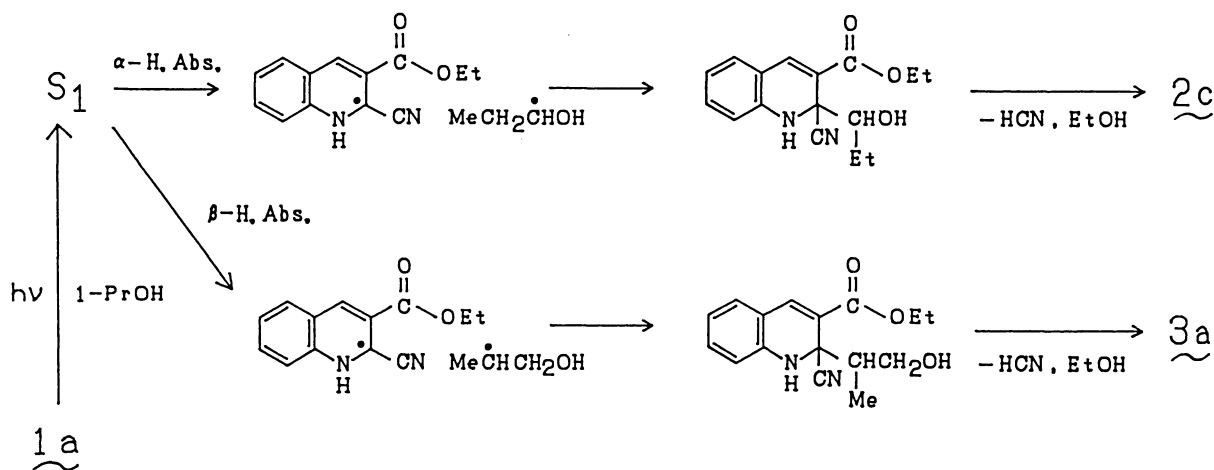
Table 1. Yield of Photoproducts of 1 in Normal Alcohols

<u>1</u>	Solvent	Conversion/%	Product(mp/°C)	Yield/%
<u>1a</u>	MeOH	68	<u>2a</u> (215-217)	64
	EtOH	80	<u>2b</u> (152-153)	77
		97	<u>2b</u>	14 ^{a)}
		65	<u>2c</u> (150-151)	38
	1-PrOH		<u>3a</u> (104-105)	8
		1-BuOH	71	<u>2d</u> (154-155)
			<u>3b</u> (111)	6
<u>1b</u>	MeOH	84	<u>4a</u> (90-91)	64
	EtOH	87	<u>2b</u>	52
<u>1c</u>	EtOH	88	<u>2b</u>	45
<u>1d</u> ^{b)}	MeOH	65	<u>2a</u>	45
	EtOH	64	<u>2b</u>	60

a) Irradiation in a nitrogen atmosphere. b) 50 mg of 1d was used on photolysis because of its poor solubility in alcohol.

tocyclization could be explained by the mechanism exemplified by the case of 1a in 1-propanol shown in Scheme 1. 1 has two reaction sites, namely the ring nitrogen and carbonyl group, but the first step is conceivable to be probably hydrogen atom abstraction from the alcohol by the ring nitrogen in the S_1 state from the analogy with the cases of other quinoline derivatives.^{1,2)} Abstraction of a hydrogen atom from the α -position of the alcohol leads to the formation of five-membered lactone (2c) through the recombination of the radical pair thus formed, followed by the elimination of ethanol and hydrogen cyanide, whereas the β -hydrogen abstraction leads to the formation of six-membered lactone (3a) as shown in Scheme 1. Such types of participation of the solvent in photochemical cyclization is rather rare, although there are many reports for intramolecular cyclization by a long side chain³⁻⁶⁾ and the cyclization of enamides.⁷⁾

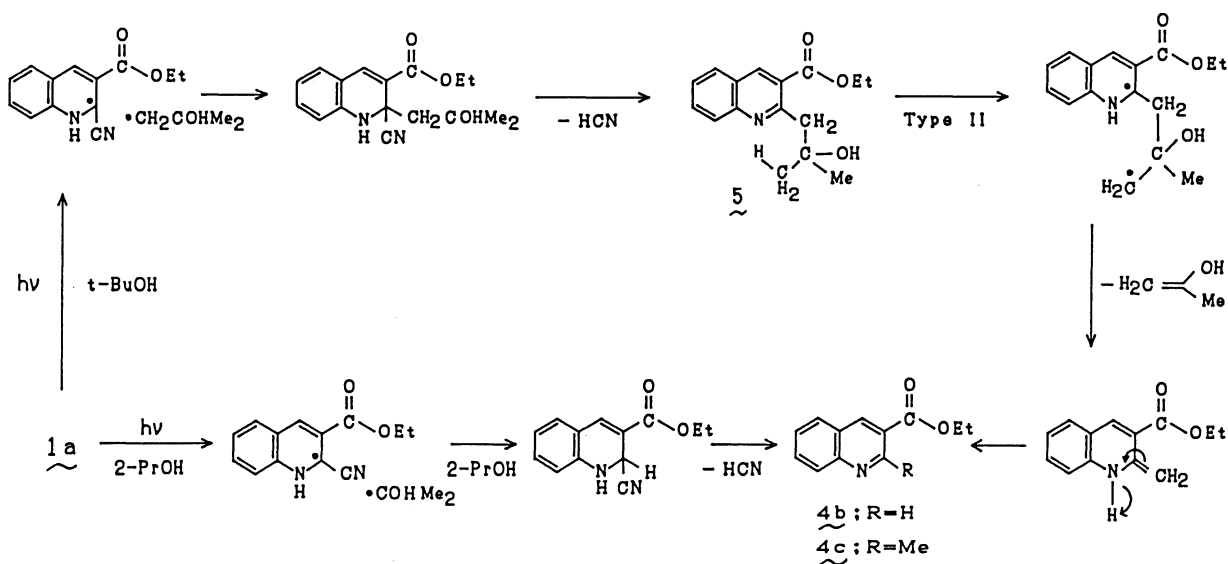
On the other hand, such cyclized products were not obtained on the irradiation in 2-propanol and t-butyl alcohol, and in the case of 1a, ethyl 3-quinolinecarboxylate (4b) and ethyl 2-methyl-3-quinolinecarboxylate (4c) were formed in 12 and 55% yields, respectively. Absence of cyclized products may be ascribed to bulkiness of radical species, $(\text{CH}_3)_2\dot{\text{C}}\text{OH}$ derived from 2-propanol, which hinders a



Scheme 1.

radical coupling process. **1a** seems to abstract two hydrogens from 2-propanol sequentially to give a dihydro compound which is converted to **4b** as the case of ethyl 3-quinolinecarboxylate.²⁾ In the case of t-butyl alcohol the hydroxyalkylated product **5** formed via recombination of the radical pair may undergo a sort of Norrish Type II reaction to give **4c**, although we could not succeed in isolating **5** (Scheme 2).

We attempted the photochemical reactions of ethyl 2-cyano-3-pyridinecarboxylates in ethanol, but many unidentified low yields products were only formed yet.



Scheme 2.

References

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- 8) 1 were given by a Reisert reaction of the N-oxides of the corresponding quinolinecarboxylates which were prepared according to the procedure described in ref. 2. Oxidation of the carboxylates was carried out by using m-chloroperbenzoic acid (Mp. 34 °C for 1a, 116 °C for 1b, 93 °C for 1c, and 116 °C for 1d).
2a: ^1H NMR (270 MHz, in CDCl_3) δ =5.50 (s, 2H, CH_2), 7.26-8.80 (m, 5H, arom H); Found: m/z 185.0478. Calcd for $\text{C}_{11}\text{H}_7\text{NO}_2$: M, 185.0477. 2b: ^1H NMR δ =1.82 (d, J=6.6 Hz, 3H, Me), 5.71 (q, J=6.6 Hz, 1H, CH), 7.69-8.77 (m, 5H, arom H); Found: m/z 199.0651. Calcd for $\text{C}_{12}\text{H}_9\text{NO}_2$: M, 199.0633. 2c: ^1H NMR δ =1.06 (t, J=7.4 Hz, 3H, Me), 1.98-2.09 (m, 1H, $\text{CH}_\text{A}\text{H}$), 2.33-2.41 (m, 1H, CHH_B), 5.57-5.61 (m, 1H, $>\text{CH}$), 7.66-8.75 (m, 5H, arom H); Found: m/z 213.0800. Calcd for $\text{C}_{13}\text{H}_{11}\text{NO}_2$: M, 213.0790. 2d: ^1H NMR δ =1.02 (t, J=7.2 Hz, 3H, Me), 1.45-1.78 (m, 2H, CH_2), 1.88-2.02 (m, 1H, $\text{CH}_\text{A}\text{H}$), 2.25-2.40 (m, 1H, $\text{CH}_\text{B}\text{H}$), 5.60-5.64 (m, 1H, $>\text{CH}$), 7.65-8.75 (m, 5H, arom H); Found: m/z 227.0942. Calcd for $\text{C}_{14}\text{H}_{13}\text{NO}_2$: M, 227.0946.
3a: ^1H NMR δ =1.55 (d, J=7.26 Hz, 3H, Me), 3.44-3.51 (m, 1H, $>\text{CH}$), 4.37-4.44 (m, 1H, $>\text{CH}_\text{A}\text{H}$), 4.67-4.73 (m, 1H, $>\text{CHH}_\text{B}$), 7.58-8.96 (m, 5H, arom H); Found: m/z 213.0799. Calcd for $\text{C}_{13}\text{H}_{11}\text{NO}_2$: M, 213.0790. 3b: ^1H NMR δ =1.14 (t, J=7.4 Hz, 3H, Me), 1.82-2.00 (m, 1H, $\text{CH}_\text{A}\text{H}$), 2.03-2.12 (m, 1H, CHH_B), 3.13-3.21 (m, 1H, $>\text{CH}$), 4.58-4.74 (m, 2H, CH_2), 7.58-8.95 (m, 5H, arom H); Found: m/z 227.0936. Calcd for $\text{C}_{14}\text{H}_{13}\text{NO}_2$: M, 227.0946. IR showed the peaks due to CO stretching at about 1760 cm^{-1} for the five-membered lactones and about 1720 cm^{-1} for the six-membered lactones.

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