was added at 0 °C 2 mmol of Et_2AlCl (25 wt % in toluene). After the mixture was stirred 5 min, 1 mmol of cyclopropane in 2 mL of toluene was added and the solution heated at 110 °C until no starting material was visible by TLC (0.3–22 h). Acetic acid (1 mL) was added to the cooled reaction mixture followed by 20 mL of H_2O. The reaction mixture was extracted with 25 mL of EtOAc and with three 20-mL portions of CH_2Cl_2. The EtOAc and CH_2Cl_2 extracts were washed separately with 20 mL of saturated aqueous Na_2CO_3 and 10 mL of H_2O. The two organic phases were then combined, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The residue was purified by flash chromatography[16] using hexane–EtOAc (4:1 to 1:4, depending on the polarity of the products).

Di-*tert*-butyl 2-[2-pyrrolidinyl-2-(4-methoxyphenyl)-ethyl]propanedioate (3a): yield, 91%; mp (fumarate) 70–80 °C; IR (free base, CH_2Cl_2) 1720, 1610, 1240, 1140 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.02 (AB q, J = 9 Hz, 4 H), 3.77 (s, 3 H), 3.07 (dd, J = 4.5, 11.5 Hz, 1 H), 2.96–2.30 (m, 7 H), 1.90–1.55 (m, 4 H), 1.48 (s, 9 H), 1.37 (s, 9 H). Anal. Calcd for $C_{24}H_{37}NO_5$: C, 68.70; H, 8.89; N, 3.34. Found: C, 68.62; H, 8.66; N, 3.38.

Di-*tert*-butyl 2-[2-(diethylamino)-2-(4-methoxyphenyl)-ethyl]propanedioate (3b): yield, 89%; mp (citrate) 70–85 °C dec; IR (citrate, CH_2Cl_2) 1720, 1140 cm^{-1}; ^1H NMR (free base, $CDCl_3$) δ 7.02 (AB q, J = 8 Hz, 4 H), 3.78 (s, 3 H), 3.66 (t, J = 7 Hz, 1 H), 3.28 (t, J = 7 Hz, 1 H), 2.95–1.91 (m, 6 H), 1.48 (s, 9 H), 1.44 (s, 9 H), 0.92 (t, J = 7 Hz, 6 H). Anal. Calcd for $C_{30}H_{47}NO_{12}$ (citrate): C, 58.71; H, 7.72; N, 2.28. Found: C, 58.35; H, 8.41; N, 1.97.

Di-*tert*-butyl 2-[2-(ethylamino)-2-(4-methoxyphenyl)-ethyl]propanedioate (3c): yield, 72%; mp (hydrochloride) 193 °C dec; IR (free base, CH_2Cl_2) 3400, 1724, 1140 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.00 (AB q, J = 8 Hz, 4 H), 3.78 (s, 3 H), 3.56 (t, J = 7 Hz, 1 H), 3.11 (t, J = 7 Hz, 1 H), 2.63–1.82 (m, 5 H), 1.46 (s, 9 H), 1.42 (s, 9 H), 1.01 (t, J = 7 Hz, 3 H). Anal. Calcd for $C_{22}H_{36}ClNO_5$ (hydrochloride): C, 61.45; H, 8.44; N, 3.26. Found: C, 61.51; H, 8.15; N, 3.06.

Di-*tert*-butyl 2-[2-[(2-(3,4-dimethoxyphenyl)ethyl)-amino]-2-(4-methoxyphenyl)ethyl]propanedioate (3d): yield, 83%; oil; IR (CH_2Cl_2) 3440, 1730, 1250, 1150 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.30–6.62 (m, 7 H), 3.82 (s, 6 H), 3.77 (s, 3 H), 3.55 (br t, J = 7 Hz, 1 H), 3.08 (t, J = 7 Hz, 1 H), 2.65 (s, 4 H), 2.26–1.88 (m, 2 H), 1.50 (s, 1 H), 1.46 (s, 9 H), 1.42 (s, 9 H). Anal. Calcd for $C_{30}H_{43}NO_7$: C, 68.03; H, 8.18; N, 2.65. Found: C, 68.30; H, 8.20; N, 2.67.

Di-*tert*-butyl 2-[2-amino-2-(4-methoxyphenyl)ethyl]-propanedioate (3e): yield, 55%; oil; IR (CH_2Cl_2) 3380, 1720, 1140 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.07 (AB q, J = 8 Hz, 4 H), 4.20–3.85 (m, 1 H), 3.79 (s, 3 H), 3.17 (t, J = 7 Hz, 1 H), 2.12 (t, J = 7 Hz, 2 H), 1.55 (s, 9 H), 1.53 (s, 9 H). Anal. Calcd for $C_{20}H_{31}NO_5$: C, 65.73; H, 8.55; N, 3.85. Found: C, 65.58; H, 8.50; N, 3.88.

***trans*-Dimethyl 2-(3,4-dihydro-6,7-dimethoxy-4-(diethylamino)-2*H*-benzopyran-3-yl)propanedioate (5)**: yield, 59%; oil; IR (CH_2Cl_2) 1748, 1733, 1230, 1170, 1130 cm^{-1}; ^1H NMR (C_6D_6) δ 6.68 (s, 1 H), 6.39 (s, 1 H), 4.44 (dd, J = 2.7, 11.2 Hz, 1 H), 4.29 (ddd, J = 1.1, 5.7, 11.2 Hz, 1 H), 3.95 (d, J = 7.9 Hz, 1 H), 3.81 (br d, J = 5.4 Hz, 1 H), 3.40 (s, 3 H), 3.19 (s, 3 H), 3.17 (s, 3 H), 3.15 (s, 3 H), 2.88 (m, 1 H), 2.52 (m, 4 H), 0.86 (t, J = 7.5 Hz, 6 H). Anal. Calcd for $C_{20}H_{29}NO_7$: C, 60.74; H, 7.39; N, 3.54. Found: C, 60.60; H, 7.30; N, 3.60.

***trans*-Di-*tert*-butyl 2-[2,3-dihydro-1-(1-pyrrolidinyl)-1*H*-inden-2-yl]propanedioate (7a)**: yield, 47%; oil; IR (CH_2Cl_2) 1720, 1130 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.40–7.00 (m, 4 H), 3.97 (d, J = 2 Hz, 1 H), 3.55–2.35 (m, 8 H), 1.87–1.50 (m, 4 H), 1.75 (s, 9 H), 1.35 (s, 9 H). Anal. Calcd for $C_{24}H_{35}NO_4$: C, 71.79; H, 8.79; N, 3.49. Found: C, 71.60; H, 8.66; N, 3.40.

***trans*-Di-*tert*-butyl 2-[2,3-dihydro-1-((2-(3,4-dimethoxyphenyl)ethyl)amino)-1*H*-inden-2-yl]propanedioate (7b)**: yield, 30%; oil; IR (CH_2Cl_2) 3600, 1720, 1260, 1150 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.16 (s, 4 H), 6.75 (s, 3 H), 4.30–4.05 (m, 2 H), 3.86 (s, 6 H), 3.64–2.38 (m, 7 H), 1.63 (br s, 1 H), 1.46 (s, 18 H). Anal. Calcd for $C_{30}H_{41}NO_6$: C, 70.42; H, 8.08; N, 2.74. Found: C, 70.26; H, 8.22; N, 2.85.

Di-*tert*-butyl 2-(1*H*-inden-2-yl)propanedioate (8): yield, 16%; mp 68–70 °C; IR (CH_2Cl_2) 1725, 1140 cm^{-1}; ^1H NMR 7.55–7.05 (m, 4 H), 6.82 (br s, 1 H), 4.43 (s, 1 H), 3.70–3.45 (m, 2 H), 1.48 (s, 18 H); mass spectrum, m/z 330 (M^+, 1), 229 (11.2), 57 (100). Anal. Calcd for $C_{20}H_{26}O_4$: C, 72.70; H, 7.93. Found: C, 72.75; H, 7.70.

***trans*-Di-*tert*-butyl 2-[1,2,3,4-tetrahydro-1-(1-pyrrolidinyl)-2-naphthalenyl]propanedioate (10)**: yield, 37%; oil; IR (CH_2Cl_2) 1740, 1725, 1170, 1140 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.11 (s, 4 H), 3.26 (d, J = 3 Hz, 1 H), 3.03–1.95 (m, 10 H), 1.88–1.55 (m, 4 H), 1.45 (s, 18 H). Anal. Calcd for $C_{25}H_{37}NO_4$: C, 72.25; H, 8.98; N, 3.37. Found: C, 71.93; H, 8.68; N, 3.19.

***tert*-Butyl 4-(1-pyrrolidinyl)-2-carbo-*tert*-butoxyhex-5-enoate (12)**:[20] yield, 71%; oil; IR (CH_2Cl_2) 1720, 1140 cm^{-1}; ^1H NMR ($CDCl_3$) δ 6.02–4.91 (m, 3 H), 3.23 (dd, J = 5.9 Hz, 1 H), 2.87–1.56 (m, 11 H), 1.48 (s, 18 H). Anal. Calcd for $C_{19}H_{33}NO_4$: C, 67.22; H, 9.80; N, 4.13. Found: C, 68.02; H, 9.70; N, 4.11.

***tert*-Butyl 4-(1-pyrrolidinyl)-2-carbo-*tert*-butoxyhexanoate (14)**: yield, 29%; oil; IR (CH_2Cl_2) 1720, 1140 cm^{-1}; ^1H NMR ($CDCl_3$) δ 3.38 (t, J = 7 Hz, 1 H), 2.75–1.57 (m, 13 H), 1.48 (s, 18 H), 0.92 (t, J = 7 Hz, 3 H). Anal. Calcd for $C_{19}H_{35}NO_4$: C, 66.82; H, 10.33; N, 4.10. Found: C, 66.77; H, 10.09; N, 4.19.

***tert*-Butyl 4-(1-pyrrolidinyl)-2-carbo-*tert*-butoxy-4-methylpentanoate (16)**: yield, 34%; oil; IR (CH_2Cl_2) 1720, 1140 cm^{-1}; ^1H NMR ($CDCl_3$) δ 3.04 (t, J = 6 Hz, 1 H), 2.80–2.30 (m, 4 H), 2.00 (d, J = 6 Hz, 2 H), 1.85–1.55 (m, 4 H), 1.46 (s, 18 H), 0.97 (s, 6 H). Anal. Calcd for $C_{19}H_{35}NO_4$: C, 66.83; H, 10.33; N, 4.10. Found: C, 66.19; H, 9.87; N, 3.97.

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Registry No. **2**, 100839-16-5; **3a**, 100839-20-1; **3a**·fumarate, 100839-21-2; **3b**, 100839-22-3; **3b**·citrate, 100839-23-4; **3c**, 100839-35-8; **3c**·HCl, 100839-24-5; **3d**, 100839-25-6; **3e**, 100839-26-7; **4**, 100839-17-6; **5**, 100839-27-8; **6**, 100857-92-9; **7a**, 100839-28-9; **7b**, 100839-29-0; **8**, 100839-30-3; **9**, 100839-18-7; **10**, 100839-31-4; **11**, 88326-58-3; **12**, 100839-32-5; **13**, 97935-31-4; **14**, 100839-33-6; **15**, 100839-19-8; **16**, 100839-34-7; 6,7-dimethoxy-2*H*-benzopyran, 41361-61-9; 4-vinylanisole, 637-69-4; di-*tert*-butyl diazomalonate, 35207-75-1; dimethyl diazomalonate, 6773-29-1; indene, 95-13-6; 1,2-dihydronaphalene, 447-53-0; di-*tert*-butyl malonate, 541-16-2; *trans*-1,4-dichloro-2-butene, 110-57-6; pyrrolidine, 123-75-1; diethylamine, 109-89-7; ethylamine, 75-04-7; 3,4-dimethoxyphenethylamine, 120-20-7; NH_3, 14798-03-9.

(20) Diethyl ester: see ref 2.

Vinyl Isocyanates as Aza Diene Equivalents. A Method for the Synthesis of Functionalized 4-Hydroxy-2(1*H*)-pyridones

James H. Rigby* and Frederick J. Burkhardt

Department of Chemistry, Wayne State University, Detroit, Michigan 48202

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We wish to report a general and efficient preparation of functionalized 4-hydroxy-2(1*H*)-pyridones from the reaction of readily available α,β-unsaturated isocyanates with various ester enolates. This two-step protocol is illustrated in eq 1. Addition of an appropriate ester enolate to the electrophilic carbonyl carbon of the isocyanate at 0 °C provided in good yield an adduct which when heated for a short period (4–10 min) at 230–240 °C underwent smooth cyclization to furnish the corresponding six-membered heterocycle.[1]

The enolates of diethyl malonate and ethyl acetoacetate were found to react cleanly with 1-isocyanato-1-cyclo-

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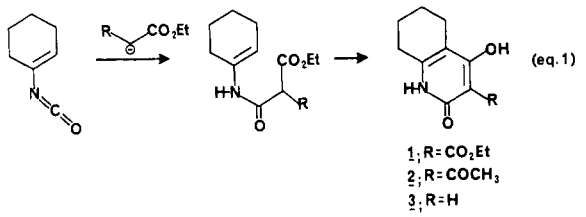
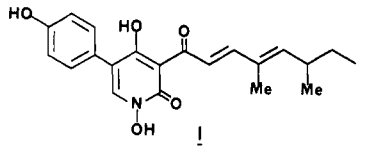


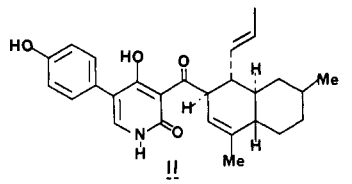
1; R = CO_2Et
2; R = $COCH_3$
3; R = H

hexene, prepared from 1-cyclohexene-1-carboxylic acid, to give 4-hydroxy-2(1*H*)-pyridones **1** and **2** after being heated in phenyl ether. The overall yields of these products based on the carboxylic acid starting material were 72% and 64%, respectively. In most instances nearly pure product crystallized directly from the reaction mixture on cooling. In contrast, the reaction of the lithium enolate of ethyl acetate[2] with 1-isocyanato-1-cyclohexene was not clean and little of the expected pyridone **3** was isolated.

The high degree of reactivity and relative ease of preparation make vinyl isocyanates particularly attractive intermediates for the construction of a variety of pyridine derivatives.[3] The 3-acyl-4-hydroxy-2-pyridone moiety accessible by this procedure is prominently displayed in a number of structurally novel and biologically interesting natural products including the fungal metabolites tenellin (I)[4] and ilicicolin H (II).[5]



I

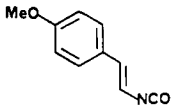
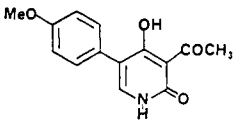
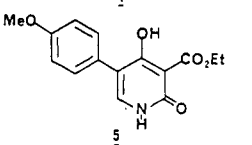
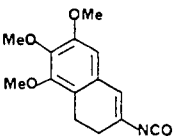
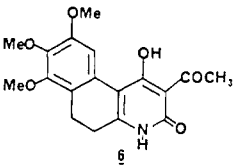
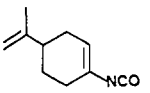
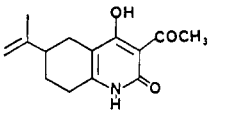
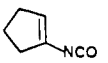
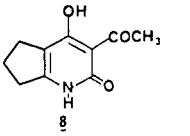


II

The scope of the process described herein is evident from Table I which lists several additional examples of functionalized pyridones prepared by this methodology. Entries 1 and 2 are of particular significance in terms of their relationship to compounds I and II.[6] It is worth noting that in those examples that employed the enolate of ethyl acetoacetate as the nucleophilic reaction partner, cyclization occurred only at the ester carbonyl group, generating the corresponding 3-acetyl-substituted pyridones (entries 1, 3–5). To date, no evidence for formation of the alternative cyclization product has been observed in any of these cases. This chemoselectivity presumably reflects the protection from nucleophilic attack afforded by the enol form of the ketone and suggest that a range of carbonyl substituents might be amenable to this cyclization methodology.

The applicability of silyl ketene acetals as nucleophilic partners in this sequence was also briefly examined. However, the overall yields of pyridone products were generally inferior to those obtained with the corresponding enolate species directly.

Table I. Preparation of 3-Acyl-4-hydroxy-2(1*H*)-pyridones

entry	isocyanate	pyridone	yield,[a] %
1		 **4**	49
2	"	 **5**	58
3		 **6**	47
4		 **7**	51
5		 **8**	52 (68)[b]

[a] Overall yields are based on the starting α,β-unsaturated carboxylic acid. [b] Yield from isolated acyl azide.

Experimental Section

Proton and ^{13}C NMR spectra were recorded on a Nicolet QE-300 spectrometer. Chemical shifts are reported in parts per million downfield from tetramethylsilane (Me_4Si). Infrared spectra were obtained on a Nicolet 20-Dx spectrophotometer. Elemental analyses were performed by Galbraith Laboratories, Knoxville, TN, and melting points were determined on a Thomas-Hoover melting point apparatus and are uncorrected. Toluene was freshly distilled from sodium, and THF was distilled from sodium benzophenone ketyl prior to use. Flash chromatography was done according to the method of Still.[7]

General Procedure for the Preparation of 4-Hydroxy-2-oxo-1,2,5,6,7,8-hexahydro-3(1*H*)-quinolinecarboxylic Acid Ethyl Ester. The method reported by Weinstock[8] was employed for the preparation of the vinyl isocyanates used in this study. 1-cyclohexene-1-carboxylic acid (0.885 g, 7.02 mmol) was suspended in 1 mL of H_2O, and acetone was added until a homogeneous solution was obtained. This solution was cooled to 0 °C, and triethylamine (0.886 g, 8.78 mmol) followed by ethyl chloroformate (0.990 g, 9.13 mmol) was slowly added. The mixture was stirred at 0 °C for 30 min, and a solution of sodium azide (0.650 g, 10.3 mmol) in 2.5 mL of H_2O was introduced. Stirring was continued for an additional 60 min at 0 °C, at which time the reaction mixture was poured into an excess of ice–water. The oil that separated was extracted into ether (200 mL) and dried over anhydrous sodium sulfate. The solvent was removed in vacuo to leave the acyl azide as a colorless oil, which was dissolved in dry toluene (38 mL) and heated at 100 °C for 40 min or until the transformation was complete as judged by IR or by the cessation of nitrogen evolution. The reaction mixture was then cooled to 0 °C and diethylsodiomalonate (prepared from diethyl malonate (1.12 g, 7.02 mmol) and sodium hydride (3.37 mg, 50% dispersion in oil, 7.02 mmol) in toluene (38 mL) at 0 °C) was added. The reaction mixture was allowed to warm to room temperature over

(1) For some additional 4-hydroxypyridone preparations, see: (a) Prelog, V.; Szpilfogel, S. *Helv. Chim. Acta* **1945**, *28*, 1684. (b) Kato, T.; Yamanaka, H.; Kawamata, J.; Shimomura, H. *Chem. Pharm. Bull.* **1969**, *17*, 1889. (c) Ziegler, E.; Junek, H.; Metallidis, A. *Monatsh. Chem.* **1969**, *100*, 1937. (d) Girora, N. N.; Wendler, N. L. *Heterocycles* **1978**, *11*, 417.
(2) Rathke, M. W. *J. Am. Chem. Soc.* **1970**, *92*, 3222.
(3) Rigby, J. H.; Balasubramanian, N. *J. Org. Chem.* **1984**, *49*, 4569.
(4) Wat, C.-K.; McInnes, A. G.; Smith, D. G.; Wright, J. L. C.; Vining, L. C. *Can. J. Chem.* **1977**, *55*, 4090.
(5) Matsumoto, M.; Minato, H. *Tetrahedron Lett.* **1976**, 3827.
(6) For a synthesis of tenellin, see: Williams, D. R.; Sit, S. Y. *J. Org. Chem.* **1982**, *47*, 2846.
(7) Still, W. C.; Kahn, M.; Mitra, A. *J. Org. Chem.* **1978**, *43*, 2923.
(8) Weinstock, J. *J. Org. Chem.* **1961**, *26*, 3511.

90 min and was quenched with a saturated aqueous ammonium chloride solution, extracted with ether (3 × 30 mL), rinsed with brine (2 × 25 mL), and dried over anhydrous sodium sulfate. The solvent was removed in vacuo to give 1.47 g (74% from the vinyl acid) of a colorless oil, which crystallized from petroleum ether (mp 90.5–91.5 °C). Cyclization was then effected by dissolving the adduct (1.47 g, 5.2 mmol) in phenyl ether (10 mL) and immersing the stirred solution into a silicone oil bath preheated to 235 °C. The solution was maintained at this temperature for 4–5 min, at which time the flask was removed from the bath and allowed to cool. The resultant tetrahydroquinolone crystallized out on cooling to yield 1.20 g (97%);: mp 236.5–238 °C (lit.[1a,9] mp 234, 236–237 °C); IR (KBr) 3420, 2945, 1655, 1633, 1496 cm^{-1}; ^1H NMR ($CDCl_3$) δ 1.42 (t, J = 7.1 Hz, 3 H), 1.78 (m, 4 H), 2.45 (t, J = 5.7 Hz, 2 H), 2.62 (t, J = 5.7 Hz, 2 H), 4.44 (q, J = 7.1 Hz, 2 H), 11.53 (br s, 1 H), 13.63 (s, 1 H); ^{13}C NMR ($CDCl_3$) δ 14.10, 20.29, 21.33, 21.70, 26.97, 61.53, 96.54, 107.46, 149.56, 162.35, 172.44, 174.68; UV (EtOH) λ_{max} 226 nm (ϵ 8322), 258 (1687) 319 (5280); mass spectrum, m/e (relative intensity) 237 (4) 191 (26) 163 (25) 135 (58); high-resolution mass spectrum calcd for $C_{12}H_{15}NO_4$ 237.1001, found 237.1006. Anal. Calcd for $C_{12}H_{15}NO_4$: C, 60.73; H, 6.38; N, 5.91. Found: C, 60.98 H, 6.27, N, 5.75. The material prepared by this method represented an overall yield of 72% from the vinyl acid and was identical (mmp, IR, ^1H NMR, ^{13}C NMR, MS) with a sample prepared by the procedure described by Prelog and Szpilfogel.[1a]

3-Acetyl-4-hydroxy-5,6,7,8-tetrahydro-2(1*H*)-quinolone (2): cyclization yield, 76% after recrystallization from 95% EtOH; overall yield from vinyl acid, 64%; mp 241–242 °C; IR (KBr) 3300, 2940, 1659, 1635, 1600 cm^{-1}; ^1H NMR ($CDCl_3$) δ 1.81 (m, 4 H), 2.47 (t, J = 7.1 Hz, 2 H), 2.62 (t, J = 7.1 Hz, 2 H), 2.75 (s, 3 H), 11.76 (br s, 1 H) 16.03 (s, 1 H); ^{13}C NMR ($CDCl_3$) δ 20.02, 21.43, 21.70, 27.14, 31.02, 105.45, 108.09, 150.32, 164.20, 176.39, 205.18; mass spectrum, m/e (relative intensity) 207 (66) 192 (100) 122 (12); high-resolution mass spectrum calcd for $C_{11}H_{13}NO_3$ 207.0895, found 207.0899.

3-Acetyl-4-hydroxy-5-(*p*-methoxyphenyl)-2(1*H*)-pyridone (4): cyclization yield, 79%; overall yield from vinyl acid, 49%; mp 234.5–235.5 °C dec; IR (KBr) 3400, 3150, 2900, 1660, 1608, 1246 cm^{-1}; ^1H NMR ($CDCl_3$) δ 2.79 (s, 3 H), 3.84 (s, 3 H), 6.95 (d, J = 8.4 Hz, 2 H), 7.37 (d, J = 8.4 Hz, 2 H), 7.44 (s, 1 H), 11.61 (br s, 1 H), 16.52 (s, 1 H); ^{13}C NMR (Me_2SO-d_6) δ 30.65, 55.02 106.38, 111.69, 113.60, 124.95, 129.98, 141.04, 158.51, 161.55 175.09, 205.46; mass spectrum (relative intensity) m/e 259 (100), 244 (54), 148 (20), 132 (19); high-resolution mass spectrum calcd for $C_{14}H_{13}NO_4$ 259.0844, found 259.0849; UV (EtOH) λ_{max} 246 nm (ϵ 18927), 342 (4419).

3-Carboethoxy-4-hydroxy-5-(*p*-methoxyphenyl)-2(1*H*)-pyridone (5): cyclization yield, 73%; overall yield from vinyl acid, 58%; mp 193.5–194.5 °C; IR (KBr) 3400, 3180, 2915, 1660, 1640, 1615, 1500, 1250 cm^{-1}; ^1H NMR ($CDCl_3$) δ 1.48 (t, J = 7.1 Hz, 3 H), 3.86 (s, 3 H), 4.53 (q, J = 7.1 Hz, 2 H), 6.99 (d, J = 8.4 Hz, 2 H), 7.40 (d, J = 8.4 Hz, 2 H), 7.52 (s, 1 H), 12.60 (br s, 1 H), 14.00 (s, 1 H); ^{13}C NMR ($CDCl_3$) δ 14.26, 55.28, 62.27, 98.71, 113.92, 114.36, 125.01, 130.23, 138.65, 159.52, 162.72, 172.40, 174.26; mass spectrum, m/e (relative intensity) 289 (8), 243 (100), 175 (24), 132 (52); high-resolution mass spectrum, calcd for $C_{15}H_{15}NO_5$ 289.0950, found 289.0947.

3-Acetyl-9,10-dihydro-4-hydroxy-6,7,8-trimethoxybenzo[*f*]quinol-2(1*H*)-one (6): cyclization occurred at 205 °C, 75% yield after recrystallization from 95% EtOH; overall yield from vinyl acid, 47%; mp 283–284 °C dec; IR (KBr) 3400, 2940, 1653, 1603 cm^{-1}; ^1H NMR ($CDCl_3$) δ 2.79 (m, 2 H), 2.82 (s, 3 H), 2.90 (m, 2 H), 3.89 (s, 3 H), 3.93 (s, 6 H), 7.80 (s, 1 H), 12.59 (br s, 1 H), 17.10 (s, 1 H); ^{13}C NMR ($CDCl_3$) δ 19.45, 27.56, 31.42, 56.10, 60.93, 61.04, 105.85, 106.92, 107.28, 120.38, 125.14, 141.05, 150.08, 151.69, 153.82, 163.93, 175.62, 205.83; mass spectrum, m/e (relative intensity) 345 (47), 330 (42), 43 (100); high-resolution mass spectrum calcd for $C_{18}H_{19}NO_6$ 345.1212, found 345.1217; UV (EtOH) λ_{max} 226 nm (ϵ 7250), 278 (8917), 364 (1667). Anal. Calcd for $C_{18}H_{19}NO_6$: C, 62.59; H, 5.55; N, 4.06. Found: C, 62.78; H, 5.42; N, 3.93.

6-(1-Methylethenyl)-3-acetyl-4-hydroxy-5,6,7,8-tetrahydro-2(1*H*)-quinolone (7): cyclization yield, 72%; overall yield from vinyl acid, 51%; mp 196.5–197.5 °C; IR (KBr) 3300, 2924, 1651, 1636, 1603 cm^{-1}; ^1H NMR ($CDCl_3$) δ 1.64 (m, 1 H), 1.78 (s, 3 H), 1.96 (m, 1 H), 2.24 (m, 2 H), 2.69 (m, 3 H), 2.71 (s, 3 H), 4.78 (d, J = 13.8 Hz, 2 H), 12.00 (br s, 1 H), 16.01 (s, 1 H); ^{13}C NMR ($CDCl_3$) δ 20.84, 25.26, 25.98, 27.12, 31.20, 40.14, 105.29, 107.64, 109.93, 147.84, 150.03, 164.34, 176.18, 205.23; mass spectrum, m/e (relative intensity) 247 (40), 232 (18), 179 (68), 164 (35), 43 (100); high-resolution mass spectrum calcd for $C_{14}H_{17}NO_3$ 247.1208, found 247.1213. Anal. Calcd for $C_{14}H_{17}NO_3$: C, 67.98; H, 6.93; N, 5.67. Found: C, 68.06; H, 6.66; N, 5.41.

3-Acetyl-4-hydroxycyclopenta[*b*]pyrid-2(1*H*)-one (8): cyclization yield, 84%; overall yield from vinyl acid, 52%; mp 251–252 °C dec; IR (KBr) 3290, 3040, 2927, 1651, 1636, 1604 cm^{-1}; ^1H NMR ($CDCl_3$) δ 2.12 (quint, J = 7.5 Hz, 2 H), 2.68 (s, 3 H), 2.74 (t, J = 7.5 Hz, 2 H), 2.86 (t, J = 7.5 Hz, 2 H), 12.15 (br s, 1 H), 15.91 (s, 1 H); ^{13}C NMR (Me_2SO-d_6) δ 21.36, 25.87, 30.43, 31.61, 104.53, 109.18, 159.43, 163.28, 173.75, 204.50; mass spectrum, m/e (relative intensity) 193 (55), 178 (100), 43 (36); high-resolution mass spectrum calcd for $C_{10}H_{11}NO_3$ 193.07388, found 193.0743. Anal. Calcd for $C_{10}H_{11}NO_3$: C, 62.15; H, 5.74; N, 7.25. Found: C, 61.75; H, 5.72; N, 7.09.

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Registry No. 1, 56517-53-4; 2, 101033-17-4; 4, 101033-19-6; 5, 101033-20-9; 6, 101033-21-0; 7, 101033-22-1; 8, 101033-23-2; $EtO_2CCH_2CO_2Et$, 105-53-3; 4-$MeOC_6H_4CH$=$CHNCO$, 101033-24-3; $MeCOCH_2CO_2Et$, 141-97-9; 1-cyclohexene-1-carboxylic acid, 636-82-8; 1-cyclohexene-1-carbonyl azide, 101033-15-2; diethyl (cyclohexenylamino)malonate, 101033-16-3; ethyl (cyclohexenylamino)acetoacetate, 101033-18-5; 3,4-dihydro-2-isocyanato-5,6,7-trimethoxy-2(1*H*)-naphthalene, 101033-25-4; 1-isocyanato-4-(2-(2-propenyl))-1-cyclohexene, 92525-48-9; 1-isocyanatocyclopent-1-ene, 92525-50-3.

(9) Buckle, D. R.; Cantello, B. C. C.; Smith, H.; Spicer, B. A. *J. Med. Chem.* **1975**, *18*, 726.