Novel Oxidations of 1,3-Disubstituted Indoles

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A study of oxidation *versus* nitration of 1,3-disubstituted indole derivatives with nitric acid in acetic acid was carried out. Oxidation of methyl and ethyl 2-cyano-2-(1-alkoxycarbonyl-1*H*-indol-3-yl)acetates **1** and **2** under the above conditions gave rise to novel functionalized 2-hydroxyindolenines as single products possessing the *Z*-configuration, **8** and **10**, respectively. The structure of **10** was determined by an X-ray analysis. In contrast, 1-methoxycarbonyl-1*H*-indol-3-acetonitrile (**3**) was nitrated to the corresponding 6-nitroindole derivative **11**, whereas the reaction of ethyl 2-cyano-2-(1-methyl-1*H*-indol-3-yl)acetate (**4**) with nitric acid effected an oxidative nitration to provide the corresponding ethyl *Z*-5-nitroisatyliene cyanoacetate (**12**), which in solution isomerized to the *E* isomer.

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In addition to nitration products, indole derivatives carrying electron-attracting groups at the nitrogen atom are reported [1,2] to add nitric acid at the 2,3-double bond, this providing after loss of the nitro group the corresponding 2,3-dihydroxyindolines as by-products.

During the course of our work on the synthesis of indole derivatives with biological activity [3,4], we planned to prepare 2-hydroxyindolenines through the intermediate formation of 2,3-dihydroxyindolines. For this purpose we chose methyl and ethyl 2-cyano-2-(1-alkoxycarbonyl-1*H*-indol-3-yl)acetates **1**, **2**, 1-methoxycarbonyl-1*H*-indol-3-acetonitrile (**3**) and ethyl 2-cyano-2-(1-methyl-1*H*-indol-3-yl)acetate (**4**) as substrates, and studied their reactivity toward nitric acid in acetic acid. The reaction conditions and results are summarized in Table 1.

Treatment of 3-indolylacetonitrile with dimethyl or diethyl carbonate in the presence of metallic sodium yielded the corresponding mono- or dialkoxycarbonylindole derivatives **1-3** [5,6], whereas the same reaction of its 1-methyl analogue **5** [7] with diethyl carbonate resulted in the formation of 1-methylindole-3-glyoxylic acid ethyl ester (**6**), which was identical with a sample prepared by known procedures [8]. The ethyl glyoxylate **6** may arise by elimination of hydrocyanic acid from an intermediate cyanohydrine, which in turn could be promoted by air oxidation [9] of the methine group at the side chain of the desired compound **4**. Performing the reaction of **5** with diethyl carbonate under an argon atmosphere, resulted in the expected formation of **4** in 80% yield. Likewise for **5**, compound **4** was easily air oxidized into the ethyl glyoxylate **6**. These results confirm the proposed pathway which leads **6** from **5**. The structure of **4** is supported by spectral and analytical data.

When the dialkoxycarbonylindole **1** was allowed to react with an excess (molar ratio 1:15) of nitric acid in acetic acid at 60° for 15 minutes, we isolated from the reaction mixture the 2-hydroxy-5-nitroindolenine **7** as the minor product, together with the more abundant 2-hydroxyindolenine **8** as a mixture of the *E*/*Z* isomers, having one of them strongly predominant. The structure and stereochemistry of the reaction products **7** and **8** were supported by the ^{1}H nmr and ir spectral data. In particular the ^{1}H nmr shows for the major isomer of **7** a doublet (one proton) at δ 6.92 and a broad doublet (one proton) at δ 4.48. The latter signal disappeared after addition of deuterium oxide, and concomitantly the doublet at δ 6.92 became a singlet. Similar results were obtained in the case of **8**, showing in this way the presence of a secondary alcohol in both compounds.

Contrary to the observed fast isomerization around the C(3)=C(CN)-CO_2Et double bond in ethyl isatylidenecyanoacetates [10] giving a solvent dependent equilibrium

Table 1

Reactions of Indole Derivatives **1-4** with Nitric Acid in Acetic Acid

Compound	Reaction Conditions	Oxidation-Nitration Products (%)	Oxidation Product (%)	Nitration Product (%)
1	[a]	**7***Z* (15)	**8***Z* (69)	–
	[b]	–	**8***Z* (85)	–
2	[a]	**9***Z* (15)	**10***Z* (67)	–
	[b]	–	**10***Z* (86)	–
3	[a]	–	–	**11** (37)
4	[c]	**12***E* (25)	–	–
	[d]	**13***Z* [e]	–	–

Reaction conditions: [a] 60°C, 15 minutes; [b] 20°C, 8 hours; [c] 17°C, 15 minutes; [d] 0°C, 6 minutes. Molar ratio of substrate to nitric acid 1:15. [e] Unstable product.

mixture of *E* and *Z* isomers in solution, in the case of the hydroxyindolenines this situation did not occur, and thus the *Z* stereochemistry for the highly abundant isomer could be established on the basis of the marked deshielding of H-4 caused by the proximity of the carbonyl group [11,12]. In addition, in the case of **7Z**, the shielded methine signal owing to H-4 at δ 9.33 (**7E**, H-4 δ 9.74) was coupled *meta* (J = 2.4 Hz) with the signal at δ 8.48 which in turn appears as a double doublet (J = 9.2, 2.4 Hz), thus indicating that the nitro group is located at position C-5.

The nitroindolenine **7Z** was formed by nitration of **1** followed by oxidation, and not *vice-versa*, since an attempt to react indolenine **8Z** under the same conditions as **1** resulted in the recovery of the starting material. The formation of **7Z** and **8Z** can arise from the corresponding 2,3-dihydroxyindoline [1,2], followed by the acid-catalyzed elimination of the protonated 3-hydroxyl group. The outcome of **8Z** could be increased by performing the reaction at 20° (yield 85%) whereby no traces of the nitroindolenine **7Z** was detectable in the reaction mixture (see Table 1). These conditions, however, required considerably longer reaction times (8 hours).

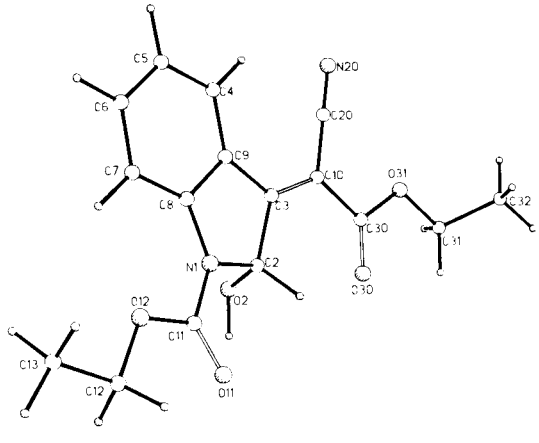
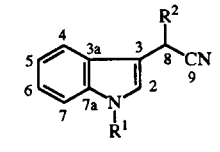


Figure. A computer-generated drawing of **10Z** from the X-ray coordinates.

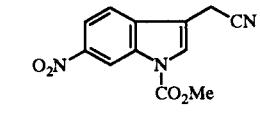
Treatment of the indole derivative **2** with nitric acid at 60° for 15 minutes also resulted in a mixture of the corresponding 2-hydroxy-5-nitroindolenine **9Z** (yield 15%) and 2-hydroxyindolenine **10Z** (yield 67%, see Table 1). Treatment of **2** at 20° for 8 hours afforded **10Z** as a single product (yield 86%). The structure and *Z* configuration of the obtained hydroxyindolenines was confirmed by a single crystal X-ray analysis of **10Z** (see Figure).

Induced by the above results we have investigated the influence of substituents at the N-1 and the C-8 atoms, considering that the oxidation over the nitration process is favoured by electron-attracting groups at both positions. In order to test this hypothesis, we investigated the same reaction using the indole derivatives **3** and **4** as the substrates. When compound **3** was subjected to nitric acid at 60° for 15 minutes, we isolated from the reaction mixture a nitrated product **11** (yield 37%, see Table 1), which was identified as the 1-methoxycarbonyl-6-nitro-1*H*-indol-3-acetonitrile on the basis of its spectral and analytical data. The location of the nitro group was supported by ^{1}H nmr spectroscopy. The H-7 signal at δ 9.08 appears as a broad doublet originated by an equilibrium between two rotamers induced through the carbamate N-C(=O)OEt bond [6]; irradiation of H-7 simplified the double doublet at δ 8.21 (J = 8.7, 2.1 Hz) to a doublet (J = 8.7 Hz), indicating that this proton is coupled *meta* with H-7 and consequently the nitro group is placed at C-6. Thus, nitration occured *para* to C-3 and *meta* to N-1, in accord with the expected deactivating effect of the ester group at N-1.

The reaction of **4** with nitric acid at 60° gave rise to much resinification, no definite products being obtained. Performing the reaction at 17° for 15 minutes gave the 5-nitroisatylidenecyanoacetate **12** as an *E,Z* isomeric mixture, with the *Z* isomer strongly favoured (^{1}H nmr analysis). By treating the resulting *E,Z* mixture in boiling methanol for purification, the *Z* isomer easily isomerized into the *E* form (yield 25%, see Table 1). As in the case of



1, $R^1 = R^2 = CO_2Me$
2, $R^1 = R^2 = CO_2Et$
3, $R^1 = CO_2Me$, $R^2 = H$
4, $R^1 = Me$, $R^2 = CO_2Et$
5, $R^1 = Me$, $R^2 = H$



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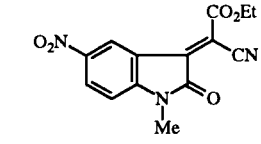
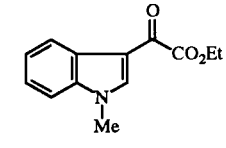


12E



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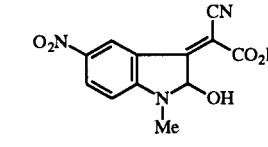
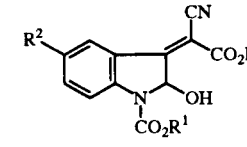
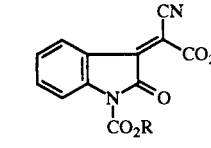


13Z



7Z, $R^1 = Me$, $R^2 = NO_2$
8Z, $R^1 = Me$, $R^2 = H$
9Z, $R^1 = Et$, $R^2 = NO_2$
10Z, $R^1 = Et$, $R^2 = H$



14Z, R = Me
15Z, R = Et

the by-products **7** and **9**, the nitro group in **12** is disposed *meta* to C-3 and *para* to N-1.

A plausible intermediate in the formation of **12** could be a 2-hydroxyindolenine. In fact, reaction of **4** with nitric acid at 0° for 6 minutes leads to the 2-hydroxy-5-nitroindolenine **13** (see Table 1) which was unstable, so it was treated with chromic acid to give the expected compound **12*E***, after workup. In accordance with this result, the oxidation of 2-hydroxyindolenines **8** and **10** with chromic acid also gave the corresponding isatylidenecyanoacetates **14*Z*** (yield 66%) and **15*Z*** (yield 69%), respectively, which remained exclusively as the *Z* isomers in chloroform solution. Compound **15*Z*** was synthesized in very poor yields by condensation of ethyl 2-oxo-3-indolinylidenecyanoacetate with ethyl chloroformate [10].

In accordance with the results outlined above, it may be concluded that successful oxidation of indole derivatives, possessing an active hydrogen at C-8, to provide indolenines depends on the combined deactivating effects of the electron-attracting substituents at N-1 and at C-3, which preclude nitration at the benzene ring in favour of oxidation and at the same time enhance the double bond character at C2-C3 of the heterocyclic ring.

Table 2
Atomic coordinates (x10^4)

Atom	x	y	z
N(1)	3114(5)	3419(5)	9828(4)
C(2)	2498(7)	2231(6)	10861(5)
O(2)	3776(5)	1267(5)	11627(4)
C(3)	1310(6)	3329(6)	11492(5)
C(4)	896(7)	6444(7)	11243(6)
C(5)	1374(8)	7859(7)	10551(7)
C(6)	2474(7)	7830(7)	9594(6)
C(7)	3148(6)	6417(7)	9267(5)
C(8)	2677(6)	4990(6)	9952(5)
C(9)	1557(6)	4993(6)	10943(5)
C(10)	263(7)	2775(7)	12420(5)
C(11)	4014(6)	2844(6)	8964(5)
O(11)	4181(5)	1454(5)	8935(4)
C(12)	5584(8)	3527(8)	7127(6)
O(12)	4646(5)	3997(5)	8138(4)
C(13)	6091(9)	5059(10)	6303(6)
C(20)	-741(7)	3869(8)	13041(6)
N(20)	-1494(7)	4728(7)	13555(6)
C(30)	47(8)	1069(8)	12805(6)
O(30)	770(6)	9(5)	12399(4)
C(31)	-1412(15)	-785(11)	14128(11)
C(32)	-3165(19)	-642(18)	14162(22)
O(31)	-1178(6)	913(6)	13648(4)

EXPERIMENTAL

Melting points were determined on a Fisher-Johns apparatus and are uncorrected. The uv spectra [ethanol, nm (log ε)] were obtained on a Unicam SP-800 spectrophotometer. The ir spectra (potassium bromide pellets, cm^{-1}) were recorded on a Perkin Elmer 599B. The ^{1}H nmr spectra were measured in deuteriochloroform solutions on a Varian XL-300GS spectrometer operating at 300 MHz. Chemical shift data are given in ppm (J, Hz) downfield from TMS. Abbreviations, s, d, t, q, m and br are used to designate singlet, doublet, triplet, quartet, multiplet and broad, respectively. Electron impact mass spectra were obtained on a Hewlett Packard 5989A spectrometer at 70 eV. Analyses were performed by the Microanalytical Laboratory Elbach, Germany. All column chromatography was performed on silica gel Merck 62 (60-200 mesh) using a mixture of ethyl acetate-hexane (1:9 v/v) as the eluent.

Ethyl 2-Cyano-2-(1-methyl-1*H*-indol-3-yl)acetate **4**.

To a stirred solution of **5** (2.9 g, 17.0 mmoles) in 5 ml of diethyl carbonate heated at reflux was added metallic sodium (450 mg, 19.0 mg-atom) in small portions under an argon atmosphere. After 30 minutes the reaction mixture was cooled in an ice bath and quenched by the addition of a mixture of acetic acid-water (1:4, 15 ml). After removal of volatiles under vacuum, the residue was extracted with ethyl acetate. The organic layer was washed with brine, dried over anhydrous sodium sulfate and evaporated under reduced pressure. The resulting pale yellow oil was crystallized from chloroform-hexane to give 2.1 g of **4**. Chromatographic workup of the mother liquors afforded in the first fractions further 1.2 g of the same compound, (80% overall yield) as colorless prisms, whose mp 78-79°; uv and ir are as reported [10]; ^{1}H nmr: δ 7.68 (ddd, $J_{4,5}$ = 7.9, $J_{4,6}$ = 1.2, $J_{4,7}$ = 0.7, 1H, H4), 7.27 (ddd, $J_{7,6}$ = 8.2, $J_{7,5}$ = 2.1, $J_{7,4}$ = 0.7, 1H, H7), 7.24 (td, $J_{6,7}$ = $J_{6,5}$ = 8.2, 1H, H6), 7.15 (ddd, $J_{5,6}$ = 8.2, $J_{5,4}$ = 7.9, $J_{5,7}$ = 2.1, 1H, H5), 7.14 (s, 1H, H2), 4.93 (s, 1H, H8), 4.18 (m, 2H, CH_2), 3.64 (s, 3H, N-CH_3), 1.22 (t, 3H, CH_3); ms: m/z 242 (M$^+$, 34), 169 (100).

Anal. Calcd. for $C_{14}H_{14}N_2O_2$: C, 69.41; H, 5.82; N, 11.56; O, 13.21. Found: C, 69.44; H, 5.67; N, 11.58; O, 13.06.

General Procedure for the Preparation of Compounds **7*Z***, **8*Z***, **9*Z***, **10*Z***, **11**, **12*E*** and **13*Z***.

The experiments summarized in Table 1 were carried out according to a standardized procedure. To a stirred solution of 2.0 mmoles of the corresponding 1,3-disubstituted indole, **1**, **2**, **3**, **4** in 6 ml of acetic acid at the appropriate temperature (see Table 1) was added nitric acid (*d* 1.4, 1.9 ml, 30 mmoles). The reaction mixture was left for the indicated time (see Table 1) and quenched by pouring it over crushed ice. The precipitate which formed was collected and washed several times with cold water. The crude solid was dissolved in ethyl acetate and again washed with water. The organic layer was dried over anhydrous sodium sulfate and evaporated under reduced pressure. The solid residue was chromatographed on silica gel and the products were recrystallized from appropriate solvents. Yields are reported in Table 1.

Methyl *Z*-1-Carbomethoxy-2-hydroxy-5-nitro-3-indolinylidenecyanoacetate **7*Z***.

The yellow brown solid was obtained from methanol, mp 192-194°; uv: λ max 295 (3.9), 225 (4.3); ir: ν 3380 (OH), 2225 (C≡N), 1725, 1700 (C=O), 1525, 1340 (NO_2); ^{1}H nmr: δ 9.33 (d, $J_{4,6}$ = 2.4, 1H, H4), 8.48 (dd, $J_{6,7}$ = 9.2, $J_{6,4}$ = 2.4, 1H, H6), 8.13 (br, 1H, H7), 6.92 (d, $J_{2,OH}$ = 4.3, 1H, H2), 4.48 (br d, $J_{OH,2}$ = 4.3, exchangeable OH), 4.00 (s, 6H, 2CH_3); ms: m/z 333 (M$^+$, 27), 301 (32), 274 (36), 59 (69), 15 (100).

Anal. Calcd. for $C_{14}H_{11}N_3O_7$: C, 50.46; H, 3.33; N, 12.61; O, 33.61. Found: C, 50.58; H, 3.12; N, 12.52; O, 33.49.

Methyl *Z*-1-Carbomethoxy-2-hydroxy-3-indolinylidenecyanoacetate **8*Z***.

The yellow solid was obtained from methanol, mp 185-187°; uv: λ max 306 (4.0), 248 (4.1), 236 (4.0); ir: ν 3390 (OH), 2225

(C≡N), 1720, 1690 (C=O); ^{1}H nmr: δ 8.46 (dd, $J_{4,5}$ = 8.0, $J_{4,6}$ = 1.3, 1H, H4), 7.98 (br, 1H, H7), 7.60 (td, $J_{6,7}$ = $J_{6,5}$ = 8.0, $J_{6,4}$ = 1.3, 1H, H6), 7.18 (td, $J_{5,6}$ = $J_{5,4}$ = 8.0, $J_{5,7}$ = 1.0, 1H, H5), 6.80 (d, $J_{2,OH}$ = 4.0, 1H, H2), 4.50 (br d, $J_{OH,2}$ = 4.0, exchangeable OH), 3.95 (s, 6H, $2CH_3$); ms: m/z 288 (M^+, 44), 256 (52), 228 (50), 59 (46), 15 (100).

Anal. Calcd. for $C_{14}H_{12}N_2O_5$: C, 58.33; H, 4.20; N, 9.72; O, 27.75. Found: C, 58.33; H, 4.07; N, 9.65; O, 27.64.

Ethyl *Z*-1-Carbethoxy-2-hydroxy-5-nitro-3-indolinylidenecyanoacetate **9Z**.

The yellow green solid was obtained from methanol, mp 185-187°; uv: λ max 295 (4.0), 225 (4.3); ir: ν 3385 (OH), 2225 (C≡N), 1715, 1700 (C=O), 1520, 1335 (NO_2); ^{1}H nmr: δ 9.33 (d, $J_{4,6}$ = 2.4, 1H, H4), 8.47 (dd, $J_{6,7}$ = 9.2, $J_{6,4}$ = 2.4, 1H, H6), 8.12 (br, 1H, H7), 6.92 (br s, 1H, H2), 4.54 (br, exchangeable OH), 4.44 (q, 2H, CH_2), 4.43 (q, 2H, CH_2), 1.44 (t, 6H, $2CH_3$); ms: m/z 361 (M^+, 11), 315 (16), 216 (16), 29 (100).

Anal. Calcd. for $C_{16}H_{15}N_3O_7$: C, 53.19; H, 4.18; N, 11.63; O, 31.00. Found: C, 53.13; H, 3.96; N, 11.52; O, 31.09.

Ethyl *Z*-1-Carbethoxy-2-hydroxy-3-indolinylidenecyanoacetate **10Z**.

The yellow solid was obtained from methanol, mp 146-148°; uv: λ max 305 (4.0), 248 (4.1), 236 (3.9); ir: ν 3380 (OH), 2225 (C≡N), 1715, 1690 (C=O); ^{1}H nmr: δ 8.46 (dd, $J_{4,5}$ = 8.0, $J_{4,6}$ = 1.3, 1H, H4), 7.95 (br, 1H, H7), 7.59 (td, $J_{6,7}$ = $J_{6,5}$ = 8.0, $J_{6,4}$ = 1.3, 1H, H6), 7.16 (td, $J_{5,6}$ = $J_{5,4}$ = 8.0, $J_{5,7}$ = 1.0, 1H, H5), 6.80 (br s, 1H, H2), 4.52 (br, exchangeable OH), 4.39 (q, 4H, $2CH_2$), 1.42 (t, 6H, $2CH_3$); ms: m/z 316 (M^+, 30), 270 (54), 242 (33), 171 (50), 29 (100).

Anal. Calcd. for $C_{16}H_{16}N_2O_5$: C, 60.76; H, 5.10; N, 8.86; O, 25.29. Found: C, 60.68; H, 4.93; N, 8.86; O, 25.23.

1-Methoxycarbonyl-6-nitro-1*H*-indol-3-acetonitrile **11**.

The pale brown microneedles were obtained from chloroform-hexane, mp 175-176°; uv: λ max 300 (3.9), 223 (4.2); ir: ν 2260 (C≡N), 1730 (C=O), 1620, 1335 (NO_2); ^{1}H nmr: δ 9.08 (br d, $J_{7,5}$ = 2.1, 1H, H7), 8.21 (dd, $J_{5,4}$ = 8.7, $J_{5,7}$ = 2.1, 1H, H5), 7.95 (t, $J_{2,8}$ = 1.2, 1H, H2), 7.65 (d, $J_{4,5}$ = 8.7, 1H, H4), 4.14 (s, 3H, CH_3), 3.85 (d, $J_{8,2}$ = 1.2, 2H, CH_2); ms: m/z 259 (M^+, 100), 184 (17), 154 (24), 127 (17), 59 (44), 15 (38).

Anal. Calcd. for $C_{12}H_9N_3O_4$: C, 55.60; H, 3.50; N, 16.21. Found: C, 55.81; H, 3.31; N, 16.06.

Ethyl *E*-1-Methyl-5-nitro-2-oxo-3-indolinylidenecyanoacetate **12E**.

Orange crystals were obtained from methanol, mp 225-227°; uv: λ max 307 (4.0), 225 (3.8); ir: ν 2220 (C≡N), 1720, 1710 (C=O), 1520, 1330 (NO_2); ^{1}H nmr: δ 9.37 (d, $J_{4,6}$ = 2.3, 1H, H4), 8.45 (dd, $J_{6,7}$ = 8.8, $J_{6,4}$ = 2.3, 1H, H6), 6.96 (d, $J_{7,6}$ = 8.8, 1H, H7), 4.54 (q, 2H, CH_2), 3.36 (s, 1H, CH_3), 1.48 (t, 3H, CH_3); ms: m/z 301 (M^+, 100), 256 (38), 229 (43), 199 (27).

Anal. Calcd. for $C_{14}H_{11}N_3O_5$: C, 55.82; H, 3.68; N, 13.95; O, 26.55. Found: C, 55.63; H, 3.59; N, 14.02; O, 26.35.

Ethyl *Z*-2-Hydroxy-1-methyl-5-nitro-3-indolinylidenecyanoacetate **13Z**.

This compound was obtained as an amorphous material (unstable); ^{1}H nmr: δ 9.20 (d, $J_{4,6}$ = 2.3, 1H, H4), 8.35 (dd, $J_{6,7}$ = 8.6, $J_{6,4}$ = 2.3, 1H, H6), 6.61 (d, $J_{7,6}$ = 8.6, 1H, H7), 6.12 (br s, 1H, H2), 4.81 (br, exchangeable OH), 4.40 (q, 2H, CH_2), 3.12 (s, 3H, N-CH_3), 1.38 (t, 3H, CH_3).

Methyl *Z*-1-Carbomethoxy-2-oxo-3-indolinylidenecyanoacetate **14Z**.

To a stirred solution of **8Z** (900 mg, 3.1 mmoles) in 10 ml of acetic acid cooled to 5° was added a solution of chromic acid (900 mg, 9.0 mmoles) in water (1 ml). The reaction mixture was allowed to stand at room temperature for 3 hours and then poured onto crushed ice. The resulting precipitate was isolated by filtration, washed several times with cold water and dissolved in ethyl acetate. The organic layer was washed with water, dried over anhydrous sodium sulfate and evaporated under reduced pressure. The solid residue was recrystallized from chloroform-hexane to afford **14Z** as a yellow solid (590 mg, 66%), mp 187-188°; uv: λ max 325 (3.7), 258 (3.9), 230 (3.9); ir: ν 2220 (C≡N), 1760, 1730 (C=O); ^{1}H nmr: δ 8.24 (dd, $J_{4,5}$ = 8.3, $J_{4,6}$ = 1.3, 1H, H4), 8.02 (br d, $J_{7,6}$ = 8.3, 1H, H7), 7.58 (td, $J_{6,7}$ = $J_{6,5}$ = 8.3, $J_{6,4}$ = 1.3, 1H, H6), 7.31 (td, $J_{5,4}$ = $J_{5,6}$ = 8.3, $J_{5,7}$ = 1.0, 1H, H5), 4.03 (s, 3H, CH_3), 4.00 (s, 3H, CH_3); ms: m/z 286 (M^+, 100), 242 (40), 183 (95), 168 (31), 59 (40).

Anal. Calcd. for $C_{14}H_{10}N_2O_5$: C, 58.75; H, 3.52; N, 9.79; O, 27.95. Found: C, 58.77; H, 3.50; N, 9.74; O, 27.77.

Ethyl *Z*-1-Carbethoxy-2-oxo-3-indolinylidenecyanoacetate **15Z**.

Operating as above, compound **10Z** (2.0 g, 6.3 mmoles) afforded yellow needles of compound **15Z** (1.4 g, 69%), whose mp 123-124°, uv, ir and ^{1}H nmr are as reported [10]; ms: m/z 314 (M^+, 59), 242 (63), 196 (100), 168 (65), 29 (66).

Anal. Calcd. for $C_{16}H_{14}N_2O_5$: C, 61.14; H, 4.49; N, 8.91; O, 25.45. Found: C, 61.10; H, 4.34; N, 8.96; O, 25.54.

X-ray Crystallographic Data for **10Z**.

Single crystals of **10Z** were triclinic space group $P\bar{1}$, with a = 8.3573(8), b = 8.866(11), c = 11.963(9)Å, α = 71.319(9), β = 83.14(7), γ = 74.745(8) deg. and d_{calc} = 1.297 g/cm^3 for Z = 2. The intensity data were measured on a Nicolet R3m four-circle difractometer with CuKα monochromated radiation in the θ:2θ scan mode. No absorption correction was applied (μ = 8.28 cm^{-1}). A total of 2160 reflections were measured for 3° ≤ θ ≤ 110° of which 1304 reflections were considered to be observed I ≥ 3σ(I). The final discrepancy indices were R = 7.38% using 1113 reflections in the final refinement. The atom coordinates are listed in Table 2.

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