THE REACTION OF ρ-Aminoenones WITH α-Amino Derivatives.
SYNTHESIS OF 2-FUNCTIONALIZED PYRROLES

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Abstract—ρ-Aminoenones react with ethyl glycinate, α-aminoacetonitrile and α-aminoacetamide hydrochlorides leading to 2-functionalized pyrroles. Although the transamination is a high-yield process, the transformation of the intermediate, in both basic or thermally induced conditions, affords the corresponding pyrroles in poor to moderate yields.

One of the most fruitful syntheses of pyrroles bearing different types of substituents and functionalities is the cyclization of 2-amino-1-alkenylcarbonyl derivatives. To this end, 1,3-dicarbonyl compounds, ρ-aminoenones, ρ-chlorovinyl ketones and 3-alkoxyacroleins, have been condensed, in both acidic or basic media, with preformed or in situ generated 4 diethylaminomalonate, α-aminoacarbonyl compounds and glycine esters and aminoacetonitrile in a two-steps or one-pot preparation of pyrroles. On the other hand, we have recently reported a regioselective synthesis of 2- and 3-acylpyrroles from ρ-aminoenones and α-amino ketone hydrochlorides.

The regioselectivity of the reaction is considerably high and it has been correlated with the structure of the enolized diketones or ρ-aminoenones, whereas the chemical yield and the rate of the process are also dependent on the protic or aprotic character of the solvent and, on the reaction temperature.

We report now our results on the reactivity of ρ-aminoenones 1A-0 with ethyl glycinate hydrochloride 2a, aminoacetonitrile hydrochloride 2b and aminoacetamide hydrochloride 2c, leading to the preparation of 2-functionalized pyrroles 4Aa-0c.
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<th>R²</th>
<th>R³</th>
<th>R⁴</th>
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<td>Me</td>
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Table 1. Transamination of α-Aminoones 1A-O with α-Amino derivatives 2a-c.

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<tr>
<th>Run</th>
<th>Compd.1</th>
<th>Compd.2</th>
<th>solvent</th>
<th>Product(%)</th>
<th>Time(h)/</th>
<th>Run</th>
<th>Compd.1</th>
<th>Compd.2</th>
<th>solvent</th>
<th>Product(%)</th>
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<td>2a</td>
<td>1/M</td>
<td>3Aa(89)b</td>
<td>23</td>
<td>1I</td>
<td>2a</td>
<td>1/M</td>
<td>31a(94)</td>
<td></td>
</tr>
<tr>
<td>2</td>
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<td>2a</td>
<td>2/M</td>
<td>3Aa(85)</td>
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<td>1.5/M</td>
<td>31a(96)</td>
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<td>1/M</td>
<td>31b(86)</td>
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<td>1/M</td>
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<td>26</td>
<td>1J</td>
<td>2a</td>
<td>1/M</td>
<td>3Ja(54)b</td>
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<td>3Ac(95)</td>
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<td>3/M</td>
<td>3Ja(87)</td>
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<td>1/M</td>
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<td>1/M</td>
<td>3Ja(82)</td>
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<td>1J</td>
<td>2c</td>
<td>1/M</td>
<td>3Je(50)</td>
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<td>3Je(89)</td>
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<td>3Ec(58)</td>
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<td>1/M</td>
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The first step of the reaction is an addition-elimination process, leading to the transamination intermediate 3 and the results are summarized on Table 1; the rate of interchange decreases in the order α-aminoacetonitrile (2b) > ethyl glycinate (2a) > α-aminoacetamide (2c). Otherwise, the rate of transamination decreases with the electron-withdrawing character of R1 (compare runs 26, 31, 34 and 37 on Table 1), and the steric requirements of R1 and R3; in this respect, when both R1 and R3 are tert-butyl substituents [1P], the intermediate 3Pa can not be isolated and ethyl 2-(3,5-di-tert-butyl)pyrrolylcarboxylate 4Pa is obtained after a long period of reflux (run 43).

The cyclocondensation step of the intermediates 3 to pyrroles 4 was tested in different conditions including a base (sodium ethoxide or methoxide or pyridine) or thermally induced reactions (DMF at reflux), and data are summarized on Table 2.

Table 2. Cyclization of 3Aa-Ob to 3-Functionalized Pyrroles 4Aa-Ob.

<table>
<thead>
<tr>
<th>Run</th>
<th>Compd.</th>
<th>Base/solvent</th>
<th>Time(h)</th>
<th>Pyrrole(%)</th>
<th>Run</th>
<th>Compd.</th>
<th>Base/solvent</th>
<th>Time(h)</th>
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<td>4Aa(10)</td>
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<td>4Ma(23)</td>
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<td>3Ob</td>
<td>DMF</td>
<td>66</td>
<td>40b(41)</td>
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a Molar ratio base:3 = 1:1 except for runs 15, 20 and 30 where molar ratio base:3 = 2:1.
b The reactions were carried out at room temperature for runs 15, 20 and 30, and at reflux temperature of the given solvent for the others.
c On the reaction mixture retrocondensation products (acetophenone, p-methylacetophenone and p-methoxyacetophenone) were isolated.
d The products were 3Ka (50%) and the corresponding diketone (50%).

The cyclization of the intermediates is a regioselective reaction leading to 2-functionalized pyrroles, and chemical yields, generally low, depend on the functional group at the α-amino derivative 2; thus, the best results are obtained from α-aminoacetonitrile 2c and β-aminoenones 1A-E (R1 = alkyl) (runs 7, 8, 11 and 14), while intermediates 3Jc-3Lc (R1 = aryl) mainly
yield retrocondensation products. These results differ from previously reported\textsuperscript{9,10} for the reaction of $\beta$-aminoenones with phenacylamine hydrochloride, leading to 2- and/or 3-acylpyrroles in high yields, and it is a consequence of the regioselective cyclization of the intermediates 3, or one of their enolic forms, to the most stable aromatic pyrrole, instead of to the pyrroldione derivative. On the other hand, attempts to increase the chemical yields by increasing the reaction time and temperature failed because retro-condensation and isomerization processes. These are specially important for $\beta$-aminoenones with different steric or electronic requeiments at $R^1$ and $R^3$ ($R^3 > R^1$ or $R^3 = \text{aryl}$ and $R^1 = \text{alkyl}$). We have investigated the regioselectivity of these transformation on intermediates 3Ja and 3Na obtained by reaction of 1J and 1N with 2a respectively. Thus, 3Na is completely transformed into its regioisomer 3Ja after heating in ethanol for 15 h with ethyl glycinate hydrochloride, while the inverse transformation does not occur; moreover, 1N does not isomerize to 1J when heated for the same period of time with or without ammonium chloride, and benzoylacetone (the product of hydrolysis) can not be detected at any stage. Otherwise, on Figure 1, it has been represented the evolution of the amount of 3Na and 3Ja in the mixture of the reaction of 1N with 2a in refluxing ethanol. The data show that the highest yield for 3Na is obtained after 36 h, and that the regioisomer 3Ja appears early in the reaction mixture, being the major product after 44 h.

The scheme given above depicts the two mechanistic path as they would operate on the formation of the intermediates. The equilibrium leading to 3Na is an addition-elimination process, and 3Ja could be obtained by irreversible isomerization of 3Na or by an alternative 1,2-addition of ethyl...
glycinate hydrochloride to the carbonyl group in 1N. Although we have proved that 3Na does not isomerize to 3, we have been unable to discount a competing direct formation of the regioisomer by 1,2-addition.

**EXPERIMENTAL**

Mo's (uncorrected) were determined in an open capillary tube. Nmr were recorded on a Brucker AC80 or Varian T60 A, and chemical shifts are given in ppm downfield from TMS. Mass spectra were measured on a Hewlett-Packard 5988A mass spectrometer by Electronic Impact at 70 eV, and combustion analysis were determined on a Perkin-Elmer 1408 analyzer. Starting materials were commercially available or synthesized as previously described.

**Synthesis of the Intermediates**

1. **General procedure** A mixture of 10 mmol of the corresponding \( \beta \)-aminoenone 1A-P and 11 mmol of \( \delta \)-amino derivative 2a-c, in anhydrous methanol or ethanol (30 ml) was refluxed for the time indicated on Table 1. The solvent was evaporated under vacuum and the residue was redissolved in THF; the salts were filtered off, the THF was eliminated under reduced pressure and the solid was recrystallized from an appropriate solvent. In this way, the following compounds were obtained:

- Ethyl N-(1-Methyl-3-oxo-1-butene)-glycinate (3Aa) Colorless solid, mp 65-66°C (from hexane) (11t., 15 66-67°C). Nmr (CDCl\(_3\)): 1.27(t, J=6 Hz, 3H); 1.90(s, 3H); 2.06(s, 3H); 4.00(d, J=6 Hz, 2H); 4.20(q, J=7 Hz, 2H); 5.07(s, 1H); 10.90(broad, 1H). Ms, m/z (%): 185(M\(^+\), 49); 112(100).

- Ethyl N-(1-Methyl-3-oxo-1-pentene)-glycinonitrile (3Ac) Colorless solid, mp 65-66°C (from hexane). Nbr (CDCl\(_3\)): 1.05(t, J=6 Hz, 2H); 4.97(s, 1H); 7.13(broad, 1H); 7.43(broad, 1H); 10.60(broad, 1H). Ms, m/z (%): 156(M\(^+\), 57); 112(100). \( \text{C}_{17}\text{H}_{22}\text{N}_{2}O_{2} \) requires: C, 63.13; H, 7.95; N, 17.94. Found: C, 63.77; H, 7.88; N, 18.82.

- Ethyl N-(1-Methyl-3-oxo-1-pentene)-glycinate (3Aa) Colorless solid, mp 66-69°C (from methanol). Nmr (CDCl\(_3\)): 1.07(t, J=7 Hz, 3H); 1.27(t, J=7 Hz, 3H); 1.92(s, 3H); 2.26(q, J=7 Hz, 2H); 4.02(d, J=6 Hz, 2H); 4.23(q, J=7 Hz, 2H); 5.08(s, 1H); 10.90(broad, 1H). Ms, m/z (%): 199(M\(^+\), 31); 170(100). \( \text{C}_{17}\text{H}_{22}\text{N}_{2}O_{2} \) requires: C, 60.28; H, 6.60; N, 7.03. Found: C, 60.13; H, 6.86; N, 7.12.

- Ethyl N-(1-Methyl-3-oxo-1-pentene)-glycinonitrile (3Ab) Colorless solid, mp 63-64°C (from hexane). Nmr (CDCl\(_3\)): 1.05(t, J=7 Hz, 3H); 2.03(s, 3H); 2.28(q, J=7 Hz, 2H); 4.14(d, J=7 Hz, 2H); 5.18(s, 1H); 10.70(broad, 1H). Ms, m/z (%): 152(M\(^+\), 9); 123(100). \( \text{C}_{17}\text{H}_{22}\text{N}_{2}O_{2} \) requires: C, 63.13; H, 7.95; N, 18.41. Found: C, 63.02; H, 7.86; N, 18.49.

- Ethyl N-(1-Methyl-3-oxo-1-pentene)-glycinamide (3Ac) Colorless solid, mp 150-151°C (from methanol). Nmr (CDCl\(_3\)): 1.05(t, J=7 Hz, 3H); 1.93(s, 3H); 2.22(q, J=7 Hz, 2H); 3.93(d, J=6 Hz, 2H); 5.06(s, 1H); 6.80(broad, 1H); 7.10(broad, 1H); 10.80(broad, 1H). Ms, m/z (%): 170(M\(^+\), 41); 141(100). \( \text{C}_{17}\text{H}_{22}\text{N}_{2}O_{2} \) requires: C, 56.45; H, 8.29; N, 16.46. Found: C, 56.32; H, 8.39; N, 16.35.

- Ethyl N-(1,4-Dimethyl-3-oxo-1-pentene)-glycinonitrile (3Ba) Colorless solid, mp 64-65°C (from hexane). Nmr (CDCl\(_3\)): 1.08(d, J=7 Hz, 2H); 1.25(t, J=7 Hz, 3H); 1.92(s, 3H); 2.43(m, 1H); 3.98(d, J=6 Hz, 2H); 5.06(s, 1H); 6.80(broad, 1H); 7.10(broad, 1H); 10.80(broad, 1H). Ms, m/z (%): 213(M\(^+\), 19); 170(100). \( \text{C}_{17}\text{H}_{22}\text{N}_{2}O_{2} \) requires: C, 61.95; H, 8.98; N, 16.57. Found: C, 61.85; H, 8.76; N, 16.69.

- Ethyl N-(1,4-Dimethyl-3-oxo-1-pentene)-glycinonitrile (3Bb) Colorless solid, mp 70-71°C (from hexane-benzene). Nmr (CDCl\(_3\)): 1.06(d, J=7 Hz, 6H); 2.05(s, 3H); 2.47(m, 1H); 4.15(d, J=7 Hz, 2H); 5.20(s, 1H); 10.60(broad, 1H). Ms, m/z (%): 166(M\(^+\), 9); 123(100). \( \text{C}_{17}\text{H}_{22}\text{N}_{2}O_{2} \) requires: C, 65.03; H, 8.49; N, 16.85. Found: C, 65.11; H, 8.57; N, 16.76.

**N-(1,4-Dimethyl-3-oxo-1-pentene)-glycinamide (3Cc) Colorless solid, mp 134-135°C (from hexane-
benzene). Nmr(CDC$_3$): 1.06(d,J=7 Hz,6H); 1.93(s,3H); 2.43(m,1H); 3.93(d,J=6 Hz,2H); 5.10(s,1H); 6.70(broad,2H); 10.90(broad,1H). Ms,m/z(%): 184(M$^+$,15); 141(100). C$_9$H$_{12}$N$_2$O requires: C, 58.68; H, 8.75; N, 15.20. Found: C, 58.79; H, 8.69; N, 15.14.

**Ethyl N-(1-Methyl-3-oxo-5-phenyl-1-pentenyl)glycinate (3Fa)** Colorless solid, mp 55-56°C (from hexane-benzene). Nmr(CDC$_3$): 1.28(t,J=7 Hz,3H); 1.87(s,3H); 2.73(m,4H); 3.97(d,J=6 Hz,2H); 4.19(q,J=7 Hz,2H); 5.00(s,1H); 7.18(s,5H); 10.96(t,J=6 Hz,1H). Ms,m/z(%): 275(M$^+$,45); 170(100). C$_{16}$H$_{11}$NO$_3$ requires: C, 69.79; H, 7.69; N, 5.09. Found: C, 69.71; H, 7.78; N, 5.16.

**N-(1-Methyl-3-oxo-5-phenyl-1-pentenyl)glycinate (3Fb)** Colorless solid, mp 84-85°C (from hexane-benzene). Nmr(CDC$_3$): 1.95(s,3H); 2.74(m,4H); 4.00(d,J=7 Hz,2H); 5.13(s,1H); 7.17(s,5H); 10.63(broad,1H). Ms,m/z(%): 228(M$^+$,11); 184(100). C$_{14}$H$_{16}$N$_2$O requires: C, 73.66; H, 7.06; N, 12.27. Found: C, 73.73; H, 7.14; N, 12.21.

**Ethyl N-(1-Ethyl-3-oxo-1-butyl)glycinate (3Ga)** Colorless solid, mp 43-44°C (lit., 25-26°C). Nmr(CC$_6$H$_5$): 1.09(t,J=7 Hz,3H); 1.27(t,J=7 Hz,3H); 1.93(s,3H); 3.07(d,J=6 Hz,2H); 4.20(d,J=7 Hz,2H); 6.08(d,J=6 Hz,2H); 6.95(d,J=6 Hz,2H); 4.98(s,1H); 10.90(broad,1H).

**Ethyl N-(1,2-Dimethyl-3-oxo-1-butyl)glycinate (3Ha)** Colorless solid, mp 84-85°C (from hexane-benzene). Nmr(CDC$_3$): 1.25(t,J=7 Hz,3H); 1.82(s,3H); 2.05(s,3H); 3.68(s,2H); 4.02(d,J=6 Hz,2H); 4.20(q,J=7 Hz,2H); 7.20(s,5H); 12.30(broad,1H). Ms,m/z(%): 199(M$^+$,16); 108(100). C$_{10}$H$_{17}$N$_2$O requires: C, 60.28; H, 8.60; N, 7.03. Found: C, 60.37; H, 8.68; N, 7.11.

**Ethyl N-(2-Benzyl-1-methyl-3-oxo-1-butyl)glycinate (3Ia)** Colorless solid, mp 88-89°C (from benzene). Nmr(CDC$_3$): 1.25(t,J=7 Hz,3H); 1.82(s,3H); 1.92(s,3H); 2.12(s,3H); 3.98(d,J=6 Hz,2H); 4.20(q,J=7 Hz,2H); 12.10(broad,1H). Ms,m/z(%): 228(M$^+$,29); 188(100). C$_{14}$H$_{16}$N$_2$O requires: C, 73.66; H, 7.06; N, 12.27. Found: C, 73.71; H, 7.01; N, 12.33.

**Ethyl N-(1-Methyl-3-oxo-3-phenyl-1-propenyl)glycinate (3Ja)** Colorless solid, mp 82-83°C (from methanol) (lit., 84°C). Nmr(CDC$_3$): 1.20(t,J=7 Hz,3H); 1.92(s,3H); 4.02(d,J=6 Hz,2H); 4.15(q,J=7 Hz,2H); 5.65(s,1H); 7.20-8.00(m,5H); 11.33(t,1H).

**N-(1-Methyl-3-oxo-3-phenyl-1-propenyl)glycinate (3Jb)** Colorless solid, mp 110-111°C (from ethanol). Nmr(CDC$_3$): 2.08(s,3H); 4.16(d,J=7 Hz,2H); 5.85(s,1H); 7.20-8.00(m,5H); 11.30(broad,1H). Ms,m/z(%): 200(M$^+$,60); 105(100). C$_{12}$H$_{12}$N$_2$O requires: C, 71.98; H, 6.04; N, 13.99. Found: C, 72.09; H, 6.12; N, 13.91.

**Ethyl N-(1-Methyl-3-oxo-3-phenyl-1-propenyl)glycinamide (3Jc)** Colorless solid, mp 212-213°C (from ethanol). Nmr(DMSO-d$_6$): 2.15(s,3H); 4.20(d,J=6 Hz,2H); 6.00(s,1H); 7.40(broad,2H); 7.40-8.30(m,5H); 11.60(t,J=6 Hz,1H). Ms,m/z(%): 218(M$^+$,11); 91(100). C$_{12}$H$_{14}$N$_2$O requires: C, 66.03; H, 6.47; N, 12.84. Found: C, 66.11; H, 6.46; N, 12.91.

**Ethyl N-(1-Methyl-3-oxo-3-p-toly-1-propenyl)glycinamide (3Ka)** Colorless solid, mp 87-88°C (from ethanol). Nmr(CDC$_3$): 1.25(t,J=7 Hz,3H); 1.98(s,3H); 2.35(m,5H); 4.05(d,J=6 Hz,2H); 4.23(q,J=7 Hz,2H); 5.77(s,1H); 6.88(d,J=9 Hz,2H); 7.88(d,J=9 Hz,2H); 11.45(broad,1H). Ms,m/z(%): 277(M$^+$,65); 121(100). C$_{16}$H$_{14}$N$_2$O requires: C, 64.96; H, 6.91; N, 5.05. Found: C, 65.05; H, 6.99; N, 5.14.

**N-(1-Methyl-3-oxo-3-p-toly-1-propenyl)glycinamide (3Kc)** Colorless solid, mp 166-167°C (from ethanol). Nmr(DMSO-d$_6$): 2.10(s,3H); 2.37(s,3H); 4.08(d,J=6 Hz,2H); 5.77(s,1H); 7.10(broad,2H); 7.56(d,J=8 Hz,2H); 7.80(d,J=8 Hz,2H); 11.40(broad,1H). Ms,m/z(%): 232(M$^+$,21); 105(100). C$_{16}$H$_{16}$N$_2$O requires: C, 67.22; H, 6.94; N, 12.06. Found: C, 67.31; H, 7.06; N, 12.14.

**Ethyl N-(1-Methyl-3-p-methoxyphenyl-3-oxo-1-propenyl)glycinamide (3La)** Colorless solid, mp 86-87°C (from ethanol). Nmr(CDC$_3$): 1.23(t,J=7 Hz,3H); 1.97(s,3H); 3.75(s,3H); 4.02(d,J=6 Hz,2H);
N-(1-Methyl-3-p-methoxyphenyl-3-oxo-1-propenyl)glycinamide (3La) Colorless solid, mp 173-174°C (from ethanol). Nmr(DMSO-d$_6$): 2.13(s,3H); 3.93(s,3H); 4.15(d,J=7 Hz,2H); 5.86(s,3H); 2.07(d,J=8 Hz,2H); 7.20(broad,1H); 7.60(broad,1H); 8.00(d,J=8 Hz,2H); 11.40(broad,1H). Ms,m/z(%): 248(M$^+$,17); 121(100). C$_{13}$H$_{16}$N$_20_3$ requires: C, 64.89; H, 6.91; N, 11.25. Found: C, 65.07; H, 6.62; N, 11.25.

Ethyl N-(1-Methyl-3-p-nitrophenyl-3-oxo-1-propenyl)glycinate (30a) Colorless solid, mp 80-81°C (from ethanol). Nmr(CDC$_3$): 1.20(t,J=7 Hz,3H); 2.05(s,3H); 3.82(d,J=6 Hz,2H); 5.13(s,1H); 7.35(s,5H); 10.80(broad,1H). Ms,m/z(%): 247(M$^+$,29); 105(100).

Ethyl N-(3-Oxo-1,3-diphenyl-1-propenyl)glycinate (30a) Colorless solid, mp 123-124°C (from ethanol). Nmr(CDC$_3$): 4.04(d,J=7 Hz,2H); 6.00(s,3H); 7.30-8.20(m,10 H); 11.17(broad,1H). Ms,m/z(%): 262(M$^+$,29); 105(100). C$_{17}$H$_{16}$N$_2$O requires: C, 73.77; H, 6.19; N, 4.53. Found: C, 73.71; H, 6.25; N, 4.64.

Cyclization of the Intermediates 3 to 2-Functionalized Pyrroles 4. General procedure. To a solution of sodium methoxide or ethoxide (10 mmol, or 20 mmol for runs 15, 20 and 30) in 5 ml of methanol or ethanol were added 10 mmol of the corresponding intermediate 3 in 10 ml of the same solvent, and the mixture was refluxed (or stirred at room temperature for runs 15, 20 and 30) for the time shown in Table 2. The mixture was cooled to room temperature and quenched with 10 g of ice in water; the aqueous layer was extracted with ether(3x20 ml), the ethereal phase was washed with water and brine and dried over anhydrous MgSO$_4$. The solvent was evaporated under vacuum and the residue was chromatographed on silica gel and CH$_2$Cl$_2$ (for 2-ethoxycarbonyl- and 2-cyanopyrroles) or ethyl acetate (for 2-carbamoylpyrroles) as eluents.

When pyridine or DMF were used as solvents, 10 mmol of compound in 10 ml of solvent were refluxed for the time indicated in Table 2. After this period, the solution was cooled to room temperature, the solvent was distilled under vacuum and the residue was chromatographed as above indicated. The physical and spectral properties of pyrroles 4 are as follows:

Ethyl 3,5-Dimethyl-2-pyrrrolecarboxylate (44a) Colorless solid, mp 121-122°C (from ethanol), (lit.,$^{13}$ 122-124°C). Nmr(CC$_3$): 1.32(t,J=7 Hz,3H); 2.20(s,3H); 2.23(s,3H); 4.23(q,J=7 Hz,2H); 5.65(d,J=2 Hz,1H); 10.70(broad,1H). Ms,m/z(%): 167(M$^+$,94); 121(100).

2-Cyano-3,5-dimethylpyrrrole(44aB) Colorless solid, mp 71-72°C (from hexane). Nmr(CC$_3$): 2.17(s,3H); 2.22(s,3H); 5.67(d,J=2 Hz,1H); 9.60(broad,1H). Ms,m/z(%): 120(M$^+$,67); 119(100). C$_{7}$H$_{8}$N$_2$ requires: C, 69.98; H, 6.71; N, 23.31. Found: C, 69.83; H, 6.80; N, 23.43.

3,5-Dimethyl-2-pyrrrolecarboxamide (44c) Colorless solid, mp 162-163°C (from diethyl ether) (lit.,$^{14}$ 163°C). Nmr(CC$_3$): 2.23(s,3H); 2.30(s,3H); 5.77(d,J=2 Hz,1H); 6.00(broad,2H); 9.90(broad,1H). Ms,m/z(%): 138(M$^+$,100).

Ethyl 3-Ethyl-5-methyl-2-pyrrrolecarboxylate (44a) Colorless solid, mp 77-78°C (from methanol) (lit.,$^{15}$ 85-86°C). Nmr(Acetone-d$_6$): 1.20(t,J=8 Hz,3H); 1.36(t,J=7 Hz,3H); 2.28(s,3H);
2-Cyano-3-ethyl-5-methylpyrrole (4Db) Colorless oil. Nmr(CC13): 1.20(t, J=7 Hz, 3H); 2.23(s, 3H); 2.55(q, J=7 Hz, 2H); 5.73(d, J=2 Hz, 1H); 9.70(broad, 1H). Ms,m/z(%): 134(M⁺,35); 119(100). C8H10N2 requires: C, 67.66; H, 8.78; N, 13.23.

3-Ethyl-5-methyl-2-pyrrolooxamide (4Cc) Colorless solid, mp 195-196°C from hexane. Nmr(CC13): 1.22(t, J=7 Hz, 3H); 2.20(s, 3H); 2.90(m, J=7 Hz, 2H); 5.73(d, J=2 Hz, 1H); 9.80(broad, 1H). Ms,m/z(%): 148(M⁺,29); 133(100). C9H12N2O requires: C, 72.94; H, 8.16; N, 18.90.

5-Methyl-3-phenyl-2-pyrrolecarboxylate (4Ea) Colorless solid, mp 166-167°C from hexane. Nmr(CC13): 1.27(t, J=7 Hz, 3H); 2.87(m, 4H); 4.25(q, J=7 Hz, 2H); 5.68(d, J=2 Hz, 1H); 7.07(s, 5H); 10.00(broad, 1H). Ms,m/z(%): 257(M⁺,44); 166(100). C16H14O2 requires: C, 74.69; H, 7.44; N, 5.44. Found: C, 74.78; H, 7.32; N, 5.56.

2-Cyano-5-methyl-3-(p-phenylethyl)pyrrole (4Fb) Colorless solid, mp 257-258°C from hexane. Nmr(CC13): 1.27(t, J=7 Hz, 3H); 2.17(s, 3H); 2.30(s, 3H); 3.13(t, J=3 Hz, 2H); 4.28(q, J=7 Hz, 2H); 5.83(d, J=2 Hz, 1H); 7.15(s, 5H); 9.60(broad, 1H). Ms,m/z(%): 210 (M⁺,17); 119(100). C14H14N2 requires: C, 79.97; H, 6.71; N, 13.32. Found: C, 79.89; H, 6.80; N, 13.21.

Ethyl 5-Methyl-3-phenyl-2-pyrrolecarboxylate (4Ga) Colorless solid, mp 74-75°C from methanol. Nmr(Acetone-d6): 1.18(t, J=7 Hz, 3H); 1.27(t, J=7 Hz, 3H); 2.30(s, 3H); 2.63(q, J=7 Hz, 2H); 4.25(q, J=7 Hz, 2H); 5.82(d, J=3 Hz, 1H); 10.10(broad, 1H).

Ethyl 5-Methyl-3-phenyl-2-pyrrolecarboxylate (4Ga) Colorless solid, mp 131-132°C from methanol. Nmr(DMSO-d6): 1.13(t, J=7 Hz, 3H); 2.33(s, 3H); 3.72(s, 2H); 6.80-7.40(m, 5H); 9.70(broad, 1H). Ms,m/z(%): 229(M⁺,81); 183(100).

2-Cyano-5-methyl-3-(p-phenyl)pyrrole (4Gb) Colorless solid, mp 210-211°C from hexane. Nmr(CC13): 2.30(t, J=7 Hz, 3H); 2.17(s, 3H); 2.22(s, 3H); 3.72(s, 2H); 4.28(q, J=7 Hz, 2H); 5.83(d, J=2 Hz, 1H); 7.00-7.60(m, 5H); 10.80(broad, 1H). Ms,m/z(%): 229(M⁺,81); 183(100).

Ethyl 5-Methyl-3-p-tolyl-2-pyrrolecarboxylate (4Ka) Colorless solid, mp 158-159°C from methanol.
HETEROCYCLES, Vol. 31, No 6, 1990

Nmr(CC14): 1.16(t, J=7 Hz, 3H); 2.30(s, 3H); 2.33(s, 3H); 4.20(q, J=7 Hz, 2H); 5.93(d, J=2 Hz, 1H); 7.07(d, J=8 Hz, 2H); 7.37(d, J=8 Hz, 2H); 10.10(broad, 1H). Ms,m/z(%): 243(M⁺,67); 197(100). C₁₇H₁₉N₂O₂ requires: C, 74.05; H, 7.04; N, 5.76. Found: C, 74.16; H, 7.12; N, 5.63.

5-Methyl-3-p-tolyl-2-pyrrolecarboxylate (4Kc) Colorless salid, mp 184-185°C(from hexane-benzene). Nmr(CDCl₃): 2.30(s, 3H); 2.37(~, 3H); 5.50-6.20(m, 3H); 7.17(d, J=8 Hz, 2H); 7.31(d, J=8 Hz, 2H); 10.50(broad, 1H). Ms,m/z(%): 214(M⁺,54); 154(100). C₁₃H₁₄N₂O requires: C, 72.87; H, 6.59; N, 13.07. Found: C, 72.76; H, 6.66; N, 13.19.

Ethyl 3-p-Methoxyphenyl-5-methyl-2-pyrrolecarboxylate (4La) Colorless salid, mp 127-128°C(from methanol). Nmr(CDCl₃): 1.20(t, J=7 Hz, 3H); 2.30(s, 3H); 3.77(s, 3H); 4.20(q, J=7 Hz, 2H); 5.92(d, J=2 Hz, 1H); 6.80(d, J=9 Hz, 2H); 7.31(d, J=9 Hz, 2H); 10.00(broad, 1H). Ms,m/z(%): 259(M⁺,100). C₁₅H₂₁N₂O₂ requires: C, 69.48; H, 6.61; N, 5.40. Found: C, 69.37; H, 6.66; N, 5.48.

Ethyl 5-Methyl-3-(p-nitrophenyl)-2-pyrrolecarboxylate (4Ma) Colorless solid, mp 184-185°C(from methanol). Nmr(Acetone-d₆): 1.23(t, J=7 Hz, 3H); 2.37(s, 3H); 4.31(q, J=7 Hz, 2H); 6.33(d, J=3 Hz, 1H); 8.00(d, J=9 Hz, 2H); 8.37(d, J=9 Hz, 2H); 10.10(broad, 1H). Ms,m/z(%): 274(M⁺,100). C₁₄H₁₄NO₄ requires: C, 61.32; H, 5.14; N, 10.21. Found: C, 61.22; H, 5.25; N, 10.12.

Ethyl 3-Methyl-5-phenyl-2-pyrrolecarboxylate (4Na) Colorless solid, mp 114-115°C (from methanol), (lit., 114-115°C). Nmr(COCl₃): 1.33(t, J=7 Hz, 3H); 2.37(s, 3H); 4.33(q, J=7 Hz, 2H); 6.38(d, J=2 Hz, 1H); 7.20-7.80(m, 5H); 9.60(broad, 1H). Ms,m/z(%): 229(M⁺,65); 183(100). C₁₃H₁₄N₂O requires: C, 74.05; H, 7.04; N, 5.76. Found: C, 74.16; H, 7.12; N, 5.63.

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