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REGIOSELECTIVE SYNTHESIS OF 2- AND 3-ACYLPYRROLES BY REACTION OF β-AMINOENONES WITH α-AMINOKETONE HYDROCHLORIDE

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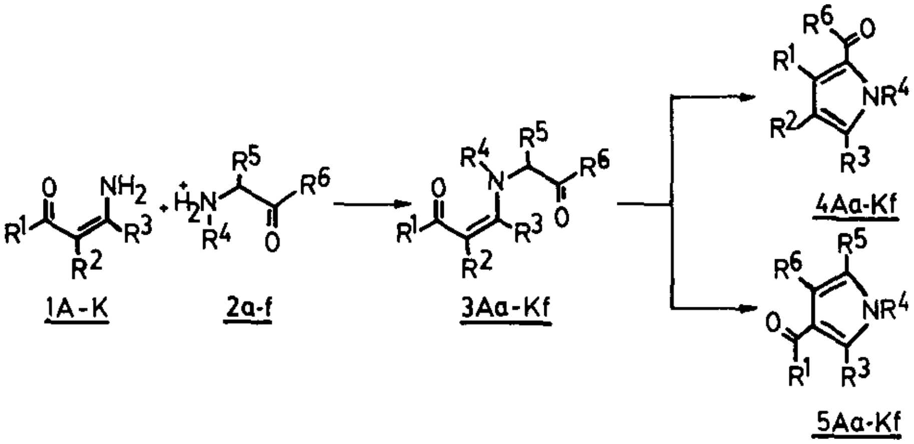
Abstract- A high regioselective synthesis, with good to excellent yields, of 2- and 3-acylpyrroles from β-aminoenones and α-aminoketones is described. The formation of 2-acylpyrroles or their 3-acylisomers depends on the pattern substitution on the reactants.

We have previously reported[1] that β-aminoenones react with phenacylamine hydrochloride in a two-steps process to give 2- and/or 3-acylpyrroles. The ratio of isomeric heterocycles depends on both the electronic requeriments and the substitution pattern on the β-aminoenones.

Now we have extended our study to the reaction of β-aminoenones 1A-K with α-aminoketone hydrochlorides 2a-f to establish the generality of the process, the influence of the substituents at the α-aminoketone moiety, and to get a regioselective synthesis of 2- and 3-acylpyrroles.

The influence of substituents on the reactivity of α-aminoketones was preliminary studied in their reactions with β-aminoenones 1A and 1H, and Table 1 summarizes the results after one hour at reflux in methanol.



	R^1	R^2	R^3
1A	CH_3	H	CH_3
B	C_2H_5	H	CH_3
C	$(CH_3)_2CH$	H	CH_3
D	$C_6H_5CH_2CH_2$	H	CH_3
E	CH_3	H	C_2H_5
F	CH_3	H	$C_6H_5CH_2CH_2$
G	CH_3	$C_6H_5CH_2CH_2$	CH_3
H	C_6H_5	H	CH_3
I	$4\text{-}CH_3OC_6H_4$	H	CH_3
J	$4\text{-}NO_2C_6H_4$	H	CH_3
K	C_6H_5	H	C_6H_5

	R^4	R^5	R^6
2 a	H	H	C_6H_5
b	H	H	$4\text{-}CH_3OC_6H_4$
c	H	H	$4\text{-}NO_2C_6H_4$
d	CH_3	H	C_6H_5
e	H	CH_3	C_6H_5
f	H	H	CH_3

Table 1. Reactions of α-aminoketone hydrochlorides 2a-f with β-aminoenones 1A and 1H in refluxing methanol for 1 hour

Entry	β-Aminoenone	α-Aminoketone	Products(%)[a]			
1	1A	2a	1A (-)	3Aa (37)	4Aa (18)	5Aa (45)
2	1A	2b	1A (-)	3Ab (80)	4Ab (5)	5Ab (5)
3	1A	2c	1A (25)	3Ac (-)	4Ac (10)	5Ac (65)
4	1A	2d	1A (96)	3Ad (4)	4Ad (-)	5Ad (-)
5	1A	2e	1A (68)	3Ae (-)	4Ae (-)	5Ae (32)
6	1A	2f	1A (-)	3Af (-)	4Af (-)	5Af (100)
7	1H	2a	1H (72)	3Ha (18)	4Ha (-)	5Ha (10)
8	1H	2b	1H (20)	3Hb (80)	4Hb (-)	5Hb (-)
9	1H	2c	1H (70)	3Hc (-)	4Hc (-)	5Hc (30)
10	1H	2d	1H (97)	3Hd (3)	4Hd (-)	5Hd (-)
11	1H	2e	1H (96)	3He (4)	4He (-)	5He (-)
12	1H	2f	1H (23)	3Hf (23)	4Hf (-)	5Hf (54)

[a] Yields are determined by nmr on the mixture of reaction.

It is noteworthy that the rate of transamination for α- or N-alkyl substituted α-aminoketones 2e and 2d is lower than that for unsubstituted substrates. Furthermore, the withdrawing character of R^6 diminishes the rate of transamination, but increases the ability of the intermediates 3 to cyclize to the final pyrrole (compare entries 3 and 9 versus 1, 2, 7 and 8 in Table 1).

On the other hand, Table 2 summarizes the results obtained in the reactions of β-aminoenones 1A-K with α-aminoketones 2b-f after completion of the process.

Table 2. Reactions of β-aminoenones 1A-K with α-aminoketones 2b-f

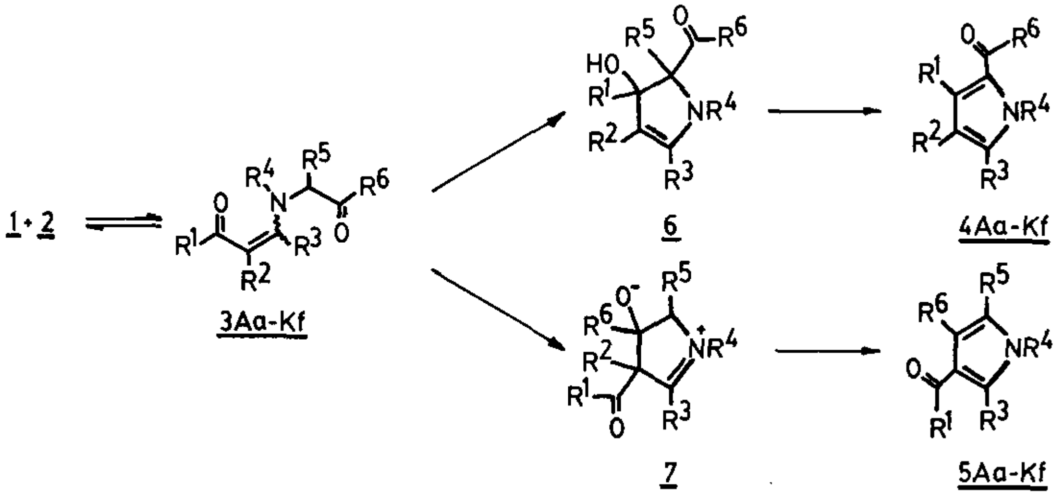
Entry	β-Amino-enone	α-Amino-ketone	Reaction conds.[a] Time (h)	Solvent	Products (%)[b] 2-acyl-	3-acyl-
1	1A	2b	14	MeOH	4Ab(30)	5Ab(47)
2	1A	2c	2	MeOH	4Ac(9)	5Ac(77)
3	1A	2d	4	n-HexOH		5Ad(64)
4	1A	2e	6	MeOH		5Ae(87)
5	1A	2f	1	MeOH		5Af(43)
6	1B	2b	14	MeOH	4Bb(26)	5Bb(58)
7	1B	2c	2	MeOH	4Bc(5)	5Bc(81)
8	1B	2e	10	MeOH		5be(83)
9	1B	2f	1.5	MeOH		5Bf(48)
10	1C	2b	18	MeOH	4Cb(20)	5Cb(64)
11	1C	2c	3	MeOH		5Cc(88)
12	1C	2d	4	n-HexOH		5Cd(49)
13	1C	2e	10	MeOH		5Ce(74)
14	1C	2f	2.5	MeOH		5Cf(62)
15	1D	2d	2	n-HexOH		5Dd(26)
16	1D	2e	11	MeOH		5De(85)
17	1D	2f	2.5	MeOH		5Df(48)
18	1E	2e	14	MeOH		5Ee(47) 5Be(35)
19	1F	2e	12	MeOH		5Fe(21) 5De(58)
20	1G	2b	10	MeOH	4Gb(83)	
21	1G	2c	5	MeOH	4Gc(81)	
22	1G	2d	4	n-HexOH[c]		
23	1G	2f	3	MeOH	4Gf(23)	
24	1H	2b	24	MeOH	4Hb(25)	5Hb(59)
25	1H	2c	5	MeOH		5Hc(85)
26	1H	2d	4	n-HexOH		5Hd(18)
27	1H	2e	12	EtOH		5He(90)
28	1H	2f	3	MeOH		5Hf(35)
29	1I	2c	4	MeOH		5Ic(83)
30	1I	2d	2	n-HexOH		5Id(24)
31	1J	2b	78	MeOH	4Jb(40)	
32	1K	2e	120	EtOH		5Ke(28)
33	1K	2f	24	MeOH		5Kf(15)

[a] The reactions were carried out at reflux of the given solvent. [b] Yields refer to pure and isolated compounds. [c] The major product of the reaction was benzylacetone.

Some special features are remarcable from Table 2. Thus, the 3-acylpyrrole is formed as a single product or always as major isomer, except for β-aminoenone 1G ($R^2 \neq H$) that leads exclusively to the 2-acylderivative because the intermediate 7 is unable to yield the final aromatic product. This fact is also observed in the reaction of 1J with 2b (entry 31); but in this case can be attributed to electronic requeriments: the oxo-carbon of the β-aminoenone moiety is much more positive than that of the aminoketone, and the intermediate 3Jb is exclusively transformed "via 6" to the 2-acylpyrrole. The observed selectivity in the reactions of α-aminoketone 2c (entries 2, 7, 11, 25 and 29) is also a consequence of the described electronic efects.

Otherwise, the less reactive α-aminoketones 2d and 2e react in more drastic conditions (n-Hexanol at reflux and longer reaction times) leading to 3-acylpyrroles in poor yields (entries 12, 15, 26, 30 and 32) or to a mixture of 2- and 3-acylpyrroles depending on the reactivity of the β-aminoenones (entries 18 and 19).

All these facts can be rationalized assuming the previously depicted pathway,[1] being the formation of the intermediates 3Aa-Kf faster than their cyclization to the final pyrroles.[2,3]



The rate of the reaction and the product distribution are affected by both the number and nature of the substituents at the reactants, and by the steric requeriments in the intermediates. In fact, the evolution of 3 depends on the nature of R^2 and R^5, leading to the 2-acylpyrrole 4 if $R^2 \neq H$, or to the 3-acylpyrrole 5 when $R^5 \neq H$ because the imposibility of the respective intermediates 7 and 6 to be aromatized.

This is specially important in the reaction of 1G with 2d (both R^2 and $R^5 \neq H$), the product in this case is the retrocondensation compound 4-phenylbutan-2-one (entry 22). On the other hand, in the reactions where 2- and 3-acylpyrroles can be formed, the ratio of isomers in the final mixture depends on the posive character of the corresponding carbonyl group.

Finally, the behaviour of α-aminoketone 2d could be referible to α-aminoketone 2a taking into account the electronic efects of the substituents. Nevertheless, 2d reacts with β-aminoenones leading exclusively to 3-acylpyrroles (entries 3, 12, 15, 26 and 30) in moderate or low yields. This fact is a consequence of the stereochemistry of the corresponding intermediate 3: N-monosubstituted β-aminoenones have Z configuration because the formation of an intramolecular hydrogen bond, while the E configuration is the most stable for N-disubstituted derivatives[4,5]; as a consequence, the intermediates derived from 2d can only adopt the conformation leading to 3-acylpyrroles.

EXPERIMENTAL

Mp's were measured in an open capillary tube and are uncorrected. Mass spectra were measured on a Hewlett-Packard 5988A mass spectrometer. Elemental analysis were determined on a Perkin-Elmer 240B analyzer and nmr were recorded on either a Varian T60A or Bruker AC80 spectrometers (chemical chifts are given downfield from TMS as internal standard).

Synthesis of acylpyrroles. General procedure. To a solution of α-aminoketone hydrochloride 2a-f (11 mmol) in 20 ml of the corresponding alcohol was added a solution of β-aminoenone (10 mmol) in 10 ml the same solvent and the reaction mixture was refluxed for the time given in the Tables. After the reaction was finished, the solvent was evaporated to dryness, the residue was redissolved in anhydrous THF, and the insoluble precipitate was filtered off. The filtrate was eliminated under vacuum, and the residue was chromatographed on silica gel using ethyl acetate/toluene (1/5) as eluent or recristallized.

The physical and spectral characteristics of the prepared compounds are as follows.

2-(p-Methoxybenzoyl)-3,5-dimethylpyrrole (4Ab). White solid, mp 135-136°C (from MeOH). Nmr ($CDCl_3$): 2.00(s, 3H); 2.26(s, 3H); 3.83(s, 3H); 5.87(d, 1H, J= 2 Hz); 6.92(d, 2H, J= 8 Hz); 7.70(d, 2H, J= 8 Hz); 9.70(broad s, 1H). Ms, m/z(%): 229 ($M^{+\cdot}$, 74); 228 (100). $C_{14}H_{15}NO_2$ requires: C, 73.34; H, 6.59; N, 6.11. Found: C, 73.27; H, 6.72; N, 6.18.

3-Acetyl-4-(p-methoxyphenyl)-2-methylpyrrole (5Ab). White solid, mp 176-177°C (from MeOH). Nmr ($CDCl_3$): 2.00(s, 3H); 2.48(s, 3H); 3.80(s, 3H); 6.47(d, 1H, J= 2 Hz); 6.87(d, 2H, J= 9 Hz); 7.23(d, 2H, J= 9 Hz); 8.80(broad s, 1H). Ms, m/z(%): 229 ($M^{+\cdot}$, 68); 214 (100). $C_{14}H_{15}NO_2$ requires: C, 73.34; H, 6.59; N, 6.11. Found: C, 73.42; H, 6.72; N, 6.18.

3,5-Dimethyl-2-(p-nitrobenzoyl)pyrrole (4Ac). Yellow solid, mp 189-190°C (from EtOH) (lit.[6] 189°C). Nmr ($CDCl_3$): 1.87(s, 3H); 2.33(s, 3H); 5.95(d, 1H, J= 2 Hz); 7.82(d, 2H, J= 8 Hz); 8.36(d, 2H, J= 8 Hz); 9.95(broad, 1H). Ms, m/z(%): 244 ($M^{+\cdot}$, 69); 197 (100).

3-Acetyl-2-methyl-4-(p-nitrophenyl)pyrrole (5Ac). Yellow solid, mp 201-202°C(from EtOH). Nmr (CCl_4): 2.17(s, 3H); 2.46(s, 3H); 6.70(d, 1H, J= 2 Hz); 7.47(d, 2H, J= 8 Hz); 8.13(d, 2H, J= 8 Hz); 11.10(broad, 1H). Ms, m/z(%): 244 ($M^{+\cdot}$, 62); 229 (100). $C_{13}H_{12}N_2O_3$ requires: C, 63.93; H, 4.95; N, 11.47. Found: C, 63.77; H, 4.87; N, 11.58.

3-Acetyl-1,3-dimethyl-4-phenylpyrrole (5Ad). White solid, mp 67-68°C (from MeOH) (lit.[7] 67-68°C). Nmr ($CDCl_3$): 1.87(s, 3H); 2.37(s, 3H); 3.43(s, 3H); 6.35(s, 1H); 7.23(s, 5H). Ms, m/z(%): 213 ($M^{+\cdot}$, 45); 198 (100).

3-Acetyl-2,5-dimethyl-4-phenylpyrrole (5Ae). White solid, mp 134-135°C (from MeOH) (lit.[8] 132-133°C). Nmr ($CDCl_3$): 1.93(s, 3H); 2.03(s, 3H); 2.50(s, 3H); 7.30(s, 5H); 9.40(broad s, 1H). Ms, m/z(%): 213 ($M^{+\cdot}$, 60); 198 (100).

3-Acetyl-2,4-dimethylpyrrole (5Af). White solid, mp 137-138°C (from MeOH) (lit.[9] 135-137°C). Nmr (CD_3COCD_3): 2.22(s, 3H); 2.32(s, 3H); 2.45(s, 3H); 6.40(d, 1H, J= 2 Hz); 10.10(broad s, 1H). Ms, m/z(%): 137 ($M^{+\cdot}$, 35); 122 (100).

3-Ethyl-2-(p-methoxybenzoyl)-5-methylpyrrole (4Bb). White solid, mp 101-102°C (from MeOH). Nmr ($CDCl_3$): 1.00(t, 3H, J= 7 Hz); 2.25(s, 3H); 2.40(q, 2H, J= 7 Hz); 3.77(s, 3H); 5.92(d, 1H, J= 2 Hz); 6.88(d, 2H, J= 8 Hz); 7.65(d, 2H, J= 8 Hz); 10.10(broad s, 1H). Ms, m/z(%): 243 ($M^{+\cdot}$, 100). $C_{15}H_{17}NO_2$ requires: C, 74.05; H, 7.04; N, 5.76. Found: C, 74.16; H, 7.11; N, 5.88.

4-(p-Methoxyphenyl)2-methyl-3-propionylpyrrole (5Bb). White solid mp 126-127 °C (from MeOH). Nmr ($CDCl_3$): 0.95(t,3H, J= 7 Hz); 2.37(q, 2H, J= 7 Hz); 2.45(s, 3H); 3.73(s, 3H); 6.43(d, 1H, J= 2 Hz); 6.83(d, 2H, J= 8 Hz); 7.22(d, 2H, J= 8 Hz); 9.80(broad s, 1H). Ms, m/z(%): 243 ($M^{+\cdot}$, 42); 214 (100). $C_{15}H_{17}NO_2$ requires: C, 74.05; H, 7.04; N, 5.76. Found: C, 74.17; H, 7.18; N, 5.63.

3-Ethyl-5-methyl-2-(p-nitrobenzoyl)pyrrole (4Bc). Yellow solid, mp 153-154°C (from EtOH). Nmr ($CDCl_3$): 1.00(t, 3H, J= 8 Hz); 2.25(q, 2H, J= 8 Hz); 2.35(s, 3H); 6.07 (d, 1H, J= 2 Hz); 7.83(d, 2H, J= 8 Hz); 8.40(d, 2H, J= 8 Hz); 10.00(broad s, 1H). Ms, m/z(%): 258 ($M^{+\cdot}$, 67); 197 (100). $C_{14}H_{14}N_2O_3$ requires: C, 65.11; H, 5.46; N, 10.85. Found: C, 6.22; H, 5.34; N, 10.91.

2-Methyl-4-(p-nitrophenyl)-3-propionylpyrrole (5Bc). Yellow solid, mp 174-175°C (from EtOH). Nmr ($CDCl_3$): 1.03(t, 3H, J= 7 Hz); 2.47(q, 2H, J= 7 Hz); 2.50(s, 3H); 6.62(d, 1H, J= 2 Hz); 7.43(d, 2H, J= 8 Hz); 8.17(d, 2H, J= 8 Hz); 10.20(broad s, 1H). Ms, m/z(%): 258 ($M^{+\cdot}$, 23); 229 (100). $C_{14}H_{14}N_2O_3$ requires: C, 65.11; H, 5.46; N, 10.85. Found: C, 65.27; H, 5.59; N, 10.70.

2,5-Dimethyl-4-phenyl-3-propionylpyrrole(5Be). White solid, mp 135-136°C (from MeOH). Nmr ($CDCl_3$): 0.90(t, 3H, J= 8 Hz); 2.02(s, 3H); 2.20(q, 2H, J= 8 Hz); 2.47 (s, 3H); 7.25(s, 5H); 10.00(broad s, 1H). Ms, m/z(%): 227 ($M^{+\cdot}$, 34); 198 (100). $C_{15}H_{17}NO$ requires: C, 79.26; H, 7.54; N, 6.16. Found: C, 79.39; H, 7.73; N, 6.05.

2,4-Dimethyl-3-propionylpyrrole (5Bf). White solid, mp 120-121°C (from MeOH). Nmr ($CDCl_3$): 1.17(t, 3H, J= 7 Hz); 2.30(s, 3H); 2.53(s, 3H); 2.78(q, 2H, J= 7 Hz); 6.43(d, 1H, J= 2 Hz); 9.20(broad s, 1H). Ms, m/z(%): 151 ($M^{+\cdot}$, 25); 122 (100). $C_9H_{13}NO$ requires: C, 71.49; H, 8.67; N, 9.26. Found: C, 71.58; H, 8.52; N, 9.38.

2-(p-Methoxybenzoyl)-5-methyl-3-isopropylpyrrole (4Cb). White solid, mp 147-148°C (from hexane-benzene). Nmr ($CDCl_3$): 1.05(d, 6H, J= 7 Hz); 2.26(s, 3H); 2.93(m,1H, J= 7 Hz); 3.80(s, 3H); 5.95(d, 1H, J= 2 Hz); 6.90(d, 2H, J= 8 Hz); 7.67(d, 2H, J= 8 Hz); 9.70(broad s, 1H). Ms, m/z(%): 257 ($M^{+\cdot}$, 100). $C_{16}H_{19}NO_2$ requires: C, 74.68; H, 7.44; N, 5.44. Found: C, 74.56; H, 7.36; N, 5.32.

3-isoButyryl-4-(p-methoxyphenyl)-2-methylpyrrole (5Cb). White solid, mp 142-143°C (from MeOH). Nmr ($CDCl_3$): 0.93(d, 6H, J= 7 Hz); 2.41(s, 3H); 2.80(m, 1H, J= 7 Hz); 3.78(s, 3H); 6.46(d, 1H, J= 2 Hz); 6.85(d, 2H, J= 7 Hz); 7.22(d, 2H, J= 7 Hz);

9.43(broad s, 1H). Ms, m/z(%): 257 ($M^{+\cdot}$, 29); 214 (100). $C_{16}H_{19}NO_2$ requires: C, 74.68; H, 7.44; N, 5.44. Found: C, 74.78; H, 7.51; N, 5.57.

3-isoButyryl-2-methyl-4-(p-nitrophenyl)pyrrole (5Cc). Yellow solid, mp 171-172°C (from EtOH). Nmr ($CDCl_3$/DMSO-d_6): 1.00(d, 6H, J= 7 Hz); 2.43(s, 3H); 2.83(m, 1H, J= 7 Hz); 6.72(d, 1H, J= 2 Hz); 7.43(d, 2H, J= 8 Hz); 8.17(d, 2H, J= 8 Hz); 11.00 (broad s, 1H). Ms, m/z(%): 272 ($M^{+\cdot}$, 13); 229 (100). $C_{15}H_{16}N_2O_3$ requires: C, 66.16; H, 5.92; N, 10.29. Found: C, 66.25; H, 5.85; N, 10.14.

3-isoButyryl-1,2-dimethyl-4-phenylpyrrole (5Cd). White solid, mp 77-78°C (from MeOH). Nmr (CCl_4): 0.82(d, 6H, J= 7 Hz); 2.26(s, 3H); 3.43(s, 3H); 2.48(m, 1H, J= 7 Hz); 6.38(s, 1H); 7.23(s, 5H). Ms, m/z(%): 241 ($M^{+\cdot}$, 17); 198 (100). $C_{16}H_{19}NO$ requires: C, 79.63; H, 7.94; N, 5.80. Found: C, 79.80, H, 7.77; N, 5.98.

3-isoButyryl-2,5-dimethyl-4-phenylpyrrole (5Ce). White solid, mp 160-161°C (from MeOH). Nmr ($CDCl_3$): 0.90(d, 6H, J= 7 Hz); 2.05(s, 3H); 2.45(s, 3H); 2.60(m, 1H, J= 7 Hz); 7.25(s, 5H); 9.20(broad s, 1H). Ms, m/z(%): 241 ($M^{+\cdot}$, 20); 198 (100). $C_{16}H_{19}NO$ requires: C, 79.63; H, 7.94; N, 5.80. Found: C, 79.79; H, 7.79; N, 5.63.

3-isoButyryl-2,4-dimethylpyrrole (5Cf). White solid, mp 165-166°C (from MeOH). Nmr ($CDCl_3$): 1.15(d, 6H, J= 7 Hz); 2.30(s, 3H); 2.50(s, 3H); 3.27(m, 1H, J= 7 Hz); 6.43 (d, 1H, J= 2 Hz); 9.40(broad s, 1H). Ms, m/z(%): 165 ($M^{+\cdot}$, 12); 122 (100). $C_{10}H_{15}NO$ requires: C, 72.69; H, 9.15; N, 8.48. Found: C, 72.76; H, 9.29; N, 8.36.

1,2-Dimethyl-4-phenyl-3-(β-phenylpropionyl)pyrrole (5Dd). White solid, mp 116-117 °C (from MeOH). Nmr (CCl_4): 2.33(s, 3H); 2.57(m, 4H); 3.45(s, 3H); 6.33(s, 1H); 6.70-7.30(m, 5H); 7.20(s, 5H). Ms, m/z(%): 303 ($M^{+\cdot}$, 25); 91 (100). $C_{21}H_{21}NO$ requires: C, 83.13; H, 6.98; N, 4.62. Found: C, 83.28; H, 7.12; N, 4.83.

2,5-Dimethyl-4-phenyl-3-(3-phenylpropionyl)pyrrole (5De). White solid, mp 121-122 °C (from MeOH). Nmr ($CDCl_3$): 2.00(s, 3H); 2.43(s, 3H); 2.65(m, 4H); 6.70-7.40(m, 5H); 7.25(s, 5H); 9.00(broad s, 1H). Ms, m/z(%): 303 ($M^{+\cdot}$, 41); 198 (100). $C_{21}H_{21}NO$ requires: C, 83.13; H, 6.98; N, 4.62. Found: C, 83.03; H, 7.12; N, 4.75.

2,4-Dimethyl-3-(β-phenylpropionyl)pyrrole (5Df). White solid, mp 97-98°C (from MeOH). Nmr ($CDCl_3$): 2.28(s, 3H); 2.47(s, 3H); 3.05(s, 4H); 6.37(d, 1H, J= 2 Hz); 7.30(s, 5H); 8.90(broad s, 1H). Ms, m/z(%): 227 ($M^{+\cdot}$, 10); 122 (100). $C_{15}H_{17}NO$ requires: C, 79.26; H, 7.54; N, 6.16. Found: C, 79.37; H, 7.67; N, 6.29.

3-Acetyl-2-ethyl-5-methyl-4-phenylpyrrole (5Ee). White solid, mp 168-169°C (from MeOH). Nmr ($CDCl_3$): 1.26(t, 3H, J= 8 Hz); 1.93(s, 3H); 2.08(s, 3H); 3.00(q, 2H, J= 8 Hz); 7.36(s, 5H); 9.30(broad s, 1H). Ms, m/z(%): 227 ($M^{+\cdot}$, 47); 212 (100). $C_{15}H_{17}NO$ requires: C, 79.26; H, 7.54; N, 6.16. Found: C, 79.40; H, 7.61; N, 6.03.

3-Acetyl-5-methyl-4-phenyl-2-(β-phenylethyl)pyrrole (5Fe). White solid, mp 136-137 °C (from hexane-benzene). Nmr ($CDCl_3$): 1.85(s, 3H); 2.00(s, 3H); 3.05(m, 4H); 7.17 (s, 5H); 7.28(s, 5H); 8.70(broad s, 1H). Ms, m/z(%): 303 ($M^{+\cdot}$, 16); 212 (100). $C_{21}H_{21}NO$ requires: C, 83.13; H, 6.98; N, 4.62. Found: C, 83.28; H, 7.12; N, 4.73.

4-Benzyl-2-(p-methoxybenzoyl)-3,5-dimethylpyrrole (4Gb). White solid, mp 139-140°C (from MeOH). Nmr ($CDCl_3$): 1.87(s, 3H); 2.20(s, 3H); 3.73(s, 5H); 6.87(d, 2H, J= 8 Hz); 7.13(s, 5H); 7.65(d, 2H, J= 8 Hz); 10.20(broad s, 1H). Ms, m/z(%): 319 ($M^{+\cdot}$, 100). $C_{21}H_{21}NO_2$ requires: C, 78.97; H, 6.63; N, 4.38. Found: C, 79.13; H, 6.72; N, 4.27.

4-Benzyl-3,5-dimethyl-2-(p-nitrobenzoyl)pyrrole (4Gc). Yellow solid, mp 213-214°C (from EtOH). Nmr ($CDCl_3$/DMSO-d_6): 1.87(s, 3H); 2.20(s, 3H); 3.73(s, 2H); 7.13(s, 5H); 7.73(d, 2H, J= 9 Hz); 8.25(d, 2H, J= 9 Hz); 11.10(broad s, 1H). Ms, m/z(%): 334 ($M^{+\cdot}$, 100). $C_{20}H_{18}N_2O_3$ requires: C, 71.84; H, 5.43; N, 8.38. Found: C, 71.75; H, 5.30; N, 8.45.

2-Acetyl-4-benzyl-3,5-dimethylpyrrole (4Gf). White solid, mp 145-146°C (from MeOH). Nmr ($CDCl_3$): 2.20(s, 3H); 2.23(s, 3H); 2.43(s, 3H); 3.80(s, 2H); 7.27(s, 5H); 9.80(broad s, 1H). Ms, m/z(%): 227 ($M^{+\cdot}$, 47); 43 (100). $C_{15}H_{17}NO$ requires: C, 79.26; H, 7.54; N, 6.16. Found: C, 79.39; H, 7.66; N, 6.25.

2-(p-Methoxybenzoyl)-5-methyl-3-phenylpyrrole (4Hb). White solid, mp 163-164°C (from EtOH). Nmr ($CDCl_3$): 2.37(s, 3H); 3.63(s, 3H); 6.10(d, 1H, J= 2 Hz); 6.50 (d, 2H, J= 8 Hz); 7.00(s, 5H); 7.47(d, 2H, J= 8 Hz); 10.80(broad s, 1H). Ms, m/z (%): 291 ($M^{+\cdot}$, 100). $C_{19}H_{17}NO_2$ requires: C, 78.33; H, 5.88; N, 4.81. Found: C, 78.46; H, 5.76; N, 4.89.

3-Benzoyl-4-(p-methoxyphenyl)-2-methylpyrrole (5Hb). White solid, mp 175-176°C (from EtOH). Nmr ($CDCl_3$): 2.25(s, 3H); 3.60(s, 3H); 6.57(d, 2H, J= 8 Hz); 6.63 (d, 1H, J= 2 Hz); 7.00(d, 2H, J= 8 Hz); 7.20-8.00(m, 5H); 10.80(broad s, 1H). Ms, m/z(%): 291 ($M^{+\cdot}$, 91); 290 (100). $C_{19}H_{17}NO_2$ requires: C, 78.33; H, 5.88; N, 4.81. Found: C, 78.42; H, 5.77; N, 4.92.

3-Benzoyl-2-methyl-4-(p-nitrophenyl)pyrrole (5Hc). Yellow solid, mp 206-207°C (from EtOH). Nmr ($CDCl_3$/DMSO-d_6): 2.30(s, 3H); 6.93(d, 1H, J= 2 Hz); 7.23(d, 2H, J= 8 Hz); 7.20-7.80(m, 5H); 7.90(d, 2H, J= 8 Hz); 11.40(broad s, 1H). Ms, m/z (%): 306 ($M^{+\cdot}$, 72); 305 (100). $C_{18}H_{14}N_2O_3$ requires: C, 70.58; H, 4.61; N, 9.14. Found: C, 70.66; H, 4.71; N, 9.23.

3-Benzoyl-1,2-dimethyl-4-phenylpyrrole (5Hd). White solid, mp 115-116°C (from MeOH). Nmr ($CDCl_3$): 2.25(s, 3H); 3.38(s, 3H); 6.58(s, 1H); 7.07(s, 5H); 7.10-7.90(m, 5H). Ms, m/z(%): 275 ($M^{+\cdot}$, 65); 274 (100). $C_{19}H_{17}NO$ requires: C, 82.88; H, 6.22; N, 5.09. Found: C, 83.04; H, 6.11; N, 5.17.

3-Benzoyl-2,5-dimethyl-4-phenylpyrrole (5He). White solid, mp 244-245°C (from EtOH) (lit.[8] 210-211°C). Nmr ($CDCl_3$/DMSO-d_6): 2.20(s, 3H); 2.26(s, 3H); 6.95(s, 5H); 6.90-7.50(m, 5H); 11.00(broad s, 1H). Ms, m/z(%): 275 ($M^{+\cdot}$, 88); 274 (100).

3-Benzoyl-2,4-dimethylpyrrole (5Hf). White solid, mp 128-129°C (from MeOH) (lit.[10] 130°C). Nmr ($CDCl_3$): 2.00(s, 3H); 2.07(s, 3H); 6.37(d, 1H, J= 2 Hz); 7.30-7.90(m, 5H); 9.70(broad s, 1H). Ms, m/z(%): 199 ($M^{+\cdot}$, 68); 122 (100).

3-(p-Methoxybenzoyl)-2-methyl-4-(p-nitrophenyl)pyrrole (5Ic). Yellow solid, mp 194-195°C (from EtOH). Nmr ($CDCl_3$/DMSO-d_6): 2.25(s, 3H); 3.75(s, 3H); 6.80(d, 2H, J= 9 Hz); 6.97(d, 1H, J= 2 Hz); 7.33(d, 2H, J= 8 Hz); 7.73(d, 2H, J= 9 Hz); 7.96(d, 2H, J= 8 Hz); 11.30(broad s, 1H). Ms, m/z(%): 336 ($M^{+\cdot}$, 72); 335 (100). $C_{19}H_{16}N_2O_4$ requires: C, 67.85; H, 4.79; N, 8.33. Found: C, 67.76; H, 4.87; N, 8.24.

3-(p-Methoxybenzoyl)-1,2-dimethyl-4-phenylpyrrole (5Id). White solid, mp 147-148°C (from EtOH). Nmr (CCl_4): 2.15(s, 3H); 3.35(s, 3H); 3.55(s, 3H); 6.53(s, 1H); 6.60 (d, 2H, J= 8 Hz); 7.00(s, 5H); 7.63(d, 2H, J= 8 Hz). Ms, m/z(%): 305 ($M^{+\cdot}$, 62); 77 (100). $C_{20}H_{19}NO_2$ requires: C, 78.66; H, 6.27; N, 4.59. Found: C, 78.82; H, 6.34; N, 4.71.

2-(p-Methoxybenzoyl)-5-methyl-3-(p-nitrophenyl)pyrrole (4Jb). Yellow solid, mp 195-196°C (from EtOH). Nmr (DMSO-d_6): 2.32(s, 3H); 3.70(s, 3H); 6.24(d, 1H, J= 2 Hz); 6.75(d, 2H, J= 9 Hz); 7.34(d, 2H, J= 9 Hz); 7.47(d, 2H, J= 9 Hz); 7.94(d, 2H, J=

9 Hz); 11.80(broad s, 1H). Ms, m/z(%): 336 ($M^{\ddagger}$, 100). $C_{19}H_{16}N_2O_4$ requires: C, 67.85; H, 4.79; N, 8.33. Found: C, 67.72; H, 4.85; N, 8.26.

3-Benzoyl-5-methyl-2,4-diphenylpyrrole (5Ke). White solid, mp 248-249°C (from EtOH) (lit.[8] 249-250°C). Nmr ($CDCl_3$/DMSO-d_6): 2.60(s, 3H); 6.80-7.80(m, 15H); 10.80 (broad s, 1H). Ms, m/z (%): 337 ($M^{\ddagger}$, 100).

3-Benzoyl-4-methyl-2-phenylpyrrole (5Kf). White solid, mp 118-119°C (from MeOH). Nmr (CCl_4): 2.03(s, 3H); 6.45(d, 1H, J= 2 Hz); 6.80-7.80(m, 10H); 10.00(broad s, 1H). Ms, m/z (%): 261 ($M^{\ddagger}$, 77); 260 (100). $C_{18}H_{15}NO$ requires: C, 82.73; H, 5.79; N, 5.36. Found: C, 82.61; H, 5.68; N, 5.48.

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