A Combinatorial Approach towards a Library of Chiral γ-Lactams and 2,3-Disubstituted Pyrroles

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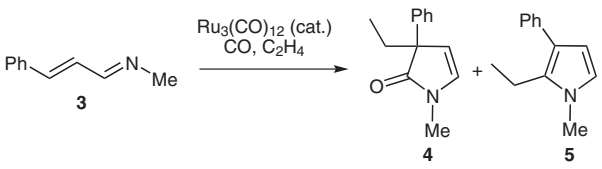
Abstract: A library of heterocyclic products with a wide variety of organic residues is produced via a four-component reaction of α,β-unsaturated aldehydes, primary amines, carbon monoxide, and ethylene using a multi-reactor station with an array of 96 autoclaves employing the same high-pressure reaction conditions for all catalytic reactions. In the presence of $Ru_3(CO)_{12}$ as a precatalyst, mixtures of chiral γ-lactams and 2,3-disubstituted pyrroles are obtained. This combinatorial approach also enables us for the first time to set up rules relating to the effects of specific substituents in the substrates on the outcome of the respective catalytic reaction.

Key words: ruthenium, C–H activation, catalysis, γ-lactams, pyrroles

The direct catalytic activation of C–H bonds with the purpose of establishing new C–C bonds is a highly attractive synthetic objective in terms of avoiding synthesis and isolation of more reactive intermediates, for example, chlorinated compounds. Progress in this field has been thoroughly reviewed in recent years.[1–8]

Some of us have developed a reaction of α,β-unsaturated imines, carbon monoxide, and ethylene (or terminal alkenes in general) to produce chiral 1,3-dihydropyrrolones as the main product in nonpolar solvents. As a side-product 2,3-disubstituted pyrroles are formed (Scheme 1).[9–15]



Scheme 1 Ruthenium-catalyzed formation of γ-lactams and pyrroles

The formation of both products obviously proceeds via the activation of a C–H bond in the β-position relative to the imine C=N bond. The product ratio is highly dependent on the relative permittivity of the solvent used; with nonpolar solvents like, for example, hydrocarbons leading to the quantitative and selective formation of racemic lactams **4**, whereas use of more polar solvents or the presence of traces of water leads to an enhancement of the yield of the pyrrole **5** (75% in anhyd MeOH).[15] γ-Lactams or γ-butyric acid derivatives have been investigated with respect to their potential as psychotropic drugs, as agents against Alzheimer's disease, Down's syndrome, osteoporosis, and cancer or as constituents of peptide mimetics exhibiting γ-turns.[16–22] It has also been demonstrated that incorporation of γ-amino acids into protein sequences considerably enhances their stability against proteases, which is an essential prerequisite to use those proteins as drugs under physiological conditions.[23]

Herein we report the combinatorial reaction of seven α,β-unsaturated aldehydes with eight different primary amines in the presence of CO and ethylene to yield the corresponding pyrrolone and pyrrole derivatives. In order to afford the same reaction conditions for all catalytic reactions we used a multi-reactor station manufactured by Advanced ChemTech Inc. This multi-reactor station is set up by 96 autoclaves with a maximum working capacity of 3.5 mL each. The reaction vessel block is covered by a top clamp plate with a septum and valve membrane sheet and is connected to a gas mixing facility allowing for the preparation of mixtures of gaseous substrates with different partial pressures (Figure 1).

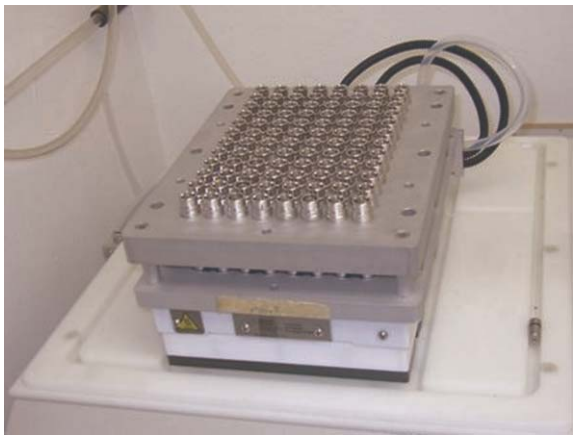


Figure 1 Multi-reactor station (without cover plate)

Initially, we planned to use ionic liquids as reaction media because we have been able to demonstrate that optimization of the reaction conditions of the reaction depicted in Scheme 1 in $[C_4mim][BTA]$ led to milder conditions with regard to reaction time and partial pressures of the gaseous substrates than when performed in classical organic solvents.[24] Beforehand only a limited number of transition-metal-catalyzed reactions in ionic liquids proceeding

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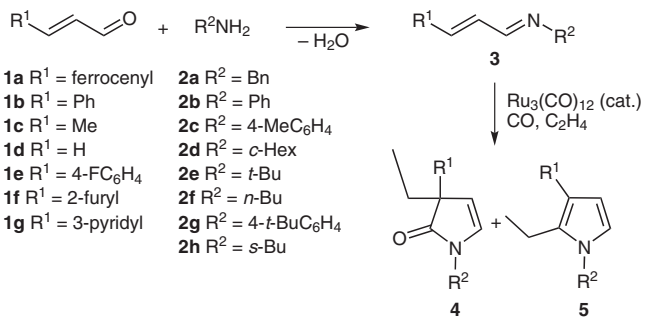
via C–H activation steps have been reported, including activation of methane, dehydrogenation of cyclooctadiene, isomerization of alkenes, or C–H activation of terminal alkynes.[25–29] Unfortunately, this reaction does not work in ionic liquids if the multi-reactor station shown in Figure 1 is employed. This is most probably due to the low solubility of CO in ionic liquids[30] in combination with the small surface, which is caused by the slim layout of the autoclaves. Nevertheless, combinatoric synthesis of heterocyclic compounds was efficiently achieved in toluene as the solvent.

Table 1 shows the primary amines and α,β-unsaturated aldehydes that have been introduced to the catalytic reaction to form the 1,3-dihydropyrrolones and 2,3-disubstituted pyrroles, respectively, after reacting with CO and ethylene in the presence of $Ru_3(CO)_{12}$ as a precatalyst (Scheme 2). Exploratory analysis at the multi-reactor station showed that the temperature in the middle of the block differs about 10 °C from the reaction vessels at the outside of the block. In order to afford the same reaction conditions for all catalytic reactions the outer autoclaves were not used. Thus, eight primary amines were combined with seven α,β-unsaturated aldehydes. Workup was easily achieved by removing the solvent under reduced pressure and the oily residue was used to get an impression of the outcome of the products **4** and **5** via ^{1}H NMR spectroscopy. The products were finally separated by column chromatography and characterized by IR, ^{1}H, and ^{13}C NMR spectroscopy as well as by mass spectrometry and high-resolution mass spectrometry (cf. experimental part).



Scheme 2 Four-component reaction leading to heterocyclic products of type **4** and **5**, all combinations of R^1 and R^2 were used in the experiments

Table 2 shows the combination of eight amines with seven aldehydes and the yields of the corresponding products **4** and **5**. From the entries in Table 2 it can be concluded that most combinations for the catalytic transformation of primary amines and unsaturated aldehydes to the heterocyclic products work very well. Acrolein and *tert*-butylamine are the only substrates examined that did not react at all. One reason in the case of acrolein might be that it is too reactive and does not even lead to the intermediate imine after combination with an amine. The resulting ^{1}H NMR spectra of crude reaction mixtures showed no signals indicating the heterocyclic products of type **4** and **5**,

Table 1 Primary Amines and α,β-Unsaturated Aldehydes Used in the Experiments

Amines	Aldehydes
2a: benzylamine	**1a**: 3-ferrocenylpropenal
2b: aniline	**1b**: *trans*-cinnamaldehyde
2c: *p*-toluidine	**1c**: *trans*-crotonic aldehyde
2d: cyclohexylamine	**1d**: acrolein
2e: *tert*-butylamine	**1e**: *trans*-4-fluorocinnamaldehyde
2f: *n*-butylamine	**1f**: 3-(2-furyl)acrolein
2g: 4-*tert*-butylaniline	**1g**: *trans*-3-(3-pyridyl)acrolein
2h: *sec*-butylamine	

which are easily identified by two doublets in the range of 5–7 ppm. Moreover, there was also no signal corresponding to the CH function of imines or even the starting aldehyde. Signals in the aliphatic and olefinic region of the spectrum might be indicative for the formation of oligomeric or polymeric products. In contrast, in the case of the *tert*-butylamine it is most probably rather a matter of steric pressure preventing the catalytic reaction. Additional reactions combining *trans*-cinnamaldehyde with *tert*-butylamine and 2,6-diisopropylphenylamine showed that it is indeed possible to get the unsaturated imine but not at all the catalytic reaction products. Other aliphatic amines give both heterocyclic products **4** and **5** when reacted with the aldehydes used. In the case of *sec*-butylamine two diastereomeric pairs of enantiomers are produced, as can be seen from the NMR data in which signals representing atoms in close proximity to one of the stereogenic centers are doubled. Moreover, aromatic amines, for example, aniline just react with 3-ferrocenylpropenal and 3-(2-furyl)acrolein to a mixture of the corresponding lactam and pyrrole. Otherwise it can be observed that just the pyrrole derivative is formed with a yield of about 50%. There is just one exception for the combination of 3-(2-furyl)acrolein with aniline where also just the pyrrole is formed. In general, it has to be pointed out that water that is produced by the condensation reaction of the aldehyde with the respective amine leads to an enhanced yield of the corresponding pyrrole compared to the reaction conditions in which the pure imine would have been introduced to the catalytic heterocycle formation in anhydrous toluene.

All amines and aldehydes except 3-ferrocenylpropenal were purchased from Sigma-Aldrich and were used without further purification. *sec*-Butylamine was used as a racemic mixture. 3-Ferrocenylpropenal was prepared by alkylation of ferrocene with 1,1,3,3-tetramethoxypropane.[31] All catalytic reaction procedures were carried out under an argon atmosphere in freshly distilled, anhydrous solvents.[32] The multi-reactor station was purchased from Advanced ChemTech Inc. Support now is provided by Activotec Inc. (http://www.activotec.com/). NMR spectra were recorded at 298 K on a Bruker AC 200 spectrometer (^{1}H: 200 MHz; ^{13}C: 50.32 MHz; $CDCl_3$ as internal standard), a Bruker DRX 400 spectrometer (^{1}H: 400.13 MHz; ^{13}C: 100.62 MHz; $CDCl_3$ as internal standard) or

Table 2 Used Aldehydes and Amines, Isolated Yields of **4** and **5**, and Numbering Scheme of All Products

R^2	R^1 = Fc		R^1 = Ph		R^1 = Me		R^1 = H		R^1 = 4-FC_6H_4		R^1 = 2-furyl		R^1 = 3-pyridyl	
	Yield (%)		Yield (%)		Yield (%)		Yield (%)		Yield (%)		Yield (%)		Yield (%)	
	4	**5**	**4**	**5**	**4**	**5**	**4**	**5**	**4**	**5**	**5**	**4**	**5**	**4**
$PhCH_2$ (**aa**–**ga**)	66	30	42	50	22	50	–	–	65	28	57	43	59	35
Ph (**ab**–**gb**)	45	53	–	57	–	57	–	–	–	57	–	47	55	45
4-MeC_6H_4 (**ac**–**gc**)	45	52	–	47	–	47	–	–	–	57	40	55	35	54
c-Hex (**ad**–**gd**)	57	42	46	48	46	27	–	–	52	34	60	37	46	49
t-Bu (**ae**–**ge**)	–	–	–	–	–	–	–	–	–	–	–	–	–	–
n-Bu (**af**–**gf**)	67	25	58	40	50	49	–	–	55	33	60	36	54	32
4-*t*-BuC_6H_4 (**ag**–**gg**)	54	44	–	52	–	46	–	–	–	54	42	41	64	31
s-Bu (**ah**–**gh**)	68	28	51	42	51	27	–	–	41	52	57	38	40	43

a Bruker Ultrashield 600+ (^{1}H: 600.15 MHz; ^{13}C: 150.91 MHz; $CDCl_3$ as internal standard). Mass spectra were recorded on a Finnigan MAT SSQ 710 instrument using direct electron impact (DEI) techniques. High-resolution mass spectra were recorded on a Finnigan MAT 95 XL using EI techniques. IR spectra were recorded at 298 K on a Shimadzu IRAffinity-1 (FTIR) at the laboratory of the Institute of Organic Chemistry and Macromolecular Chemistry of Friedrich-Schiller-University of Jena.

One-Pot Synthesis of γ-Lactams and Pyrroles; General Procedure

Each reaction vessel was charged with a primary amine **2** (1 mmol), an α,β-unsaturated aldehyde **1** (1 mmol) as well as $Ru_3(CO)_{12}$ (19 mg, 0.03 mmol) and anhyd, freshly distilled toluene (1.5 mL). Afterwards, the multi-reactor station was pressurized with CO (12 bar) and ethylene (8 bar), and heated up to 140 °C for a reaction time of 16 h. After the autoclaves had cooled to r.t., the reaction mixtures were transferred to Schlenk tubes. The solvent was removed in vacuo and the remaining oily residue was used to determine yields of the products **4** and **5** by ^{1}H NMR spectroscopy. If resonances corresponding to the respective products were observed, the solvent used for the ^{1}H NMR spectroscopic investigation was removed under reduced pressure. Preparative separation of **4** and **5** was achieved by column chromatography (10 × 2 cm, silica gel). Using a mixture of light petroleum (bp 40–60 °C) and CH_2Cl_2, depending on the reaction mixture, led to elution of **5**, whereas **4** was obtained by using EtOH as eluent. The exact ratio of solvents for the elution of all derivatives of **4** and **5** are specified in connection with the physical data of each compound (vide infra). Analytical data of **4ba** and **5ba** are in accordance with values published earlier by us.[13] All compounds were either light yellow (R^1 = aliphatic moiety) or yellow-orange (R^1 = aromatic) oils.

N-Benzyl-3-ethyl-3-ferrocenyl-1,3-dihydropyrrol-2-one (4aa)

Yield: 253 mg (66%); eluent: EtOH.

IR (neat): 3090 (w), 2967 (w), 2932 (w), 2874 (w), 2021 (m), 1952 (m), 1694 (s), 1605 (m), 1354 (s), 1103 (s), 999 (s), 818 (vs), 698 cm^{-1} (vs).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.74 (t, *J* = 7.4 Hz, 2 H), 1.16 (t, *J* = 7.5 Hz, 1 H), 1.83 (q, *J* = 7.4 Hz, 1.3 H), 2.23 (q, *J* = 7.6 Hz, 0.6 H), 4.09–4.47 (m, 4 H), 4.65 (AB spin system, *J* = 14.8, 51.3 Hz, 2 H), 5.45 (d, *J* = 4.8 Hz, 1 H), 6.44 (d, *J* = 4.8 Hz, 1 H), 7.28–7.31 (m, 5 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 9.2, 9.8,, 29.6, 32.9, 43.5, 45.6, 54.2, 65.8, 66.5, 67.2, 67.8, 68.5, 87.9, 113.7, 127.7, 128.1, 128.8, 130.2, 136.7, 179.2.

MS (DEI): *m*/*z* (%) = 385 (100, [M^+]), 356 (50, [M^+ – Et]), 265 (21, [$M^+ – C_9H_{12}$]), 91 (30, [$C_7H_7^+$]).

HRMS: *m*/*z* calcd for $C_{23}H_{23}{}^{54}FeNO$: 383.11759; found: 383.11679, Δ = 0.80 mmu.

N-Benzyl-2-ethyl-3-ferrocenylpyrrole (5aa)

Yield: 110 mg (30%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 1.12 (t, *J* = 7.6 Hz, 3 H), 2.68 (q, *J* = 7.6 Hz, 2 H), 4.07 (s, 5 H), 4.18 (t, *J* = 1.8 Hz, 2 H), 4.43 (t, *J* = 1.8 Hz, 2 H), 5.04 (s, 2 H), 6.30 (d, *J* = 2.8 Hz, 1 H), 6.54 (d, *J* = 2.8 Hz, 1 H), 6.99–7.31 (m, 5 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.9, 18.1, 50.2, 66.7, 67.2, 69.1, 83.2, 108.0, 117.1, 120.2, 126.2, 127.3, 128.7, 131.0, 138.8.

MS (DEI): *m*/*z* (%) = 369 (100, [M^+]), 354 (6, [M^+ – Me]), 278 (9, [$M^+ – C_7H_7$]), 263 (22, [$M^+ – C_8H_{10}$]), 91 (22, [$C_7H_7^+$]).

HRMS: *m*/*z* calcd for $C_{23}H_{23}{}^{54}FeN$: 367.12267; found: 367.12247, Δ = 0.2 mmu.

3-Ethyl-3-ferrocenyl-*N*-phenyl-1,3-dihydropyrrol-2-one (4ab)

Yield: 166 mg (45%); eluent: EtOH.

IR (neat): 2955 (m), 2924 (vs), 2855 (m), 1717 (s), 1701 (s), 1597 (m), 1501 (s), 1458 (m), 1385 (m), 1273 (s), 1211 (m), 1072 (m), 741 (vs), 691 cm^{-1} (vs).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.80 (t, *J* = 7.4 Hz, 3 H), 1.86 (q, *J* = 7.4 Hz, 2 H), 4.05 (s, 5 H), 4.11–4.55 (m, 4 H), 5.66 (d, *J* = 5.2 Hz, 1 H), 6.99 (d, *J* = 5.2 Hz, 1 H), 7.10–7.58 (m, 5 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 8.3, 32.7, 54.1, 65.4, 67.3, 67.5, 86.5, 113.4, 120.3, 124.5, 128.2, 129.6, 136.0, 176.8.

MS (DEI): *m*/*z* (%) = 371 (100, [M^+]), 342 (58, [M^+ – Et]), 314 (6, [M^+ – Et – CO]), 121 (6, [$FeC_5H_5^+$]), 77 (7, [Ph^+]).

HRMS: *m*/*z* calcd for $C_{22}H_{21}{}^{54}FeNO$: 369.10194; found: 369.10251, Δ = 0.57 mmu.

2-Ethyl-3-ferrocenyl-*N*-phenylpyrrole (5ab)

Yield: 188 mg (53%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.98 (t, *J* = 7.4 Hz, 3 H), 2.74 (q, *J* = 7.4 Hz, 2 H), 4.13 (s, 5 H), 4.22 (t, *J* = 1.8 Hz, 2 H), 4.46 (t,

J = 1.8 Hz, 2 H), 6.38 (d, J = 3.0 Hz, 1 H), 6.68 (d, J = 3.0 Hz, 1 H), 7.32– 7.50 (m, 5 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.7, 18.2, 67.1, 67.3, 69.1, 83.0, 109.1, 117.8, 121.1, 126.4, 127.1, 129.0, 131.6, 140.5.

MS (DEI): m/z (%) = 355 (100, [M^+]), 340 (14, [M^+ – Me]), 170 (10, [$M^+ – C_{10}H_9Fe$]).

HRMS: m/z calcd for $C_{22}H_{21}{}^{54}FeN$: 353.10702; found: 353.10452, Δ = 2.50 mmu.

3-Ethyl-3-ferrocenyl-*N*-*p*-tolyl-1,3-dihydropyrrol-2-one (4ac)
Yield: 174 mg (45%); eluent: EtOH.

IR (neat): 2963 (w), 2924 (m), 2855 (w), 1956 (w), 1709 (s), 1612 (m), 1512 (vs), 1454 (m), 1385 (s), 1204 (s), 999 (m), 814 (vs), 702 cm^{-1} (m).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.80 (t, J = 7.4 Hz, 3 H), 1.85 (q, J = 7.4 Hz, 2 H), 2.34 (s, 3 H), 4.05 (s, 5 H), 4.11–4.56 (m, 4 H), 5.66 (d, J = 5.0 Hz, 1 H), 6.95 (d, J = 5.0 Hz, 1 H), 7.22 (dd, J = 2.0 Hz, J = 6.7 Hz, 2 H), 7.43 (dd, J = 2.0, 6.7 Hz, 2 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 9.3, 20.9, 33.7, 55.0, 66.0, 68.0, 68.5, 87.5, 114.1, 120.3, 129.7, 130.9, 134.4, 135.3, 177.8.

MS (DEI): m/z (%) = 385 (100, [M^+]), 356 (25, [M^+ – Et]), 328 (4, [M^+ – Et – CO]), 121 (4, [$FeC_5H_5^+$]).

HRMS: m/z calcd for $C_{23}H_{23}{}^{54}FeNO$: 383.11759; found: 383.11799, Δ = 0.40 mmu.

2-Ethyl-3-ferrocenyl-*N*-*p*-tolylpyrrole (5ac)
Yield: 192 mg (52%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.99 (t, J = 7.4 Hz, 3 H), 2.43 (s, 3 H), 2.72 (q, J = 7.4 Hz, 2 H), 4.13 (s, 5 H), 4.21 (t, J = 1.8 Hz, 2 H), 4.46 (t, J = 1.8 Hz, 2 H), 6.37 (d, J = 2.8 Hz, 1 H), 6.65 (d, J = 2.8 Hz, 1 H), 7.24 (s, 4 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.7, 18.2, 21.1, 67.1, 67.3, 69.1, 83.1, 108.8, 117.4, 121.1, 126.3, 129.6, 131.7, 137.0, 138.0.

MS (DEI): m/z (%) = 369 (100, [M^+]), 354 (9, [M^+ – Me]), 339 (4, [$M^+ – C_2H_6$]), 185 (4, [$FeC_{10}H_9^+$]), 121 (7, [$FeC_5H_5^+$]).

HRMS: m/z calcd for $C_{23}H_{23}{}^{54}FeN$: 367.12267; found: 367.12031, Δ = 2.36 mmu.

***N*-Cyclohexyl-3-ethyl-3-ferrocenyl-1,3-dihydropyrrol-2-one (4ad)**
Yield: 216 mg (57%); eluent: EtOH.

IR (neat): 3094 (w), 2932 (m), 2855 (w), 1967 (w), 1686 (s), 1605 (m), 1450 (m), 1377 (s), 1254 (m), 999 (s), 818 (vs), 752 (vs), 691 cm^{-1} (s).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 0.69 (t, J = 7.2 Hz, 3 H), 1.12–1.70 (m, 10 H), 1.80 (q, J = 7.2 Hz, 2 H), 3.94–3.98 (m, 1 H), 4.03 (s, 5 H), 4.05–4.47 (m, 4 H), 5.43 (d, J = 4.8 Hz, 1 H), 6.60 (d, J = 5.0 Hz, 1 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 9.1, 25.4, 32.0, 32.3, 33.5, 50.3, 54.6, 65.8, 66.5, 67.1, 67.8, 68.5, 87.9, 113.3, 127.8, 178.6.

MS (DEI): m/z (%) = 377 (100, [M^+]), 348 (54, [M^+ – Et]), 266 (16, [$M^+ – C_8H_{15}$]), 83 (30, [$C_6H_{11}^+$]).

HRMS: m/z calcd for $C_{22}H_{27}{}^{54}FeNO$: 375.14889; found: 375.14465, Δ = 4.24 mmu.

***N*-Cyclohexyl-2-ethyl-3-ferrocenylpyrrole (5ad)**
Yield: 153 mg (42%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.20 (t, J = 7.6 Hz, 3 H), 1.38–2.03 (m, 10 H), 2.76 (q, J = 7.6 Hz, 2 H), 3.74–3.82 (m, 1 H), 4.09 (s, 5 H), 4.16 (t, J = 1.6 Hz, 2 H), 4.38 (t, J = 1.6 Hz, 2 H), 6.25 (d, J = 3.2 Hz, 1 H), 6.61 (d, J = 3.2 Hz, 1 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 15.4, 17.9, 25.5, 26.1, 34.9, 54.7, 67.0, 69.0, 83.8, 107.9, 115.1, 115.5, 130.1.

MS (DEI): m/z (%) = 361 (100, [M^+]), 331 (2, [$M^+ – C_2H_6$]), 279 (3, [$M^+ – C_6H_{10}$]), 264 (6, [$M^+ – C_7H_{13}$]), 83 (11, [$C_6H_{11}^+$]).

HRMS: m/z calcd for $C_{22}H_{27}{}^{54}FeN$: 359.15397; found: 359.15152, Δ = 2.45 mmu.

***N*-Butyl-3-ethyl-3-ferrocenyl-1,3-dihydropyrrol-2-one (4af)**
Yield: 236 mg (67%); eluent: EtOH.

IR (neat): 2959 (w), 2932 (w), 2874 (vw), 1967 (vw), 1694 (vs), 1454 (m), 1377 (m), 1261 (m), 1107 (s), 999 (s), 818 (vs), 691 cm^{-1} (m).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.72 (t, J = 7.4 Hz, 3 H), 0.93 (t, J = 7.2 Hz, 3 H), 1.33–1.37 (m, 2 H), 1.56–1.60 (m, 2 H), 1.77 (q, J = 7.4 Hz, 2 H), 3.28–3.64 (m, 2 H), 4.03 (s, 5 H), 4.05–4.43 (m, 4 H), 5.44 (d, J = 5.0 Hz, 1 H), 6.50 (d, J = 5.0 Hz, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 9.2, 13.7, 20.0, 31.1, 33.0, 41.5, 54.3, 65.9, 66.6, 67.1, 67.8, 68.5, 88.0, 113.3, 130.8, 179.3.

MS (DEI): m/z (%) = 351 (100, [M^+]), 322 (63, [M^+ – Et]), 280 (9, [$M^+ – C_5H_{11}$]), 121 (5, [$FeC_5H_5^+$]).

HRMS: m/z calcd for $C_{20}H_{25}{}^{54}FeNO$ (349.13324): 349.13138, Δ = 1.86 mmu.

***N*-Butyl-2-ethyl-3-ferrocenylpyrrole (5af)**
Yield: 84 mg (25%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.97 (t, J = 7.2 Hz, 3 H), 1.22 (t, J = 7.4 Hz, 3 H), 1.39–1.43 (m, 2 H), 1.72–1.76 (m, 2 H), 2.74 (q, J = 7.4 Hz, 2 H), 3.79 (t, J = 7.4 Hz, 2 H), 4.08 (s, 5 H), 4.17 (t, J = 1.8 Hz, 2 H), 4.40 (t, J = 1.8 Hz, 2 H), 6.24 (d, J = 3.0 Hz, 1 H), 6.53 (d, J = 3.0 Hz, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 13.8, 15.0, 17.9, 20.1, 33.7, 46.2, 66.9, 67.1, 69.1, 83.6, 107.7, 116.1, 118.7, 130.2.

MS (DEI): m/z (%) = 335 (100, [M^+]), 320 (9, [M^+ – Me]), 306 (4, [M^+ – Et]), 291 (2, [$M^+ – C_3H_8$]), 186 (3, [$FeC_{10}H_{10}$]).

HRMS: m/z calcd for $C_{20}H_{25}{}^{54}FeN$: 333.13832; found: 333.13537, Δ = 2.95 mmu.

***N*-(4-*tert*-Butylphenyl)-3-ethyl-3-ferrocenyl-1,3-dihydropyrrol-2-one (4ag)**
Yield: 230 mg (54%); eluent: EtOH.

IR (neat): 2962 (m), 2365 (s), 2330 (m), 1697 (vs), 1616 (m), 1516 (vs), 1454 (s), 1389 (s), 1204 (s), 999 (s), 818 (vs), 706 cm^{-1} (s).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.79 (t, J = 7.4 Hz, 3 H), 1.31 (s, 9 H), 1.85 (q, J = 7.4 Hz, 2 H), 4.05 (s, 5 H), 4.02–4.56 (m, 4 H), 5.63 (d, J = 5.2 Hz, 1 H), 6.96 (d, J = 5.2 Hz, 1 H), 7.45 (d, J = 3.8 Hz, 4 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 8.3, 30.3, 32.7, 33.5, 54.0, 64.9, 65.8, 66.1, 67.0, 68.5, 86.6, 113.2, 120.0, 125.1, 129.8, 133.4, 147.6, 176.8.

MS (DEI): m/z (%) = 427 (100, [M^+]), 398 (55, [M^+ – Et]), 370 (2, [M^+ – Et – CO]), 313 (2, [M^+ – Et – CO – C_4H_9]), 121 (11, [$FeC_5H_5^+$]).

HRMS: m/z calcd for $C_{26}H_{29}{}^{54}FeNO$: 425.16454; found: 425.16345, Δ = 1.09 mmu.

***N*-(4-*tert*-Butylphenyl)-2-ethyl-3-ferrocenylpyrrole (5ag)**
Yield: 180 mg (44%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.00 (t, *J* = 7.6 Hz, 3 H), 1.38 (s, 9 H), 2.72 (q, *J* = 7.6 Hz, 2 H), 4.13 (s, 5 H), 4.21 (t, *J* = 1.6 Hz, 2 H), 4.46 (t, *J* = 1.6 Hz, 2 H), 6.37 (d, *J* = 2.8 Hz, 1 H), 6.66 (d, *J* = 2.8 Hz, 1 H), 7.26 (d, *J* = 2.8 Hz, 2 H), 7.45 (d, *J* = 2.8 Hz, 2 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.8, 18.2, 31.4, 34.6, 67.1, 67.3, 69.1, 83.2, 108.8, 117.4, 121.1, 125.8, 126.0, 131.7, 137.9, 150.2.

MS (DEI): *m*/*z* (%) = 411 (100, [M$^+$]), 396 (6, [M$^+$ – Me]), 339 (4, [M$^+$ – C_5H_{12}]), 266 (10, [$C_{11}H_{13}^+$]), 121 (6, [$FeC_5H_5^+$]).

HRMS: *m*/*z* calcd for $C_{26}H_{29}{}^{54}FeN$: 409.16962; found: 409.16677, Δ = 2.85 mmu.

N-sec-Butyl-3-ethyl-3-ferrocenyl-1,3-dihydropyrrol-2-one (4ah)
Yield: 239 mg (68%); eluent: EtOH.

IR (neat): 3094 (vw), 2967 (w), 2932 (vw), 2874 (vw), 1967 (w), 1686 (vs), 1605 (m), 1454 (m), 1381 (s), 1258 (s), 999 (s), 818 (vs), 752 cm^{-1} (s).

^{1}H NMR (600 MHz, $CDCl_3$): δ = 0.69 (t, *J* = 7.2 Hz, 3 H), 0.84 (t, *J* = 7.6 Hz, 3 H), 1.13 (d, *J* = 6.7 Hz, 1.8 H), 1.20 (d, *J* = 6.9 Hz, 1.2 H), 1.52–1.57 (m, 2 H), 1.69–1.88 (m, 2 H), 3.98–4.02 (m, 1 H), 4.00–4.04 (m, 2 H), 4.03 (s, 5 H), 4.23–4.27 (m, 2 H), 5.40 (d, *J* = 4.8 Hz, 0.6 H), 5.43 (d, *J* = 4.8 Hz, 0.4 H), 6.49 (d, *J* = 4.8 Hz, 0.6 H), 6.50 (d, *J* = 4.8 Hz, 0.4 H).

^{13}C NMR (150 MHz, $CDCl_3$): δ = 8.0, 8.4, 9.8, 10.0, 18.4, 18.6, 27.5, 27.8, 31.3, 32.2, 47.1, 47.6, 53.7, 53.8, 64.8, 64.9, 65.3, 65.6, 66.1, 66.4, 66.7, 66.8, 67.5, 87.2, 87.8, 112.7, 113.0, 126.2, 126.6, 178.1, 178.2.

MS (DEI): *m*/*z* (%) = 351 (100, [M$^+$]), 323 (18, [M$^+$ – CO]), 322 (73, [M$^+$ – Et]), 266 (18, [M$^+$ – C_6H_{13}]), 121 (12, [$FeC_5H_5^+$]).

HRMS: *m*/*z* calcd for $C_{20}H_{25}{}^{54}FeNO$: 349.13324; found: 349.13179, Δ = 1.45 mmu.

N-sec-Butyl-2-ethyl-3-ferrocenylpyrrole (5ah)
Yield: 94 mg (28%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (600 MHz, $CDCl_3$): δ = 0.76 (t, *J* = 7.2 Hz, 3 H), 1.12 (t, *J* = 7.2 Hz, 3 H), 1.32 (d, *J* = 7.2 Hz, 3 H), 1.67 (q, *J* = 7.2 Hz, 2 H), 2.67–2.75 (m, 2 H), 3.88 (q, *J* = 7.2 Hz, 1 H), 3.99 (s, 5 H), 4.10 (d, *J* = 7.2 Hz, 2 H), 4.33 (d, *J* = 7.2 Hz, 2 H), 6.17 (d, *J* = 3.0 Hz, 1 H), 6.47 (d, *J* = 3.0 Hz, 1 H).

^{13}C NMR (150 MHz, $CDCl_3$): δ = 10.0, 14.3, 16.9, 21.2, 30.2, 51.2, 65.9, 66.1, 68.1, 82.9, 107.0, 113.4, 114.3, 129.7.

MS (DEI): *m*/*z* (%) = 335 (100, [M$^+$]), 320 (6, [M$^+$ – Me]), 306 (2, [M$^+$ – Et]), 278 (2, [M$^+$ – C_4H_9]).

HRMS: *m*/*z* calcd for $C_{20}H_{25}{}^{54}FeN$: 333.13832; found: 333.13618, Δ = 2.14 mmu.

2-Ethyl-_N_,3-diphenylpyrrole (5bb)
Yield: 140 mg (57%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.92 (t, *J* = 7.4 Hz, 3 H), 2.78 (q, *J* = 7.4 Hz, 2 H), 6.39 (d, *J* = 2.8 Hz, 1 H), 6.76 (d, *J* = 2.8 Hz, 1 H), 7.35–7.50 (m, 10 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.3, 17.7, 108.5, 121.3, 122.3, 125.1, 126.3, 127.1, 127.8, 128.0, 128.8, 131.4, 137.1, 140.2.

MS (DEI): *m*/*z* (%) = 247 (100, [M$^+$]), 232 (83, [M$^+$ – Me]), 141 (5, [M$^+$ – C_8H_{10}]), 91 (15, [$C_7H_7^+$]), 77 (22, [Ph$^+$]).

HRMS: *m*/*z* calcd for $C_{18}H_{17}N$: 247.13610; found: 247.13522 (M$^+$), Δ = 0.88 mmu.

2-Ethyl-3-phenyl-_N_-_p_-tolylpyrrole (5bc)
Yield: 122 mg (47%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.93 (t, *J* = 7.4 Hz, 3 H), 2.43 (s, 3 H), 2.76 (q, *J* = 7.4 Hz, 2 H), 6.37 (d, *J* = 2.8 Hz, 1 H), 6.73 (d, *J* = 2.8 Hz, 1 H), 7.22–7.49 (m, 9 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.7, 18.1, 21.1, 108.5, 121.6, 122.4, 125.3, 126.4, 128.1, 128.3, 129.6, 131.8, 137.3, 137.4, 138.0.

MS (DEI): *m*/*z* (%) = 261 (100, [M$^+$]), 246 (82, [M$^+$ – Me]), 168 (4, [M$^+$ – C_7H_9]), 154 (4, [M$^+$ – C_8H_{11}]), 91 (7, [$C_7H_7^+$]).

HRMS: *m*/*z* calcd for $C_{19}H_{19}N$: 261.15175; found: 261.15148 (M$^+$), Δ = 0.27 mmu.

_N_-Cyclohexyl-3-ethyl-3-phenyl-1,3-dihydropyrrol-2-one (4bd)
Yield: 125 mg (46%); eluent: EtOH.

IR (neat): 2924 (s), 2855 (m), 1967 (w), 1700 (m), 1601 (w), 1447 (m), 1377 (m), 1253 (m), 752 (s), 698 cm^{-1} (vs).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.78 (t, *J* = 7.4 Hz, 3 H), 1.11–1.78 (m, 10 H), 1.99 (q, *J* = 7.4 Hz, 2 H), 3.86–3.93 (m, 1 H), 5.57 (d, *J* = 5.0 Hz, 1 H), 6.61 (d, *J* = 5.0 Hz, 1 H), 7.18–7.45 (m, 5 H).

^{13}C NMR (500 MHz, $CDCl_3$): δ = 9.0, 25.4, 31.0, 31.7, 32.1, 50.4, 58.8, 113.3, 126.6, 126.8, 128.3, 128.4, 140.2, 179.1.

MS (DEI): *m*/*z* (%) = 269 (100, [M$^+$]), 240 (59, [M$^+$ – Et]), 187 (13, [M$^+$ – C_6H_{10}]), 172 (12, [M$^+$ –C_7H_{13}]), 158 (48, [M$^+$ – C_8H_{15}]), 77 (5, [Ph$^+$]).

HRMS: *m*/*z* calcd for $C_{18}H_{23}NO$: 269.17796; found: 269.17795, Δ = 0.01 mmu.

_N_-Cyclohexyl-2-ethyl-3-phenylpyrrole (5bd)
Yield: 122 mg (48%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 1.24 (t, *J* = 7.4 Hz, 3 H), 1.34–2.07 (m, 10 H), 2.74 (q, *J* = 7.4 Hz, 2 H), 3.77–3.92 (m, 1 H), 6.27 (d, *J* = 3.0 Hz, 1 H), 6.71 (d, *J* = 3.0 Hz, 1 H), 7.18–7.41 (m, 5 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 15.6, 17.8, 25.5, 26.1, 35.0, 55.0, 107.7, 115.8, 120.8, 125.0, 128.0, 128.2, 130.1, 137.8.

MS (DEI): *m*/*z* (%) = 253 (100, [M$^+$]), 238 (18, [M$^+$ – Me]), 224 (4, [M$^+$ – Et]), 170 (3, [M$^+$ – C_6H_{11}]), 156 (8, [M$^+$ – C_7H_{13}]).

HRMS: *m*/*z* calcd for $C_{18}H_{23}N$: 253.18305; found: 253.18344, Δ = 0.39 mmu.

_N_-Butyl-3-ethyl-3-phenyl-1,3-dihydropyrrol-2-one (4bf)
Yield: 142 mg (58%); eluent: EtOH.

IR (neat): 2959 (w), 2932 (w), 2874 (vw), 1686 (s), 1447 (w), 1373 (w), 1261 (m), 1076 (m), 1015 (m), 791 (m), 698 cm^{-1} (vs).

^{1}H NMR (600 MHz, $CDCl_3$): δ = 0.80 (t, *J* = 7.2 Hz, 3 H), 0.90 (t, *J* = 7.2 Hz, 3 H), 1.30 (q, *J* = 7.2 Hz, 2 H), 1.50–1.56 (m, 2 H), 2.00 (q, *J* = 7.2 Hz, 2 H), 3.32–3.48 (m, 2 H), 5.61 (d, *J* = 5.4 Hz, 1 H), 6.52 (d, *J* = 5.4 Hz, 1 H), 7.20–7.44 (m, 5 H).

^{13}C NMR (150 MHz, $CDCl_3$): δ = 9.2, 13.6, 20.0, 31.0, 31.3, 41.7, 58.5, 113.2, 126.7, 126.9, 128.4, 131.5, 140.2, 179.6.

MS (DEI): *m*/*z* (%) = 243 (100, [M$^+$]), 214 (76, [M$^+$ – Et]), 200 (17, [M$^+$ – C_3H_7]), 186 (4, [M$^+$ – C_4H_9]), 172 (50, [M$^+$ – C_3H_7 – CO]).

HRMS: *m*/*z* calcd for $C_{16}H_{21}NO$: 243.16231; found: 243.16213, Δ = 0.18 mmu.

_N_-Butyl-2-ethyl-3-phenylpyrrole (5bf)
Yield: 91 mg (40%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (600 MHz, $CDCl_3$): δ = 0.90 (t, *J* = 7.2 Hz, 3 H), 1.24 (t, *J* = 7.2 Hz, 3 H), 1.42 (dt, *J* = 7.2 Hz, 2 H), 1.76–1.81 (m, 2 H), 2.75 (q, *J* = 7.2 Hz, 2 H), 3.85 (t, *J* = 7.2 Hz, 2 H), 6.26 (d, *J* = 3.0 Hz, 1 H), 6.63 (d, *J* = 3.0 Hz, 1 H), 7.19–7.41 (m, 5 H).

^{13}C NMR (150 MHz, $CDCl_3$): δ = 12.8, 14.2, 16.8, 19.2, 32.8, 45.3, 106.6, 118.3, 120.4, 124.0, 126.9, 127.2, 129.7, 136.8.

MS (DEI): *m*/*z* (%) = 227 (100, [M$^+$]), 212 (72, [M$^+$ – Me]), 198 (27, [M$^+$ – Et]), 184 (26, [M$^+$ – C_3H_7]), 170 (19, [M$^+$ – C_4H_9]).

HRMS: *m*/*z* calcd for $C_{16}H_{21}N$: 227.16740; found: 227.16754, Δ = 0.14 mmu.

***N*-4-*tert*-Butylphenyl-2-ethyl-3-phenylpyrrole (5bg)**
Yield: 158 mg (52%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 1.35 (t, *J* = 7.4 Hz, 3 H), 1.41 (s, 9 H), 2.80 (q, *J* = 7.4 Hz, 2 H), 6.40 (d, *J* = 3.0 Hz, 1 H), 6.77 (d, *J* = 3.0 Hz, 1 H), 7.29–7.53 (m, 9 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.4, 17.8, 31.1, 34.6, 108.3, 120.3, 120.8, 121.3, 122.0, 125.0, 125.7, 127.7, 128.0, 131.5, 137.4, 150.1.

MS (DEI): *m*/*z* (%) = 303 (100, [M$^+$]), 288 (40, [M$^+$ – Me]), 244 (7, [M$^+$ – C_4H_{11}]), 232 (22, [M$^+$ – C_5H_{11}]).

HRMS: *m*/*z* calcd for $C_{22}H_{25}N$: 303.19870; found: 303.19795, Δ = 0.75 mmu.

***N*-*sec*-Butyl-3-ethyl-3-phenyl-1,3-dihydropyrrol-2-one (4bh)**
Yield: 124 mg (51%); eluent: EtOH.

IR (neat): 2967 (m), 2916 (m), 2851 (w), 2361 (w), 1971 (w), 1686 (s), 1601 (m), 1454 (m), 1377 (s), 1253 (m), 907 (m), 752 (vs), 698 cm^{-1} (vs).

^{1}H NMR (600 MHz, $CDCl_3$): δ = 0.70–0.83 (m, 6 H), 1.09 (d, *J* = 6.8 Hz, 1.5 H), 1.13 (d, *J* = 6.8 Hz, 1.5 H), 1.45–1.52 (m, 2 H), 1.94–1.98 (m, 2 H), 4.00 (q, *J* = 6.6 Hz, 1 H), 5.54 (d, *J* = 5.4 Hz, 0.5 H), 5.56 (d, *J* = 5.4 Hz, 0.5 H), 6.51 (d, *J* = 5.4 Hz, 1 H), 7.15 (m, 1 H), 7.22 (m, 2 H), 7.39 (m, 2 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 9.1, 9.3 10.7, 10.8, 19.5, 19.6, 28.5, 29.7, 31.0, 31.2, 48.4, 59.0, 113.5, 113.7, 126.6, 126.7, 126.8, 127.9, 128.0, 128.4, 128.8, 140.2, 179.4.

MS (DEI): *m*/*z* (%) = 243 (100, [M$^+$]), 214 (93, [M$^+$ – Et]), 186 (17, [M$^+$ – C_4H_9]), 158 (43, [M$^+$ – C_4H_9 – CO]), 77 (8, [Ph$^+$]).

HRMS: *m*/*z* calcd for $C_{16}H_{21}NO$: 243.16231; found: 243.16212, Δ = 0.19 mmu.

***N*-*sec*-Butyl-2-ethyl-3-phenylpyrrole (5bh)**
Yield: 95 mg (42%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.89 (t, *J* = 3.7 Hz, 3 H), 1.26 (t, *J* = 7.0 Hz, 3 H), 1.43 (d, *J* = 6.6 Hz, 3 H), 1.78 (q, *J* = 7.4 Hz, 2 H), 2.73 (q, *J* = 7.6 Hz, 2 H), 4.03 (q, *J* = 7.0 Hz, 1 H), 6.29 (d, *J* = 3.0 Hz, 1 H), 6.66 (d, *J* = 3.0 Hz, 1 H), 7.18–7.38 (m, 5 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 11.1, 15.6, 17.7, 22.3, 31.2, 52.5, 109.0, 115.0, 120.6, 124.9, 128.0, 128.2, 130.7, 137.9.

MS (DEI): *m*/*z* (%) = 227 (100, [M$^+$]), 212 (97, [M$^+$ – Me]), 198 (28, [M$^+$ – Et]), 156 (48, [M$^+$ – C_5H_{11}]).

HRMS: *m*/*z* calcd for $C_{16}H_{21}N$: 227.16740; found: 227.16730, Δ = 0.10 mmu.

***N*-Benzyl-3-ethyl-3-methyl-1,3-dihydropyrrol-2-one (4ca)**
Yield: 47 mg (22%); eluent: light petroleum–CH_2Cl_2 (50:50).

IR (neat): 2959 (w), 2928 (m), 2859 (w), 1705 (vs), 1454 (s), 1396 (m), 1273 (s), 1072 (m), 698 cm^{-1} (vs).

^{1}H NMR (200 MHz, $CDCl_3$): d = 0.75 (t, *J* = 7.4 Hz, 3 H), 1.19 (s, 3 H), 1.63 (q, *J* = 7.4 Hz, 2 H), 4.60 (AB spin system, *J* = 15.2, 20.1 Hz, 2 H), 5.24 (d, *J* = 5.0 Hz, 1 H), 6.29 (d, *J* = 5.0 Hz, 1 H), 7.18–7.32 (m, 5 H).

^{13}C NMR (50 MHz, $CDCl_3$): d = 9.1, 23.8, 38.8, 45.5, 68.2, 115.5, 126.3, 127.7, 128.7, 130.8, 137.0, 177.5.

MS (DEI): *m*/*z* (%) = 215 (100, [M$^+$]), 186 (11, [M$^+$ – Et]), 149 (38, [M$^+$ – C_5H_6]), 91 (72, [$C_7H_7^+$]), 65 (8, [$C_5H_5^+$]).

HRMS: *m*/*z* calcd for $C_{14}H_{17}NO$: 215.13101; found: 215.13078, Δ = 0.23 mmu.

***N*-Benzyl-2-ethyl-3-methylpyrrole (5ca)**
Yield: 100 mg (50%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (200 MHz, $CDCl_3$): d = 1.01 (t, *J* = 7.6 Hz, 3 H), 2.10 (s, 3 H), 2.52 (q, *J* = 7.6 Hz, 2 H), 5.03 (s, 2 H), 6.01 (d, *J* = 2.8 Hz, 1 H), 6.53 (d, *J* = 2.8 Hz, 1 H), 7.01–7.38 (m, 5 H).

^{13}C NMR (50 MHz, $CDCl_3$): d = 11.3, 14.6, 17.4, 50.4, 108.7, 114.6, 119.3, 126.3, 126.7, 127.2, 128.6, 130.9.

MS (DEI): *m*/*z* (%) = 199 (52, [M$^+$]), 184 (62, [M$^+$ – Me]), 91 (100, [$C_7H_7^+$]), 65 (13, [$C_5H_5^+$]).

HRMS: *m*/*z* calcd for $C_{14}H_{17}N$: 199.13610; found: 199.13673, Δ = 0.63 mmu.

2-Ethyl-3-methyl-*N*-phenylpyrrole (5cb)
Yield: 106 mg (57%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.96 (t, *J* = 7.4 Hz, 3 H), 2.12 (s, 3 H), 2.56 (q, *J* = 7.4 Hz, 2 H), 6.08 (d, *J* = 2.8 Hz, 1 H), 6.64 (d, *J* = 2.8 Hz, 1 H), 7.26–7.47 (m, 5 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 11.3, 14.5, 17.6, 109.8, 115.5, 120.2, 126.1, 126.8, 128.9, 131.5, 140.8.

MS (DEI): *m*/*z* (%) = 185 (78, [M$^+$]), 170 (100, [M$^+$ – Me]), 77 (15, [Ph$^+$]).

HRMS: *m*/*z* calcd for $C_{13}H_{15}N$: 185.12045; found: 185.11962, Δ = 0.83 mmu.

2-Ethyl-3-methyl-*N*-*p*-tolylpyrrole (5cc)
Yield: 94 mg (47%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.96 (t, *J* = 7.4 Hz, 3 H), 2.12 (s, 3 H), 2.40 (s, 3 H), 2.55 (q, *J* = 7.4 Hz, 2 H), 6.06 (d, *J* = 2.8 Hz, 1 H), 6.61 (d, *J* = 2.8 Hz, 1 H), 7.14–7.24 (m, 4 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 11.3, 14.5, 17.6, 21.0, 109.5, 115.2, 120.2, 126.0, 129.5, 131.6, 136.7, 138.3.

MS (DEI): *m*/*z* (%) = 199 (100, [M$^+$]), 184 (80, [M$^+$ – Me]), 154 (18, [M$^+$ – C_2H_6 – Me$^+$]), 91 (17, [$C_7H_7^+$]), 77 (5, [Ph$^+$]).

HRMS: *m*/*z* calcd for $C_{14}H_{17}N$: 199.13610; found: 199.13607 (M$^+$), Δ = 0.03 mmu.

***N*-Cyclohexyl-3-ethyl-3-methyl-1,3-dihydropyrrol-2-one (4cd)**
Yield: 96 mg (46%); eluent: CH_2Cl_2.

IR (neat): 2928 (vs), 2855 (m), 1971 (m), 1937 (m), 1674 (vs), 1450 (s), 1377 (s), 1258 (s), 1188 (s), 1138 (s), 895 (m), 691 cm^{-1} (m).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.66 (t, *J* = 7.4 Hz, 3 H), 1.09 (s, 3 H), 1.53 (q, *J* = 7.4 Hz, 2 H), 1.20–1.75 (m, 10 H), 3.80–3.86 (m, 1 H), 5.17 (d, *J* = 5.0 Hz, 1 H), 6.43 (d, *J* = 5.0 Hz, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 8.8, 21.9, 25.3, 25.4, 31.7, 32.1, 50.0, 51.2, 115.0, 127.3, 181.5.

MS (DEI): *m*/*z* (%) = 207 (68, [M$^+$]), 192 (7, [M$^+$ – Et]), 178 (100, [M$^+$ – Et]).

HRMS: *m*/*z* calcd for $C_{13}H_{21}NO$: 207.16231; found: 207.16278, Δ = 0.47 mmu.

***N*-Cyclohexyl-2-ethyl-3-methylpyrrole (5cd)**
Yield: 51 mg (27%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 1.11 (t, *J* = 7.4 Hz, 3 H), 1.25–1.94 (m, 10 H), 2.05 (s, 3 H), 2.58 (q, *J* = 7.4 Hz, 2 H), 3.68–3.83 (m, 1 H), 5.96 (d, *J* = 2.8 Hz, 1 H), 6.58 (d, *J* = 2.8 Hz, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 11.2, 15.0, 17.4, 25.5, 26.1, 35.0, 54.9, 108.4, 113.2, 114.5, 130.0.

MS (DEI): *m*/*z* (%) = 191 (88, [M^+]), 176 (100, [M^+ – Me]), 162 (29, [M^+ – Et]).

HRMS: *m*/*z* calcd for $C_{13}H_{21}N$: 191.16740; found: 191.16732, Δ = 0.08 mmu.

_N_-Butyl-3-ethyl-3-methyl-1,3-dihydropyrrol-2-one (4cf)
Yield: 90 mg (50%); eluent: light petroleum–CH_2Cl_2 (50:50).

IR (neat): 2963 (m), 2928 (m), 2874 (w), 1694 (vs), 1458 (m), 1362 (m), 1265 (m), 1192 (m), 1111 (m), 741 (m), 691 cm^{-1} (s).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.68 (t, *J* = 7.4 Hz, 3 H), 0.87 (t, *J* = 7.2 Hz, 3 H), 1.10 (s, 3 H), 1.20–1.31 (m, 2 H), 1.41–1.66 (m, 4 H), 3.31–3.38 (m, 2 H), 5.19 (d, *J* = 5.0 Hz, 1 H), 6.33 (d, *J* = 5.0 Hz, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 8.9, 13.6, 19.8, 22.0, 29.9, 30.9, 41.4, 50.9, 114.9, 130.3, 182.0.

MS (DEI): *m*/*z* (%) = 181 (58, [M^+]), 166 (11, [M^+ – Me]), 152 (100, [M^+ – Et]), 138 (22, [M^+ – C_3H_7]), 110 (62, [M^+ – C_5H_{11}]), 96 (17, [M^+ – C_6H_{13}]).

HRMS: *m*/*z* calcd for $C_{11}H_{19}NO$: 181.14666; found: 181.14621, Δ = 0.45 mmu.

_N_-Butyl-2-ethyl-3-methylpyrrole (5cf)
Yield: 81 mg (49%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.94 (t, *J* = 7.4 Hz, 3 H), 1.11 (t, *J* = 7.4 Hz, 3 H), 1.30–1.41 (m, 2 H), 1.62–1.77 (m, 2 H), 2.04 (s, 3 H), 2.55 (q, *J* = 7.4 Hz, 2 H), 3.85 (t, *J* = 7.4 Hz, 2 H), 5.91 (d, *J* = 2.8 Hz, 1 H), 6.47 (d, *J* = 2.8 Hz, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 11.2, 13.7, 14.7, 17.3, 20.1, 33.9, 46.3, 108.1, 113.8, 118.0, 130.4.

MS (DEI): *m*/*z* (%) = 165 (66, [M^+]), 150 (100, [M^+ – Me]), 136 (30, [M^+ – Et]), 122 (20, [M^+ – C_3H_7]), 108 (31, [M^+ – C_4H_9]), 94 (22, [M^+ – C_5H_{11}]), 28 (24, [$C_2H_4^+$]).

HRMS: *m*/*z* calcd for $C_{11}H_{19}N$: 165.15175; found: 165.15189, Δ = 0.14 mmu.

_N_-(4-*tert*-Butylphenyl)-2-ethyl-3-methylpyrrole (5cg)
Yield: 111 mg (46%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.98 (t, *J* = 7.4 Hz, 3 H), 1.36 (s, 9 H), 2.12 (s, 3 H), 2.56 (q, *J* = 7.4 Hz, 2 H), 6.06 (d, *J* = 2.8 Hz, 1 H), 6.63 (d, *J* = 2.8 Hz, 1 H), 7.21 (d, *J* = 8.0 Hz, 2 H), 7.43 (d, *J* = 8.0 Hz, 2 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 11.3, 14.6, 17.6, 31.4, 34.6, 109.5, 115.2, 120.2, 125.7, 125.8, 131.6, 138.2, 149.8.

MS (DEI): *m*/*z* (%) = 241 (100, [M^+]), 226 (72, [M^+ – Me]), 196 (10, [M^+ – C_3H_9]), 170 (31, [M^+ – C_5H_{11}]), 57 (7, [$C_4H_9^+$]).

HRMS: *m*/*z* calcd for $C_{17}H_{23}N$: 241.18305; found: 241.18335, Δ = 0.30 mmu.

N-sec-Butyl-3-ethyl-3-methyl-1,3-dihydropyrrol-2-one (4ch)
Yield: 93 mg (51%); eluent: CH_2Cl_2.

IR (neat): 2967 (m), 2928 (w), 1694 (vs), 1454 (m), 1381 (m), 1258 (s), 1069 (m), 745 (m), 691 cm^{-1} (s).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.63–0.83 (m, 6 H), 1.10 (s, 1.8 H), 1.08–1.13 (m, 1.8 H), 1.13 (s, 1.2 H), 1.10–1.16 (m, 1.2 H), 1.41–1.71 (m, 4 H), 4.02 (q, *J* = 7.0 Hz, 1 H), 5.21 (d, *J* = 5.0 Hz, 1 H), 6.38 (d, *J* = 5.0 Hz, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 8.9, 9.1, 10.6, 10.7, 19.5, 19.7, 22.2, 22.2, 28.4, 28.5, 29.9, 47.9, 48.1, 51.3, 51.4, 115.3, 126.7, 126.8, 181.9.

MS (DEI): *m*/*z* (%) = 181 (50, [M^+]), 152 (100, [M^+ – Et]), 124 (30, [M^+ – C_4H_9]), 110 (7, [M^+ – C_5H_{11}]), 96 (42, [M^+ – C_6H_{13}]), 57 (11, [$C_4H_9^+$]).

HRMS: *m*/*z* calcd for $C_{11}H_{19}NO$: 181.14666; found: 181.14699, Δ = 0.33 mmu.

N-sec-Butyl-2-ethyl-3-methylpyrrole (5ch)
Yield: 45 mg (27%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.84 (t, *J* = 7.4 Hz, 3 H), 1.10 (t, *J* = 7.6 Hz, 3 H), 1.37 (d, *J* = 6.8 Hz, 3 H), 1.66–1.81 (m, 2 H), 2.05 (s, 3 H), 2.57 (q, *J* = 7.6 Hz, 2 H), 3.93 (q, *J* = 6.8 Hz, 1 H), 5.98 (d, *J* = 3.0 Hz, 1 H), 6.53 (d, *J* = 3.0 Hz, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 11.0, 11.2, 15.0, 17.3, 22.2, 31.1, 52.4, 108.6, 112.9, 113.8, 130.5.

MS (DEI): *m*/*z* (%) = 165 (85, [M^+]), 150 (100, [M^+ – Me]), 136 (40, [M^+ – Et]), 122 (19, [M^+ –C_3H_7]), 108 (18, [M^+ – C_4H_9]), 94 (64, [M^+ – C_5H_{11}]), 57 (25, [$C_4H_9^+$]).

HRMS: *m*/*z* calcd for $C_{11}H_{19}N$: 165.15175; found: 165.15098, Δ = 0.77 mmu.

_N_-Benzyl-3-ethyl-3-(4-fluorophenyl)-1,3-dihydropyrrol-2-one (4ea)
Yield: 193 mg (65%); eluent: EtOH.

IR (neat): 2967 (w), 2932 (w), 1967 (w), 1682 (s), 1601 (s), 1508 (vs), 1393 (m), 1358 (s), 1227 (vs), 1157 (s), 1076 (m), 833 (vs), 729 (vs), 698 cm^{-1} (vs).

^{1}H NMR (600 MHz, $CDCl_3$): δ = 0.74 (t, *J* = 7.2 Hz, 2.25 H), 1.10 (t, *J* = 7.6 Hz, 0.75 H), 1.94 (q, *J* = 7.2 Hz, 1.5 H), 2.16 (q, *J* = 7.6 Hz, 0.5 H), 4.52 (AB spin system, *J* = 15.0, 85.1 Hz, 2 H), 5.54 (d, *J* = 4.8 Hz, 1 H), 6.39 (d, *J* = 4.8 Hz, 1 H), 6.91–7.39 (m, 9 H).

^{13}C NMR (150 MHz, $CDCl_3$): δ = 9.3, 9.9, 29.7, 31.6, 43.6, 45.8, 57.8, 113.3, 115.3, 127.8, 128.8, 128.3, 131.3, 135.6, 136.7, 138.4, 162.0, 179.5.

MS (DEI): *m*/*z* (%) = 295 (100, [M^+]), 280 (4, [M^+ – Me]), 266 (49, [M^+ – Et]), 204 (3, [M^+ – C_7H_7]), 91 (62, [$C_7H_7^+$]).

HRMS: *m*/*z* calcd for $C_{19}H_{18}FNO$: 295.13724; found: 295.13726, Δ = 0.02 mmu.

_N_-Benzyl-2-ethyl-3-(4-fluorophenyl)pyrrole (5ea)
Yield: 78 mg (28%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 1.12 (t, *J* = 7.6 Hz, 3 H), 2.65 (q, *J* = 7.6 Hz, 2 H), 5.10 (s, 2 H), 6.26 (d, *J* = 2.8 Hz, 1 H), 6.61 (d, *J* = 2.8 Hz, 1 H), 7.00–7.36 (m, 9 H).

^{13}C NMR (150 MHz, $CDCl_3$): δ = 14.1, 16.8, 49.4, 107.0, 114.8, 119.6, 125.4, 126.4, 127.7, 128.3, 129.4, 130.1, 132.6, 137.4, 159.3.

MS (DEI): *m*/*z* (%) = 279 (100, [M^+]), 264 (22, [M^+ – Me]), 188 (6, [M^+ – C_7H_7]), 91 (95, [$C_7H_7^+$]).

HRMS: *m*/*z* calcd for $C_{19}H_{18}FN$: 279.14233; found: 279.14283, Δ = 0.50 mmu.

2-Ethyl-3-(4-fluorophenyl)-_N_-phenylpyrrole (5eb)
Yield: 150 mg (57%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.88 (t, *J* = 7.4 Hz, 3 H), 2.72 (q, *J* = 7.4 Hz, 2 H), 6.32 (d, *J* = 2.8 Hz, 1 H), 6.74 (d, *J* = 2.8 Hz, 1 H), 7.01–7.43 (m, 9 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.6, 18.0, 108.8, 115.1, 121.6, 126.6, 127.5, 129.1, 129.4, 129.6, 131.6, 133.4, 140.5, 163.6.

MS (DEI): *m*/*z* (%) = 265 (89, [M^+]), 250 (100, [M^+ – Me]), 235 (4, [M^+ – C_2H_6]), 77 (8, [Ph^+]), 28 (3, [C_2H_4]).

HRMS: *m*/*z* calcd for $C_{18}H_{16}FN$: 265.12668: found: 265.12490 (M^+), Δ = 1.78 mmu.

2-Ethyl-3-(4-fluorophenyl)-*N*-*p*-tolylpyrrole (5ec)
Yield: 140 mg (50%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.90 (t, *J* = 7.4 Hz, 3 H), 2.41 (s, 3 H), 2.70 (q, *J* = 7.4 Hz, 2 H), 6.31 (d, *J* = 2.8 Hz, 1 H), 6.71 (d, *J* = 2.8 Hz, 1 H), 7.00–7.40 (m, 8 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.3, 17.7, 20.7, 108.2, 114.7, 121.3, 125.6, 126.1, 129.2, 129.3, 131.4, 133.1, 137.0, 137.6, 160.8.

MS (DEI): *m*/*z* (%) = 279 (100, [M^+]), 264 (82, [M^+ – Me]), 91 (6, [$C_7H_7^+$]).

HRMS: *m*/*z* calcd for $C_{19}H_{18}FN$: 279.14233; found: 279.14268, Δ = 0.35 mmu.

***N*-Cyclohexyl-3-ethyl-3-(4-fluorophenyl)-1,3-dihydropyrrol-2-one (4ed)**
Yield: 148 mg (52%); eluent: EtOH.

IR (neat): 2963 (m), 2932 (m), 1967 (w), 1686 (m), 1601 (m), 1508 (s), 1381 (m), 1261 (vs), 1223 (s), 1161 (m), 1096 (vs), 1015 (vs), 802 (vs), 690 cm^{-1} (s).

^{1}H NMR (600 MHz, $CDCl_3$): δ = 0.77 (t, *J* = 7.2 Hz, 3 H), 1.11–1.81 (m, 10 H), 1.95 (q, *J* = 7.2 Hz, 2 H), 3.85–3.91 (m, 1 H), 5.56 (d, *J* = 5.4 Hz, 1 H), 6.62 (d, *J* = 5.2 Hz, 1 H), 6.96 (t, *J* = 8.4 Hz, 2 H), 7.40 (t, *J* = 4.2 Hz, 2 H).

^{13}C NMR (150 MHz, $CDCl_3$): δ = 9.1, 25.4, 25.5, 31.6, 32.1, 50.5, 58.2, 113.0, 115.1, 128.3, 128.6, 136.0, 161.9, 179.0.

MS (DEI): *m*/*z* (%) = 287 (100, [M^+]), 258 (50, [M^+ – Et]), 204 (3, [$M^+ – C_6H_{11}$]), 176 (9, [$M^+ – C_6H_{11} – C_2H_4$]), 109 (4, [$M^+ – C_6H_{11} – C_6H_4F$]).

HRMS: *m*/*z* calcd for $C_{18}H_{22}FNO$: 287.16854; found: 287.16825, Δ = 0.29 mmu.

***N*-Cyclohexyl-2-ethyl-3-(4-fluorophenyl)pyrrole (5ed)**
Yield: 92 mg (34%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (600 MHz, $CDCl_3$): δ = 1.21 (t, *J* = 7.2 Hz, 3 H), 1.40–2.04 (m, 10 H), 2.70 (q, *J* = 7.2 Hz, 2 H), 3.80–3.84 (m, 1 H), 6.22 (d, *J* = 3.0 Hz, 1 H), 6.69 (d, *J* = 3.0 Hz, 1 H), 7.03 (t, *J* = 8.4 Hz, 2 H), 7.31 (dd, *J* = 3.0, 5.4 Hz, 2 H).

^{13}C NMR (150 MHz, $CDCl_3$): δ = 14.6, 16.7, 24.5, 25.1, 34.0, 54.0, 106.7, 113.9, 114.8, 118.9, 128.4, 129.0, 132.8, 160.0.

MS (DEI): *m*/*z* (%) = 271 (100, [M^+]), 256 (25, [M^+ – Me]), 242 (4, [M^+ – Et]), 188 (7, [$M^+ – C_6H_{11}$]), 83 (3, [$C_6H_{11}^+$]).

HRMS: *m*/*z* calcd for $C_{18}H_{22}FN$: 271.17363; found: 271.17367, Δ = 0.04 mmu.

***N*-Butyl-3-ethyl-3-(4-fluorophenyl)-1,3-dihydropyrrol-2-one (4ef)**
Yield: 144 mg (55%); eluent: EtOH.

IR (neat): 2963 (w), 2932 (w), 2874 (vw), 1967 (vw), 1686 (s), 1601 (m), 1508 (vs), 1369 (m), 1261 (w), 1223 (vs), 1161 (m), 833 (vs), 691 cm^{-1} (w).

^{1}H NMR (600 MHz, $CDCl_3$): δ = 0.77 (t, *J* = 7.2 Hz, 3 H), 0.78 (t, *J* = 7.2 Hz, 3 H), 0.89 (t, *J* = 7.2 Hz, 3 H), 1.28 (q, *J* = 7.2 Hz, 2 H), 1.48–1.55 (m, 2 H), 1.95 (q, *J* = 7.2 Hz, 2 H), 3.69 (q, *J* = 7.2 Hz, 2 H), 5.58 (d, *J* = 4.8 Hz, 1 H), 6.53 (d, *J* = 4.8 Hz, 1 H), 6.96 (t, *J* = 9.0 Hz, 1 H), 7.42 (dd, *J* = 5.4 Hz, *J* = 8.4 Hz, 2 H).

^{13}C NMR (150 MHz, $CDCl_3$): δ = 9.2, 13.6, 19.9, 30.9, 31.6, 41.8, 57.8, 112.8, 115.2, 128.4, 131.7, 135.9, 162.7, 179.5.

MS (DEI): *m*/*z* (%) = 261 (100, [M^+]), 232 (49, [M^+ – Et]), 218 (6, [$M^+ – C_3H_7$]), 204 (4, [$M^+ – C_4H_9$]), 190 (16, [$M^+ – C_5H_{11}$]).

HRMS: *m*/*z* calcd for $C_{16}H_{20}FNO$: 261.15289; found: 261.15165, Δ = 1.24 mmu.

***N*-Butyl-2-ethyl-3-(4-fluorophenyl)pyrrole (5ef)**
Yield: 82 mg (33%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (600 MHz, $CDCl_3$): δ = 0.97 (t, *J* = 7.2 Hz, 3 H), 1.20 (t, *J* = 7.2 Hz, 3 H), 1.40 (q, *J* = 7.2 Hz, 2 H), 1.70–1.79 (m, 2 H), 2.70 (q, *J* = 7.2 Hz, 2 H), 3.83 (t, *J* = 7.2 Hz, 2 H), 6.19 (d, *J* = 3.0 Hz, 1 H), 6.61 (d, *J* = 3.0 Hz, 1 H), 7.03 (t, *J* = 9.0 Hz, 2 H), 7.31 (t, *J* = 4.2 Hz, 2 H).

^{13}C NMR (150 MHz, $CDCl_3$): δ = 12.8, 14.2, 16.7, 19.1, 32.8, 45.3, 106.5, 114.0, 118.3, 119.4, 128.3, 129.6, 132.8, 160.00.

MS (DEI): *m*/*z* (%) = 245 (100, [M^+]), 230 (74, [M^+ – Me]), 216 (28, [M^+ – Et]), 202 (28, [$M^+ – C_3H_7$]), 188 (26, [$M^+ – C_4H_9$]).

HRMS: *m*/*z* calcd for $C_{16}H_{20}FN$: 245.15798; found: 245.15760, Δ = 0.38 mmu.

***N*-(4-*tert*-Butylphenyl-2-ethyl-3-(4-fluorophenyl)pyrrole (5eg)**
Yield: 174 mg (54%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 1.26 (t, *J* = 7.4 Hz, 3 H), 1.37 (s, 9 H), 2.71 (q, *J* = 7.4 Hz, 2 H), 6.31 (d, *J* = 2.8 Hz, 1 H), 6.72 (d, *J* = 2.8 Hz, 1 H), 7.01–7.48 (m, 8 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.7, 18.0, 31.4, 34.7, 108.5, 115.1, 121.6, 126.0, 126.0, 126.1, 129.4, 131.8, 133.5, 137.8, 150.6, 163.6.

MS (DEI): *m*/*z* (%) = 321 (100, [M^+]), 306 (36, [M^+ – Me]), 250 (12, [$M^+ – C_5H_{11}$]), 132 (4, [$C_{10}H_{12}^+$]), 57 (6, [$C_4H_9^+$]).

HRMS: *m*/*z* calcd for $C_{22}H_{24}FN$: 321.18928; found: 321.18829, Δ = 0.99 mmu.

***N*-*sec*-Butyl-3-ethyl-3-(4-fluorophenyl)-1,3-dihydropyrrol-2-one (4eh)**
Yield: 108 mg (41%); eluent: EtOH.

IR (neat): 2967 (m), 2932 (w), 1694 (s), 1508 (s), 1381 (m), 1258 (vs), 1161 (m), 1015 (vs), 791 (vs), 694 cm^{-1} (m).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.70–0.89 (m, 6 H), 1.12 (d, *J* = 6.8 Hz, 1.5 H), 1.17 (d, *J* = 6.8 Hz, 1.5 H), 1.41–1.61 (m, 2 H), 1.96 (q, *J* = 7.4 Hz, 1 H), 1.96 (q, *J* = 7.4 Hz, 1 H), 4.03 (m, 1 H), 5.57 (d, *J* = 3.1 Hz, 0.5 H), 5.60 (d, *J* = 3.1 Hz, 0.5 H), 6.57 (d, *J* = 5.0 Hz, 1 H), 6.95 (t, *J* = 8.8 Hz, 2 H), 7.37–7.45 (m, 2 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 9.0, 9.2, 10.6, 10.7, 19.4, 19.6, 28.4, 31.3, 31.4, 48.4, 58.2, 113.1, 113.3, 114.8, 115.3, 128.1, 128.2, 128.3, 135.9, 159.3, 164.2, 179.2.

MS (DEI): *m*/*z* (%) = 261 (100, [M^+]), 246 (3, [M^+ – Me]), 232 (96, [M^+ – Et]), 204 (20, [$M^+ – C_4H_9$]), 190 (4, [$M^+ – C_5H_{11}$]), 176 (52, [$M^+ – C_6H_{13}$]), 57 (9, [$C_4H_9^+$]), 29 (18, [Et^+]).

HRMS: *m*/*z* calcd for $C_{16}H_{20}FNO$: 261.15289; found: 261.15237, Δ = 0.52 mmu.

***N*-*sec*-Butyl-2-ethyl-3-(4-fluorophenyl)pyrrole (5eh)**
Yield: 128 mg (52%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.84 (t, *J* = 7.4 Hz, 3 H), 1.19 (t, *J* = 7.4 Hz, 3 H), 1.41 (d, *J* = 6.6 Hz, 3 H), 1.77 (q, *J* = 7.6 Hz, 2 H), 2.67 (q, *J* = 7.6 Hz, 2 H), 3.99 (q, *J* = 6.8 Hz, 1 H), 6.21 (d, *J* = 3.0 Hz, 1 H), 6.63 (d, *J* = 3.0 Hz, 1 H), 6.96–7.05 (m, 2 H), 7.23–7.32 (m, 2 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 11.0, 15.5, 17.6, 22.3, 31.1, 52.6, 107.9, 114.9, 119.7, 129.3, 129.4, 130.6, 133.9, 160.9.

MS (DEI): *m*/*z* (%) = 245 (100, [M^+]), 230 (32, [M^+ – Me]), 216 (13, [M^+ – Et]), 188 (6, [$M^+ – C_4H_9$]), 174 (20, [$M^+ – C_5H_{11}$]), 95 (3, [C_6H_4F]).

HRMS: *m*/*z* calcd for $C_{16}H_{20}FN$: 245.15798; found: 245.15786, Δ = 0.12 mmu.

_N_-Benzyl-3-ethyl-3-furyl-1,3-dihydropyrrol-2-one (4fa)
Yield: 151 mg (57%); eluent: EtOH.

IR (neat): 2970 (w), 2932 (w), 2878 (w), 2361 (w), 2021 (m), 1952 (m), 1667 (s), 1605 (m), 1497 (s), 1454 (s), 1354 (s), 1258 (m), 1076 (m), 1011 (s), 729 (vs), 689 cm^{-1} (vs).

^1H NMR (200 MHz, $CDCl_3$): δ = 0.84 (t, *J* = 7.4 Hz, 1.5 H), 1.16 (t, *J* = 7.6 Hz, 1.5 H), 2.06 (q, *J* = 7.4 Hz, 1 H), 2.23 (q, *J* = 7.6 Hz, 1 H), 4.52 (AB spin system, *J* = 7.8, 36.6 Hz, 2 H), 5.46 (d, *J* = 2.8 Hz, 1 H), 6.19 (dd, *J* = 0.8, 3.2 Hz, 1 H), 6.30 (dd, *J* = 1.8, 3.3 Hz, 1 H), 6.41 (d, *J* = 2.8 Hz, 1 H), 7.21–7.32 (m, 5 H), 7.35 (dd, *J* = 0.8, 1.8 Hz, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 8.5, 9.5, 28.2, 29.3, 43.2, 43.4, 55.2, 58.0, 105.6, 109.8, 111.3, 126.0, 127.1, 127.4, 128.4, 131.5, 141.8, 152.2, 177.2.

MS (DEI): *m*/*z* (%) = 267 (100, $[M^+]$), 238 (39, $[M^+ - Et]$), 200 (11, $[M^+ - C_4H_3O]$), 176 (6, $[M^+ - C_7H_7]$), 91 (52, $[C_7H_7^+]$).

HRMS: *m*/*z* calcd for $C_{17}H_{17}NO_2$: 267.12593; found: 267.12572, Δ = 0.21 mmu.

_N_-Benzyl-2-ethyl-3-furylpyrrole (5fa)
Yield: 109 mg (43%); eluent: light petroleum–CH_2Cl_2 (70:30).

^1H NMR (200 MHz, $CDCl_3$): δ = 1.11 (t, *J* = 7.6 Hz, 3 H), 2.78 (q, *J* = 7.6 Hz, 2 H), 5.08 (s, 2 H), 6.24 (dd, *J* = 0.8, 3.2 Hz, 1 H), 6.43 (d, *J* = 2.8 Hz, 1 H), 6.43 (dd, *J* = 0.8, 3.2 Hz, 1 H), 6.60 (d, *J* = 2.8 Hz, 1 H), 7.03–7.33 (m, 5 H), 7.38 (dd, *J* = 0.8, 1.8 Hz, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.0, 18.1, 49.9, 102.0, 105.8, 110.6, 120.6, 126.0, 127.1, 128.4, 131.4, 138.0, 139.4, 151.8.

MS (DEI): *m*/*z* (%) = 251 (100, $[M^+]$), 236 (38, $[M^+ - Me]$), 160 (7, $[M^+ - C_7H_7]$), 91 (73, $[C_7H_7^+]$).

HRMS: *m*/*z* calcd for $C_{17}H_{17}NO$: 251.13101; found: 251.13106, Δ = 0.05 mmu.

2-Ethyl-3-furyl-_N_-phenylpyrrole (5fb)
Yield: 111 mg (47%); eluent: light petroleum–CH_2Cl_2 (70:30).

^1H NMR (200 MHz, $CDCl_3$): δ = 1.06 (t, *J* = 7.4 Hz, 3 H), 2.80 (q, *J* = 7.4 Hz, 2 H), 6.29 (dd, *J* = 0.8, 3.4 Hz, 1 H), 6.39 (dd, *J* = 1.8, 3.2 Hz, 1 H), 6.49 (d, *J* = 3.0 Hz, 1 H), 6.70 (d, *J* = 3.0 Hz, 1 H), 7.35 (dd, *J* = 0.8, 1.8 Hz, 1 H), 7.31–7.47 (m, 5 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.4, 18.6, 102.9, 106.8, 110.9, 113.2, 121.7, 126.6, 127.5, 129.1, 132.3, 140.0, 151.8.

MS (DEI): *m*/*z* (%) = 237 (100, $[M^+]$), 222 (70, $[M^+ - Me]$), 208 (2, $[M^+ - Et]$), 91 (3, $[C_7H_7^+]$), 77 (5, $[Ph^+]$).

HRMS: *m*/*z* calcd for $C_{16}H_{15}NO$: 237.11536; found: 237.11537 (M^+), Δ = 0.01 mmu.

3-Ethyl-3-furyl-_N_-_p_-tolyl-1,3-dihydropyrrol-2-one (4fc)
Yield: 108 mg (40%); eluent: EtOH.

IR (neat): 2963 (w), 2928 (m), 2859 (w), 1717 (vs), 1612 (m), 1512 (vs), 1458 (m), 1385 (vs), 1277 (s), 1207 (s), 1072 (s), 1015 (s), 864 (s), 813 (vs), 736 (vs), 706 cm^{-1} (s).

^1H NMR (200 MHz, $CDCl_3$): δ = 0.89 (t, *J* = 7.4 Hz, 3 H), 2.11 (q, *J* = 7.4 Hz, 2 H), 2.32 (s, 3 H), 5.63 (d, *J* = 5.0 Hz, 1 H), 6.24 (dd, *J* = 0.8, 3.4 Hz, 1 H), 6.30 (dd, *J* = 1.8, 3.2 Hz, 1 H), 6.93 (d, *J* = 5.0 Hz, 1 H), 7.15–7.36 (m, 4 H), 7.50 (dd, *J* = 3.6, 5.6 Hz, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 8.8, 20.9, 30.4, 56.2, 106.1, 110.2, 112.1, 121.5, 128.8, 129.6, 132.5, 135.6, 142.2, 152.4, 176.0.

MS (DEI): *m*/*z* (%) = 267 (80, $[M^+]$), 252 (2, $[M^+ - Me]$), 238 (100, $[M^+ - Et]$), 223 (7, $[M^+ - C_3H_8]$), 210 (17, $[M^+ - CO - Et]$), 91 (23, $[C_7H_7^+]$).

HRMS: *m*/*z* calcd for $C_{17}H_{17}NO_2$: 267.12593; found: 267.12564, Δ = 0.29 mmu.

2-Ethyl-3-furyl-_N_-_p_-tolylpyrrole (5fc)
Yield: 139 mg (55%); eluent: light petroleum–CH_2Cl_2 (60:40).

^1H NMR (200 MHz, $CDCl_3$): δ = 1.05 (t, *J* = 7.4 Hz, 3 H), 2.42 (s, 3 H), 2.77 (q, *J* = 7.4 Hz, 2 H), 6.27 (dd, *J* = 0.8, 3.2 Hz, 1 H), 6.43 (dd, *J* = 1.8, 3.4 Hz, 1 H), 6.46 (d, *J* = 2.8 Hz, 1 H), 6.67 (d, *J* = 3.0 Hz, 1 H), 7.18–7.28 (m, 4 H), 7.39 (dd, *J* = 0.8, 1.8 Hz, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.1, 18.3, 20.7, 102.4, 106.3, 110.6, 112.4, 121.4, 121.4, 126.1, 129.3, 132.0, 137.2, 139.6, 151.6.

MS (DEI): *m*/*z* (%) = 251 (100, $[M^+]$), 236 (98, $[M^+ - Me]$), 222 (17, $[M^+ - Et]$), 208 (17, $[M^+ - C_3H_7]$), 91 (8, $[C_7H_7^+]$).

HRMS: *m*/*z* calcd for $C_{17}H_{17}NO$: 251.13101; found: 251.13079, Δ = 0.22 mmu.

_N_-Cyclohexyl-3-ethyl-3-furyl-1,3-dihydropyrrol-2-one (4fd)
Yield: 155 mg (60%); eluent: EtOH.

IR (neat): 2932 (m), 2855 (w), 1967 (w), 1694 (s), 1605 (m), 1450 (m), 1381 (m), 1254 (m), 1011 (s), 730 (vs), 694 cm^{-1} (s).

^1H NMR (200 MHz, $CDCl_3$): δ = 0.79 (t, *J* = 7.4 Hz, 3 H), 1.12–1.80 (m, 10 H), 2.00 (q, *J* = 7.4 Hz, 2 H), 3.87–3.94 (m, 1 H), 5.43 (d, *J* = 5.0 Hz, 1 H), 6.15 (dd, *J* = 0.8, 3.2 Hz, 1 H), 6.26 (dd, *J* = 2.0, 3.2 Hz, 1 H), 6.59 (d, *J* = 5.0 Hz, 1 H), 7.31 (dd, *J* = 1.0, 1.8 Hz, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 8.6, 25.4, 28.5, 31.8, 32.1, 50.5, 55.9, 105.7, 110.1, 111.2, 129.4, 142.0, 152.9, 177.0.

MS (DEI): *m*/*z* (%) = 259 (100, $[M^+]$), 230 (44, $[M^+ - Et]$), 177 (21, $[M^+ - C_6H_{10}]$), 148 (62, $[M^+ - C_6H_{11} - C_2H_4]$), 120 (7, $[M^+ - C_6H_{11} - C_2H_4 - CO]$).

HRMS: *m*/*z* calcd for $C_{16}H_{21}NO_2$: 259.15723; found: 259.15696, Δ = 0.27 mmu.

_N_-Cyclohexyl-2-ethyl-3-furylpyrrole (5fd)
Yield: 90 mg (37%); eluent: light petroleum–CH_2Cl_2 (70:30).

^1H NMR (200 MHz, $CDCl_3$): δ = 1.20 (t, *J* = 7.4 Hz, 3 H), 1.39–2.02 (m, 10 H), 2.84 (q, *J* = 7.4 Hz, 2 H), 3.80–3.85 (m, 1 H), 6.18 (dd, *J* = 0.8, 3.4 Hz, 1 H), 6.35 (d, *J* = 3.0 Hz, 1 H), 6.39 (dd, *J* = 1.8, 3.4 Hz, 1 H), 6.65 (d, *J* = 3.0 Hz, 1 H), 7.35 (dd, *J* = 0.8, 1.8 Hz, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.9, 18.3, 25.5, 26.1, 34.8, 54.8, 102.2, 105.9, 110.8, 111.2, 116.1, 130.8, 139.6, 152.3.

MS (DEI): *m*/*z* (%) = 243 (100, $[M^+]$), 228 (35, $[M^+ - Me]$), 214 (5, $[M^+ - Et]$), 161 (9, $[M^+ - C_6H_{10}]$), 146 (30, $[M^+ - C_6H_{11} - Me]$).

HRMS: *m*/*z* calcd for $C_{16}H_{21}NO$: 243.16231; found: 243.16212, Δ = 0.19 mmu.

_N_-Butyl-3-ethyl-3-furyl-1,3-dihydropyrrol-2-one (4ff)
Yield: 140 mg (60%); eluent: EtOH.

IR (neat): 2959 (m), 2920 (m), 2851 (m), 1701 (w), 1462 (m), 1377 (w), 1258 (vs), 1080 (s), 1015 (vs), 864 (m), 794 (vs), 729 cm^{-1} (m).

^1H NMR (200 MHz, $CDCl_3$): δ = 0.85 (t, *J* = 7.2 Hz, 3 H), 0.89 (t, *J* = 7.2 Hz, 3 H), 1.24–1.29 (m, 2 H), 1.49–1.55 (m, 2 H), 2.02 (q, *J* = 7.2 Hz, 2 H), 3.35–3.42 (m, 2 H), 5.45 (d, *J* = 5.0 Hz, 1 H), 6.15 (dd, *J* = 0.8, 3.2 Hz, 1 H), 6.26 (dd, *J* = 1.8, 3.2 Hz, 1 H), 6.49 (d, *J* = 5.0 Hz, 1 H), 7.31 (dd, *J* = 0.8, 1.8 Hz, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 8.7, 13.6, 19.8, 28.5, 30.9, 41.7, 55.6, 105.7, 110.1, 111.2, 132.3, 142.0, 152.8, 177.5.

MS (DEI): *m*/*z* (%) = 233 (93, $[M^+]$), 204 (86, $[M^+ - Et]$), 190 (11, $[M^+ - C_3H_7]$), 162 (39, $[M^+ - C_3H_7 - CO]$), 151 (100, $[M^+ - C_4H_3O - Me]$), 148 (26, $[M^+ - C_6H_{13}]$).

HRMS: *m*/*z* calcd for $C_{14}H_{19}NO_2$: 233.14158; found: 233.14188, Δ = 0.30 mmu.

***N*-Butyl-2-ethyl-3-furylpyrrole (5ff)**
Yield: 79 mg (36%); eluent: light petroleum–CH_2Cl_2 (80:20).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.96 (t, *J* = 7.4 Hz, 3 H), 1.21 (t, *J* = 7.4 Hz, 3 H), 1.34–1.43 (m, 2 H), 1.70–1.78 (m, 2 H), 2.82 (q, *J* = 7.4 Hz, 2 H), 3.82 (t, *J* = 7.4 Hz, 2 H), 6.19 (dd, *J* = 0.8, 3.4 Hz, 1 H), 6.33 (d, *J* = 3.0 Hz, 1 H), 6.40 (dd, *J* = 1.8, 3.4 Hz, 1 H), 6.55 (d, *J* = 3.0 Hz, 1 H), 7.36 (dd, *J* = 0.8, 1.8 Hz, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 13.7, 14.5, 18.3, 20.0, 33.7, 46.2, 102.1, 105.6, 110.8, 111.8, 119.6, 131.2, 139.6, 152.3.

MS (DEI): *m*/*z* (%) = 217 (100, [M$^+$]), 202 (72, [M$^+$ – Me]), 188 (16, [M$^+$ – Et]), 174 (7, [M$^+$ – C_3H_7]), 160 (18, [M$^+$ – C_4H_9]), 146 (14, [M$^+$ – C_5H_{12}]).

HRMS: *m*/*z* calcd for $C_{14}H_{19}NO$: 217.14666; found: 217.14699, Δ = 0.33 mmu.

***N*-(4-*tert*-Butylphenyl)-3-ethyl-3-furyl-1,3-dihydropyrrol-2-one (4fg)**
Yield: 131 mg (42%); eluent: light petroleum–CH_2Cl_2 (70:30).

IR (neat): 2959 (m), 2928 (m), 2870 (w), 1717 (vs), 1609 (m), 1516 (s), 1462 (m), 1385 (s), 1269 (m), 1211 (s), 1072 (m), 1015 (m), 864 (m), 833 (s), 729 (vs), 702 cm^{-1} (s).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.90 (t, *J* = 7.4 Hz, 3 H), 1.30 (s, 9 H), 2.12 (q, *J* = 7.4 Hz, 2 H), 5.64 (d, *J* = 5.0 Hz, 1 H), 6.25 (dd, *J* = 0.8, 3.2 Hz, 1 H), 6.31 (dd, *J* = 1.8, 3.2 Hz, 1 H), 6.95 (d, *J* = 5.0 Hz, 1 H), 7.38 (s, 4 H), 7.36 (dd, *J* = 0.8, 2.0 Hz, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 8.7, 29.7, 31.3, 34.5, 56.3, 106.1, 110.2, 112.1, 121.1, 126.0, 132.4, 142.2, 148.8, 152.4, 176.0.

MS (DEI): *m*/*z* (%) = 309 (100, [M$^+$]), 294 (12, [M$^+$ – Me]), 280 (46, [M$^+$ – Et]), 266 (7, [M$^+$ – C_3H_7]), 252 (17, [M$^+$ – CO – Et]), 133 (4, [$C_{10}H_{13}^+$]), 57 (14, [$C_4H_9^+$]).

HRMS: *m*/*z* calcd for $C_{20}H_{23}NO_2$: 309.17288; found: 309.17227, Δ = 0.61 mmu.

***N*-(4-*tert*-Butylphenyl-2-ethyl-3-furylpyrrole (5fg)**
Yield: 121 mg (41%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 1.08 (t, *J* = 7.4 Hz, 3 H), 1.38 (s, 9 H), 2.79 (q, *J* = 7.4 Hz, 2 H), 6.28 (dd, *J* = 0.8, 3.2 Hz, 1 H), 6.44 (dd, *J* = 1.8, 3.2 Hz, 1 H), 6.48 (d, *J* = 3.0 Hz, 1 H), 6.69 (d, *J* = 3.0 Hz, 1 H), 7.25 (d, *J* = 8.8 Hz, 2 H), 7.40 (dd, *J* = 0.8, 1.8 Hz, 1 H), 7.47 (d, *J* = 8.8 Hz, 2 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.5, 18.6, 31.4, 34.7, 102.7, 106.6, 110.9, 112.8, 121.7, 126.0, 126.1, 132.4, 137.4, 139.9, 150.6, 151.9.

MS (DEI): *m*/*z* (%) = 293 (100, [M$^+$]), 278 (71, [M$^+$ – Me]), 222 (15, [M$^+$ – C_5H_{11}]).

HRMS: *m*/*z* calcd for $C_{20}H_{23}NO$: 293.17796; 293.17873, Δ = 0.77 mmu.

***N-sec*-Butyl-3-ethyl-3-furyl-1,3-dihydropyrrol-2-one (4fh)**
Yield: 134 mg (57%); eluent: EtOH.

IR (neat): 2967 (w), 2936 (w), 2878 (vw), 2045 (w), 1971 (w), 1695 (vs), 1609 (m), 1462 (m), 1377 (s), 1254 (s), 1219 (s), 1011 (s), 802 (m), 735 cm^{-1} (vs).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.77–0.86 (m, 6 H), 1.15 (d, *J* = 2.1 Hz, 1.5 H), 1.19 (d, *J* = 2.1 Hz, 1.5 H), 1.53 (m, 2 H), 2.02 (q, *J* = 7.4 Hz, 2 H), 4.07 (m, 1 H), 5.46 (d, *J* = 2.4 Hz, 0.5 H), 5.47 (d, *J* = 2.4 Hz, 0.5 H), 6.14 (m, 1 H), 6.26 (m, 1 H), 6.54 (d, *J* = 5.0 Hz, 1 H), 7.13 (t, *J* = 0.8 Hz, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 8.6, 8.9, 10.6, 10.8, 19.4, 19.7, 28.3, 28.4, 28.6, 48.4, 48.6, 56.0, 56.1, 105.7, 110.1, 111.5, 111.7, 128.7, 128.9, 142.0, 153.0, 177.4.

MS (DEI): *m*/*z* (%) = 233 (100, [M$^+$]), 204 (75, [M$^+$ – Et]), 190 (3, [M$^+$ – C_3H_7]), 176 (15, [M$^+$ – C_4H_9]), 148 (24, [M$^+$ – C_4H_9 – CO]), 57 (3, [$C_4H_9^+$]).

HRMS: *m*/*z* calcd for $C_{14}H_{19}NO_2$: 233.14158; found: 233.14174, Δ = 0.16 mmu.

***N-sec*-Butyl-2-ethyl-3-furylpyrrole (5fh)**
Yield: 82 mg (38%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.84 (t, *J* = 7.4 Hz, 3 H), 1.19 (t, *J* = 7.4 Hz, 3 H), 1.40 (d, *J* = 6.8 Hz, 2 H), 1.76 (t, *J* = 7.4 Hz, 3 H), 2.83 (q, *J* = 7.4 Hz, 2 H), 4.01 (q, *J* = 7.0 Hz, 1 H), 6.18 (dd, *J* = 0.8, 3.4 Hz, 1 H), 6.37 (d, *J* = 3.0 Hz, 1 H), 6.39 (dd, *J* = 1.8, 3.4 Hz, 1 H), 6.60 (d, *J* = 3.0 Hz, 1 H), 7.35 (dd, *J* = 0.8, 1.8 Hz, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 10.9, 14.8, 18.2, 22.3, 30.9, 52.4, 102.1, 106.2, 110.8, 111.1, 115.3, 131.3, 139.6, 152.4.

MS (DEI): *m*/*z* (%) = 217 (100, [M$^+$]), 202 (50, [M$^+$ – Me]), 188 (10, [M$^+$ – Et]), 146 (31, [M$^+$ - C_5H_{11}]), 57 (6, [$C_4H_9^+$]).

HRMS: *m*/*z* calcd for $C_{14}H_{19}NO$: 217.14666; found: 217.14709, Δ = 0.43 mmu.

***N*-Benzyl-3-ethyl-3-(3-pyridyl)-1,3-dihydropyrrol-2-one (4ga)**
Yield: 163 mg (59%); eluent: EtOH.

IR (neat): 2967 (w), 2932 (w), 2874 (w), 1670 (m), 1420 (m), 1261 (m), 1026 (m), 806 (m), 748 (s), 698 cm^{-1} (vs).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 0.81 (t, *J* = 7.6 Hz, 3 H), 2.05 (q, *J* = 7.6 Hz, 2 H), 4.59 (AB spin system, *J* = 15.2, 53.9 Hz, 2 H), 5.64 (d, *J* = 5.2 Hz, 1 H), 6.49 (d, *J* = 5.2 Hz, 1 H), 7.17–7.30 (m, 5 H), 7.91–8.60 (m, 4 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 9.2, 31.5, 45.8, 56.7, 112.0, 123.5, 127.8, 128.3, 128.7, 131.9, 134.5, 135.7, 136.4, 148.3, 148.4, 178.9.

MS (DEI): *m*/*z* (%) = 278 (25, [M$^+$]), 249 (25, [M$^+$ – Et]), 221 (2, [M$^+$ – Et – CO]), 91 (100, [$C_7H_7^+$]), 77 (7, [Ph$^+$]).

HRMS: *m*/*z* calcd for $C_{18}H_{18}N_2O$: 278.14191; found: 278.14185, Δ = 0.06 mmu.

***N*-Benzyl-2-ethyl-3-(3-pyridyl)pyrrole (5ga)**
Yield: 91 mg (35%); eluent: light petroleum–CH_2Cl_2 (40:60).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.15 (t, *J* = 7.6 Hz, 3 H), 2.65 (q, *J* = 7.6 Hz, 2 H), 5.10 (s, 2 H), 6.31 (d, *J* = 2.8 Hz, 1 H), 6.64 (d, *J* = 2.8 Hz, 1 H), 7.03–7.33 (m, 5 H), 7.25–8.67 (m, 4 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 15.1, 17.9, 50.5, 107.9, 121.3, 126.4, 127.6, 127.9, 128.3, 128.8, 132.0, 133.6, 134.7, 138.1, 146.4, 148.9.

MS (DEI): *m*/*z* (%) = 262 (100, [M$^+$]), 247 (50, [M$^+$ – Me]), 234 (3, [M$^+$ – C_2H_4]), 91 (47, [$C_7H_7^+$]).

HRMS: *m*/*z* calcd for $C_{18}H_{18}N_2$: 262.14700; found: 262.14649, Δ = 0.51 mmu.

3-Ethyl-3-(3-pyridyl)-*N*-phenyl-1,3-dihydropyrrol-2-one (4gb)
Yield: 146 mg (55%); eluent: EtOH.

IR (neat): 2963 (vw), 2928 (vw), 1705 (w), 1597 (m), 1497 (s), 1385 (m), 1026 (m), 806 (m), 752 (s), 691 cm^{-1} (vs).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.89 (t, *J* = 7.4 Hz, 3 H), 2.11 (q, *J* = 7.4 Hz, 2 H), 5.84 (d, *J* = 5.2 Hz, 1 H), 7.04 (d, *J* = 5.2 Hz, 1 H), 7.28–7.47 (m, 5 H), 7.28–7.47 (m, 1 H), 7.96 (dt, *J* = 2.0, 8.0 Hz, 1 H), 8.44–8.51 (m, 1 H), 8.63–8.70 (m, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 9.1, 31.9, 57.5, 112.7, 121.5, 123.5, 126.0, 129.2, 132.3, 134.6, 136.7, 140.2, 148.2, 148.5, 177.5.

MS (DEI): *m*/*z* (%) = 264 (91, [M$^+$]), 235 (100 [M$^+$ – Et]), 77 (19, [Ph$^+$]).

HRMS: *m*/*z* calcd for $C_{17}H_{16}N_2O$: 264.12626; found: 264.12627, Δ = 0.01 mmu.

2-Ethyl-*N*-phenyl-3-(3-pyridyl)pyrrole (5gb)
Yield: 111 mg (45%); eluent: light petroleum–CH_2Cl_2 (50:50).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.86 (t, *J* = 7.4 Hz, 3 H), 2.72 (q, *J* = 7.4 Hz, 2 H), 6.37 (d, *J* = 3.0 Hz, 1 H), 6.77 (d, *J* = 3.0 Hz, 1 H), 7.32–7.53 (m, 5 H), 7.70 (m, 2 H), 8.38–8.45 (m, 1 H), 8.62–8.67 (m, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.1, 18.1, 108.6, 122.2, 126.6, 127.7, 128.8, 129.2, 129.8, 130.9, 132.5, 135.0, 140.1, 146.6, 149.1.

MS (DEI): *m*/*z* (%) = 248 (100, [M$^+$]), 233 (47, [M$^+$ – Me]), 77 (7, [$C_6H_7^+$]).

HRMS: *m*/*z* calcd for $C_{17}H_{16}N_2$: 248.13135; found: 248.13104, Δ = 0.31 mmu.

3-Ethyl-3-(3-pyridyl)-*N*-*p*-tolyl-1,3-dihydropyrrol-2-one (4gc)
Yield: 98 mg (35%); eluent: EtOH.

IR (neat): 2955 (w), 2920 (m), 2851 (w), 1709 (s), 1512 (vs), 1385 (s), 1026 (s), 810 (vs), 714 cm^{-1} (vs).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.88 (t, *J* = 7.4 Hz, 3 H), 2.05–2.14 (m, 2 H), 2.32 (s, 3 H), 5.82 (d, *J* = 5.0 Hz, 1 H), 6.99 (d, *J* = 5.0 Hz, 1 H), 7.17 (d, *J* = 8.4 Hz, 2 H), 7.31 (d, *J* = 8.4 Hz, 2 H), 7.51–7.60 (m, 1 H), 7.96 (dt, *J* = 2.0, 8.4 Hz, 1 H), 8.45–8.51 (m, 1 H), 8.62–8.69 (m, 1 H).

^{13}C NMR (150 MHz, $CDCl_3$): δ = 9.2, 20.9, 31.9, 57.4, 112.5, 121.6, 123.5, 129.7, 132.1, 132.6, 134.2, 134.6, 135.9, 148.3, 148.5, 177.5.

MS (DEI): *m*/*z* (%) = 278 (100, [M$^+$]), 249 (87, [M$^+$ – Et]), 221 (15, [M$^+$ – Et – CO]), 91 (10, [$C_7H_7^+$]).

HRMS: *m*/*z* calcd for $C_{18}H_{18}N_2O$: 278.14191; found: 278.14141, Δ = 0.50 mmu.

2-Ethyl-3-(3-pyridyl)-*N*-*p*-tolylpyrrole (5gc)
Yield: 142 mg (54%); eluent: CH_2Cl_2.

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.90 (t, *J* = 7.4 Hz, 3 H), 2.41 (s, 3 H), 2.70 (q, *J* = 7.4 Hz, 2 H), 6.35 (d, *J* = 3.0 Hz, 1 H), 6.73 (d, *J* = 3.0 Hz, 1 H), 7.03–7.38 (m, 4 H), 7.72 (dt, *J* = 2.0, 8.0 Hz, 1 H), 8.34–8.71 (m, 3 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.7, 18.1, 21.1, 108.3, 118.6, 120.8, 122.3, 123.3, 126.5, 129.7, 130.3, 132.6, 134.9, 137.7, 146.5, 149.1.

MS (DEI): *m*/*z* (%) = 262 (100, [M$^+$]), 247 (53, [M$^+$ – Me]), 91 (4, [$C_7H_7^+$]).

HRMS: *m*/*z* calcd for $C_{18}H_{18}N_2$: 262.14700; found: 262.14701, Δ = 0.01 mmu.

***N*-Cyclohexyl-3-ethyl-3-(3-pyridyl)-1,3-dihydropyrrol-2-one (4gd)**
Yield: 146 mg (54%); eluent: EtOH.

IR (neat): 2932 (m), 2855 (w), 1686 (vs), 1605 (m), 1381 (s), 1254 (s), 1196 (m), 1138 (m), 810 (m), 694 cm^{-1} (vs).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.72 (t, *J* = 7.4 Hz, 3 H), 1.24–1.75 (m, 10 H), 1.92 (q, *J* = 7.4 Hz, 2 H), 3.78–3.82 (m, 1 H), 5.54 (d, *J* = 5.0 Hz, 1 H), 6.61 (d, *J* = 5.0 Hz, 1 H), 7.19 (dd, *J* = 4.8, 8.0 Hz, 1 H), 7.81 (dt, *J* = 1.8, 8.0 Hz, 1 H), 8.37 (d, *J* = 3.6 Hz, 1 H), 8.68 (d, *J* = 1.8 Hz, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 8.57, 24.86, 25.03, 31.3, 31.7, 50.3, 56.7, 111.3, 123.0, 129.1, 134.1, 135.7, 147.8, 178.0.

MS (DEI): *m*/*z* (%) = 270 (100, [M$^+$]), 255 (2, [M$^+$ – Me]), 241 (48, [M$^+$ – Et]), 188 (17, [M$^+$ – C_6H_{10}]), 84 (10, [$C_6H_{12}^+$]).

HRMS: *m*/*z* calcd for $C_{17}H_{22}N_2O$: 270.17321; found: 270.17314, Δ = 0.07 mmu.

***N*-Cyclohexyl-2-ethyl-3-(3-pyridyl)pyrrole (5gd)**
Yield: 52 mg (20%); eluent: CH_2Cl_2.

^{1}H NMR (200 MHz, $CDCl_3$): δ = 1.12 (t, *J* = 7.6 Hz, 3 H), 1.30–2.03 (m, 10 H), 2.70 (q, *J* = 7.6 Hz, 2 H), 3.78–3.85 (m, 1 H), 6.25 (d, *J* = 3.0 Hz, 1 H), 6.72 (d, *J* = 3.0 Hz, 1 H), 7.20–7.26 (m, 1 H), 7.63 (dt, *J* = 2.0, 8.0 Hz, 1 H), 8.35–8.42 (m, 1 H), 8.60–8.65 (m, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 15.6, 17.8, 25.4, 26.1, 34.9, 55.1, 107.6, 116.5, 117.1, 123.2, 128.7, 133.5, 134.9, 146.2, 149.0.

MS (DEI): *m*/*z* (%) = 254 (100, [M$^+$]), 239 (13, [M$^+$ – Me]), 156 (10, [M$^+$ – C_7H_{14}]), 29 (18, [Et$^+$]).

HRMS: *m*/*z* calcd for $C_{17}H_{22}N_2$: 254.17830; found: 254.17875, Δ = 0.45 mmu.

***N*-Butyl-3-ethyl-3-(3-pyridyl)-1,3-dihydropyrrol-2-one (4gf)**
Yield: 133 mg (54%); eluent: EtOH.

IR (neat): 2959 (m), 2932 (m), 2874 (w), 1694 (vs), 1670 (vs), 1655 (vs), 1547 (m), 1416 (m), 1373 (m), 1261 (m), 1026 (m), 806 (s), 714 cm^{-1} (vs).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.79 (t, *J* = 7.4 Hz, 1.5 H), 0.88 (t, *J* = 7.2 Hz, 1.5 H), 0.89 (t, *J* = 7.2 Hz, 1.5 H), 1.12 (t, *J* = 7.6 Hz, 1.5 H), 1.24–1.31 (m, 2 H), 1.44–1.50 (m, 2 H), 1.98 (q, *J* = 7.4 Hz, 1 H), 2.16 (q, *J* = 7.6 Hz, 1 H), 3.18–3.24 (m, 1 H), 3.34–3.42 (m, 1 H), 5.63 (d, *J* = 5.0 Hz, 1 H), 6.57 (d, *J* = 5.0 Hz, 1 H), 7.22 (q, *J* = 4.8 Hz, 1 H), 7.89 (dt, *J* = 2.0, 8.0 Hz, 1 H), 8.39–8.43 (m, 1 H), 8.52–8.59 (m, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 9.1, 9.9, 13.6, 13.7, 19.8, 20.0, 29.8, 30.9, 31.4, 31.7, 39.2, 41.8, 56.8, 111.6, 123.5, 132.4, 134.6, 136.5, 148.2, 178.9.

MS (DEI): *m*/*z* (%) = 245 (100, [M$^+$ + 1]), 244 (68, [M$^+$]), 215 (41, [M$^+$ – Et]), 201 (4, [M$^+$ – C_3H_7]), 173 (23, [M$^+$ – C_5H_{11}]), 27 (60, [Et$^+$]).

HRMS: *m*/*z* calcd for $C_{15}H_{20}N_2O$: 244.15756; found: 244.15759, Δ = 0.03 mmu.

***N*-Butyl-2-ethyl-3-(3-pyridyl)pyrrole (5gf)**
Yield: 72 mg (32%); eluent: light petroleum–CH_2Cl_2 (70:30).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.95 (t, *J* = 7.2 Hz, 3 H), 1.20 (t, *J* = 7.4 Hz, 3 H), 1.40 (q, *J* = 7.2 Hz, 2 H), 1.68–1.75 (m, 2 H), 2.69 (q, *J* = 7.4 Hz, 2 H), 3.83 (t, *J* = 7.2 Hz, 2 H), 6.22 (d, *J* = 2.8 Hz, 1 H), 6.63 (d, *J* = 2.8 Hz, 1 H), 7.50 (dd, *J* = 3.2, 5.8 Hz, 1 H), 7.64 (dt, *J* = 2.0, 8.0 Hz, 1 H), 8.34–8.41 (m, 1 H), 8.56–8.63 (m, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 13.8, 15.2, 17.8, 20.1, 33.7, 46.4, 107.4, 119.9, 123.1, 123.6, 128.8, 130.9, 134.8, 146.0, 148.8.

MS (DEI): *m*/*z* (%) = 228 (100, [M$^+$]), 213 (19, [M$^+$ – Me]), 185 (7, [M$^+$ – C_3H_7]), 157 (8, [M$^+$ – C_5H_{11}]), 149 (14, [M$^+$ – C_5H_5N]), 57 (6, [$C_4H_9^+$]), 29 (20, [Et$^+$]).

HRMS: *m*/*z* calcd for $C_{15}H_{20}N_2$: 228.16265; found: 228.16302, Δ = 0.37 mmu.

***N*-(4-*tert*-Butylphenyl)-3-ethyl-3-(3-pyridyl)-1,3-dihydropyrrol-2-one (4gg)**
Yield: 204 mg (64%); eluent: EtOH.

IR (neat): 2920 (vs), 2851 (s), 1709 (w), 1462 (m), 1261 (w), 1022 (w), 802 (m), 718 cm^{-1} (w).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.88 (t, *J* = 7.4 Hz, 3 H), 1.29 (s, 9 H), 2.10 (q, *J* = 7.4 Hz, 2 H), 5.81 (d, *J* = 5.0 Hz, 1 H), 7.01 (d, *J* = 5.0 Hz, 1 H), 7.33–7.43 (m, 4 H), 7.50 (dd, *J* = 3.4, 5.8 Hz, 1 H), 7.96 (dt, *J* = 1.8, 8.0 Hz, 1 H), 8.47–8.52 (m, 1 H), 8.59–8.64 (m, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 9.1, 31.3, 31.8, 34.5, 57.4, 112.6, 121.2, 123.3, 126.1, 130.9, 132.5, 134.1, 134.6, 148.3, 148.5, 149.1, 177.7.

MS (DEI): *m*/*z* (%) = 320 (100, [M$^+$]), 305 (42, [M$^+$ – Me]), 291 (61, [M$^+$ – Et]), 277 (22, [M$^+$ – C_3H_7]), 134 (95, [$C_{10}H_{14}^+$]), 57 (14, [$C_4H_9^+$]).

HRMS: *m*/*z* calcd for $C_{21}H_{24}N_2O$: 320.18886; found: 320.18865, Δ = 0.21 mmu.

***N*-(4-*tert*-Butylphenyl)-2-ethyl-3-(3-pyridyl)pyrrole (5gg)**
Yield: 93 mg (31%); eluent: CH_2Cl_2.

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.94 (t, *J* = 7.4 Hz, 3 H), 1.36 (s, 9 H), 2.72 (q, *J* = 7.4 Hz, 2 H), 5.35 (d, *J* = 3.0 Hz, 1 H), 6.75 (d, *J* = 3.0 Hz, 1 H), 6.95–7.03 (m, 2 H), 7.32–7.39 (m, 2 H), 7.37–7.43 (m, 1 H), 8.32–8.38 (m, 1 H), 8.54–8.67 (m, 2 H).

^{13}C NMR (150 MHz, $CDCl_3$): δ = 14.1, 19.2, 31.3, 34.4, 108.3, 114.9, 119.4, 122.3, 126.3, 128.9, 132.4, 130.9, 134.1, 134.9, 146.5, 148.0, 148.7.

MS (DEI): *m*/*z* (%) = 304 (100, [M$^+$]), 289 (68, [M$^+$ – Me]), 233 (21, [M$^+$ – C_5H_{11}]), 57 (14, [$C_4H_9^+$]).

HRMS: *m*/*z* calcd for $C_{21}H_{24}N_2$: 304.19395; found: 304.19406, Δ = 0.11 mmu.

***N*-*sec*-Butyl-3-ethyl-3-(3-pyridyl)-1,3-dihydropyrrol-2-one (4gh)**
Yield: 98 mg (40%); eluent: EtOH.

IR (neat): 2967 (w), 2932 (vw), 2878 (vw), 1694 (vs), 1609 (m), 1458 (m), 1381 (s), 1258 (s), 1219 (s), 1026 (m), 910 (m), 806 (m), 714 cm^{-1} (vs).

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.66–0.86 (m, 6 H), 1.10 (d, *J* = 6.8 Hz, 1.5 H), 1.15 (d, *J* = 6.8 Hz, 1.5 H), 1.44–1.51 (m, 2 H), 1.96 (q, *J* = 7.4 Hz, 2 H), 3.96–4.08 (m, 1 H), 5.59 (d, *J* = 3.0 Hz, 0.5 H), 5.62 (d, *J* = 3.0 Hz, 0.5 H), 6.59 (d, *J* = 5.2 Hz, 1 H), 7.19 (q, *J* = 4.8 Hz, 1 H), 7.79–7.83 (m, 1 H), 8.41 (dd, *J* = 1.4, 4.8 Hz, 1 H), 8.54 (d, *J* = 2.2 Hz, 1 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 8.9, 9.2, 10.6, 10.7, 19.4, 19.5, 28.3, 28.4, 31.1, 31.2, 48.6, 48.6, 57.1, 57.2, 111.9, 112.0, 123.4, 128.8, 128.9, 134.3, 134.4, 135.9, 136.0, 148.2, 178.6.

MS (DEI): *m*/*z* (%) = 244 (100, [M$^+$]), 229 (3, [M$^+$ – Me]), 215 (89, [M$^+$ – Et]), 201 (2, [M$^+$ – C_3H_7]), 187 (24, [M$^+$ – C_4H_9]), 173 (6, [M$^+$ – C_5H_{11}]), 159 (76, [M$^+$ – C_6H_{13}]), 57 (8, [$C_4H_9^+$]).

HRMS: *m*/*z* calcd for $C_{15}H_{20}N_2O$: 244.15756; found: 244.15763, Δ = 0.07 mmu.

***N*-*sec*-Butyl-2-ethyl-3-(3-pyridyl)pyrrole (5gh)**
Yield: 97 mg (43%); eluent: CH_2Cl_2.

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.84 (t, *J* = 7.4 Hz, 3 H), 1.22 (t, *J* = 7.4 Hz, 3 H), 1.42 (d, *J* = 6.8 Hz, 3 H), 1.77 (q, *J* = 7.4 Hz, 2 H), 2.69 (q, *J* = 7.6 Hz, 2 H), 4.02 (q, *J* = 6.8 Hz, 1 H), 6.27 (d, *J* = 3.0 Hz, 1 H), 6.67 (d, *J* = 3.0 Hz, 1 H), 7.24 (dq, *J* = 0.8, 4.8 Hz, 1 H), 7.64 (dt, *J* = 2.0, 7.8 Hz, 1 H), 8.39 (dd, *J* = 1.6, 4.8 Hz, 1 H), 8.63 (dd, *J* = 0.8, 2.2 Hz, 1 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 11.0, 15.5, 17.7, 22.3, 31.1, 52.7, 107.8, 115.7, 116.9, 123.2, 131.4, 133.5, 134.9, 146.1, 149.0.

MS (DEI): *m*/*z* (%) = 228 (100, [M$^+$]), 213 (78, [M$^+$ – Me]), 199 (24, [M$^+$ – Et]), 157 (41, [M$^+$ – C_5H_{11}]).

HRMS: *m*/*z* calcd for $C_{15}H_{20}N_2$: 228.16265; found: 228.16293, Δ = 0.28 mmu.

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