Synthesis of substituted maleimide derivatives using the Baylis–Hillman adducts

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The Baylis–Hillman alcohols, 3-ethoxycarbonyl-3-hydroxy-3-aryl(alkyl)-2-methylenepropanenitriles, derived from α-keto esters and acrylonitrile, have been conveniently transformed into 3,4-disubstituted 1H-pyrrole-2,5-dione (maleimide) derivatives on treatment with $FeCl_3/RCO_2H$ in a one-pot operation.

Keywords: Baylis–Hillman adducts, cyclization, Friedel–Crafts reaction, pyrrole-2,5-diones, α-keto esters.

Introduction

THE Baylis–Hillman (B–H) reaction has emerged, in recent years, as an useful and popular carbon–carbon bond forming reaction providing diverse classes of densely functionalized molecules through the reaction between activated alkenes and electrophiles under the influence of a catalyst in an operationally simple one-pot atom-economical process[1–8]. These densely functionalized molecules are usually referred to as the B–H adducts and have been extensively used as valuable synthons for obtaining a number of heterocyclic and carbocyclic compounds including various natural products and bioactive molecules[1–8]. In continuation of our research on the B–H reaction[9–13], we herein report a facile simple and one-pot methodology for synthesis of 3,4-disubstituted maleimide derivatives through the treatment of 3-ethoxycarbonyl-3-hydroxy-3-aryl(alkyl)-2-methylenepropanenitriles (the B–H adducts derived from α-keto esters and acrylonitrile) with $FeCl_3/RCO_2H$.

3,4-Disubstituted maleimide framework[14–19] represents an interesting structural organization in heterocyclic chemistry as this skeleton is present in a number of natural products such as arcyriarubins A, B[14], polycitrins A, B[15] and himanimides A–D[16]. Certain compounds having this framework have also been known to exhibit various biological activities such as protein kinase C inhibitors[17], vascular endothelial cell proliferation[18] and angiogenesis inhibitor[19].

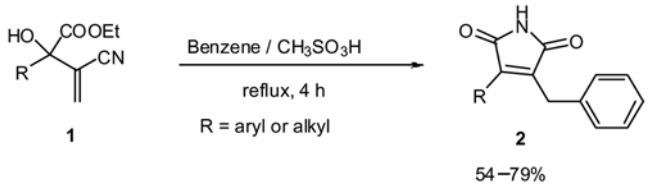
Recently, we have reported a facile one-pot methanesulphonic acid mediated transformation of the B–H adducts, 3-ethoxycarbonyl-3-hydroxy-3-aryl(alkyl)-2-methylenepropanenitrile (**1**) (obtained from α-keto esters and acrylonitrile) into unsymmetrical maleimides **2** in the presence of benzene (Scheme 1)[10]. This strategy involves Friedel–Crafts reaction of benzene with B–H adducts **1** (as electrophile), partial hydrolysis of nitrile into amide and then imide formation.

We have also reported a convenient methodology for synthesis of 3-arylmethylidene (or alkylidene) piperidine-2,6-diones **4** from the B–H alcohols **3** (derived from aldehydes and acrylonitrile) in a facile one-pot procedure involving Johnson–Claisen (J–C) rearrangement followed by partial hydrolysis of nitrile into amide, and cyclization using $FeCl_3/CH_3CO_2H$ (Scheme 2)[20].

Results and discussion

On the basis of the above-mentioned observations, it occurred to us that the B–H adducts **1**, derived from α-keto esters and acrylonitrile, should, in principle, be easily transformed into the desired 3-alkylcarbonyloxymethyl-4-aryl(or alkyl) maleimide derivatives by treating with $FeCl_3$ (refs 20–22) in the presence of a appropriate carboxylic acid (retrosynthetic strategy, see Scheme 3).

Accordingly, we have first selected 3-ethoxycarbonyl-3-hydroxy-3-phenyl-2-methylenepropanenitrile (**1a**) (B–H adduct obtained from ethyl phenylglyoxylate and acrylonitrile) as a substrate. The best results were obtained when **1a** was treated with anhydrous $FeCl_3$ (4 mmol) in propanoic acid (5 ml) at reflux temperature for 5 h, thus providing the desired 3-(ethylcarbonyloxy)methyl-4-phenyl-1H-pyrrole-2,5-dione (**5**) in 61% isolated yield (Table 1, entry 1). To understand the general nature of this one-pot process, various B–H alcohols **1b–e** (obtained from various aromatic α-keto esters and acrylonitrile) were subjected to this treatment (with $FeCl_3$ in the presence of propanoic acid) to provide the desired



Scheme 1. Friedel–Crafts reaction of B–H adducts: synthesis of 4-substituted 3-benzyl-1H-pyrrole-2,5-dione derivatives.

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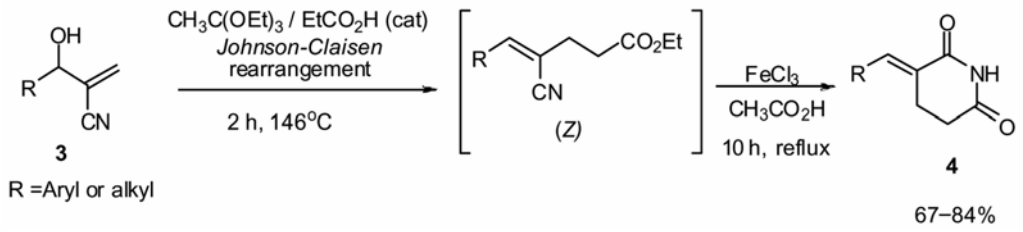
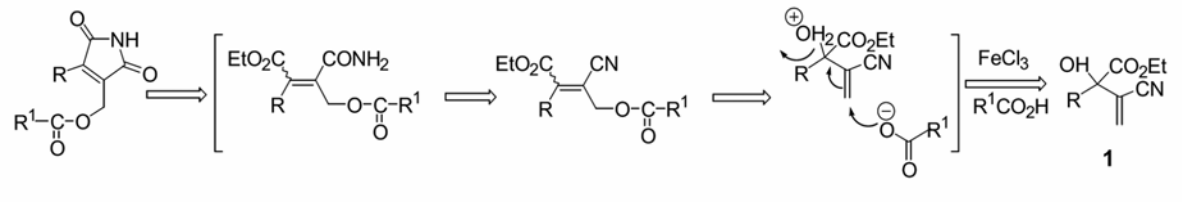
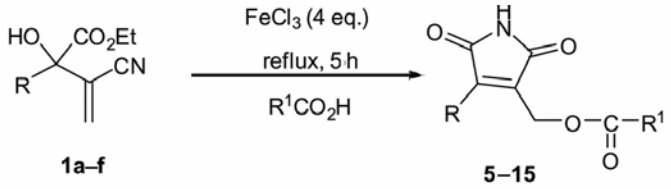


Scheme 2. Transformation of the B–H adducts into piperidine-2,6-dione derivatives.



Scheme 3. Retrosynthetic strategy for the synthesis of 3,4-disubstituted pyrrole-2,5-diones.

Table 1. Synthesis of 3,5-disubstituted 1H-pyrrole-2,5-diones[a]



Entry	B–H alcohol	R	R^1	Product[b]	Yield[c] (%)
1	**1a**	C_6H_5	Et	**5**	61
2	**1b**	2-MeC_6H_4	Et	**6**	54
3	**1c**	3-MeC_6H_4	Et	**7**[d]	60
4	**1d**	3-$MeOC_6H_4$	Et	**8**	61
5	**1e**	4-MeC_6H_4	Et	**9**	55
6	**1f**	Me	Et	**10**	63
7	**1a**	C_6H_5	Me	**11**	50
8	**1c**	3-MeC_6H_4	Me	**12**[d]	65
9	**1d**	3-$MeOC_6H_4$	Me	**13**	52
10	**1e**	4-MeC_6H_4	Me	**14**	62
11	**1f**	Me	Me	**15**	59

[a]All reactions were carried out on a 1 mmol scale of B–H adducts (**1a–f**). [b]All the compounds (**5–15**) were obtained as light yellow solids and well characterized (see Experimental Part). [c]Isolated yields based on B–H adducts. [d]Structures of these molecules were also confirmed by single crystal X-ray data analysis (Figures 1 and 2).

3-(ethylcarbonyloxy)methyl-4-aryl-1H-pyrrole-2,5-diones (**6–9**) in 54–61% isolated yields (Table 1, entries 2–5).

To understand the applicability of this strategy to other carboxylic acids, we have also used acetic acid. Thus, the treatment of representative B–H alcohols **1a**, **c–e** with $FeCl_3$ in the presence of acetic acid at reflux temperature for 5 h provided the expected 3-(methylcarbonyloxy) methyl-4-aryl-1H-pyrrole-2,5-diones (**11–14**) in 50–65% isolated yields (Table 1, entries 7–10). We have then extended this methodology to B–H adduct **1f**, i.e. 3-ethoxycarbonyl-3-hydroxy-2-methylenebutanenitrile (obtained from ethyl pyruvate and acrylonitrile). Thus, the reaction between **1f** and $FeCl_3$ in the presence of propanoic acid and acetic acid under similar conditions provided 3-(ethylcarbonyloxy)methyl-4-methyl-1H-pyrrole-2,5-dione (**10**) (Table 1, entry 6), and 3-(methylcarbonyloxy)methyl-4-methyl-1H-pyrrole-2,5-dione (**15**) (Table 1, entry 11) in 63% and 59% yields respectively. The structures of the compounds **7** (Figure 1) and **12** (Figure 2) were further confirmed by single crystal X-ray data analysis (detailed X-ray crystallographic data is available from the CCDC, 12 Union Road, Cambridge CB2 1EZ, UK for compounds **7** (CCDC # 778561), **12** (CCDC # 778562)).

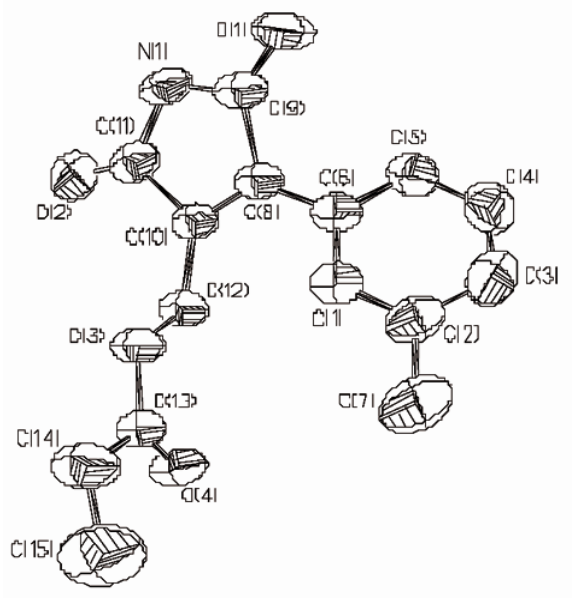


Figure 1. ORTEP diagram of compound **7** (H-atoms were omitted for clarity).

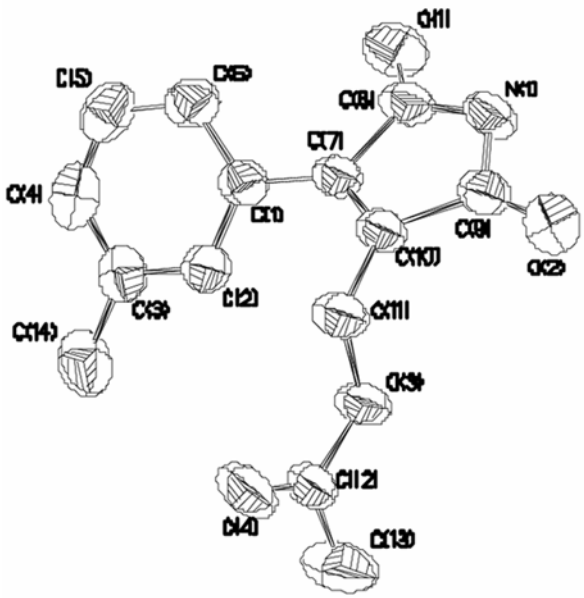
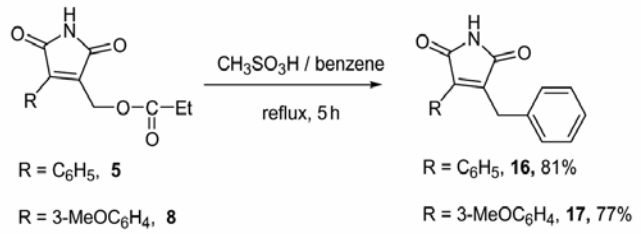


Figure 2. ORTEP diagram of compound **12** (H-atoms were omitted for clarity).



Scheme 4. Synthesis of 3-benzyl-4-aryl-1H-pyrrole-2,5-diones.

To understand the applicability of these maleimides as electrophiles in the Friedel–Crafts reaction, we have performed the reaction between 3-(ethylcarbonyloxy) methyl-4-phenyl-1H-pyrrole-2,5-dione (**5**) and benzene in the presence of methanesulphonic acid. The expected Friedel–Crafts product, 3-benzyl-4-phenyl-1H-pyrrole-2,5-dione (**16**) was obtained in 81% isolated yield. To understand the general nature of this reaction, we have also subjected 3-(ethylcarbonyloxy)methyl-4-(3-methoxyphenyl)-1H-pyrrole-2,5-dione (**8**), to the Friedel–Crafts reaction with benzene in the presence of methanesulphonic acid which provided 3-benzyl-4-(3-methoxyphenyl)-1H-pyrrole-2,5-dione (**17**) in 77% isolated yield (Scheme 4). A plausible mechanism for the formation of 3,4-disubstituted maleimide derivatives from B–H adducts **1** is shown in Scheme 5.

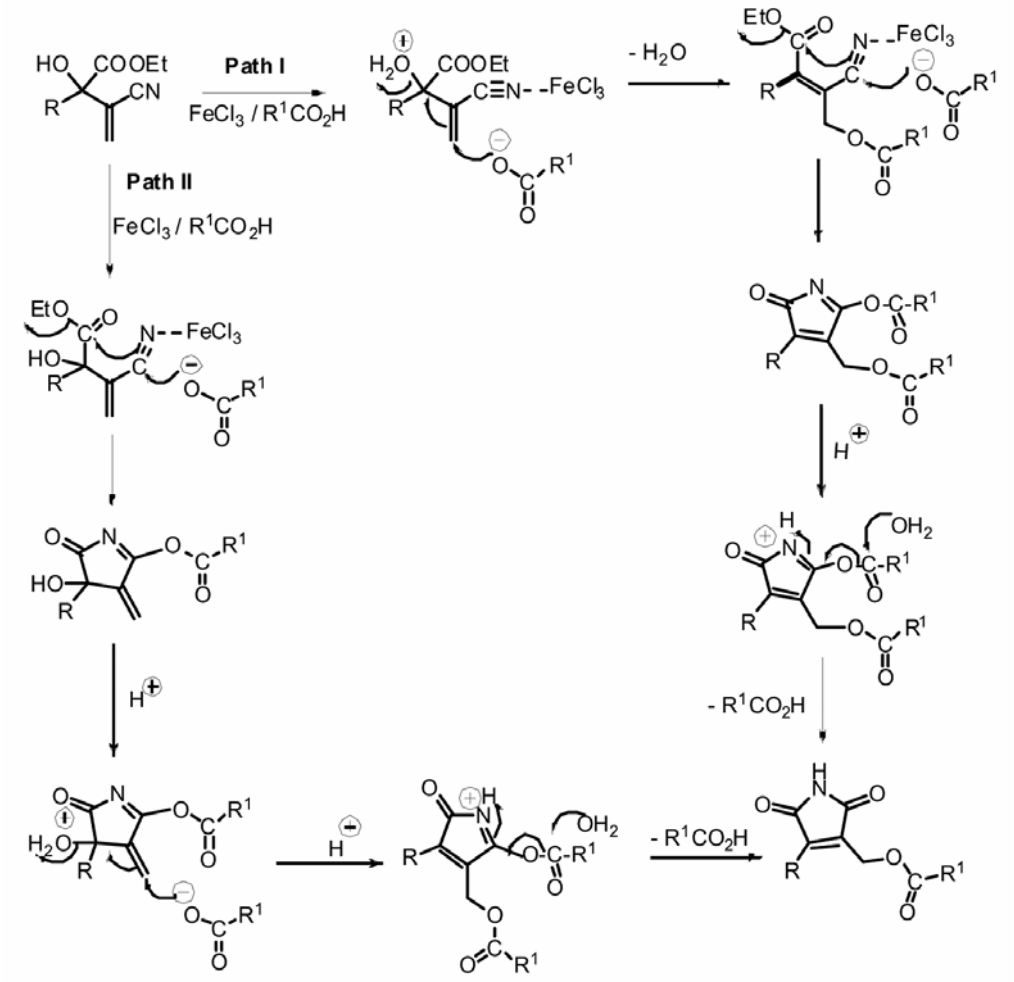
Although the yields of maleimide derivatives are not very high, this study presents a facile and convenient strategy for one-pot synthesis of 3,4-disubstituted maleimide derivatives from the B–H alcohols, obtained from acrylonitrile and α-keto esters. (As the yields of maleimide derivatives are not quantitative, we cannot completely rule out the formation of fumaric acid derivatives in this process.)

Experimental

General

Melting points were recorded on a Superfit (India) capillary melting point apparatus and were uncorrected. Infrared spectra were recorded on a JASCO FT/IR 5300 spectrophotometer. All the spectra were calibrated against polystyrene absorption at 1601 cm^{-1}. Solid samples were recorded on KBr plates. Proton magnetic resonance spectra and carbon-13 magnetic resonance spectra were recorded on a Bruker-AVANCE-400 spectrometer. ^1H NMR (400 MHz) spectrum were recorded in $CDCl_3$, with tetramethylsilane (TMS) ($\delta = 0$ ppm) as an internal standard. ^{13}C NMR (100 MHz) spectrum were measured in $CDCl_3$ (in the case of dimethyl sulphoxide (DMSO)-d_6, $\delta = 39.70$ ppm its middle peak of the septet) with its middle peak of the triplet ($\delta = 77.10$ ppm) as an internal standard. Elemental analyses were recorded on a Thermo–Finnigan Flash EA 1112 analyser. Mass spectra were recorded on Shimadzu-LCMS-2010 A mass spectrometer. The X-ray diffraction measurements were carried out at 298 K on a Bruker SMART APEX CCD area detector system equipped with a graphite monochromator and a Mo-Kα fine-focus sealed tube ($\lambda = 0.71073$ Å).

*3-(Ethylcarbonyloxy)methyl-4-phenyl-1H-pyrrole-2,5-dione (**5**):* To a stirred solution of 3-ethoxycarbonyl-3-hydroxy-3-phenyl-2-methylenepropanenitrile (**1a**) (1 mmol,



Scheme 5. A plausible mechanism for the formation of 3,4-disubstituted maleimides.

0.231 g) in propanoic acid (5 ml) was added anhydrous $FeCl_3$ (4 mmol, 0.649 g) and heated under reflux for 5 h. The reaction mixture was cooled to room temperature and diluted with aqueous 4 N HCl (5 ml) and extracted with dichloromethane (3 × 10 ml). The combined organic layer was washed with saturated $NaHCO_3$ solution and water and dried over anhydrous Na_2SO_4. The solvent was removed and the residue thus obtained was purified by column chromatography (silica gel, 20% ethyl acetate (EtOAc) in hexanes) to provide 3-(ethylcarbonyloxy) methyl-4-phenyl-1H-pyrrole-2,5-dione (**5**) as a light yellow solid in 61% (0.157 g) yield. R_f = 0.69 (40% EtOAc in hexanes). Mp: 78–80°C. IR (KBr): ν 3460, 1768, 1730, 1714, 1633 cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$): δ 1.09 (t, 3H, J = 7.6 Hz), 2.29 (q, 2H, J = 7.6 Hz), 5.05 (s, 2H), 7.42–7.64 (m, 5H), 8.17 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 8.88, 27.22, 55.16, 127.61, 128.71, 129.84, 130.70, 133.28, 142.42, 170.24, 173.79. LCMS (*m/z*): 260 ($[M + H]^+$). Analysis calculated for $C_{14}H_{13}NO_4$: C, 64.86; H, 5.05; N, 5.40; found: C, 64.67; H, 5.09; N, 5.45.

*3-(Ethylcarbonyloxy)methyl-4-(2-methylphenyl)-1H-pyrrole-2,5-dione (**6**):* Yield: 54%. R_f = 0.69 (40% EtOAc in hexanes). Mp: 74–75°C. IR (KBr): ν 3229, 1768, 1728, 1716, 1645 cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$): δ 0.94 (t, 3H, J = 7.2 Hz), 1.90–2.09 (m, 2H), 2.23 (s, 3H), 4.90 (s, 1H)$^{\#}$, 4.99 (s, 1H)$^{\#}$, 7.06–7.56 (m, 4H), 8.01 (bs, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 8.68, 20.10, 26.72, 56.16, 125.74, 127.36, 129.50, 130.03, 130.48, 136.65, 136.94, 143.53, 169.80, 169.86, 173.55. LCMS (*m/z*): 272 ($[M - H]^-$). Analysis calculated for $C_{15}H_{15}NO_4$: C, 65.92; H, 5.53; N, 5.13; found: C, 66.03; H, 5.56; N, 5.18. $^{\#}$These two singlets for allyl methyl protons arise from 2-methyl substitutions on the phenyl ring.

*3-(Ethylcarbonyloxy)methyl-4-(3-methylphenyl)-1H-pyrrole-2,5-dione (**7**):* Yield: 60%. R_f = 0.66 (40% EtOAc in hexanes). Mp: 78–79°C. IR (KBr): ν 3232, 1774, 1714, 1710, 1645 cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$): δ 1.10 (t, 3H, J = 7.6 Hz), 2.30 (q, 2H, J = 7.6 Hz), 2.40 (s, 3H), 5.04 (s, 2H), 7.27–7.42 (m, 4H), 7.76 (bs, 1H). ^{13}C NMR

(100 MHz, $CDCl_3$): δ 8.94, 21.43, 27.26, 55.12, 126.97, 127.51, 128.64, 130.35, 131.57, 133.07, 138.49, 142.77, 170.26, 173.78. LCMS (*m/z*): 272 ($[M - H]^-$). Analysis calculated for $C_{15}H_{15}NO_4$: C, 65.92; H, 5.53; N, 5.13; found: C, 66.12; H, 5.48; N, 5.20.

*3-(Ethylcarbonyloxy)methyl-4-(3-methoxyphenyl)-1H-pyrrole-2,5-dione (**8**):* Yield: 61%. R_f = 0.61 (40% EtOAc in hexanes). Mp: 96–98°C. IR (KBr): ν 3256, 1778, 1721, 1705, 1640 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 1.10 (t, 3H, J = 7.6 Hz), 2.31 (q, 2H, J = 7.6 Hz), 3.84 (s, 3H), 5.05 (s, 2H), 7.03 (dd, 1H, J = 8.0, 2.0 Hz), 7.09–7.18 (m, 2H), 7.36–7.44 (m, 1H), 7.66 (bs, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 8.95, 27.29, 55.09, 55.40, 115.11, 116.73, 122.28, 128.74, 129.88, 133.46, 142.49, 159.64, 169.95, 170.00, 173.78. LCMS (*m/z*): 290 ($[M + H]^+$). Analysis calculated for $C_{15}H_{15}NO_5$: C, 62.28; H, 5.23. N, 4.84; found: C, 62.38; H, 5.25; N, 4.58.

*3-(Ethylcarbonyloxy)methyl-4-(4-methylphenyl)-1H-pyrrole-2,5-dione (**9**):* Yield: 55%. R_f = 0.69 (40% EtOAc in hexanes). Mp: 91–93°C. IR (KBr): ν 3232, 1739, 1714, 1708, 1635 cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$): δ 1.11 (t, 3H, J = 7.6 Hz), 2.32 (q, 2H, J = 7.6 Hz), 2.41 (s, 3H), 5.04 (s, 2H), 7.29 (d, 2H, J = 8.0 Hz), 7.48 (d, 2H, J = 8.0 Hz), 7.69 (bs, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 8.95, 21.55, 27.30, 55.12, 124.83, 129.54, 129.86, 132.21, 141.41, 142.65, 170.35, 173.84. LCMS (*m/z*): 274 ($[M + H]^+$); Analysis calculated for $C_{15}H_{15}NO_4$: C, 65.92; H, 5.53; N, 5.13; found: C, 65.84; H, 5.58; N, 5.33.

*3-(Ethylcarbonyloxy)methyl-4-methyl-1H-pyrrole-2,5-dione (**10**):* Yield: 63%. R_f = 0.72 (40% EtOAc in hexanes). Mp: 56–57°C. IR (KBr): ν 3468, 1765, 1743, 1703 cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$): δ 1.16 (t, 3H, J = 7.6 Hz), 2.10 (s, 3H), 2.39 (q, 2H, J = 7.6 Hz), 4.93 (s, 2H), 7.67 (bs, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 8.98, 9.04, 27.26, 54.88, 134.70, 142.97, 170.49, 171.32, 173.97. LCMS (*m/z*): 198 ($[M + H]^+$). Analysis calculated for $C_9H_{11}NO_4$: C, 54.82; H, 5.62; N, 7.10; found: C, 54.65; H, 5.63; N, 7.08.

The compounds **11–15** were prepared from **1a**, **c–f** via the treatment with $FeCl_3$ in the presence of acetic acid.

*3-(Methylcarbonyloxy)methyl-4-phenyl-1H-pyrrole-2,5-dione (**11**):* Yield: 50%. R_f = 0.66 (40% EtOAc in hexanes). Mp: 106–108°C. IR (KBr): ν 3200, 1770, 1736, 1714, 1641 cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$): δ 2.03 (s, 3H), 5.04 (s, 2H), 7.44–7.62 (m, 5H), 7.97 (bs, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 20.62, 55.27, 127.57, 128.84, 129.91, 130.87, 133.20, 142.72, 169.87, 170.32. LCMS (*m/z*): 246 ($[M + H]^+$). Analysis calculated for $C_{13}H_{11}NO_4$: C, 63.67; H, 4.52; N, 5.71; found: C, 63.73; H, 4.60; N, 5.87.

*3-(Methylcarbonyloxy)methyl-4-(3-methylphenyl)-1H-pyrrole-2,5-dione (**12**):* Yield: 65%. R_f = 0.51 (40% EtOAc in hexanes). Mp: 92–94°C. IR (KBr): ν 3205, 1770, 1714, 1705, 1645 cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$): δ 2.03 (s, 3H), 2.41 (s, 3H), 5.03 (s, 2H), 7.29–7.45 (m, 4H), 7.99 (bs, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 20.55, 21.41, 55.21, 126.95, 127.45, 128.64, 130.34, 131.57, 132.88, 138.48, 142.85, 170.25, 170.31, 170.38. LCMS (*m/z*): 260 ($[M + H]^+$). Analysis calculated for $C_{14}H_{13}NO_4$: C, 64.86; H, 5.05; N, 5.40; found: C, 64.82; H, 5.04; N, 5.57.

*3-(Methylcarbonyloxy)methyl-4-(3-methoxyphenyl)-1H-pyrrole-2,5-dione (**13**):* Yield: 52%. R_f = 0.49 (40% EtOAc in hexanes). Mp: 81–82°C. IR (KBr): ν 3271, 1778, 1749, 1712, 1640 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 2.04 (s, 3H), 3.84 (s, 3H), 5.04 (s, 2H), 7.04 (d, 1H, J = 8.4 Hz), 7.09–7.19 (m, 2H), 7.34–7.44 (m, 1H), 7.95 (bs, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 20.55, 55.17, 55.34, 115.08, 116.69, 122.26, 128.69, 129.84, 133.24, 142.54, 159.59, 170.06, 170.17, 170.38. LCMS (*m/z*): 274 ($[M - H]^-$); Analysis calculated for $C_{14}H_{13}NO_5$: C, 61.09; H, 4.76; N, 5.09; found: C, 61.00; H, 4.47; N, 5.22.

*3-(Methylcarbonyloxy)methyl-4-(4-methylphenyl)-1H-pyrrole-2,5-dione (**14**):* Yield: 62%. R_f = 0.53 (40% EtOAc in hexanes). Mp: 132–134°C. IR (KBr): ν 3227, 1768, 1745, 1714, 1640 cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$): δ 2.05 (s, 3H), 2.41 (s, 3H), 5.02 (s, 2H), 7.29 (d, 2H, J = 8.0 Hz), 7.48 (d, 2H, J = 8.0 Hz), 7.81 (bs, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 20.66, 21.58, 55.23, 124.79, 129.58, 129.87, 132.07, 141.47, 142.81, 170.26, 170.29, 170.41. LCMS (*m/z*): 258 ($[M - H]^-$). Analysis calculated for $C_{14}H_{13}NO_4$: C, 64.86; H, 5.05; N, 5.40, found: C, 64.75; H, 5.00; N, 5.48.

*3-(Methylcarbonyloxy)methyl-4-methyl-1H-pyrrole-2,5-dione (**15**):* Yield: 59%. R_f = 0.75 (40% EtOAc in hexanes). Mp: 84–86°C. IR (KBr): ν 3470, 1770, 1741, 1699, 1640 cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$): δ 2.10 (s, 6H), 4.92 (s, 2H), 7.59 (bs, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 9.03, 20.61, 54.90, 134.55, 143.10, 170.44, 170.51, 171.23. LCMS (*m/z*): 184 ($[M + H]^+$). Analysis calculated for $C_8H_9NO_4$: C, 52.46; H, 4.95; N, 7.65; found: C, 52.50; H, 4.90; N, 7.60.

*3-Benzyl-4-phenyl-1H-pyrrole-2,5-dione (**16**)[$]:* To a stirred solution of 3-(ethylcarbonyloxy)methyl-4-phenyl-1H-pyrrole-2,5-dione (**5**) (0.5 mmol, 129.5 mg), in benzene (3 ml) was added methanesulphonic acid (1.5 mmol, 0.144 g, 0.1 ml) and heated under reflux for 5 h. Then the reaction mixture was allowed to cool to room temperature. Then aqueous K_2CO_3 solution was added slowly to neutralize the acid and extracted with EtOAc (3 × 10 ml). The combined organic layer was dried over anhydrous

Na_2SO_4. Solvent was evaporated and the residue thus obtained was purified by column chromatography (silica gel 20% EtOAc in hexanes) to furnish the compound (**16**) as a colourless solid in 81% (0.106 g) isolated yield. Mp: 118–120°C (lit. 118–120)[10]. R_f = 0.75 (40% EtOAc in hexanes). IR (KBr): ν 3236, 1772, 1699, 1650 cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$): δ 3.94 (s, 2H), 7.15–7.32 (m, 5H), 7.41–7.47 (m, 3H), 7.49–7.55 (m, 2H), 7.73 (bs, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 29.75, 126.91, 128.41, 128.48, 128.74, 128.90, 129.47, 130.06, 136.98, 139.30, 139.55, 171.03, 171.62. LCMS (*m/z*): 264 ($[M + H]^+$).

*3-Benzyl-4-(3-methoxyphenyl)-1H-pyrrole-2,5-dione (**17**)*[$]: Yield: 77%. R_f = 0.74 (40% EtOAc in hexanes). Mp: 104–106°C (lit. 103–105)[10]. IR (KBr): ν 3219, 1768, 1716, 1640 cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$): δ 3.75 (s, 3H), 3.94 (s, 2H), 6.96–7.04 (m, 2H), 7.11 (d, 1H, J = 8.0 Hz), 7.16–7.41 (m, 6H), 7.66 (bs, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 29.75, 55.31, 114.65, 116.13, 121.87, 126.92, 128.48, 128.91, 129.57, 129.83, 137.03, 139.42, 139.45, 159.63, 170.91, 171.58. LCMS (*m/z*): 294 ($[M + H]^+$).

[$]The compounds (**16**) and (**17**) are known in the literature. Their spectral data and melting points are in complete agreement with that of literature data[10].

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