Supporting Information

Synthesis of Novel Polysubstituted *N*-Benzyl-1*H*-Pyrroles via Cascade Reaction of Alkynyl FischerCarbenes with *α*-Imino Glycine Methyl Esters

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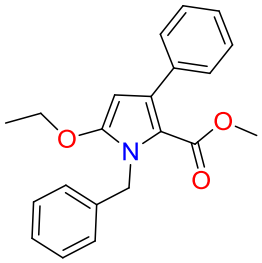
EXPERIMENTAL SECTION

All reactions were carried out under nitrogen. The solvents were dried before use: THF and Et_2O were distilled from Na°; dichloromethane was dried with $CaCl_2$. The alkynyl Fischer carbene complexes and the imino glycine ester were prepared following previous described methods.[1,2]

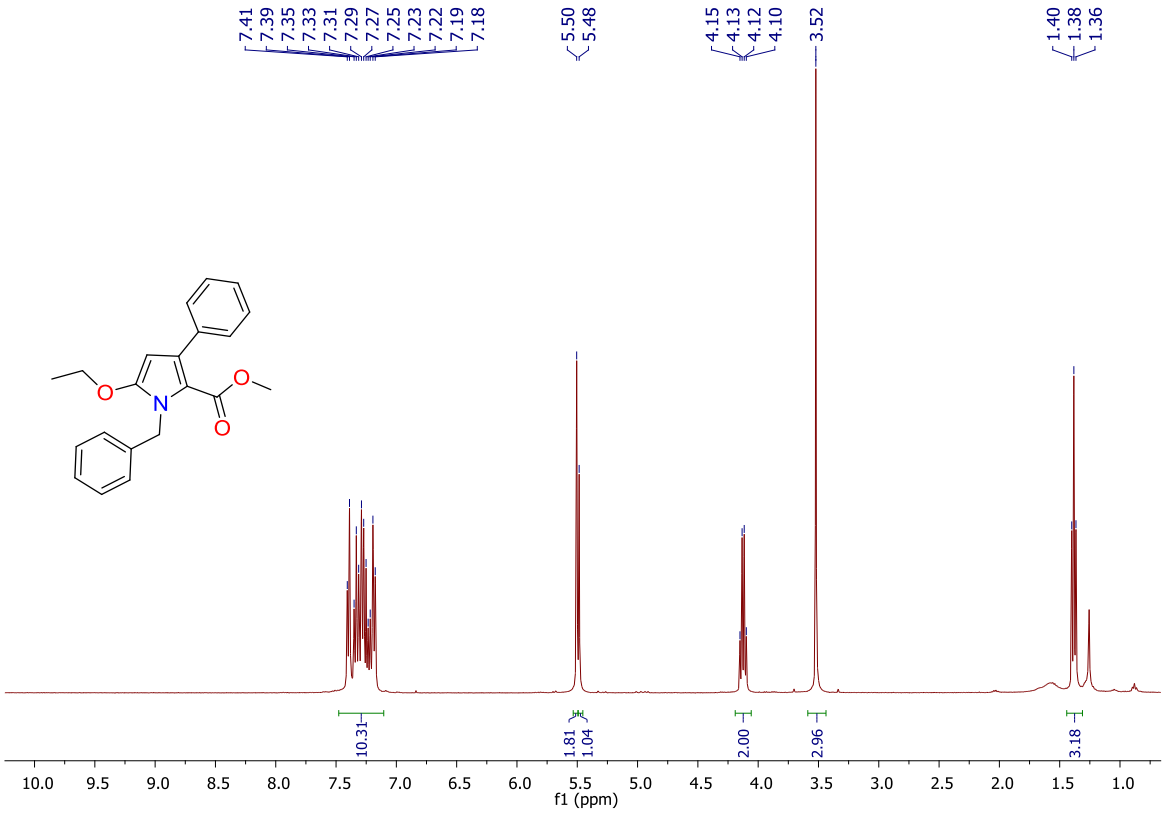
The products were purified by column chromatography with silica gel (MN Kieselgel 60, 230-400 mesh). Mixtures of ethyl acetate and hexane were used as eluents. Analytical TLC was used (aluminium sheets, silica gel 60 F/UV254). Visualization was carried out with UV light and iodine. Melting points were determined on a digital Electrothermal 90100 melting point apparatus. ^1H and ^{13}C NMR spectra were recorded with a Varian Gemini [300 MHz], or a Varian VNMR System [500 MHz], or a Bruker Ascend [400 MHz] or a Bruker Ultrashield [500 MHz] spectrometer in $CDCl_3$. Chemical shifts are reported in ppm, relative to Me_4Si and $CHCl_3$ was used as the internal standard. IR spectra were recorded in potassium bromide plates on a Perkin-Elmer Spectrum 100 FT-IR spectrophotometer. High-resolution mass spectra (HRMS) were determined with electrospray ionization on a Bruker micrOTOF-Q II or electronebulization ionization on a Bruker QTOF mass spectrometer. X-ray data were collected on an Oxford Diffraction Gemini "A" diffractometer with a CCD area detector.

General Procedure for the Synthesis of 1,2,3,5-Tetrasubstituted Pyrroles 6a-r. A mixture of imine **3a-k** (1.04 mmol), alkynyl Fischer carbene complexes **1a-f, 2a** (1.04 mmol), LDA (1.04 mmol) in dry THF (20 mL) was stirred at -78 °C for 2-10 h. The progress of the reaction was monitored by TLC (hexane/EtOAc, 8:2). The resulting reaction mixture was purified by column chromatography. The product was dried under vacuum, quantified and characterized.

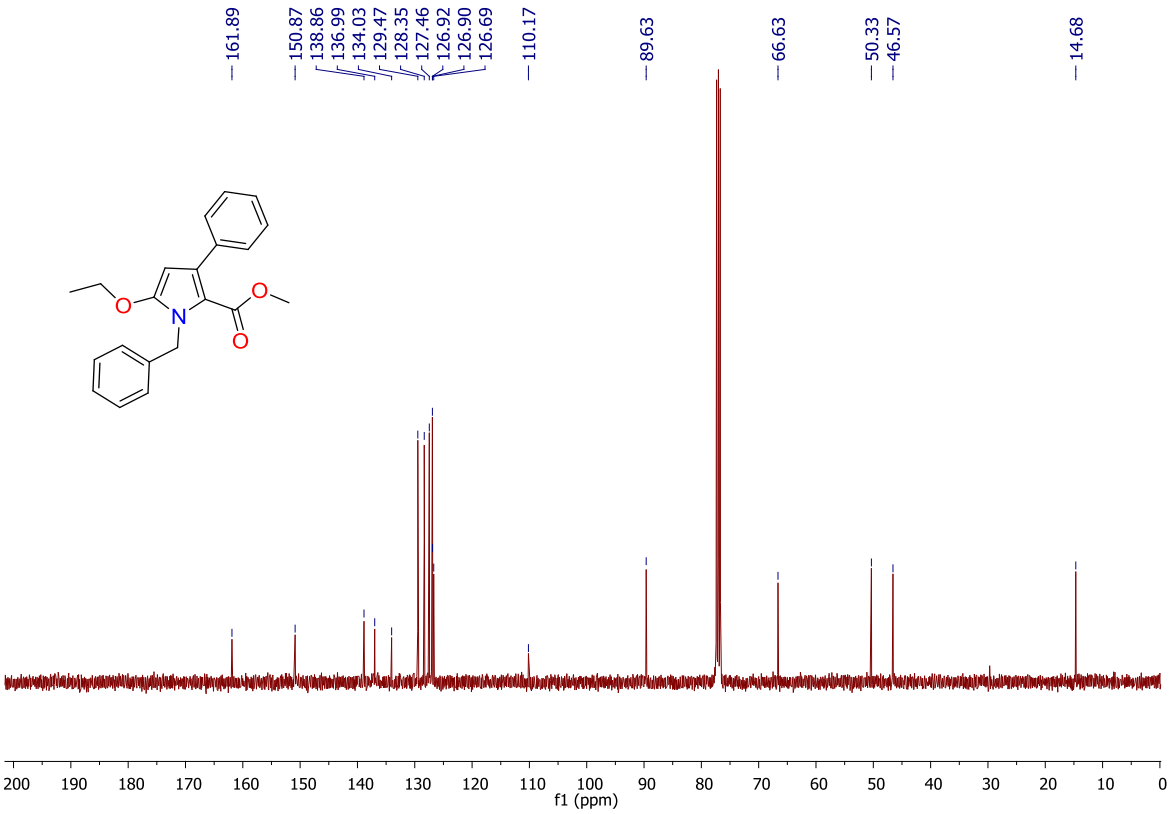


Methyl 1-benzyl-5-ethoxy-3-phenyl-1*H*-pyrrole-2-carboxylate (6a).

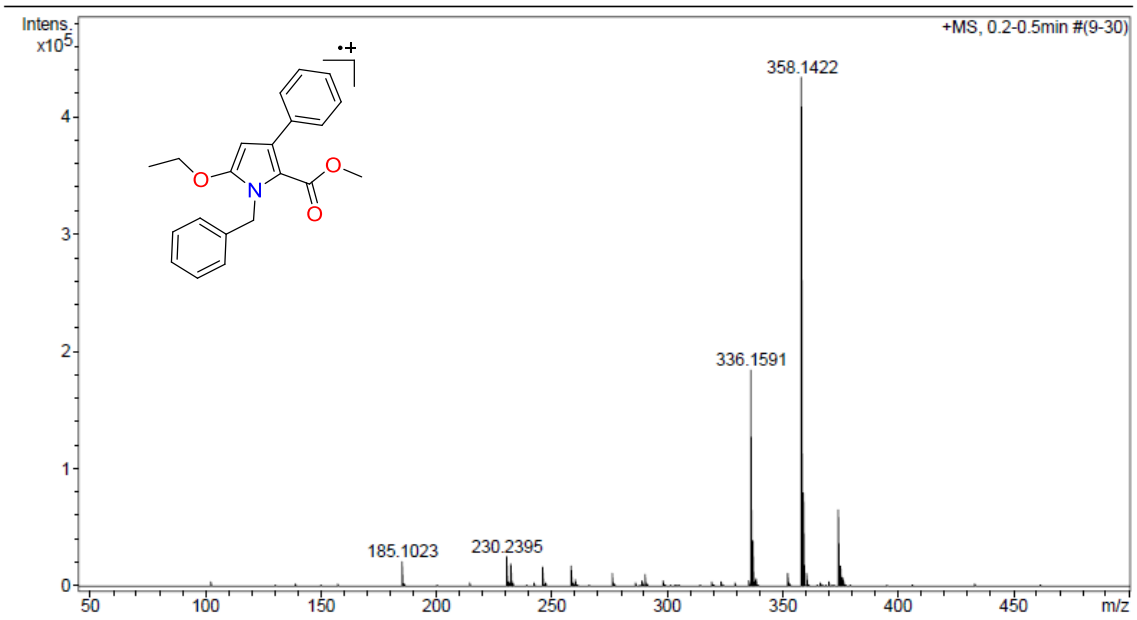
Yield: 80%; brown crystals, mp 80-81 °C. IR (cm^{-1}) 1674 (C=O), 1051 (N-C). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.41-7.18 (m, 10H, C*H*), 5.50 (s, 2H, NCH_2), 5.48 (s, 1H, C*H*), 4.12 (q, J = 8.0 Hz, 2H, OCH_2CH$_3$), 3.52 (s, 3H, CO_2CH_3), 1.38 (t, J = 8.0 Hz, 3H, OCH_2CH_3). ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.9 (CO_2CH_3), 150.9, 138.9, 137.0, 134.0, 129.5, 128.4, 127.5, 126.9, 126.9, 126.7, 110.2, 89.6 (*C*H), 66.6 (OCH_2CH_3), 50.3 (CO_2CH_3), 46.6 (NCH_2), 14.7 (OCH_2CH_3). HRMS (ESI+): m/z calcd for $C_{21}H_{21}NO_3$ $[M+Na]^+$ 358.1419, found 358.1422.



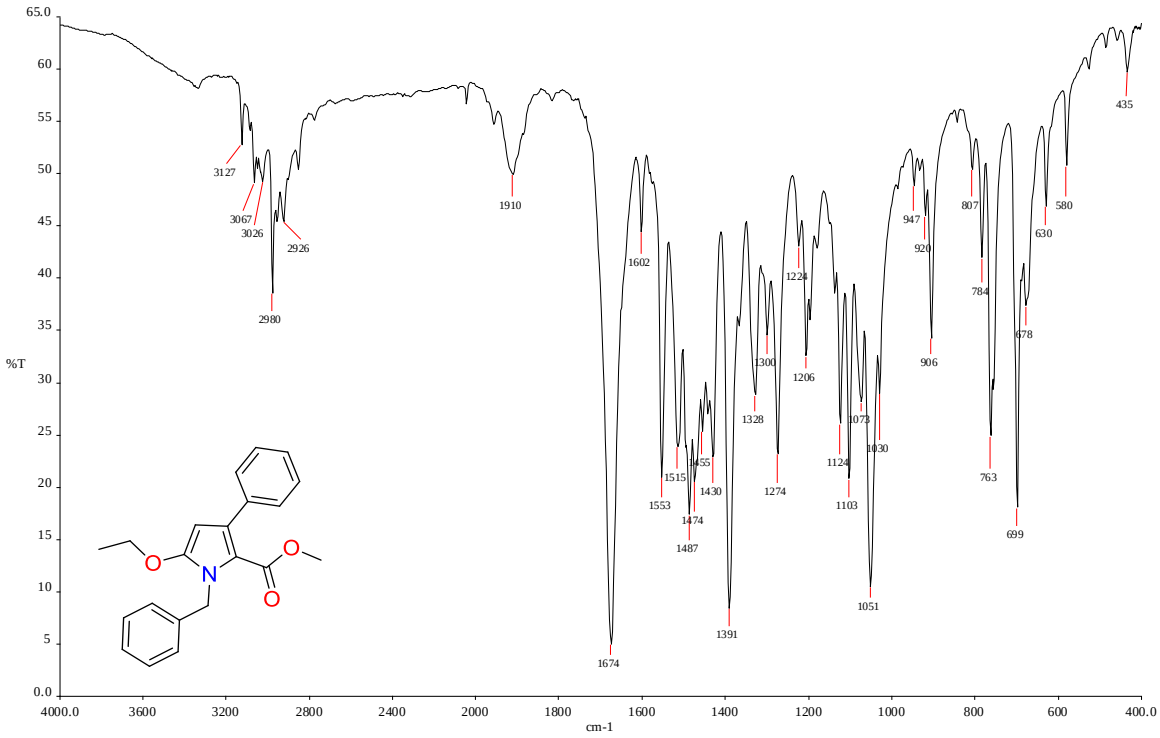
^{1}H, $CDCl_3$, 400 MHz **6a**



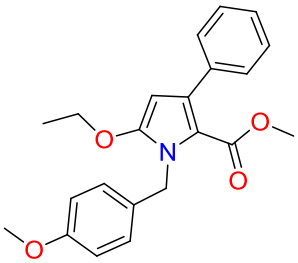
^{13}C, $CDCl_3$, 100 MHz **6a**



HRMS (ESI+) **6a**

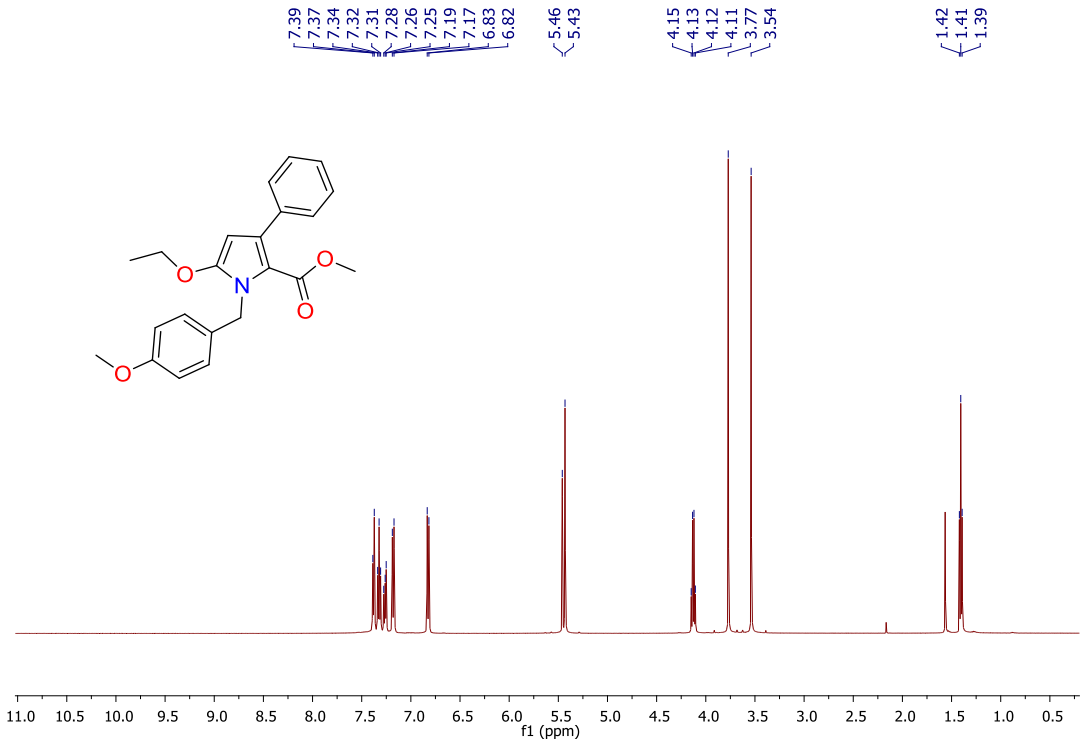


FT-IR (KBr) **6a**

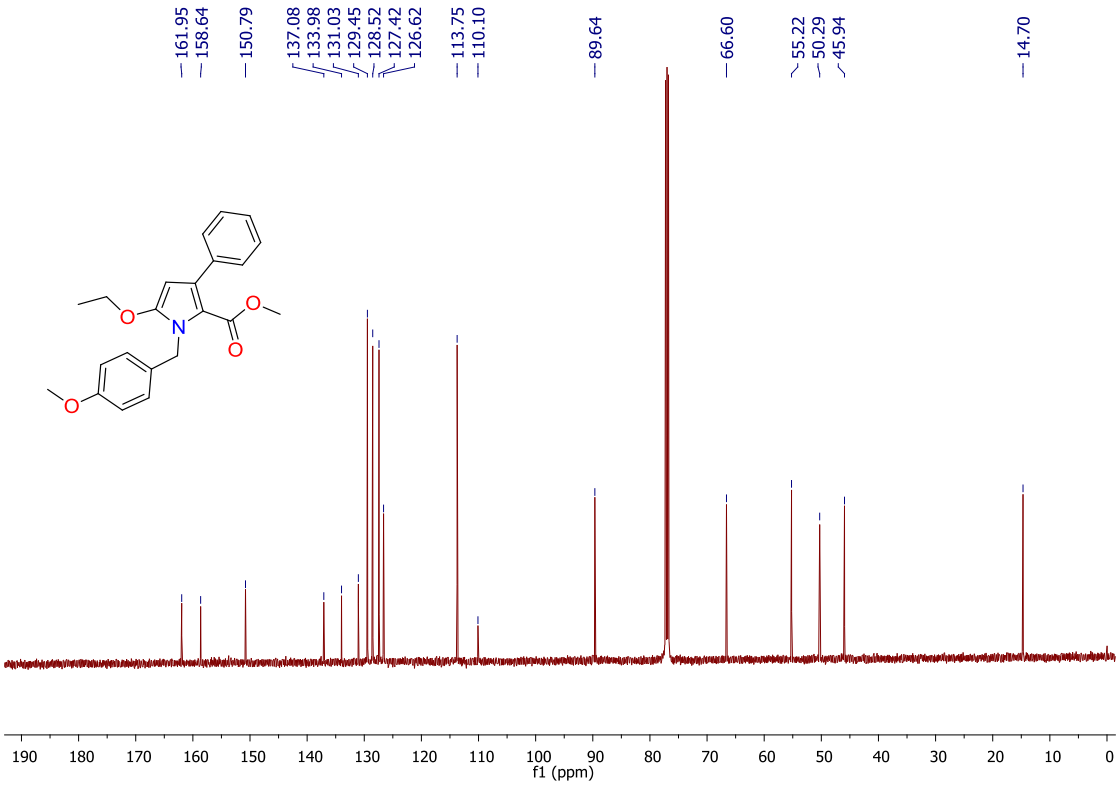


Methyl 5-ethoxy-1-(4-methoxybenzyl)-3-phenyl-1*H*-pyrrole-2-carboxylate (6b).

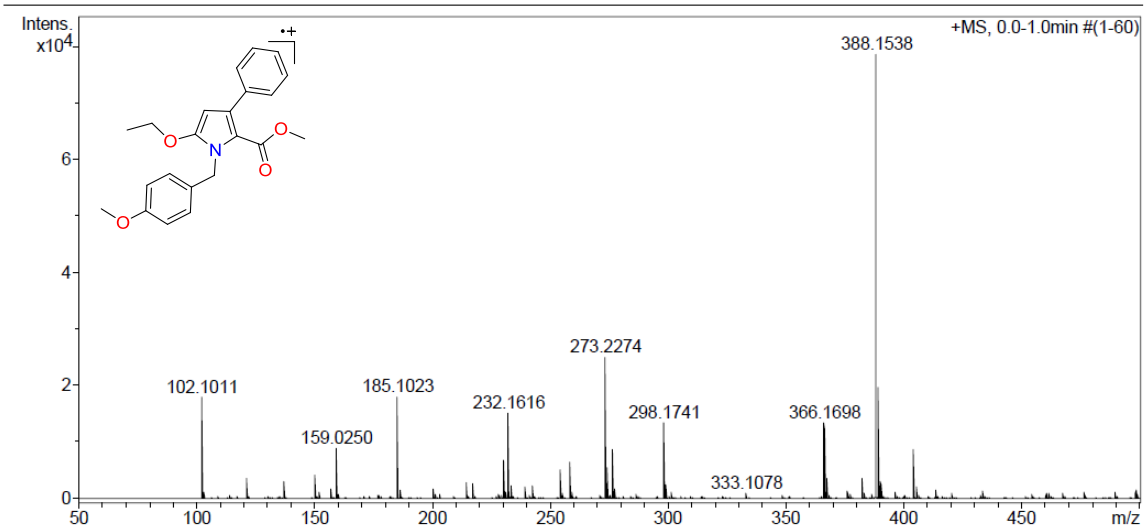
Yield: 49%; brown solid, mp 108-109 °C. IR (cm^{-1}) 1678 (C=O), 1062 (N-C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.39 (d, J = 7.2 Hz, 2H, C*H*), 7.32 (t, J = 7.5 Hz, 2H, C*H*), 7.27 (d, J = 7.3 Hz, 1H, C*H*), 7.18 (d, J = 8.6 Hz, 2H, C*H*), 6.83 (d, J = 8.6 Hz, 2H, C*H*), 5.46 (s, 1H, C*H*), 5.43 (s, 2H, NCH_2), 4.13 (q, J = 7.5 Hz, 2H, OCH_2CH$_3$), 3.77 (s, 3H, OCH_3), 3.54 (s, 3H, CO_2CH_3), 1.41 (t, J = 7.5 Hz, 3H, OCH_2CH_3). ^{13}C NMR (125 MHz, $CDCl_3$) δ 161.9 (CO_2CH_3), 158.6, 150.8, 137.1, 133.98, 131.0, 129.5, 128.5, 127.4, 126.6, 113.8, 110.1, 89.6 (*C*H), 66.6 (OCH_2CH_3), 55.2 (CO_2CH_3), 50.3 (OCH_3), 45.9 (NCH_2), 14.7 (OCH_2CH_3). HRMS (ESI+): m/z calcd for $C_{22}H_{23}NO_4$ $[M+Na]^+$ 388.1525, found 388.1538.



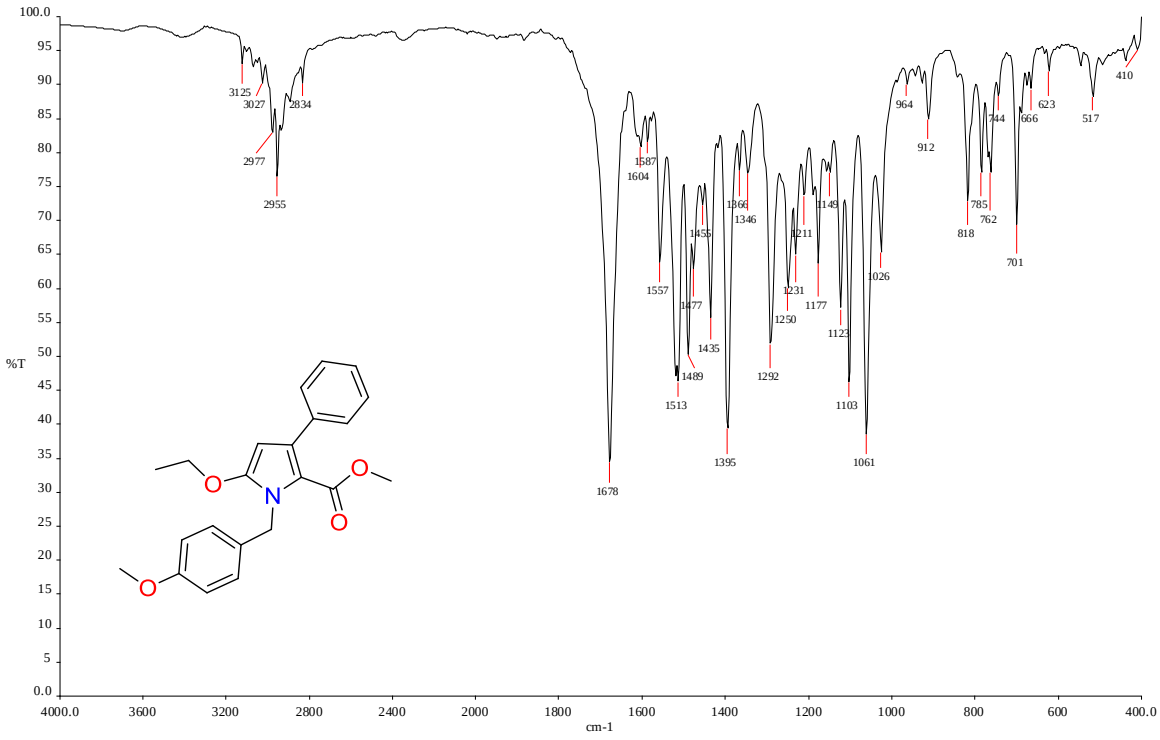
^{1}H, $CDCl_3$, 500 MHz **6b**



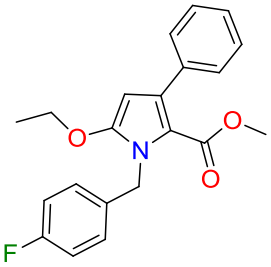
^{13}C, $CDCl_3$, 125 MHz **6b**



HRMS (ESI+) **6b**

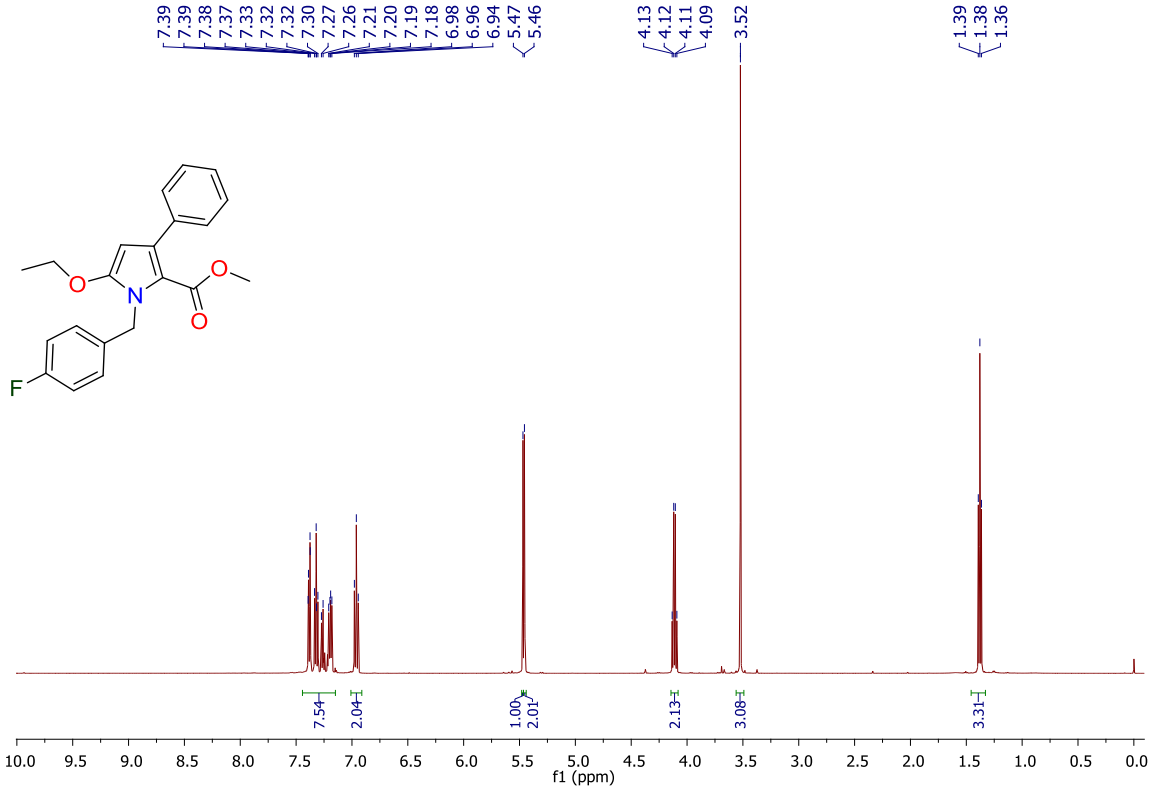


FT-IR (KBr) **6b**

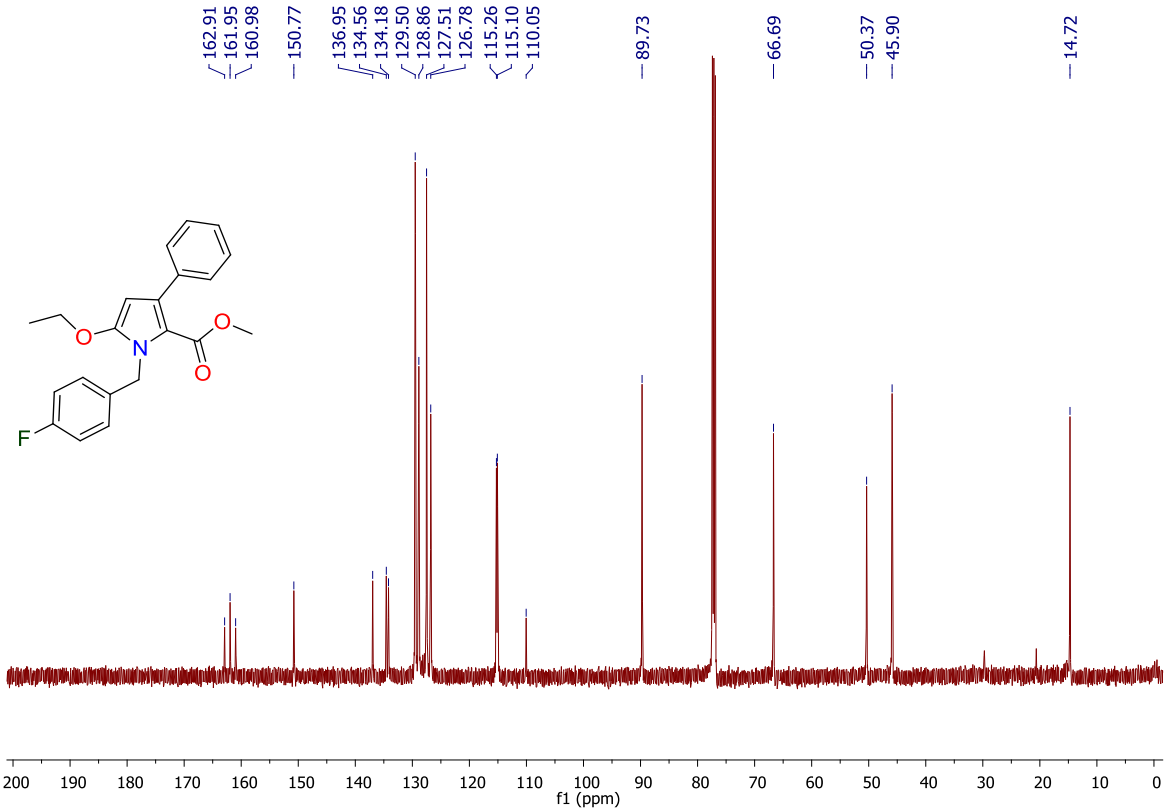


Methyl 5-ethoxy-1-(4-fluorobenzyl)-3-phenyl-1*H*-pyrrole-2-carboxylate (6c).

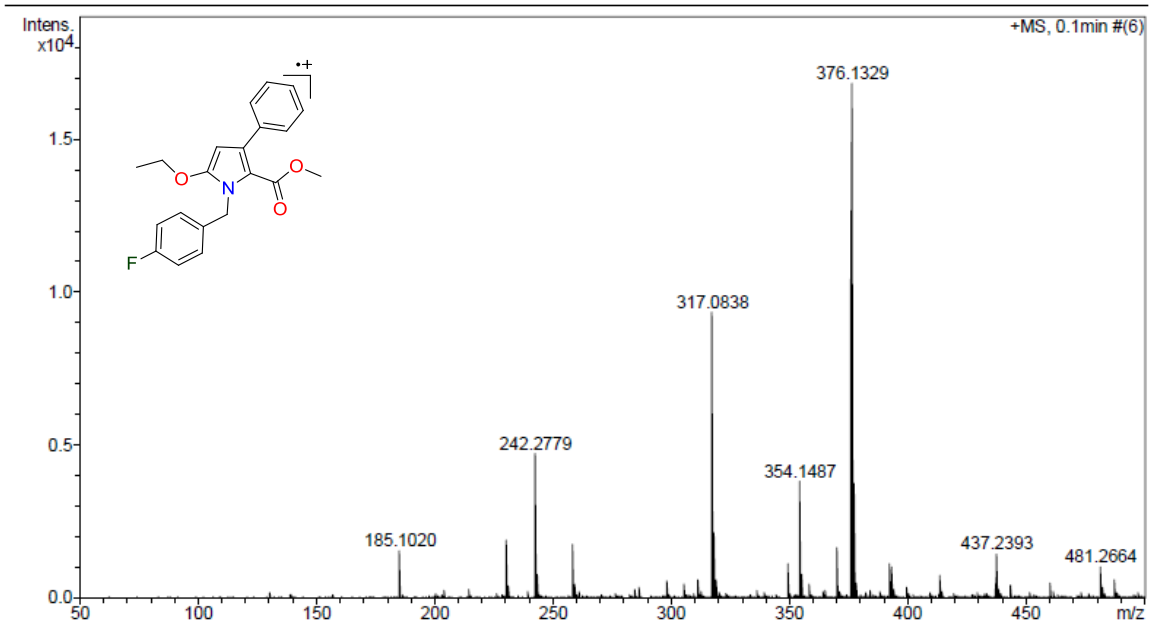
Yield: 75%; amber crystals, mp 100-101 °C. IR (cm^{-1}) 1676 (C=O), 1054 (N-C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.41-7.18 (m, 7H, C*H*), 6.97 (t, J = 9.0 Hz, 2H, C*H*), 5.48 (s, 1H, C*H*), 5.46 (s, 2H, NCH_2), 4.13 (q, J = 7.5 Hz, 2H, OCH_2CH$_3$), 3.53 (s, 3H, CO_2CH_3), 1.40 (t, J = 7.5 Hz, 3H, OCH_2CH_3). ^{13}C NMR (75 MHz, $CDCl_3$) δ 162.9 (J = 144.8 Hz), 162.0 (CO_2CH_3), 150.8, 137.0, 134.6, 134.2, 129.5, 128.9 (J = 7.5 Hz), 127.5, 126.8, 115.1 (J = 21.8 Hz), 110.1, 89.7 (*C*H), 66.7 (OCH_2CH_3), 50.4 (CO_2CH_3), 45.9 (NCH_2), 14.7 (OCH_2CH_3). HRMS (ESI+): m/z calcd for $C_{21}H_{20}FNO_3$ $[M+Na]^+$ 376.1325, found 376.1329.



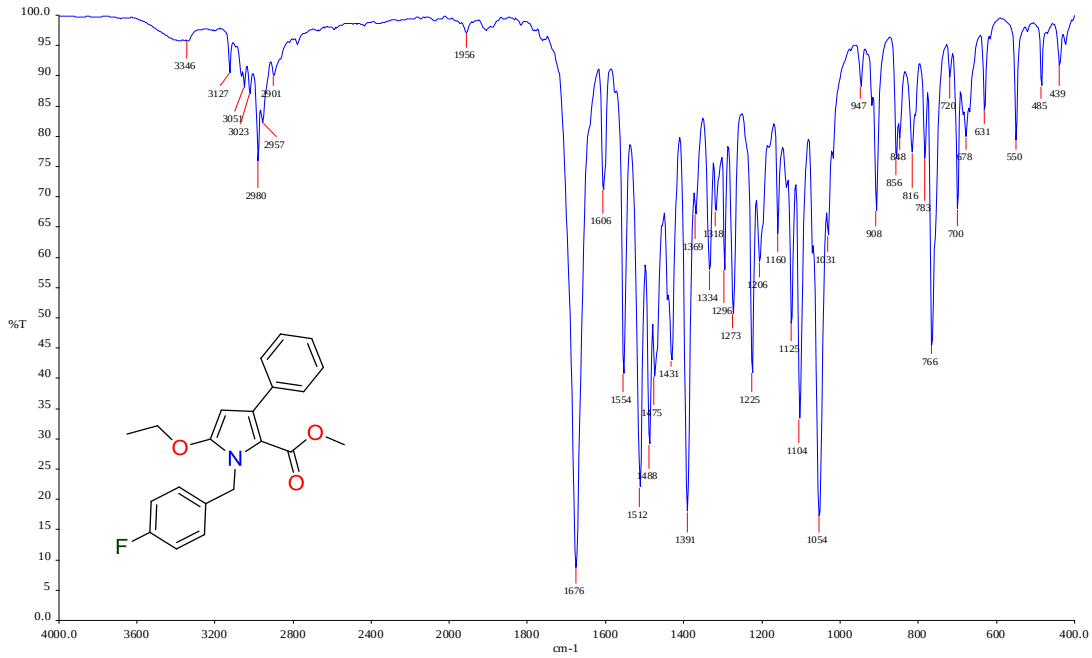
^{1}H, $CDCl_3$, 500 MHz **6c**



^{13}C, $CDCl_3$, 75 MHz **6c**

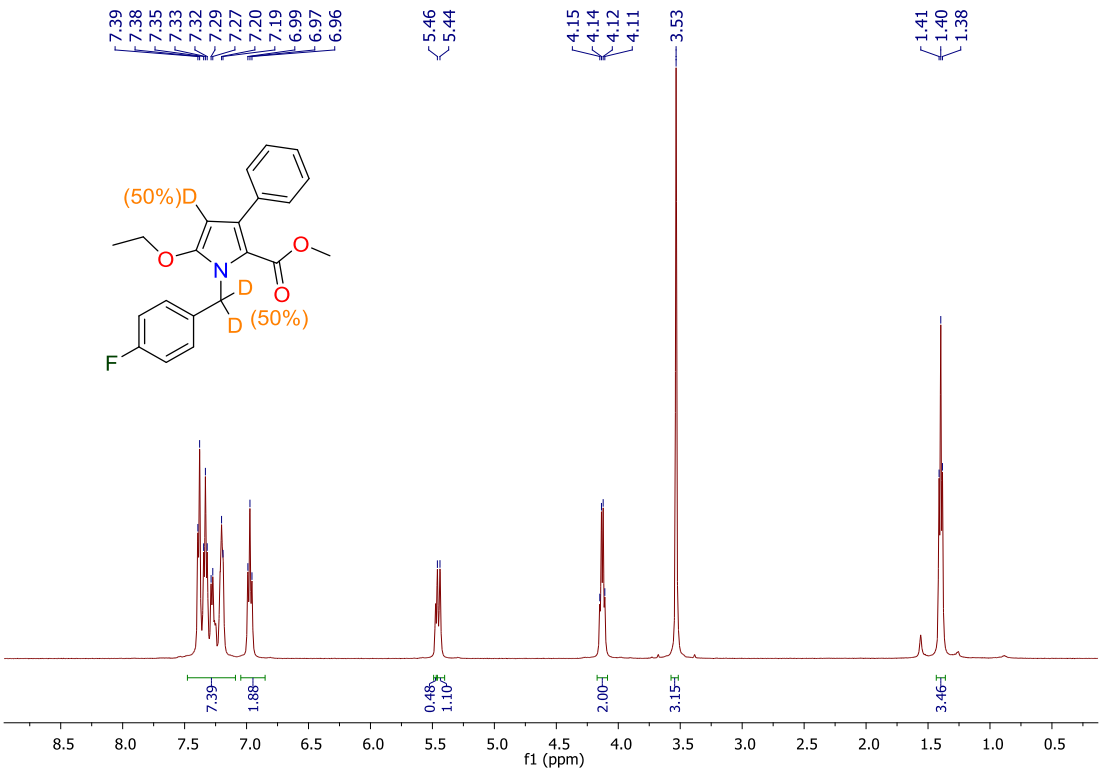


HRMS (ESI+) **6c**

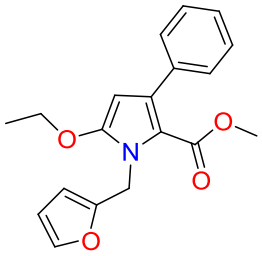


FT-IR (KBr) **6c**

Methyl 5-ethoxy-1-(4-fluorobenzyl)-3-phenyl-1*H*-pyrrole-2-carboxylate (*d*$_2$-6c).

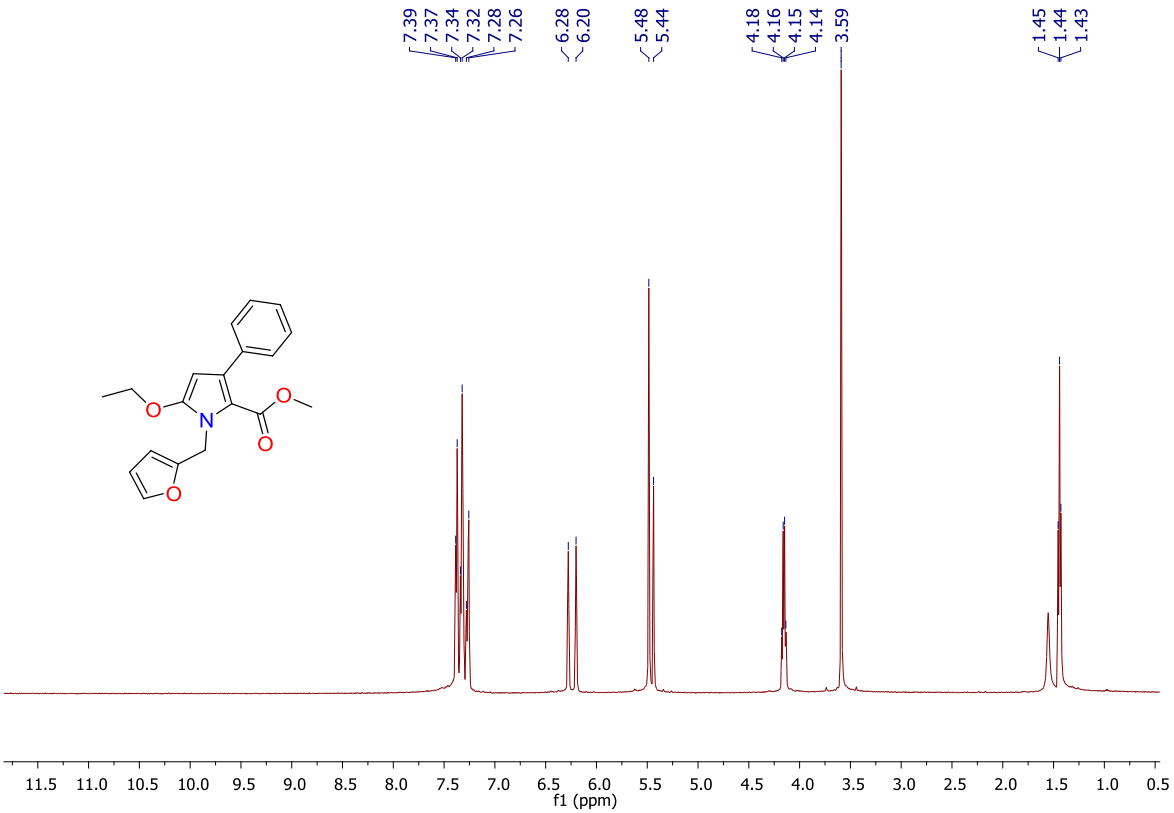


^{1}H, $CDCl_3$, 500 MHz *d*$_2$-**6c**

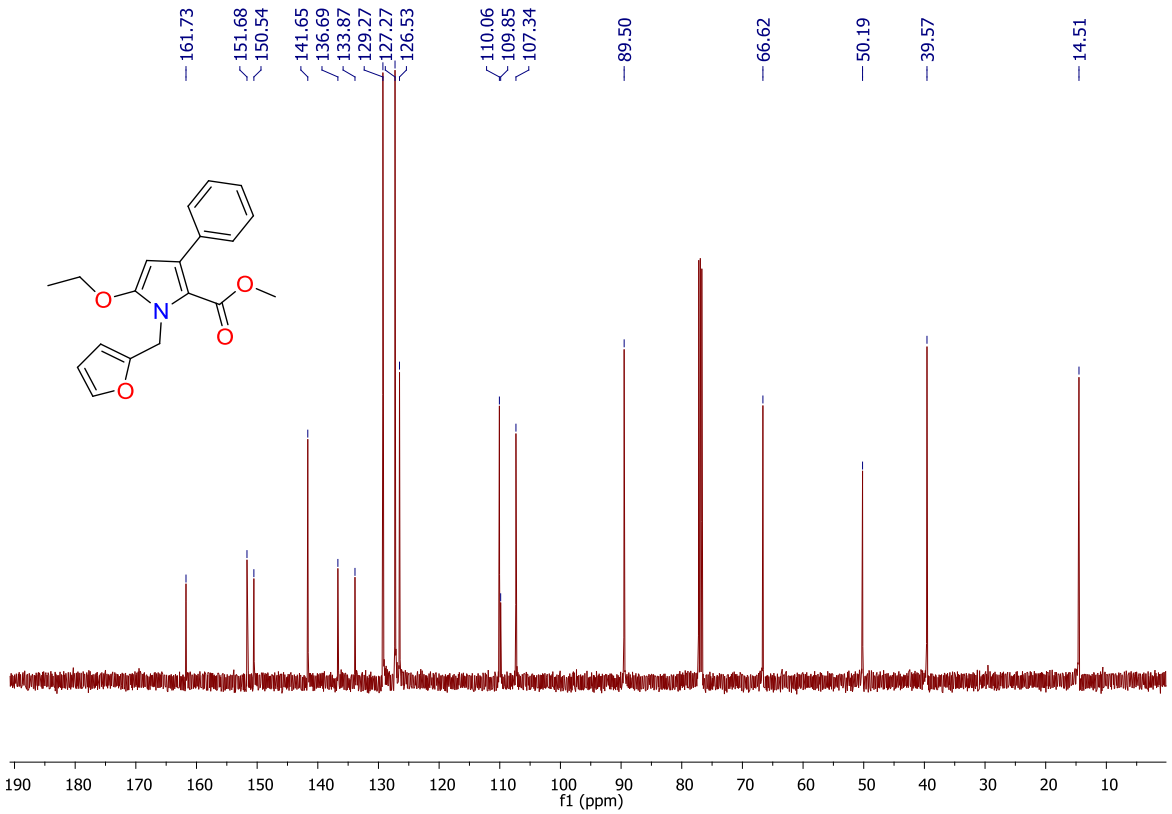


Methyl 5-ethoxy-1-(furan-2-ylmethyl)-3-phenyl-1*H*-pyrrole-2-carboxylate (6d).

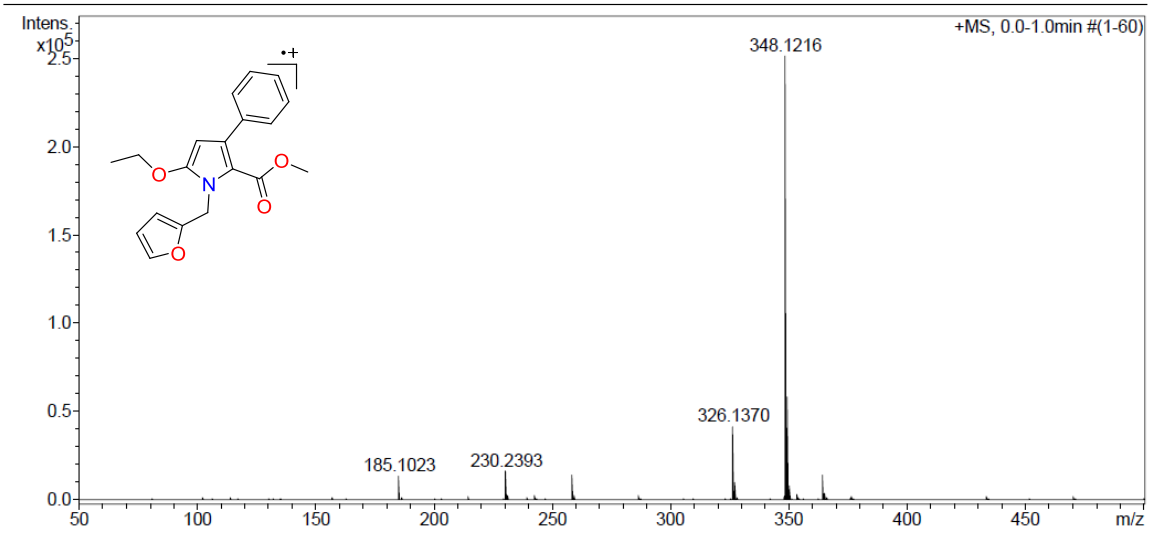
Yield: 71%; brown crystals, mp 106-107 °C. IR (cm^{-1}) 1674 (C=O), 1052 (N-C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.39-7.26 (m, 6H, C*H*), 6.28 (s, 1H, C*H*), 6.20 (s, 1H, C*H*), 5.48 (s, 2H, NCH_2), 5.44 (s, 1H, C*H*), 4.16 (q, J = 7.5 Hz, 2H, OCH_2CH$_3$), 3.59 (s, 3H, CO_2CH_3), 1.44 (t, J = 6.8 Hz, 3H, OCH_2CH_3). ^{13}C NMR (125 MHz, $CDCl_3$) δ 161.7 (CO_2CH_3), 151.7, 150.5, 141.7, 136.7, 133.9, 129.3, 127.3, 126.5, 110.1, 109.9, 107.3, 89.5 (*C*H), 66.6 (OCH_2CH_3), 50.2 (CO_2CH_3), 39.6 (NCH_2), 14.5 (OCH_2CH_3). HRMS (ESI+): m/z calcd for $C_{19}H_{19}NO_4$ $[M+Na]^+$ 348.1212, found 348.1216.



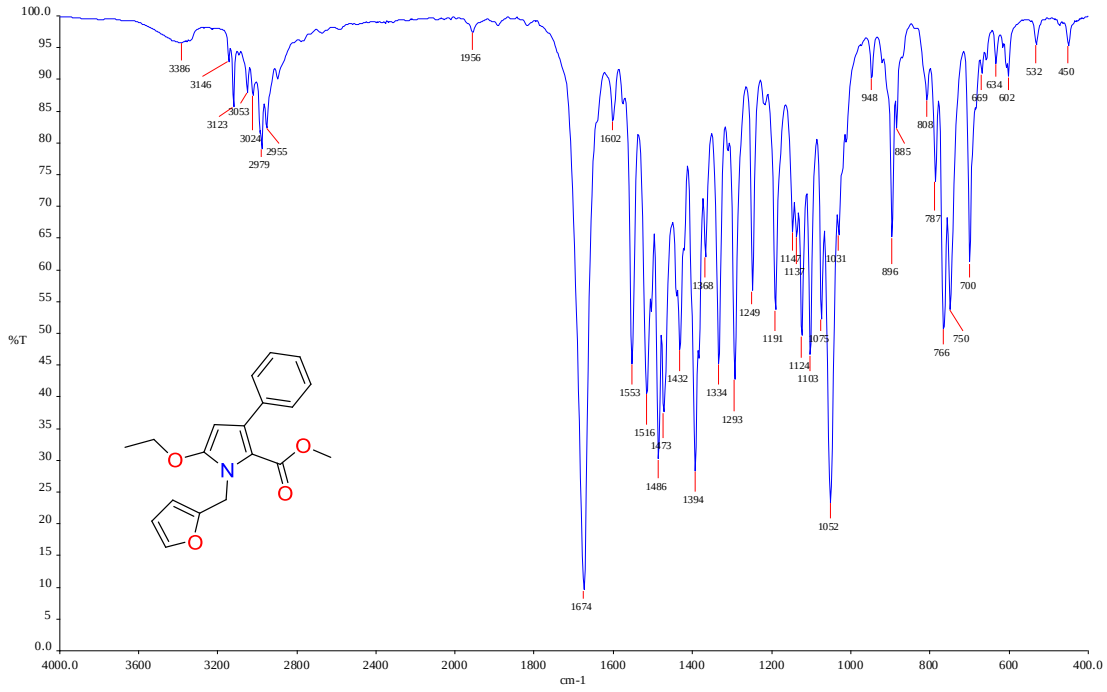
^{1}H, $CDCl_3$, 500 MHz **6d**



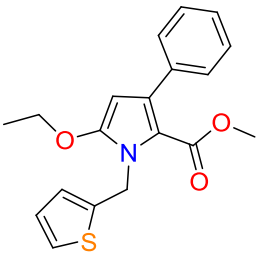
^{13}C, $CDCl_3$, 125 MHz **6d**



HRMS (ESI+) **6d**

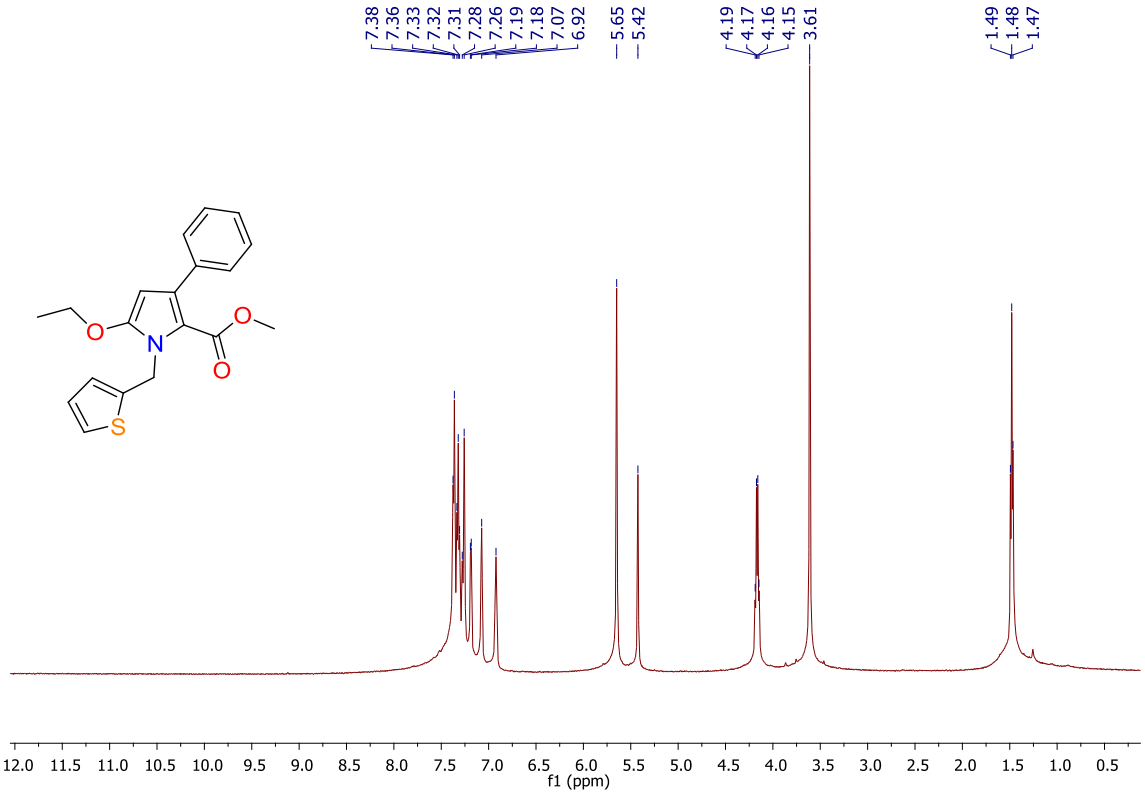


FT-IR (KBr) **6d**

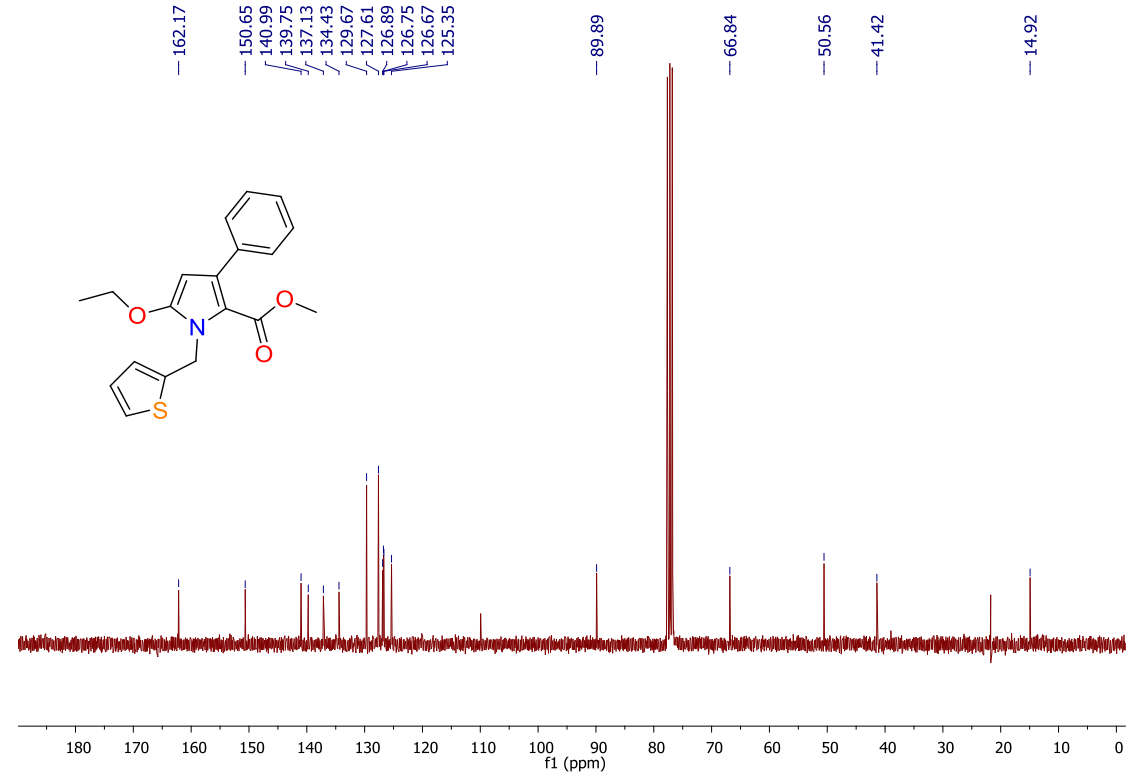


Methyl 5-ethoxy-1-(thiophen-2-ylmethyl)-3-phenyl-1*H*-pyrrole-2-carboxylate (6e).

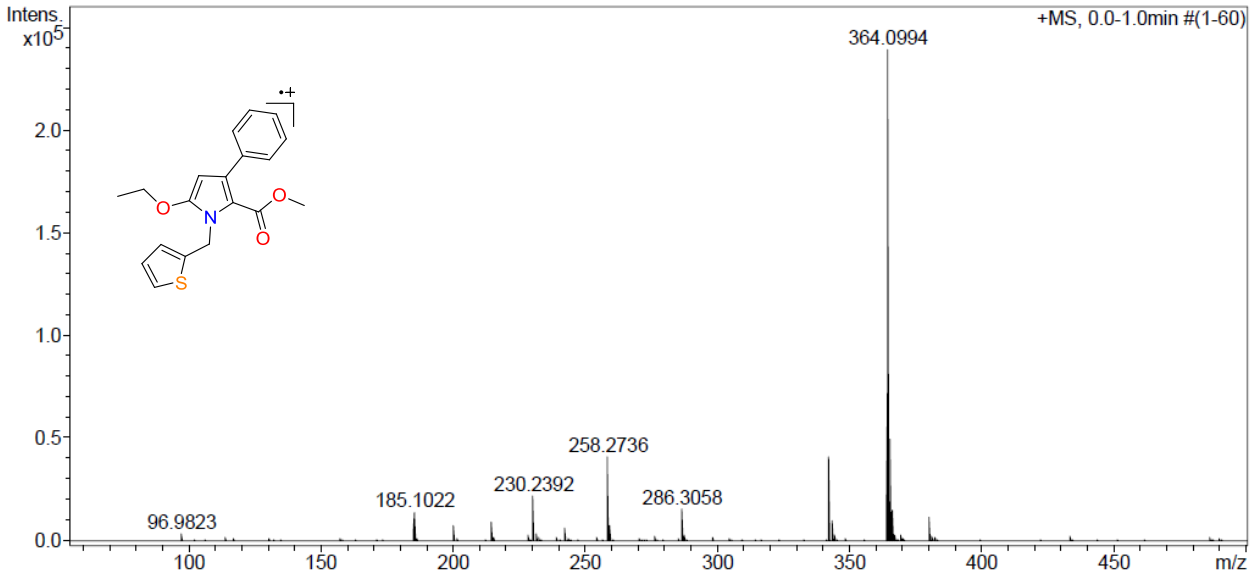
Yield: 70%; amber crystals, mp 98-99 °C. IR (cm^{-1}) 1672 (C=O), 1054 (N-C), 763 (C-S). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.38-7.26 (m, 5H, C*H*), 7.19 (d, *J* = 5.0 Hz, 1H, C*H*), 7.07 (s, 1H, C*H*), 6.92 (s, 1H, C*H*), 5.65 (s, 2H, NCH_2), 5.42 (s, 1H, C*H*), 4.17 (q, *J* = 7.5 Hz, 2H, OCH_2CH_3), 3.61 (s, 3H, CO_2CH_3), 1.48 (t, *J* = 6.7 Hz, 3H, OCH_2CH_3). ^{13}C NMR (75 MHz, $CDCl_3$) δ 162.2 (CO_2CH_3), 150.7, 141.0, 139.8, 137.1, 134.4, 129.7, 127.6, 126.9, 126.8, 126.7, 125.4, 89.9 (*C*H), 66.8 (OCH_2CH_3), 50.6 (CO_2CH_3), 41.4 (NCH_2), 14.9 (OCH_2CH_3). HRMS (ESI+): m/z calcd for $C_{19}H_{19}NO_3S$ $[M+Na]^+$ 364.0983, found 364.0994.



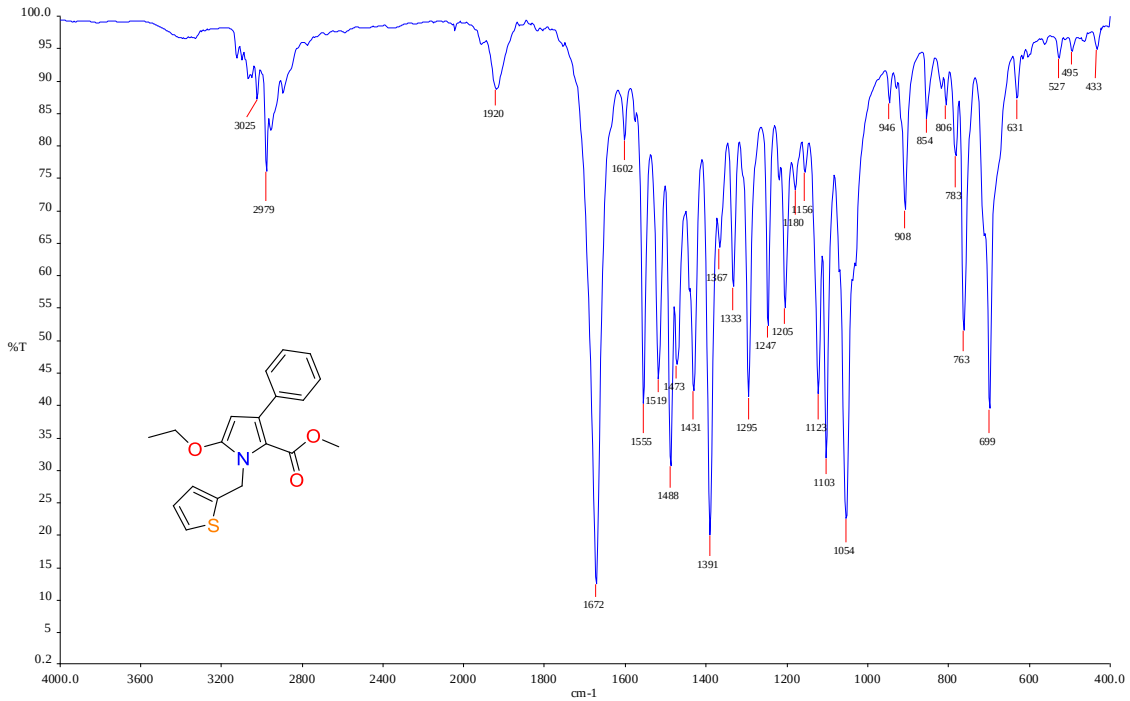
^{1}H, $CDCl_3$, 500 MHz **6e**



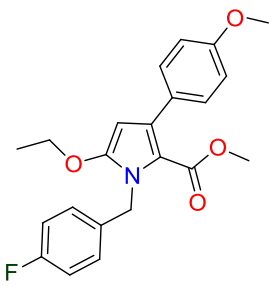
^{13}C, $CDCl_3$, 75 MHz **6e**



HRMS (ESI+) **6e**

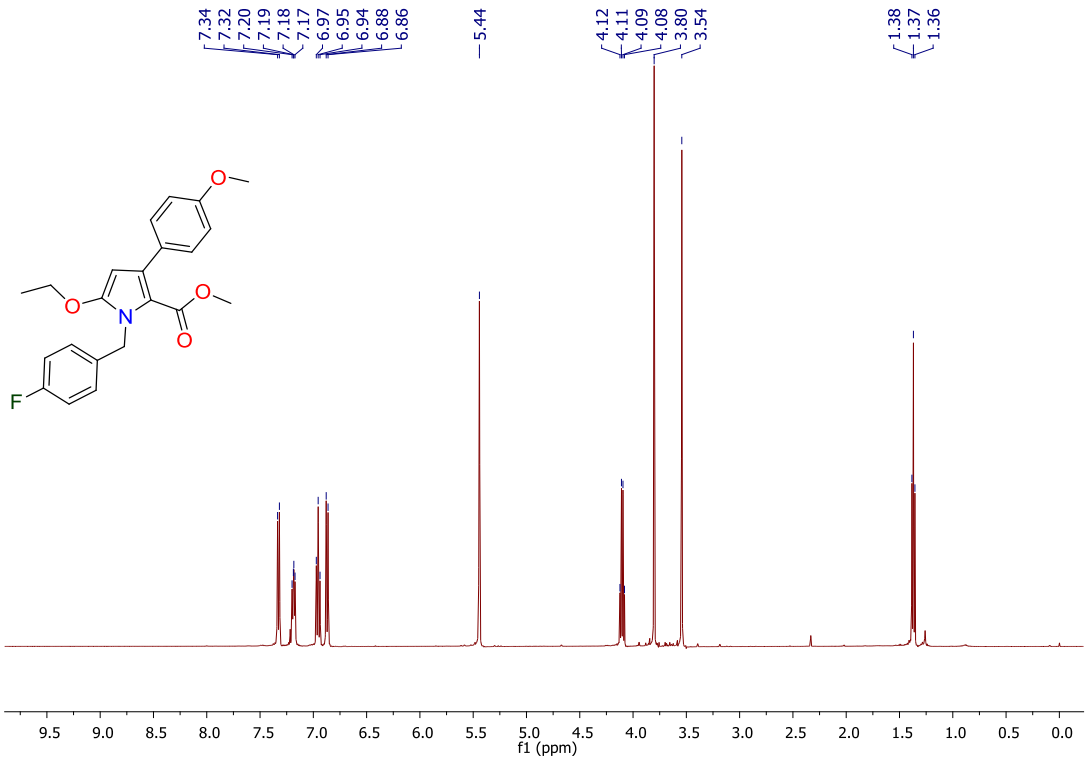


FT-IR (KBr) **6e**

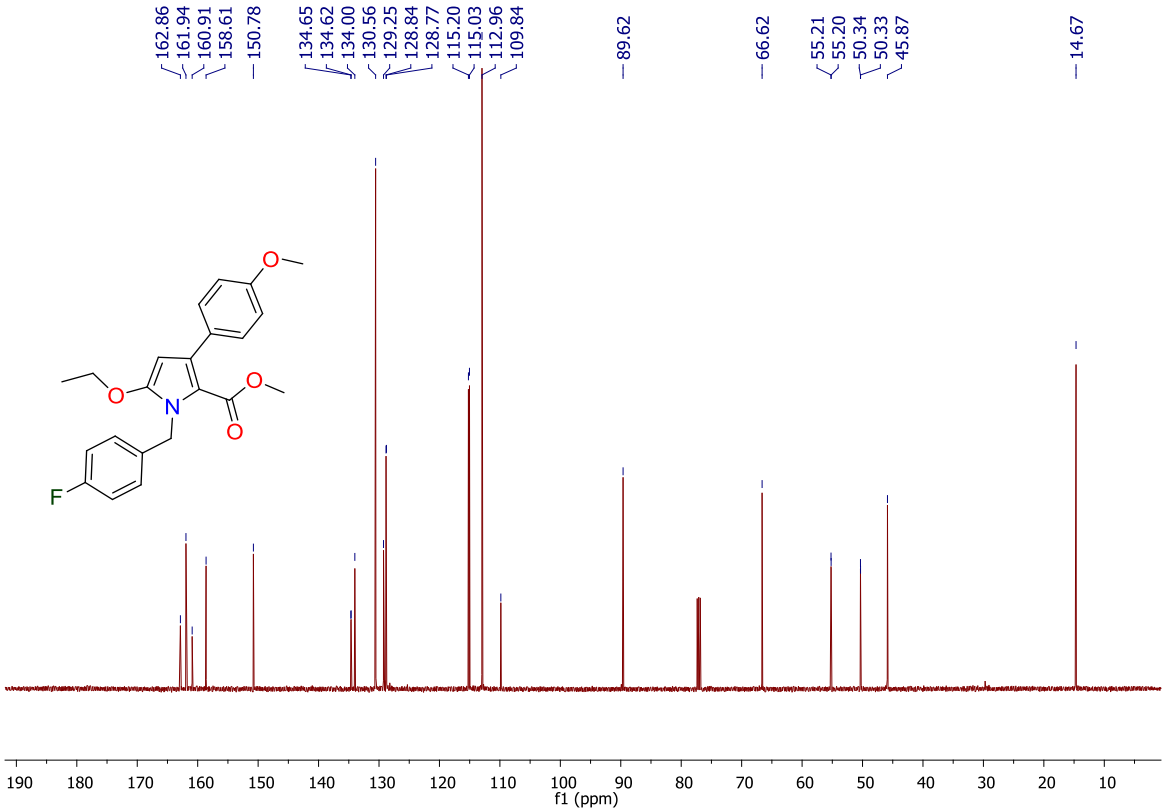


Methyl 5-ethoxy-1-(4-fluorobenzyl)-3-(4-methoxyphenyl)-1*H*-pyrrole-2-carboxylate (6f).

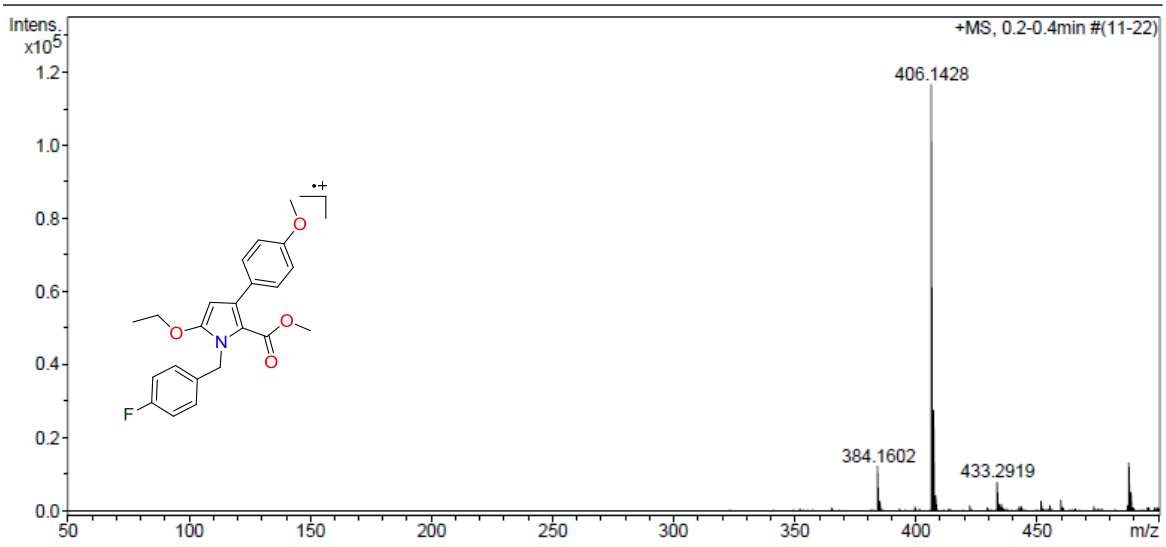
Yield: 72%; white crystals, mp 110-111 °C. IR (cm^{-1}) 1674 (C=O), 1054 (N-C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.33 (d, J = 8.6 Hz, 2H, C*H*), 7.18 (t, J = 7.5 Hz, 2H, C*H*), 6.95 (t, J = 8.7 Hz, 2H, C*H*), 6.87 (d, J = 8.7 Hz, 2H, C*H*), 5.44 (s, 3H, C*H*, NC*H*$_2$), 4.10 (q, J = 7.5 Hz, 2H,OC*H*$_2$CH$_3$), 3.80 (s, 3H, OC*H*$_3$), 3.54 (s, 3H, CO_2CH_3), 1.37 (t, J = 7.0 Hz, 3H, OCH_2CH_3). ^{13}C NMR (125 MHz, $CDCl_3$) δ 162.9 (J = 243.8 Hz), 161.9 (CO_2CH_3), 158.6, 150.8, 134.7 (J = 3.8 Hz), 134.0, 130.6, 129.3, 128.8 (J = 8.8 Hz), 115.2 (J = 21.3 Hz), 113.0, 109.8, 89.6 (*C*H), 66.6 (OCH_2CH_3), 55.2 (OCH_3), 50.3 (CO_2CH_3), 45.9 (NCH_2), 14.7 (OCH_2CH_3). HRMS (ESI+): m/z calcd for $C_{22}H_{22}FNO_4$ $[M+Na]^+$ 406.1431, found 406.1428.



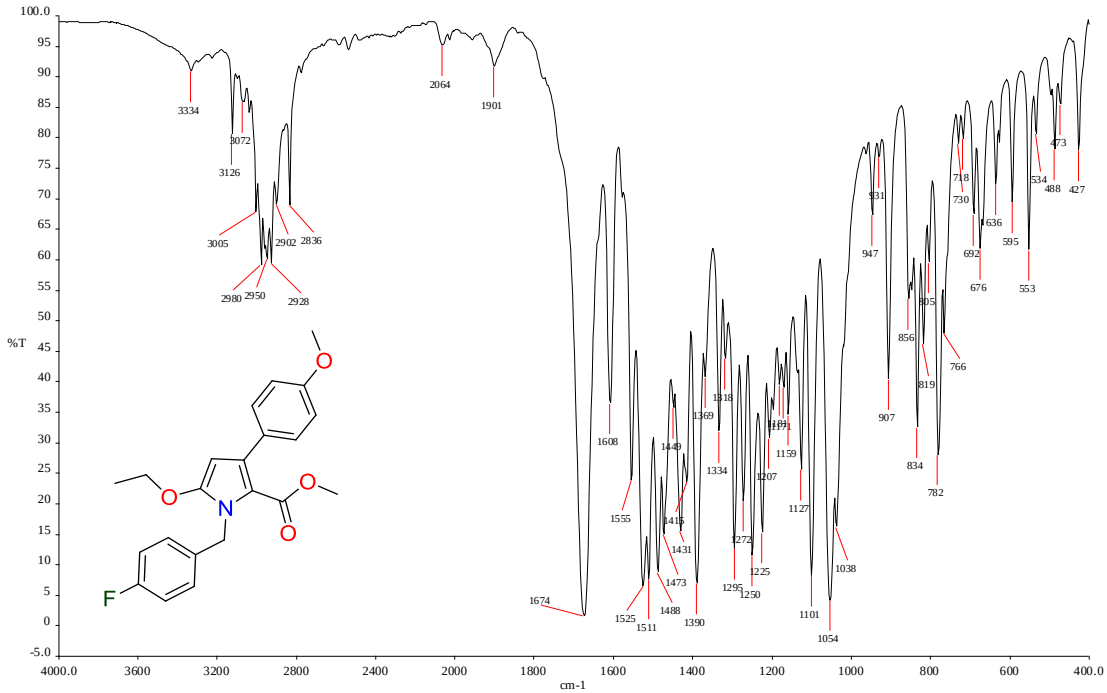
^{1}H, $CDCl_3$, 500 MHz **6f**



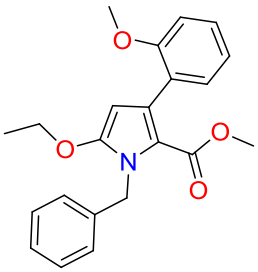
^{13}C, $CDCl_3$, 125 MHz **6f**



HRMS (ESI+) **6f**

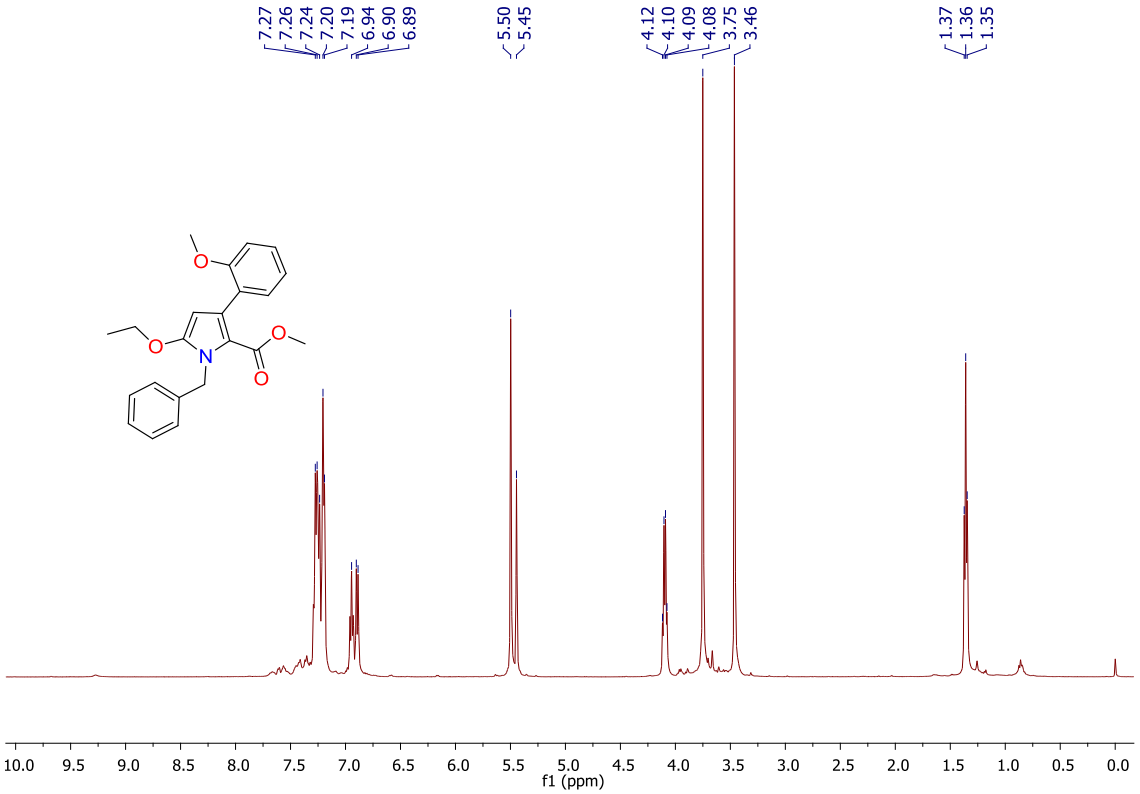


FT-IR (KBr) **6f**

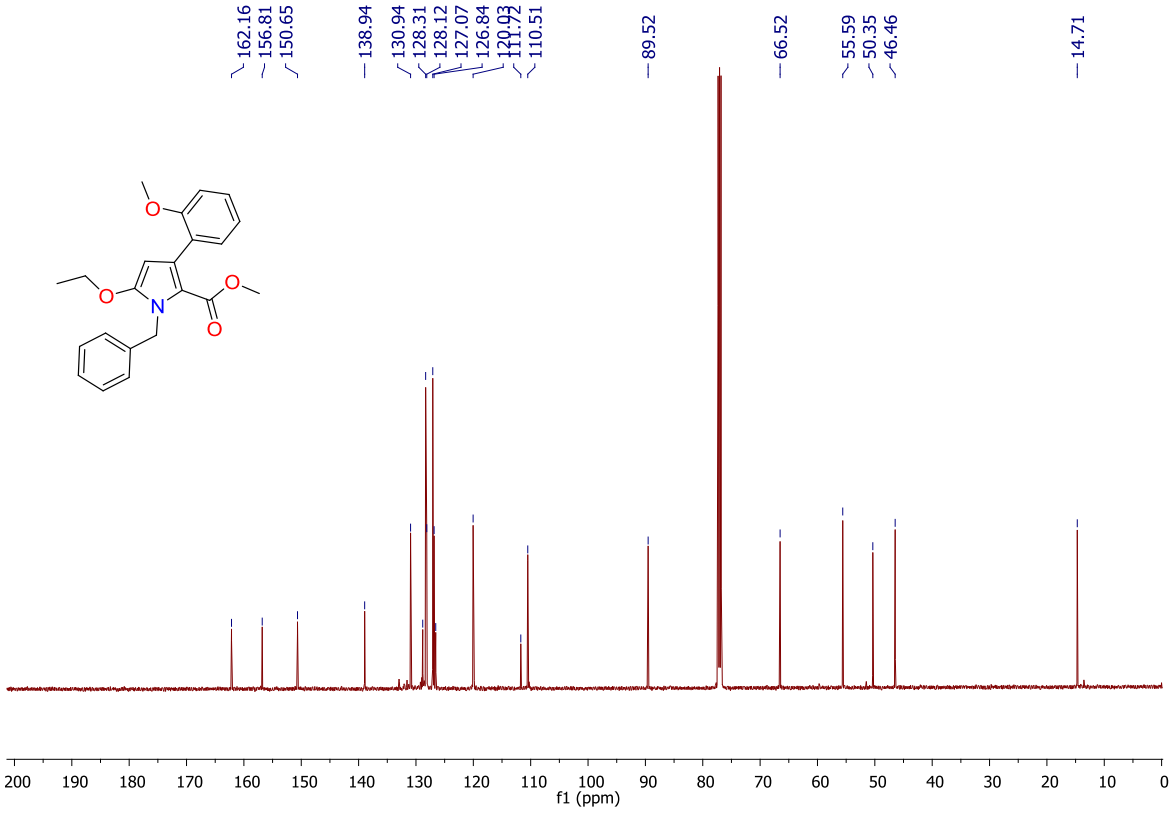


Methyl 1-benzyl-5-ethoxy-3-(2-methoxyphenyl)-1*H*-pyrrole-2-carboxylate (6g).

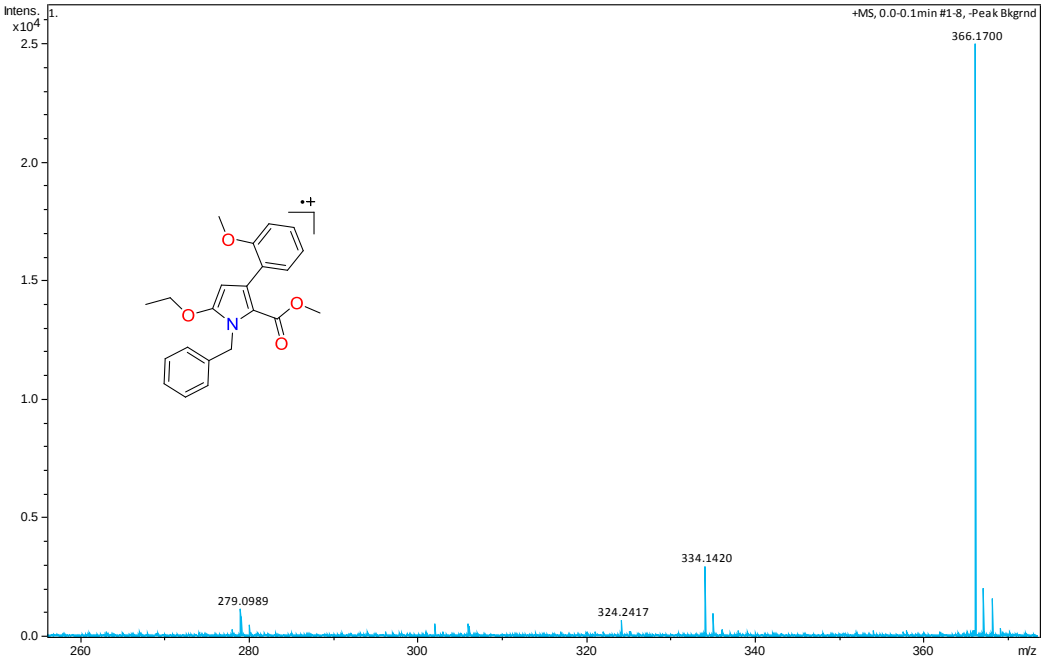
Yield: 48%; brown oil. IR (cm^{-1}) 1691 (C=O), 1057 (N-C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.29-7.19 (m, 7H, C*H*), 6.94 (t, *J* = 7.5 Hz, 1H, C*H*), 6.90 (d, *J* = 5.0 Hz, 1H, C*H*), 5.50 (s, 2H, NCH_2), 5.45 (s, 1H, C*H*), 4.10 (q, *J* = 6.3 Hz, 2H, OCH_2CH$_3$), 3.75 (s, 3H, OCH_3), 3.46 (s, 3H, CO_2CH_3), 1.36 (t, *J* = 5.0 Hz, 3H, OCH_2CH_3). ^{13}C NMR (125 MHz, $CDCl_3$) δ 162.2 (CO_2CH_3), 156.8, 150.6, 138.9, 130.9, 128.8, 128.3, 128.1, 127.1, 126.8, 126.6, 120.0, 111.7, 110.5, 89.5 (*C*H), 66.5 (OCH_2CH_3), 55.6 (OCH_3), 50.4 (CO_2CH_3), 45.5 (NCH_2), 14.7 (OCH_2CH_3). HRMS (ESI+): m/z calcd for $C_{22}H_{23}NO_4$ $[M+H]^+$ 366.1705, found 366.1700.



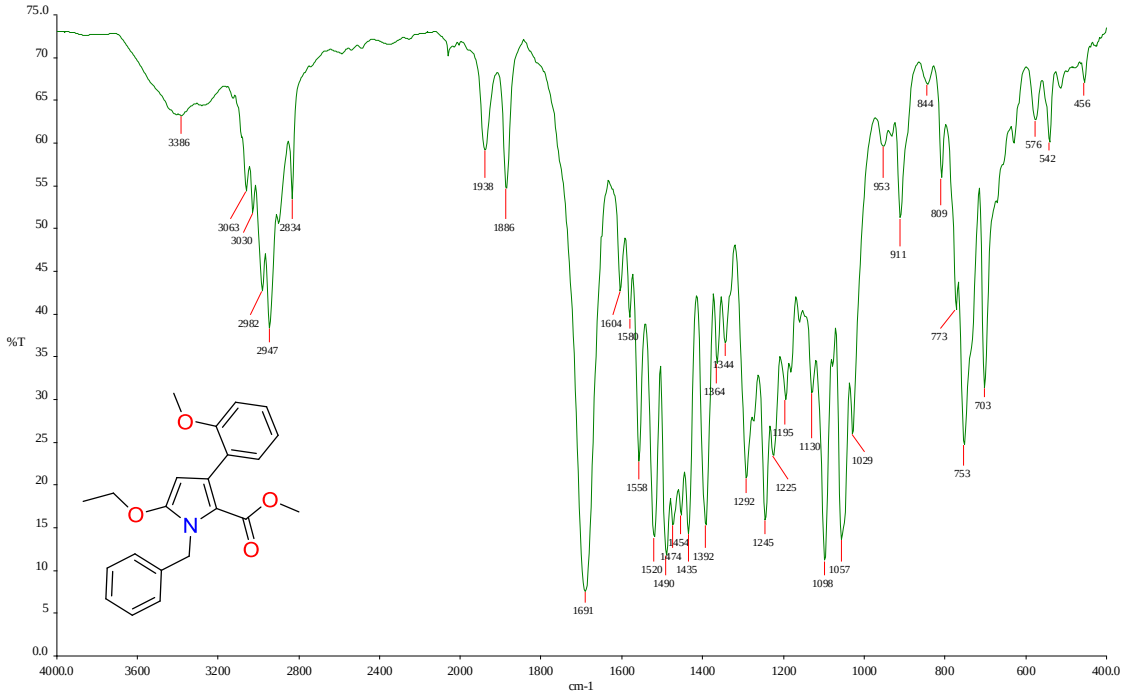
^{1}H, $CDCl_3$, 500 MHz **6g**



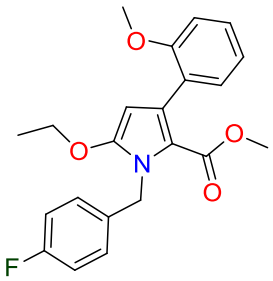
^{13}C, $CDCl_3$, 125 MHz **6g**



HRMS (ESI+) **6g**

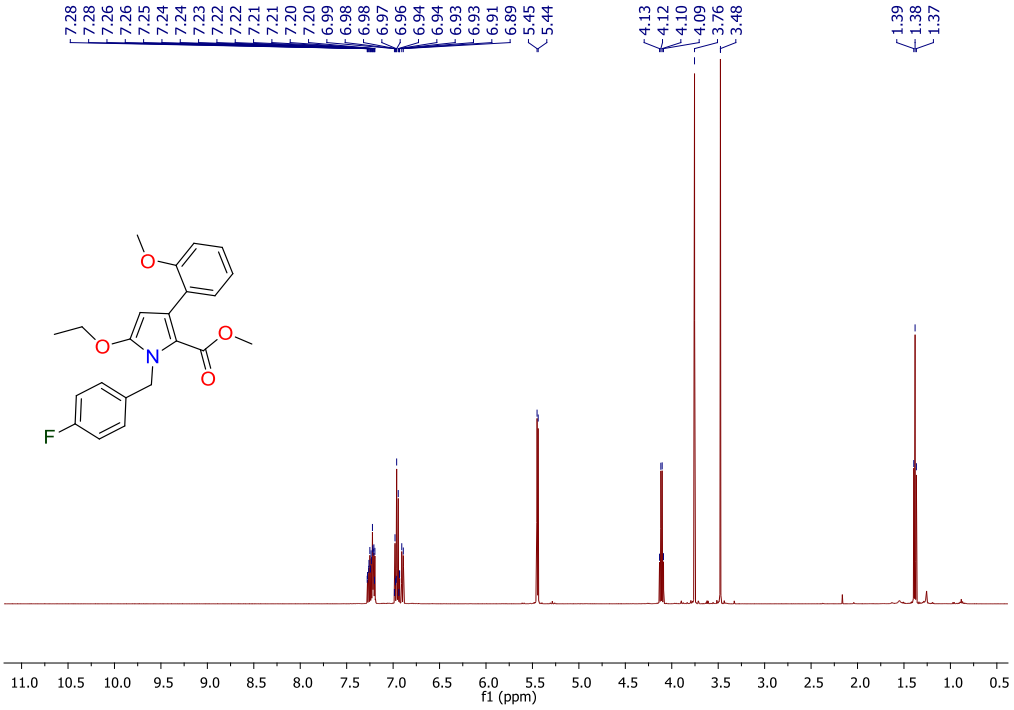


FT-IR (KBr) **6g**

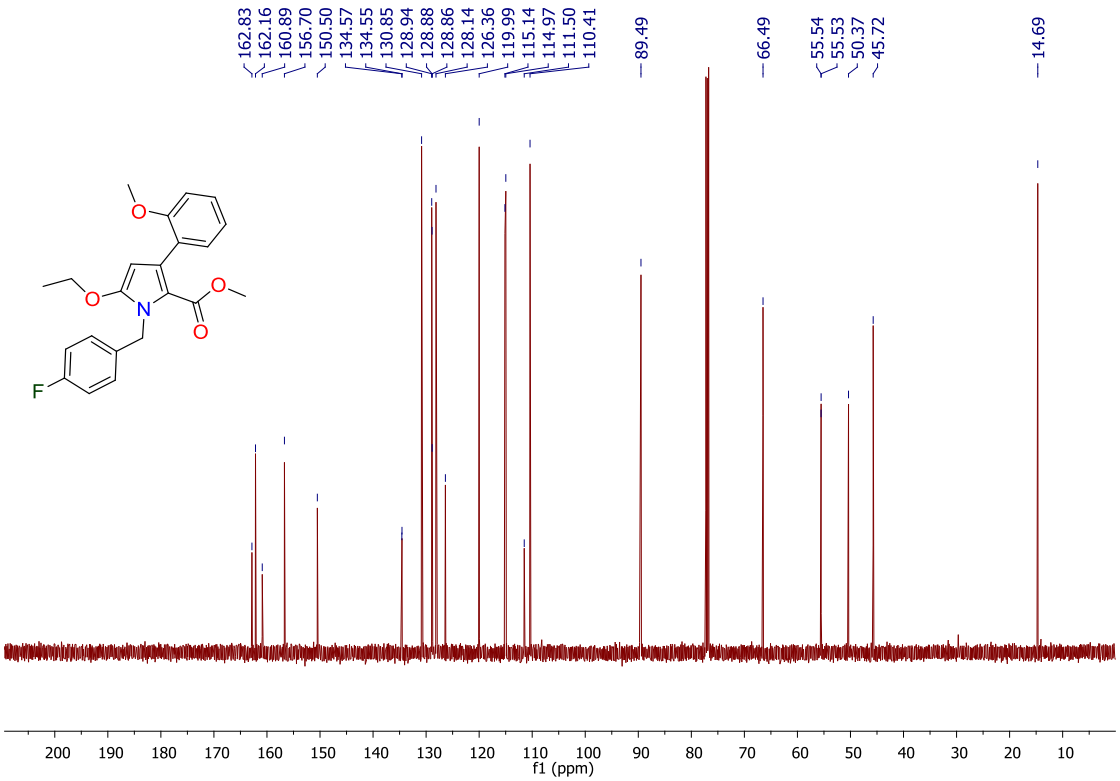


Methyl 5-ethoxy-1-(4-fluorobenzyl)-3-(2-methoxyphenyl)-1*H*-pyrrole-2-carboxylate (6h).

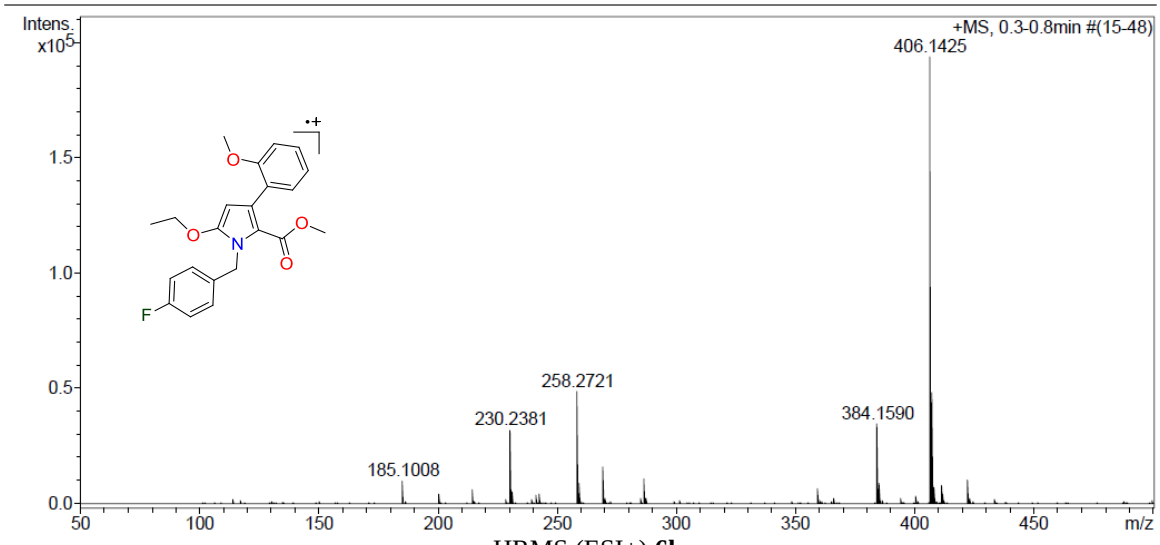
Yield: 49%; light yellow solid, mp 89-90 °C. IR (cm^{-1}) 1696 (C=O), 1052 (N-C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.28-7.20 (m, 4H, C*H*), 6.99-6.89 (m, 4H, C*H*), 5.45 (s, 2H, NCH_2), 5.44 (s, 1H, C*H*), 4.11 (q, J = 7.0 Hz, 2H, OCH_2CH$_3$), 3.76 (s, 3H, OCH_3), 3.48 (s, 3H, CO_2CH_3), 1.38 (t, J = 7.0 Hz, 3H, OCH_2CH_3). ^{13}C NMR (125 MHz, $CDCl_3$) δ 162.8 (J = 242.5 Hz), 162.2 (CO_2CH_3), 156.7, 150.5, 134.6 (J = 2.5 Hz), 130.9, 128.9 (J = 7.5 Hz), 128.9, 128.1, 126.4, 120.0, 115.1 (J = 21.3 Hz), 111.5, 110.4, 89.5 (*C*H), 66.5 (OCH_2CH_3), 55.5 (OCH_3), 50.4 (CO_2CH_3), 45.7 (NCH_2), 14.7 (OCH_2CH_3). HRMS (ESI+): m/z calcd for $C_{22}H_{22}FNO_4$ $[M+Na]^+$ 406.1431, found 406.1425.



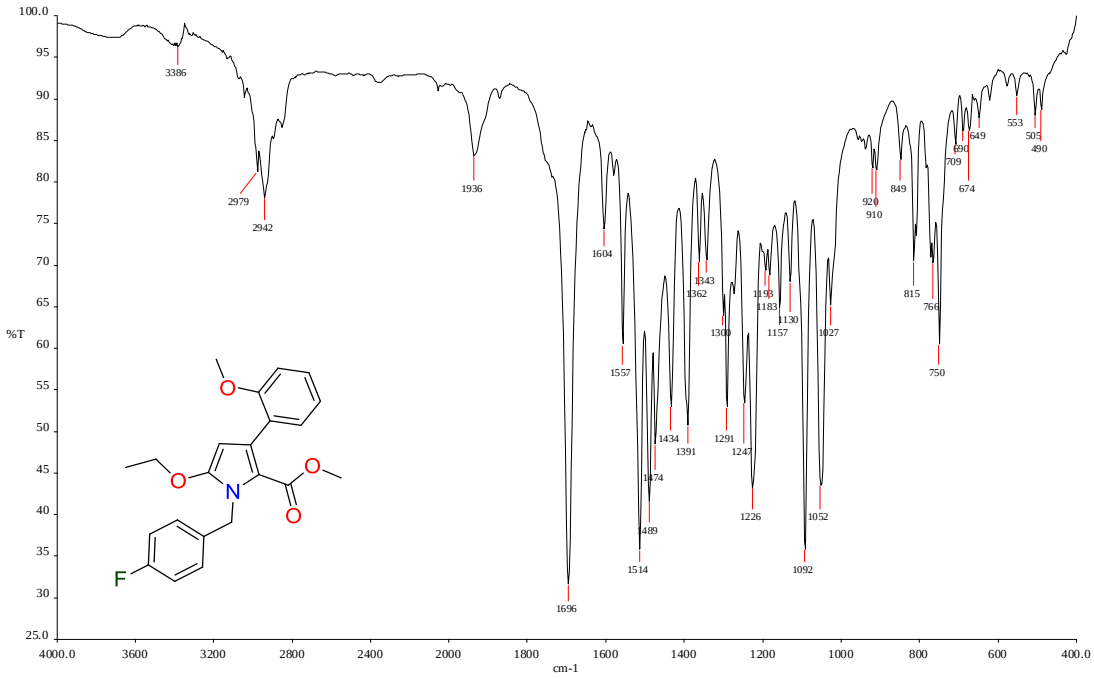
^{1}H, $CDCl_3$, 500 MHz **6h**



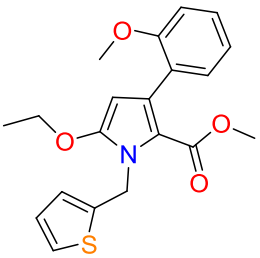
^{13}C, $CDCl_3$, 125 MHz **6h**



HRMS (ESI+) **6h**

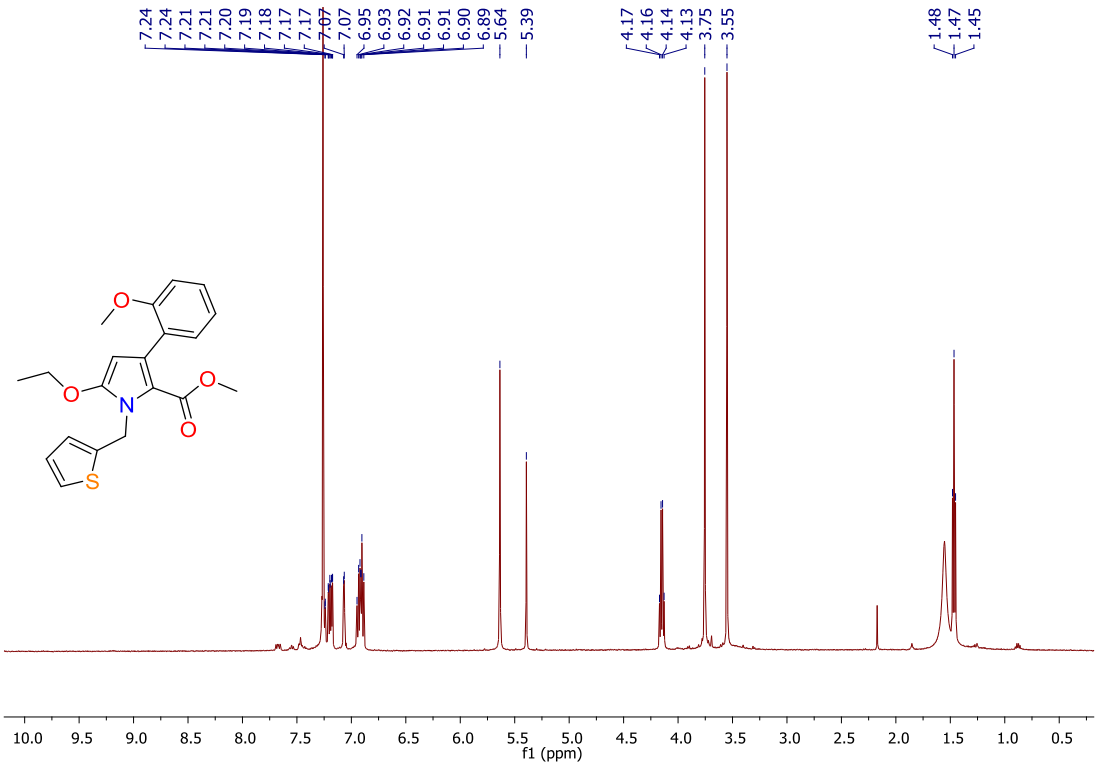


FT-IR (KBr) **6h**

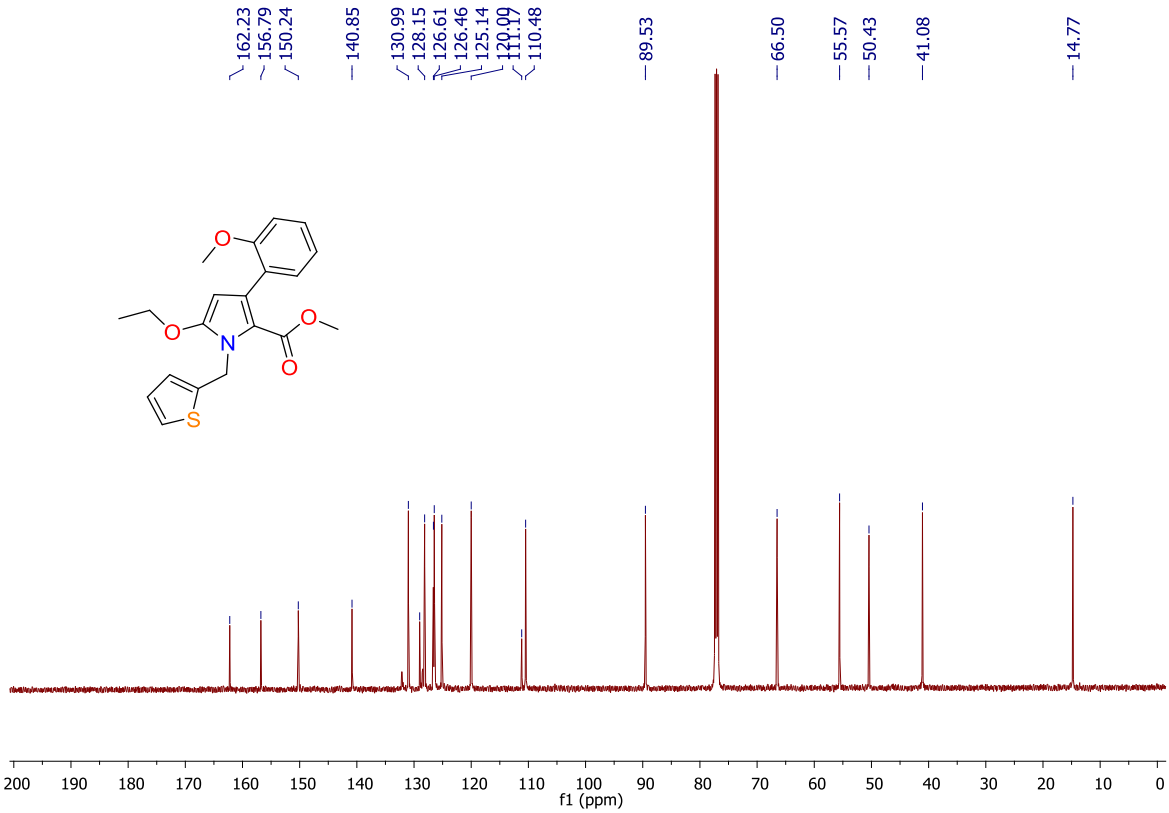


Methyl-5-ethoxy-3-(2-methoxyphenyl)-1-(thiophen-2-ylmethyl)-1*H*-pyrrole-2-carboxylate (6i).

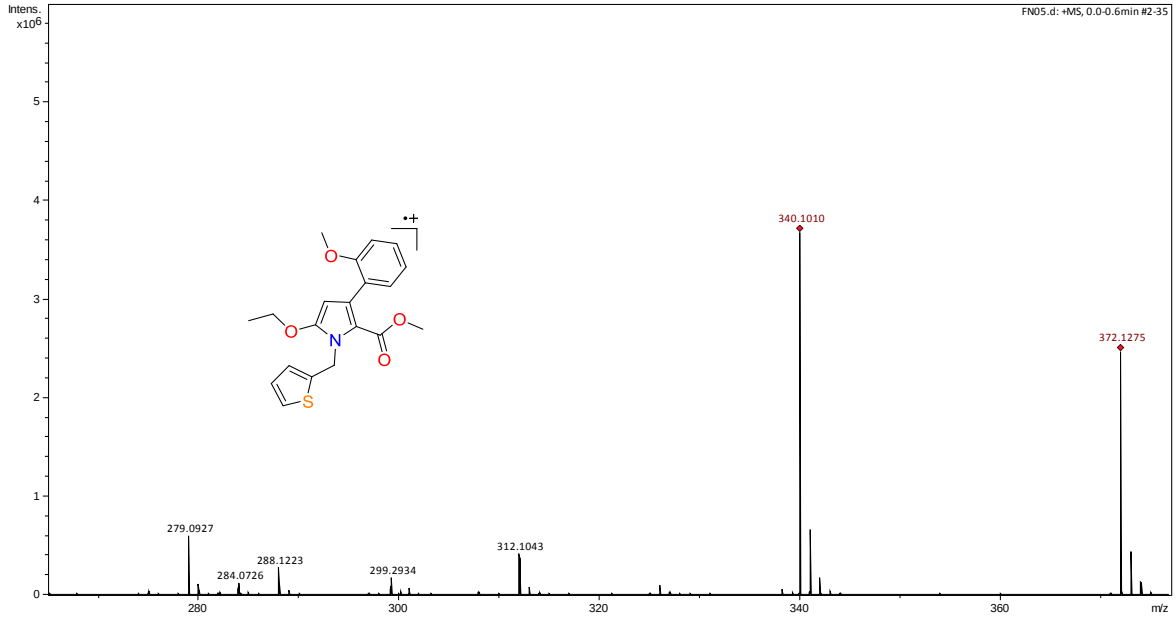
Yield: 47%; brown solid, mp 93-94 °C. IR (cm^{-1}) 1682 (C=O), 1056 (N-C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.24-7.17 (m, 3H, C*H*), 7.07 (d, *J* = 3.0 Hz, 1H, C*H*), 6.95-6.89 (m, 3H, C*H*), 5.64 (s, 2H, NCH_2), 5.39 (s, 1H, C*H*), 4.15 (q, *J* = 7.5 Hz, 2H, OCH_2CH$_3$), 3.75 (s, 3H, OCH_3), 3.55 (s, 3H, CO_2CH_3), 1.47 (t, *J* = 7.5 Hz, 3H, OCH_2CH_3). ^{13}C NMR (125 MHz, $CDCl_3$) δ 162.2 (CO_2CH_3), 156.8, 150.2, 140.9, 131.0, 129.0, 128.2, 126.6, 126.5, 125.1, 120.0, 111.2, 110.5, 89.5 (*C*H), 66.5 (OCH_2CH_3), 55.6 (OCH_3), 50.4 (CO_2CH_3), 41.1 (NCH_2), 14.8 (OCH_2CH_3). HRMS (ESI+): m/z calcd for $C_{20}H_{21}NO_4S$ $[M+H]^+$ 372.1269, found 372.1275.



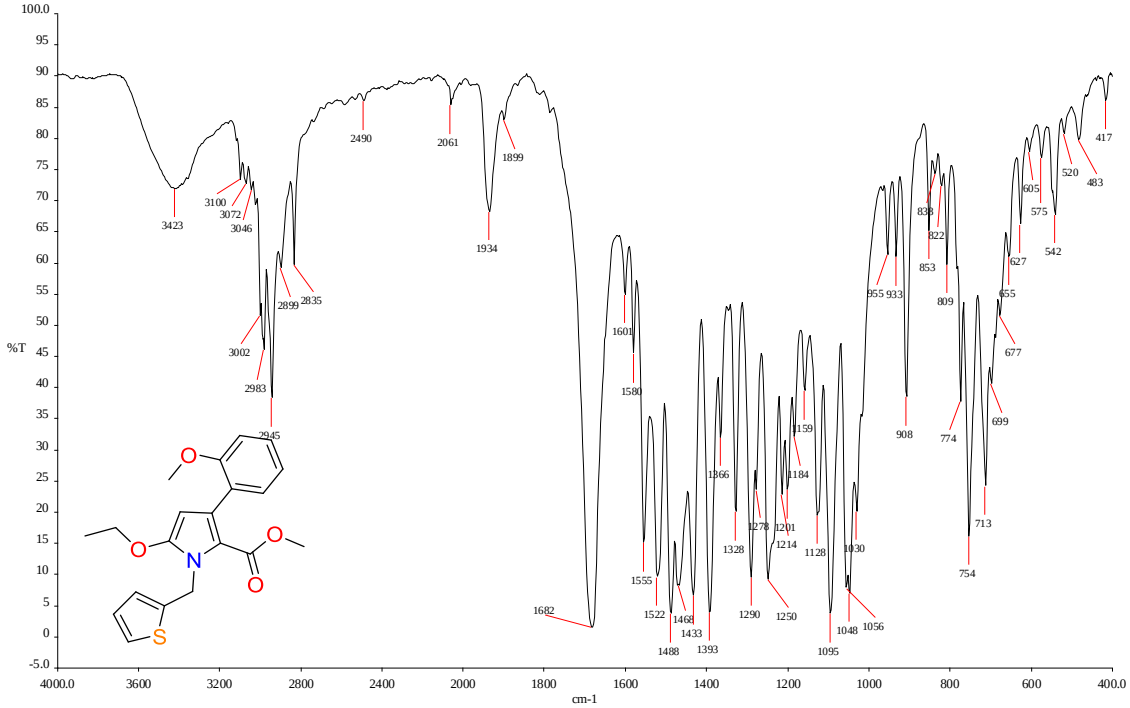
^{1}H, $CDCl_3$, 500 MHz **6i**



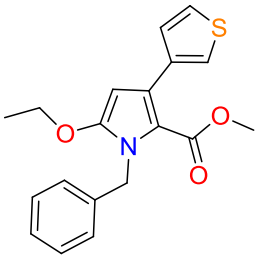
^{13}C, $CDCl_3$, 125 MHz **6i**



HRMS (ESI+) **6i**

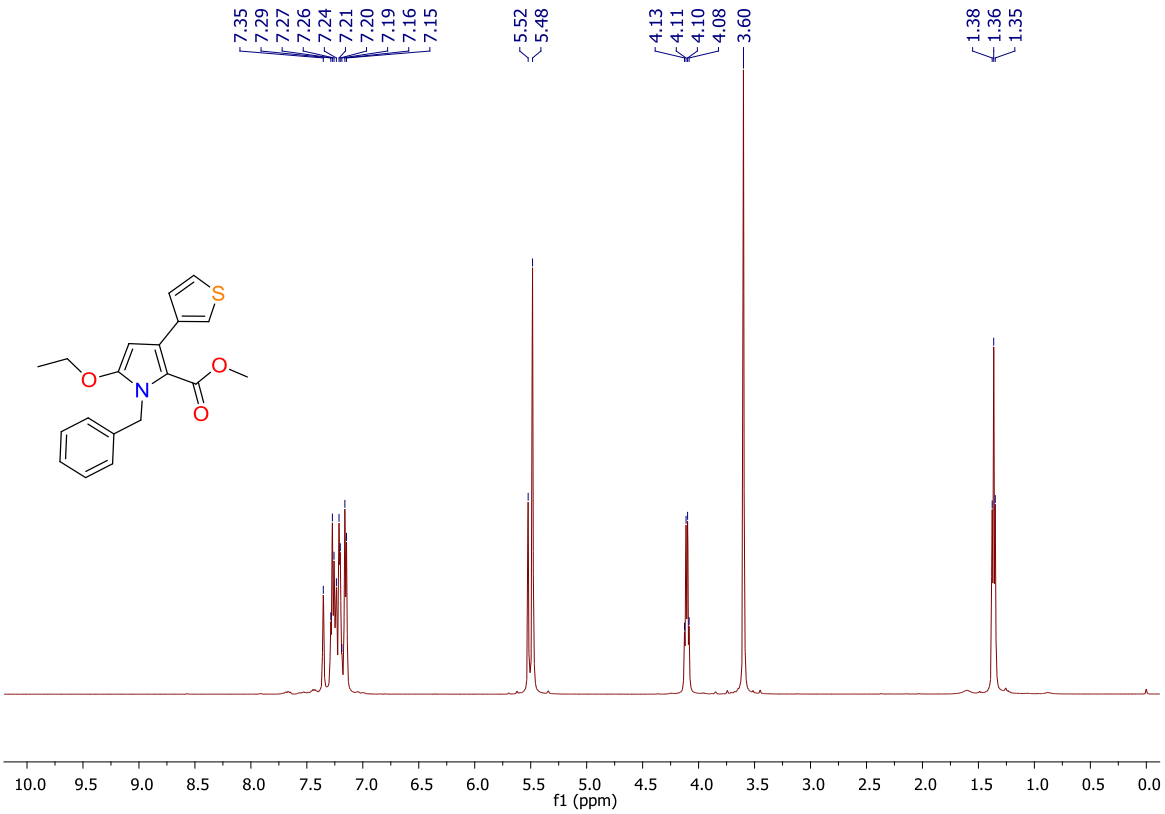


FT-IR (KBr) **6i**

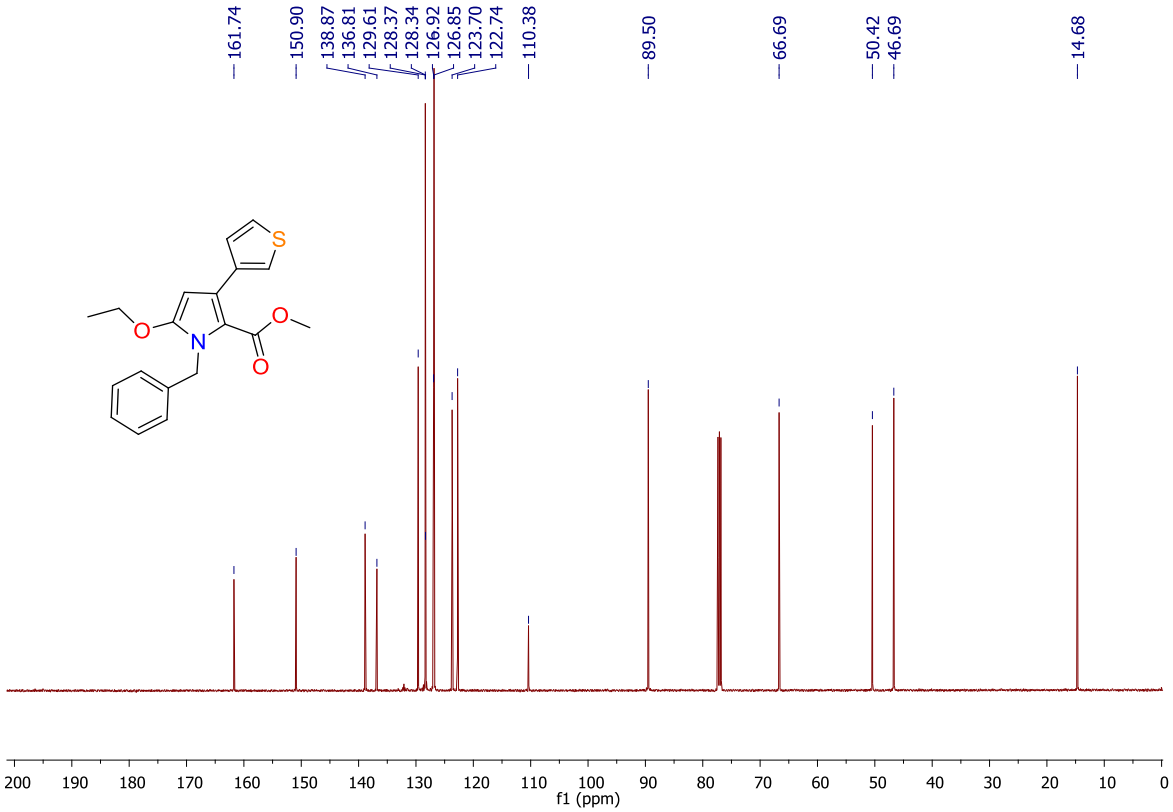


Methyl 1-benzyl-5-Ethoxy-3-(thiophen-3-yl)-1*H*-pyrrole-2-carboxylate (6j).

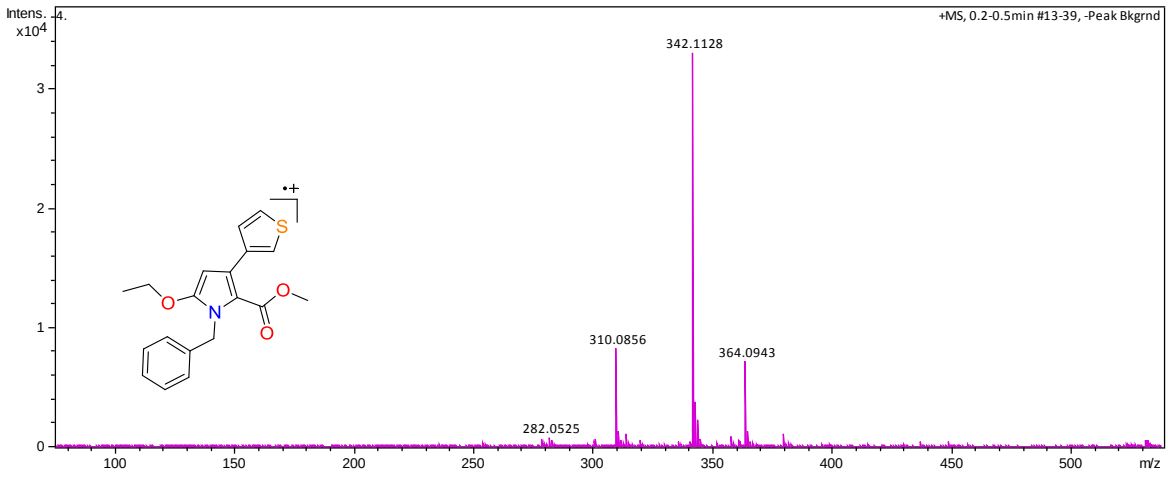
Yield: 66%; brown solid, mp 64-65 °C. IR (cm^{-1}) 1678 (C=O), 1059 (N-C), 776 (C-S). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.35 (s, 1H, C*H*), 7.29-715 (m, 7H, C*H*), 5.52 (s, 1H, C*H*), 5.48 (s, 2H, NCH_2), 4.11 (q, J = 7.5 Hz, 2H, OCH_2CH$_3$), 3.60 (s, 3H, OCH_3), 1.36 (t, J = 7.5 Hz, 3H, OCH$_2$CH_3). ^{13}C NMR (125 MHz, $CDCl_3$) δ 161.7 (*C*O$_2$CH$_3$), 150.9, 138.9, 136.8, 129.6, 128.4, 128.3, 126.9, 126.8, 123.7, 122.7, 110.4, 89.5 (*C*H), 66.7 (OCH$_2$CH$_3$), 50.4 (CO$_2$*C*H$_3$), 46.7 (N*C*H$_2$), 14.7 (OCH$_2$*C*H$_3$). HRMS (ESI+): m/z calcd for $C_{19}H_{19}NO_3S$ $[M+H]^+$ 342.1164, found 342.1128.



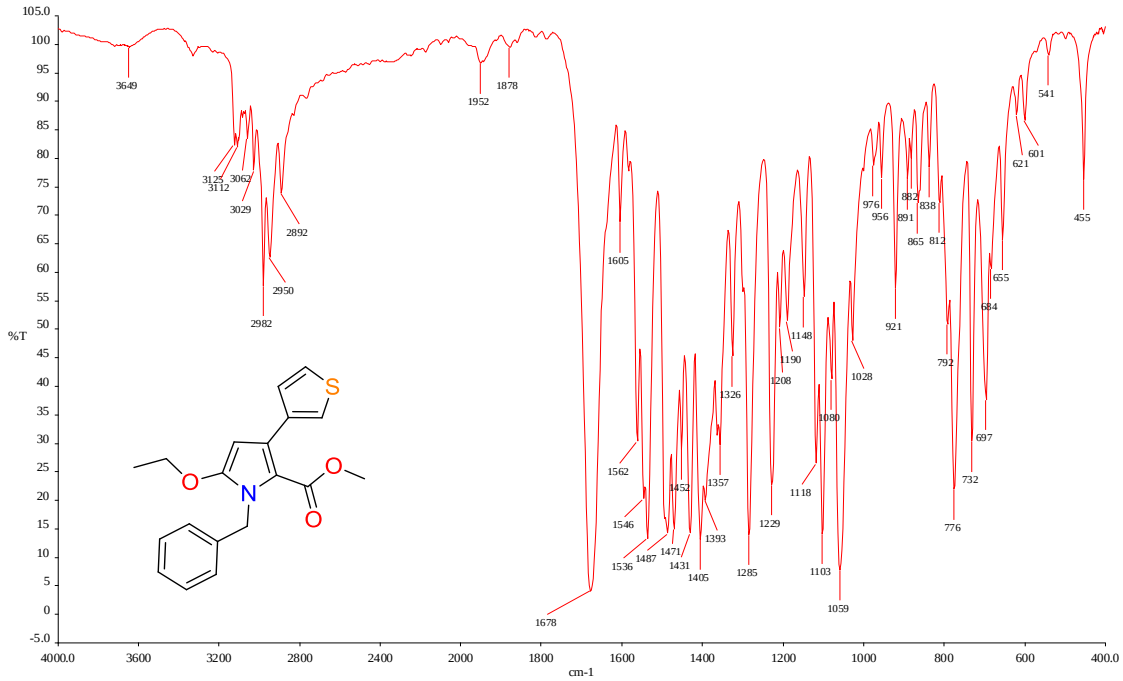
^{1}H, $CDCl_3$, 500 MHz **6j**



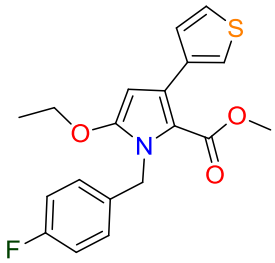
^{13}C, $CDCl_3$, 125 MHz **6j**



HRMS (ESI+) **6j**

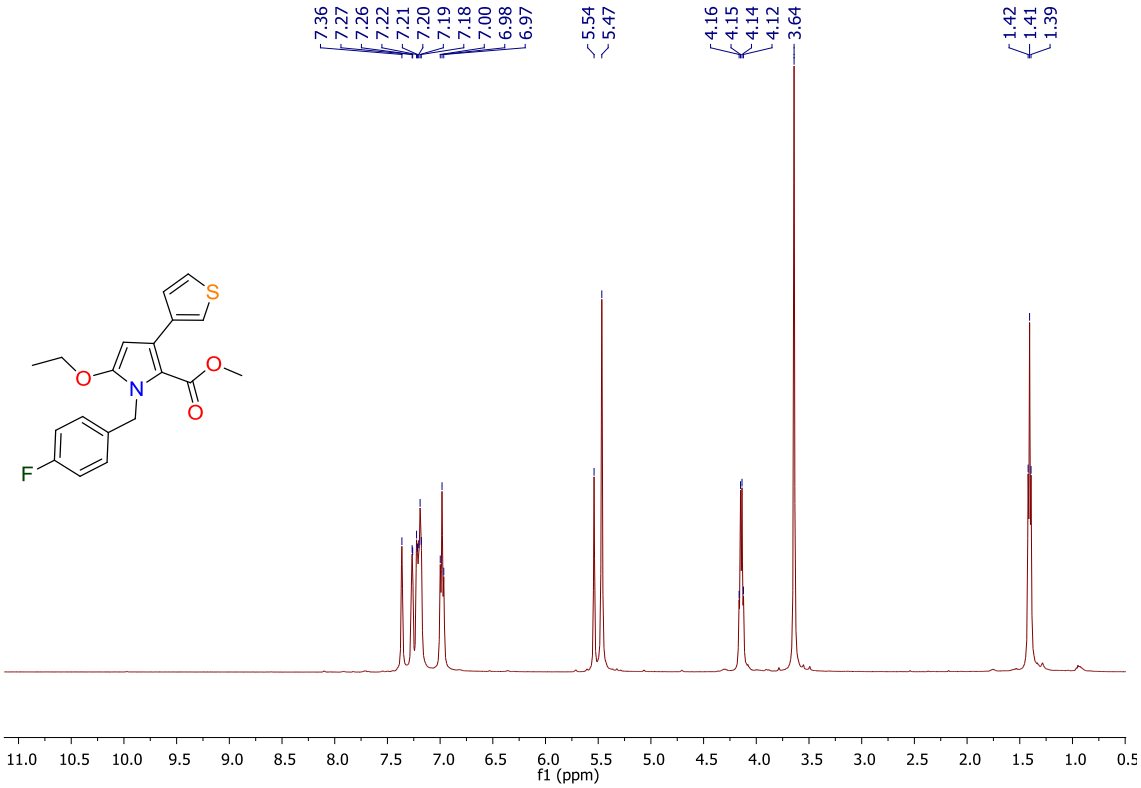


FT-IR (KBr) **6j**

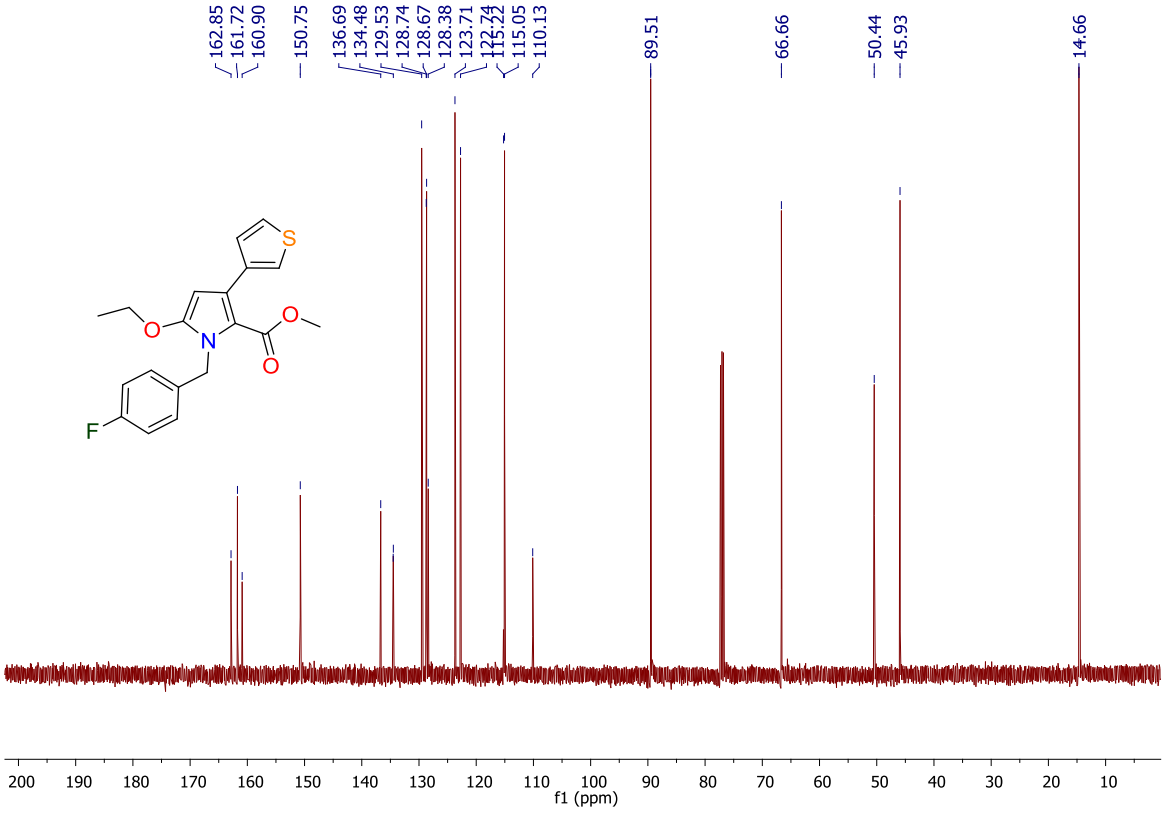


Methyl 5-ethoxy-1-(4-fluorobenzyl)-3-(thiophen-3-yl)-1*H*-pyrrole-2-carboxylate (6k).

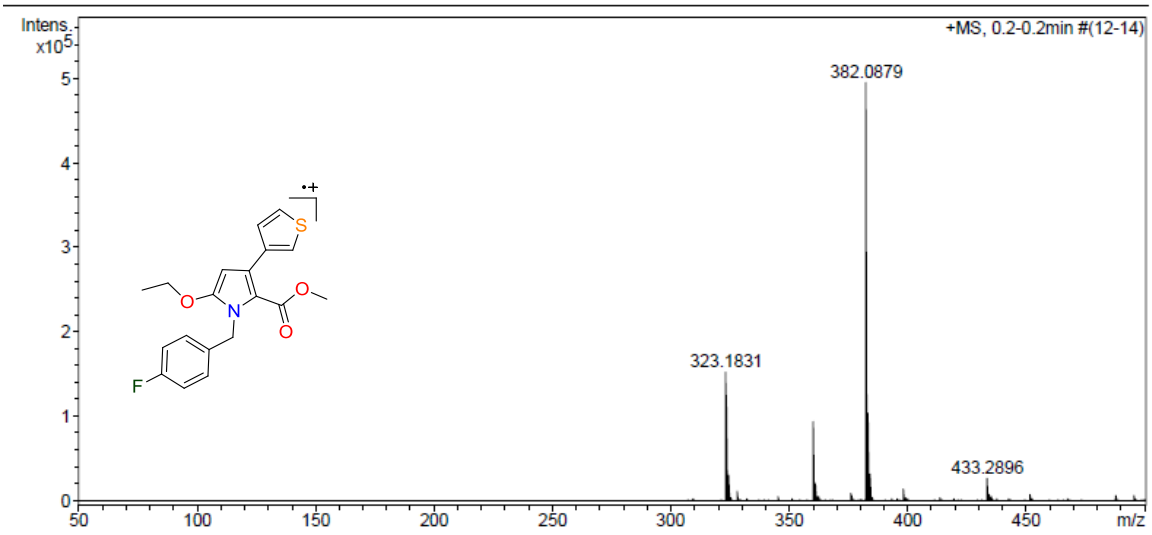
Yield: 72%; gray crystals, mp 76-77 °C. IR (cm^{-1}) 1685 (C=O), 1059 (N-C), 775 (C-S). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.36 (s, 1H, C*H*), 7.27-718 (m, 4H, C*H*), 6.98 (t, *J* = 7.5 Hz, 2H, C*H*), 5.54 (s, 1H, C*H*), 5.47 (s, 2H, NCH_2), 4.15 (q, *J* = 7.5 Hz, 2H, OCH_2CH$_3$), 3.64 (s, 3H, OCH_3), 1.41 (t, *J* = 7.5 Hz, 3H, OCH$_2$CH_3). ^{13}C NMR (125 MHz, $CDCl_3$) δ 162.9 (*J* = 243.8 Hz), 161.7 (*C*O$_2$CH$_3$), 150.8, 136.7, 134.5 (*J* = 3.8 Hz), 129.5, 128.7 (*J* = 8.8 Hz), 128.4, 123.7, 122.7, 115.2 (*J* = 21.3 Hz), 110.1, 89.5 (*C*H), 66.7 (O*C*H$_2$CH$_3$), 50.4 (CO$_2$*C*H$_3$), 45.9 (N*C*H$_2$), 14.7 (OCH$_2$*C*H$_3$). HRMS (ESI+): m/z calcd for $C_{19}H_{18}FNO_3S$ $[M+Na]^+$ 382.0889, found 382.0879.



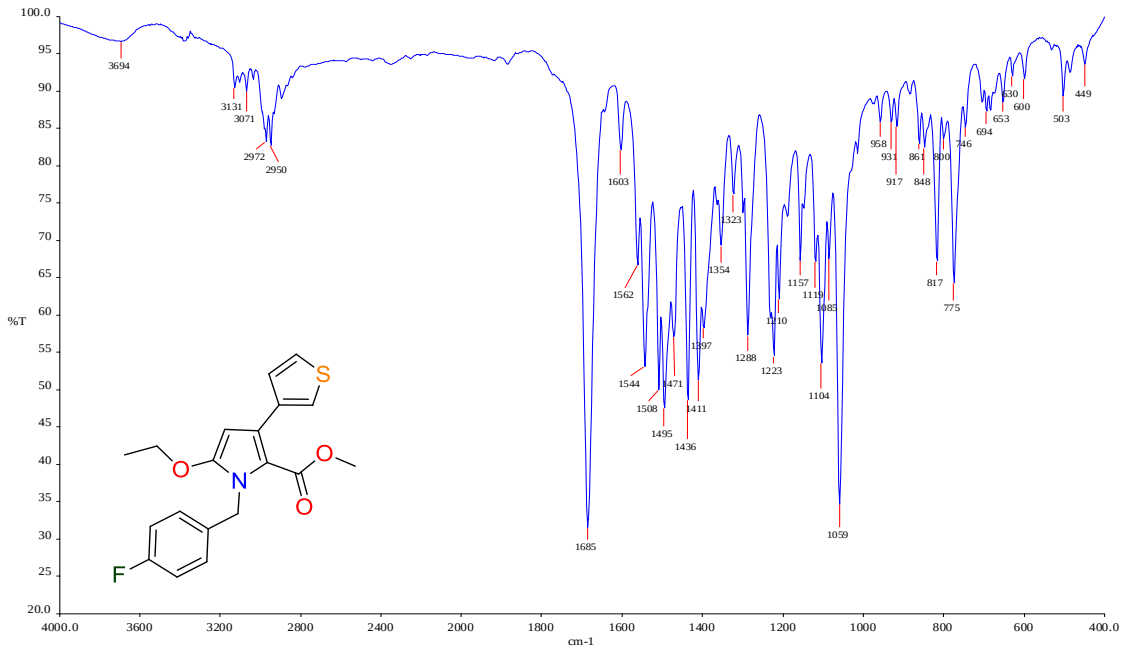
^{1}H, $CDCl_3$, 500 MHz **6k**



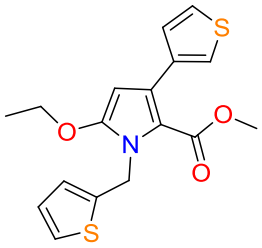
^{13}C, $CDCl_3$, 125 MHz **6k**



HRMS (ESI+) **6k**

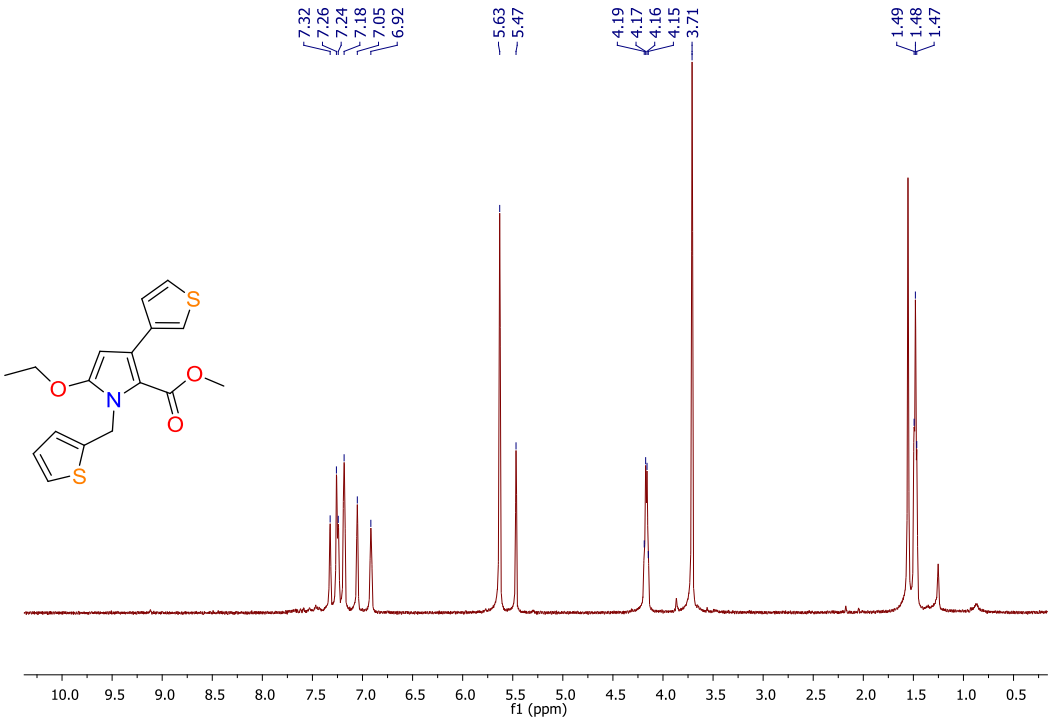


FT-IR (KBr) **6k**

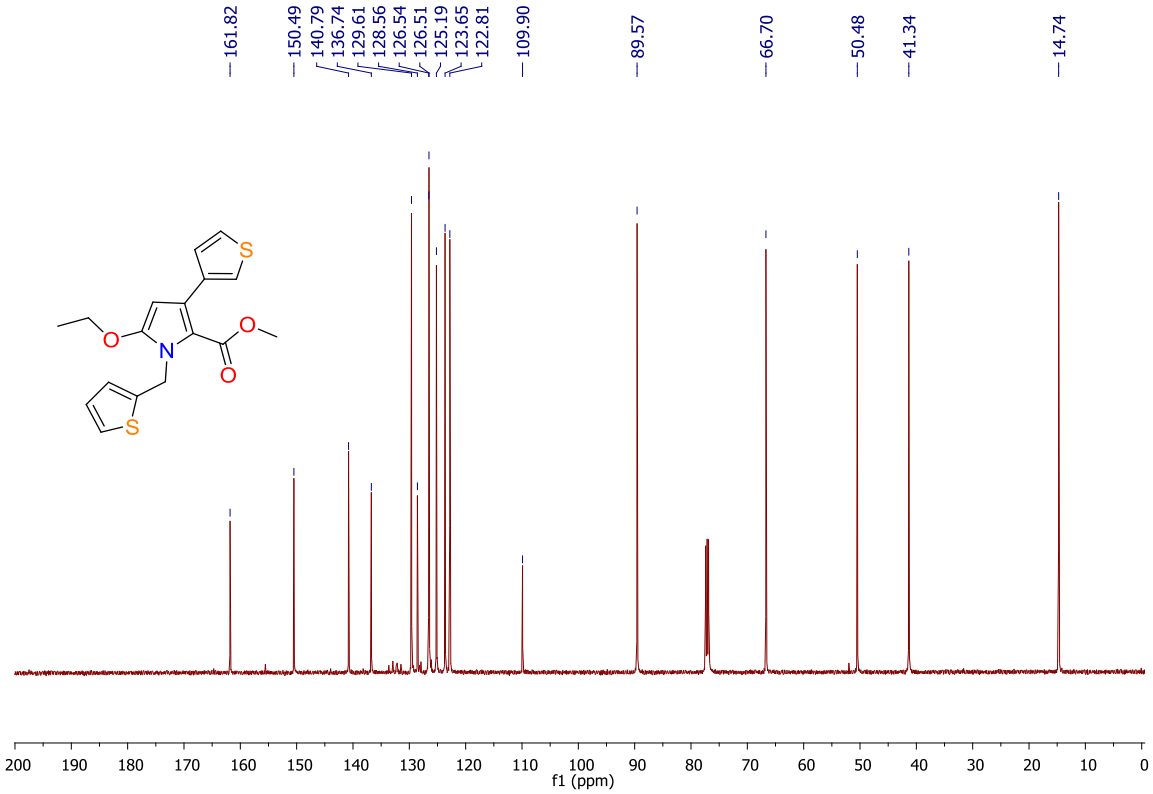


Methyl-5-ethoxy-1-(thiophen-2-ylmethyl)-3-(thiophen-3-yl)-1*H*-pyrrole-2-carboxylate (6l).

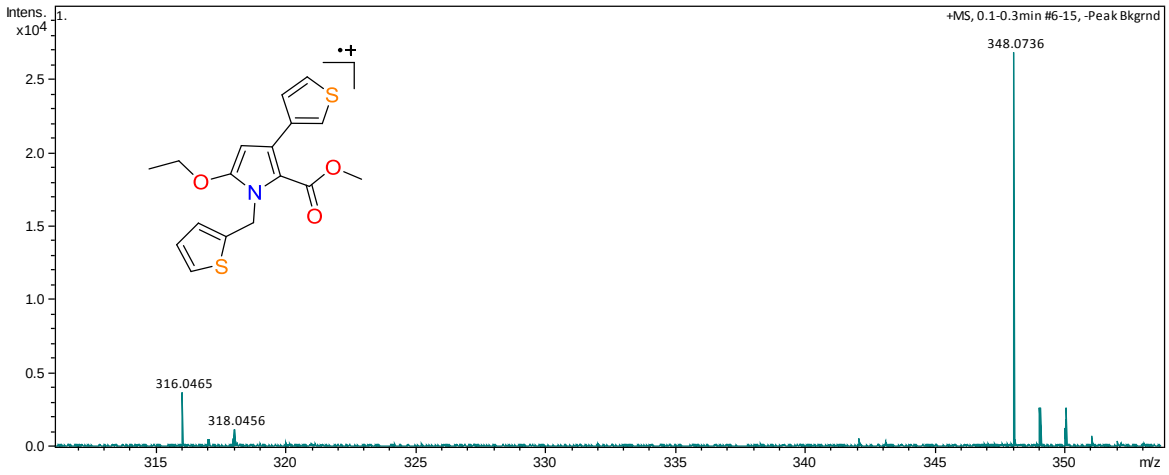
Yield: 45%; brown crystals, mp 84-86 °C. IR (cm^{-1}) 1674 (C=O), 1056 (N-C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.32 (s, 1H, C*H*), 7.26-7.24 (m, 2H, C*H*), 7.18 (s, 2H, C*H*), 7.05 (s, 1H, C*H*), 6.92 (s, 1H, C*H*), 5.63 (s, 2H, NCH_2), 5.47 (s, 1H, C*H*), 4.17 (q, J = 6.3 Hz, 2H, OCH_2CH$_3$), 3.71 (s, 3H, CO_2CH_3), 1.48 (t, J = 5.0 Hz, 3H, OCH_2CH_3). ^{13}C NMR (125 MHz, $CDCl_3$) δ 161.8 (CO_2CH_3), 150.5, 140.8, 136.7, 129.6, 128.6, 126.5, 126.5, 125.2, 123.7, 122.8, 109.9, 89.6 (*C*H), 66.7 (OCH_2CH_3), 50.5 (OCH_3), 41.3 (NCH_2), 14.7 (OCH_2CH_3). HRMS (ESI+): m/z calcd for $C_{17}H_{17}NO_3S_2$ $[M+H]^+$ 348.0728, found 348.0736.



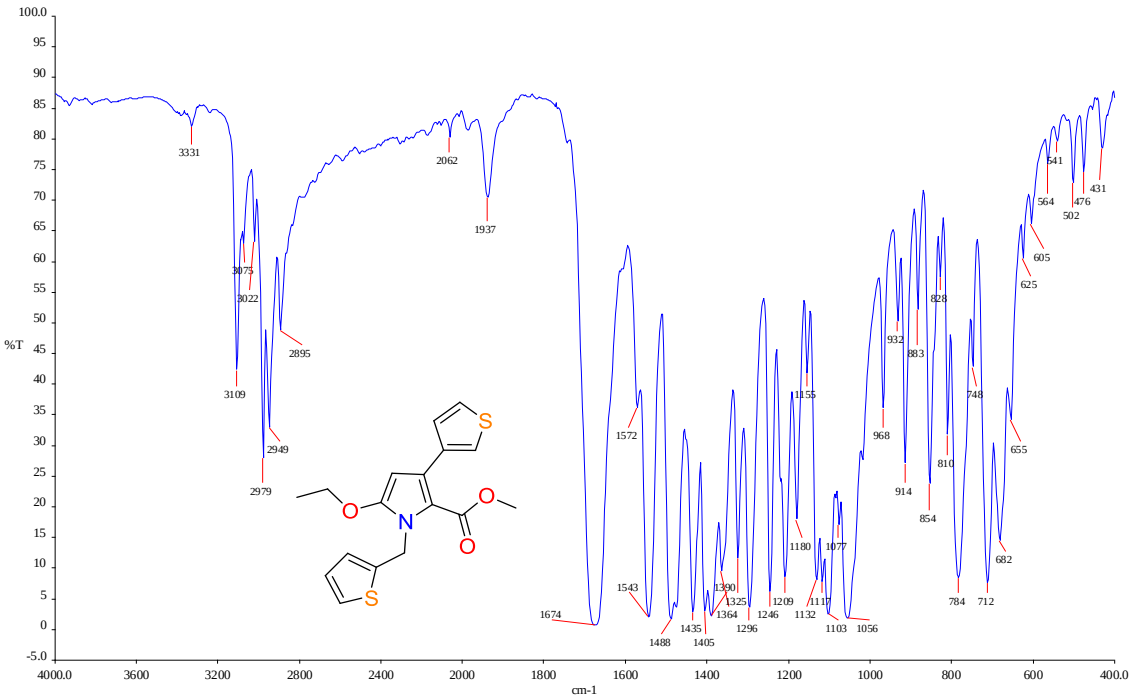
^{1}H, $CDCl_3$, 500 MHz **6l**



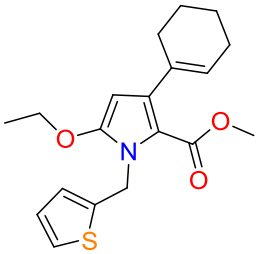
^{13}C, $CDCl_3$, 125 MHz **6l**



HRMS (ESI+) **6l**



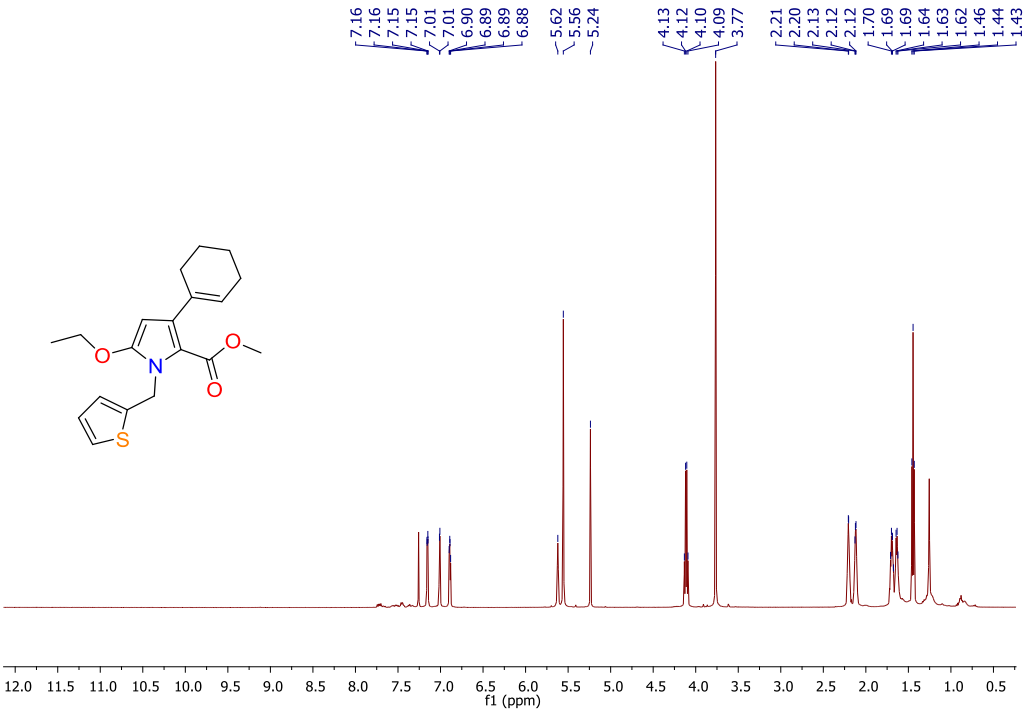
FT-IR (KBr) **6l**



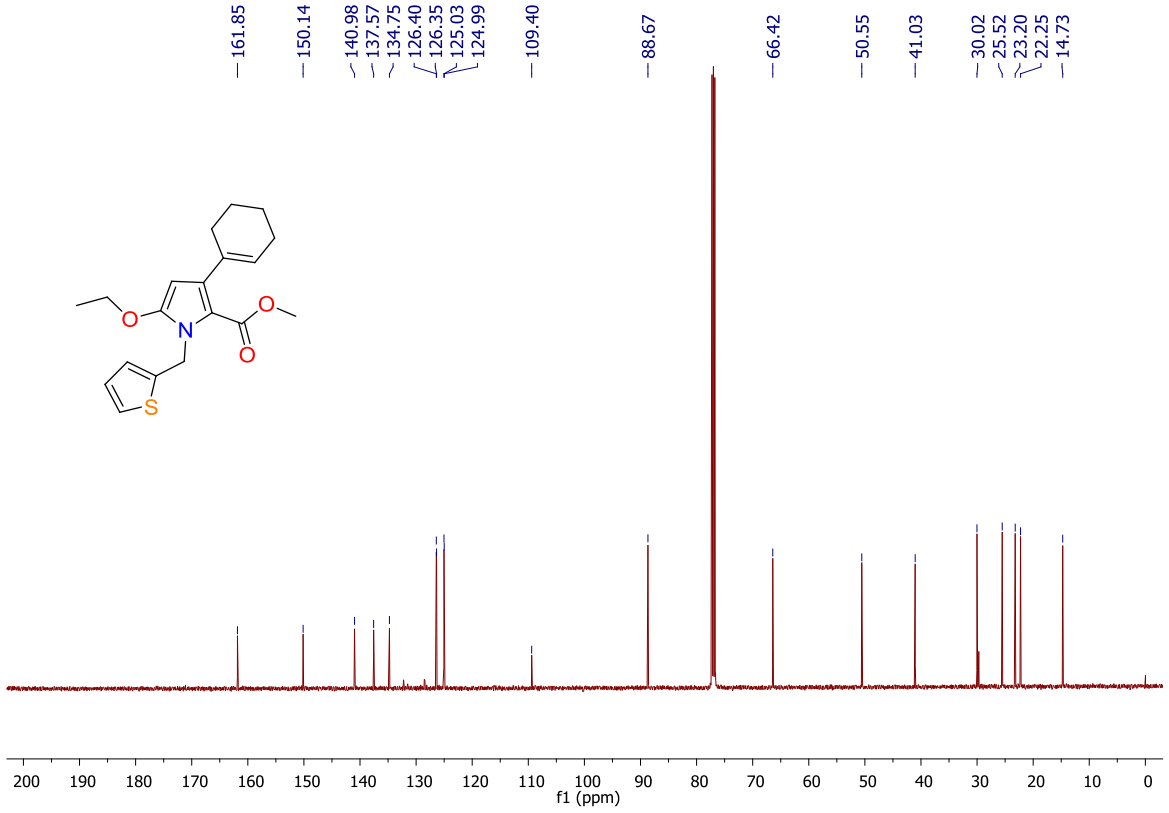
Methyl 3-(cyclohex-1-en-1-yl)-5-ethoxy-1-(thiophen-2-ylmethyl)-1*H*-pyrrole-2-carboxylate (3m).

Yield: 65%; yellow crystals, mp 83-84 °C. IR (cm^{-1}) 1672 (C=O), 1056 (N-C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.16-7.15 (m, 1H, C*H*), 7.01 (d, *J* = 2.5 Hz, 1H, C*H*), 6.90-6.88 (m, 1H, C*H*), 5.62 (s, 1H, C*H*), 5.56 (s, 2H, NCH_2), 5.24 (s, 1H, C*H*), 4.11 (q, *J* = 7.5 Hz, 2H, OCH_2CH$_3$), 3.77 (s, 3H, OCH_3), 2.21-220 (m, 2H, CH_2), 2.13-2-12 (m, 2H, CH_2), 1.71-1.68 (m, 2H, CH_2), 1.64-1.62 (m, 2H, CH_2), 1.44 (t, *J* = 7.5 Hz, 3H, OCH$_2$CH_3). ^{13}C NMR (125 MHz, $CDCl_3$) δ 161.9 (*C*O$_2$CH$_3$), 150.1, 141.0, 137.6, 134.8, 126.4, 126.4, 125.0, 125.0, 109.4, 88.7 (*C*H), 66.4 (O*C*H$_2$CH$_3$), 50.6 (CO$_2$*C*H$_3$), 41.03 (N*C*H$_2$), 30.0 (*C*H$_2$), 25.5

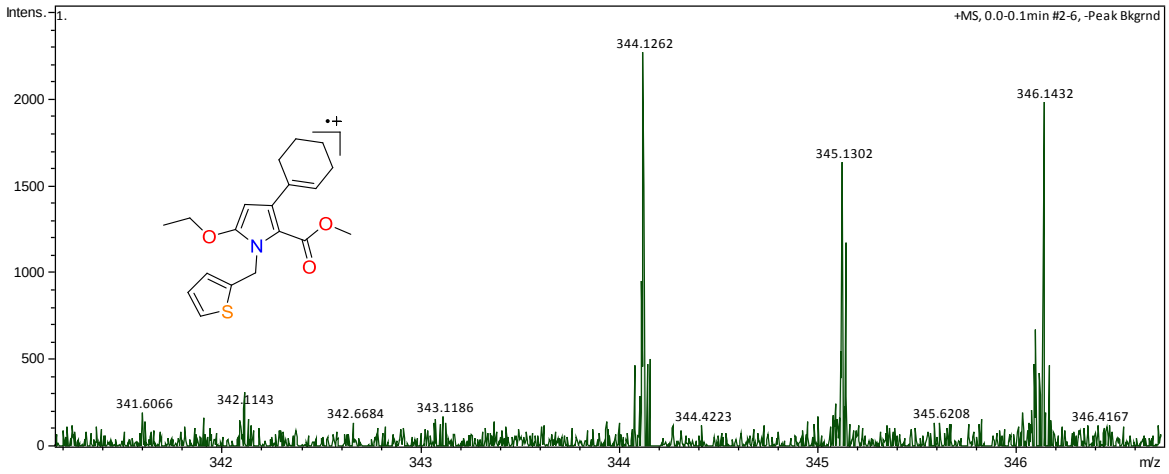
(CH_2), 23.2 (CH_2), 22.3 (CH_2), 14.7 (OCH_2CH_3). HRMS (ESI+): m/z calcd for $C_{19}H_{23}NO_3S$ $[M+H]^+$ 346.1477, found 346.1432.



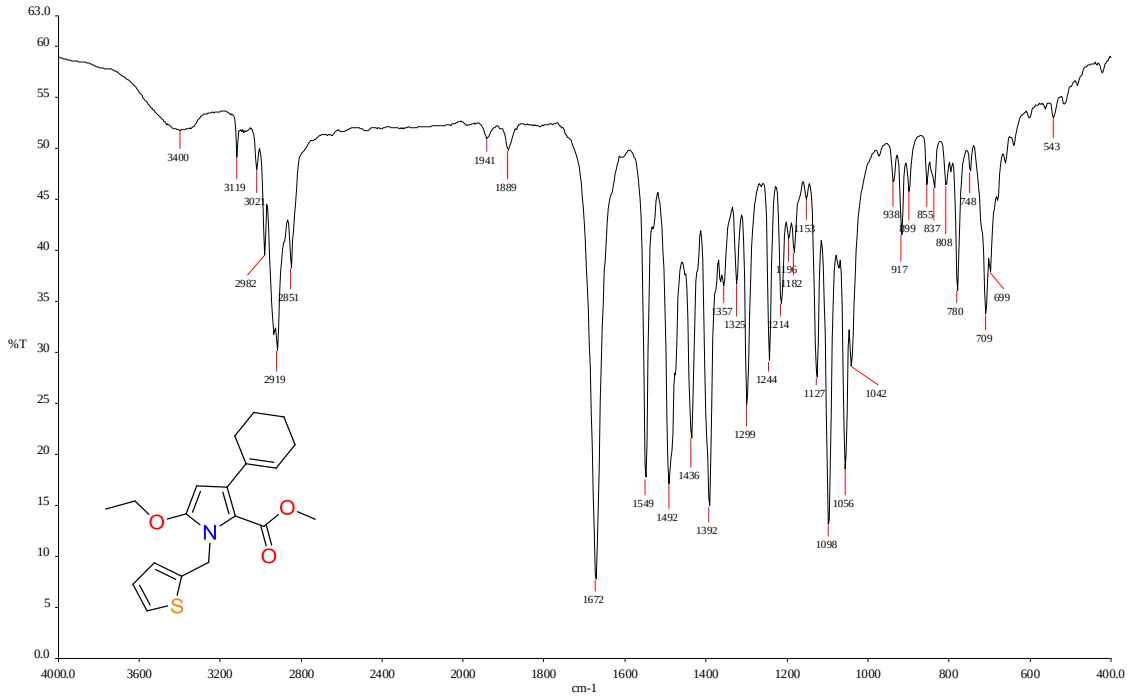
^1H, $CDCl_3$, 500 MHz **6m**



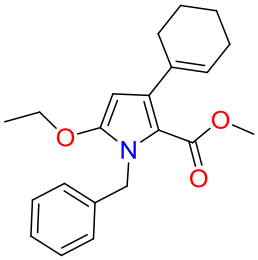
^{13}C, $CDCl_3$, 125 MHz **6m**



HRMS (ESI+) **6m**

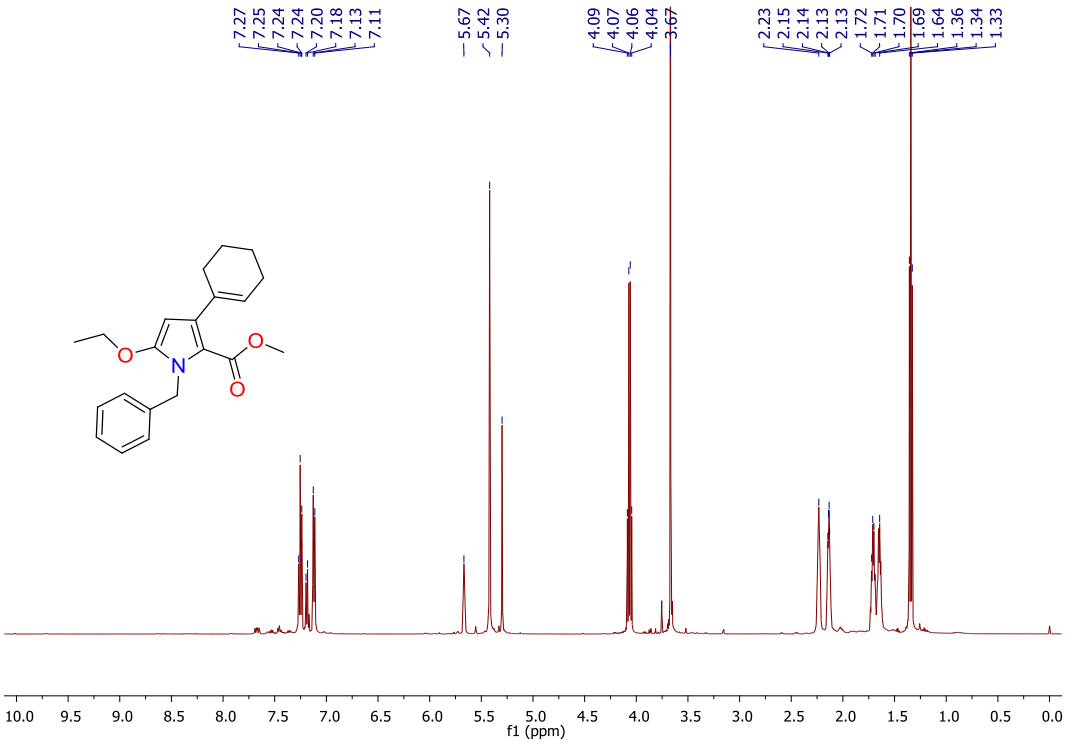


FT-IR (KBr) **6m**

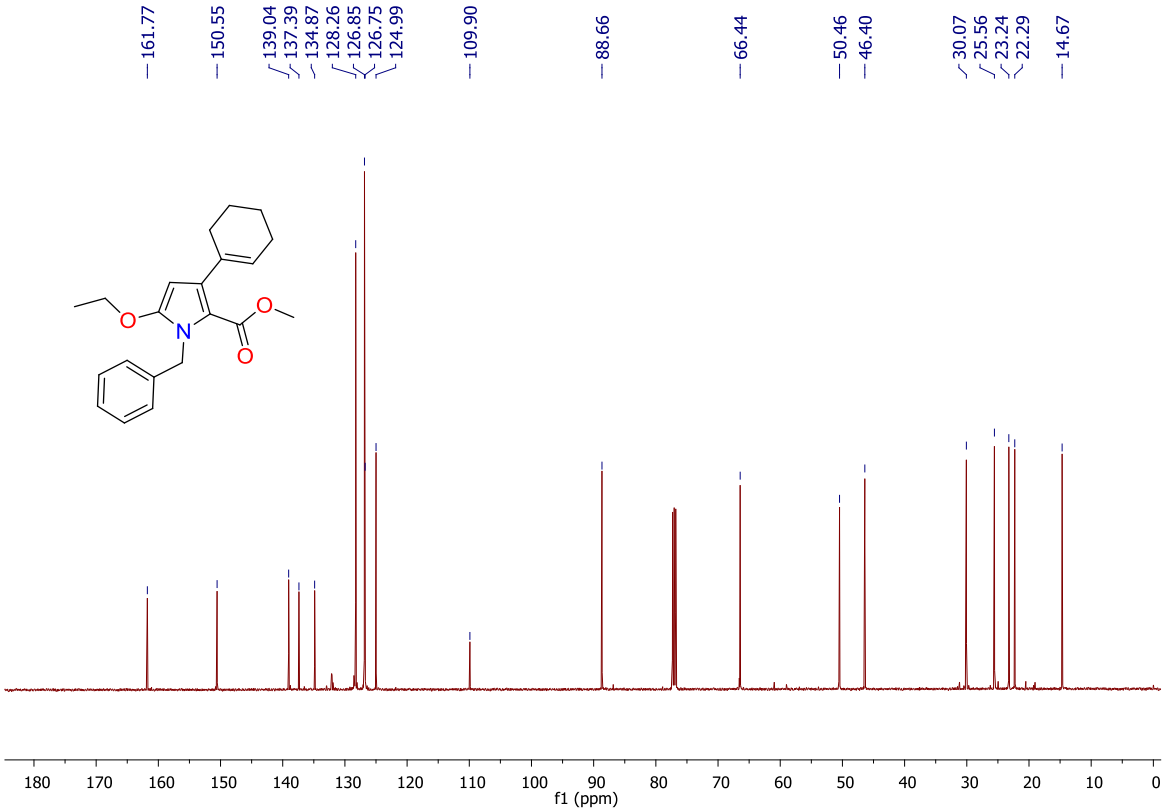


Methyl 1-benzyl-3-(cyclohex-1-en-1-yl)-5-ethoxy-1*H*-pyrrole-2-carboxylate (6n).

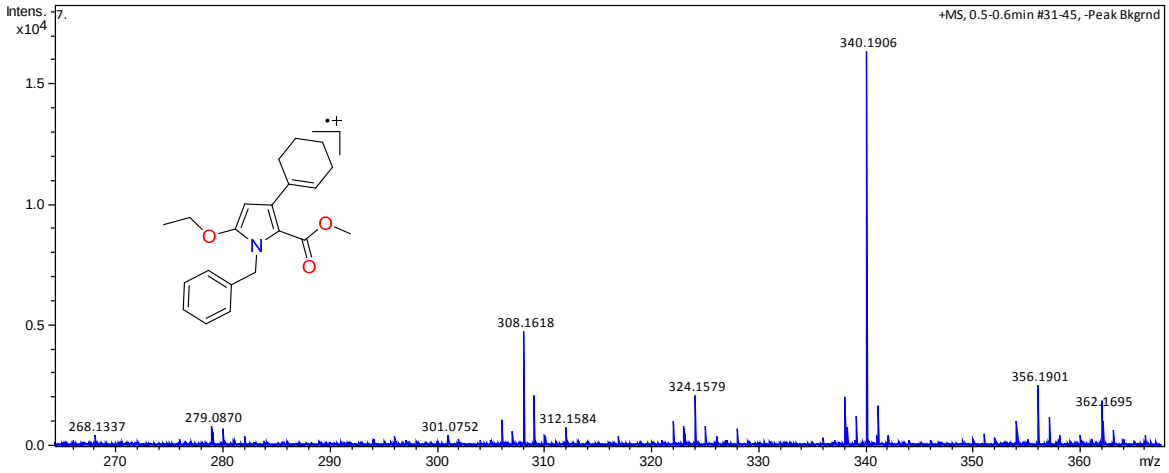
Yield: 53%; yellow liquid. IR (cm^{-1}) 1690 (C=O), 1056 (N-C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.27-7.24 (m, 2H, C*H*), 7.20-7.18 (m, 1H, C*H*), 7.13-7.11 (m, 2H, C*H*), 5.67 (s, 1H, C*H*), 5.42 (s, 2H, NCH_2), 5.30 (s, 1H, C*H*), 4.07 (q, J = 7.5 Hz, 2H, OC$H_2$$CH_3$), 3.67 (s, 3H, OC$H_3$), 2.23 (s, 2H, C$H_2$), 2.15-2.13 (m, 2H, C$H_2$), 1.73-1.69 (m, 2H, C$H_2$), 1.67-1.62 (m, 2H, C$H_2$), 1.34 (t, J = 7.5 Hz, 3H, OCH_2CH_3). ^{13}C NMR (125 MHz, $CDCl_3$) δ 161.8 (CO_2CH_3), 150.6, 139.0, 137.4, 134.9, 128.3, 126.9, 126.8, 125.0, 109.9, 88.7 (*C*H), 66.4 (OCH_2CH_3), 50.5 (CO_2CH_3), 46.4 (NCH_2), 30.1 (CH_2), 25.6 (CH_2), 23.2 (CH_2), 22.3 (CH_2), 14.7 (OCH_2CH_3). HRMS (ESI+): m/z calcd for $C_{21}H_{25}NO_3$ $[M+H]^+$ 340.1913, found 340.1908.



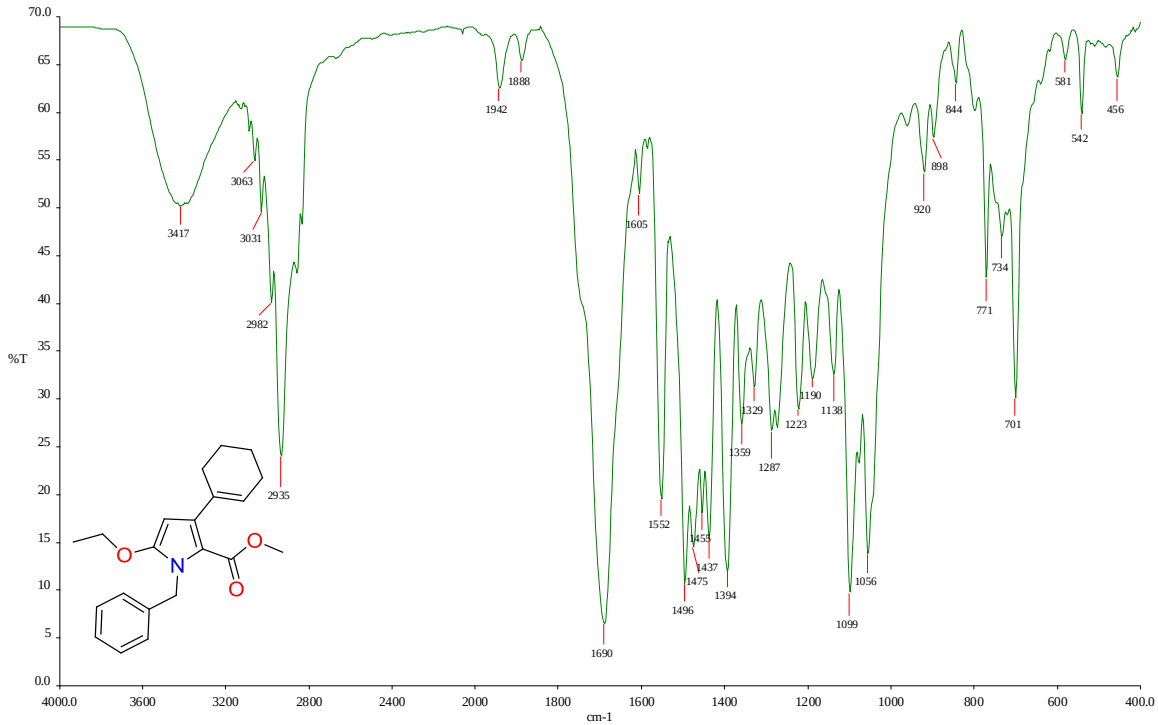
^{1}H, $CDCl_3$, 500 MHz **6n**



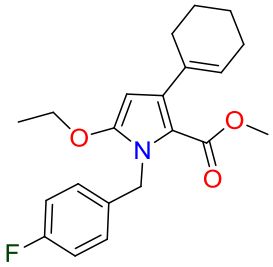
^{13}C, $CDCl_3$, 125 MHz **6n**



HRMS (ESI+) **6n**

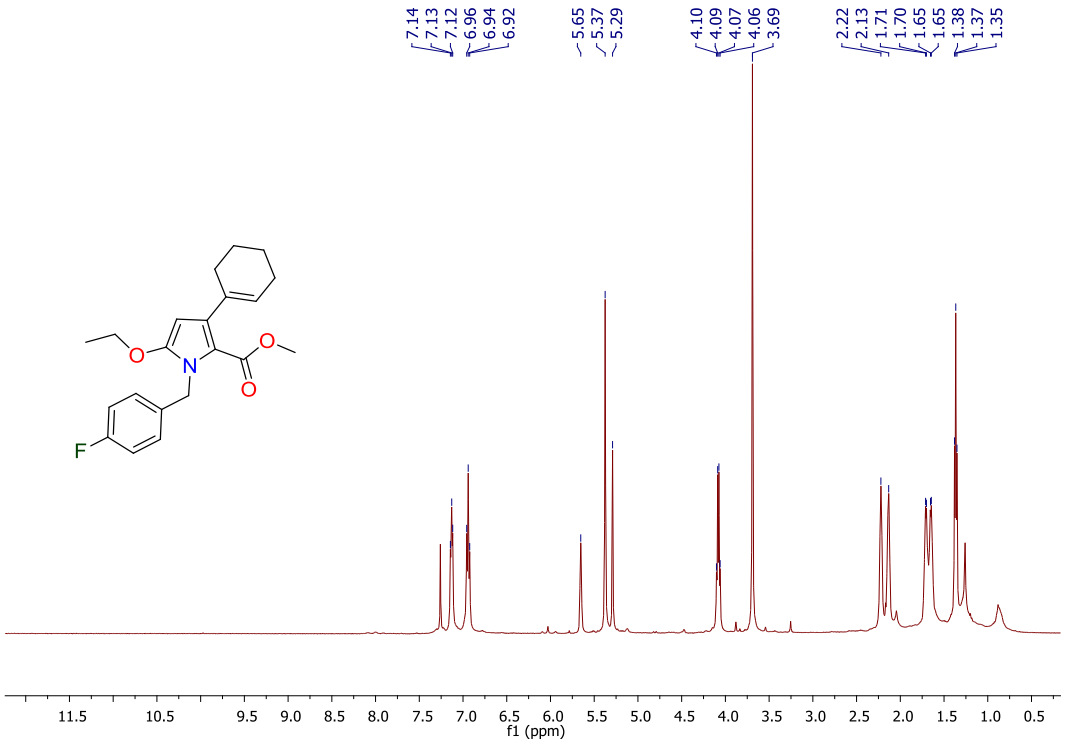


FT-IR (KBr) **6n**

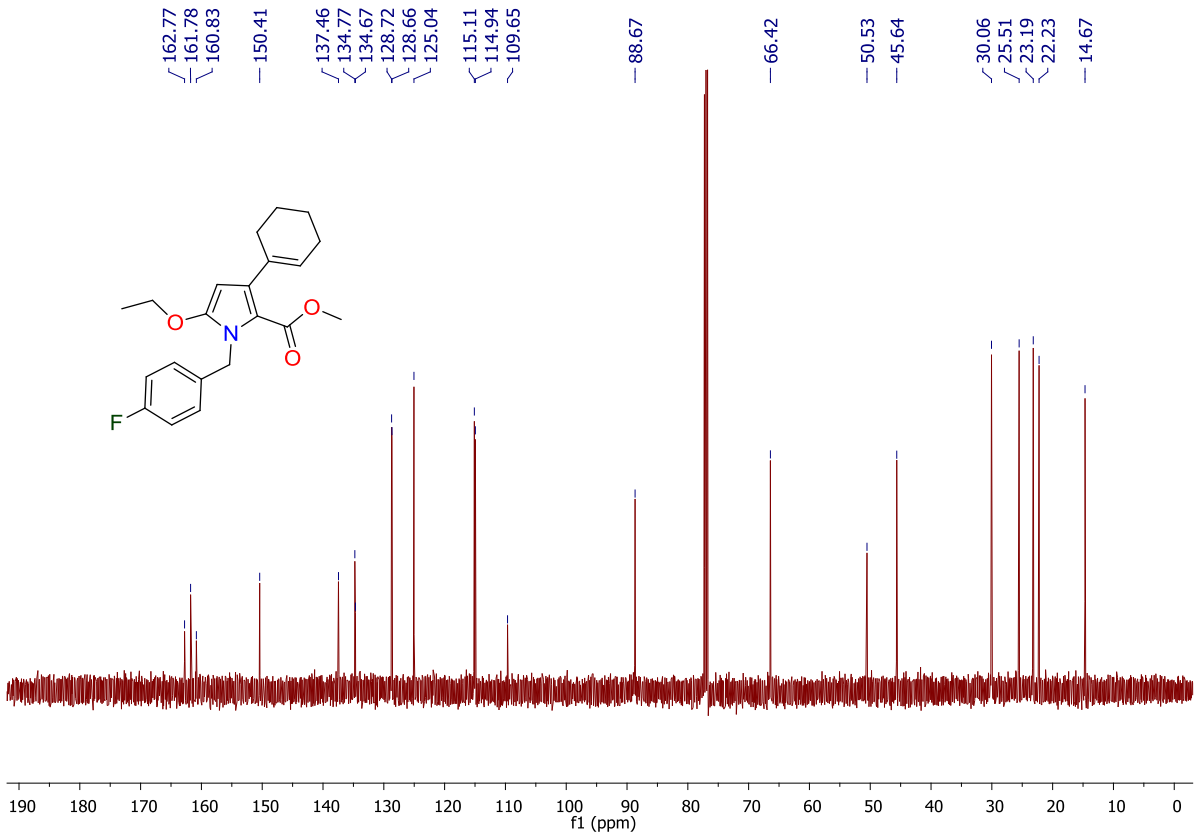


Methyl 3-(cyclohex-1-en-1-yl)-5-ethoxy-1-(4-fluorobenzyl)-1*H*-pyrrole-2-carboxylate (6o).

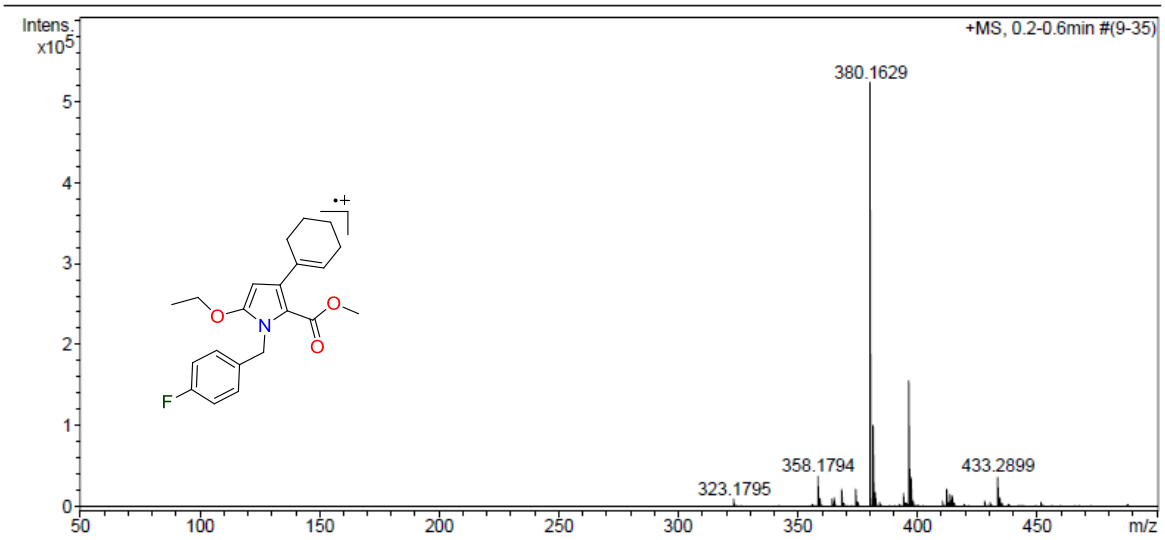
Yield: 37%; amber oil. IR (cm^{-1}) 1679 (C=O), 1056 (N-C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.14-7.12 (m, 2H, C*H*), 6.94 (t, *J* = 8.5 Hz, 2H, C*H*), 5.65 (s, 1H, C*H*), 5.37 (s, 2H, NCH_2), 5.29 (s, 1H, C*H*), 4.08 (q, *J* = 7.5 Hz, 2H, OCH_2CH$_3$), 3.69 (s, 3H, OCH_3), 2.22 (s, 2H, CH_2), 2.13 (s, 2H, CH_2), 1.71-1.65 (m, 4H, CH_2), 1.37 (t, *J* = 7.5 Hz, 3H, OCH$_2$CH_3). ^{13}C NMR (125 MHz, $CDCl_3$) δ 162.8 (*J* = 242.5 Hz), 161.8 (*C*O$_2$CH$_3$), 150.4, 137.5, 134.8, 134.7, 128.7 (*J* = 7.5 Hz, *C*H), 125.0, 115.1 (*J* = 21.3 Hz, *C*H), 109.7, 88.7 (*C*H), 66.4 (O*C*H$_2$CH$_3$), 50.5 (CO$_2$*C*H$_3$), 45.6 (N*C*H$_2$), 30.1 (*C*H$_2$), 25.5 (*C*H$_2$), 23.2 (*C*H$_2$), 22.2 (*C*H$_2$), 14.7 (OCH$_2$*C*H$_3$). HRMS (ESI+): m/z calcd for $C_{21}H_{24}FNO_3$ $[M+Na]^+$ 380.1638, found 380.1629.



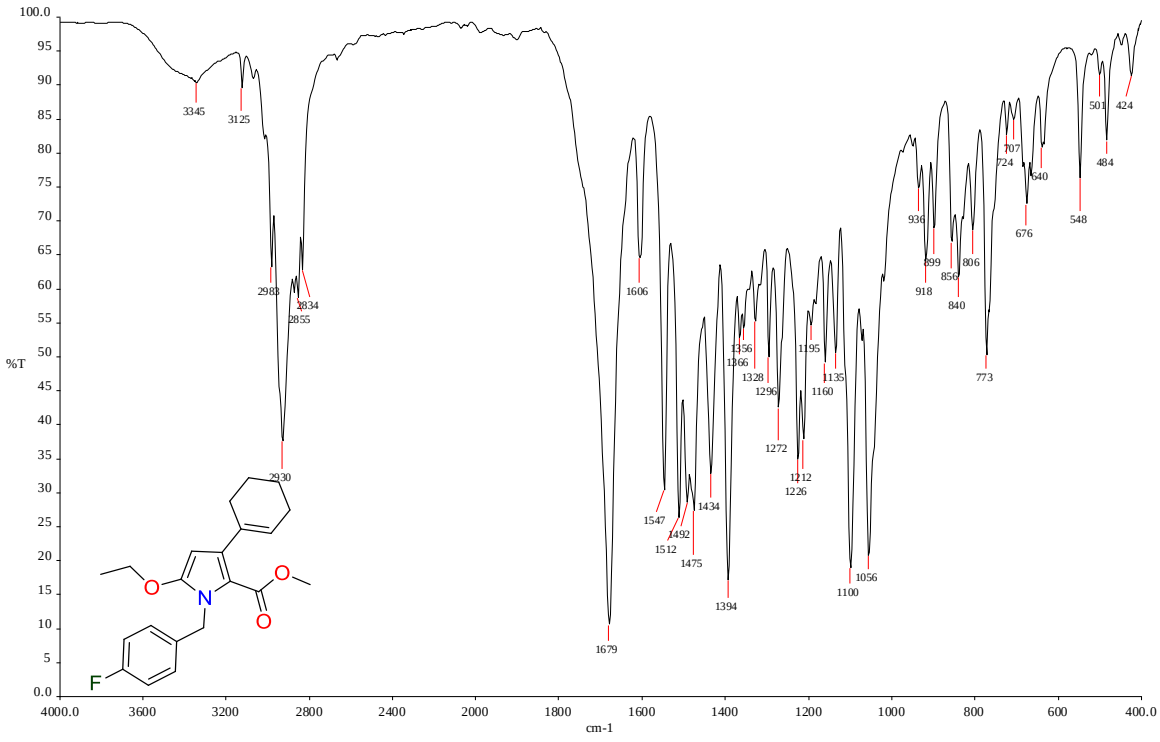
^{1}H, $CDCl_3$, 500 MHz **6o**



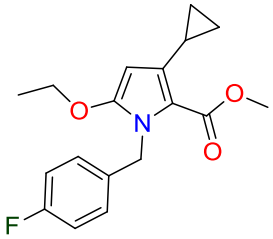
^{13}C, $CDCl_3$, 125 MHz **6o**



HRMS (ESI+) **6o**

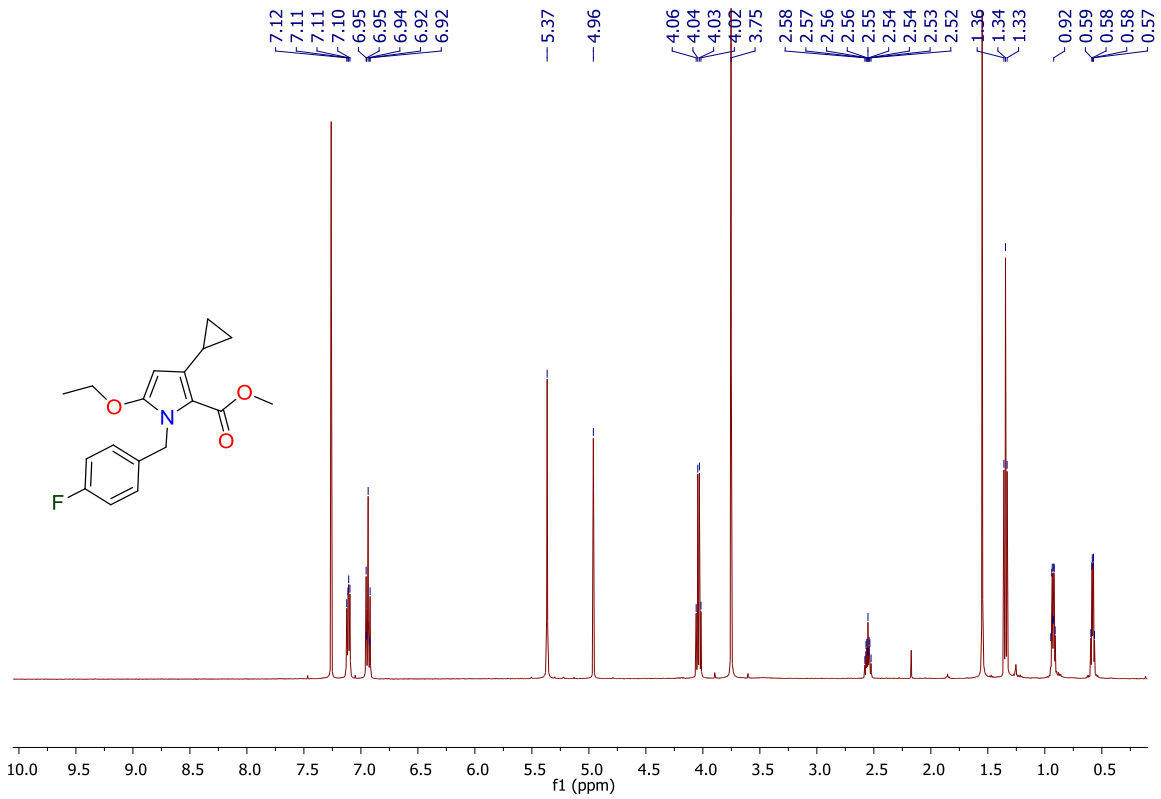


FT-IR (KBr) **6o**

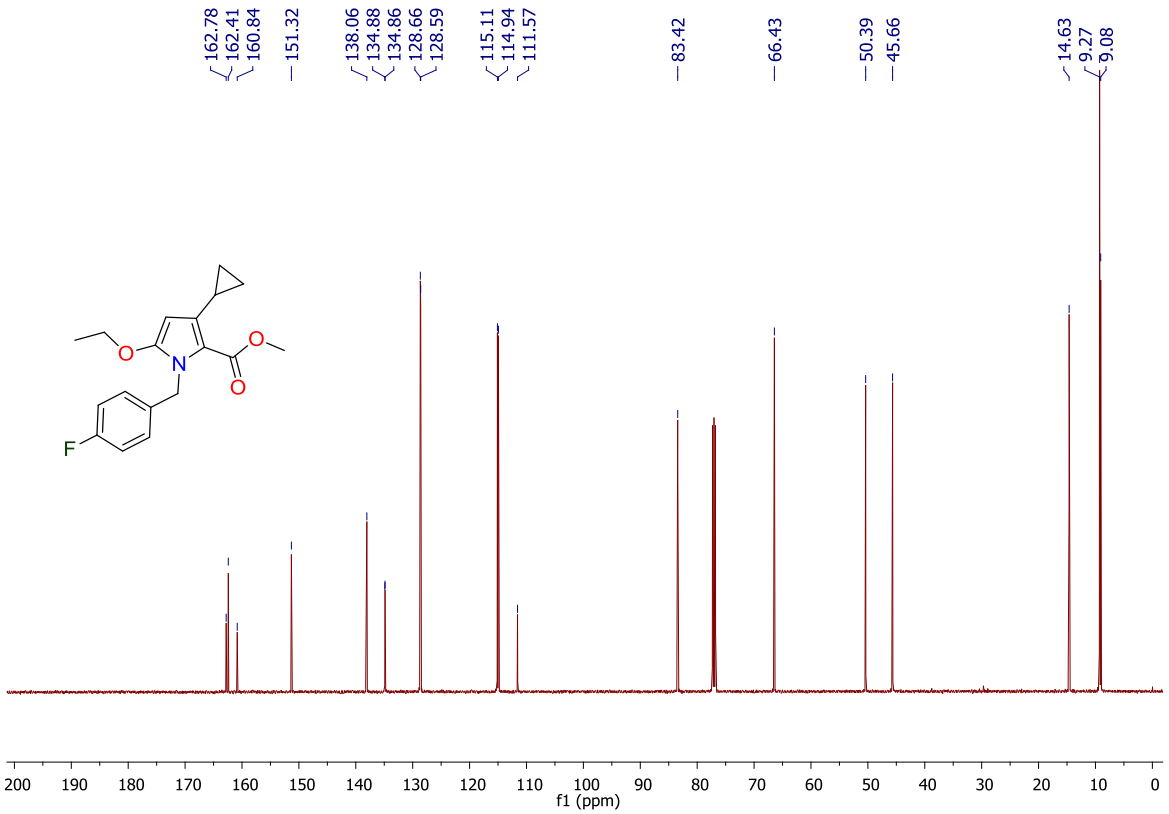


Methyl 3-(cyclopropyl)-5-ethoxy-1-(4-fluorobenzyl)-1*H*-pyrrole-2-carboxylate (6p).

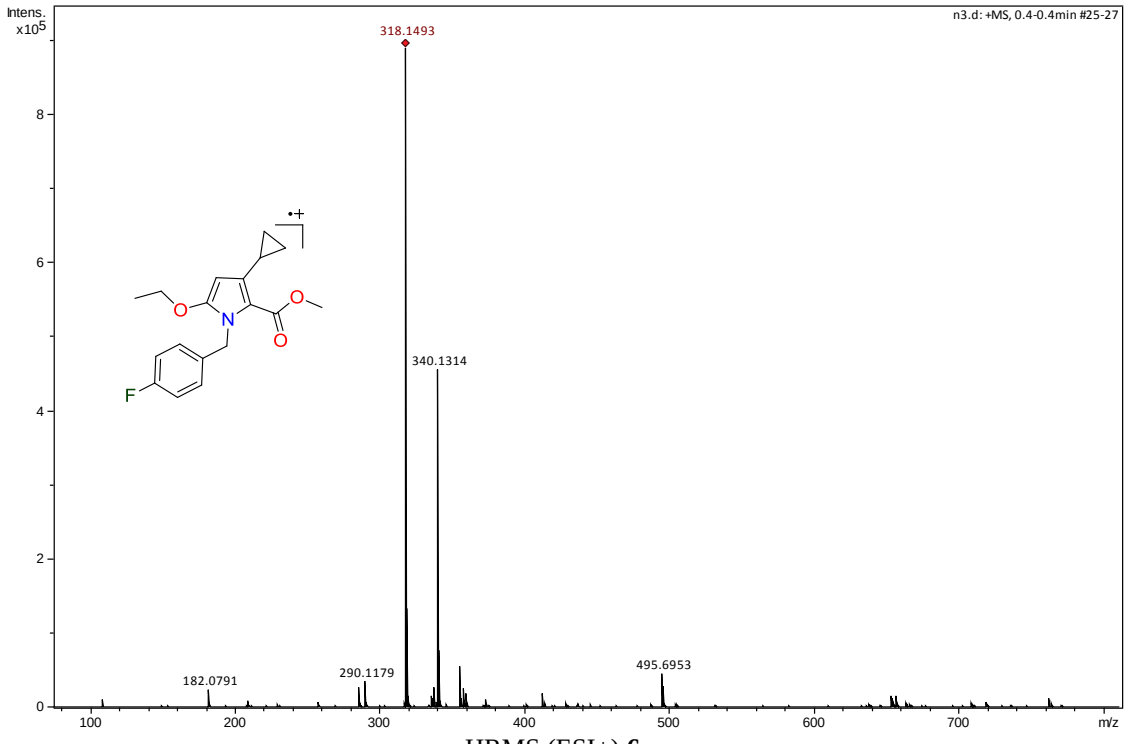
Yield: 56%; white solid, mp 88-89 °C. IR (cm^{-1}) 1688 (C=O), 1070 (N-C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.12-7.10 (m, 2H, C*H*), 6.95-6.92 (m, 2H, C*H*), 5.37 (s, 2H, NCH_2), 4.96 (s, 1H, C*H*), 4.03 (q, *J* = 6.3 Hz, 2H, OCH_2CH$_3$), 3.75 (s, 3H, OCH_3), 2.58-2.52 (m, 1H, C*H*), 1.34 (t, *J* = 7.5 Hz, 3H, OCH$_2$CH_3), 0.95-0.91 (m, 2H, CH_2), 0.60-0.56 (m, 2H, CH_2). ^{13}C NMR (125 MHz, $CDCl_3$) δ 162.8 (*J* = 242.5 Hz), 162.4 (*C*O$_2$CH$_3$), 151.3, 138.1, 134.9 (*J* = 2.5 Hz), 128.6 (*J* = 8.8 Hz, *C*H), 115.0 (*J* = 21.3 Hz, *C*H), 111.6, 83.4 (*C*H), 66.4 (O*C*H$_2$CH$_3$), 50.4 (CO$_2$*C*H$_3$), 45.7 (N*C*H$_2$), 14.6 (*C*H$_3$), 9.3 (*C*H$_2$, *C*H), 9.1 (*C*H$_2$). HRMS (ESI+): m/z calcd for $C_{18}H_{20}FNO_3$ $[M+H]^+$ 318.1505, found 318.1493.



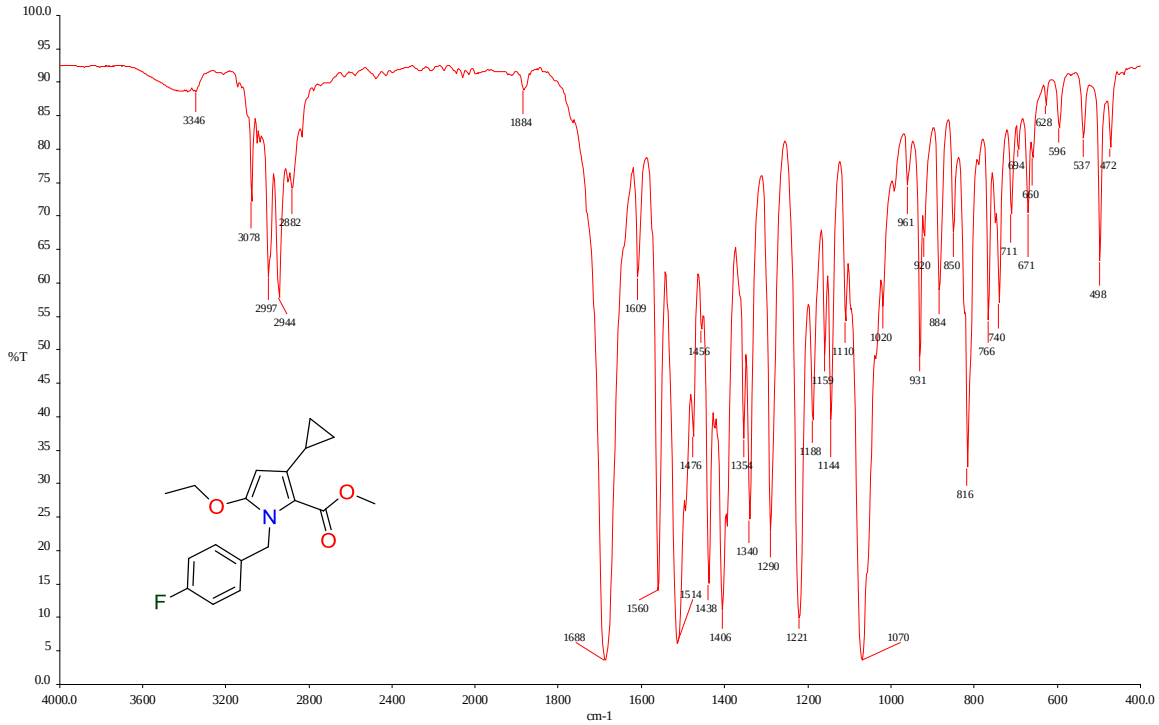
^{1}H, $CDCl_3$, 500 MHz **6p**



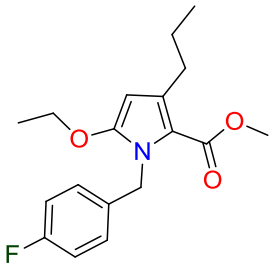
^{13}C, $CDCl_3$, 125 MHz **6p**



HRMS (ESI+) **6p**

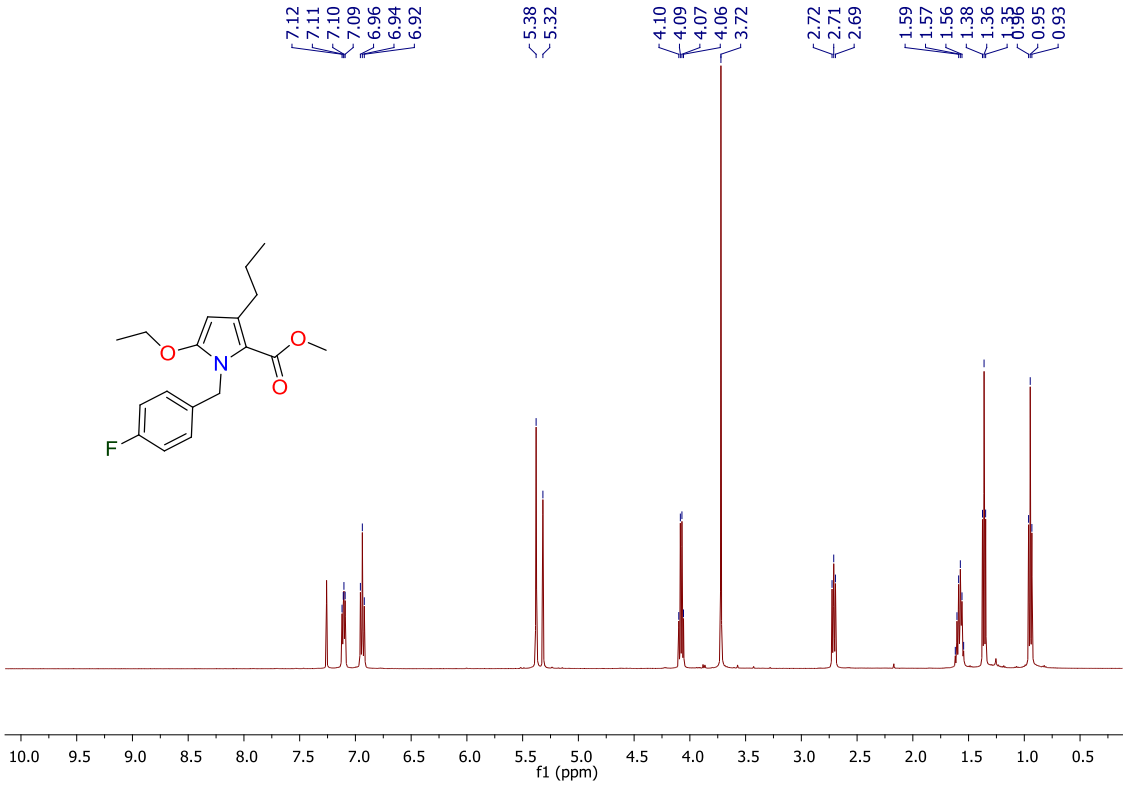


FT-IR (KBr) **6p**

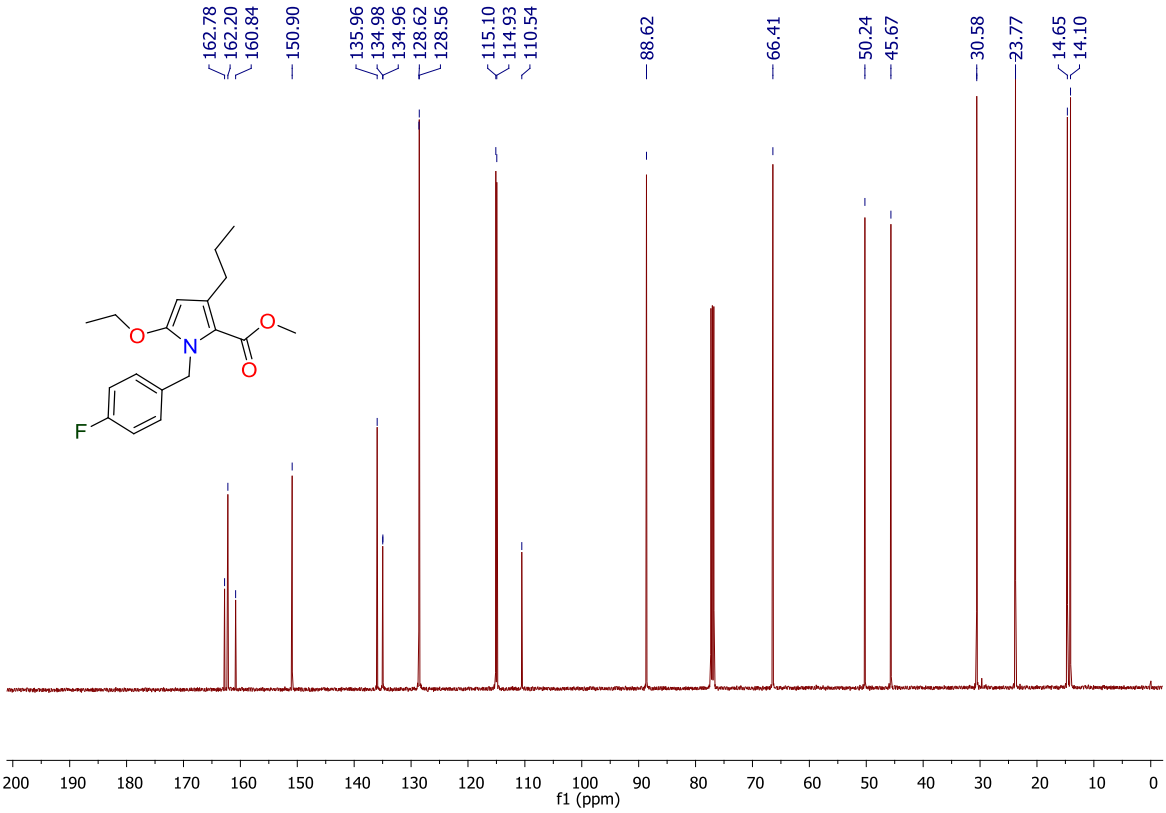


Methyl 5-ethoxy-1-(4-fluorobenzyl)-3-propyl-1*H*-pyrrole-2-carboxylate (6q).

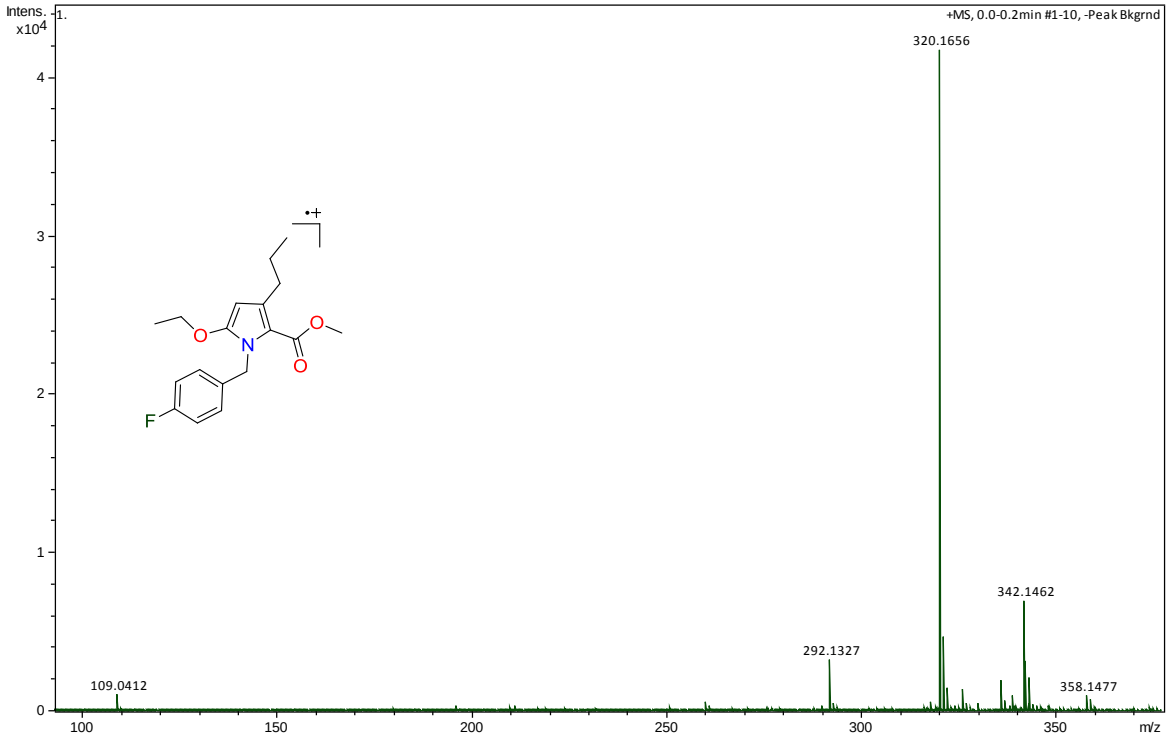
Yield: 59%; yellow liquid. IR (cm^{-1}) 1686 (C=O), 1062 (N-C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.12-7.09 (m, 2H, C*H*), 6.96-6.92 (m, 2H, C*H*), 5.38 (s, 2H, NCH_2), 5.32 (s, 1H, C*H*), 4.08 (q, *J* = 7.5 Hz, 2H, OC$H_2$$CH_3$), 3.72 (s, 3H, OC$H_3$), 2.71 (t, *J* = 7.5 Hz, 2H, CH_2), 1.62-1.54 (m, 2H, CH_2), 1.36 (t, *J* = 7.5 Hz, 3H, OCH_2CH_3), 0.95 (t, *J* = 7.5 Hz, 3H, CH_3). ^{13}C NMR (125 MHz, $CDCl_3$) δ 162.8 (*J* = 242.5 Hz), 162.2 (*C*$O_2$$CH_3$), 150.9, 136.0, 135.0 (*J* = 2.5 Hz), 128.6 (*J* = 7.5 Hz, *C*H), 115.0 (*J* = 21.3 Hz, *C*H), 110.5, 88.6 (*C*H), 66.4 (O*C*$H_2$$CH_3$), 50.2 ($CO_2$*C*$H_3$), 45.7 (N*C*$H_2$), 30.6 (*C*$H_2$), 23.8 (*C*$H_2$), 14.6 (*C*$H_3$), 14.1 (*C*$H_3$). HRMS (ESI+): m/z calcd for $C_{18}H_{22}FNO_3$ $[M+H]^+$ 320.1662, found 320.1656.



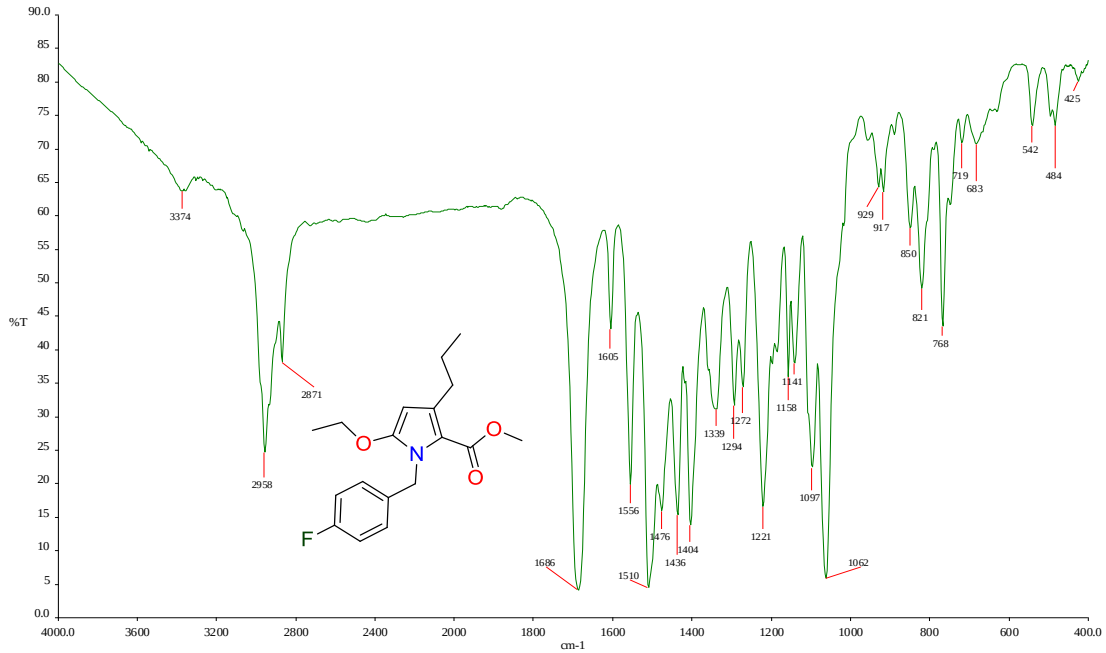
^{1}H, $CDCl_3$, 500 MHz **6q**



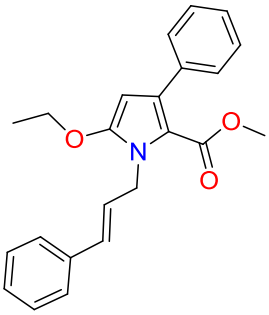
^{13}C, $CDCl_3$, 125 MHz **6q**



HRMS (ESI+) **6q**

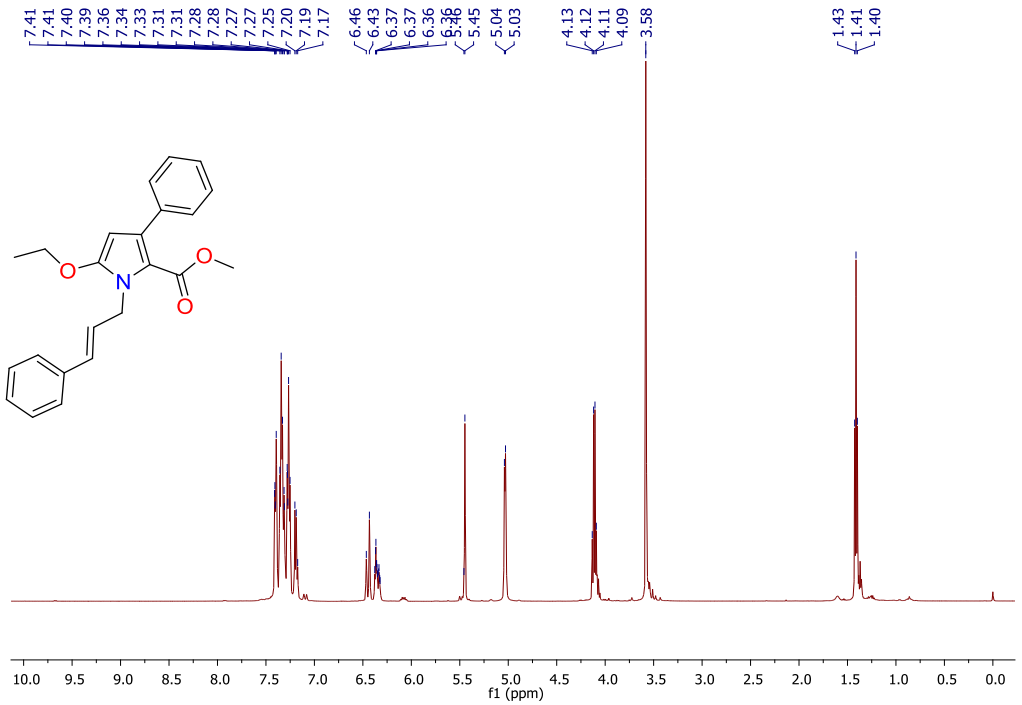


FT-IR (KBr) **6q**

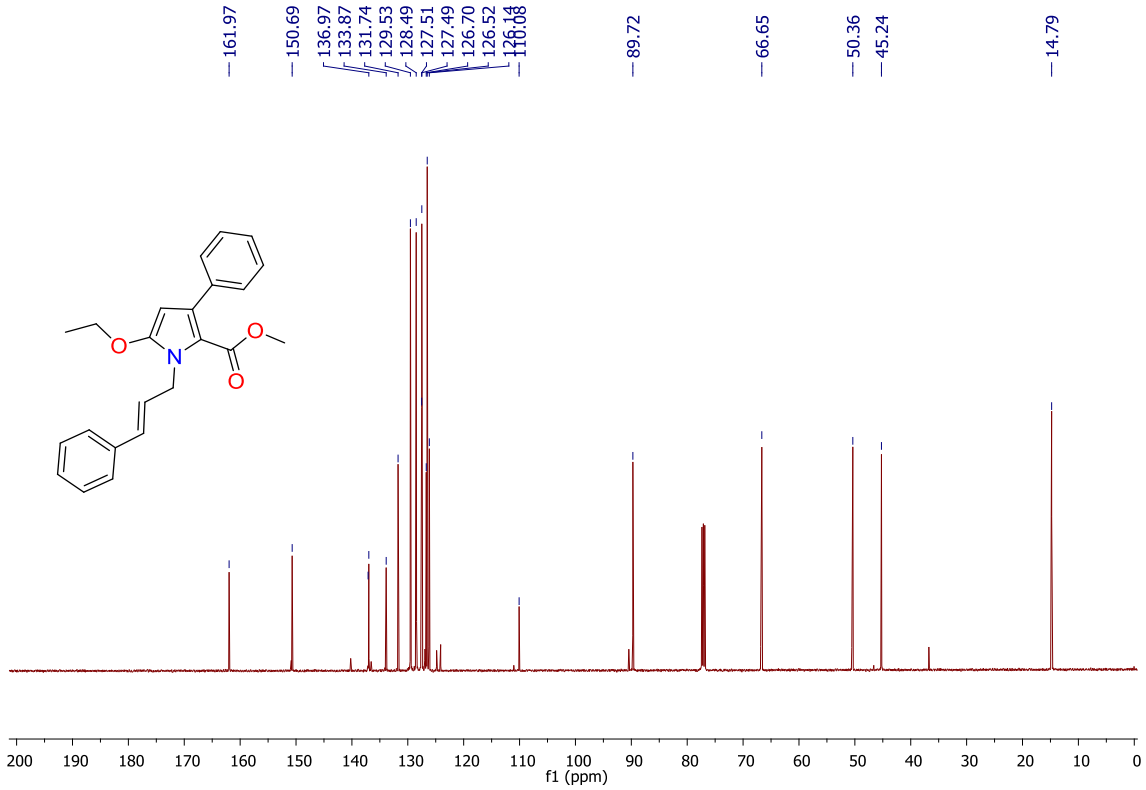


Methyl 1-(2*E*-cinnamyl)-5-ethoxy-3-phenyl-1*H*-pyrrole-2-carboxylate (6r).

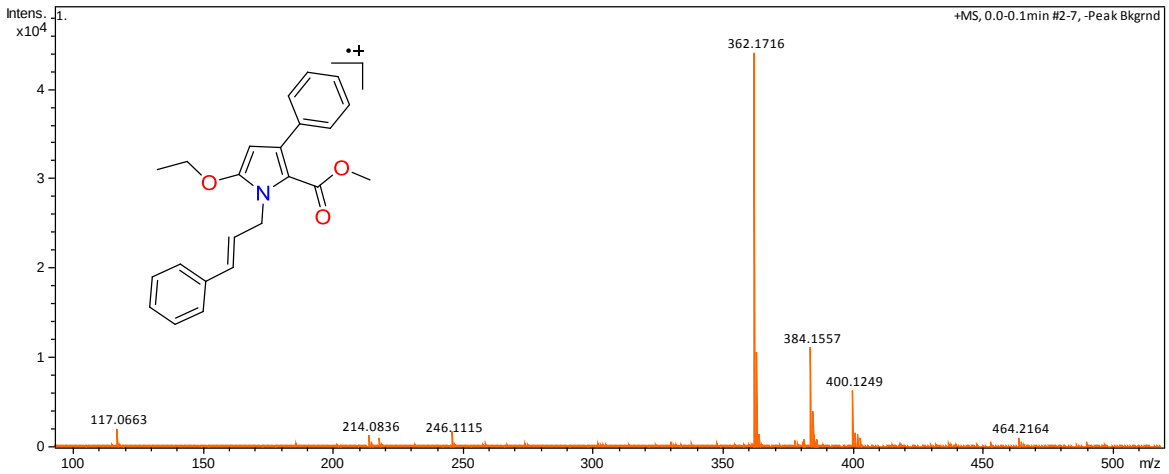
Yield: 38%; yellow crystals, mp 43-44 °C. IR (cm^{-1}) 1676 (C=O), 1049 (N-C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.41-7.39 (m, 2H, C*H*), 7.36-7.31 (m, 4H, C*H*), 7.28-7.25 (m, 3H, C*H*), 7.20-7.17 (m, 1H, C*H*), 6.45 (d, *J* = 15.0 Hz, 1H, C*H*), 6.38-6.32 (m, 1H, C*H*), 5.45 (s, 1H, C*H*), 5.04 (d, *J* = 5.0 Hz, 2H, NCH_2), 4.12 (q, *J* = 6.3 Hz, 2H, OCH_2CH$_3$), 3.58 (s, 3H, CO_2CH_3), 1.41 (t, *J* = 7.5 Hz, 3H, OCH_2CH_3). ^{13}C NMR (125 MHz, $CDCl_3$) δ 162.0 (CO_2CH_3), 150.7, 137.1, 137.0, 133.9, 131.7, 129.5, 128.5, 127.5, 126.7, 126.5, 126.1, 110.1, 89.7 (*C*H), 66.7 (OCH_2CH_3), 50.4 (CO_2CH_3), 45.2 (NCH_2), 14.8 (OCH_2CH_3). HRMS (ESI+): m/z calcd for $C_{23}H_{23}NO_3$ $[M+H]^+$ 362.1756, found 362.1716.



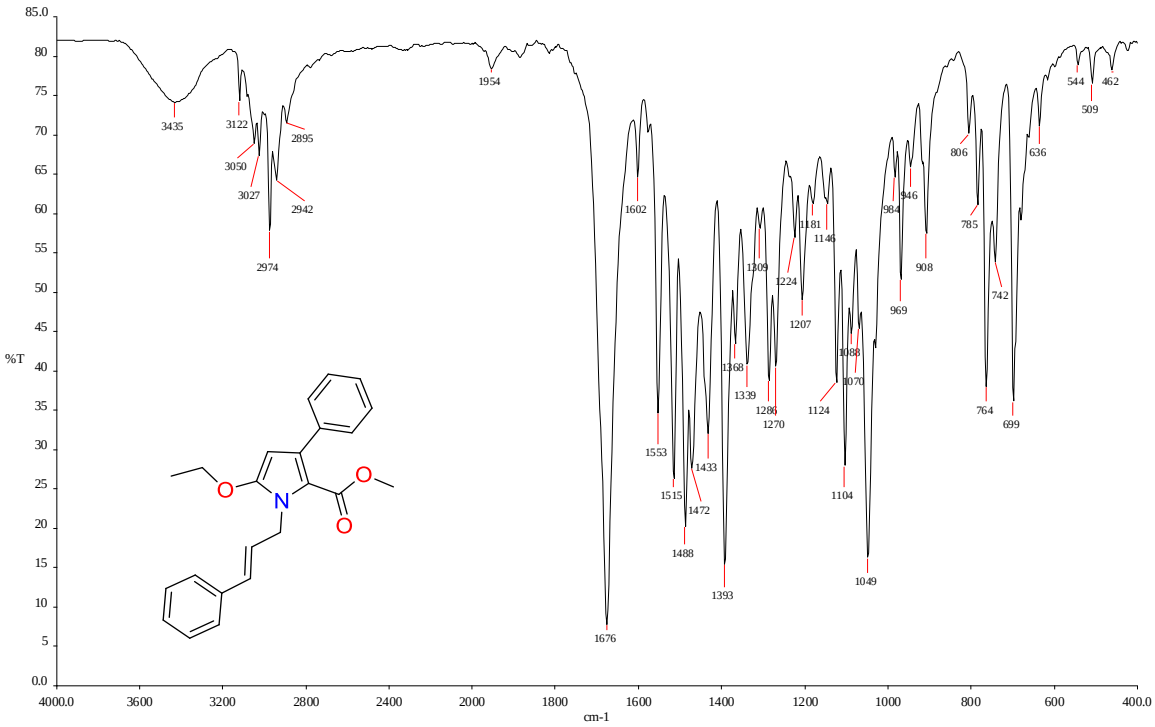
^{1}H, $CDCl_3$, 500 MHz **6r**



^{13}C, $CDCl_3$, 125 MHz **6r**



HRMS (ESI+) **6r**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1602
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1368
1339
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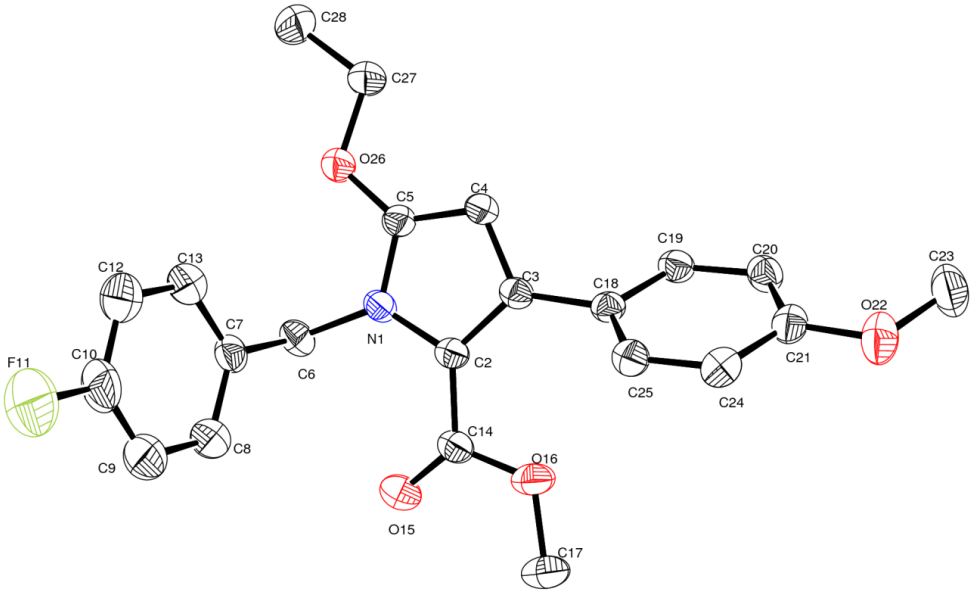
1286
1270
1224
1207
1181
1146
1124
1104
1088
1070
1049
984
969
946
908
806
785
764
742
699
636
544
509
462

FT-IR (KBr) **6r**

Table S1. Crystallographic Data for **6f**.

Compound	(**6f**)	
Empirical formula	$C_{22}H_{22}FNO_4$	
Formula weight	383.41	
Temperature	298(2) K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	P 21/c	
Unit cell dimensions	a = 23.3264(13) Å	α= 90°.
	b = 8.0732(5) Å	β= 92.206(5)°.
	c = 10.6434(6) Å	γ = 90°.
Volume	2002.9(2) $Å^3$	
Z	4	
Density (calculated)	1.271 Mg/m^3	
Absorption coefficient	0.093 mm^{-1}	
F(000)	808	
Theta range for data collection	3.50 to 25.34°.	
Index ranges	-28<=h<=27, -9<=k<=7, -12<=l<=10	
Reflections collected	8362	
Independent reflections	3644 [R(int) = 0.0239]	
Completeness to theta = 25.34°	99.5 %	
Refinement method	Full-matrix least-squares on F2	
Data / restraints / parameters	3644 / 0 / 257	
Goodness-of-fit on F2	1.026	
Final R indices [I>2sigma(I)]	R1 = 0.0486, wR2 = 0.1156	
R indices (all data)	R1 = 0.0749, wR2 = 0.1308	
Extinction coefficient	0.044(3)	
Largest diff. peak and hole	0.233 and -0.165 $e.Å^{-3}$	



ORTEP drawing of **6f** (ellipsoids at 40% probability, hydrogens omitted).

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1. M. A. Vázquez, L. Reyes, R. Miranda, J. J. García, H. A. Jiménez-Vázquez, J. Tamariz, R. Delgado, *Organometallics*, 2005, **24**, 3413.
2. W. Chun-Jiang, L. Gang, X. Zhi-Yong, G. Feng, *J. Am. Chem. Soc.*, 2008, **130**, 17250.