Supporting Information

Atroposelective Synthesis of N-N Axially Chiral Pyrrolylamides by Combined-acid Catalytic Paal-Knorr Reaction

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(A) General information

Commercially available reagents were used directly without further purification. For others, we prepared them in suitable reaction conditions. NMR spectra were recorded on a Brucker ADVANCE III 400MHz spectrometer (^{1}H NMR: 400 MHz, ^{13}C NMR: 100 MHz). Chemical shifts (δ) were reported in ppm relative to $CDCl_3$ (δ 7.26) for the ^{1}H NMR and to $CDCl_3$ (δ 77.16) for the ^{13}C NMR measurements. Mass spectra were recorded on Therno Finnigan MAT 95 XL spectrometer and Bruker solariX 9.4 Tesla FTICR spectrometer. GC/MS analysis was conducted on a Shimadzu GCMSQP2010 instrument equipped with a Restec-5HT column (30 m × 0.25 mm, Hewlett-Packard). IR spectra were recorded on a PerkinElmer FT-IR spectrophotometer and reported in terms of wavenumber of absorption (cm^{-1}). Flash column chromatography was performed on 300-400 mesh silica gel from Qingdao Haiyang Chemical Co., Ltd. Reactions were monitored by thin-layer chromatography (TLC) using 254 nm UV light to visualize the progress of the reactions.

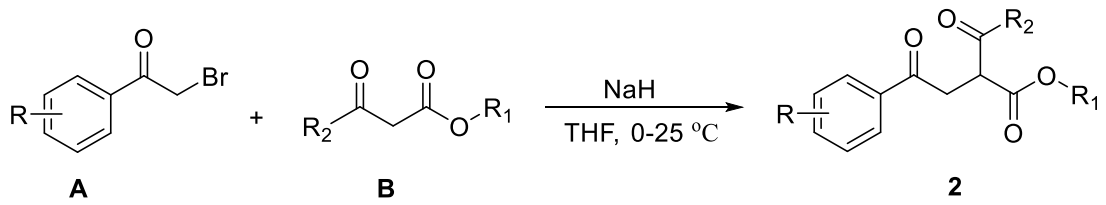
(B) General procedure for the synthesis of the substrate

Typical procedure for the synthesis of hydrazines 1

Substrates **1** could be conveniently synthesized according to the known literature procedures.[1,2] Their ^{1}H NMR spectroscopic and physical data were compared with reporting data, ensuring correct structures.

Typical procedure for the synthesis of 1,4-dikitones 2

Substrates **2** could be synthesized according to the known literature procedures.[3] Their 1H NMR spectroscopic and physical data were compared with reporting data, ensuring correct structures。

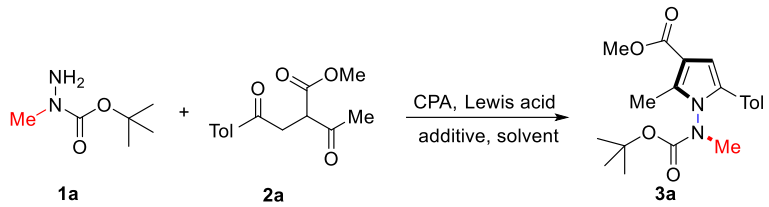


A **B** **2**

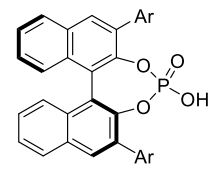
General procedure:

To a solution of sodium hydride (60% dispersion in mineral oil) (400 mg, 11 mmol) in anhydrous THF (20 mL) was slowly added the solution of methyl acetoacetate **B** (1.16 g, 10 mmol) in THF (10 mL) at 0 °C. The reaction mixture was stirred at 0 °C for 0.5 h. Then, a solution of 2-bromo-1-phenylethan-1-one **A** (10 mmol) in THF (5 mL) was added to the mixture, which was stirred at room temperature for another 12 h. After the completion of the reaction which was indicated by TLC, the reaction mixture was quenched with H_2O and the aqueous layer was extracted with EtOAc (3×30 mL). The combined organic layers were dried over anhydrous Na_2SO_4 and then concentrated under reduced pressure. Then the crude product was purified by silica gel column chromatography to give 1,4-dikitones **2**

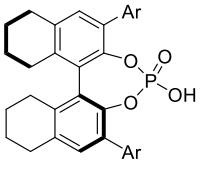
(C) Table S1. Optimization of reaction conditions[a]



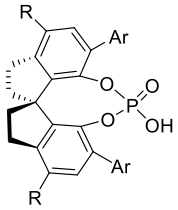
1a 2a 3a



C1: Ar = 2,4,6-(^{i}Pr)$_3$C$_6$H$_2$
C2: Ar = 2,4,6-(Me)$_3$C$_6$H$_2$
C3: Ar = 9-phenanthrenyl
C4: Ar = 9-anthracenyl



C5: Ar = 9-phenanthrenyl

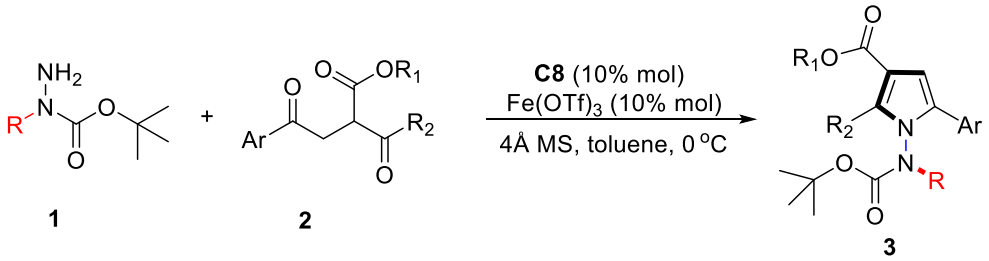


C6: Ar = 9-phenanthrenyl, R = H
C7: Ar = 2,4,6-(Me)$_3$C$_6$H$_2$, R = H
C8: Ar = 2,4,6-(Me)$_3$C$_6$H$_2$, R = Me

entry	CPA	solvent	Lewis acid	T (℃)	additive	yield (%)	ee (%)[b]
1	-	toluene	$Fe(OTf)_3$	25	4Å MS	70	0
2	**C1**	toluene	-	25	4Å MS	80	–1
3	**C1**	toluene	$Fe(OTf)_3$	25	4Å MS	90	–6
4	**C2**	toluene	$Fe(OTf)_3$	25	4Å MS	92	–53
5	**C3**	toluene	$Fe(OTf)_3$	25	4Å MS	93	–65
6	**C4**	toluene	$Fe(OTf)_3$	25	4Å MS	60	–46
7	**C5**	toluene	$Fe(OTf)_3$	25	4Å MS	70	–50
8	**C6**	toluene	$Fe(OTf)_3$	25	4Å MS	92	53
9	**C7**	toluene	$Fe(OTf)_3$	25	4Å MS	90	85
10	**C8**	toluene	$Fe(OTf)_3$	25	4Å MS	94	87
11	**C8**	toluene	$Fe(OTf)_3$	25	5Å MS	70	73
12	**C8**	toluene	$Fe(OTf)_3$	25	3Å MS	90	60
13	**C8**	toluene	$Fe(OTf)_3$	25	$MgSO_4$	92	79
14	**C8**	toluene	$Fe(OTf)_3$	25	Na_2SO_4	88	72
15	**C8**	toluene	$Fe(OTf)_3$	25	-	82	76
16	**C8**	$CHCl_3$	$Fe(OTf)_3$	25	4Å MS	10	2
17	**C8**	CH_2Cl_2	$Fe(OTf)_3$	25	4Å MS	30	40
18	**C8**	CCl_4	$Fe(OTf)_3$	25	4Å MS	85	72
19	**C8**	hexane	$Fe(OTf)_3$	25	4Å MS	88	70
20	**C8**	toluene	$Fe(OTf)_3$	0	4Å MS	96	93
21	**C8**	toluene	$Fe(OTf)_3$	-20	4Å MS	94	92
22	**C8**	toluene	$FeCl_3$	0	4Å MS	85	20
23	**C8**	toluene	$Cu(OTf)_2$	0	4Å MS	70	30
24	**C8**	toluene	$In(OTf)_3$	0	4Å MS	86	35
25	**C8**	toluene	$Sc(OTf)_3$	0	4Å MS	92	87
26	**C8**	toluene	$Bi(OTf)_3$	0	4Å MS	94	77
27	**C8**	toluene	-	0	4Å MS	82	24

[a] Reaction conditions: **1a** (0.0375 mmol), **2a** (0.025 mmol), catalyst (10 mol%), Lewis acid (10 mol%), additivity (20 mg), solvent (1.0 mL) at given temperature for 8 h. [b] Determined by HPLC analysis.

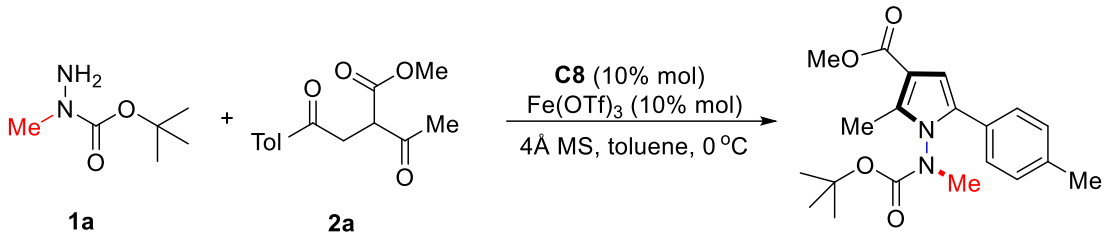
(D) General procedure for the asymmetric synthesis of axially chiral N-N amide-pyrrole 3



1 2 3

Hydrazide **1** (0.075 mmol, 1.5 eq) was added to a solution of 1,4-diketones **2** (0.05 mmol, 1.0 eq), **C8** (10 mol%), $Fe(OTf)_3$ (10 mol%), and 4 Å MS (40 mg) in toluene (2.0 mL) at 0 °C. The reaction was stirred for 8 h until the 1,4-diketones **2** was fully consumed (monitored by TLC), then the mixture was concentrated under reduced pressure and purified by flash chromatography eluted with PE/EA to afford the corresponding axially chiral N-N amide-pyrroles product **3**.

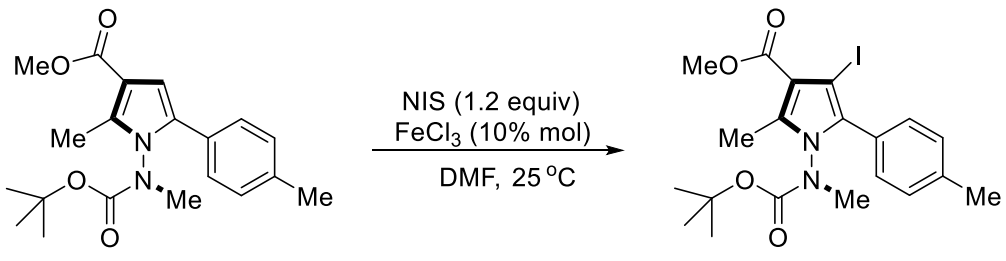
(E) General procedure for gram-scale reaction



1a 2a (2 mmol) 3a 96% yield, 91% ee

Hydrazide **1a** (3 mmol, 1.5 eq) was added to a solution of 1,4-diketones **2a** (2 mmol, 1.0 eq), **C8** (10 mol%), $Fe(OTf)_3$ (10 mol%), and 4 Å MS (1.2 g) in toluene (60 mL) at 0 °C. The reaction was stirred for 8 h until the 1,4-diketones **2** was fully consumed (monitored by TLC), then the mixture was concentrated under reduced pressure and purified by flash chromatography eluted with PE/EA to afford the corresponding axially chiral N-N amide-pyrrole product **3a** (687.4 mg, 96% yield, 91% ee).

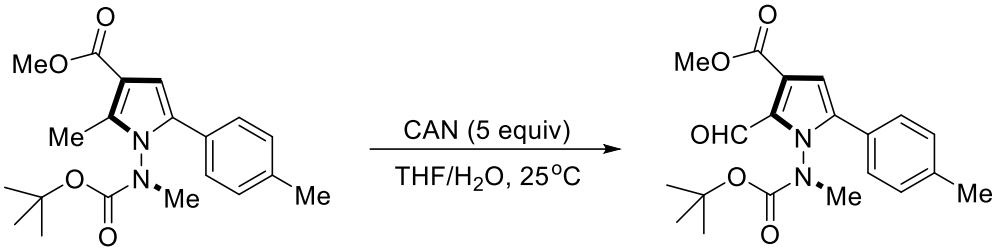
(F) Synthetic transformations



3a 4 94% yield, 93% ee

To a dry round-bottom flask equipped with a magnetic stir bar, **3a** (35.8 mg, 0.1 mmol) was dissolved in DMF (2 mL). Then $FeCl_3$ (10 mol%) and NIS (1.2 eq) were added to

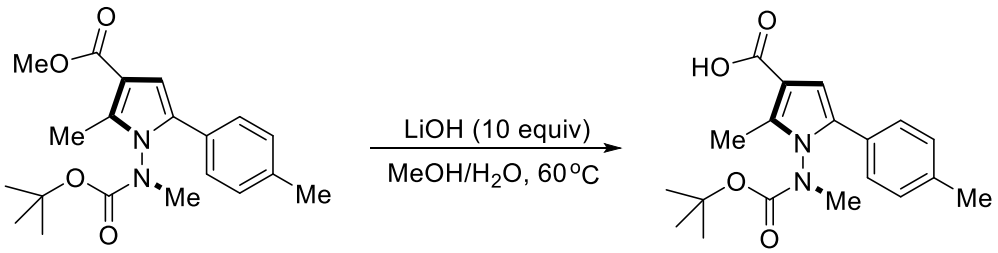
the mixture at 25 ºC. After the completion of the reaction which was indicated by TLC, H_2O (5 mL) was added and the mixture was extracted with EtOAc (3×10 mL). The combined organic layers were washed with brine, dried with Na_2SO_4 and concentrated under reduced pressure. Further purification by flash column chromatography on silica gel to provide product **4** (45.5 mg, 94% yield, 93% ee).



3a **5**

85% yield, 90% ee

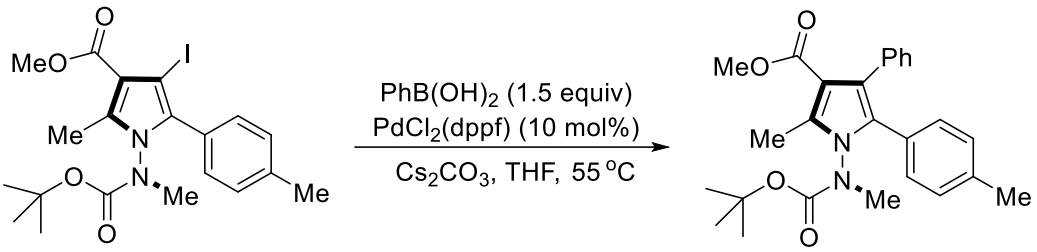
To a dry round-bottom flask equipped with a magnetic stir bar, **3a** (35.8 mg, 0.1 mmol) was dissolved in THF (4 mL) and H_2O (0.4 mL) at 25 ºC. Then ceric ammonium nitrate (CAN) (274 mg, 0.5 mmol) was added in small portions to the mixture. After the completion of the reaction which was indicated by TLC, H_2O (10 mL) was added and the mixture was extracted with EtOAc (3×10 mL). The combined organic layers were washed with brine, dried with Na_2SO_4 and concentrated under reduced pressure. Further purification by flash column chromatography on silica gel to provide product **5** (31.6 mg, 85% yield, 90% ee).



3a **6**

80% yield, 90% ee

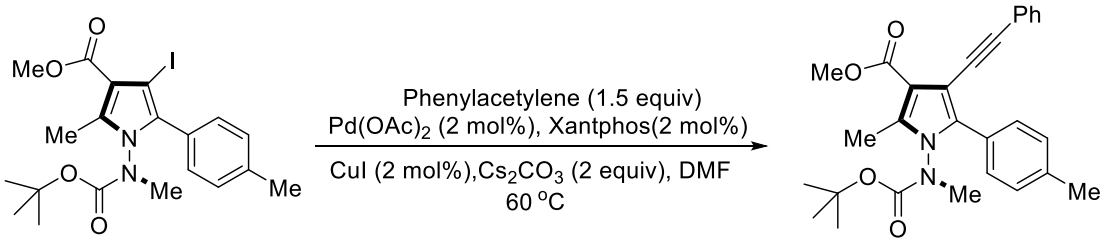
To a dry round-bottom flask equipped with a magnetic stir bar, **3a** (35.8 mg, 0.1 mmol) was dissolved in MeOH (1 mL) and H_2O (1 mL). Then LiOH (10 eq) was added to the mixture, and the reaction was stirred at 60 ºC. After the completion of the reaction which was indicated by TLC, H_2O (5 mL) was added and the mixture was extracted with EtOAc (3×10 mL). The combined organic layers were washed with brine, dried with Na_2SO_4 and concentrated under reduced pressure. Further purification by flash column chromatography on silica gel to provide product **6** (27.5 mg, 80% yield, 90% ee).



4 **7**

90% yield, 92% ee

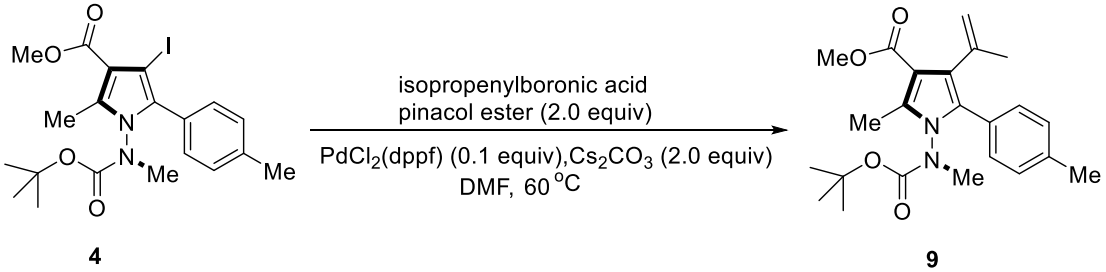
Under Ar atmosphere, to a dry round-bottom flask equipped with a magnetic stir bar, **4** (48.4 mg, 0.1 mmol), $PdCl_2$(dppf) (7.4 mg, 0.01 mmol), Cs_2CO_3 (65.2 mg, 0.2 mmol), boronic acid (18.3 mg, 0.15 mmol) was added in THF (3 mL). Then the reaction mixture was stirred at 55 °C for 3 h. After cooling to room temperature, H_2O (5 mL) was added. The suspension was filtered through a pad of Celite washing with ethyl acetate (5 mL) and filtrate was extracted with EtOAc (3×10 mL). The combined organic layers were washed with brine, dried with Na_2SO_4 and concentrated under reduced pressure. The residual crude product was chromatographed on silica gel to give the product **7** (31.6 mg, 90% yield, 92% ee).



4 **8**

85% yield, 91% ee

Under Ar atmosphere, to a dry round-bottom flask equipped with a magnetic stir bar, **4** (48.4 mg, 0.1 mmol), $Pd(OAc)_2$ (0.48 mg, 0.002 mmol), CuI (0.38 mg, 0.002 mmol), Xantphos (1.16 mg, 0.002 mmol), Cs_2CO_3 (65.2 mg, 0.2 mmol), ethynylbenzene (15.3 mg, 0.15 mmol) was added in DMF (3 mL). Then the reaction mixture was stirred at 60 °C for 3 h. After cooling to room temperature, H_2O (10 mL) was added. The suspension was filtered through a pad of celite, washing and then extracted with EtOAc (3×10 mL). The combined organic layers were washed with brine, dried with Na_2SO_4 and concentrated under reduced pressure. The residual crude product was chromatographed on silica gel to give the product **8** (38.9 mg, 85% yield, 91% ee).

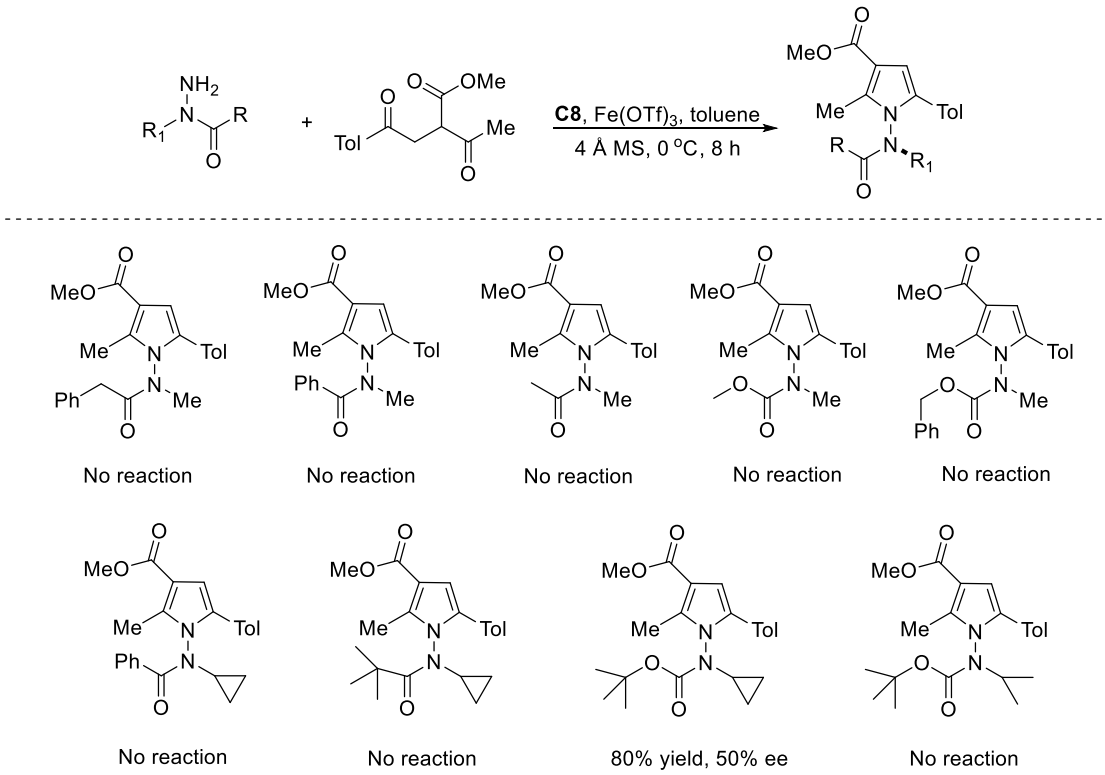


4 **9**

82% yield, 90% ee

Under Ar atmosphere, to a dry round-bottom flask equipped with a magnetic stir bar, **4** (48.4 mg, 0.1 mmol), $PdCl_2$(dppf) (7.4 mg, 0.01 mmol), Cs_2CO_3 (65.2 mg, 0.2 mmol), isopropenylboronica acid pinacol ester (33.6 mg, 0.2 mmol) was added in THF (3 mL). Then the reaction mixture was stirred at 50°C for 2 h. After cooling to room temperature, H_2O (5 mL) was added. The suspension was filtered through a pad of celite, washing and then extracted with EtOAc (3×10 mL). The combined organic layers were washed with brine, dried with Na_2SO_4 and concentrated under reduced pressure. The residual crude product was chromatographed on silica gel to give the product **9** (32.6 mg, 82% yield, 90% ee).

(G) Unsuccessful examples



(H) Mechanistic studies

To a flame-dried Schlenk tube was added **C8** (0.01 mmol) and $Fe(OTf)_3$ (0.01 mmol) and $CDCl_3$ (0.5 mL). After 30 min stirring at rt, the solution was transferred to a NMR tube and the ^{31}P NMR was taken, a new peak was transferred from -9.0 ppm to -9.4 ppm.

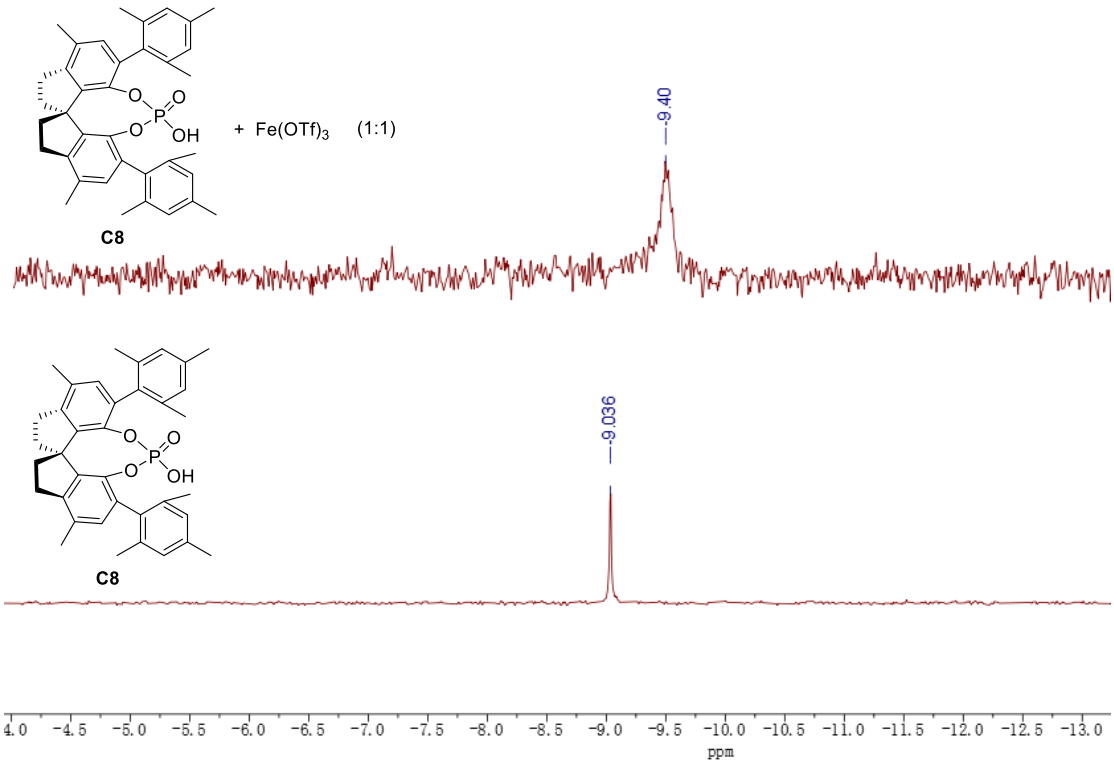


Fig. 1 ^{31}P NMR spectra of **C8** and binary-acid **C8**/Fe(OTf)$_3$

To a flame-dried Schlenk tube was added **C8** (0.01 mmol), Fe(OTf)$_3$ (0.01 mmol), and CH_2Cl_2 (0.5 mL). After 30 min stirring at rt, an aliquot was diluted with CH_3CN (CH_3CN:CH_2Cl_2 = 5:1) and subjected to analysis by ESI-MS.

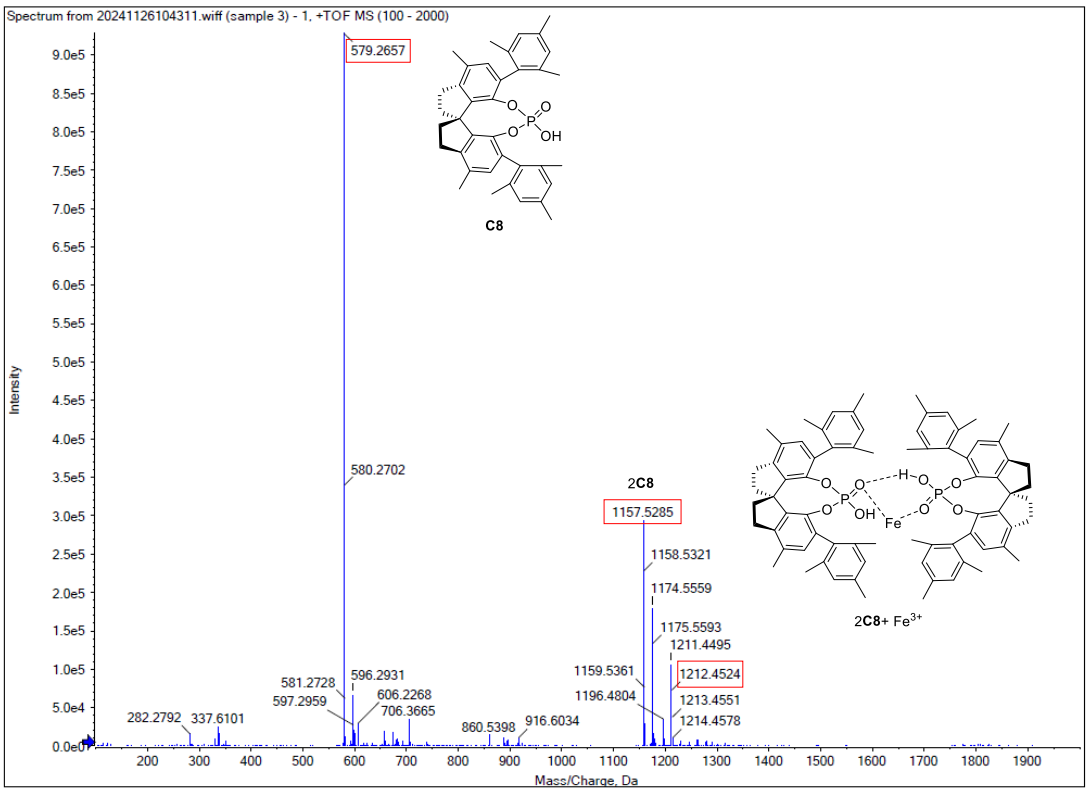


Fig. 2 ESI-MS of binary-acid **C8**/Fe(OTf)$_3$

To a flame-dried Schlenk tube was added **C8** (0.01 mmol), $Fe(OTf)_3$ (0.01 mmol), and CH_2Cl_2 (0.5 mL). After 30 min stirring at rt, **1a** (0.01 mmol) and **2a** (0.01 mmol) were added, then stirred for another 30 min, an aliquot was diluted with CH_3CN (CH_3CN:CH_2Cl_2 = 5:1) and subjected to analysis by ESI-MS.

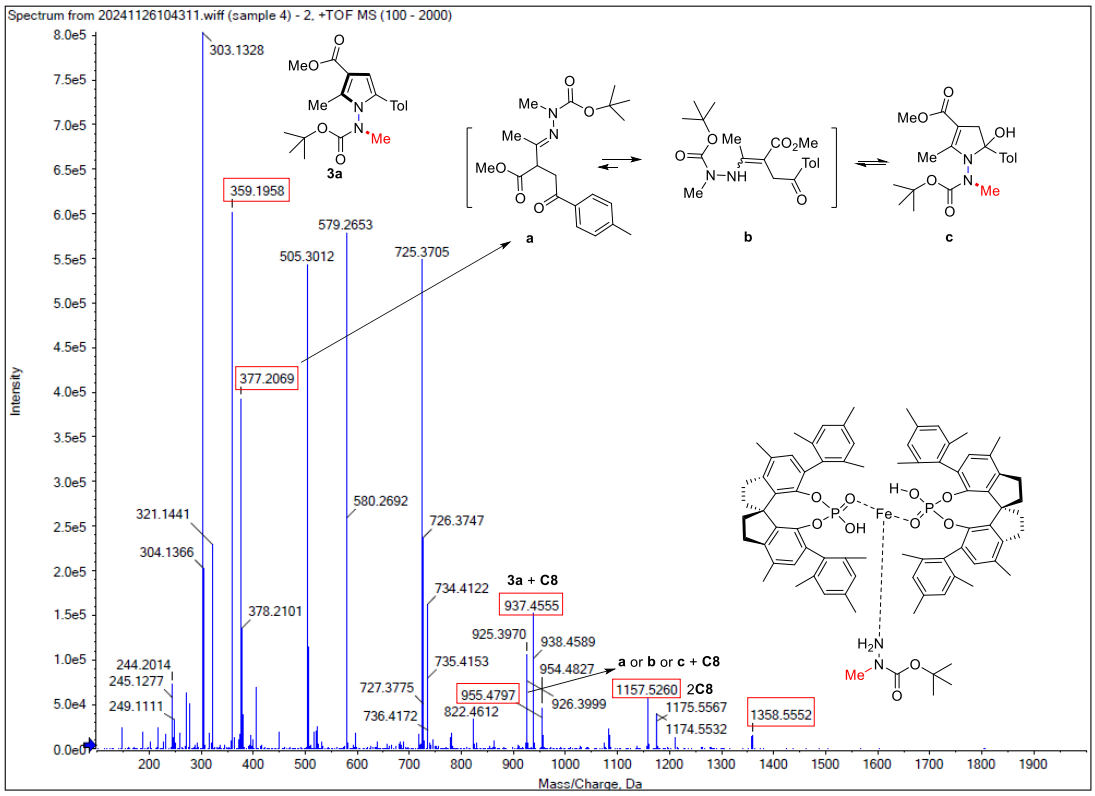
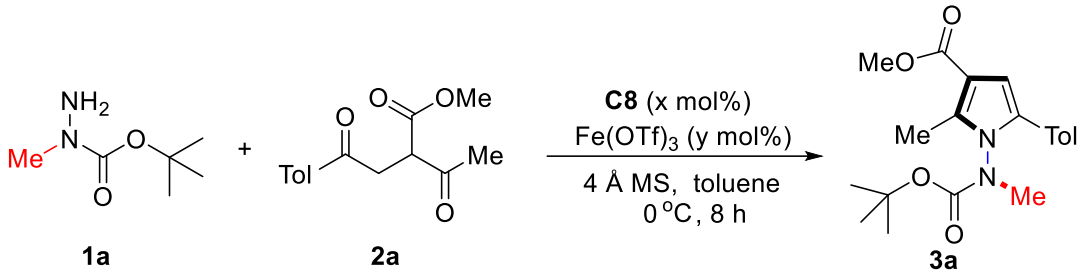


Fig. 3 ESI-MS of binary-acid **C8**/$Fe(OTf)_3$ catalyzed the Paal-Knorr reaction of **1a** and **2a**

The amount of $Fe(OTf)_3$ was investigated for the enantioselectivity of the Paal-Knorr reaction

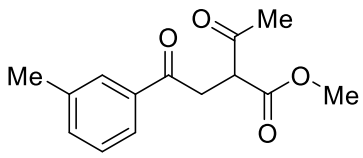


1a **2a** **3a**

entry	x	y	yield (%)	ee (%)
1	10	0	82	24
2	10	2.5	89	32
3	10	5	92	75
4	10	10	96	93
5	10	20	97	90
6	10	40	96	86
7	5	5	91	85

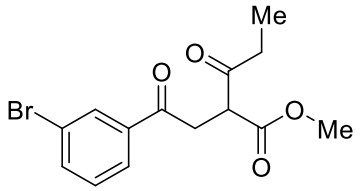
[a]Reactions were carried out with **1a** (0.075 mmol), **2a** (0.05 mmol), **C8** (x mol%), $Fe(OTf)_3$ (y mmol%), and 4Å MS (40 mg) in toluene (2 mL) at 0 °C.

(I) Analytical Data



methyl 2-acetyl-4-oxo-4-(m-tolyl)butanoate (2j)

^{1}H NMR (400 MHz, $CDCl_3$) δ 2.21-2.43 (m, 6H), 3.43 (m, 1H), 3.54-3.75 (m, 4H), 4.14 (m, 1H), 7.27 (m, 2H), 7.68 (d, J = 7.6, 2H).^{13}C NMR (100 MHz, $CDCl_3$) δ 202.4, 197.2, 169.5, 138.5, 136.0, 134.3, 128.7, 128.6, 125.4, 53.6, 52.7, 37.5, 30.3, 21.3. HRMS (ESI) calcd for $C_{14}H_{16}O_4$ m/z $[M+H]^+$: 249.1121, found: 249.1123.



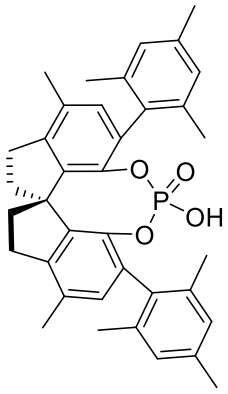
methyl 2-(2-(3-bromophenyl)-2-oxoethyl)-3-oxopentanoate (2w)

^{1}H NMR (400 MHz, $CDCl_3$) δ 1.11 (m, 3H), 2.79 (m, 2H), 3.39-3.59 (m, 1H), 3.61-3.86 (m, 4H), 4.12-4.27 (m, 1H), 7.35 (m, 1H), 7.70 (d, J = 8.0, 1H), 7.90 (d, J = 7.9, 1H), 8.09 (d, J = 2.1, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 205.0, 196.1, 169.5, 137.9, 136.5, 131.4, 130.4, 126.8, 123.2, 52.9, 52.8, 37.7, 36.5, 7.8. HRMS (ESI) calcd for $C_{14}H_{15}BrO_4$ m/z $[M+H]^+$: 327.0226 , found: 327.0222.

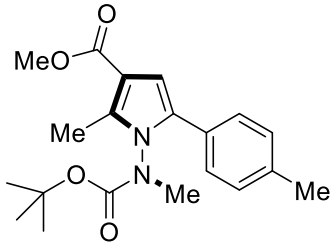
CPA catalysts

All chiral phosphoric acid catalysts are commercially available **(C1-C7)**. Catalyst **C8** had synthesized according to the known literature procedures.[4]

Chiral phosphoric acid C8

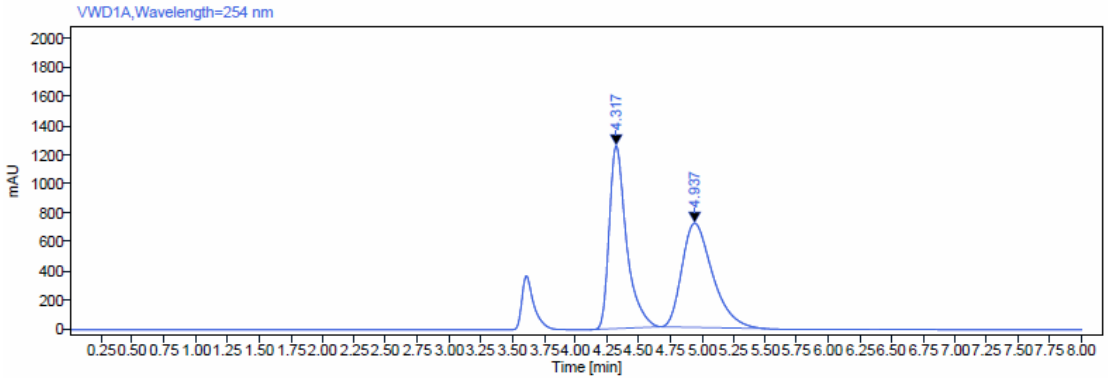


^{1}H NMR (400 MHz, $CDCl_3$) δ 1.98 (s, 6H), 2.05 (s, 8H), 2.18 (s, 6H), 2.28 (s, 8H), 2.82 (m, 2H), 2.96 (m, 2H), 6.48 (s, 1H), 6.73 (s, 4H), 6.82 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 142.9, 142.9, 141.2, 139.3, 139.3, 136.8, 136.4, 136.3, 133.6, 132.5, 132.5, 132.1, 132.1, 130.8, 128.6, 127.4, 60.4, 38.3, 28.9, 21.3, 21.0, 20.4, 18.5. ^{31}P NMR (162 MHz, $CDCl_3$) δ -8.90. HRMS (ESI) calcd for $C_{37}H_{39}O_4P$ *m/z* $[M+H]^+$: 579.2658, found: 579.2654.

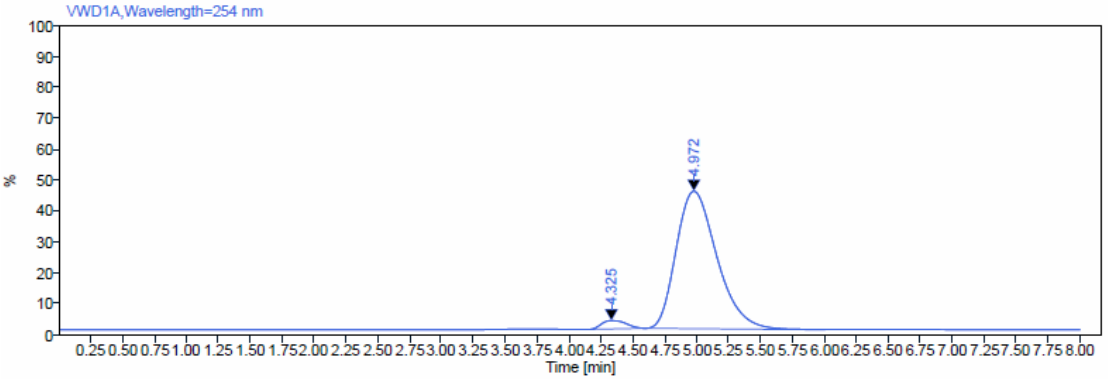


(*R*)-methyl 1-((tert-butoxycarbonyl)(methyl)amino)-2-methyl-5-(p-tolyl)-1H-pyrrole-3-carboxylate (3a)

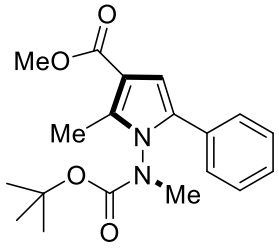
Colorless oil. $[\alpha]_D^{25}$ = – 67.9 (*c* 0.44, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.35 (s, 6H), 1.54 (s, 3H), 2.36 (s, 3H), 2.45 (s, 3H), 2.97 (s, 1H), 3.09 (s, 2H), 3.81(s, 1H), 3.83 (s, 2H), 6.57-6.59 (m, 1H), 7.17-7.19 (m, 2H), 7.24-7.28 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.8, 165.7, 154.4, 154.2, 137.6, 137.5, 137.1, 136.9, 132.1, 129.5, 129.3, 128.4, 128.3, 128.0, 127.4, 110.6, 110.4, 107.6, 107.2, 82.5, 82.3, 51.1, 51.0, 38.7, 37.5, 28.3, 28.2, 21.4, 21.3, 10.6, 10.5. HRMS (ESI) calcd for $C_{20}H_{26}N_2O_4$ *m/z* $[M+H]^+$: 359.1965, found: 359.1956. Enantiomeric excess was found to be 93% by chiral HPLC (ChiralPak OD column, hexane/*i*-PrOH = 90:10, 1.0 ml/min, t_{major} = 4.9 min, t_{minor} = 4.3 min).



RT [min]	Type	Width [min]	Area	Height	Area%
4.317	MM m	0.56	11938.59	1257.02	49.71
4.937	MM m	0.83	12077.67	716.53	50.29

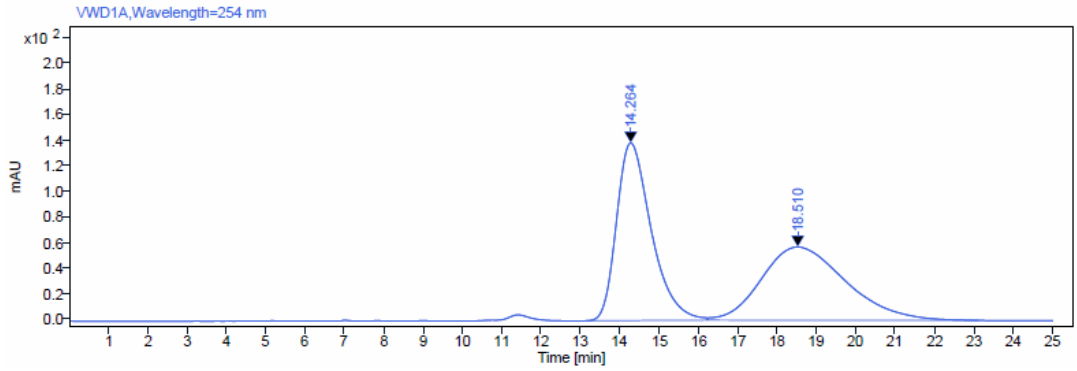


RT [min]	Type	Width [min]	Area	Height	Area%
4.325	MM m	0.43	442.46	33.03	3.50
4.972	MM m	1.40	12214.41	549.68	96.50

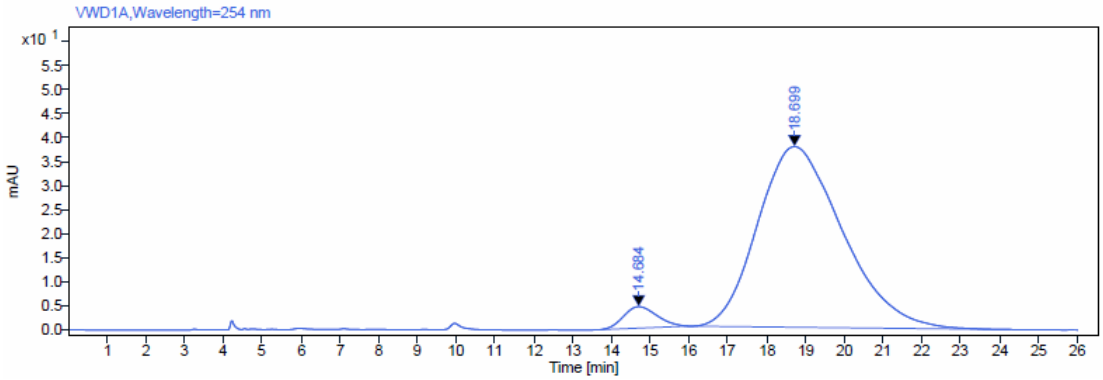


(*R*)-methyl 1-((tert-butoxycarbonyl)(methyl)amino)-2-methyl-5-phenyl-1H-pyrrole-3-carboxylate(3b)

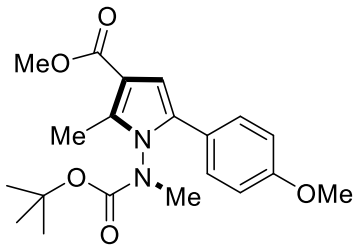
Yellow oil. $[\alpha]_D^{25}$ = – 55.8 (*c* 0.25, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 1.34 (s, 6H), 1.53 (s, 3H), 2.46 (s, 3H), 2.98 (s, 1H), 3.12 (s, 2H), 3.81 (s, 1H), 3.84 (s, 2H), 6.61-6.63 (m, 1H), 7.30-7.40 (m, 5H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.7, 165.6, 154.4, 154.2, 137.3, 137.2, 132.0, 131.3, 131.2, 128.8, 128.6, 128.1, 127.2, 127.5, 110.8, 110.5, 108.0, 107.6, 82.5, 82.4, 51.2, 51.1, 38.7, 37.6, 28.3, 28.1, 10.6, 10.5. HRMS (ESI) calcd for $C_{19}H_{24}N_2O_4$ *m/z* $[M+H]^+$: 345.1809, found: 345.1807. Enantiomeric excess was found to be 91% by chiral HPLC (ChiralPak OD column, hexane/*i*-PrOH = 99:1, 1.0 ml/min, t_{major} = 18.7 min, t_{minor} = 14.3 min).



RT [min]	Type	Width [min]	Area	Height	Area%
14.264	MM m	3.07	8503.22	138.88	49.98
18.510	MM m	6.89	8511.19	57.34	50.02

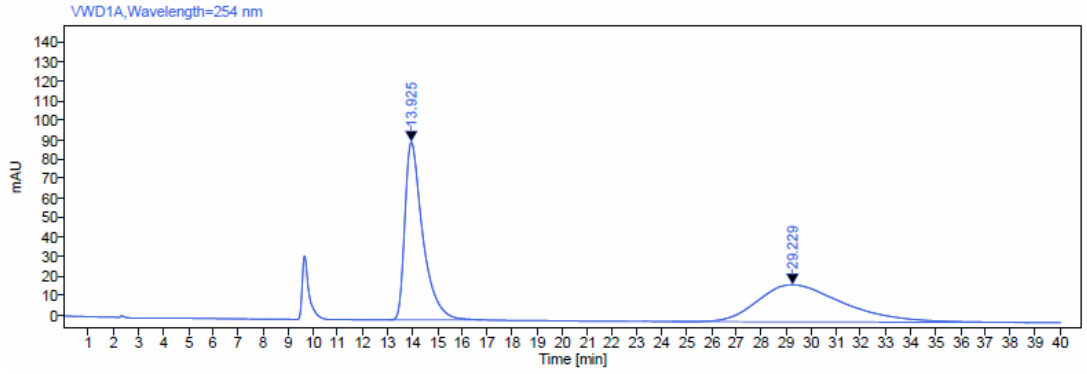


RT [min]	Type	Width [min]	Area	Height	Area%
14.684	MM m	2.28	267.72	4.49	4.45
18.699	MM m	8.29	5748.87	37.80	95.55

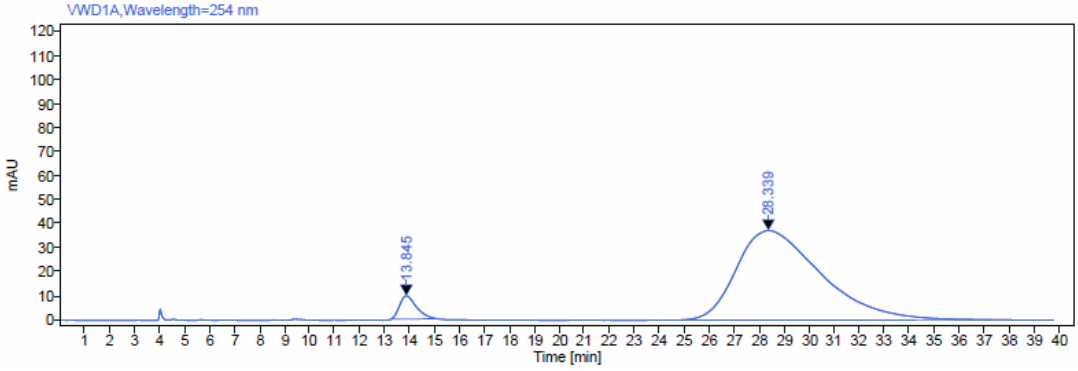


(*R*)-methyl1-((tert-butoxycarbonyl)(methyl)amino)-5-(4-methoxyphenyl)-2-methyl-1H-pyrrole-3-carboxylate (3c)

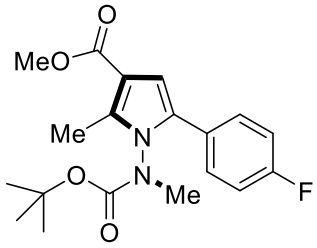
Yellow oil. $[\alpha]_D^{25}$ = – 65.7 (*c* 0.51, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 1.36 (s, 6H), 1.52 (s, 3H), 2.44 (s, 3H), 2.96 (s, 1H), 3.09 (m, 3H), 3.80 (s, 1H), 3.83 (s, 5H), 6.53-6.54 (m, 1H), 6.88-6.91 (m, 2H), 7.26-7.31 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.8, 165.7, 159.4, 159.3, 154.4, 154.3, 136.8, 136.6, 131.9, 129.7, 129.0, 123.8, 123.7, 114.2, 114.0, 110.5, 110.3, 107.3, 106.8, 82.5, 82.3, 55.5, 55.4, 51.1, 51.0, 38.7, 37.5, 28.6, 28.3, 28.2, 10.6, 10.5. HRMS (ESI) calcd for $C_{20}H_{26}N_2O_5$ *m/z* $[M+H]^+$: 375.1914, found: 375.1905. Enantiomeric excess was found to be 90% by chiral HPLC (ChiralPak OD column, hexane/*i*-PrOH = 99:1, 1.0 ml/min, t_{major} = 28.3 min, t_{minor} = 13.8 min).



RT [min]	Type	Width [min]	Area	Height	Area%
13.925	BM m	3.71	4560.17	91.44	50.01
29.229	MM m	14.34	4557.44	19.05	49.99



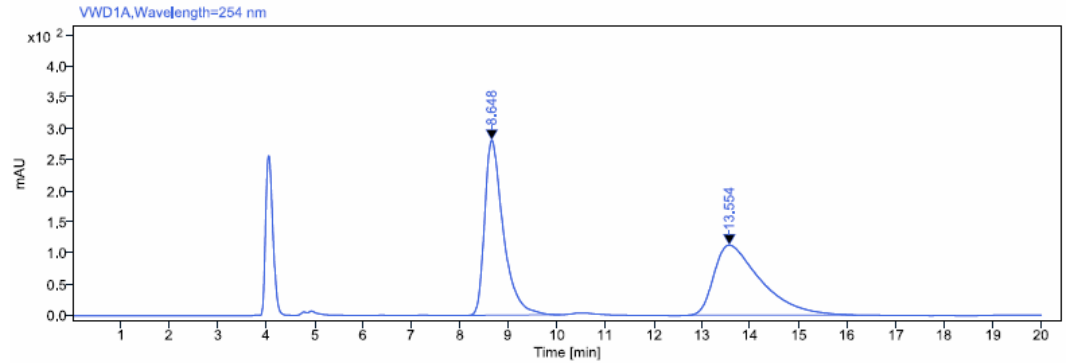
RT [min]	Type	Width [min]	Area	Height	Area%
13.845	MM m	1.85	452.61	9.65	4.91
28.339	BB	13.06	8772.80	37.32	95.09



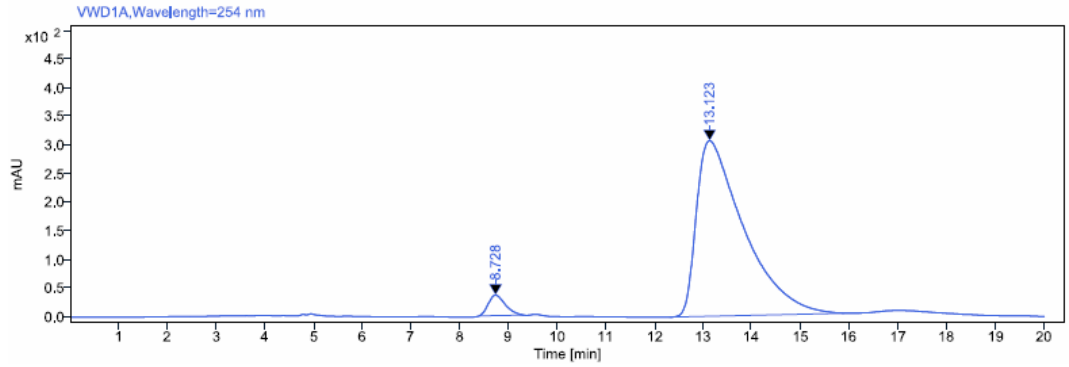
(*R*)-methyl 1-((tert-butoxycarbonyl)(methyl)amino)-5-(4-fluorophenyl)-2-methyl-1H-pyrrole-3-carboxylate (3d)

Pale yellow oil. $[\alpha]_D^{25}$ = – 69.2 (*c* 0.09, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 1.35 (s, 6H), 1.53 (s, 3H), 2.45 (s, 3H), 2.98 (s, 1H), 3.10 (m, 2H), 3.81 (s, 1H), 3.83 (s, 2H), 6.57-6.58 (m, 1H), 7.03-7.09 (m, 2H), 7.30-7.37 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.6, 165.6, 163.8, 163.7, 161.3, 161.2, 154.4, 154.1, 137.2, 137.0, 131.1 (2), 130.1, 130.0, 129.4 (2), 127.4 (3), 127.3, 115.9, 115.7, 115.5, 110.8, 110.5, 108.0, 107.6, 82.7, 82.5, 51.2, 51.1, 38.8, 37.6, 28.3, 28.2, 10.6, 10.5. HRMS (ESI) calcd for $C_{19}H_{23}FN_2O_4$ *m/z* $[M+H]^+$: 363.1715, found: 363.1710. Enantiomeric excess was found to be 92% by chiral HPLC (ChiralPak OD column, hexane/*i*-PrOH = 99:1, 1.0 ml/min, t_{major} = 13.1

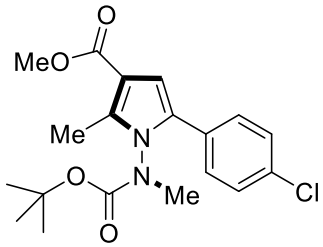
min, t_{minor} = 8.7 min).



RT [min]	Type	Width [min]	Area	Height	Area%
8,648	BB	1,98	7547,00	281,32	50,06
13,554	MM m	3,44	7528,78	112,54	49,94



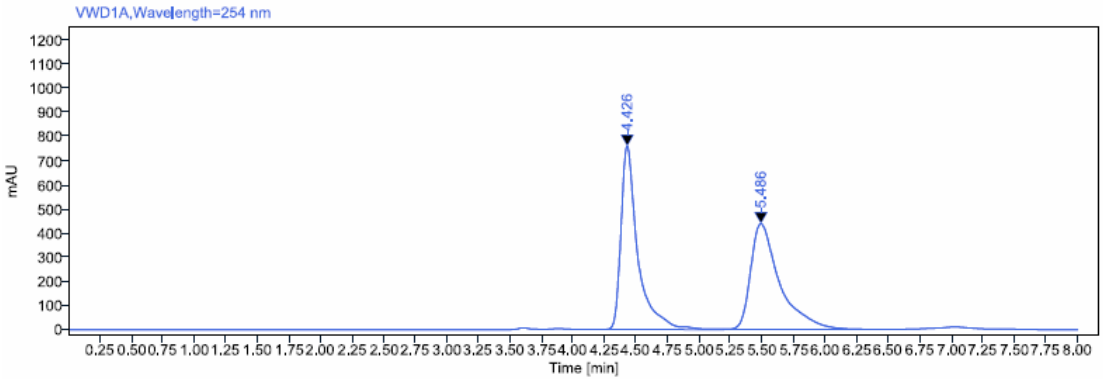
RT [min]	Type	Width [min]	Area	Height	Area%
8,728	MM m	0,92	863,82	35,70	4,00
13,123	BM m	3,97	20746,60	306,70	96,00



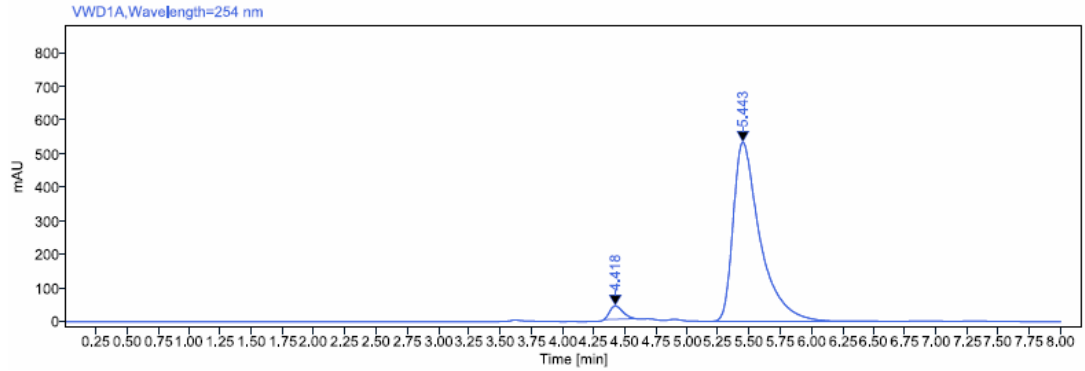
(*R*)-methyl 1-((tert-butoxycarbonyl)(methyl)amino)-5-(4-chlorophenyl)-2-methyl-1H-pyrrole-3-carboxylate (3e)

Colorless oil. $[\alpha]_D^{25}$ = – 56.8 (*c* 0.17, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 1.35 (s, 6H), 1.53 (s, 3H), 2.45 (s, 3H), 2.98 (s, 1H), 3.10 (m, 2H), 3.81 (s, 1H), 3.83 (s, 2H), 6.62 (d, *J* = 8.4, 1H), 7.26-7.36 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.5 (2), 154.4, 154.1, 137.6, 137.4, 133.7 (2), 130.9, 130.8, 129.7, 129.6, 129.3, 129.1, 128.9, 128.6, 111.0, 110.7, 108.4, 108.0, 82.8, 82.6, 51.2, 51.1, 38.8, 37.6, 28.3, 28.2, 10.6, 10.5. HRMS (ESI) calcd for $C_{19}H_{23}ClN_2O_4$ *m/z* $[M+H]^+$: 379.1419, found: 379.1417. Enantiomeric excess was found to be 93% by chiral HPLC (ChiralPak OD column,

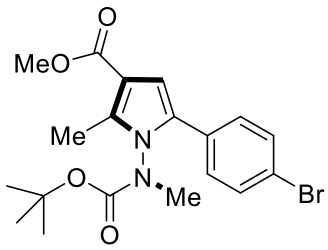
hexane/*i*-PrOH = 90:10, 1.0 ml/min, t_{major} = 5.4 min, t_{minor} = 4.4 min).



RT [min]	Type	Width [min]	Area	Height	Area%
4,426	BV	1,05	7082,92	762,39	49,97
5,486	VV	1,32	7090,49	440,81	50,03



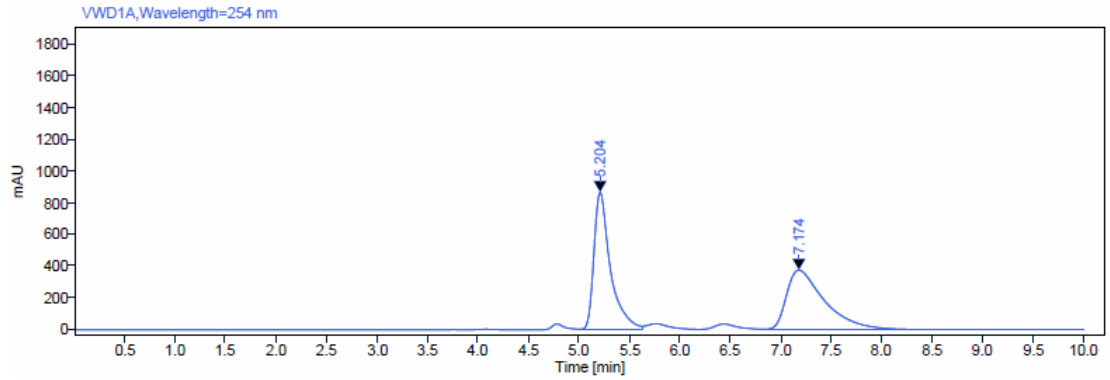
RT [min]	Type	Width [min]	Area	Height	Area%
4,418	MM m	0,25	286,76	39,85	3,44
5,443	BV	1,46	8050,79	533,72	96,56



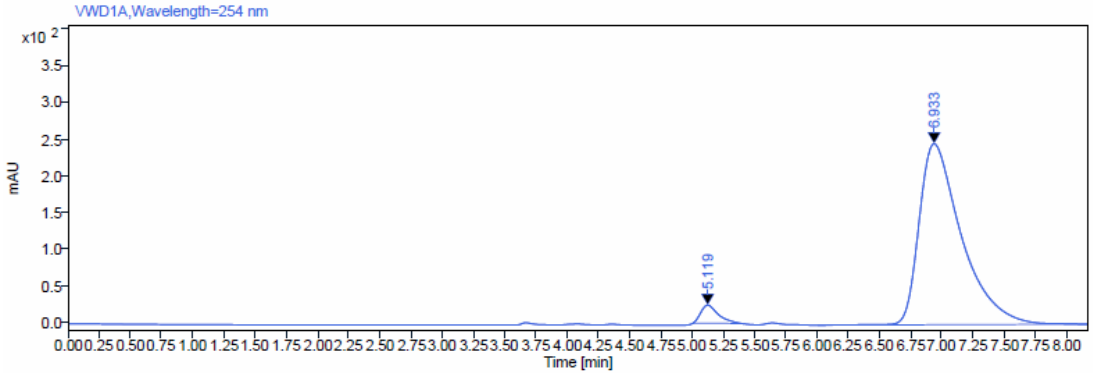
(*R*)-methyl 5-(4-bromophenyl)-1-((tert-butoxycarbonyl)(methyl)amino)-2-methyl-1H-pyrrole-3-carboxylate (3f)

Yellow oil. $[\alpha]_D^{25}$ = – 80.7 (*c* 0.73, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 1.35 (s, 6H), 1.54 (s, 3H), 2.45 (s, 3H), 2.99 (s, 1H), 3.11 (m, 2H), 3.81 (s, 1H), 3.83 (s, 2H), 6.63 (d, *J* = 8.4, 1H), 7.24 (t, *J* = 8.4, 2H), 7.50 (t, *J* = 7.2, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.5 (2), 154.4, 154.1, 137.6, 137.5, 132.0, 131.8, 130.8 (2), 130.2, 130.1, 129.6, 128.8, 121.9, 121.8, 111.0, 110.7, 108.4, 108.0, 82.8, 82.6, 51.2, 51.1, 38.8, 37.6, 28.3, 28.2, 10.6, 10.5. HRMS (ESI) calcd for $C_{19}H_{23}BrN_2O_4$ *m/z* $[M+H]^+$: 423.0914, found:

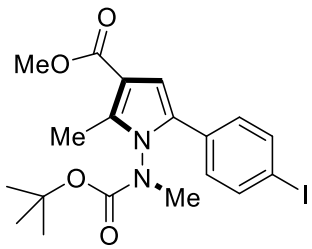
423.0914. Enantiomeric excess was found to be 92% by chiral HPLC (ChiralPak OD column, hexane/*i*-PrOH = 95:5, 1.0 ml/min, t_{major} = 6.9 min, t_{minor} = 5.1 min).



RT [min]	Type	Width [min]	Area	Height	Area%
5.204	VV	0.62	9836.14	867.35	50.10
7.174	VB	1.70	9796.54	374.86	49.90



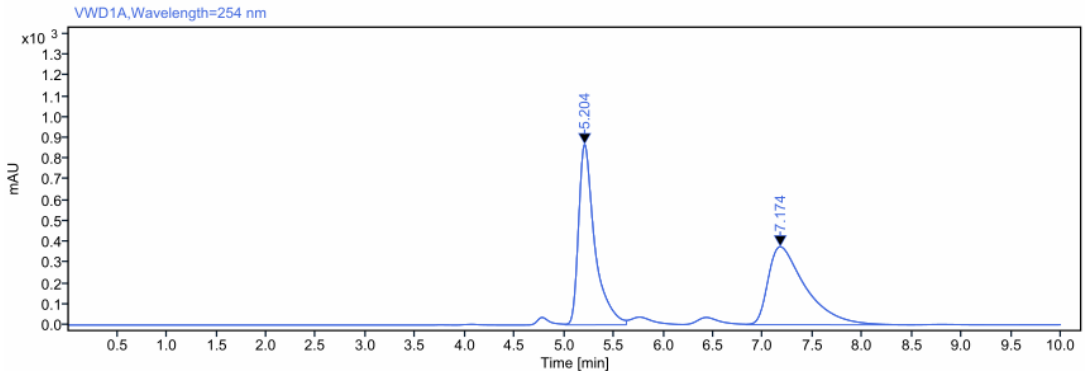
RT [min]	Type	Width [min]	Area	Height	Area%
5.119	MM m	0.39	240.50	24.65	3.98
6.933	BM m	2.27	5805.49	246.15	96.02



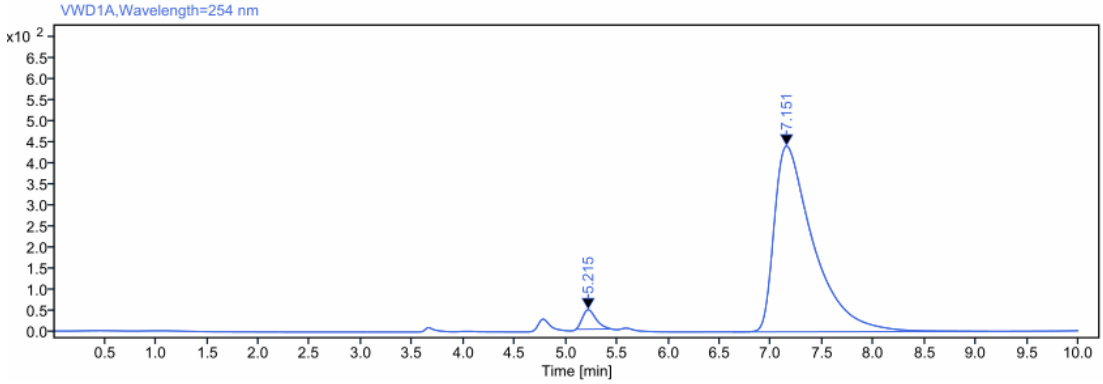
(*R*)-methyl 1-((tert-butoxycarbonyl)(methyl)amino)-5-(4-iodophenyl)-2-methyl-1H-pyrrole-3-carboxylate (3g)

Yellow oil. $[\alpha]_D^{25}$ = – 81.2 (*c* 0.79, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 1.35 (s, 6H), 1.54 (s, 3H), 2.44 (s, 3H), 2.90-3.19 (m, 3H), 3.78-3.91 (m, 3H), 6.63 (d, *J*=9.1, 1H), 7.01-7.17 (m, 2H), 7.70 (d, *J* = 7.5, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.5, 154.0, 138.0, 137.8, 137.6, 130.8, 130.6, 129.7, 128.9, 110.8, 108.4, 108.0, 93.2, 82.8, 82.6, 51.2, 51.1, 38.8, 37.6, 28.3, 28.2, 10.6. HRMS (ESI) calcd for $C_{19}H_{23}IN_2O_4$ *m/z* $[M+H]^+$:

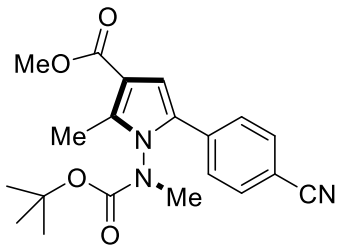
471.0775, found: 471.0766. Enantiomeric excess was found to be 93% by chiral HPLC (ChiralPak OD column, hexane/*i*-PrOH = 95:5, 1.0 ml/min, t_{major} = 7.2 min, t_{minor} = 5.2 min).



RT [min]	Type	Width [min]	Area	Height	Area%
5.204	VV	0.62	9836.14	867.35	50.10
7.174	VB	1.70	9796.54	374.86	49.90



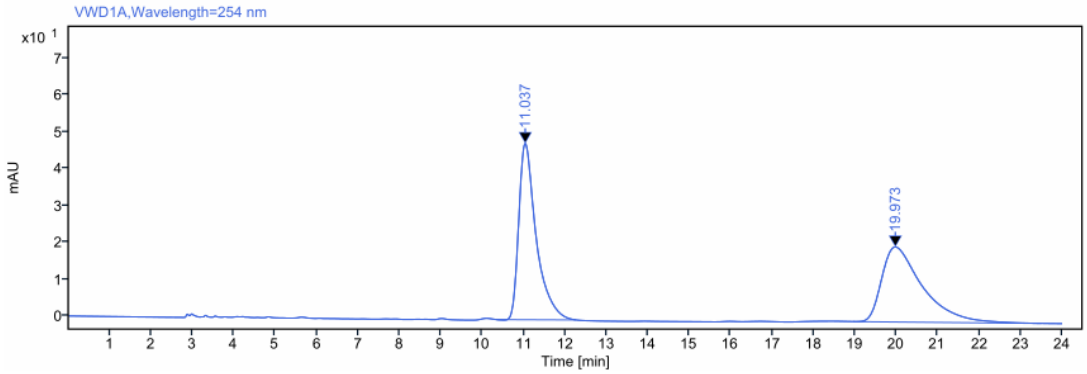
RT [min]	Type	Width [min]	Area	Height	Area%
5.215	MM m	0.34	421.91	46.15	3.47
7.151	BB	2.49	11734.37	441.76	96.53



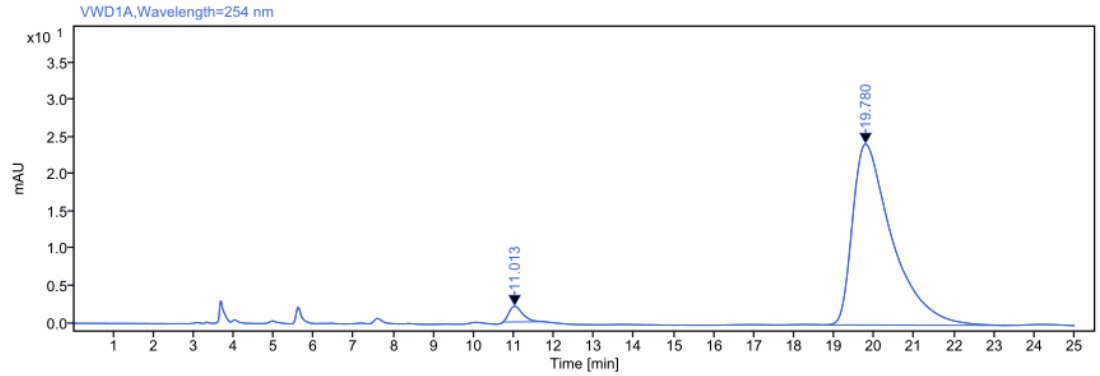
(*R*)-methyl 1-((tert-butoxycarbonyl)(methyl)amino)-5-(4-cyanophenyl)-2-methyl-1H-pyrrole-3-carboxylate (3h)

Yellow oil. $[\alpha]_D^{25}$ = – 117.1 (*c* 0.67, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.33 (s, 6H), 1.54 (s, 3H), 2.46 (d, *J* = 1.9, 3H), 3.10 (d, *J* = 50.5, 3H), 3.83 (d, *J* = 9.4, 3H), 6.77 (d, *J* = 15.6, 1H), 7.48 (t, *J* = 6.8, 2H), 7.65 (t, *J* = 7.0, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.2, 153.9, 138.8, 135.4, 132.7, 132.6, 129.8, 127.7, 127.0, 118.8, 111.4, 110.8,

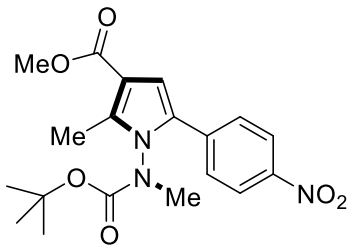
110.0, 109.8, 83.2, 82.9, 51.3, 51.3, 38.9, 37.7, 28.3, 28.1, 10.6, 10.6.. HRMS (ESI) calcd for $C_{20}H_{23}N_3O_4$ *m/z* $[M+Na]^+$: 392.1581, found: 392.1590. Enantiomeric excess was found to be 94% by chiral HPLC (ChiralPak OD column, hexane/*i*-PrOH = 95:5, 1.0 ml/min, t_{major} = 19.8 min, t_{minor} = 11.0 min).



RT [min]	Type	Width [min]	Area	Height	Area%
11.037	MM m	1.91	1399.22	47.88	50.19
19.973	MM m	4.53	1388.62	20.38	49.81



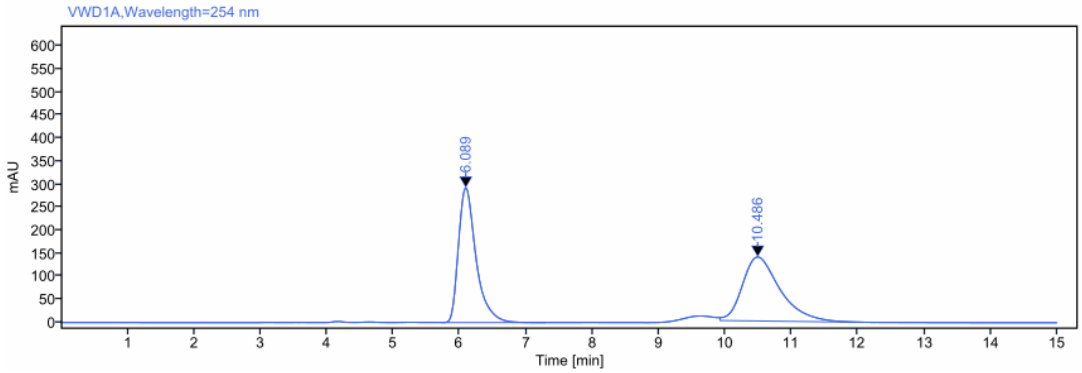
RT [min]	Type	Width [min]	Area	Height	Area%
11.013	MM m	1.03	49.92	2.10	2.91
19.780	BB	4.54	1665.90	24.31	97.09



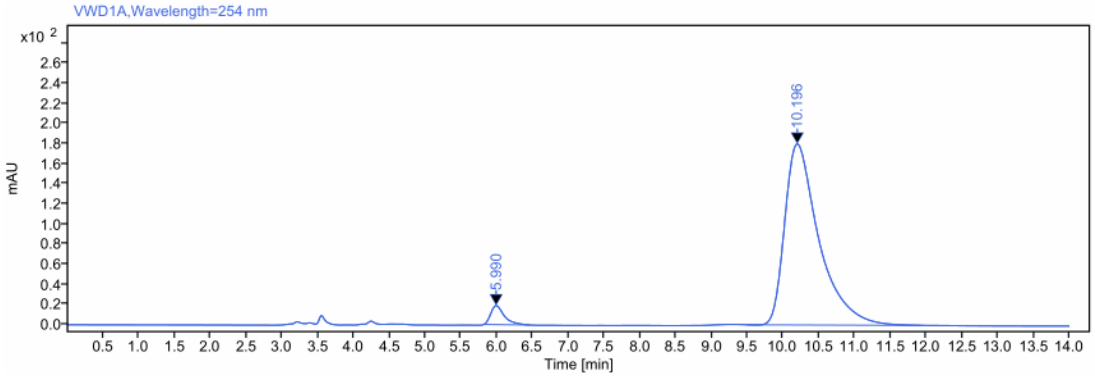
(*R*)-methyl 1-((tert-butoxycarbonyl)(methyl)amino)-2-methyl-5-(4-nitrophenyl)-1H-pyrrole-3-carboxylate (3i)

Brown solid. $[\alpha]_D^{25}$ = – 43.5 (*c* 0. 7, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.34 (s, 6H), 1.56 (s, 3H), 2.47 (s, 3H), 3.12 (d, *J* = 48.2, 3H), 3.84 (d, *J* = 9.2, 3H), 6.84 (d, *J* = 14.4, 1H), 7.53 (d, *J* = 7.8, 2H), 8.23 (t, *J* = 7.7, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.1, 153.8, 146.6, 139.2, 137.3, 129.5, 127.6, 126.9, 124.4, 124.2, 111.6, 110.6, 110.4, 83.3,

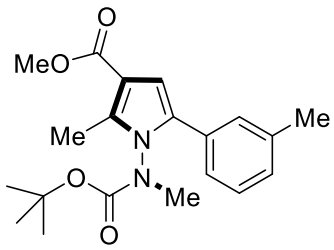
83.0, 51.4, 51.3, 38.9, 37.7, 28.3, 28.1, 10.6, 10.6. HRMS (ESI) calcd for $C_{19}H_{24}N_3O_6$ *m/z* $[M+H]^+$: 390.1660, found: 390.1664. Enantiomeric excess was found to be 92% by chiral HPLC (ChiralPak OD column, hexane/*i*-PrOH = 80:20, 1.0 ml/min, t_{major} = 10.2 min, t_{minor} = 6.0 min).



RT [min]	Type	Width [min]	Area	Height	Area%
6.089	BM m	1.57	5393.36	292.19	49.60
10.486	MM m	2.36	5479.61	138.78	50.40



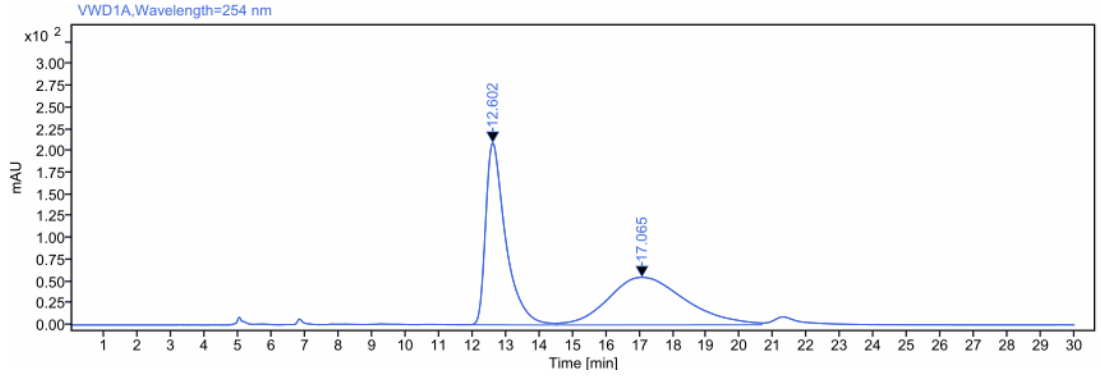
RT [min]	Type	Width [min]	Area	Height	Area%
5.990	MM m	0.64	246.56	18.81	3.96
10.196	MM m	2.44	5976.39	180.18	96.04



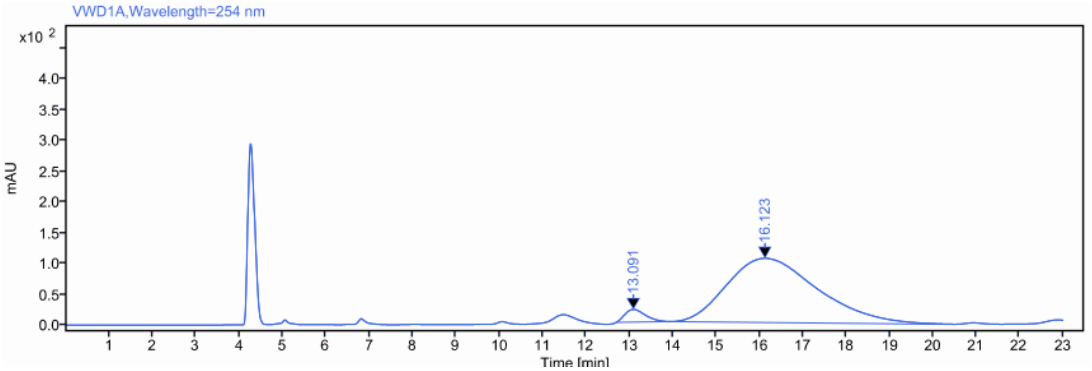
(*R*)-methyl 1-((tert-butoxycarbonyl)(methyl)amino)-2-methyl-5-(m-tolyl)-1H-pyrrole-3-carboxylate (3j)

Yellow oil. $[\alpha]_D^{25}$ = -54.2 (*c* 0.25, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 1.37 (s, 6H), 1.54 (s, 3H), 2.40 (d, *J* = 39.1, 6H), 3.03 (d, *J* = 44.8, 3H), 3.82 (d, *J* = 8.9, 3H), 6.60 (d, *J* = 4.8, 1H), 7.08-7.27 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.7, 154.2, 138.3, 137.1, 132.1, 131.1, 128.8, 128.7, 128.5, 128.3, 125.1, 124.6, 110.4, 107.9, 107.5, 82.3,

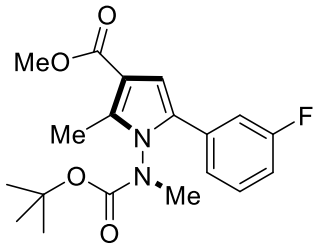
51.1, 51.1, 38.7, 37.5, 28.3, 28.2, 21.6, 10.5, 10.5. HRMS (ESI) calcd for $C_{20}H_{26}N_2O_4$ *m/z* $[M+H]^+$: 359.1965, found: 359.1963. Enantiomeric excess was found to be 91% by chiral HPLC (ChiralPak OD column, hexane/*i*-PrOH = 99:1, 1.0 ml/min, t_{major} = 16.1 min, t_{minor} = 13.1 min).



RT [min]	Type	Width [min]	Area	Height	Area%
12.602	MM m	2.99	8699.99	209.03	49.84
17.065	MM m	6.14	8755.66	54.65	50.16



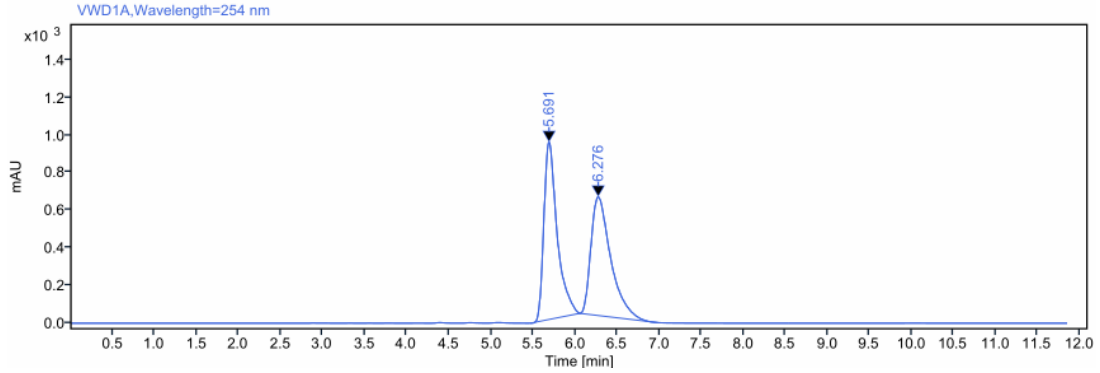
RT [min]	Type	Width [min]	Area	Height	Area%
13.091	MB m	1.25	679.15	20.61	4.29
16.123	MB m	6.51	15168.50	104.29	95.71



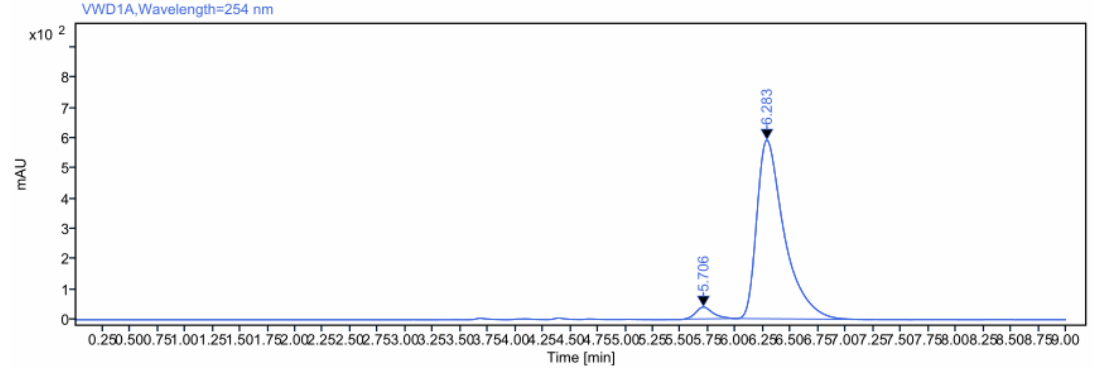
(*R*)-methyl 1-((tert-butoxycarbonyl)(methyl)amino)-5-(3-fluorophenyl)-2-methyl-1H-pyrrole-3-carboxylate (3k)

Colorless oil. $[\alpha]_D^{25}$ = – 76.6 (*c* 0.62, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 1.36 (s, 6H), 1.54 (s, 3H), 2.45 (s, 3H), 3.07 (d, *J* = 47.7, 3H), 3.72-4.04 (m, 3H), 6.66 (d, *J* = 2.2, 1H), 6.93-7.22 (m, 3H), 7.34 (q, *J* = 7.2, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.5, 161.8, 154.0, 137.6, 133.2, 130.7, 130.4, 130.3, 130.2, 130.1, 123.7, 123.6, 122.9, 122.9, 114.7, 114.7, 114.6, 114.5, 114.5, 114.4, 114.2, 111.0, 110.8, 108.7, 108.3, 82.9, 82.6,

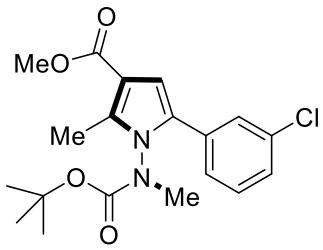
51.2, 51.2, 38.7, 37.6, 28.3, 28.1, 10.5, 10.5. HRMS (ESI) calcd for $C_{19}H_{23}FN_2O_4$ *m/z* $[M+H]^+$: 363.1715, found: 359.1724. Enantiomeric excess was found to be 92% by chiral HPLC (ChiralPak OD column, hexane/*i*-PrOH = 95:5, 1.0 ml/min, t_{major} = 6.2 min, t_{minor} = 5.7 min).



RT [min]	Type	Width [min]	Area	Height	Area%
5.691	MM m	0.59	10351.73	941.10	50.03
6.276	MM m	0.93	10340.43	629.87	49.97



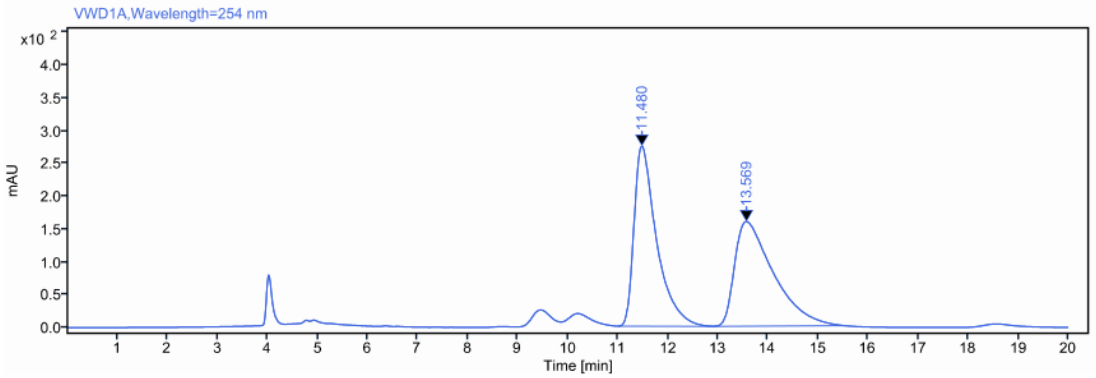
RT [min]	Type	Width [min]	Area	Height	Area%
5.706	MM m	0.47	425.50	39.09	3.98
6.283	MM m	1.24	10254.35	589.90	96.02



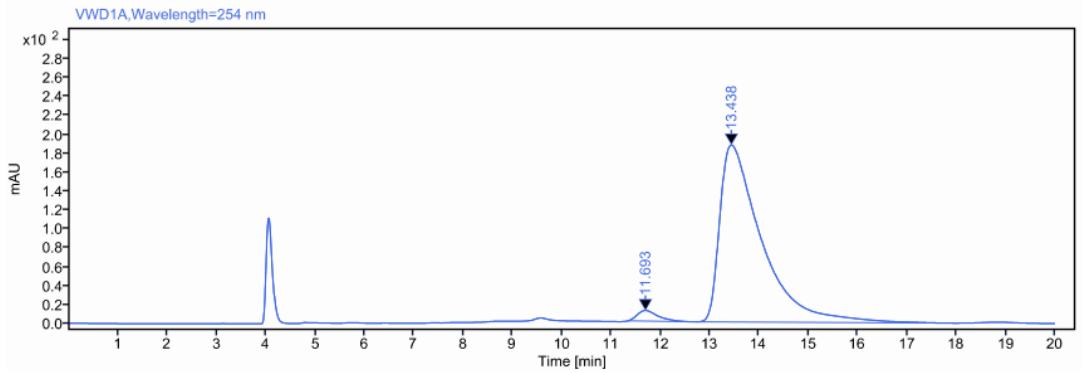
(*R*)-methyl 1-((tert-butoxycarbonyl)(methyl)amino)-5-(3-chlorophenyl)-2-methyl-1H-pyrrole-3-carboxylate (3l)

Colorless oil. $[\alpha]_D^{25}$ = – 71.9 (*c* 0.23, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 1.35 (s, 6H), 1.53 (s, 3H), 2.43 (s, 3H), 3.03 (d, *J* = 40.2, 3H), 3.80 (d, *J* = 9.0, 3H), 6.62 (d, *J* = 2.0, 1H), 7.18-7.30 (m, 3H), 7.35 (d, *J* = 3.0, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.5, 154.0, 137.6, 134.7, 132.9, 130.6, 130.1, 129.9, 127.7, 127.6, 126.1, 125.4, 110.8, 108.8, 108.4, 82.9, 82.7, 51.2, 51.1, 38.8, 37.6, 28.3, 28.2, 10.5, 10.5. HRMS (ESI) calcd for $C_{19}H_{23}ClN_2O_4$ *m/z* $[M+H]^+$: 379.1419, found: 379.1414. Enantiomeric excess was

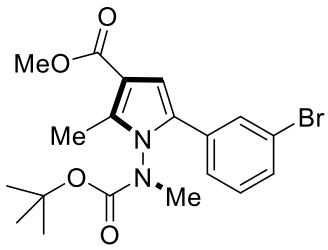
found to be 94% by chiral HPLC (ChiralPak OD column, hexane/*i*-PrOH = 99:1, 1.0 ml/min, t_{major} = 13.5 min, t_{minor} = 11.5 min).



11.480	MM m	1.89	8590.62	274.38	49.99
13.569	MM m	2.63	8595.10	159.29	50.01



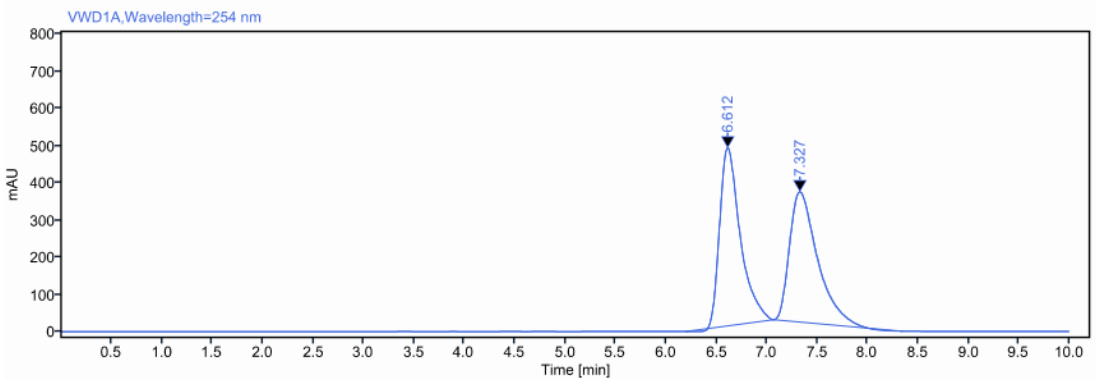
RT [min]	Type	Width [min]	Area	Height	Area%
11.693	MM m	1.37	330.79	11.27	2.91
13.438	BB	5.19	11050.30	187.45	97.09



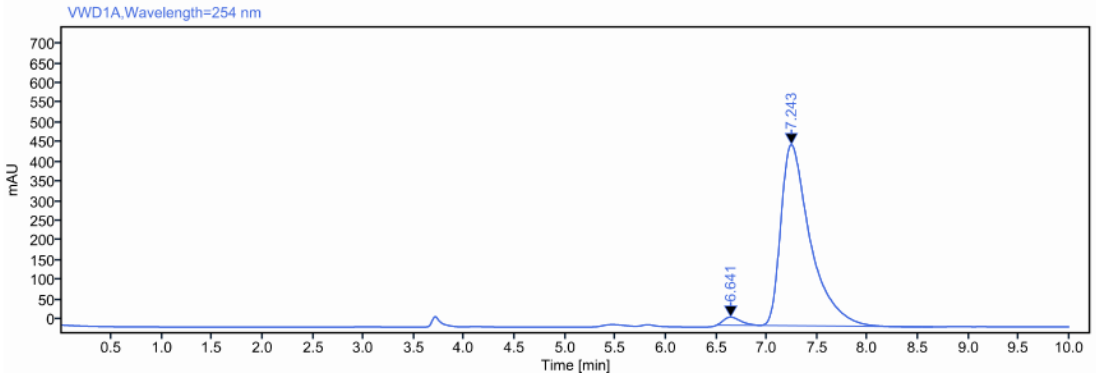
(*R*)-methyl 5-(3-bromophenyl)-1-((tert-butoxycarbonyl)(methyl)amino)-2-methyl-1H-pyrrole-3-carboxylate (3m)

Yellow oil. $[\alpha]_D^{25}$ = – 58.9 (*c* 0.92, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 1.38 (s, 6H), 2.45 (s, 3H), 3.05 (d, *J* = 37.9, 3H), 3.82 (d, *J* = 8.8, 3H), 6.64 (s, 1H), 7.22-7.33 (m, 2H), 7.44 (d, *J* = 7.8, 1H), 7.53 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.5, 154.0, 137.6, 133.1, 130.6, 130.6, 130.5, 130.4, 130.3, 130.2, 126.6, 125.8, 122.8, 110.8, 108.8, 108.4, 82.9, 82.7, 51.2, 51.1, 38.8, 37.6, 28.3, 28.2, 10.5, 10.5. HRMS (ESI) calcd for $C_{19}H_{23}BrN_2O_4$ *m/z* $[M+H]^+$: 423.0914, found: 423.0921. Enantiomeric excess was

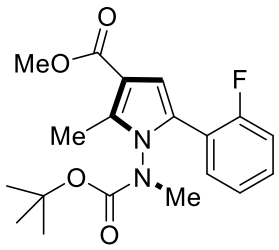
found to be 95% by chiral HPLC (ChiralPak OD column, hexane/*i*-PrOH = 98:2, 1.0 ml/min, t_{major} = 7.3 min, t_{minor} = 6.6 min).



RT [min]	Type	Width [min]	Area	Height	Area%
6.612	BM m	0.87	6818.73	478.49	50.19
7.327	MM m	1.28	6765.85	350.08	49.81



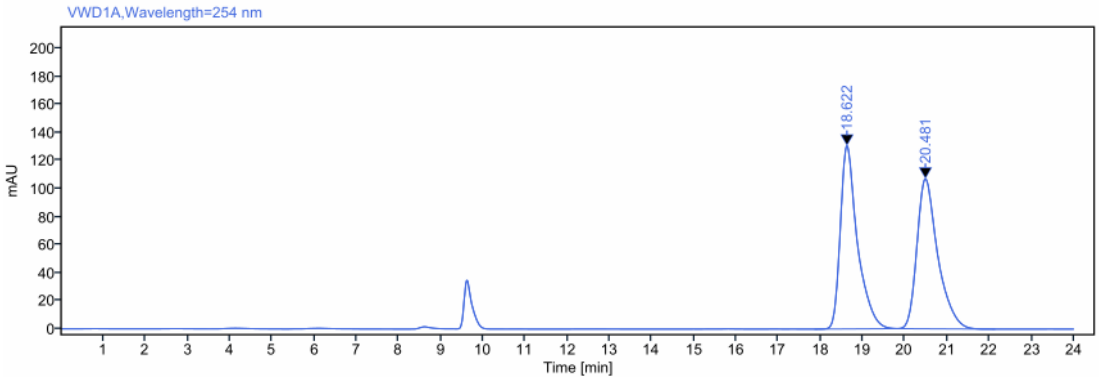
RT [min]	Type	Width [min]	Area	Height	Area%
6.641	MM m	0.41	235.55	20.41	2.46
7.243	MB m	1.73	9339.57	459.28	97.54



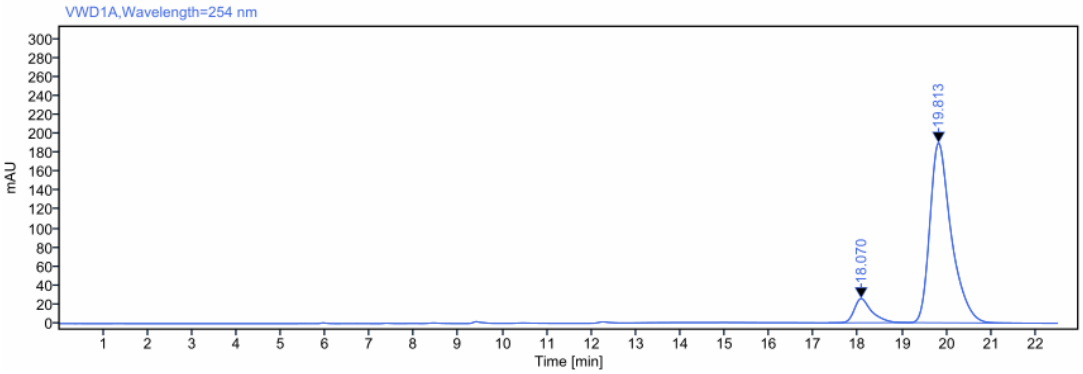
(*R*)-methyl 1-((tert-butoxycarbonyl)(methyl)amino)-5-(2-fluorophenyl)-2-methyl-1H-pyrrole-3-carboxylate (3n)

Colorless oil. $[\alpha]_D^{25}$ = – 34.5 (*c* 0.35, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 1.39 (d, *J* = 56.7, 9H), 2.46 (s, 3H), 3.09 (d, *J* = 43.0, 3H), 3.82 (d, *J* = 9.4, 3H), 6.65 (d, *J* = 13.1, 1H), 7.13 (q, *J* = 8.7, 9.4, 2H), 7.25 (d, *J* = 7.5, 1H), 7.29-7.33 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.6, 161.6, 159.1, 154.1, 137.3, 131.8, 131.5, 131.5, 130.2, 130.1, 129.9, 125.7, 124.2, 124.1, 124.1, 119.2, 116.2, 116.0, 115.7, 110.6, 110.3, 109.8, 109.8, 82.5, 82.2, 51.1, 51.1, 38.8, 37.7, 37.7, 28.2, 28.1, 10.7, 10.6.. HRMS (ESI) calcd for

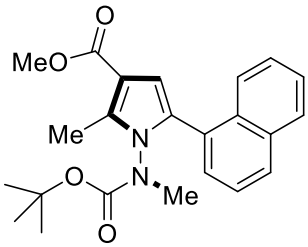
$C_{19}H_{23}FN_2O_4$ *m/z* $[M+H]^+$: 363.1715, found: 363.1707. Enantiomeric excess was found to be 92% by chiral HPLC (ChiralPak OD column, hexane/*i*-PrOH = 99:1, 1.0 ml/min, t_{major} = 19.8 min, t_{minor} = 18.6 min).



RT [min]	Type	Width [min]	Area	Height	Area%
18.622	BB	1.96	3674.34	130.71	50.03
20.481	BB	2.32	3670.33	107.05	49.97



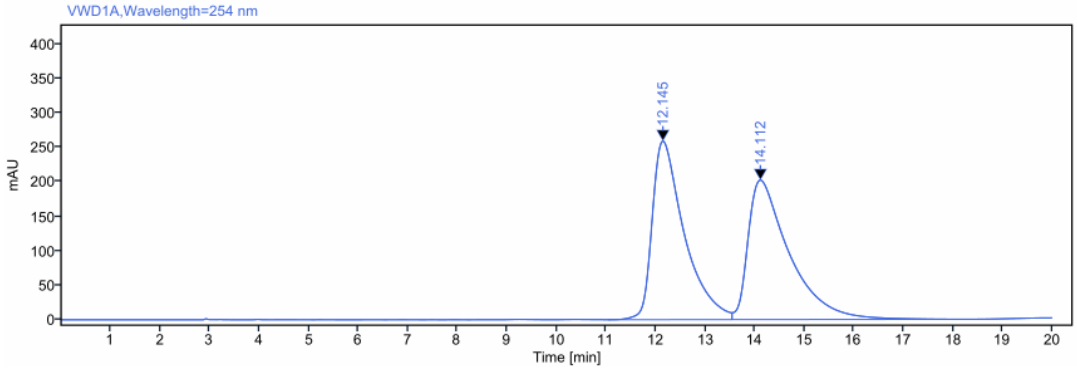
RT [min]	Type	Width [min]	Area	Height	Area%
18.070	BB	1.80	699.35	25.48	9.91
19.813	BB	2.69	6361.20	189.42	90.09



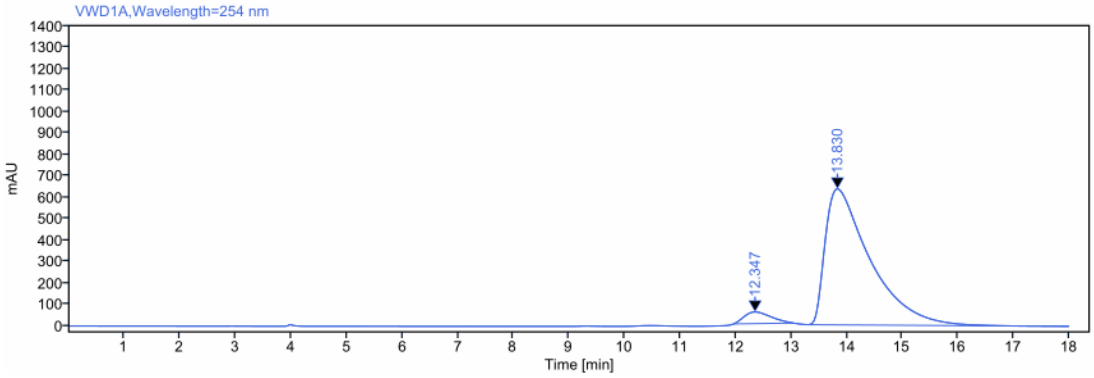
(*R*)-methyl 1-((tert-butoxycarbonyl)(methyl)amino)-2-methyl-5-(naphthalen-1-yl)-1H-pyrrole-3-carboxylate (3o)

Colorless oil. $[\alpha]_D^{25}$ = – 50.1 (*c* 0.50, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 1.38 (d, *J* = 18.3, 9H), 2.50 (s, 3H), 2.86 (d, *J* = 59.1, 3H), 3.85 (d, *J* = 9.6, 3H), 6.65 (dd, *J* = 2.8, 13.2, 1H), 7.38-7.67 (m, 4H), 7.78-8.05 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.0, 133.8, 133.2, 129.6, 129.2, 129.0, 128.9, 128.7, 128.3, 128.2, 126.5, 126.4, 126.1, 126.1, 125.1, 125.0, 110.2, 109.9, 82.3, 51.2, 51.1, 38.9, 38.0, 28.2, 28.1, 10.8, 10.7. HRMS

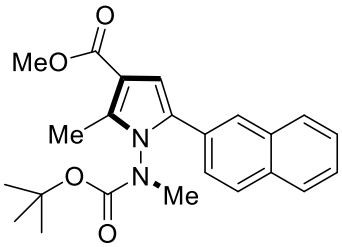
(ESI) calcd for $C_{23}H_{26}N_2O_4$ *m/z* $[M+H]^+$: 395.1965, found: 395.1958. Enantiomeric excess was found to be 90% by chiral HPLC (ChiralPak OD column, hexane/*i*-PrOH = 99:1, 1.0 ml/min, t_{major} = 13.8 min, t_{minor} = 12.3 min).



RT [min]	Type	Width [min]	Area	Height	Area%
12.145	BV	2.50	11630.71	258.86	49.91
14.112	VB	4.64	11672.52	202.09	50.09



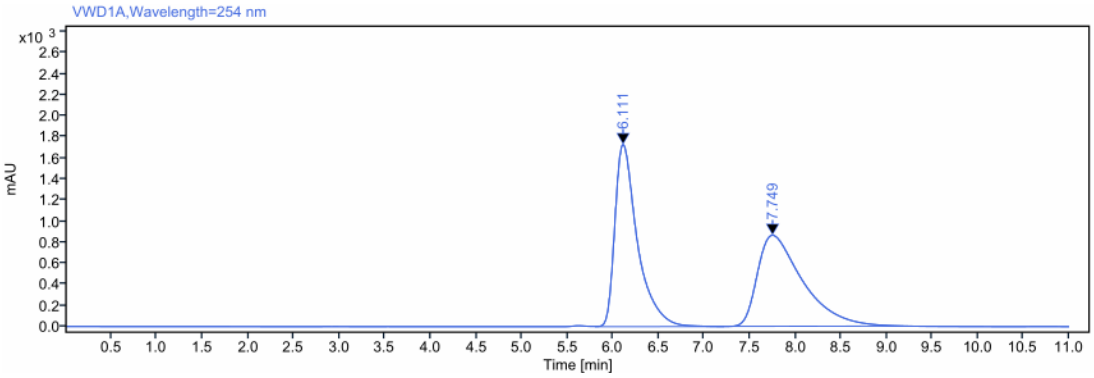
RT [min]	Type	Width [min]	Area	Height	Area%
12.347	MM m	1.07	1799.98	54.13	4.82
13.830	MB m	4.69	35569.11	634.50	95.18



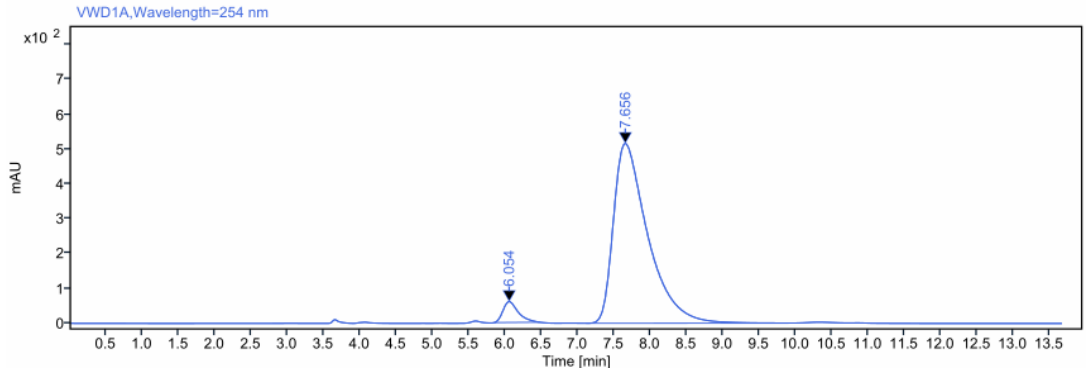
(*R*)-methyl 1-((tert-butoxycarbonyl)(methyl)amino)-2-methyl-5-(naphthalen-2-yl)-1H-pyrrole-3-carboxylate (3p)

Colorless oil. $[\alpha]_D^{25}$ = – 73.6 (*c* 0.70, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 1.49 (d, *J* = 67.9, 9H), 2.50 (s, 3H), 3.05 (d, *J* = 54.6, 3H), 3.85 (d, *J* = 9.4, 3H), 6.75 (d, *J* = 10.8, 1H), 7.41-7.63 (m, 3H), 7.69-8.01 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.7, 154.3, 137.5, 133.5, 132.7, 131.8, 128.5, 128.4, 128.2, 128.2, 127.8, 127.8, 126.6, 126.5, 126.3, 126.3, 126.2, 125.8, 125.6, 110.7, 108.6, 108.2, 82.6, 82.5, 51.2, 51.1, 38.7, 37.5, 28.4,

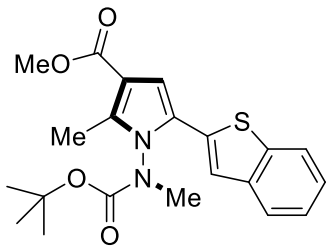
28.2, 10.6, 10.5. HRMS (ESI) calcd for $C_{23}H_{26}N_2O_4$ *m/z* $[M+H]^+$: 395.1965, found: 395.1961. Enantiomeric excess was found to be 90% by chiral HPLC (ChiralPak OD column, hexane/*i*-PrOH = 95:5, 1.0 ml/min, t_{major} = 7.6min, t_{minor} = 6.0 min).



RT [min]	Type	Width [min]	Area	Height	Area%
6.111	VM m	1.41	29766.50	1730.03	49.97
7.749	MM m	1.88	29796.50	865.08	50.03



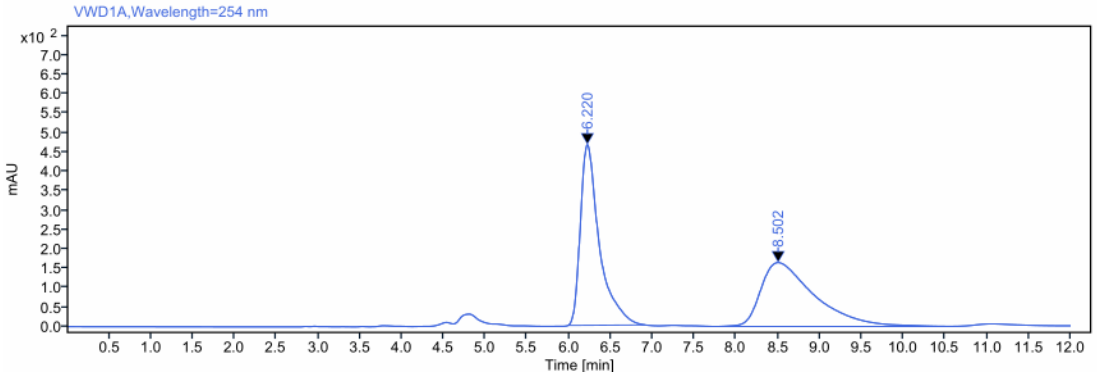
RT [min]	Type	Width [min]	Area	Height	Area%
6.054	MM m	0.63	875.73	59.85	4.89
7.656	BB	2.79	17036.83	516.94	95.11



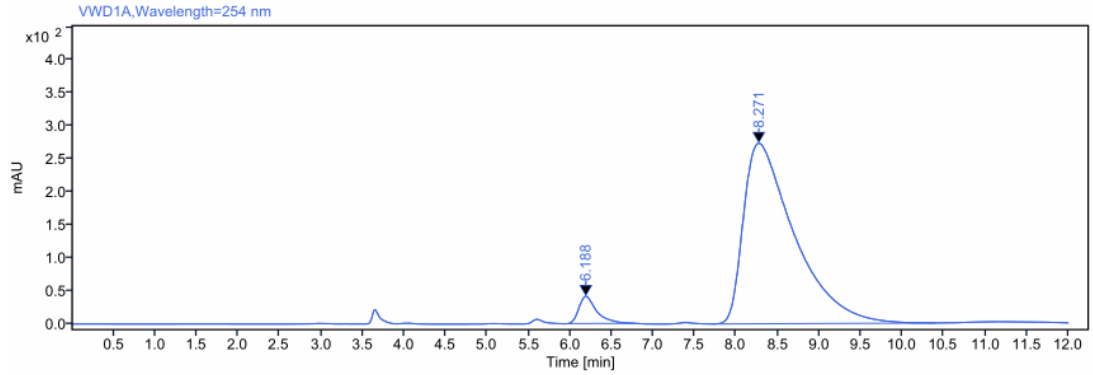
(*R*)-methyl 5-(benzo[b]thiophen-2-yl)-1-((tert-butoxycarbonyl)(methyl)amino)-2-methyl-1H-pyrrole-3-carboxylate (3q)

Brown oil. $[\alpha]_D^{25}$ = – 101.1 (*c* 0.72, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.33 (s, 7H), 1.57 (s, 2H), 2.46 (s, 3H), 3.26 (d, *J* = 23.3, 3H), 3.83 (d, *J* = 10.0, 3H), 6.87 (s, 1H), 7.22-7.38 (m, 3H), 7.75 (dd, *J* = 7.6, 24.0, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.3, 154.1, 140.0, 139.0, 137.9, 132.2, 125.7, 124.7, 124.6, 124.5, 124.4, 123.5, 123.4, 122.1, 122.1, 120.1, 119.3, 111.0, 109.2, 108.5, 82.8, 51.3, 38.9, 37.4, 28.4, 28.1, 10.5, 10.5.

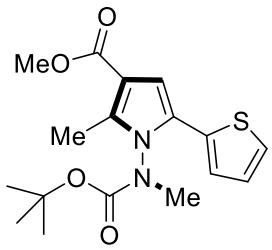
HRMS (ESI) calcd for $C_{21}H_{24}N_2O_4S$ *m/z* $[M+H]^+$: 401.1530, found: 401.1522. Enantiomeric excess was found to be 90% by chiral HPLC (ChiralPak OD column, hexane/*i*-PrOH = 95:5, 1.0 ml/min, t_{major} = 8.2 min, t_{minor} = 6.2 min).



RT [min]	Type	Width [min]	Area	Height	Area%
6.220	MM m	0.92	7382.68	466.32	50.17
8.502	BB	2.80	7332.30	164.96	49.83



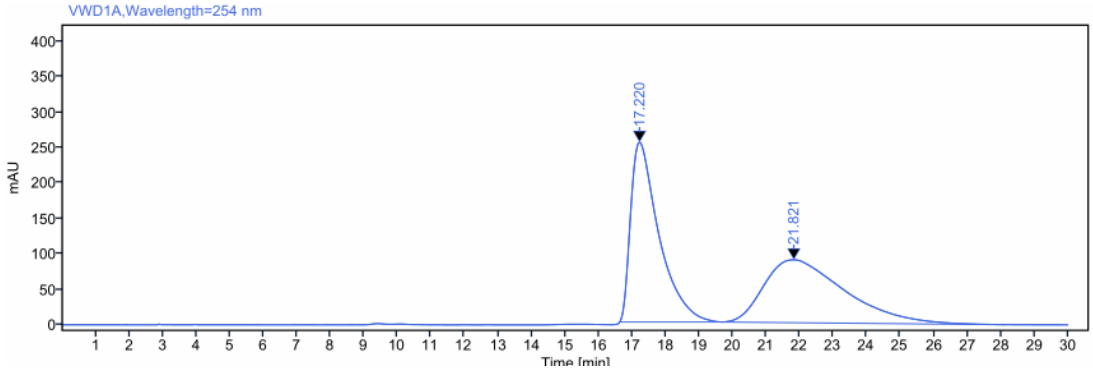
RT [min]	Type	Width [min]	Area	Height	Area%
6.188	MM m	0.79	611.47	41.21	4.98
8.271	BB	2.69	11668.04	273.97	95.02



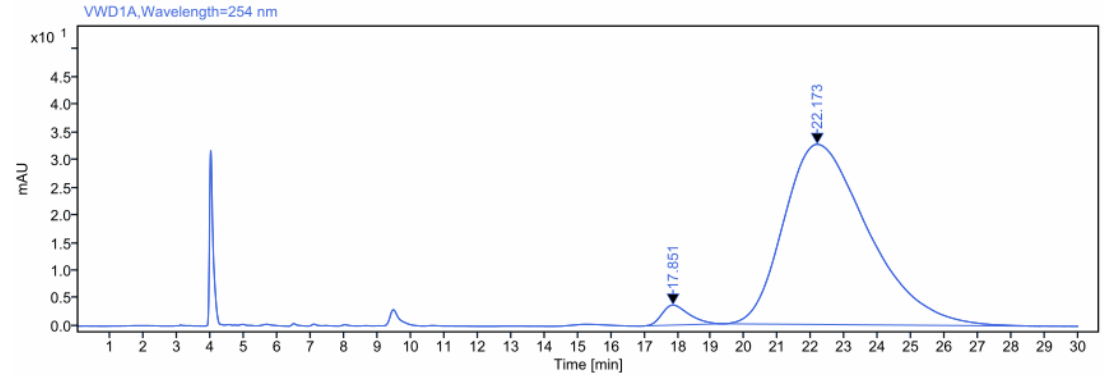
(*R*)-methyl 1-((tert-butoxycarbonyl)(methyl)amino)-2-methyl-5-(thiophen-2-yl)-1H-pyrrole-3-carboxylate (3r)

Ink green oil $[\alpha]_D^{25}$ = – 57.8 (*c* 0.56, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.33 (s, 7H), 1.57 (s, 2H), 2.46 (s, 3H), 3.26 (d, *J* = 23.3, 3H), 3.83 (d, *J* = 10.0, 3H), 6.87 (s, 1H), 7.22-7.38 (m, 3H), 7.75 (dd, *J* = 7.6, 24.0, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.3, 154.1, 140.0, 139.0, 137.9, 132.2, 125.7, 124.7, 124.6, 124.5, 124.4, 123.5, 123.4, 122.1,

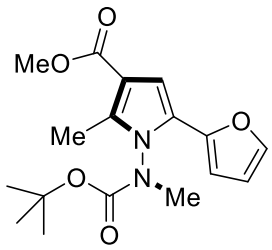
122.1, 120.1, 119.3, 111.0, 109.2, 108.5, 82.8, 51.3, 38.9, 37.4, 28.4, 28.1, 10.5, 10.5. HRMS (ESI) calcd for $C_{17}H_{22}N_2O_4S$ *m/z* $[M+H]^+$: 351.1373, found: 351.1375. Enantiomeric excess was found to be 93% by chiral HPLC (ChiralPak OD column, hexane/*i*-PrOH = 99:1, 1.0 ml/min, t_{major} = 22.2 min, t_{minor} = 17.2 min).



RT [min]	Type	Width [min]	Area	Height	Area%
17.220	MM m	3.07	14856.99	253.75	50.14
21.821	MM m	8.40	14773.75	88.64	49.86



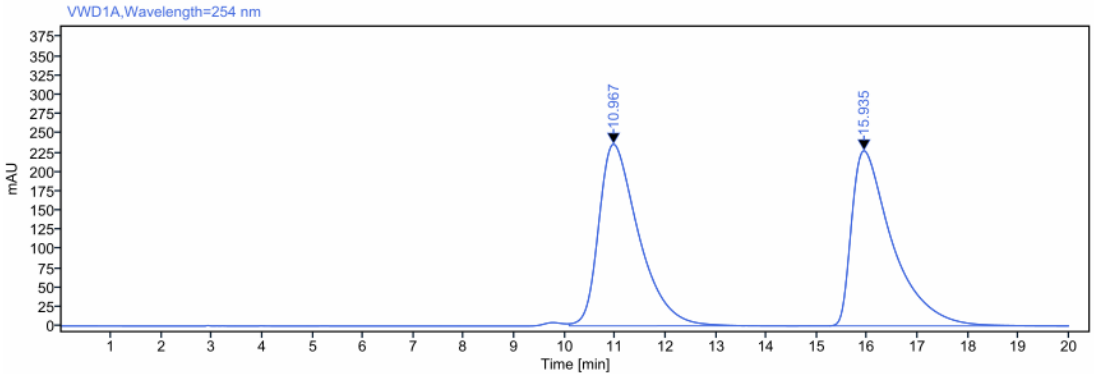
RT [min]	Type	Width [min]	Area	Height	Area%
17.851	MM m	2.31	203.13	3.62	3.43
22.173	BB	9.52	5727.12	32.54	96.57



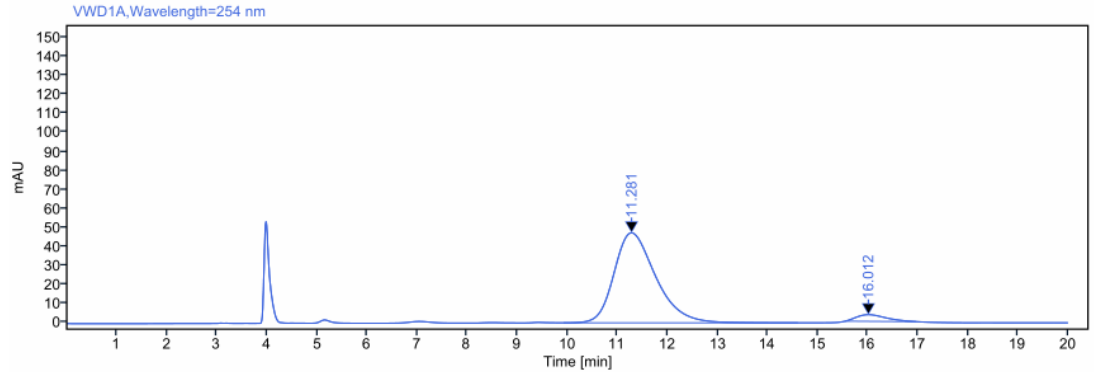
(*R*)-methyl 1-((tert-butoxycarbonyl)(methyl)amino)-5-(furan-2-yl)-2-methyl-1H-pyrrole-3-carboxylate (3s)

Yellow oil. $[\alpha]_D^{25}$ = – 25.5 (*c* 0.17, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 1.29 (s, 7H), 1.54 (s, 2H), 2.45 (s, 3H), 3.26 (s, 3H), 3.82 (d, *J* = 9.4, 3H), 6.36 (dd, *J* = 3.4, 51.9, 2H), 6.78 (d, *J* = 11.7, 1H), 7.39 (d, *J* = 6.8, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) 165.5, 154.3, 145.6, 141.6, 141.5, 137.4, 123.0, 111.4, 111.3, 110.5, 107.2, 106.7, 105.2, 105.1,

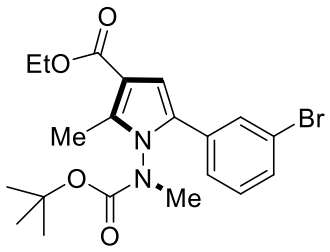
82.2, 51.2, 51.1, 38.6, 37.1, 28.3, 28.0, 10.3. HRMS (ESI) calcd for $C_{17}H_{22}N_2O_5$ *m/z* $[M+H]^+$: 335.1601, found: 335.1595. Enantiomeric excess was found to be 90% by chiral HPLC (ChiralPak OD column, hexane/*i*-PrOH = 99:1, 1.0 ml/min, t_{major} = 16.0 min, t_{minor} = 11.3 min).



RT [min]	Type	Width [min]	Area	Height	Area%
10.967	MM m	3.49	12968.50	235.83	50.36
15.935	MB m	4.76	12780.80	227.25	49.64



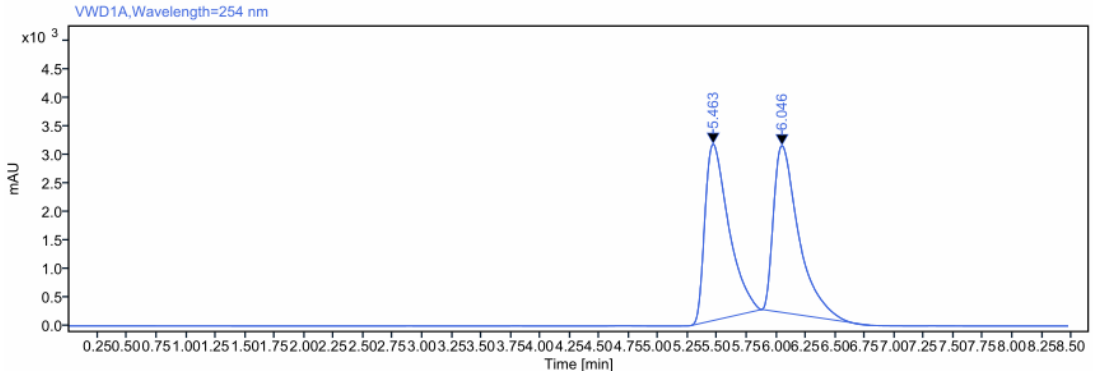
RT [min]	Type	Width [min]	Area	Height	Area%
11.281	BM m	4.67	2738.23	47.35	95.02
16.012	MM m	1.42	143.64	3.50	4.98



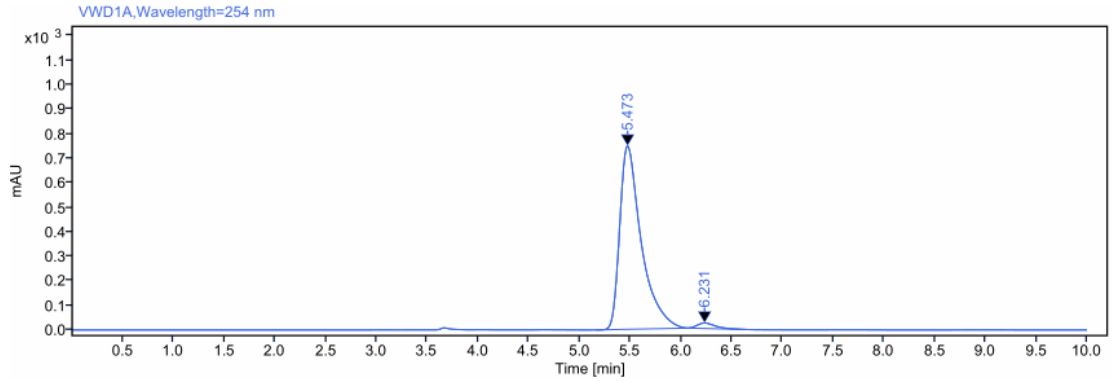
(*R*)-ethyl 5-(3-bromophenyl)-1-((tert-butoxycarbonyl)(methyl)amino)-2-methyl-1H-pyrrole-3-carboxylate (3t)

Colorless oil. $[\alpha]_D^{25}$ = – 58.5 (*c* 0.77, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 1.47 (d, *J* = 68.1, 12H), 2.45 (s, 3H), 3.05 (d, *J* = 35.8, 3H), 4.26-4.29 (m, 2H), 6.66 (s, 1H), 7.23 (*m*, 1H), 7.27-7.35 (m, 1H), 7.44 (d, *J* = 7.9, 1H), 7.54 (s, 1H).; ^{13}C NMR (100 MHz,

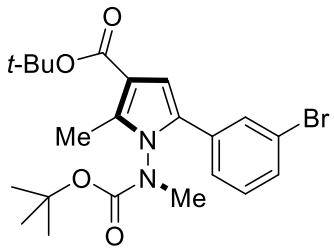
$CDCl_3$) δ 154.1, 137.5, 133.2, 130.6, 130.5, 130.4, 130.3, 130.2, 126.6, 125.8, 122.8, 111.1, 108.9, 108.5, 82.9, 82.7, 59.9, 59.8, 38.8, 37.6, 28.4, 28.2, 14.6, 14.6, 10.5, 10.5. HRMS (ESI) calcd for $C_{20}H_{25}BrN_2O_4$ *m/z* $[M+H]^+$: 437.1070, found: 437.1060. Enantiomeric excess was found to be 96% by chiral HPLC (ChiralPak OD column, hexane/*i*-PrOH = 95:5, 1.0 ml/min, t_{major} = 6.2 min, t_{minor} = 5.4 min).



RT [min]	Type	Width [min]	Area	Height	Area%
5.463	MM m	0.60	43476.02	3092.36	49.99
6.046	MM m	0.92	43493.45	2923.83	50.01



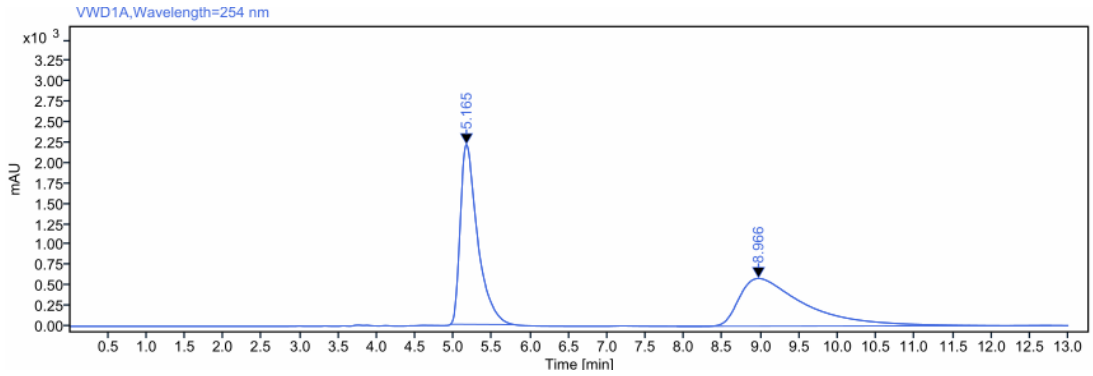
RT [min]	Type	Width [min]	Area	Height	Area%
5.473	MM m	0.91	11038.84	747.96	97.59
6.231	MM m	0.56	272.66	22.10	2.41



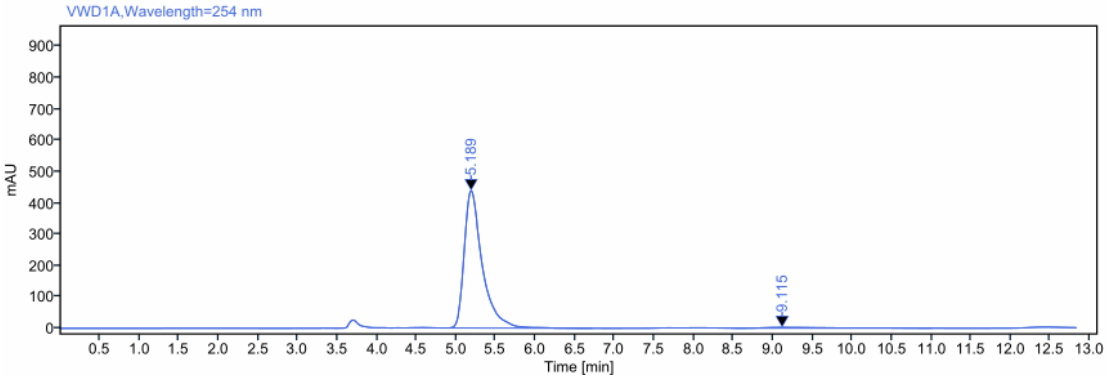
(*R*)-tert-butyl 5-(3-bromophenyl)-1-((tert-butoxycarbonyl)(methyl)amino)-2-methyl-1H-pyrrole-3-carboxylate (3u)

Colorless oil. $[\alpha]_D^{25}$ = – 61.3 (*c* 0.66, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.36-1.60 (m, 18H), 2.42 (s, 3H), 3.04 (d, *J* = 31.9, 3H), 6.60 (d, *J* = 5.0, 1H), 7.11-7.25 (m, 1H), 7.27-7.33 (m, 1H), 7.43 (d, *J* = 7.8, 1H), 7.53 (d, *J* = 2.2, 1H); ^{13}C NMR (100 MHz,

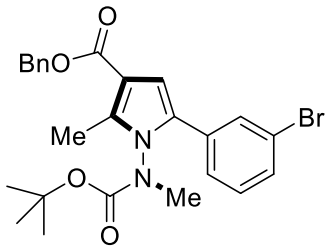
$CDCl_3$) δ 164.5, 154.1, 136.9, 133.3, 130.6, 130.5, 130.5, 130.3, 130.1, 130.1, 130.0, 126.6, 125.8, 122.8, 112.6, 109.1, 108.7, 82.8, 82.7, 80.1, 79.9, 38.8, 37.6, 28.6, 28.6, 28.4, 28.2, 10.5. HRMS (ESI) calcd for $C_{22}H_{29}BrN_2O_4$ *m/z* $[M+H]^+$: 465.1383, found: 465.1393. Enantiomeric excess was found to be 96% by chiral HPLC (ChiralPak OD column, hexane/*i*-PrOH = 95:5, 1.0 ml/min, t_{major} = 9.1 min, t_{minor} = 5.2 min).



RT [min]	Type	Width [min]	Area	Height	Area%
5.165	MM m	0.83	34444.48	2203.26	50.09
8.966	MM m	4.88	34313.97	584.72	49.91



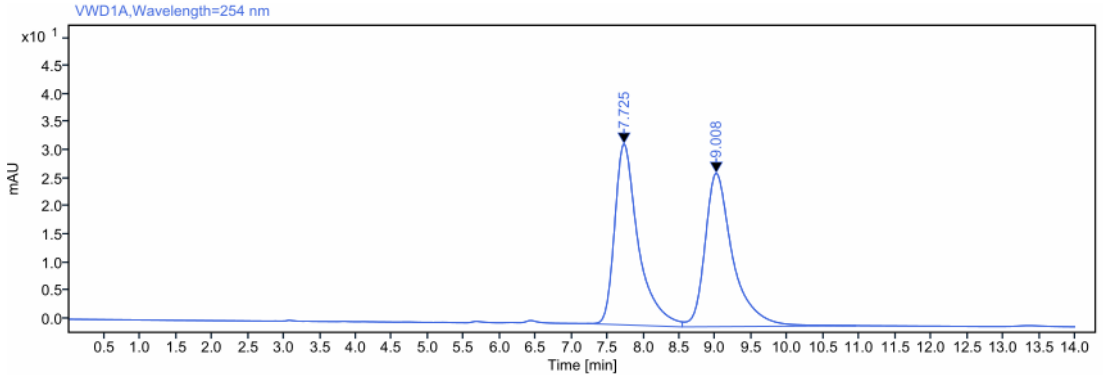
RT [min]	Type	Width [min]	Area	Height	Area%
5.189	BB	1.91	6958.47	438.49	98.03
9.115	MM m	2.53	139.63	2.29	1.97



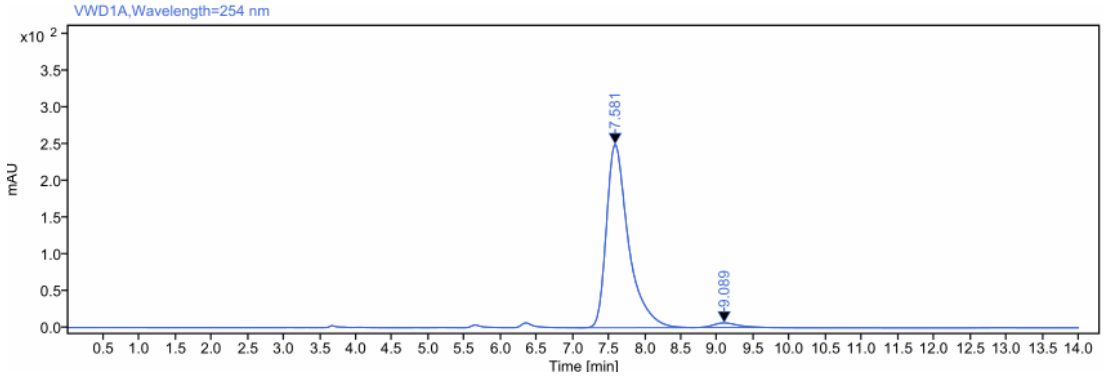
(*R*)-benzyl 5-(3-bromophenyl)-1-((tert-butoxycarbonyl)(methyl)amino)-2-methyl-1H-pyrrole-3-carboxylate (3v)

Colorless oil. $[\alpha]_D^{25}$ = – 59.1 (*c* 0.54, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.47 (d, *J* = 67.0, 9H), 2.46 (s, 3H), 3.05 (d, *J* = 35.5, 3H), 5.30 (d, *J* = 5.4, 2H), 6.69 (t, *J* = 2.5, 1H), 7.22-7.50 (m, 8H), 7.53 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.8, 154.0, 137.9, 133.1, 130.7, 130.6, 130.5, 130.5, 130.4, 130.3, 130.2, 128.7, 128.6, 128.2, 128.2,

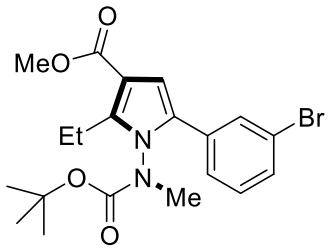
128.1, 128.1, 126.6, 125.8, 122.8, 110.8, 109.0, 108.6, 82.9, 82.7, 65.7, 65.6, 38.8, 37.6, 28.3, 28.2, 10.6, 10.6. HRMS (ESI) calcd for $C_{25}H_{27}BrN_2O_4$ *m/z* $[M+H]^+$: 499.1227, found: 499.1220. Enantiomeric excess was found to be 95% by chiral HPLC (ChiralPak OD column, hexane/*i*-PrOH = 95:5, 1.0 ml/min, t_{major} = 9.1 min, t_{minor} = 5.2 min).



RT [min]	Type	Width [min]	Area	Height	Area%
7.725	BM m	1.33	737.86	32.19	49.97
9.008	MB m	2.42	738.78	27.30	50.03



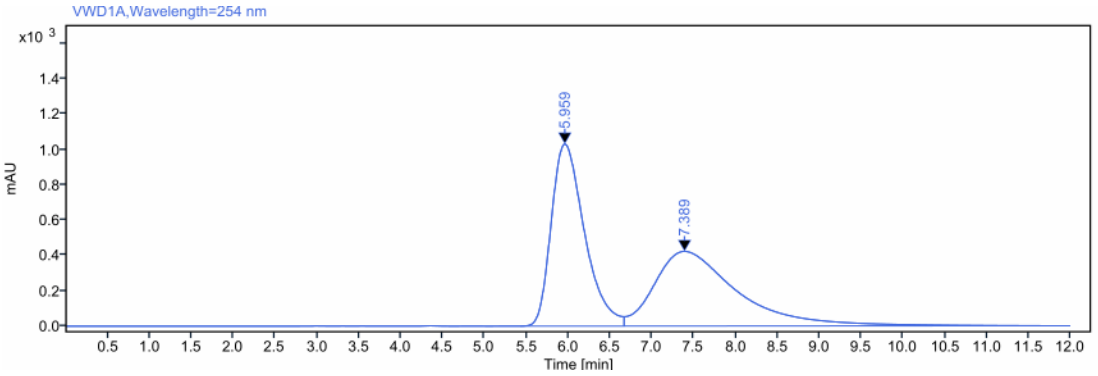
RT [min]	Type	Width [min]	Area	Height	Area%
7.581	BB	1.61	5312.60	249.89	97.52
9.089	MM m	0.84	135.36	6.05	2.48



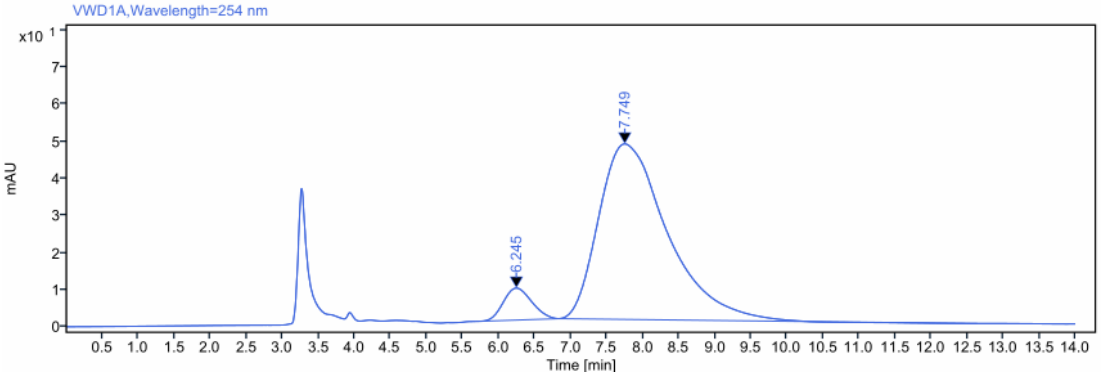
(*R*)-methyl 5-(3-bromophenyl)-1-((tert-butoxycarbonyl)(methyl)amino)-2-ethyl-1H-pyrrole-3-carboxylate (3w)

Colorless oil. $[\alpha]_D^{25}$ = – 64.1 (*c* 0.41, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ1.24 (t, *J* = 7.4, 3H), 1.36 (s, 6H), 1.55 (s, 3H), 2.84-2.90 (m, 2H), 3.01 (s, 1H), 3.15 (s, 2H), 3.82 (d, *J* = 8.1, 3H), 6.65 (d, *J* = 4.4, 1H), 7.17-7.25 (m, 1H), 7.27-7.38 (m, 1H), 7.44 (dd, *J* = 2.0, 7.6, 1H), 7.54 (dd, *J* = 1.9, 8.5, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.1,

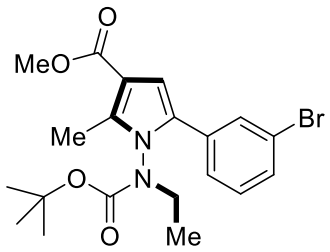
154.1, 143.6, 133.3, 130.9, 130.7, 130.7, 130.7, 130.5, 130.3, 130.1, 126.9, 126.0, 122.8, 110.3, 109.2, 108.8, 82.8, 51.2, 51.1, 39.4, 38.5, 28.3, 28.1, 18.6, 18.4, 13.8, 13.5. HRMS (ESI) calcd for $C_{20}H_{25}BrN_2O_4$ *m/z* $[M+H]^+$: 437.1070, found: 437.1064. Enantiomeric excess was found to be 86% by chiral HPLC (ChiralPak OD column, hexane/*i*-PrOH = 95:5, 1.0 ml/min, t_{major} = 7.7 min, t_{minor} = 6.2 min).



RT [min]	Type	Width [min]	Area	Height	Area%
5.959	BV	1.24	28452.65	1029.94	49.66
7.389	VBA	4.91	28840.10	422.18	50.34



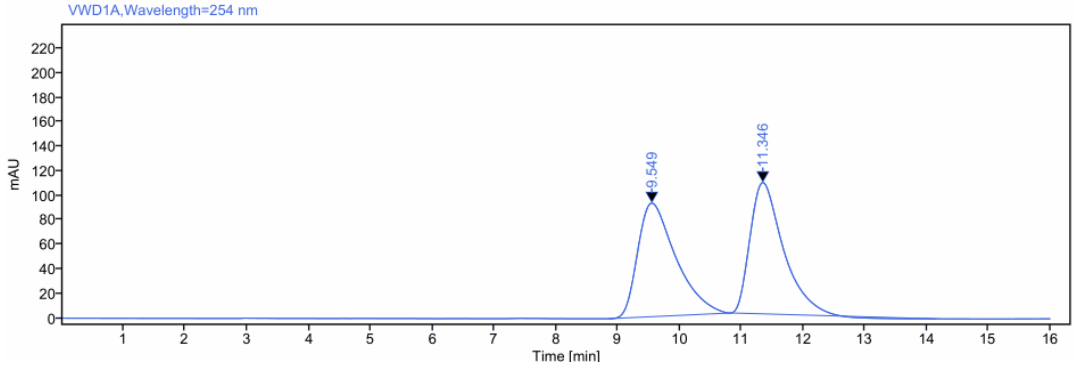
RT [min]	Type	Width [min]	Area	Height	Area%
6.245	MM m	1.10	234.82	8.60	6.98
7.749	MB m	5.80	3127.66	47.24	93.02



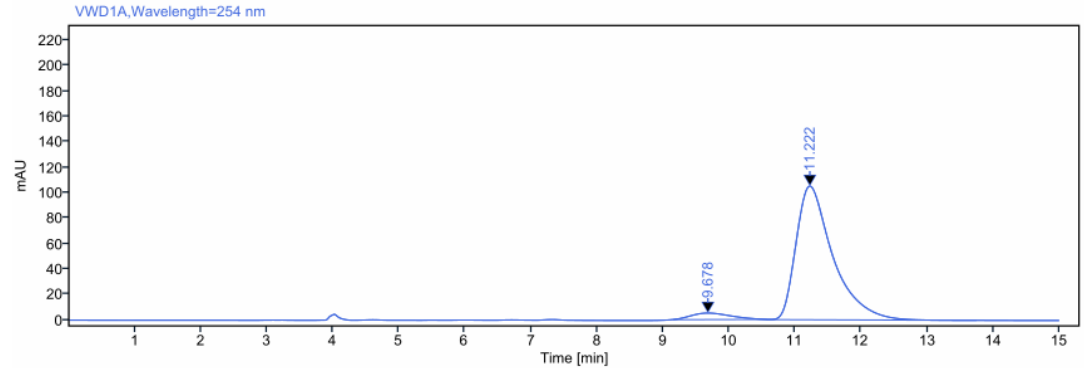
(*R*)-methyl 5-(3-bromophenyl)-1-((tert-butoxycarbonyl)(ethyl)amino)-2-methyl-1H-pyrrole-3-carboxylate (3x)

Colorless oil. $[\alpha]_D^{25}$ = – 74.1 (*c* 0.35, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 0.78-0.81 (m, 3H), 1.47 (d, *J* = 2.3, 5H), 1.59 (s, 4H), 2.44 (s, 3H), 3.21-3.70 (m, 2H), 3.74-4.08 (m, 3H), 6.65 (d, *J* = 2.6, 1H), 7.25-7.27 (m, 2H), 7.43 (d, *J* = 7.9, 1H), 7.53 (s, 1H); ^{13}C

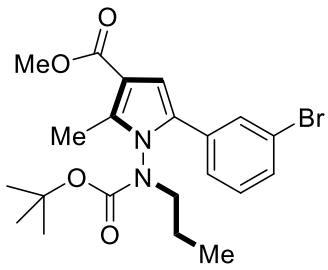
NMR (100 MHz, $CDCl_3$) δ 165.5, 154.1, 138.6, 138.5, 133.5, 130.9, 130.6, 130.3, 130.1, 126.9, 126.1, 122.8, 108.8, 108.6, 82.8, 82.7, 51.2, 51.1, 46.9, 45.3, 28.4, 28.4, 12.7, 12.2, 11.0, 10.9. HRMS (ESI) calcd for $C_{20}H_{25}BrN_2O_4$ *m/z* $[M+H]^+$: 437.1070, found: 437.1063. Enantiomeric excess was found to be 86% by chiral HPLC (ChiralPak OD column, hexane/*i*-PrOH = 99:1, 1.0 ml/min, t_{major} = 11.2 min, t_{minor} = 9.6 min).



RT [min]	Type	Width [min]	Area	Height	Area%
9.549	MM m	1.98	3975.67	92.82	49.88
11.346	MM m	3.32	3995.45	107.25	50.12



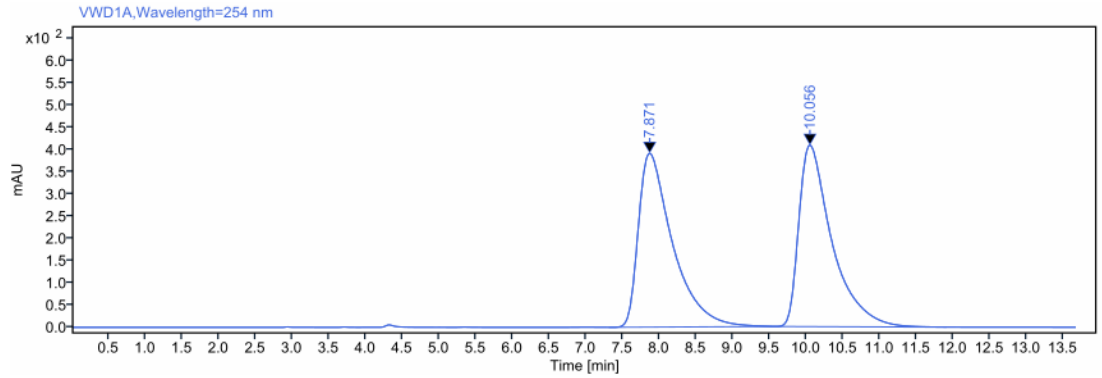
RT [min]	Type	Width [min]	Area	Height	Area%
9.678	MM m	1.41	214.08	5.11	4.99
11.222	MM m	3.18	4079.50	105.27	95.01



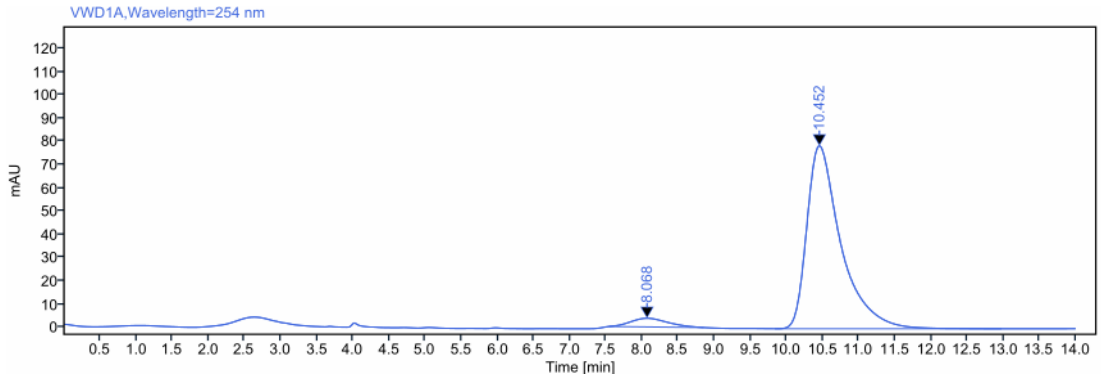
(*R*)-methyl 5-(3-bromophenyl)-1-((tert-butoxycarbonyl)(propyl)amino)-2-methyl-1H-pyrrole-3-carboxylate (3y)

Colorless oil. $[\alpha]_D^{25}$ = – 62.2 (*c* 0.39, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ = 0.68 (q, *J* = 6.7, 3H), 1.22-1.25 (m, 2H), 1.48 (s, 5H), 1.59 (s, 4H), 2.44 (s, 3H), 3.10-3.45 (m, 2H), 3.82 (d, *J* = 8.8, 3H), 6.64 (d, *J* = 2.7, 1H), 7.23 (d, *J* = 6.5, 1H), 7.30 (t, *J* = 8.0,

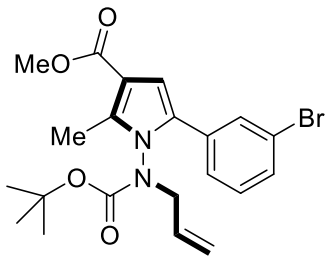
1H), 7.44 (d, J = 7.9, 1H), 7.54 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.3, 138.3, 133.4, 131.0, 130.9, 130.7, 130.6, 130.3, 130.1, 126.9, 126.2, 122.8, 110.6, 108.8, 108.6, 82.8, 82.7, 54.0, 52.5, 51.2, 51.1, 28.4, 28.4, 21.0, 20.5, 11.2, 11.1, 11.0, 10.9. HRMS (ESI) calcd for $C_{21}H_{27}BrN_2O_4$ *m/z* $[M+H]^+$: 451.1227, found: 451.1219. Enantiomeric excess was found to be 90% by chiral HPLC (ChiralPak OD column, hexane/*i*-PrOH = 99:1, 1.0 ml/min, t_{major} = 10.4 min, t_{minor} = 8.0 min).



RT [min]	Type	Width [min]	Area	Height	Area%
7.871	BM m	2.25	12656.65	390.26	49.75
10.056	MM m	2.35	12785.87	407.30	50.25



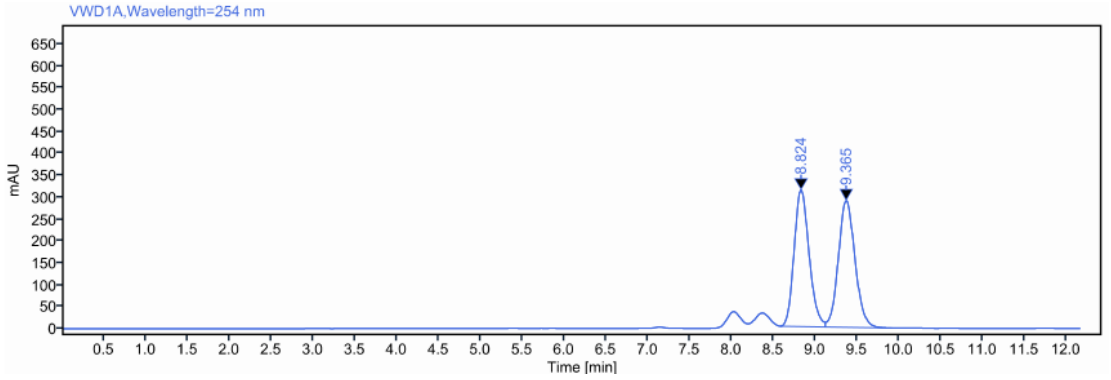
RT [min]	Type	Width [min]	Area	Height	Area%
8.068	MM m	1.31	132.40	3.71	4.88
10.452	BB	3.13	2578.41	78.65	95.12



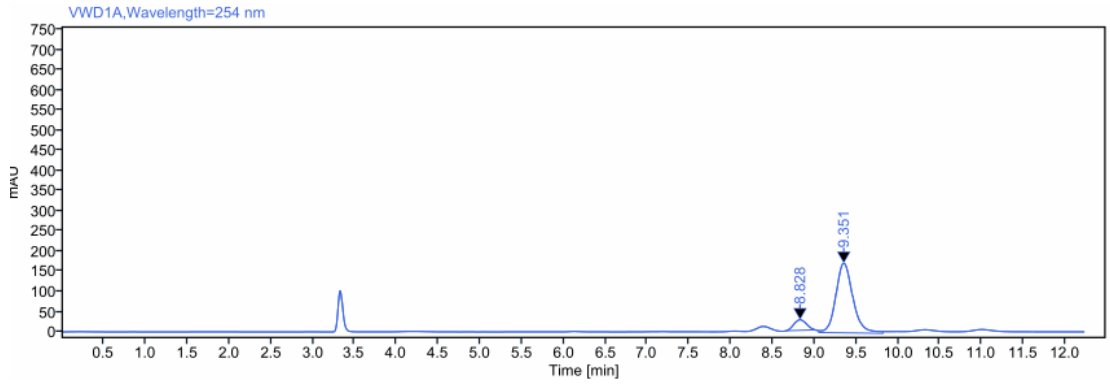
(*R*)-methyl 1-(allyl(tert-butoxycarbonyl)amino)-5-(3-bromophenyl)-2-methyl-1H-pyrrole-3-carboxylate (3z)

Yellow oil. $[\alpha]_D^{25}$ = – 36.5 (*c* 0.5, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.13-0.35 (m, 1H), 0.35-0.49 (m, 1H), 0.57 (d, J = 15.8, 2H), 1.47 (s, 5H), 1.59 (s, 4H), 2.41 (s, 3H), 2.76 (d, J = 53.1, 1H), 3.82 (d, J = 6.4, 3H), 6.62 (s, 1H), 7.22 (d, J = 7.9, 1H), 7.28 (s,

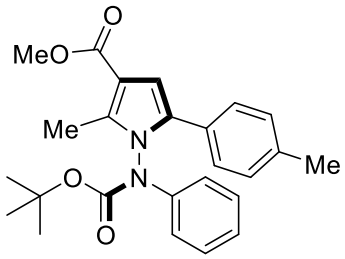
1H), 7.43-7.45 (m, 1H), 7.51 (d, J = 2.7, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.6, 154.7, 137.8, 131.2, 131.0, 130.8, 130.7, 130.6, 130.3, 126.9, 126.3, 122.7, 110.5, 108.3, 83.1, 82.9, 51.2, 33.1, 32.8, 28.3, 10.7, 7.7, 6.9, 6.7. HRMS (ESI) calcd for $C_{21}H_{26}BrN_2O_4$ m/z $[M+H]^+$: 449.1071, found: 449.1078. Enantiomeric excess was found to be 80% by chiral HPLC (ChiralPak OD column, hexane/i-PrOH = 99:1, 1.0 ml/min, t_{major} = 9.3 min, t_{minor} = 8.8 min).



RT [min]	Type	Width [min]	Area	Height	Area%
8.824	BV	0.54	3882.33	311.50	49.19
9.365	VB	0.79	4010.49	288.69	50.81



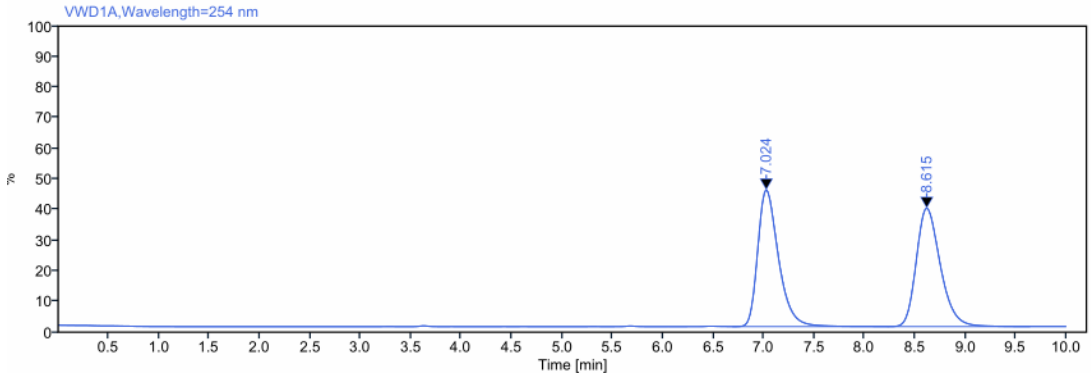
RT [min]	Type	Width [min]	Area	Height	Area%
8.828	MM m	0.35	271.69	26.17	9.95
9.351	MM m	0.77	2457.59	172.40	90.05



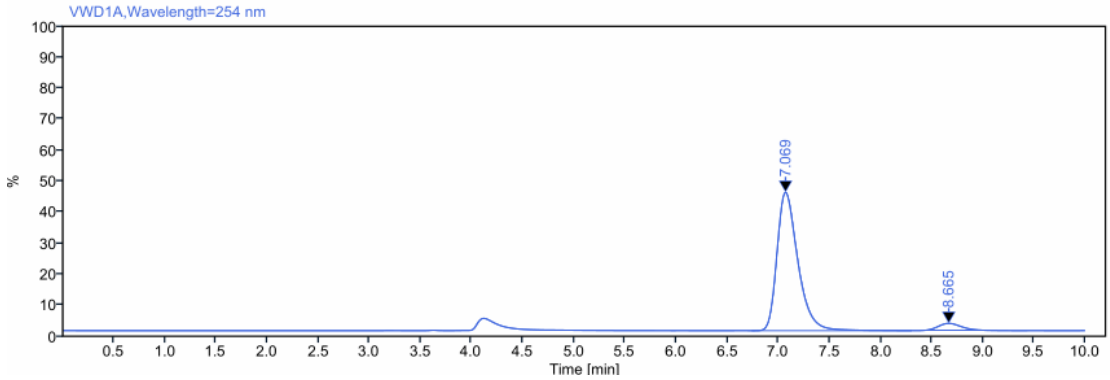
(*S*)-methyl 5-(3-bromophenyl)-1-((tert-butoxycarbonyl)(phenyl)amino)-2-methyl-1H-pyrrole-3-carboxylate (3aa)

Colorless oil. $[\alpha]_D^{25}$ = – 0.49 (c 0.41, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.33 (s, 9H), 2.35 (d, J = 40.6, 6H), 3.85 (s, 3H), 6.71 (s, 1H), 7.04-7.31 (m, 9H); ^{13}C NMR (100

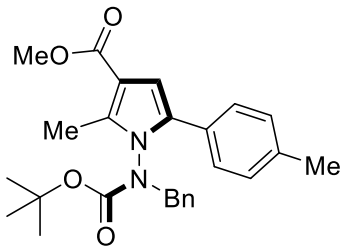
MHz, $CDCl_3$) δ 165.2, 153.9, 138.5, 137.0, 136.4, 131.4, 131.4, 129.3, 129.1, 129.0, 128.3, 128.2, 127.6, 127.5, 126.5, 124.4, 91.5, 84.5, 82.7, 51.3, 51.2, 38.6, 37.5, 28.3, 28.2, 21.6, 21.5, 10.8, 10.7. HRMS (ESI) calcd for $C_{25}H_{28}N_2O_4$ *m/z* $[M+H]^+$: 421.2122, found: 421.2126. Enantiomeric excess was found to be 90% by chiral HPLC (ChiralPak IC column, hexane/*i*-PrOH = 95:5, 1.0 ml/min, t_{major} = 7.0 min, t_{minor} = 8.6 min).



RT [min]	Type	Width [min]	Area	Height	Area%
7.024	VB	1.54	11654.84	810.59	50.01
8.615	BB	1.41	11650.81	701.88	49.99



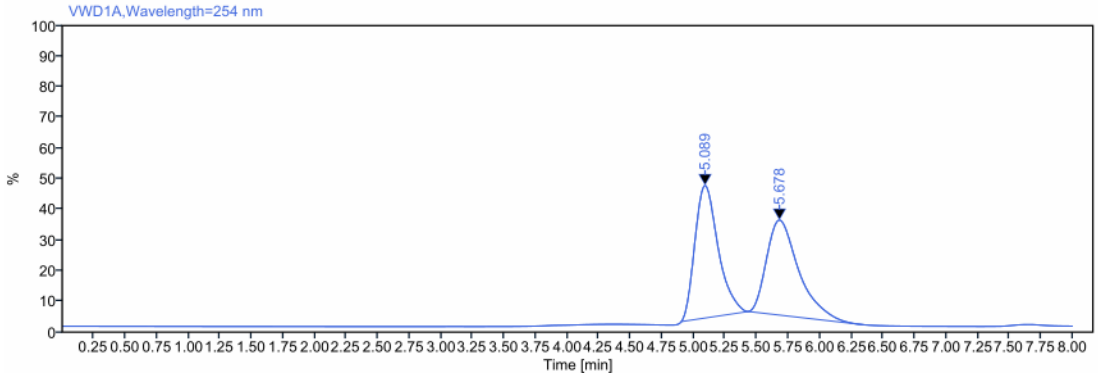
RT [min]	Type	Width [min]	Area	Height	Area%
7.069	VM m	1.56	11431.74	803.48	95.00
8.665	MM m	0.55	601.52	39.91	5.00



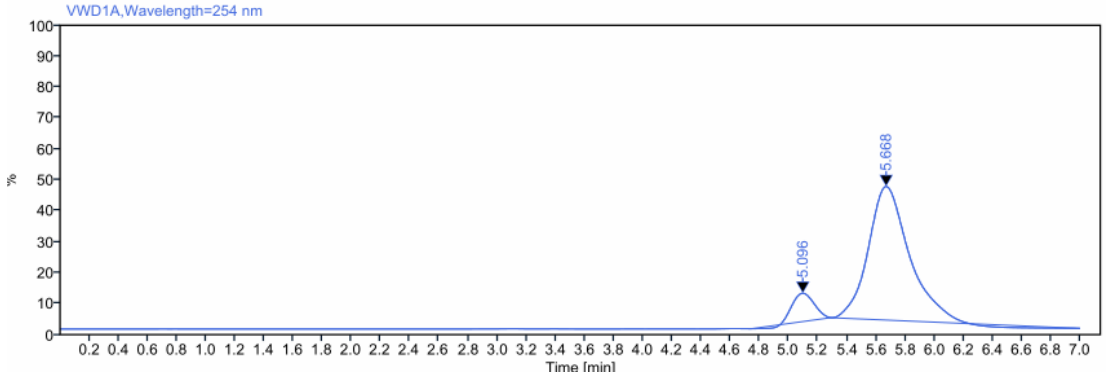
(*S*)-methyl 1-(benzyl(tert-butoxycarbonyl)amino)-2-methyl-5-(p-tolyl)-1H-pyrrole-3-carboxylate (3ab)

Colorless oil. $[\alpha]_D^{25}$ = – 12.8 (*c* 1.0, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 1.56 (t, *J* = 2.0, 6H), 1.71 (s, 3H), 1.95 (dt, *J* = 2.0, 14.6, 3H), 2.47 (d, *J* = 3.1, 3H), 3.77-3.90 (m, 3H), 3.95 (t, *J* = 13.4, 1H), 4.92 (dd, *J* = 14.6, 89.8, 1H), 6.67 (d, *J* = 3.0, 1H), 7.01 (dd, *J* =

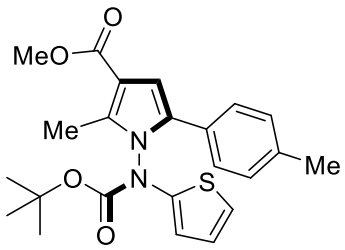
7.4, 24.5, 2H), 7.18-7.39 (m, 8H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.8, 154.2, 138.5, 137.6, 134.6, 131.4, 129.9, 129.6, 129.5, 129.4, 128.6, 128.6, 128.5, 128.4, 128.4, 128.1, 127.5, 109.8, 108.0, 107.7, 82.9, 82.6, 55.3, 53.4, 51.0, 51.0, 28.5, 28.4, 21.3, 10.5. HRMS (ESI) calcd for $C_{26}H_{30}N_2O_4$ *m/z* $[M+H]^+$: 435.2278, found: 435.2273. Enantiomeric excess was found to be 80% by chiral HPLC (ChiralPak IC column, hexane/*i*-PrOH = 96:4, 1.0 ml/min, t_{major} = 5.6 min, t_{minor} = 5.0 min).



RT [min]	Type	Width [min]	Area	Height	Area%
5.089	MM m	0.53	3254.66	253.62	50.18
5.678	MM m	0.92	3230.70	181.76	49.82



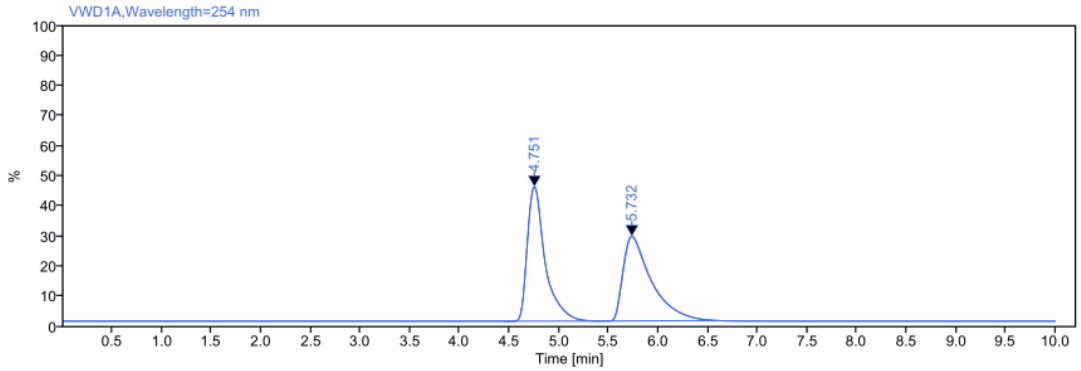
RT [min]	Type	Width [min]	Area	Height	Area%
5.096	MM m	0.55	250.28	24.88	9.94
5.668	MM m	1.71	2268.84	117.41	90.06



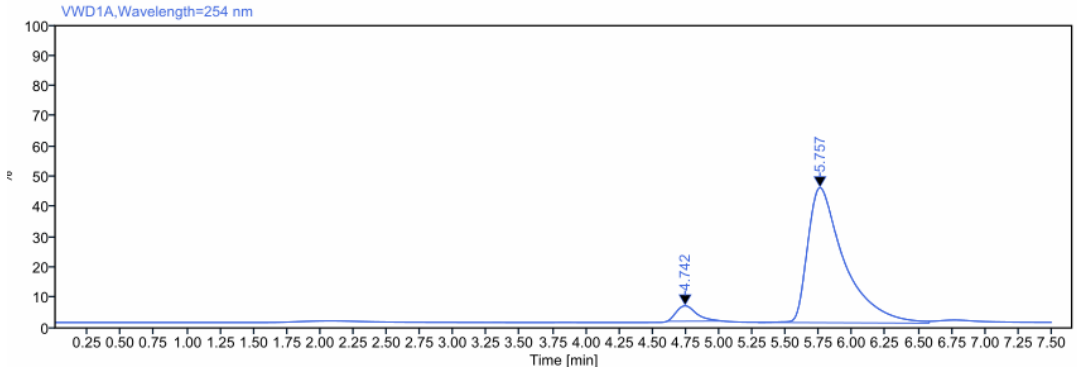
(*S*)-methyl 1-((tert-butoxycarbonyl)(thiophen-2-yl)amino)-2-methyl-5-(p-tolyl)-1H-pyrrole-3-carboxylate (3ac)

Yellow oil. $[\alpha]_D^{25}$ = – 28.6 (*c* 0.29, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.28 (s, 9H), 2.35 (d, *J* = 39.2, 6H), 3.85 (s, 3H), 6.06 (s, 1H), 6.73 (d, *J* = 17.8, 2H), 6.91 (d, *J* = 5.2,

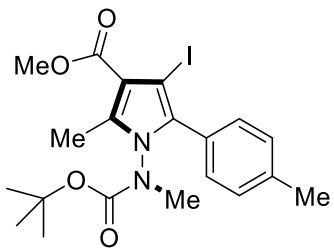
1H), 7.01-7.23 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.6, 151.1, 142.7, 137.7, 137.0, 132.8, 129.5, 127.7, 127.3, 124.6, 119.5, 112.4, 111.2, 107.5, 84.3, 51.2, 27.9, 21.3, 10.5. HRMS (ESI) calcd for $C_{23}H_{26}N_2O_4S$ *m/z* $[M+H]^+$: 427.1686, found: 427.1684. Enantiomeric excess was found to be 88% by chiral HPLC (ChiralPak IC column, hexane/*i*-PrOH = 95:5, 1.0 ml/min, t_{major} = 5.7 min, t_{minor} = 4.7 min).



RT [min]	Type	Width [min]	Area	Height	Area%
4.751	BB	1.00	40919.68	3273.76	50.00
5.732	BM m	1.14	40922.49	2063.71	50.00



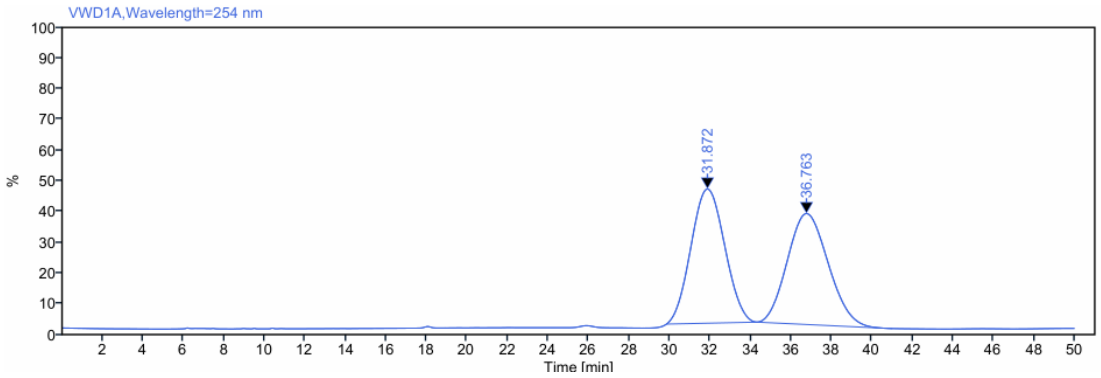
RT [min]	Type	Width [min]	Area	Height	Area%
4.742	MM m	0.42	934.45	88.94	5.90
5.757	MM m	1.29	14890.73	779.37	94.10



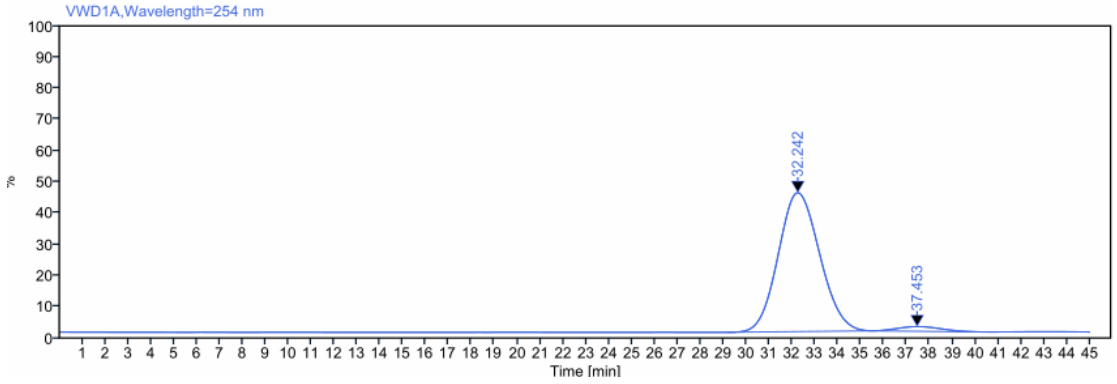
(*R*)-methyl 1-((tert-butoxycarbonyl)(methyl)amino)-4-iodo-2-methyl-5-(p-tolyl)-1H-pyrrole-3-carboxylate (4)

Yellow solid. $[\alpha]_D^{25}$ = – 59.3 (*c* 0.46, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.46 (d, *J* = 29.5, 9H), 2.43 (d, *J* = 10.5, 6H), 2.94 (d, *J* = 34.4, 3H), 3.88 (d, *J* = 9.4, 3H), 7.16-7.31

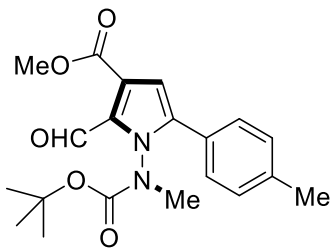
(m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.5, 153.7, 139.0, 138.8, 137.6, 135.8, 130.7, 130.5, 129.2, 129.1, 127.9, 112.0, 82.6, 82.5, 63.1, 51.0, 51.0, 38.7, 37.7, 28.2, 28.2, 21.6, 21.5, 11.6, 11.5. HRMS (ESI) calcd for $C_{20}H_{25}IN_2O_4$ *m/z* $[M+H]^+$: 485.0932, found: 485.0929. Enantiomeric excess was found to be 93% by chiral HPLC (ChiralPak IF column, hexane/*i*-PrOH = 99:1, 0.5 ml/min, t_{major} = 37.4 min, t_{minor} = 32.2 min).



RT [min]	Type	Width [min]	Area	Height	Area%
31.872	MB m	4.46	4731.26	40.68	50.03
36.763	BM m	6.69	4725.30	33.62	49.97



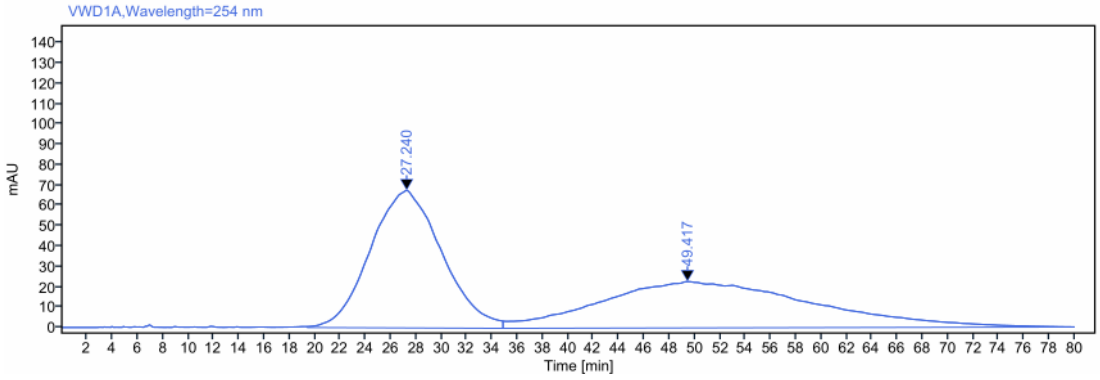
RT [min]	Type	Width [min]	Area	Height	Area%
32.242	BB	6.36	20183.34	160.42	96.64
37.453	MM m	5.06	702.51	5.36	3.36



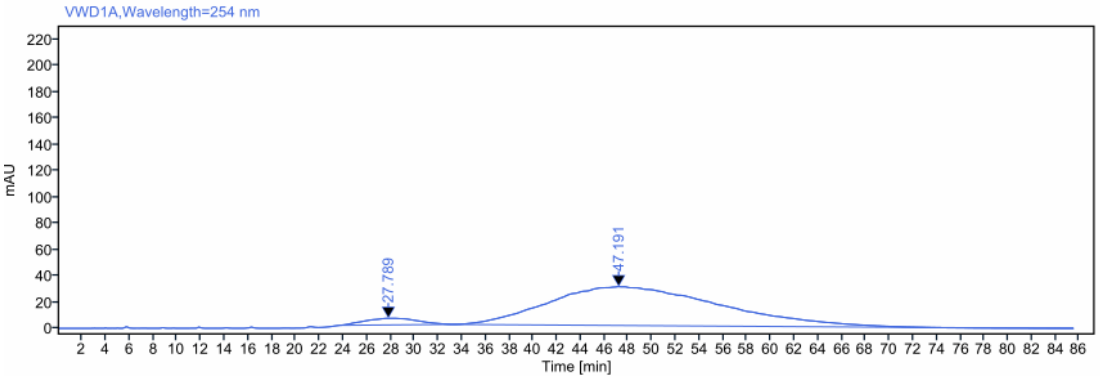
(*R*)-methyl 1-((tert-butoxycarbonyl)(methyl)amino)-2-formyl-5-(p-tolyl)-1H-pyrrole-3-carboxylate (5)

Colorless oil. $[\alpha]_D^{25}$ = – 42.9 (*c* 0.72, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.32 (s, 6H), 1.54 (s, 3H), 2.40 (s, 3H), 3.07 (d, *J* = 15.0, 3H), 3.91 (d, *J* = 10.4, 3H), 6.76 (t, *J* = 2.8,

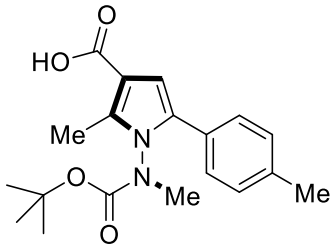
1H), 7.24 (d, J = 7.9, 2H), 7.36 (dd, J = 2.9, 8.0, 2H), 10.23-10.60 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 181.0, 180.7, 154.1, 139.8, 139.6, 129.6, 129.5, 129.4, 128.6, 128.3, 126.2, 126.1, 123.1, 110.2, 109.9, 82.8, 82.3, 52.2, 52.1, 39.2, 37.8, 28.3, 28.1, 21.5, 21.5. HRMS (ESI) calcd for $C_{20}H_{24}N_2O_5$ *m/z* $[M+H]^+$: 373.1758, found: 373.1755. Enantiomeric excess was found to be 90% by chiral HPLC (ChiralPak AD column, hexane/*i*-PrOH = 99:1, 1 ml/min, t_{major} = 47.2 min, t_{minor} = 27.8 min).



RT [min]	Type	Width [min]	Area	Height	Area%
27.240	MM m	15.46	26572.97	67.54	50.15
49.417	MM m	45.15	26409.19	22.74	49.85



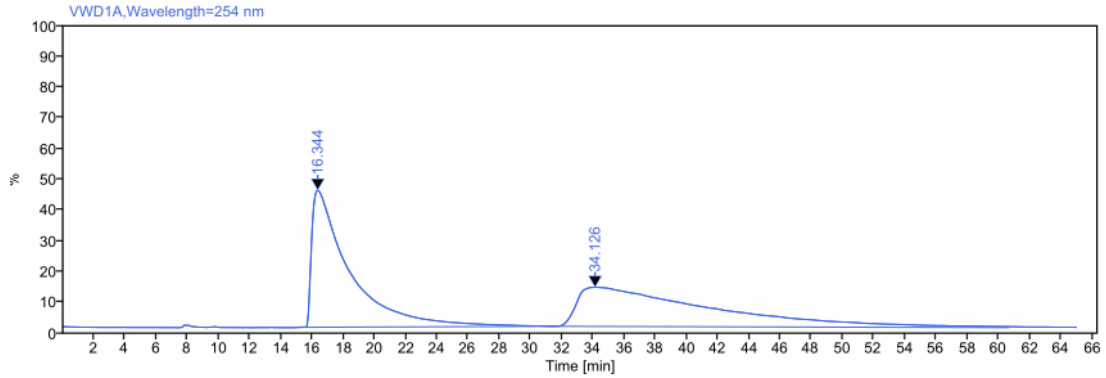
RT [min]	Type	Width [min]	Area	Height	Area%
27.789	MM m	9.36	1527.40	4.99	4.90
47.191	MM m	52.35	29632.03	29.59	95.10



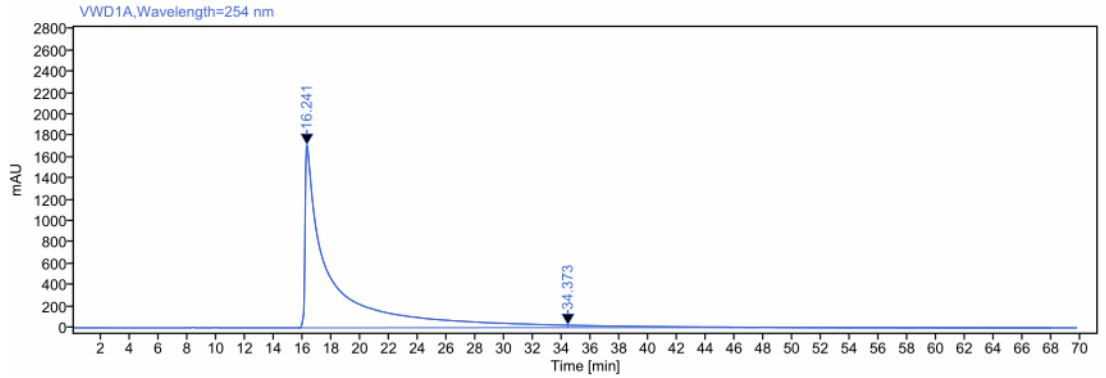
(*R*)- 1-((tert-butoxycarbonyl)(methyl)amino)-2-methyl-5-(p-tolyl)-1H-pyrrole-3-carboxylic acid (6)

Colorless oil. $[\alpha]_D^{25}$ = – 63.8 (*c* 0.27, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.46 (d, J =

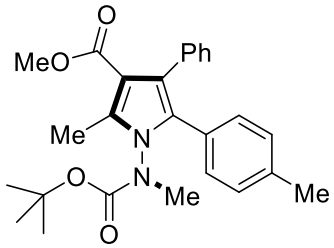
73.3, 9H), 2.43 (d, J = 40.1, 6H), 3.05 (d, J = 51.9, 3H), 6.66 (s, 1H), 7.14-7.27 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.4, 170.2, 154.2, 138.4, 138.2, 137.7, 132.4, 129.5, 129.4, 128.2, 128.1, 127.5, 109.8, 108.2, 107.8, 82.6, 82.4, 38.7, 37.5, 28.3, 28.2, 21.4, 21.3, 10.7, 10.7. HRMS (ESI) calcd for $C_{19}H_{24}N_2O_4$ *m/z* $[M+H]^+$: 345.1809, found: 345.1817. Enantiomeric excess was found to be 92% by chiral HPLC (ChiralPak IC column, hexane/*i*-PrOH = 80:20, 0.7 ml/min, t_{major} = 34.1 min, t_{minor} = 16.3 min).



RT [min]	Type	Width [min]	Area	Height	Area%
16.344	MM m	16.41	10772.49	64.03	49.98
34.126	MM m	29.02	10781.39	18.25	50.02



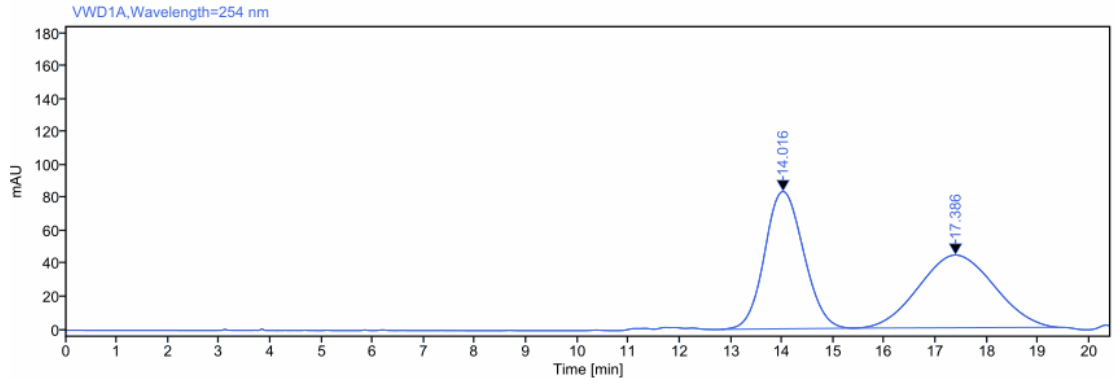
RT [min]	Type	Width [min]	Area	Height	Area%
16.241	VM m	18.70	207020.97	1713.93	95.92
34.373	MM m	33.58	8800.91	21.72	4.08



(*R*)-methyl 1-((tert-butoxycarbonyl)(methyl)amino)-2-methyl-4-phenyl-5-(p-tolyl)-1H-pyrrole-3-carboxylate (7)

Yellow oil. $[\alpha]_D^{25}$ = – 91.6 (*c* 0.31, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.47 (d, J =

42.9, 9H), 2.37 (d, J = 73.4, 6H), 2.98 (d, J = 47.7, 3H), 3.62 (d, J = 11.9, 3H), 7.00 (d, J = 11.1, 4H), 7.16 (d, J = 11.0, 5H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.1, 154.2, 137.6, 137.4, 136.0, 135.3, 130.9, 130.8, 130.5, 130.4, 130.3, 129.0, 128.9, 127.4, 127.3, 126.1, 126.0, 122.2, 82.4, 82.2, 50.8, 50.7, 38.8, 37.7, 28.3, 28.3, 21.4, 21.4, 11.0, 10.9. HRMS (ESI) calcd for $C_{26}H_{30}N_2O_4$ *m/z* $[M+H]^+$: 435.2278, found: 435.2269. Enantiomeric excess was found to be 92% by chiral HPLC (ChiralPak IF column, hexane/*i*-PrOH = 99:1, 1 ml/min, t_{major} = 13.4 min, t_{minor} = 16.8 min).



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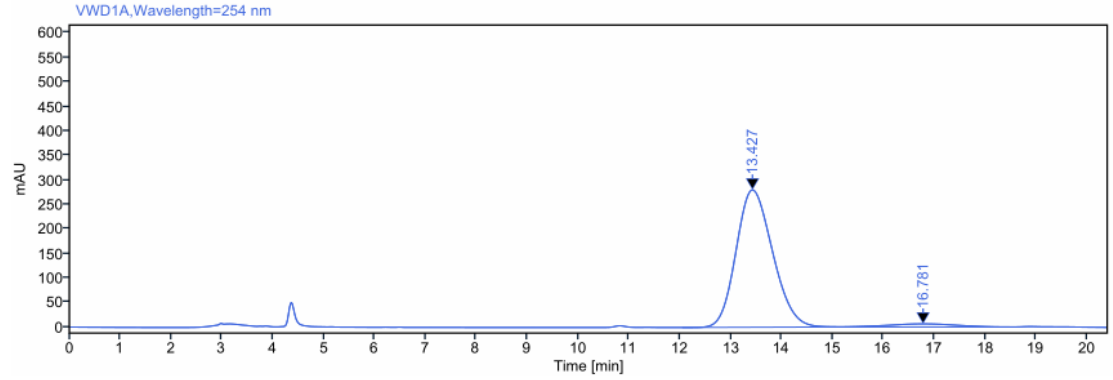
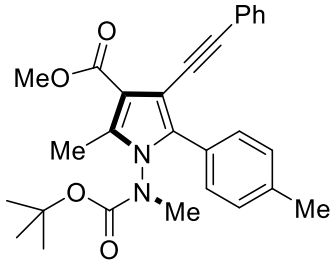
14.016	MM m	2.57	4416.07	83.34	49.44
17.386	MM m	3.99	4516.13	44.12	50.56

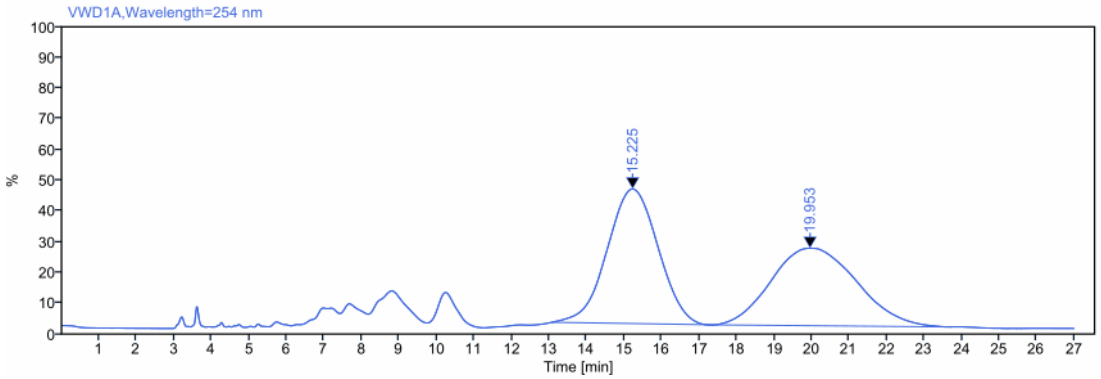


RT [min]	Type	Width [min]	Area	Height	Area%
13.427	MM m	3.13	13996.05	280.45	96.11
16.781	MM m	3.30	566.00	6.22	3.89

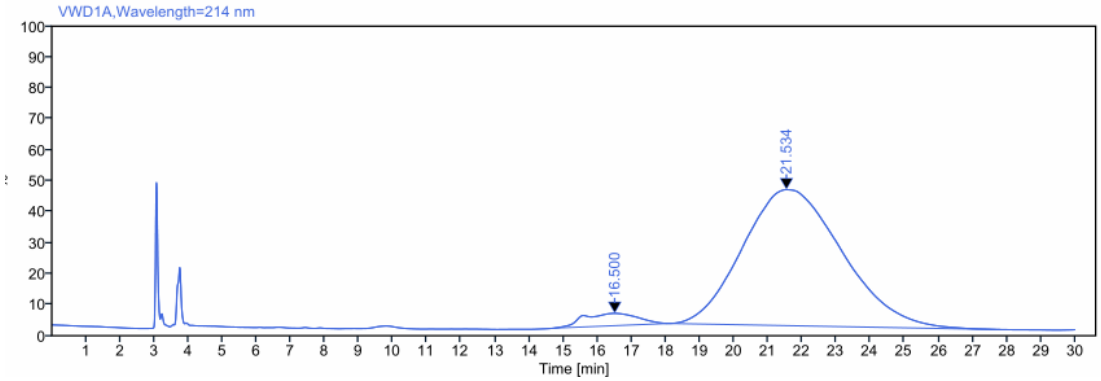


(*R*)-methyl 1-((tert-butoxycarbonyl)(methyl)amino)-2-methyl-4-(phenylethynyl)-5-(p-tolyl)-1H-pyrrole-3-carboxylate (8)

Colorless oil. $[\alpha]_D^{25}$ = – 69.5 (*c* 0.37, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 1.47 (d, *J* = 60.1, 9H), 2.43 (d, *J* = 23.3, 6H), 2.97 (d, *J* = 48.7, 3H), 3.91 (d, *J* = 10.1, 3H), 7.26 (q, *J* = 6.4, 7.4, 6H), 7.33-7.50 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.7, 152.0, 141.1, 137.5, 137.3, 133.0, 129.4, 129.0, 128.1, 127.4, 124.9, 110.8, 107.5, 83.4, 51.2, 28.0, 21.3, 10.8. HRMS (ESI) calcd for $C_{28}H_{30}N_2O_4$ *m/z* $[M+H]^+$: 459.2278, found: 459.2282. Enantiomeric excess was found to be 91% by chiral HPLC (ChiralPak IC column, hexane/*i*-PrOH = 96:4, 1 ml/min, t_{major} = 21.5 min, t_{minor} = 16.5 min).



RT [min]	Type	Width [min]	Area	Height	Area%
15.225	MM m	4.34	738.34	7.84	50.81
19.953	MM m	6.30	714.70	4.51	49.19



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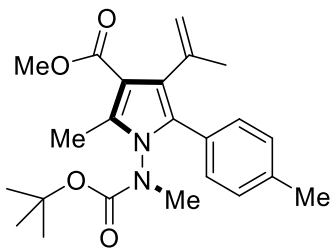
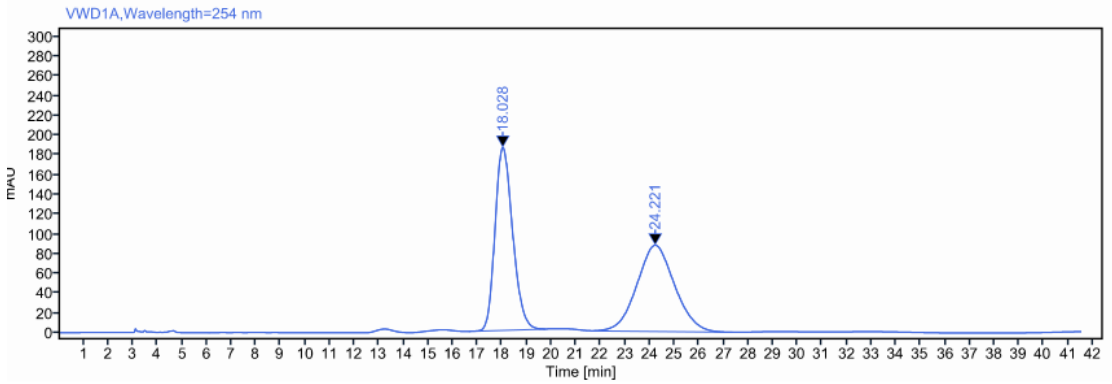
16.500	MM m	3.36	1009.79	9.05	4.72
21.534	BB	9.70	20379.68	100.37	95.28



(*R*)-methyl 1-((tert-butoxycarbonyl)(methyl)amino)-2-methyl-4-(prop-1-en-2-yl)-5-(p-tolyl)-1H-pyrrole-3-carboxylate (9)

Colorless oil. $[\alpha]_D^{25}$ = – 55.2 (*c* 0.72, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 1.43 (d, *J* = 37.7, 9H), 1.95 (s, 3H), 2.37 (d, *J* = 16.7, 6H), 2.94 (d, *J* = 43.5, 3H), 3.79 (dd, *J* = 2.6, 11.0, 3H), 4.67 (d, *J* = 9.6, 1H), 4.96 (s, 1H), 7.09-7.22 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.2, 139.7, 137.9, 137.7, 135.7, 130.3, 130.1, 129.0, 128.8, 127.8, 127.8, 115.9, 115.8, 82.3, 51.0, 50.9, 38.8, 37.7, 28.2, 25.0, 24.9, 21.5, 21.5, 10.9, 10.9. HRMS (ESI) calcd for $C_{23}H_{31}N_2O_4$ *m/z* $[M+H]^+$: 399.2278, found: 399.2283. Enantiomeric excess was found to be 90% by chiral HPLC (ChiralPak IC column, hexane/*i*-PrOH = 99:1, 1 ml/min, t_{major} = 18.4 min, t_{minor} = 25.0 min).



RT [min]	Type	Width [min]	Area	Height	Area%
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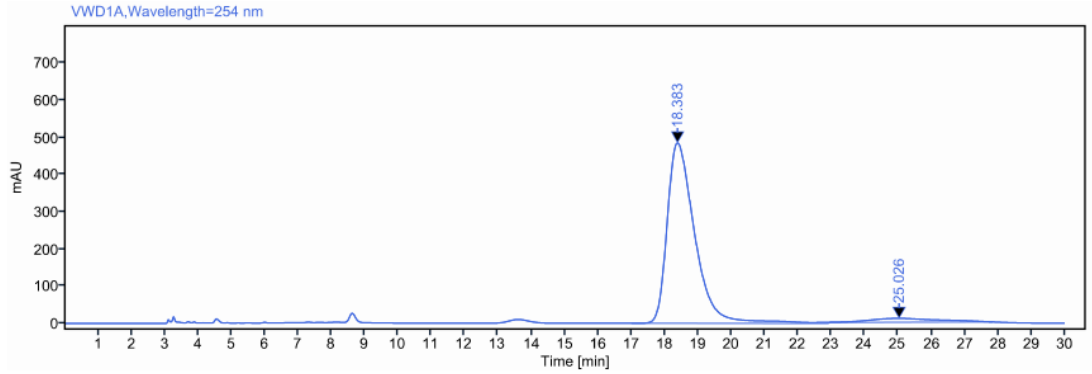
24.221	BB	5.67	9302.04	87.37	50.24



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18.383	BM m	5.91	27922.78	484.49	95.00
25.026	MM m	4.90	1468.15	10.18	5.00

(J) References

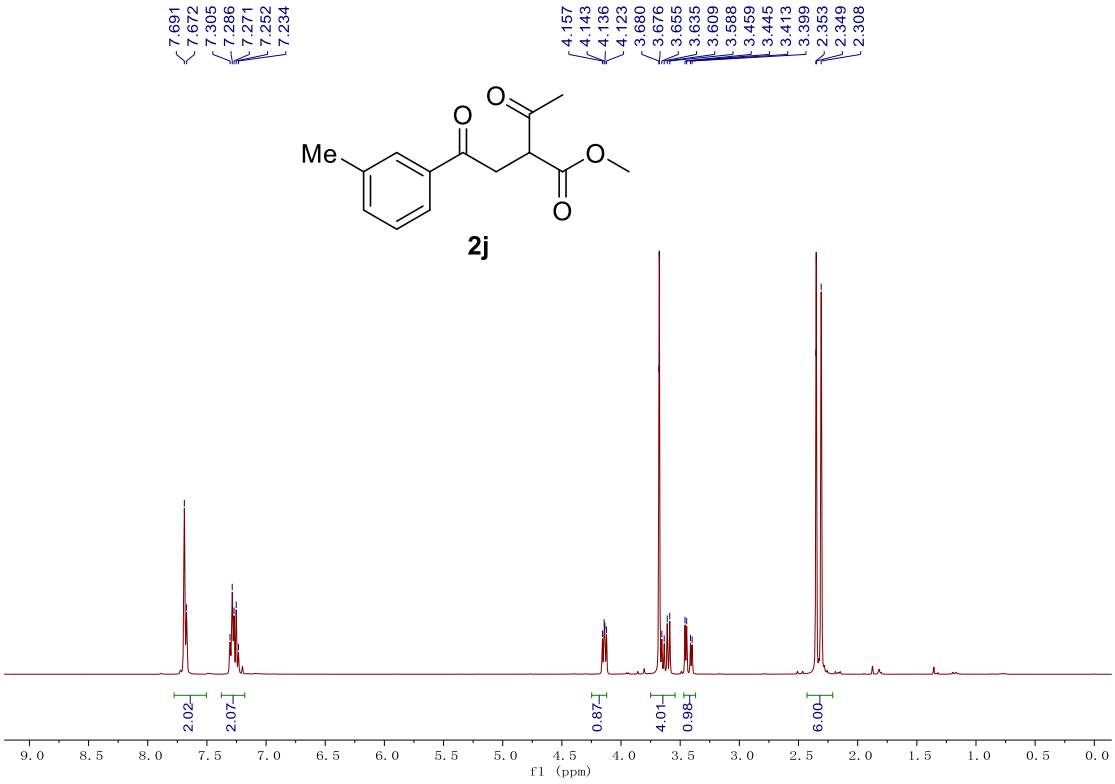
[1] Matheson, C. J.; Casalvieri, K. A.; Backos, D. S.; et al. Development of Potent Pyrazolopyrimidinone-Based WEE1 Inhibitors with Limited Single-Agent Cytotoxicity for Cancer Therapy. *ChemMedChem*, **2018**, *13*, 1681–1694.

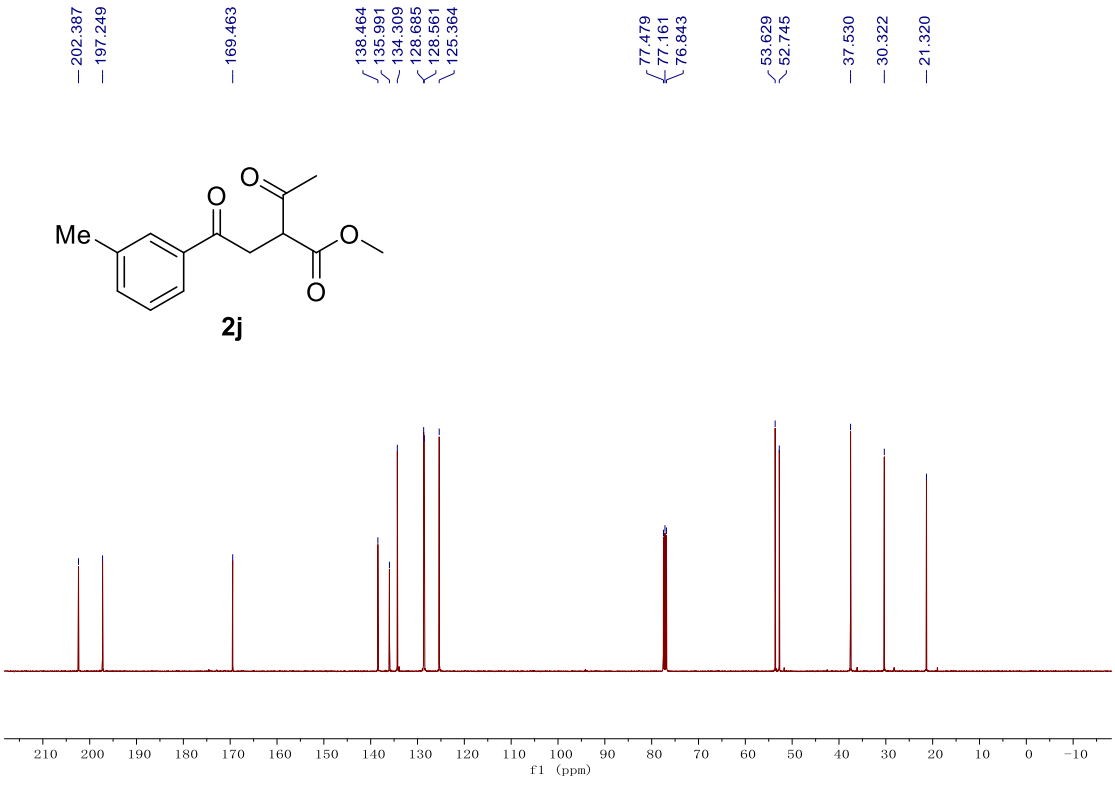
[2] Strick, B. F.; Mundal, D. A.; Thomson, R. J. An oxidative [2, 3]-sigmatropic rearrangement of allylic hydrazides. *J. Am. Chem. Soc.* **2011**, *133*, 14252–14255.

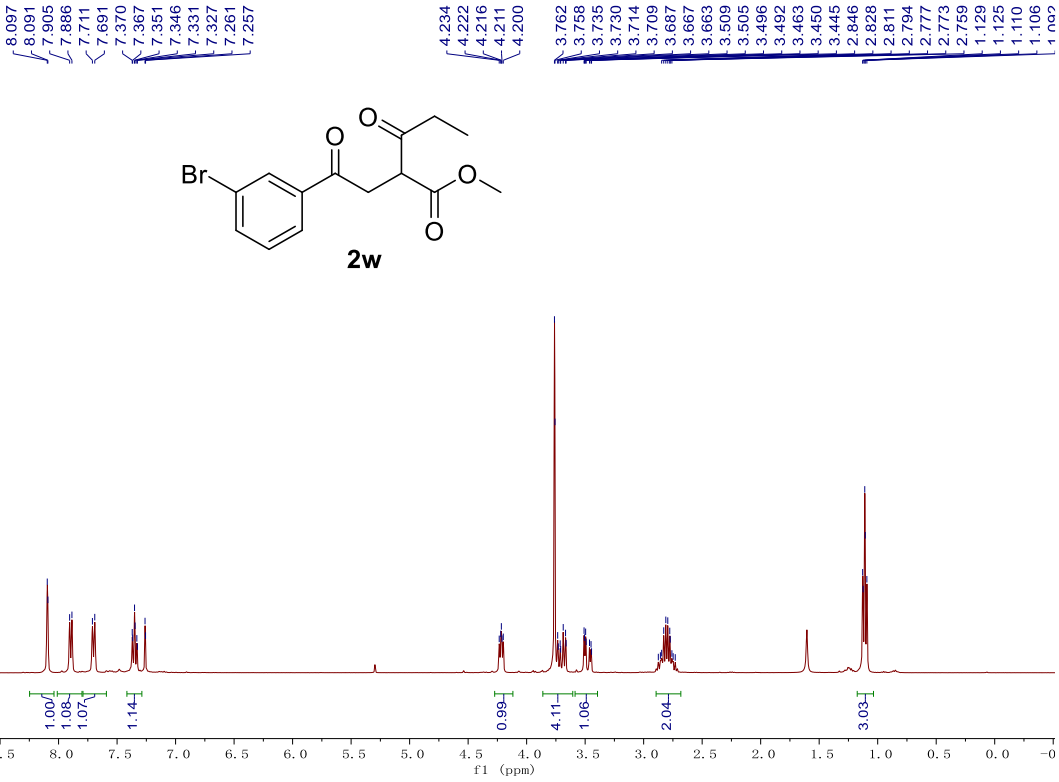
[3] Wei, Y.; Sun, F.; Li, G.; et al. Enantioselective synthesis of N–N amide–pyrrole atropisomers via Paal–Knorr reaction. *Org. Lett.* **2023**, *26*, 2343–2348.

[4] Lin, J. S.; Li, T. T.; Liu, J. R.; et al. Cu/chiral phosphoric acid-catalyzed asymmetric three-component radical-initiated 1, 2-dicarbofunctionalization of alkenes. *J. Am. Chem. Soc.* **2018**, *141*, 1074–1083.

(K) NMR Spectra



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7.257
4.234
4.222
4.216
4.211
4.200
3.762
3.758
3.735
3.730
3.714
3.709
3.687
3.667
3.663
3.509
3.505
3.496
3.492
3.463
3.450
3.445
2.846
2.828
2.811
2.794
2.777
2.773
2.759
1.129
1.125
1.110
1.106
Br
O
O
O
O
2w
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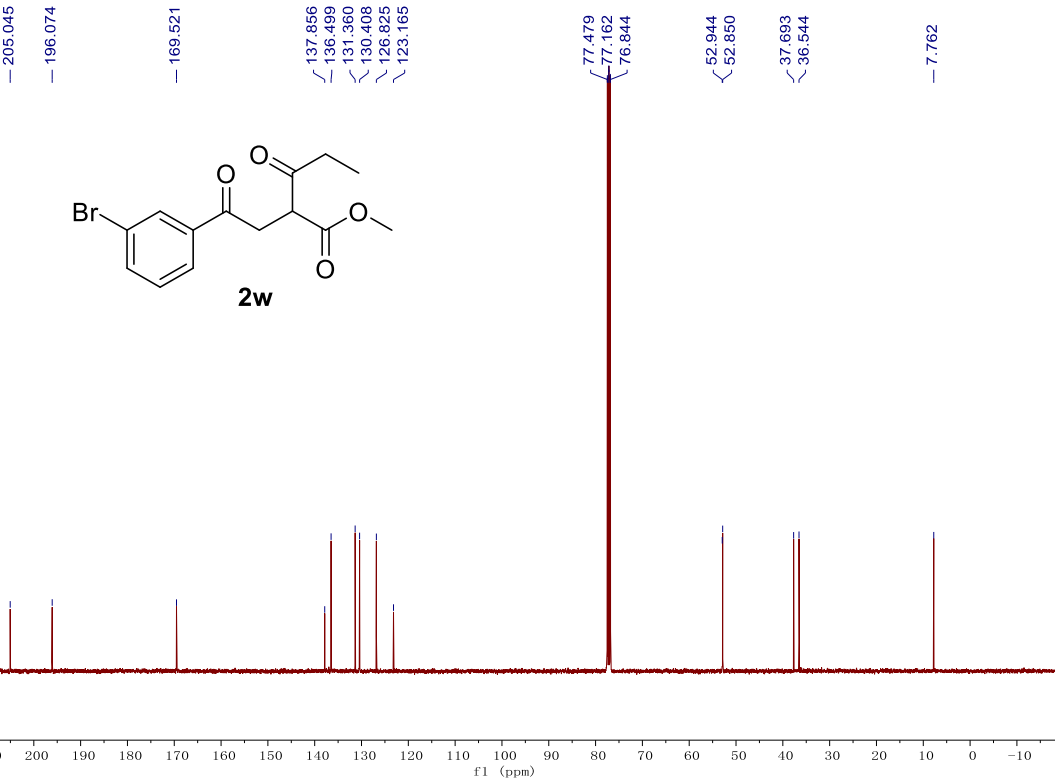
1.08
1.07
1.14
0.99
4.11
1.06
2.04
3.03
f1 (ppm)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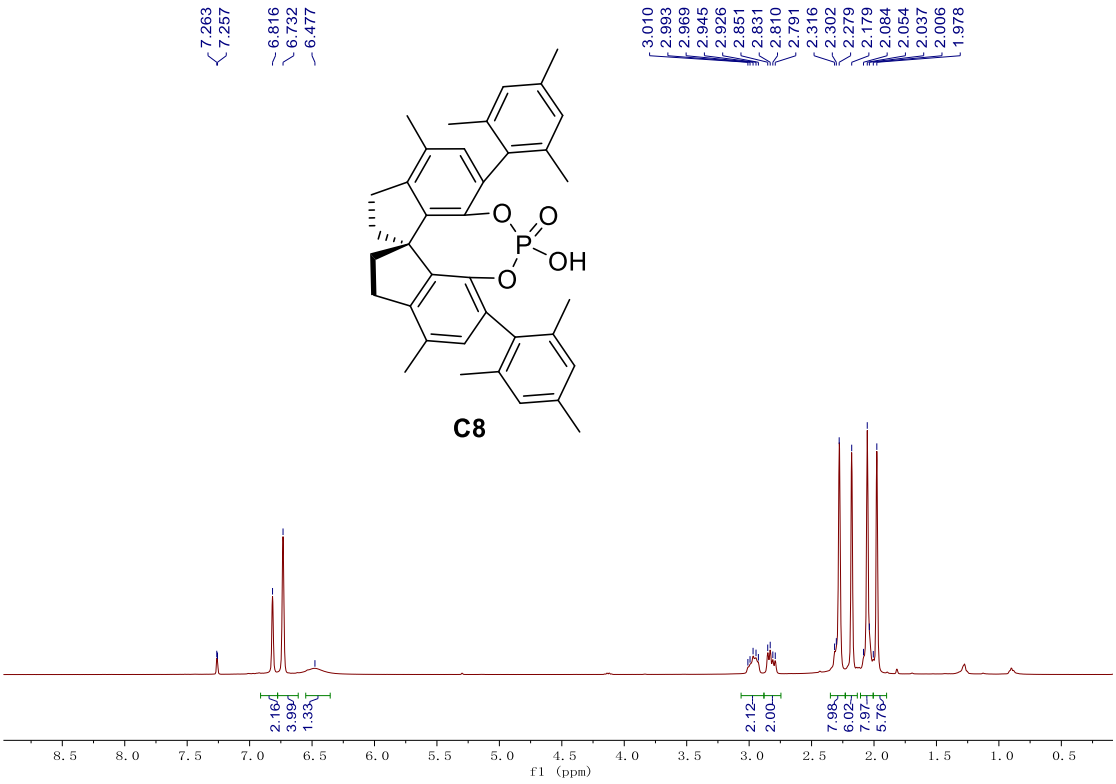
37.693
36.544
7.762
Br
O
O
O
O
2w
f1 (ppm)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6.477
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2.810
2.791
2.316
2.302
2.279
2.179
2.084
2.054
2.037
2.006
1.978
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O
P
OH
O
C8
2.16
3.99
1.33
2.12
2.00
7.98
6.02
7.97
5.76
8.5
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7.5
7.0
6.5
6.0
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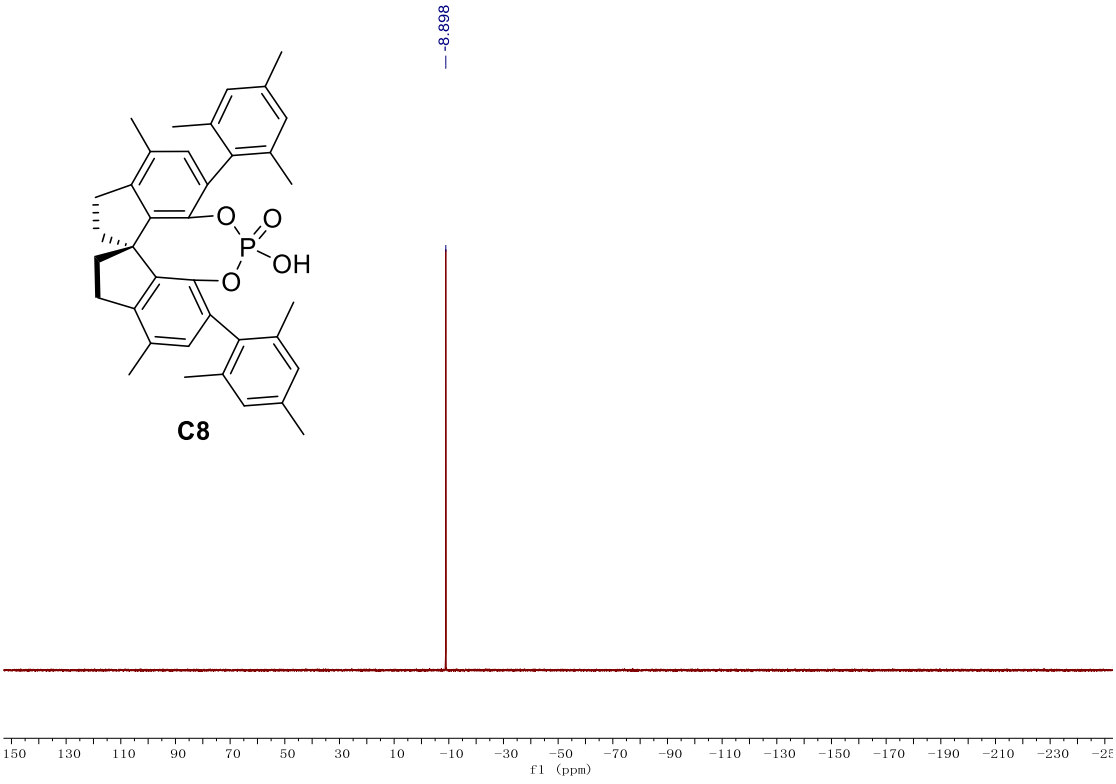
0.5
f1 (ppm)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P
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70
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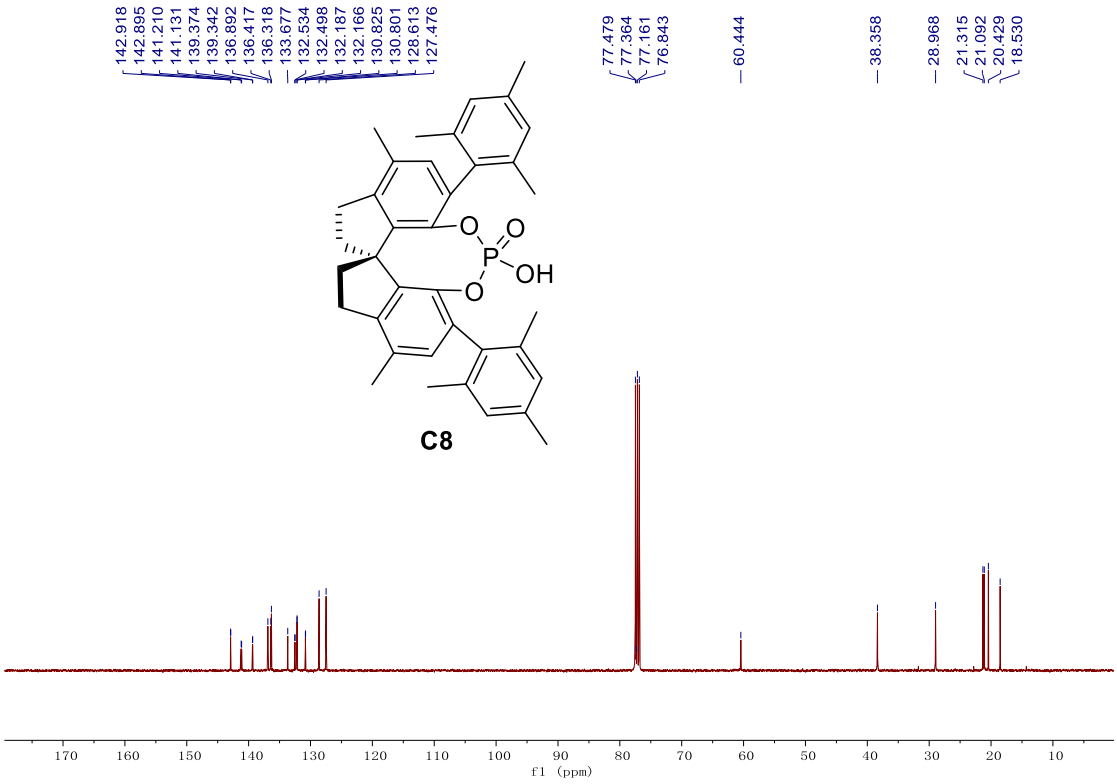
-170
-190
-210
-230
f1 (ppm)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132.187
132.166
130.825
130.801
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77.161
76.843
60.444
38.358
28.968
21.315
21.092
20.429
18.530
O
O
P
OH
O
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120
110
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90
80
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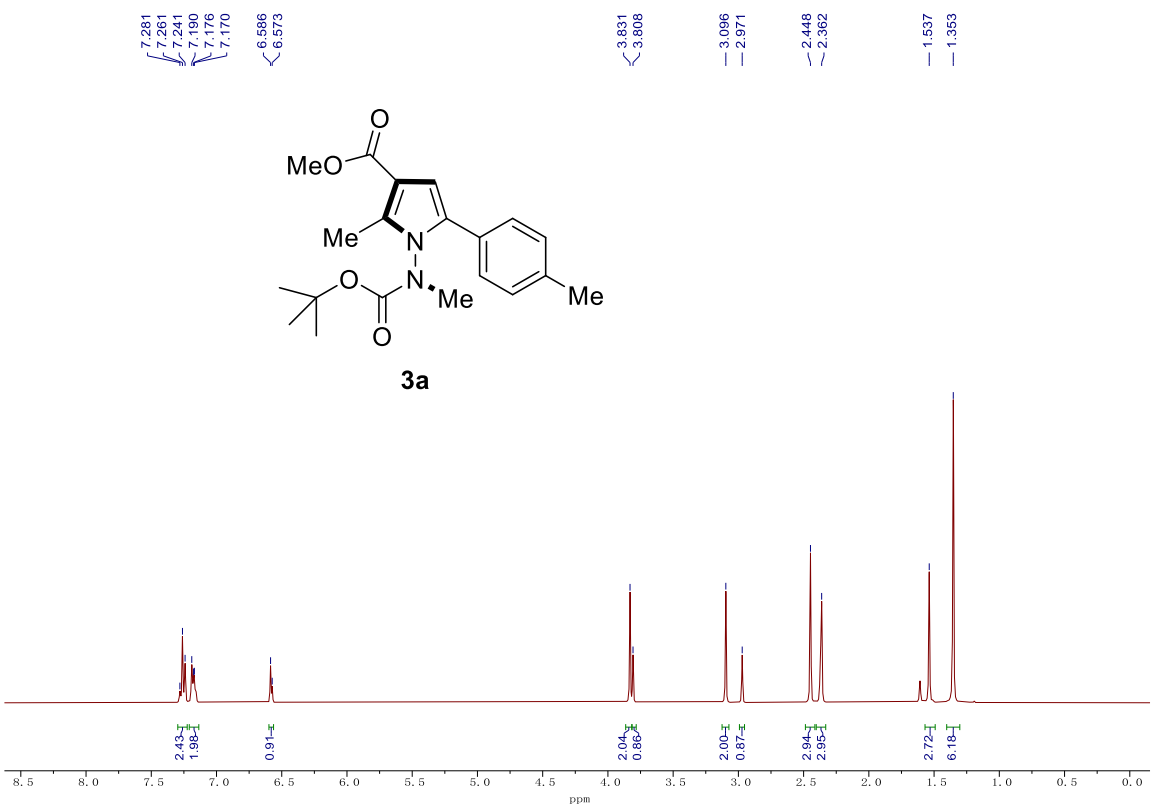
60
50
40
30
20
10
f1 (ppm)

C8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1.537
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N
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Me
O
O
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2.43
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2.04
0.86
2.00
0.87
2.94
2.95
2.72
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8.5
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7.5
7.0
6.5
6.0
5.5
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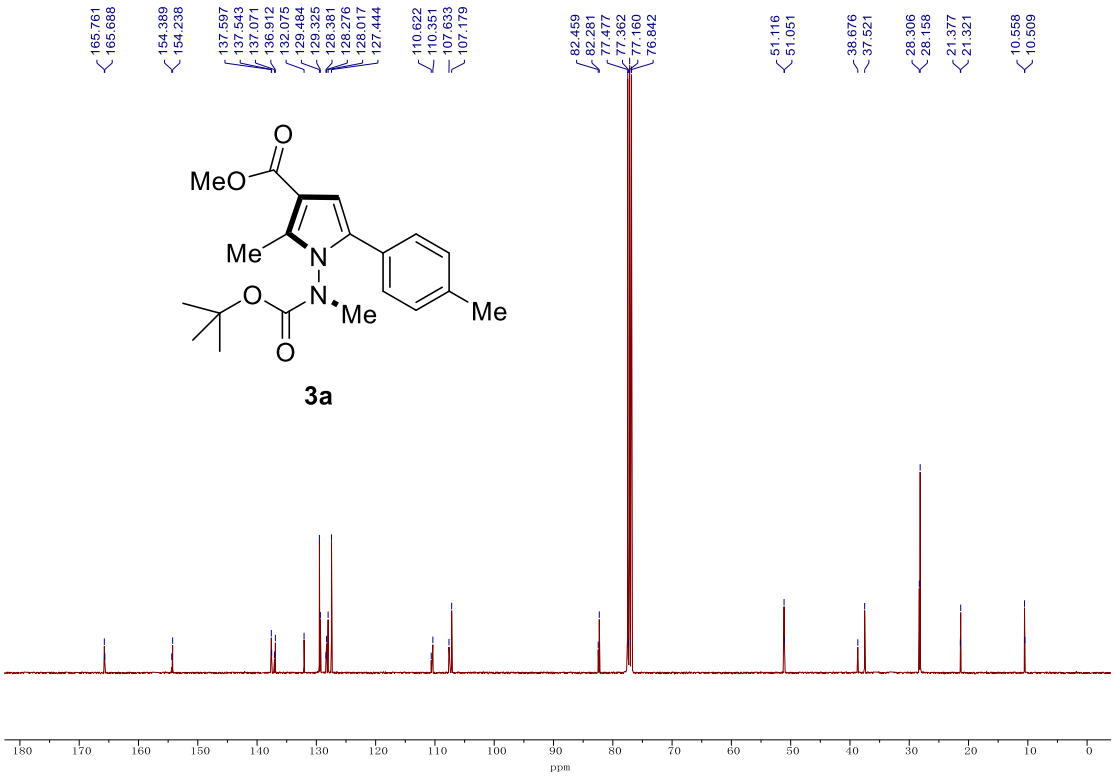
0.0
ppm

3a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128.017
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107.179
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82.281
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77.362
77.160
76.842
51.116
51.051
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37.521
28.306
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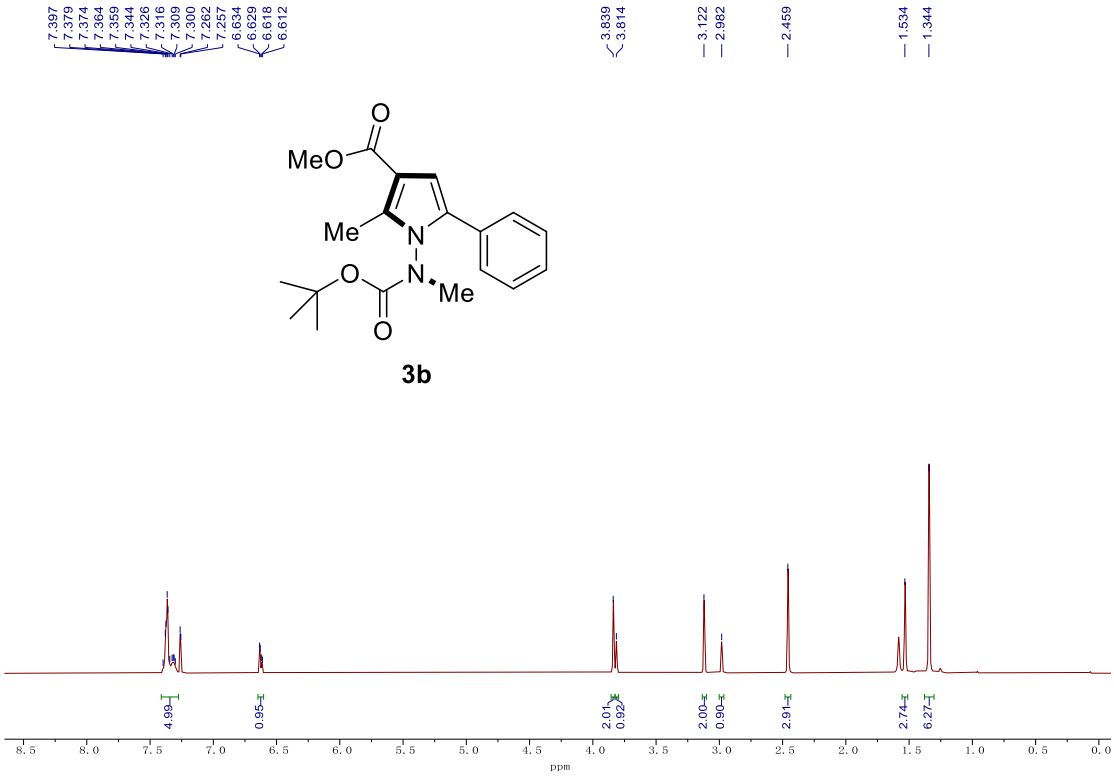
Me
O
O
ppm

3a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6.618
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3.839
3.814
3.122
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2.459
1.534
1.344
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Me
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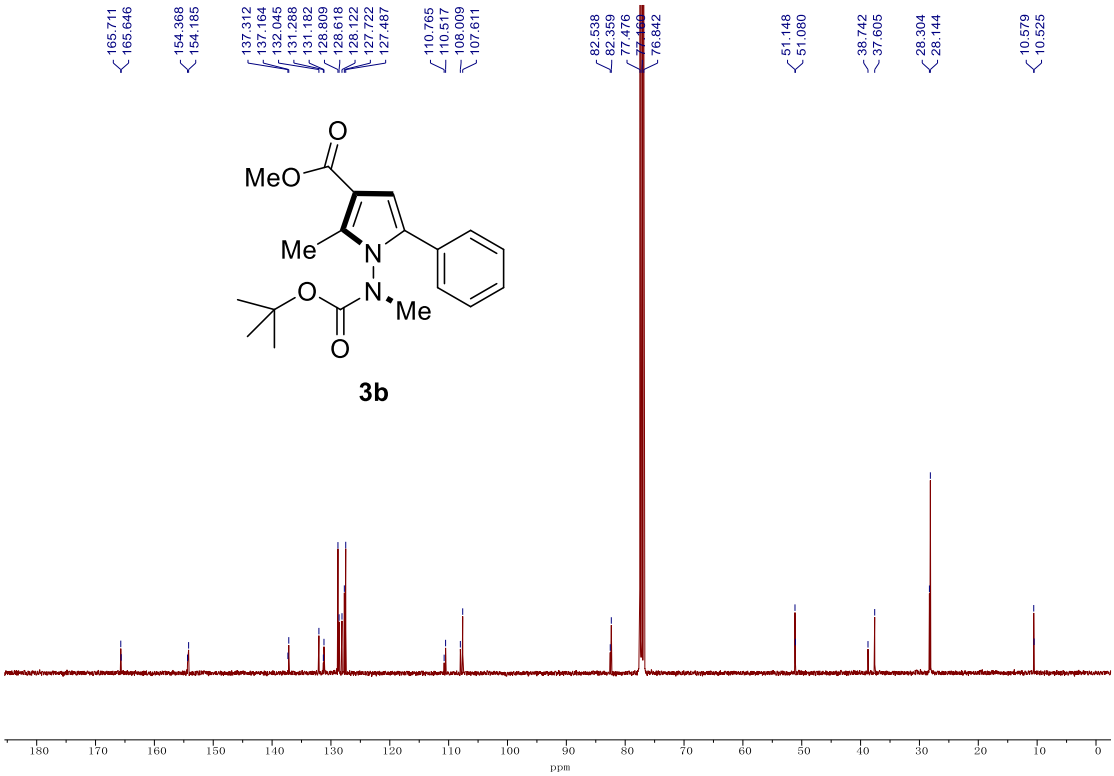
6.27
ppm

3b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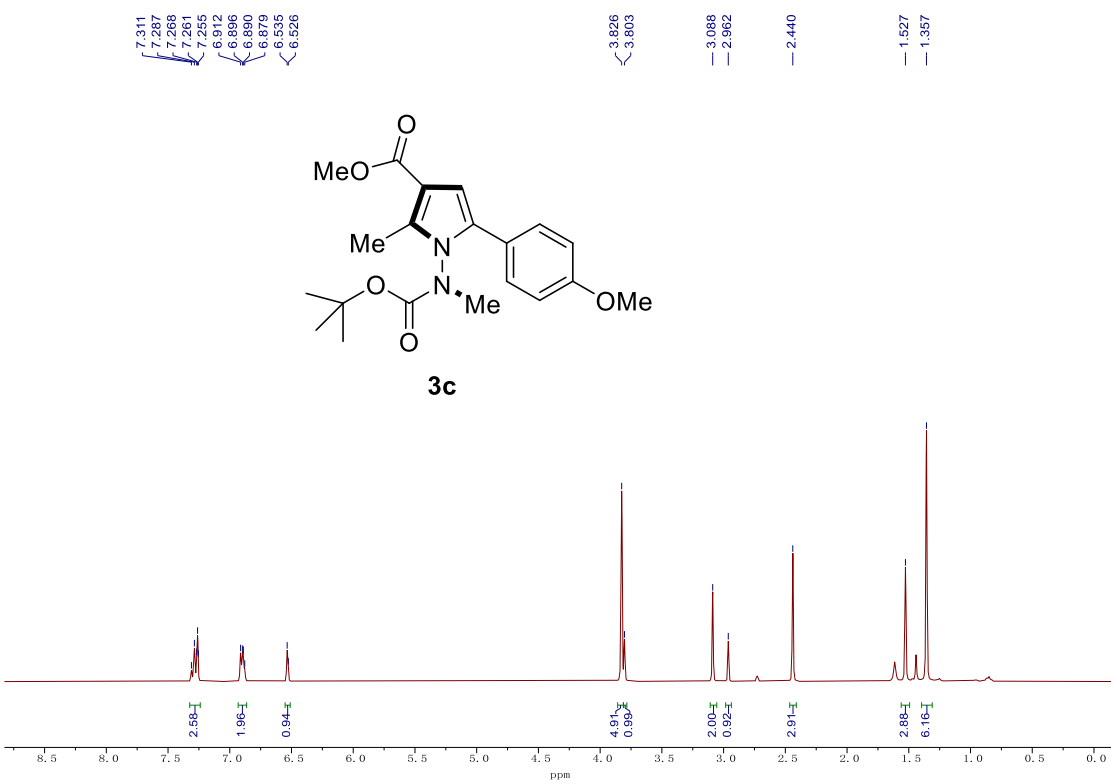
Me
O
O
ppm

3b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2.440
1.527
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Me
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O
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Me
OMe
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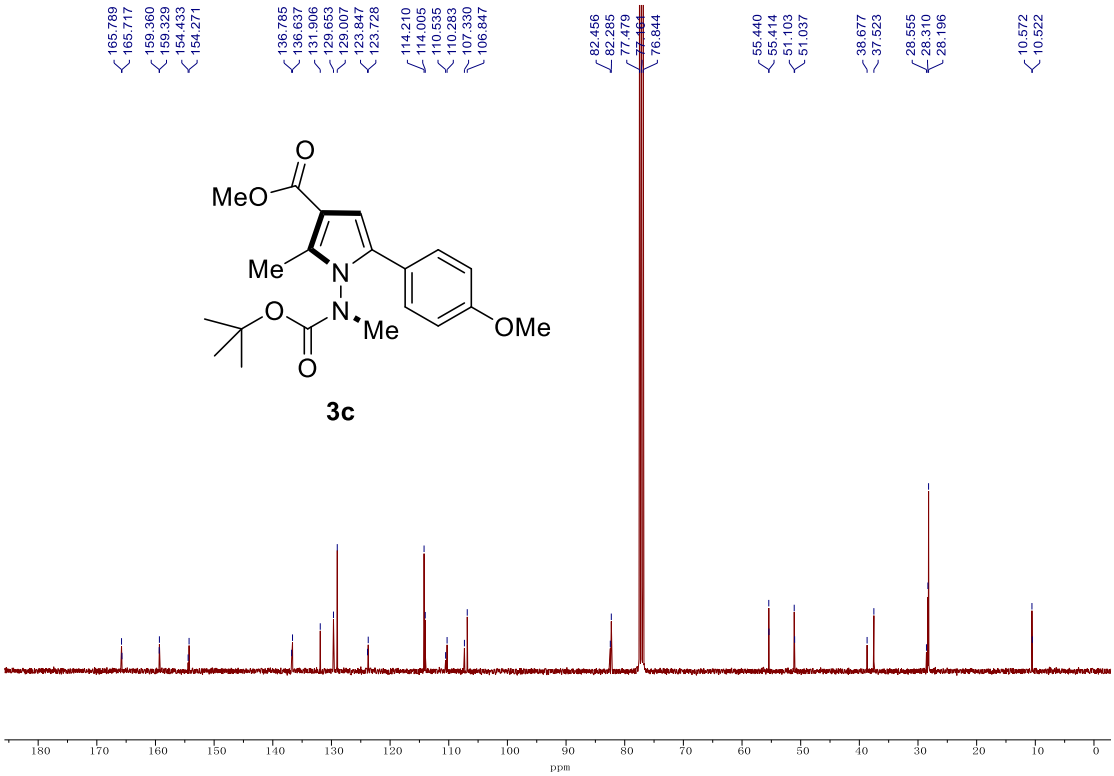
ppm

3c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114.005
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77.161
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55.440
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51.037
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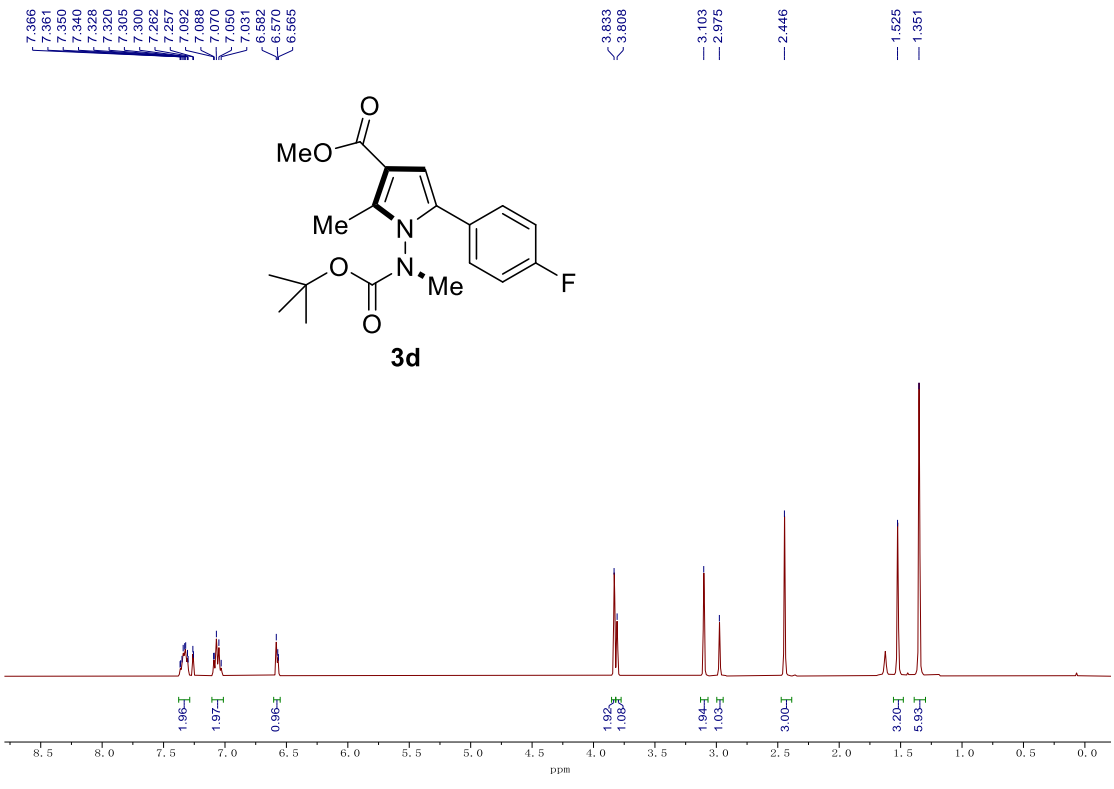
Me
O
O
O
OMe
ppm

3c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6.570
6.565
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3.808
3.103
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1.525
1.351
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N
N
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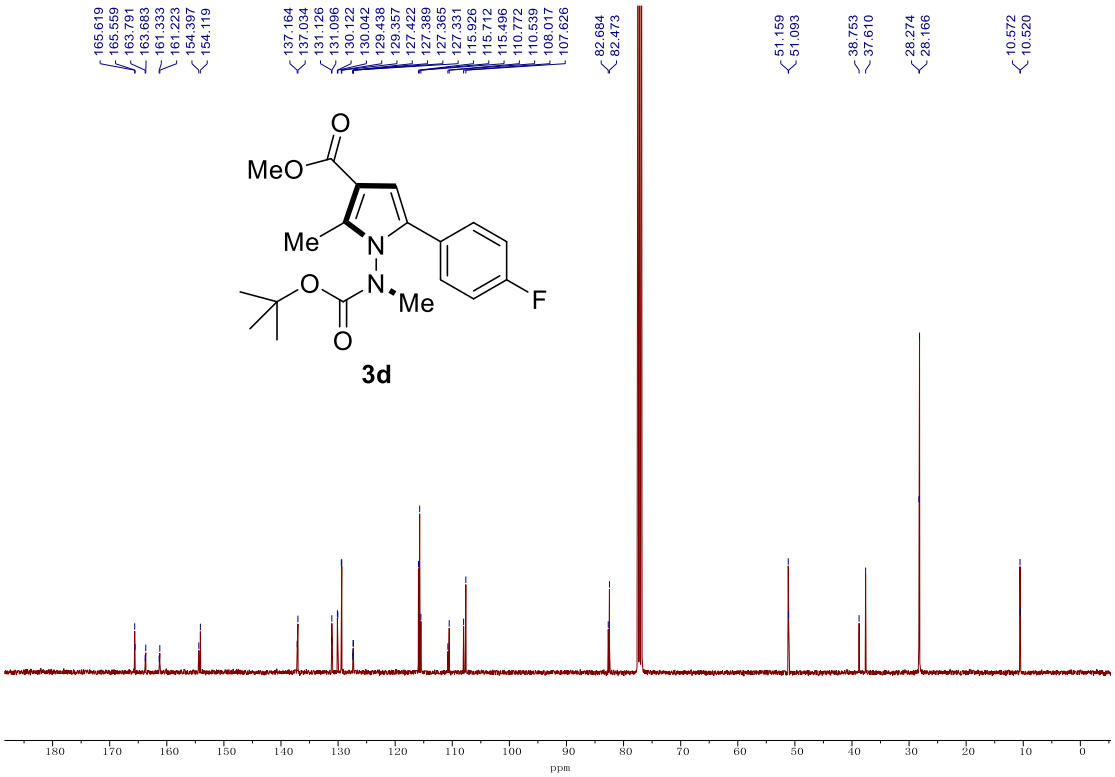
ppm

3d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3d
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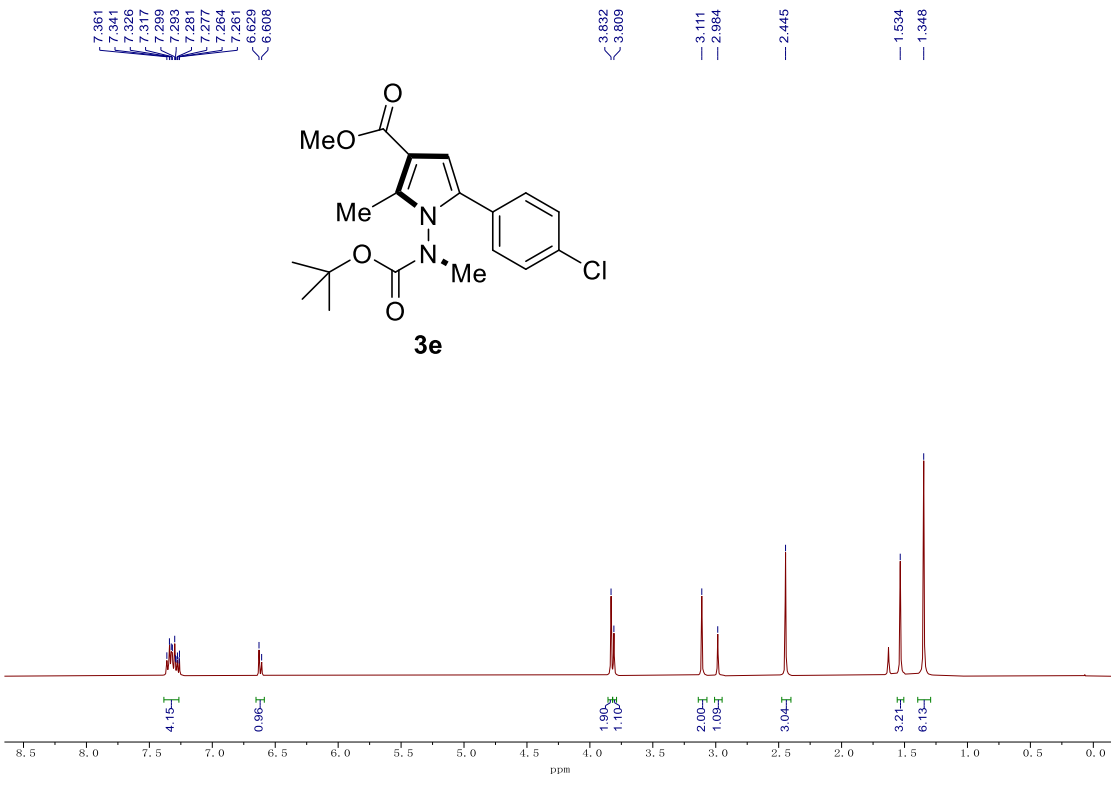
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3.809
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2.984
2.445
1.534
1.348
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N
O
N
Me
Cl
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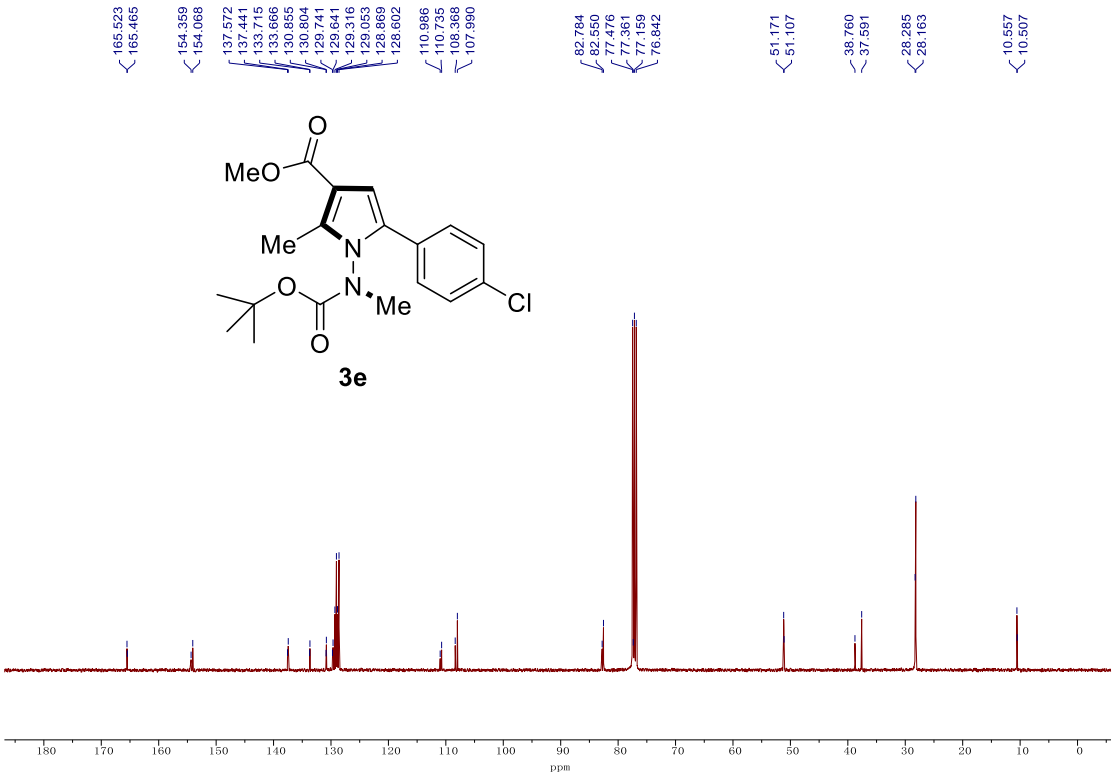
6.13
ppm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128.602
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110.735
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77.159
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51.107
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O
O
Cl
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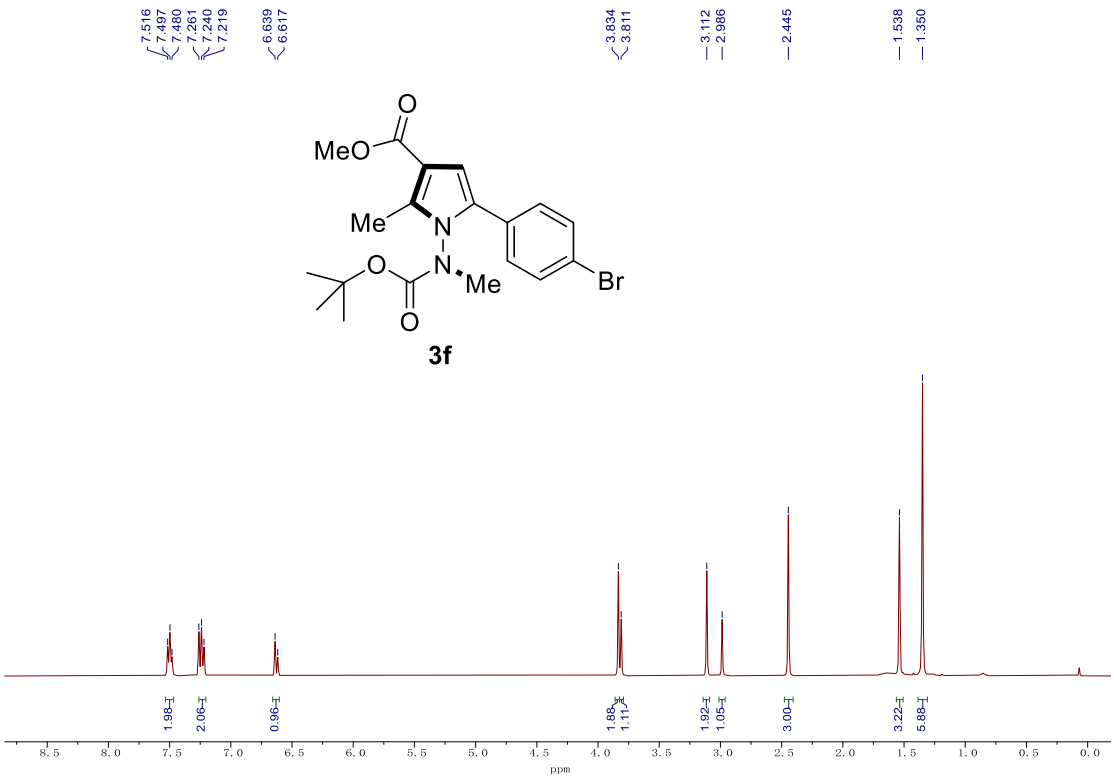
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O
O
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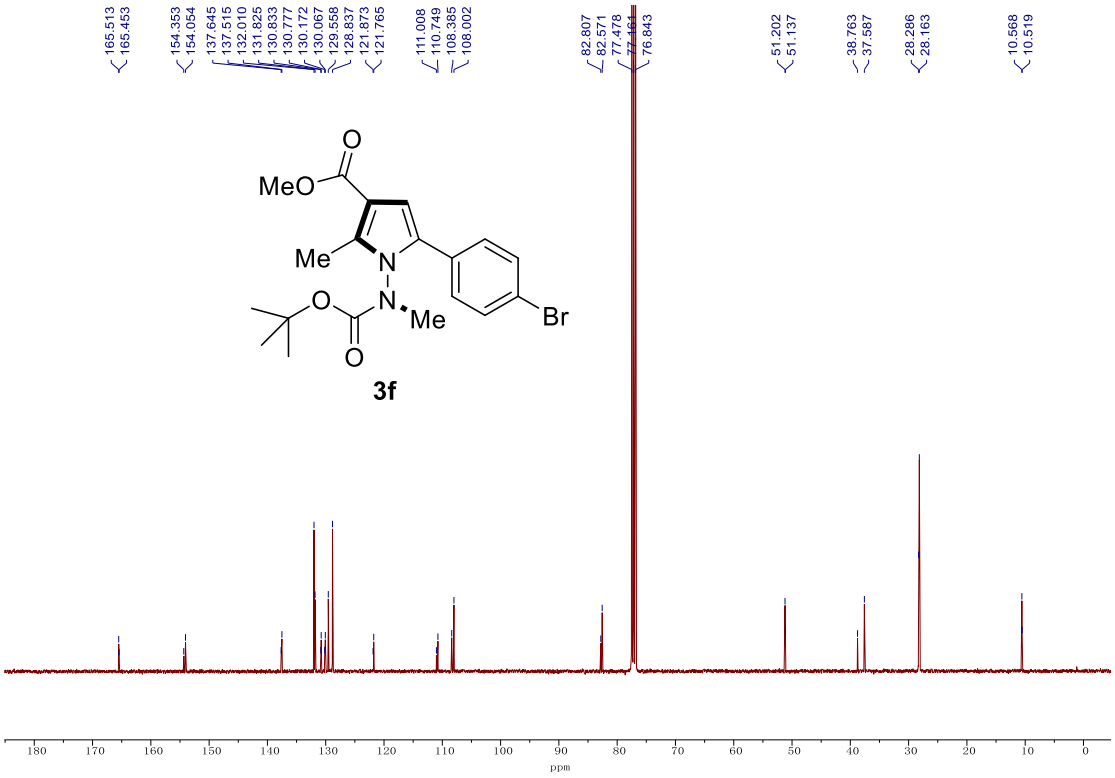
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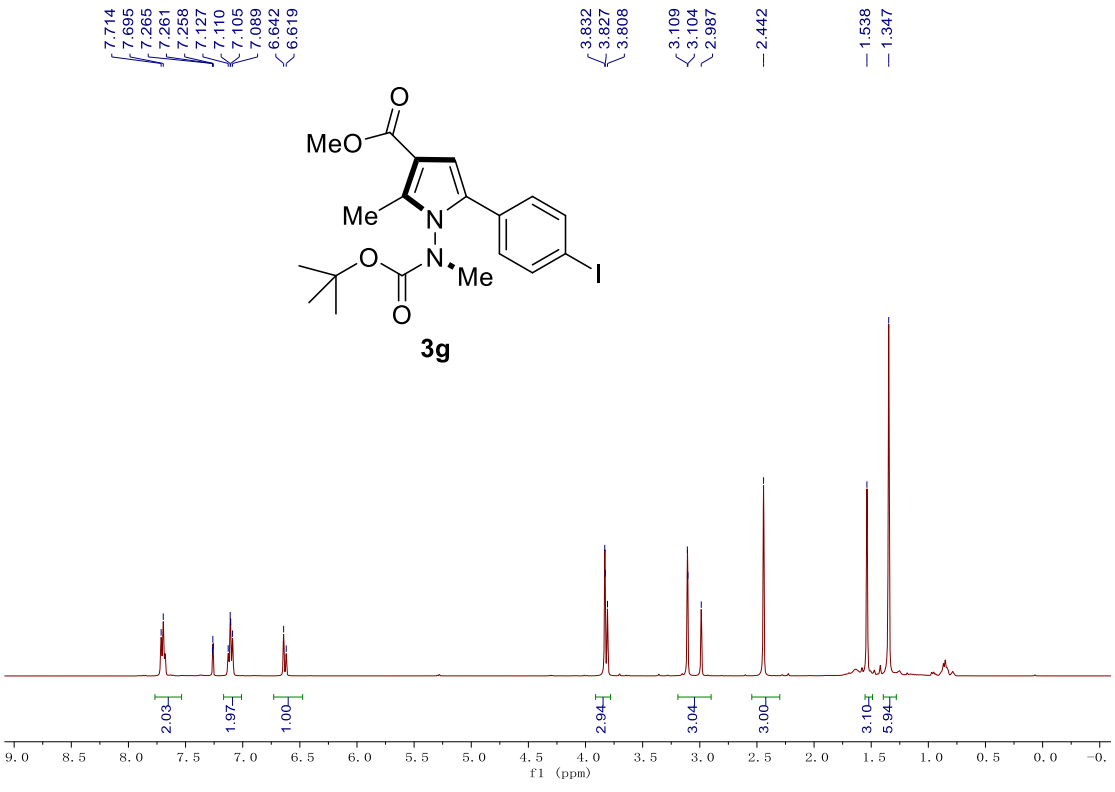
O
Br
3f
ppm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Me
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N
Me
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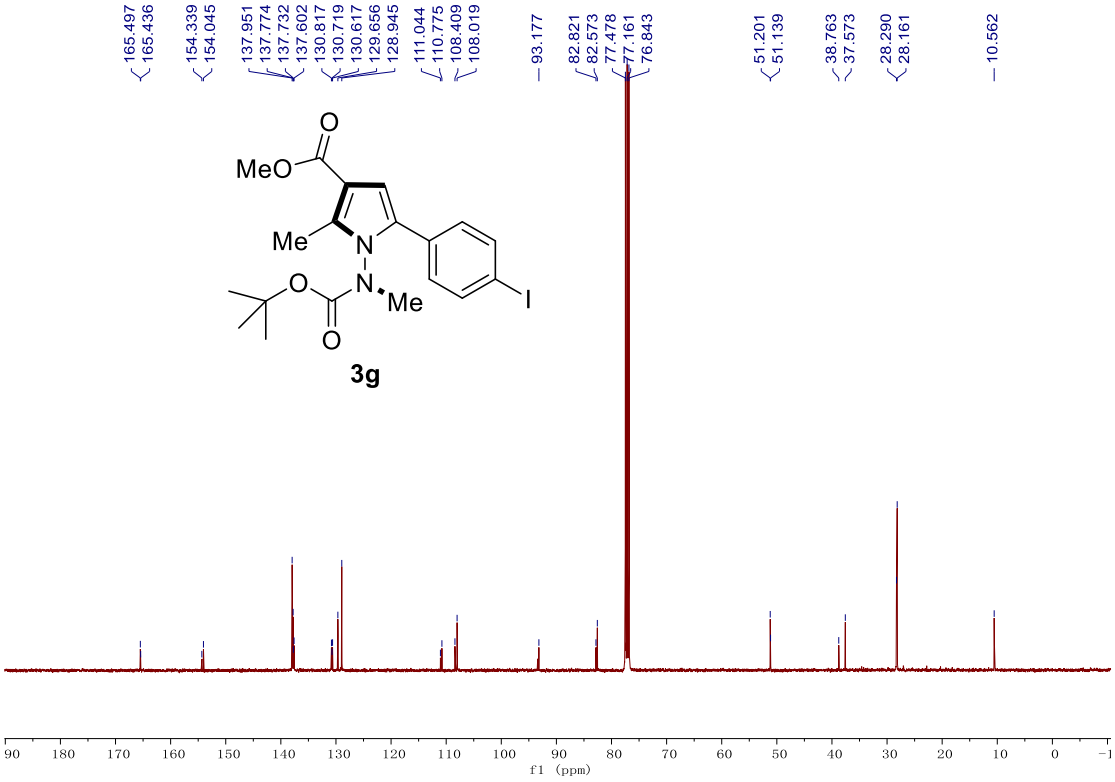
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108.409
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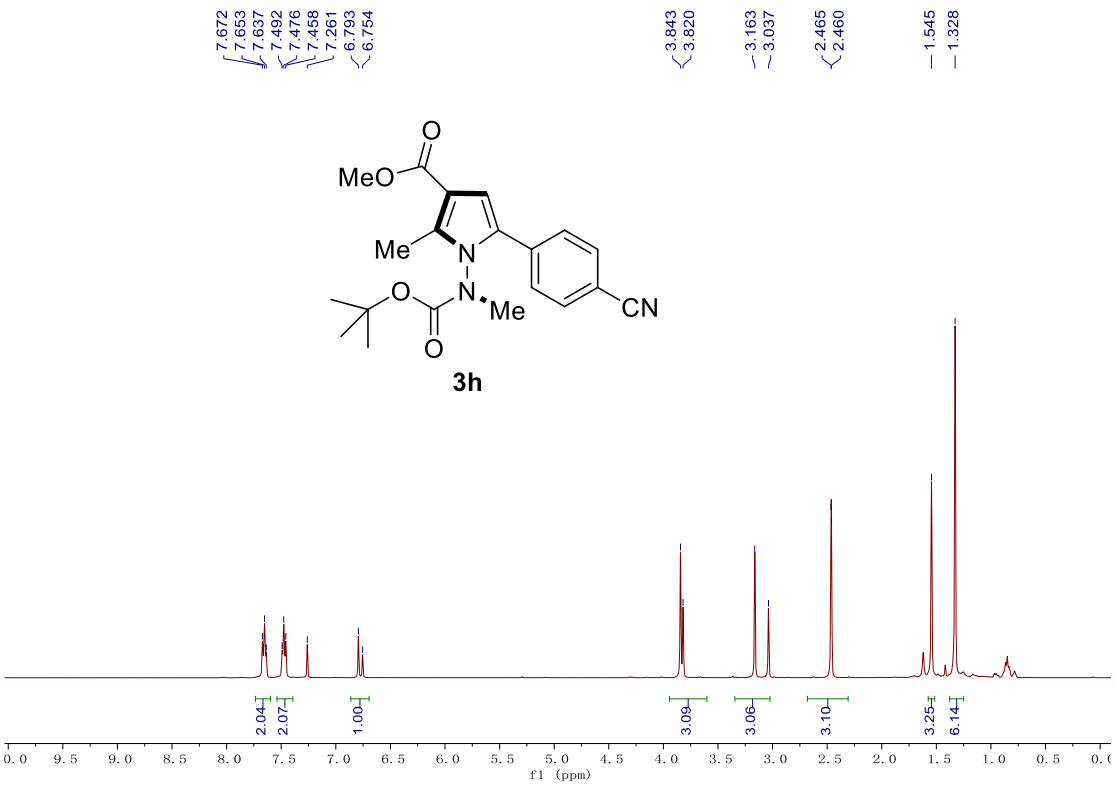
3g
f1 (ppm)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2.460
1.545
1.328
MeO
O
Me
N
N
Me
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2.04
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1.00
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3.06
3.10
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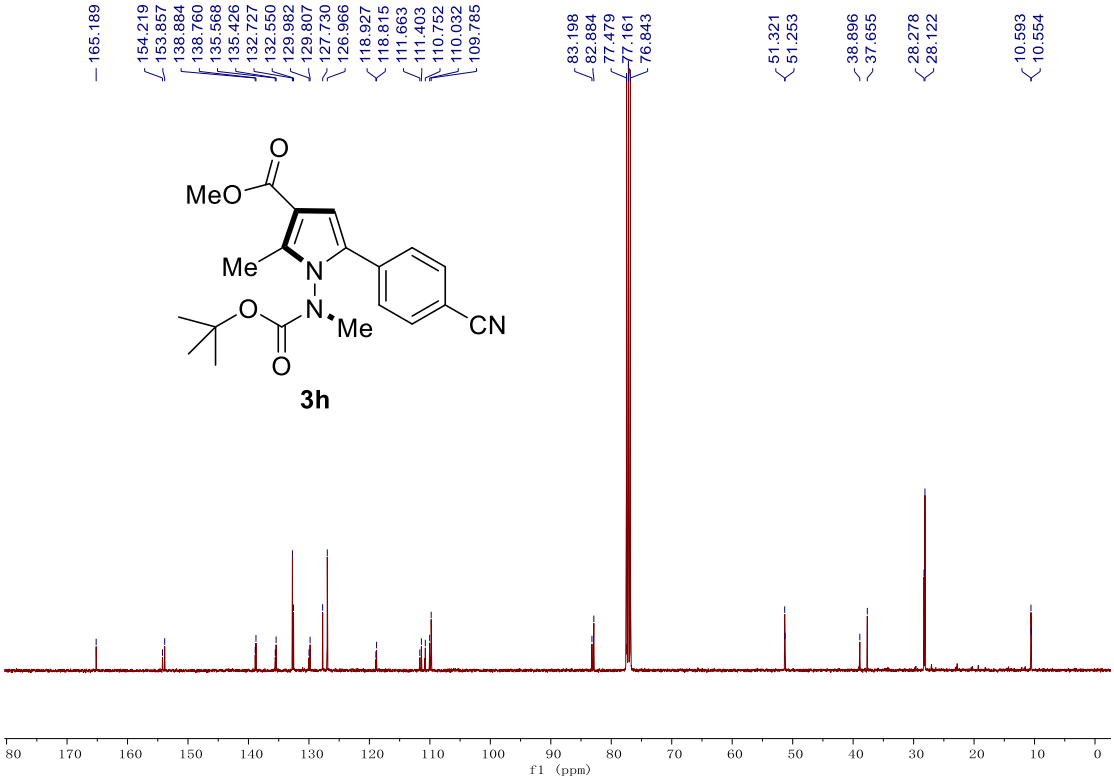
f1 (ppm)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37.655
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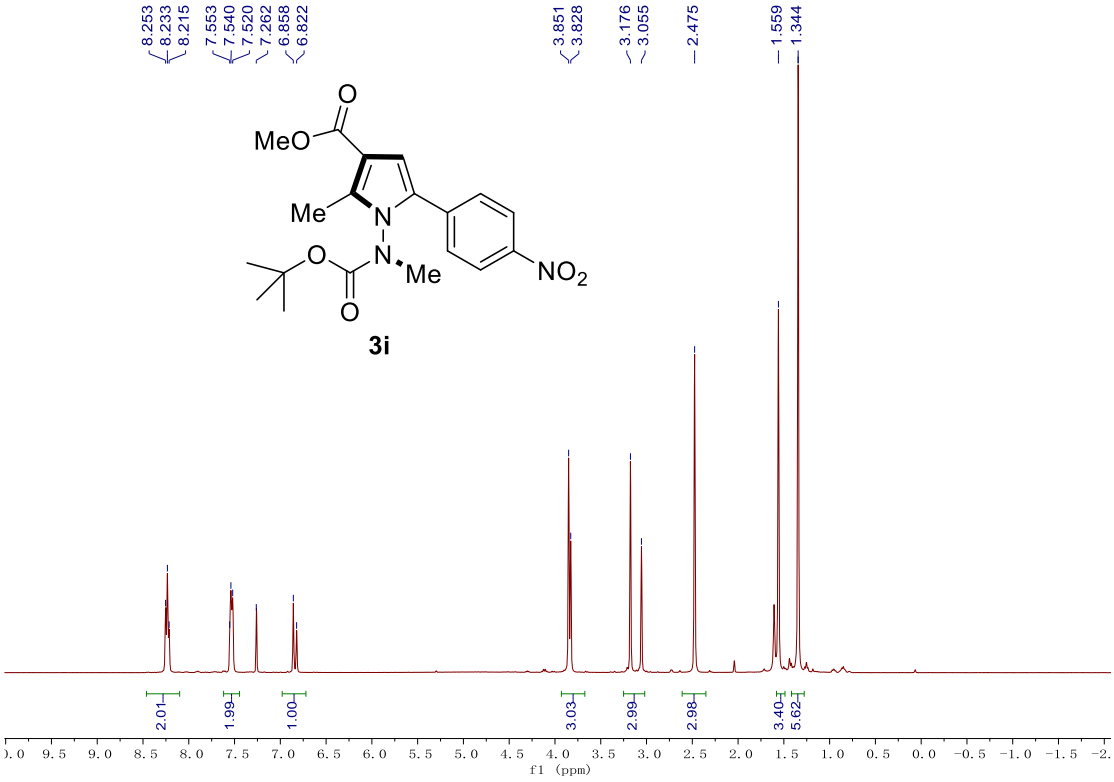
CN
3h
f1 (ppm)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3.176
3.055
2.475
1.559
1.344
MeO
Me
N
N
Me
O
O
O
O
NO2
3i
2.01
1.99
1.00
3.03
2.99
2.98
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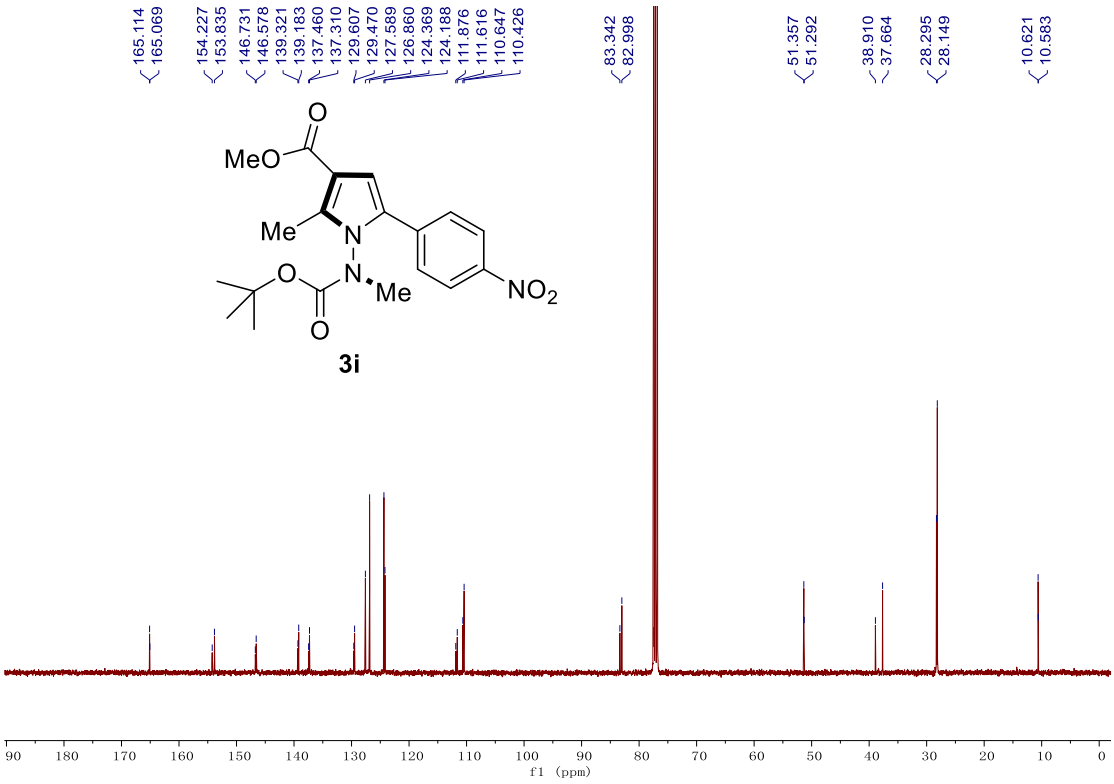
5.62
f1 (ppm)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127.589
126.860
124.369
124.188
111.876
111.616
110.647
110.426
83.342
82.998
51.357
51.292
38.910
37.664
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10.583
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Me
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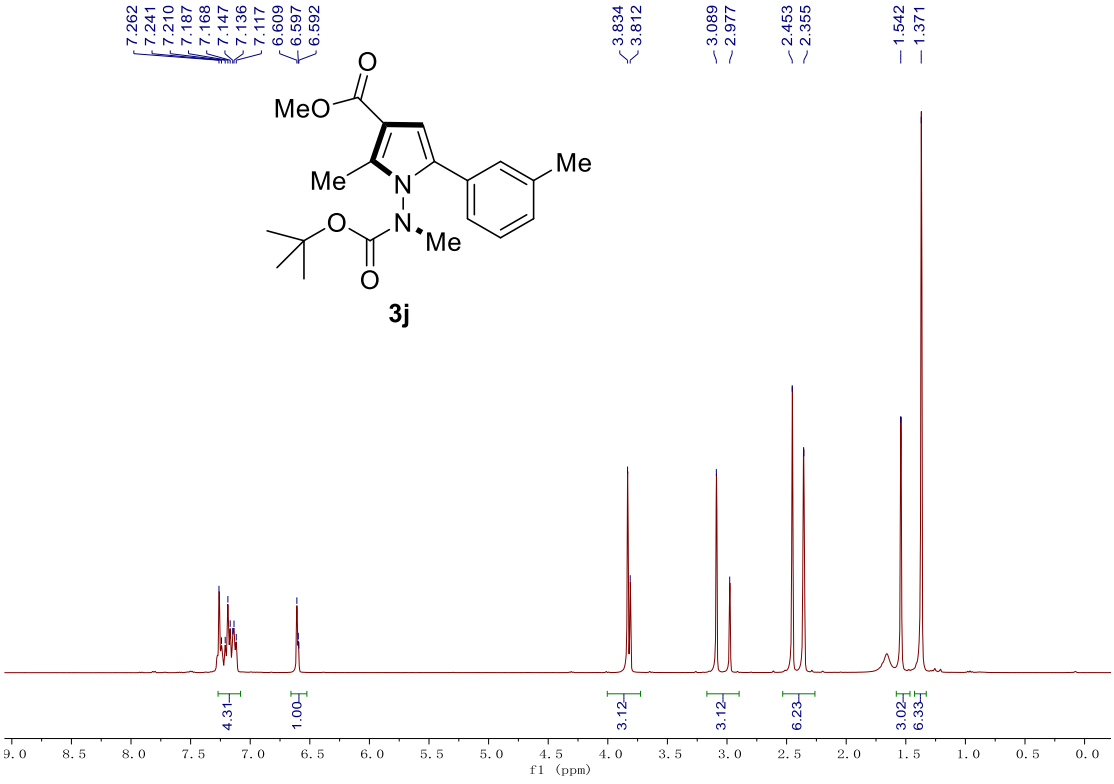
O
N
Me
O
O
NO2
3i
f1 (ppm)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6.597
6.592
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3.812
3.089
2.977
2.453
2.355
1.542
1.371
MeO
Me
N
O
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Me
3j
4.31
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3.12
6.23
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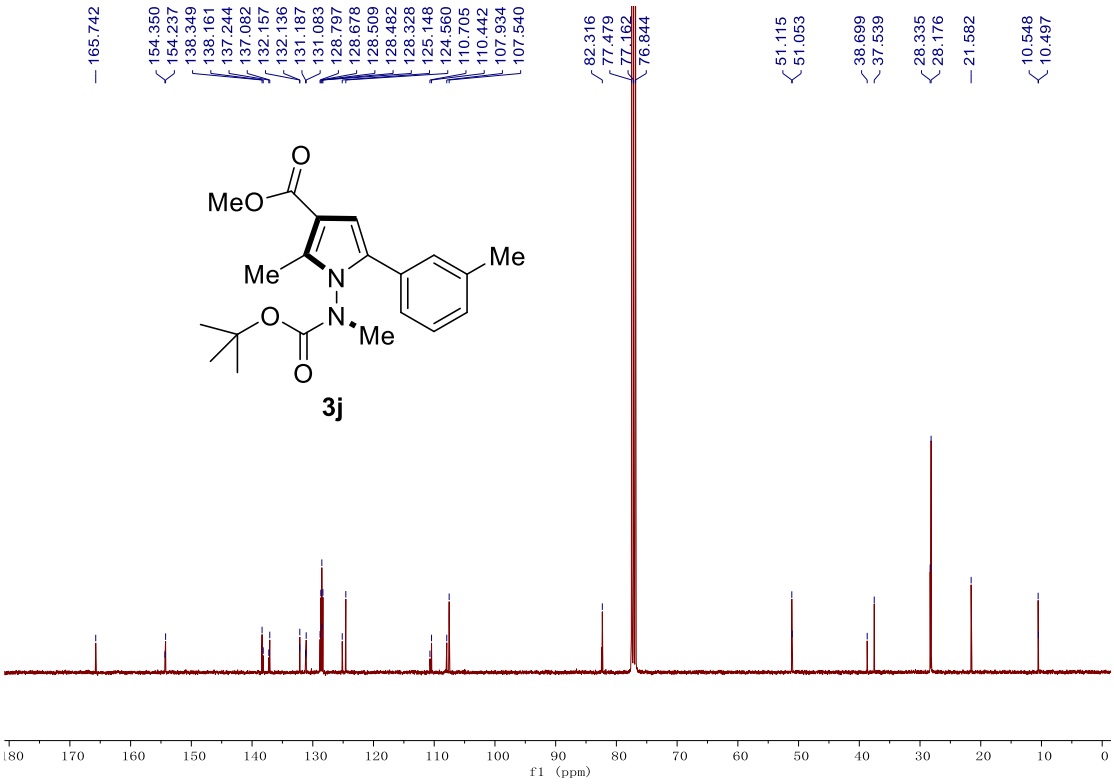
6.33
f1 (ppm)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38.699
37.539
28.335
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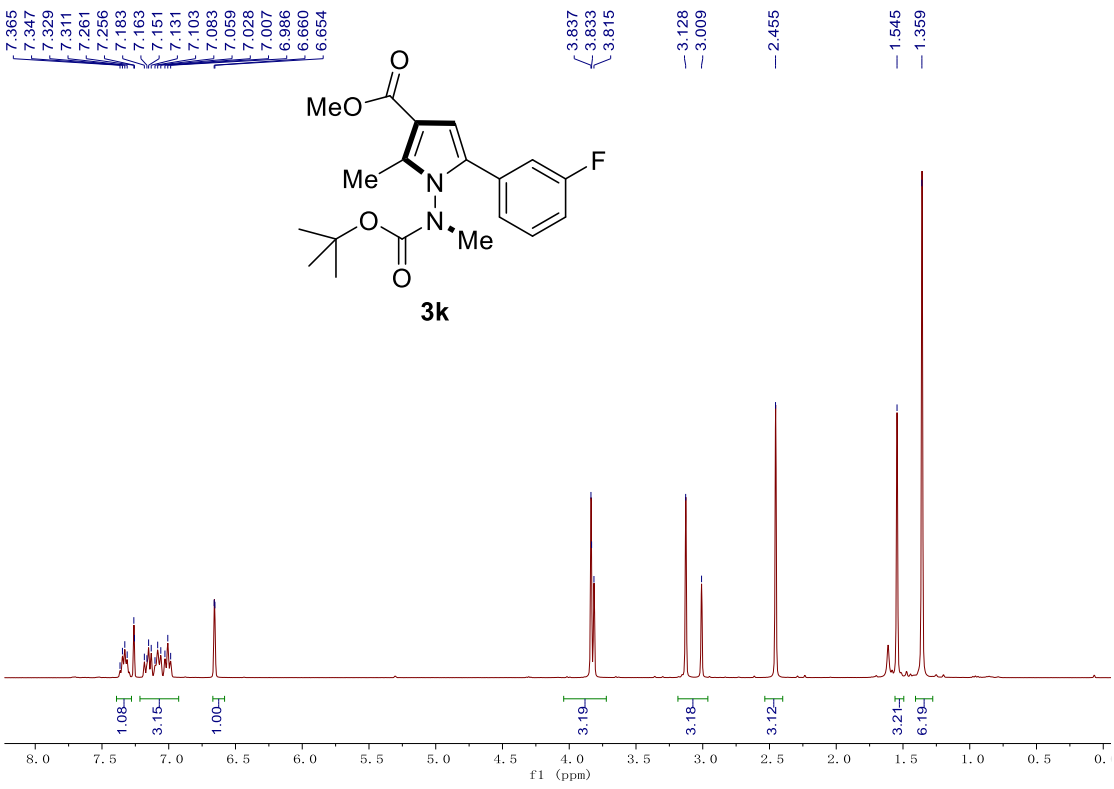
Me
O
N
Me
O
Me
3j
f1 (ppm)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7.007
6.986
6.660
6.654
3.837
3.833
3.815
3.128
3.009
2.455
1.545
1.359
MeO
O
Me
N
F
Me
O
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1.00
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3.12
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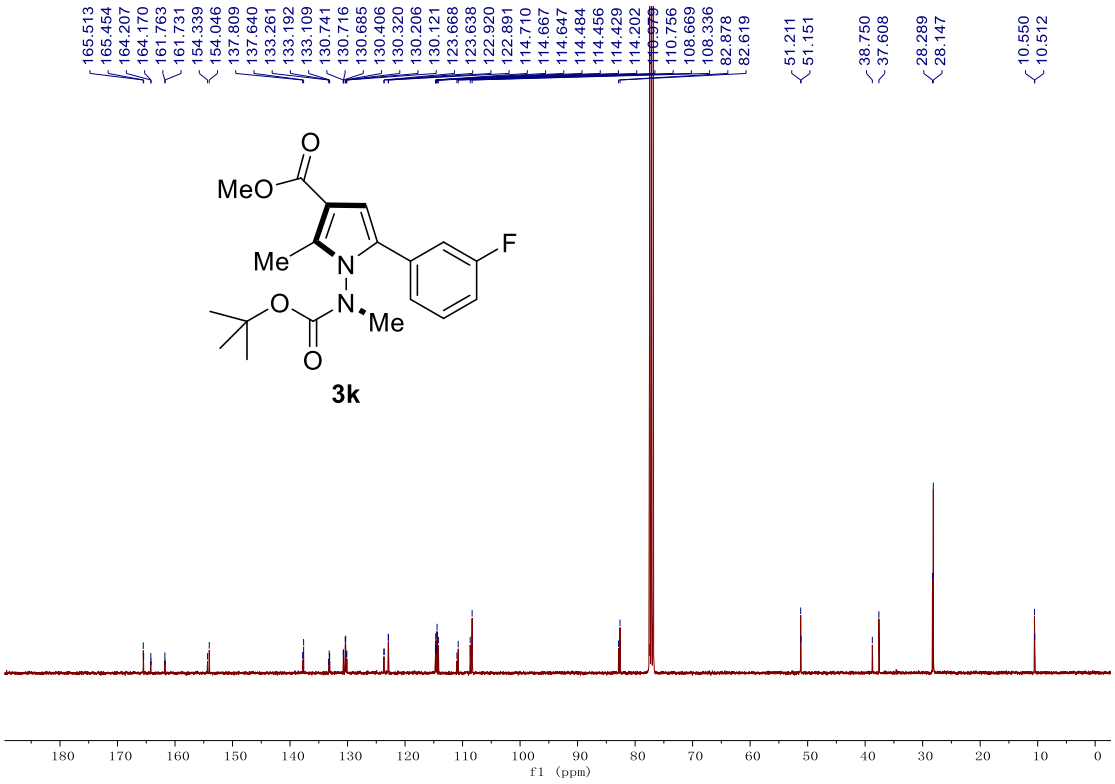
6.19
f1 (ppm)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123.638
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114.429
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N
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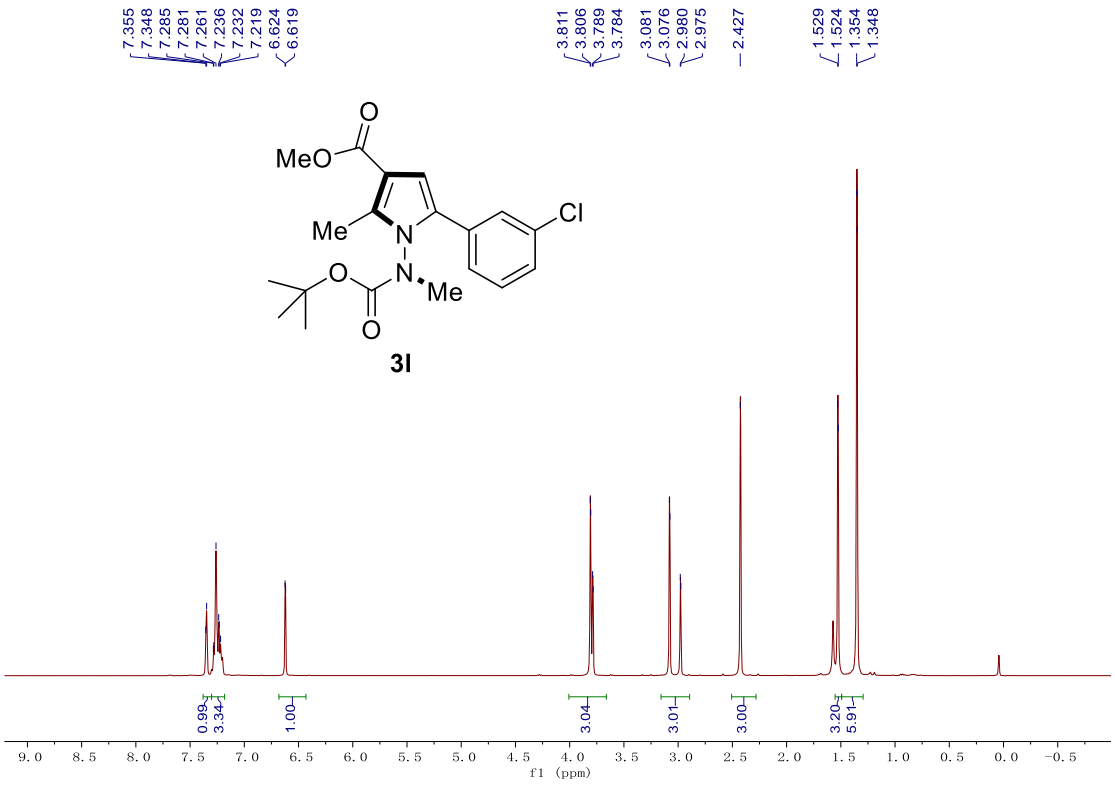
O
O
3k
f1 (ppm)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3.784
3.081
3.076
2.980
2.975
2.427
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1.524
1.354
1.348
MeO
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Me
N
Cl
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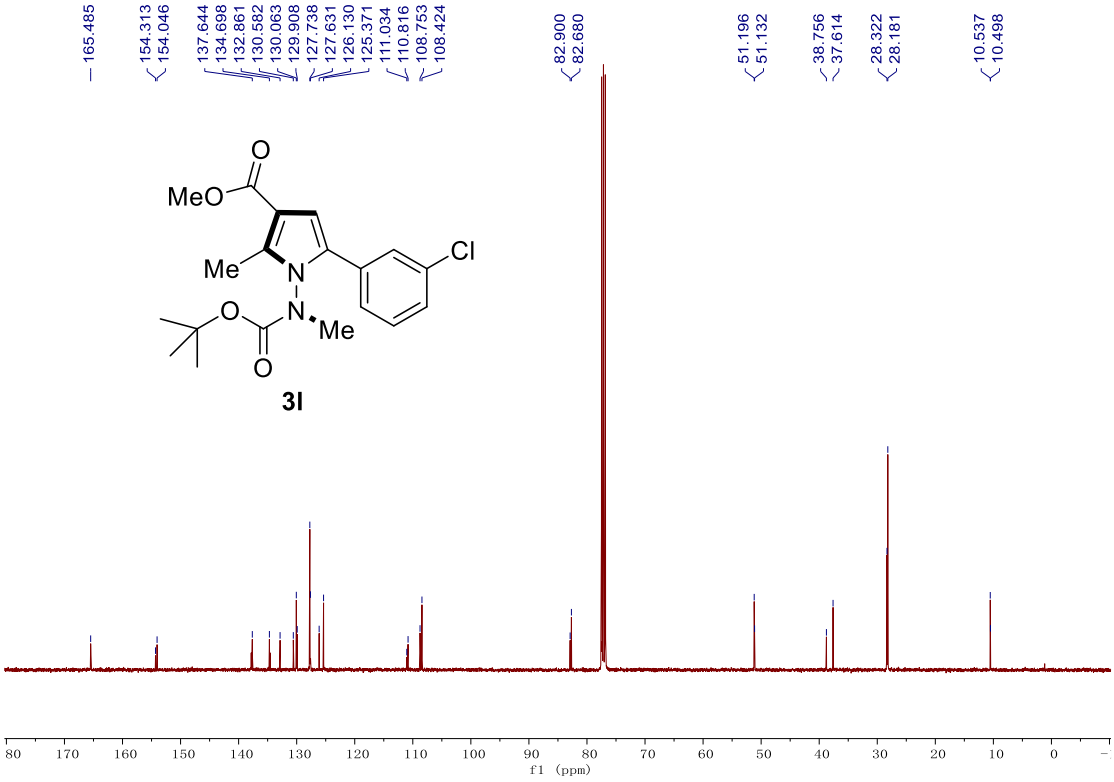
f1 (ppm)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110.816
108.753
108.424
82.900
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51.132
38.756
37.614
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Me
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Cl
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N
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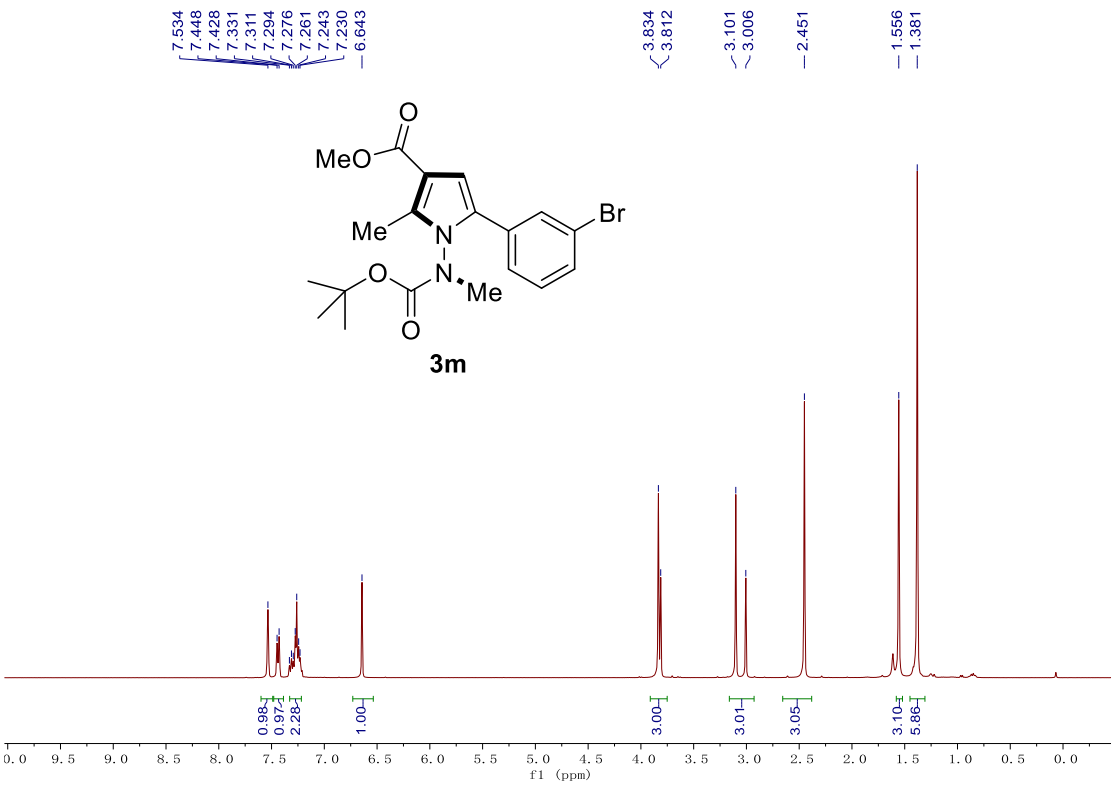
O
O
3l
f1 (ppm)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N
Br
O
N
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3.05
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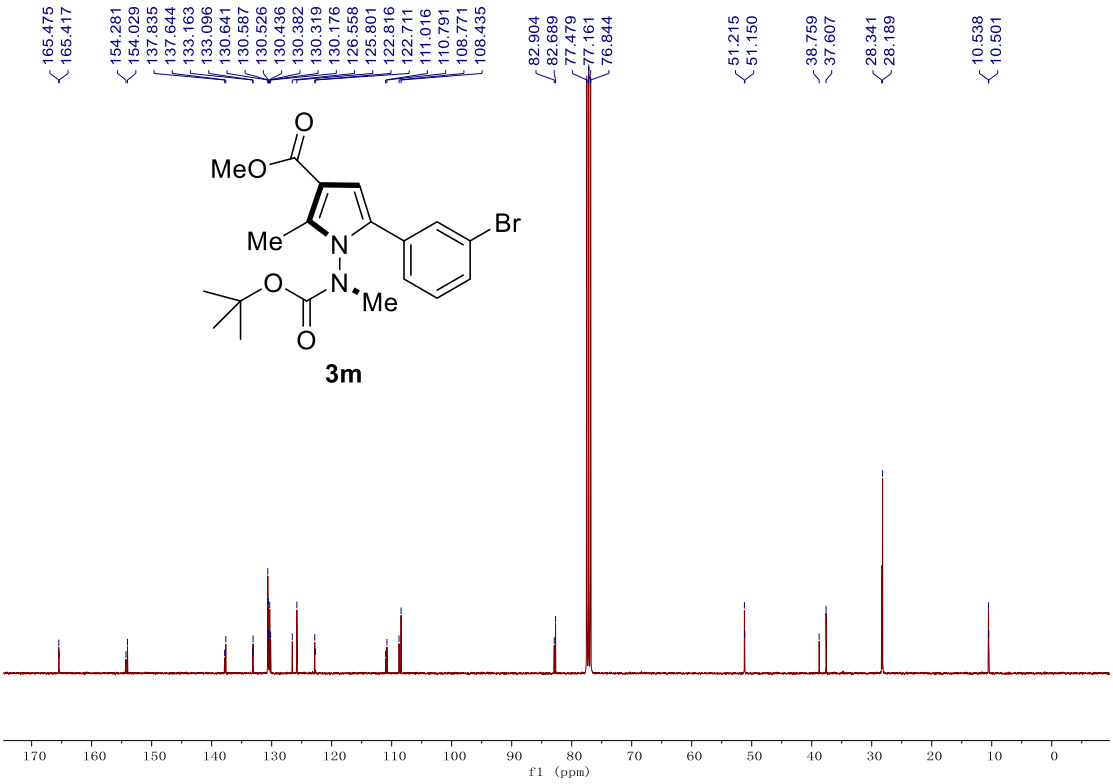
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MeO
O
Me
N
Br
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Me
O
O
3m
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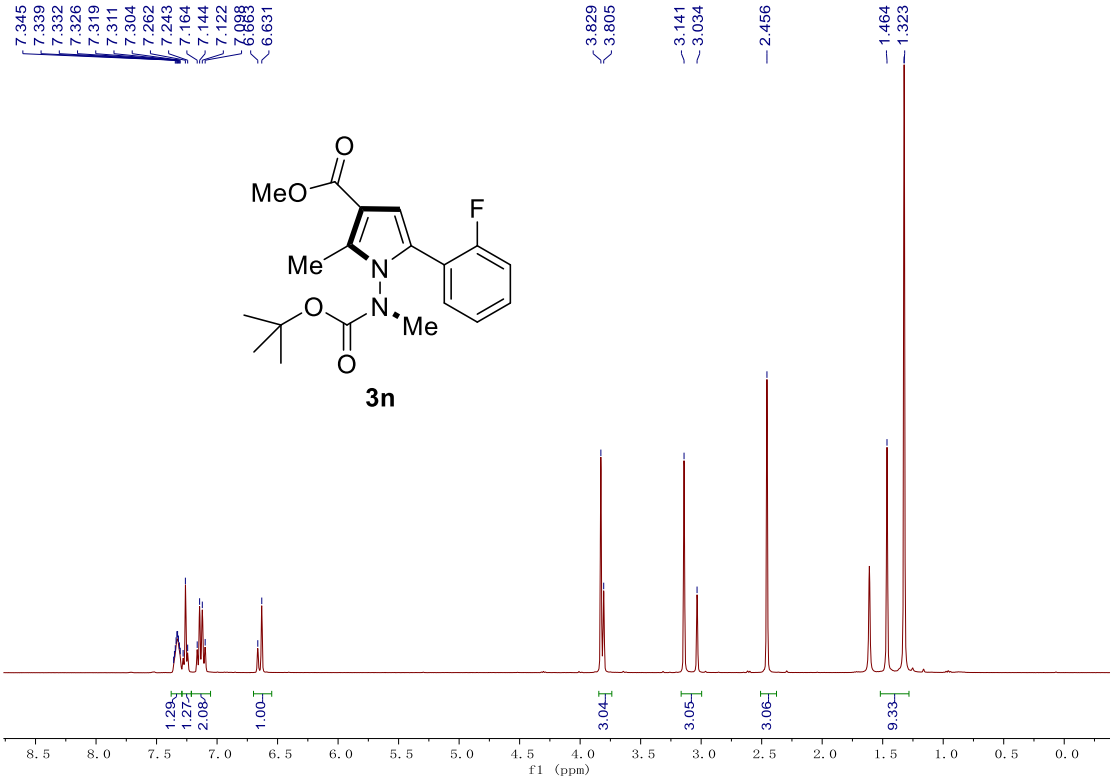
f1 (ppm)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7.164
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7.098
7.083
6.631
3.829
3.805
3.141
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2.456
1.464
1.323
MeO
O
Me
N
F
O
N
Me
O
O
3n
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1.27
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1.00
3.04
3.05
3.06
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7.0
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6.0
5.5
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2.5
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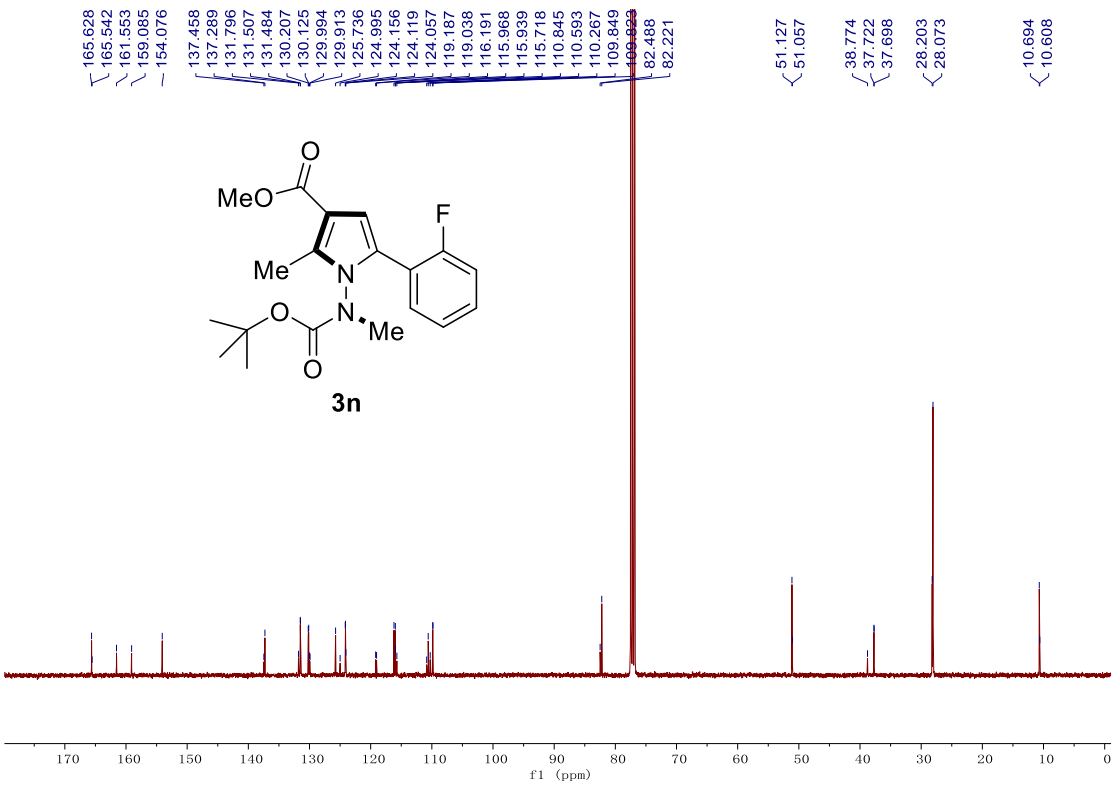
0.0
f1 (ppm)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F
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O
O
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3n
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50
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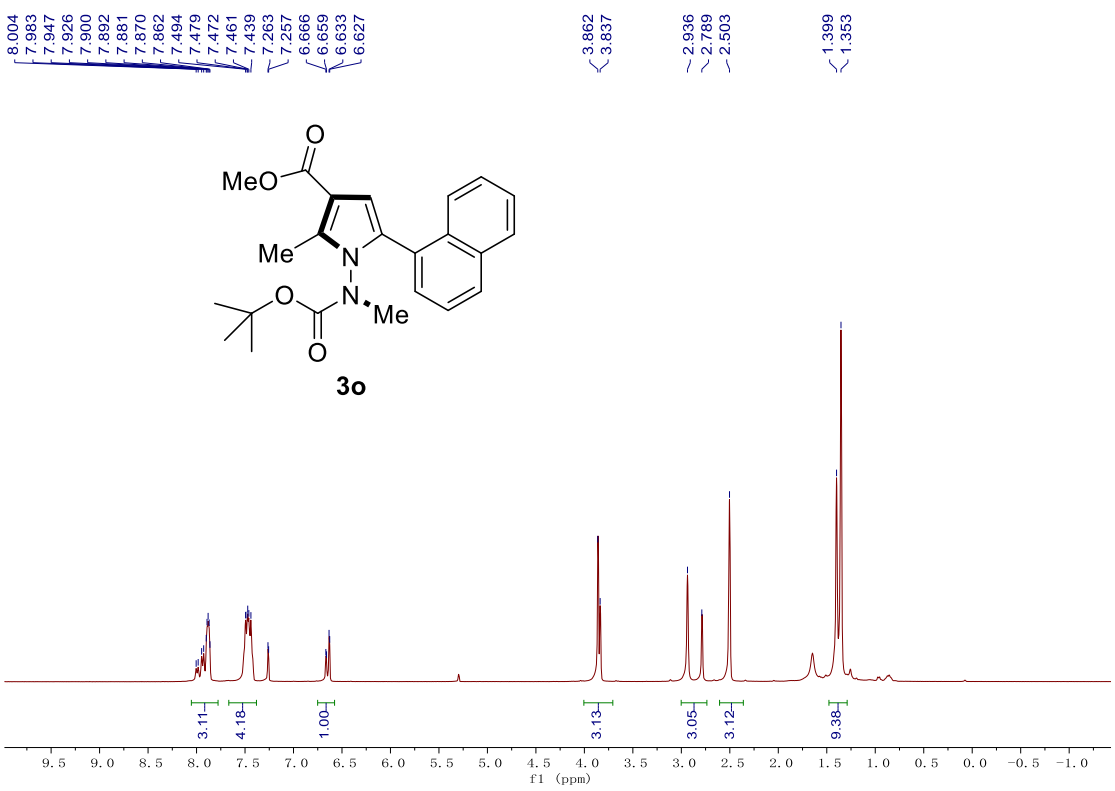
f1 (ppm)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1.353
MeO
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N
N
Me
O
O
O
3o
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4.18
1.00
3.13
3.05
3.12
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9.5
9.0
8.5
8.0
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7.0
6.5
6.0
5.5
5.0
4.5
4.0
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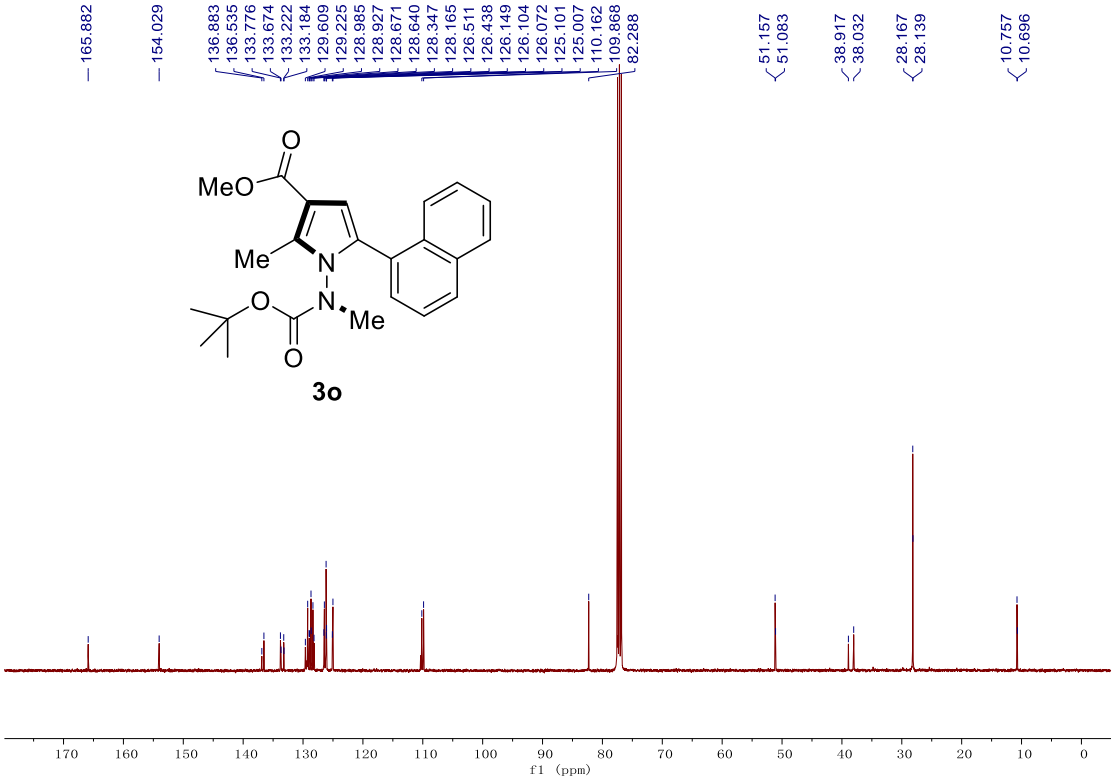
f1 (ppm)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125.101
125.007
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51.083
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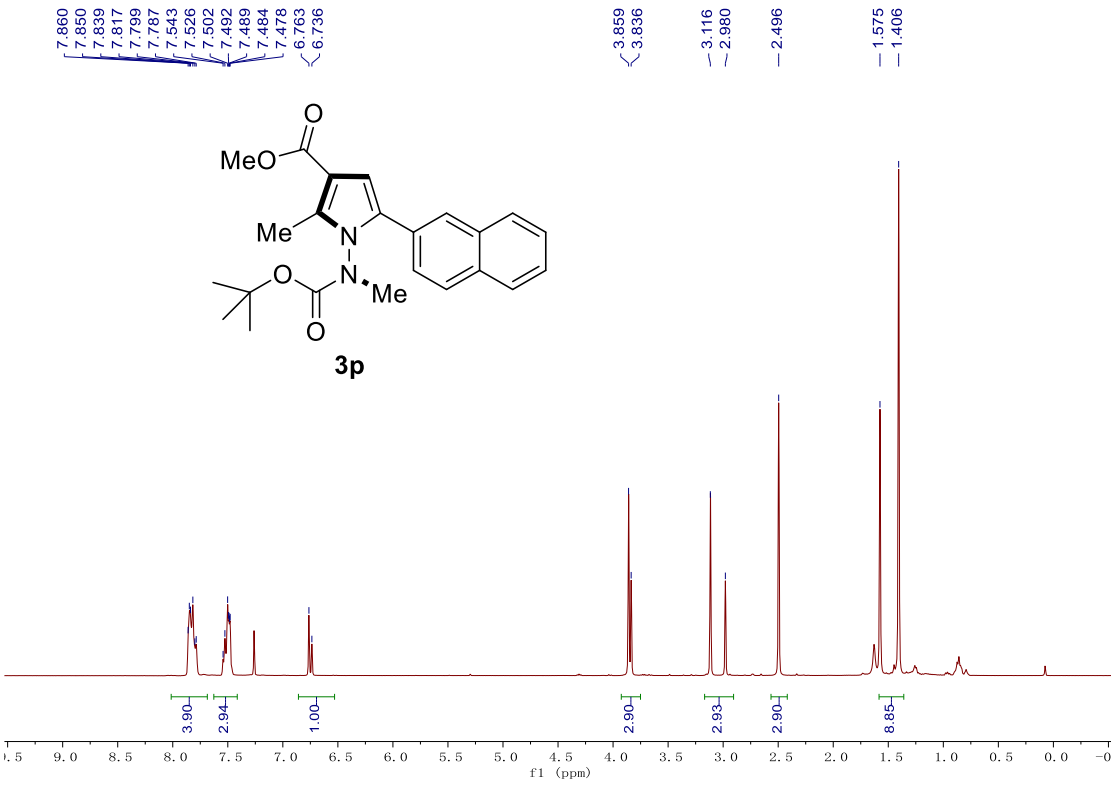
3o
f1 (ppm)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6.736
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2.496
1.575
1.406
MeO
Me
N
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8.85
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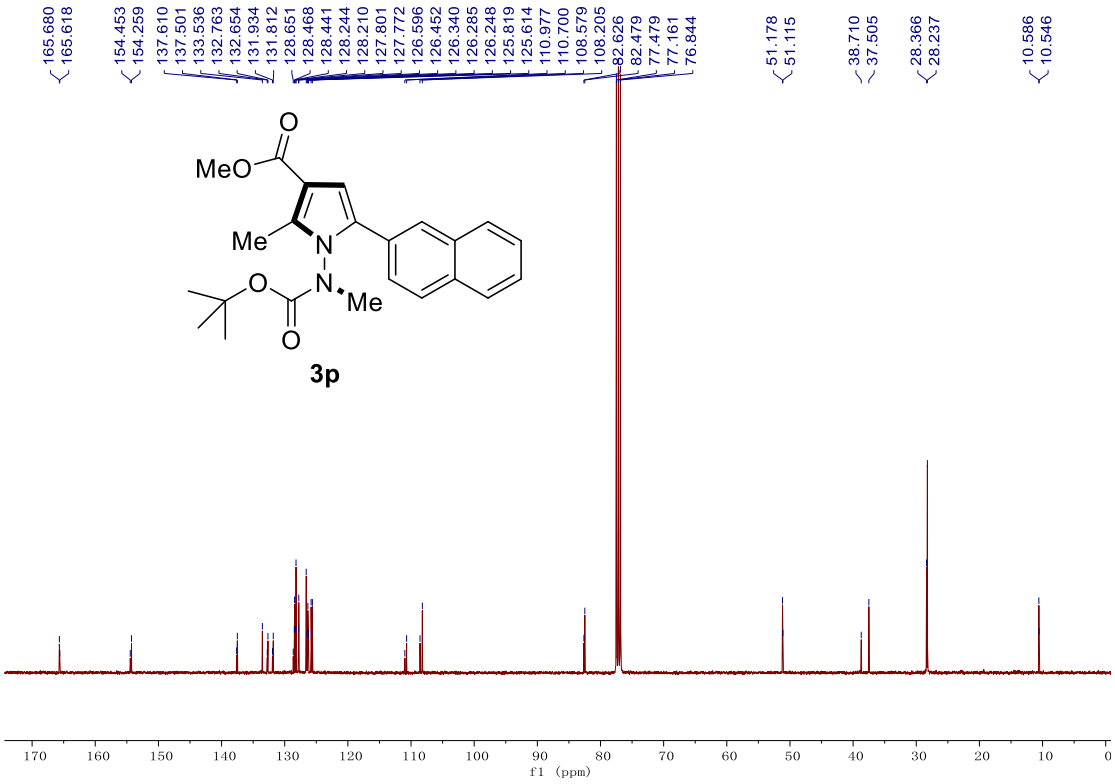
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77.479
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76.844
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51.115
38.710
37.505
28.366
28.237
10.586
10.546
MeO
O
Me
N
N
Me
O
O
O
3p
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70
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50
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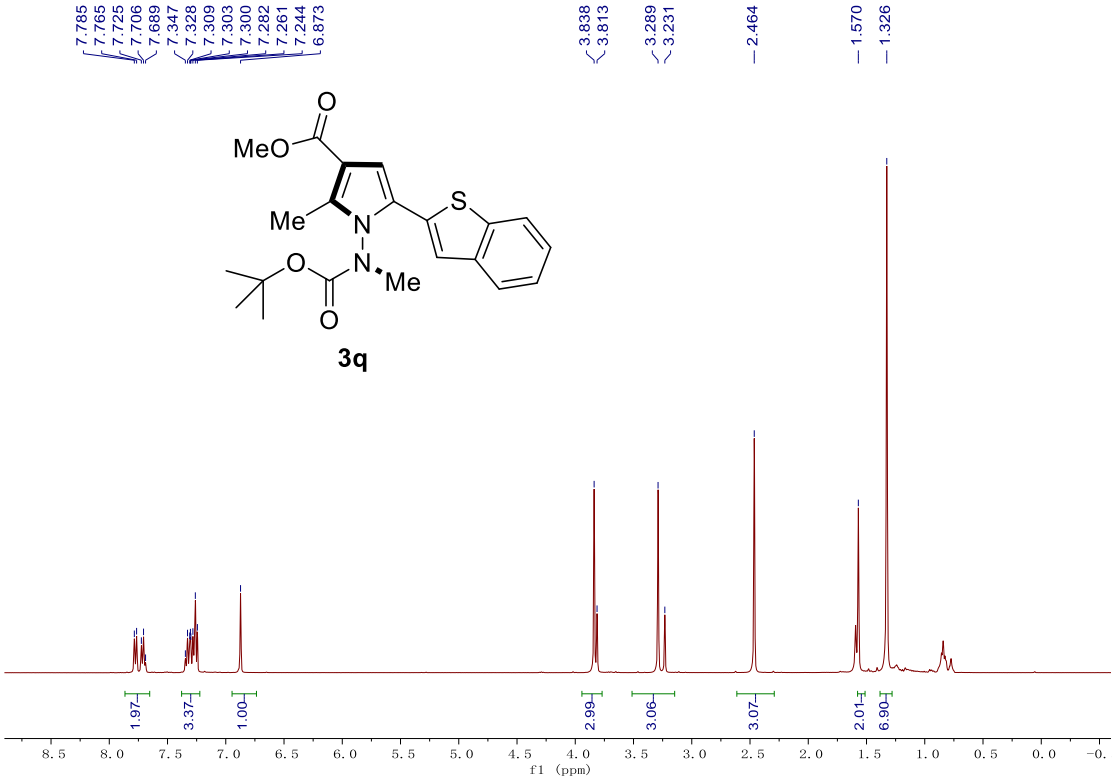
f1 (ppm)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7.244
6.873
3.838
3.813
3.289
3.231
2.464
1.570
1.326
MeO
O
Me
N
S
N
Me
O
O
3q
1.97
3.37
1.00
2.99
3.06
3.07
2.01
6.90
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
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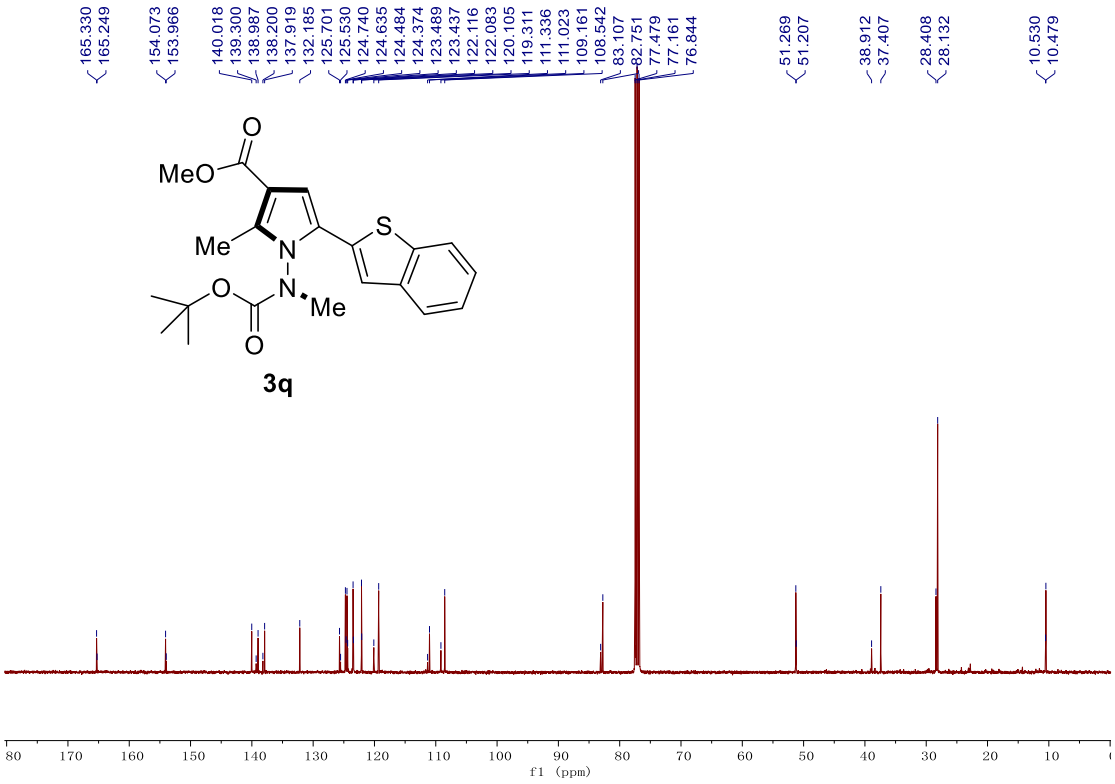
-0.
f1 (ppm)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124.635
124.484
124.374
123.489
123.437
122.116
122.083
120.105
119.311
111.336
111.023
109.161
108.542
83.107
82.751
77.479
77.161
76.844
51.269
51.207
38.912
37.407
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10.530
10.479
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Me
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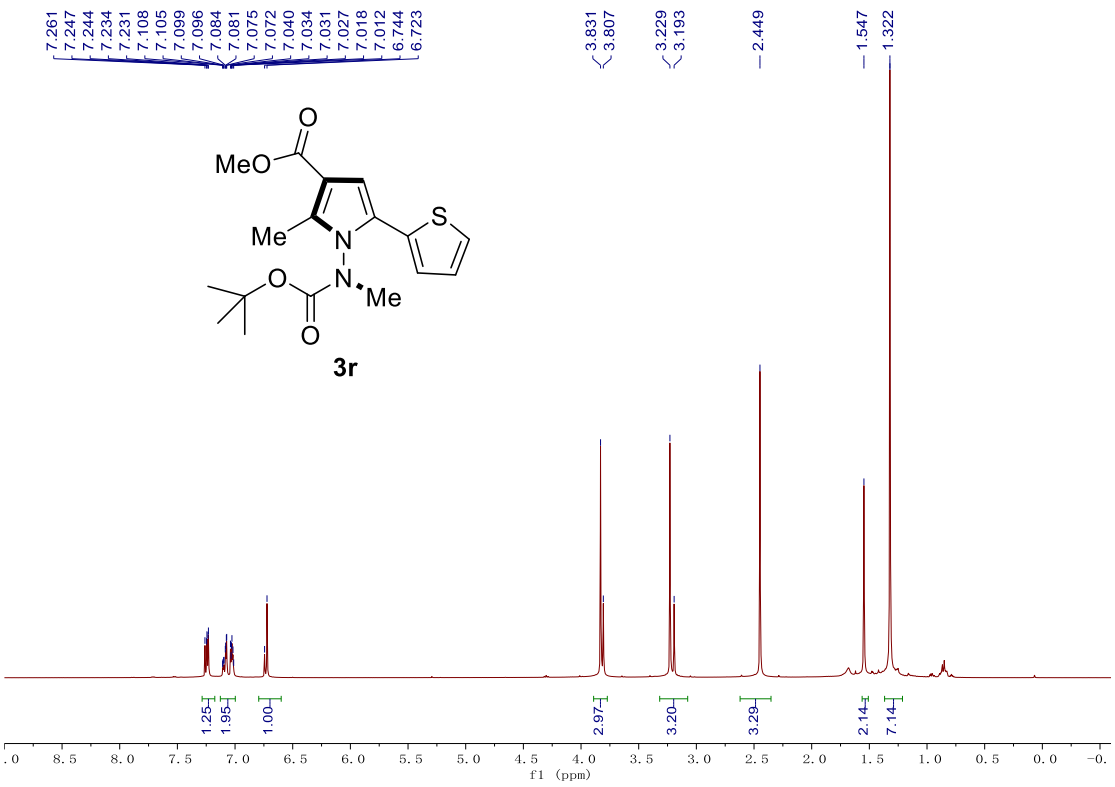
S
O
N
Me
O
O
3q
f1 (ppm)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7.075
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7.040
7.034
7.031
7.027
7.018
7.012
6.744
6.723
3.831
3.807
3.229
3.193
2.449
1.547
1.322
MeO
Me
N
S
O
N
Me
O
O
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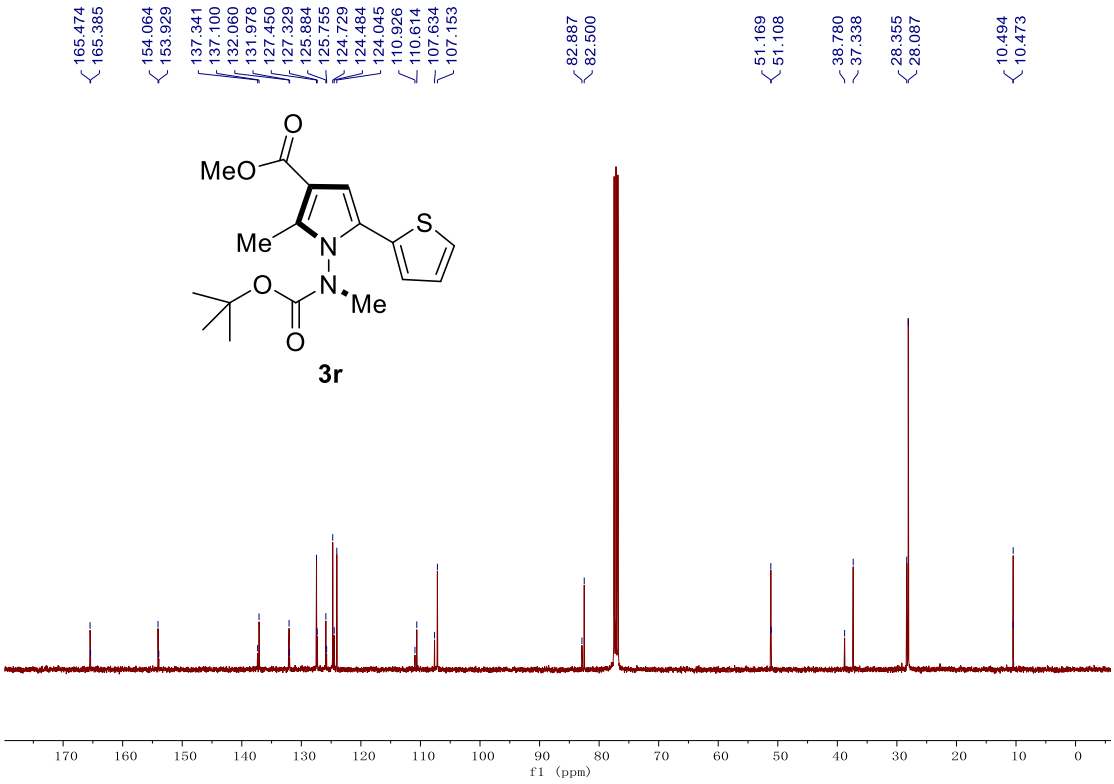
1.95
1.00
2.97
3.20
3.29
2.14
7.14
f1 (ppm)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124.484
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110.614
107.634
107.153
82.887
82.500
51.169
51.108
38.780
37.338
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10.473
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Me
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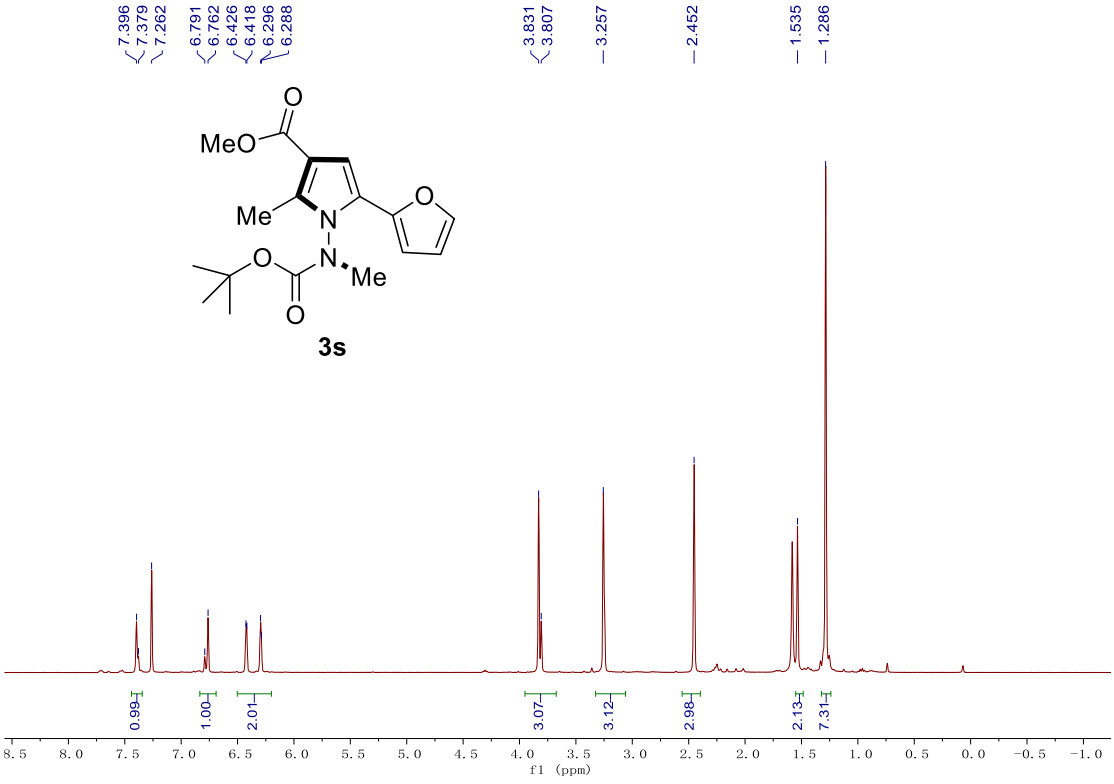
S
O
N
Me
O
O
3r
f1 (ppm)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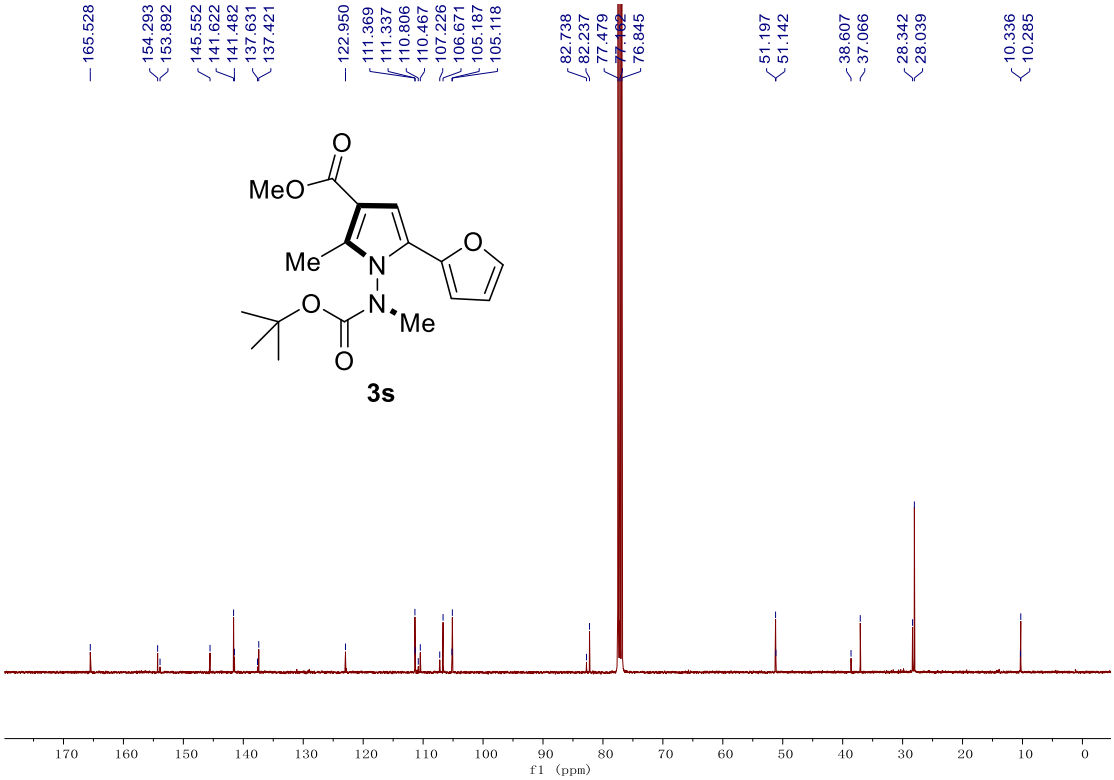
3.831
3.807
3.257
2.452
1.535
1.286
MeO
Me
N
O
N
Me
O
O
3s
0.99
1.00
2.01
3.07
3.12
2.98
2.13
7.31
f1 (ppm)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110.467
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106.671
105.187
105.118
82.738
82.237
77.479
77.162
76.845
51.197
51.142
38.607
37.066
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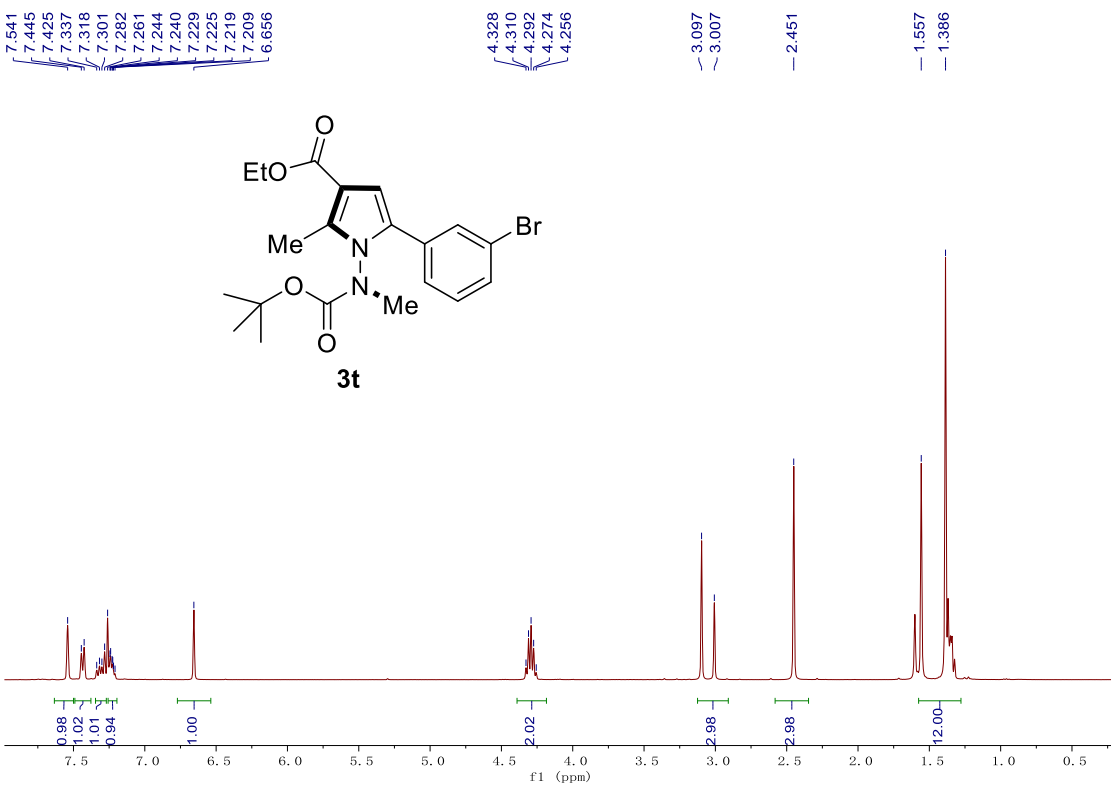
10.336
10.285
MeO
O
Me
N
O
N
Me
O
O
3s
f1 (ppm)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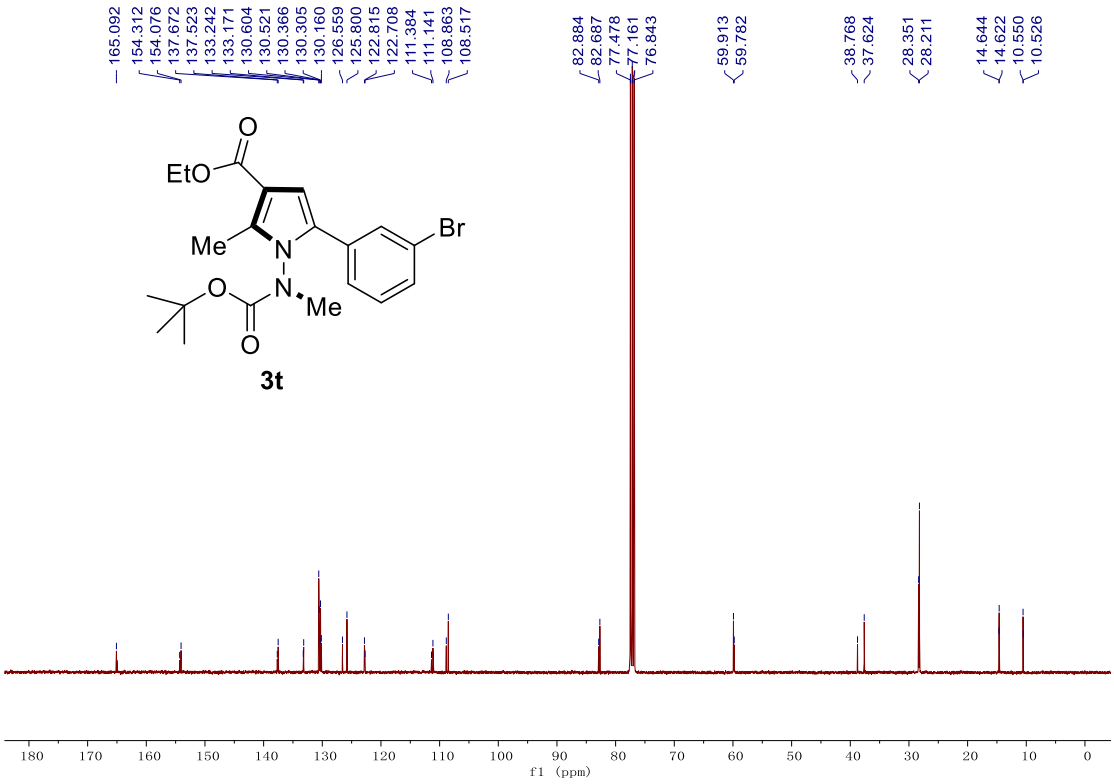
7.261
7.244
7.240
7.229
7.225
7.219
7.209
6.656
4.328
4.310
4.292
4.274
4.256
3.097
3.007
2.451
1.557
1.386
EtO
O
Me
N
Br
O
N
Me
O
3t
0.98
1.02
1.01
0.94
1.00
2.02
2.98
2.98
12.00
f1 (ppm)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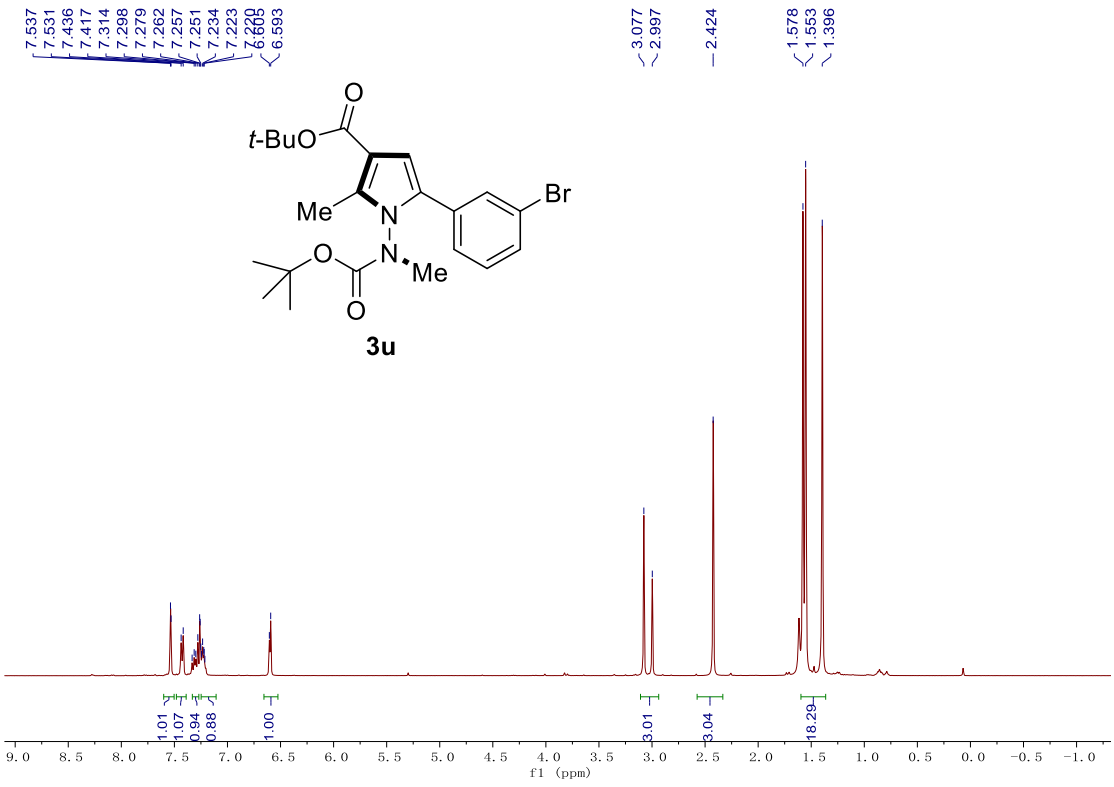
130.521
130.366
130.305
130.160
126.559
125.800
122.815
122.708
111.384
111.141
108.863
108.517
82.884
82.687
77.478
77.161
76.843
59.913
59.782
38.768
37.624
28.351
28.211
14.644
14.622
10.550
10.526
EtO
O
Me
N
Br
O
N
Me
O
3t
f1 (ppm)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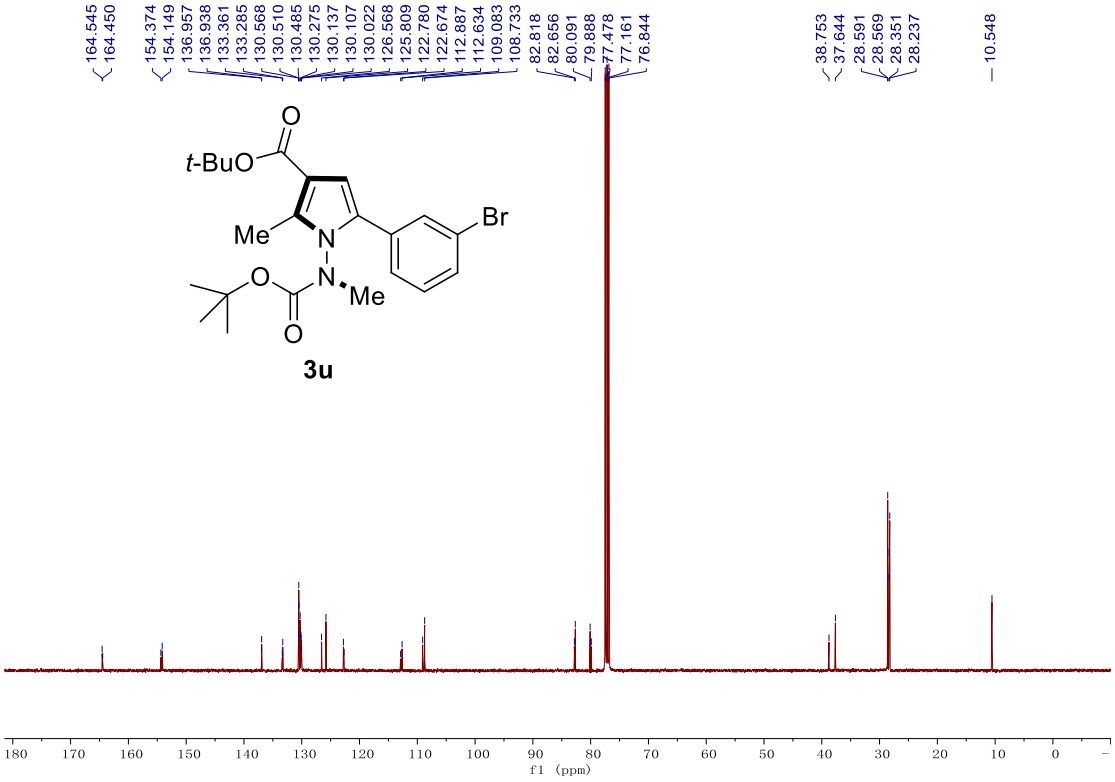
7.262
7.257
7.251
7.234
7.223
7.220
7.205
6.593
3.077
2.997
2.424
1.578
1.553
1.396
t-BuO
O
Me
N
Br
O
N
Me
O
3u
1.01
1.07
0.94
0.88
1.00
3.01
3.04
18.29
f1 (ppm)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133.285
130.568
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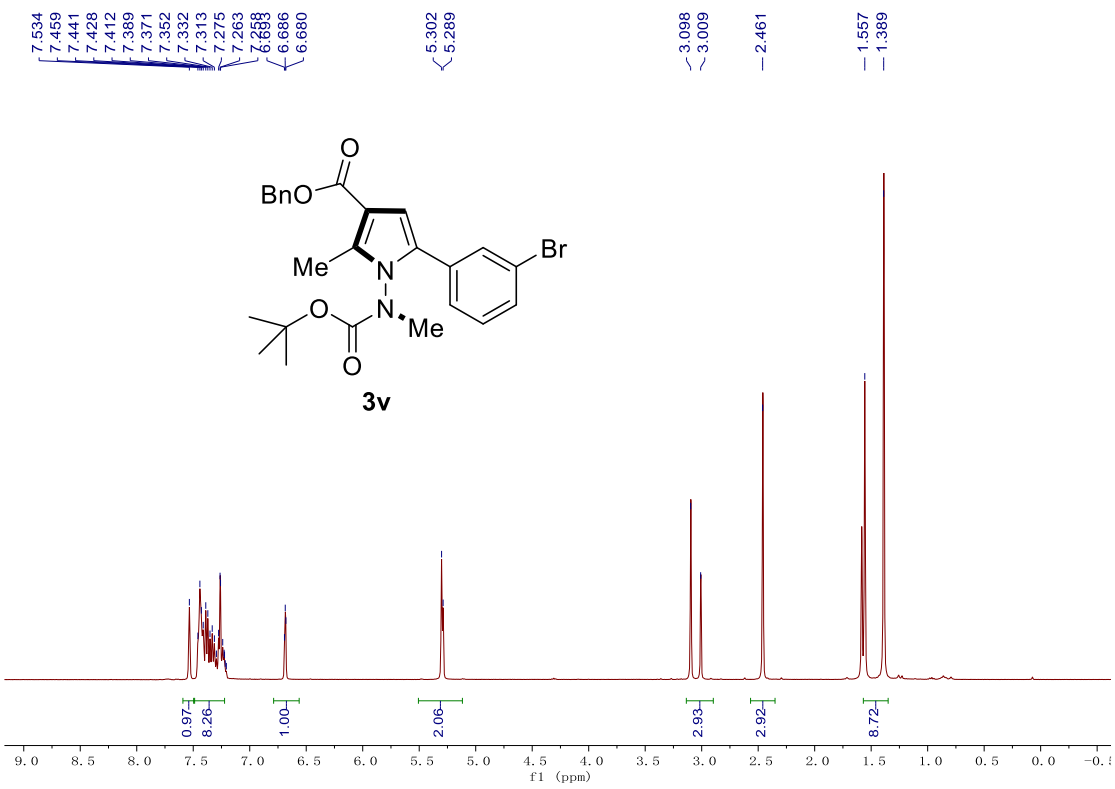
130.485
130.275
130.137
130.107
130.022
126.568
125.809
122.780
122.674
112.887
112.634
109.083
108.733
82.818
82.656
80.091
79.888
77.478
77.161
76.844
38.753
37.644
28.591
28.569
28.351
28.237
10.548
t-BuO
O
Me
N
Br
O
N
Me
O
f1 (ppm)

3u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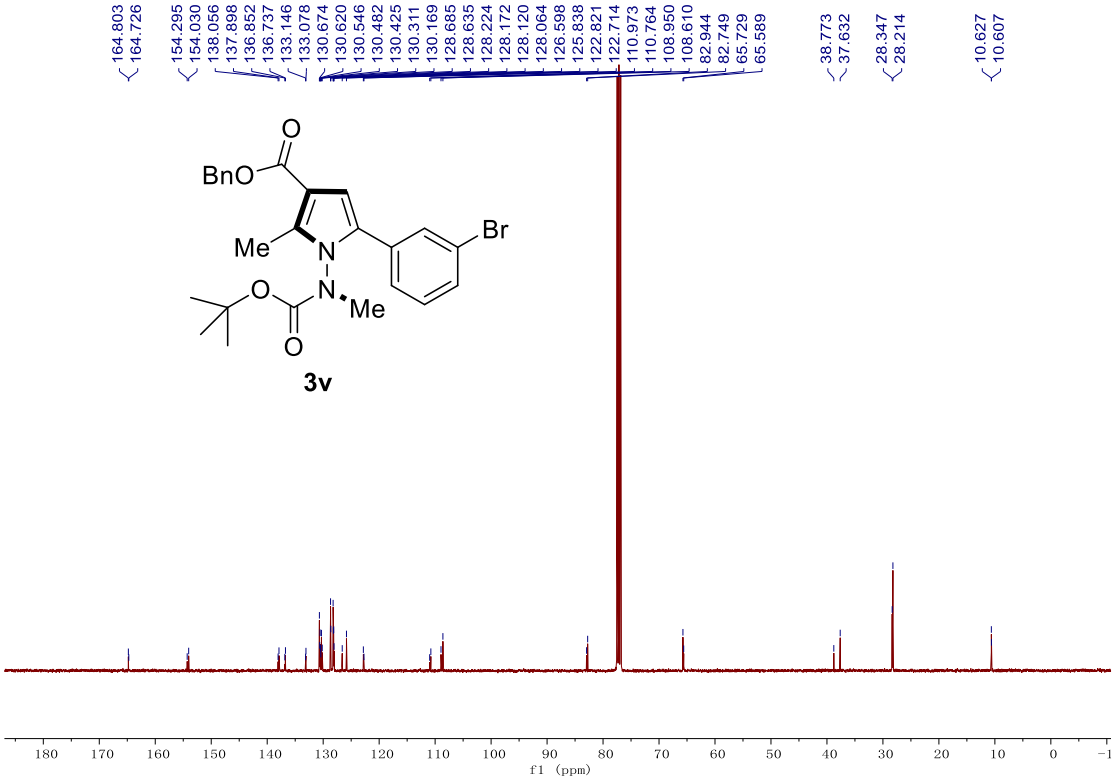
7.352
7.332
7.313
7.275
7.263
6.686
6.680
5.302
5.289
3.098
3.009
2.461
1.557
1.389
BnO
O
Me
N
Br
O
N
Me
O
0.97
8.26
1.00
2.06
2.93
2.92
8.72
f1 (ppm)

3v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130.674
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130.546
130.482
130.425
130.311
130.169
128.685
128.635
128.224
128.172
128.120
128.064
126.598
125.838
122.821
122.714
110.973
110.764
108.950
108.610
82.944
82.749
65.729
65.589
38.773
37.632
28.347
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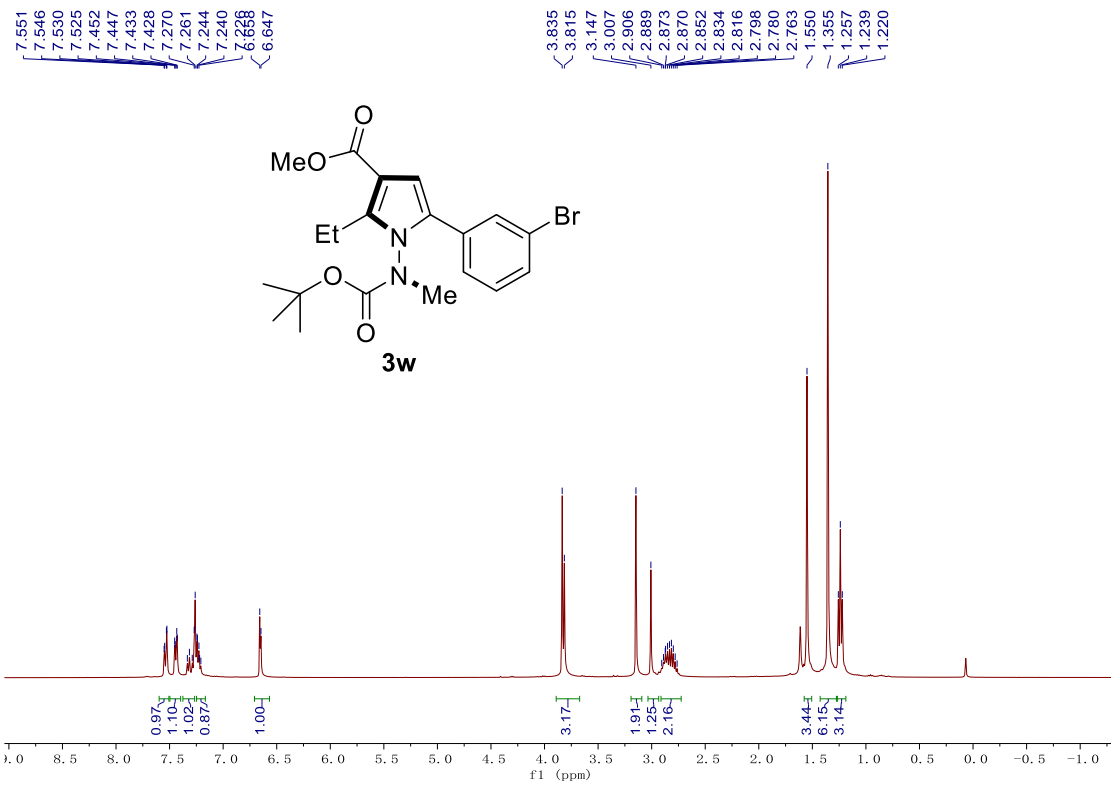
10.627
10.607
BnO
O
Me
N
Br
O
N
Me
O
O
3v
f1 (ppm)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7.428
7.270
7.261
7.244
7.240
6.647
3.835
3.815
3.147
3.007
2.906
2.889
2.873
2.870
2.852
2.834
2.816
2.798
2.780
2.763
1.550
1.355
1.257
1.239
1.220
MeO
O
Et
N
Br
O
N
Me
O
3w
0.97
1.10
1.02
0.87
1.00
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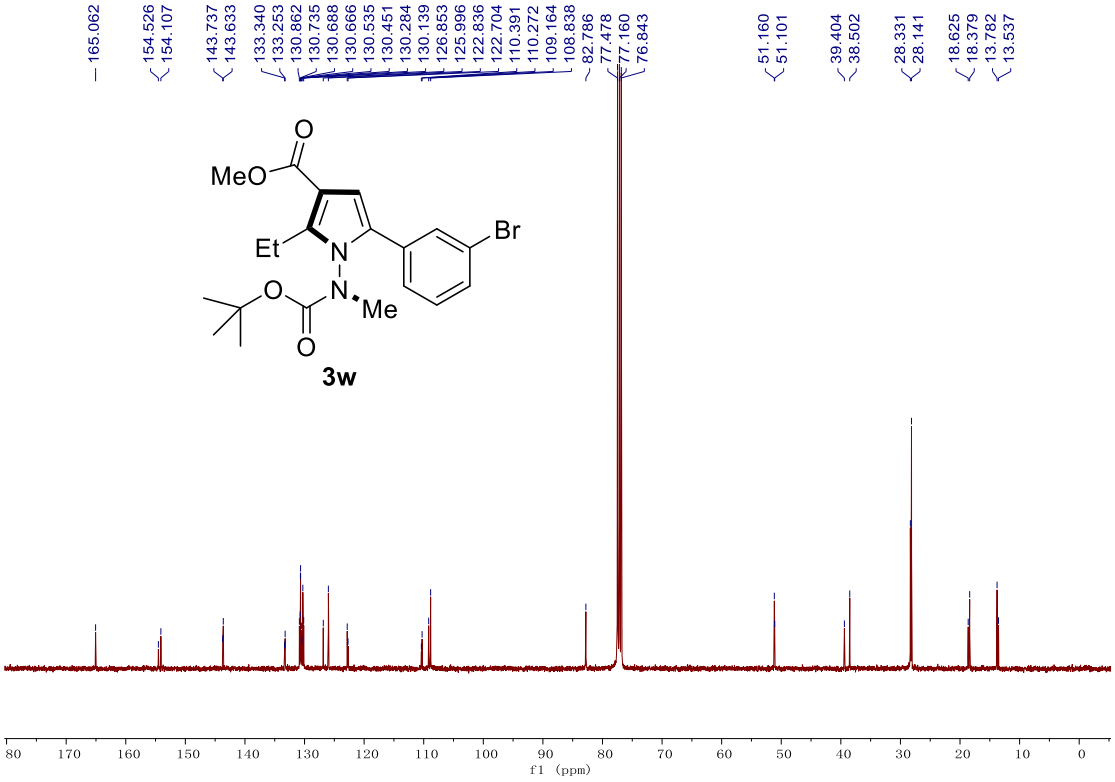
1.91
1.25
2.16
3.44
6.15
3.14
f1 (ppm)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130.451
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130.139
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125.996
122.836
122.704
110.391
110.272
109.164
108.838
82.786
77.478
77.160
76.843
51.160
51.101
39.404
38.502
28.331
28.141
18.625
18.379
13.782
13.537
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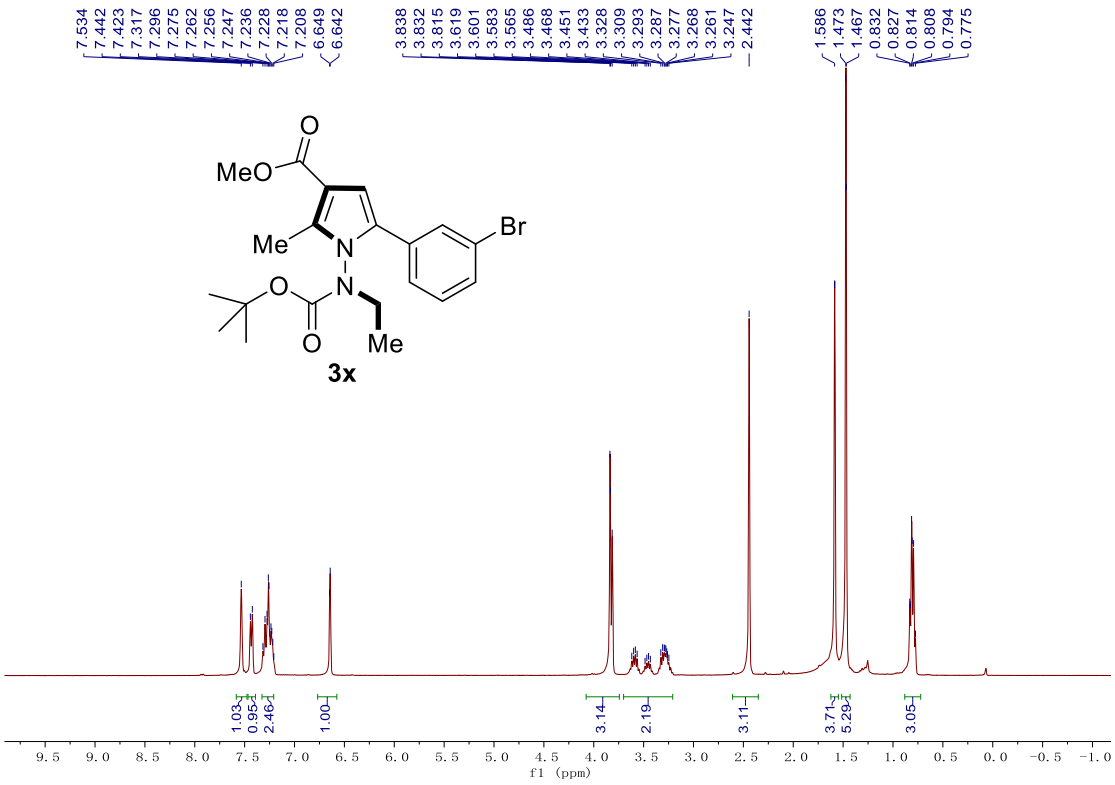
O
Et
N
Br
O
N
Me
O
3w
80 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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7.236
7.228
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7.208
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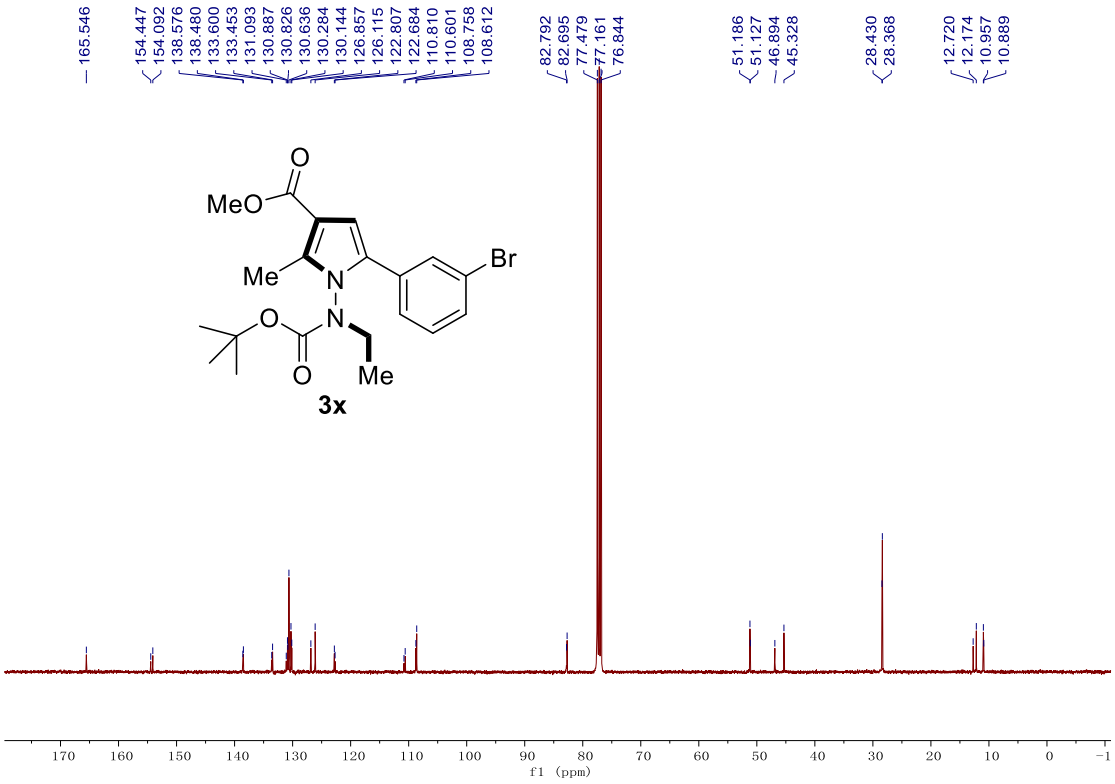
6.642
3.838
3.832
3.815
3.619
3.601
3.583
3.565
3.486
3.468
3.451
3.433
3.328
3.309
3.293
3.287
3.277
3.268
3.261
3.247
2.442
1.586
1.473
1.467
0.832
0.827
0.814
0.808
0.794
0.775
MeO
O
Me
N
Br
O
N
O
Me
3x
1.03
0.95
2.46
1.00
3.14
2.19
3.11
3.71
5.29
3.05
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)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126.115
122.807
122.684
110.810
110.601
108.758
108.612
82.792
82.695
77.479
77.161
76.844
51.186
51.127
46.894
45.328
28.430
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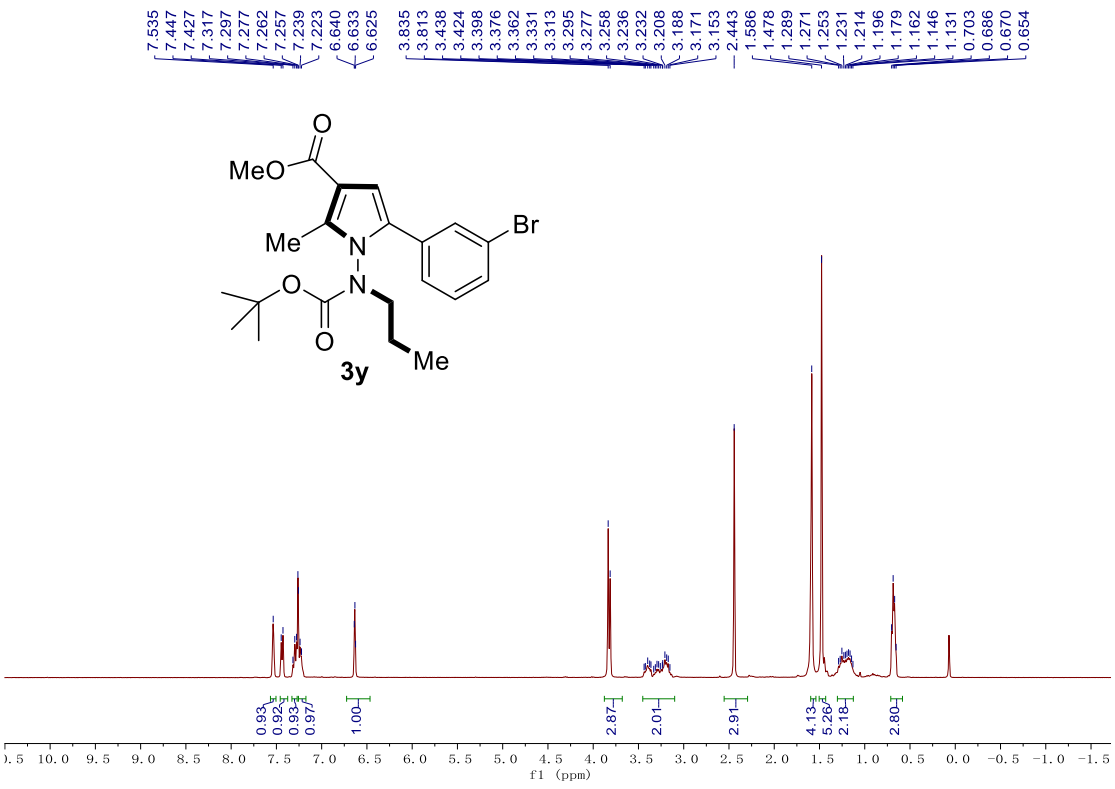
12.174
10.957
10.889
MeO
Me
N
Br
O
N
Me
3x
f1 (ppm)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6.633
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3.313
3.295
3.277
3.258
3.236
3.232
3.208
3.188
3.171
3.153
2.443
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1.478
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1.271
1.253
1.231
1.214
1.196
1.179
1.162
1.146
1.131
0.703
0.686
0.670
0.654
MeO
Me
N
Br
O
N
Me
3y
0.93
0.92
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0.97
1.00
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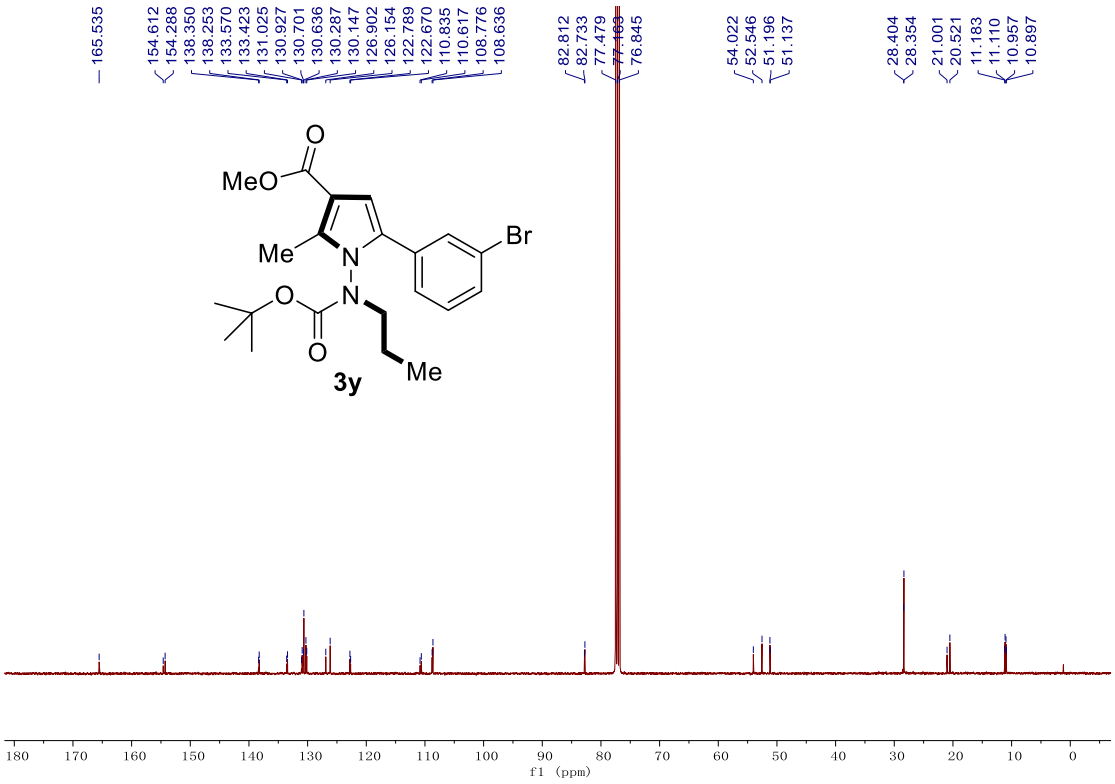
2.01
2.91
4.13
5.26
2.18
2.80
f1 (ppm)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110.617
108.776
108.636
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82.733
77.479
77.163
76.845
54.022
52.546
51.196
51.137
28.404
28.354
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11.110
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MeO
O
Me
N
Br
O
N
O
Me
3y
180
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70
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50
40
30
20
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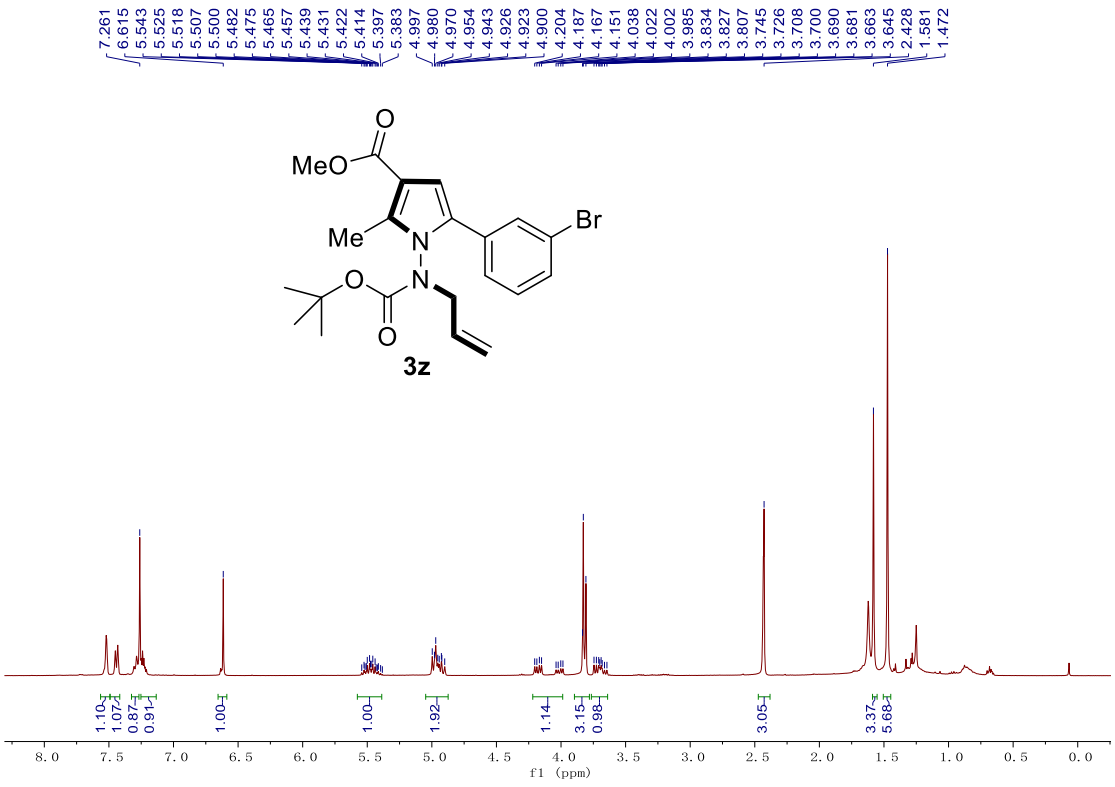
0
f1 (ppm)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5.422
5.414
5.397
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4.943
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4.923
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4.002
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3.834
3.827
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3.745
3.726
3.708
3.700
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3.681
3.663
3.645
2.428
1.581
1.472
MeO
O
Me
N
Br
O
N
O
3z
1.10
1.07
0.87
0.91
1.00
1.00
1.92
1.14
3.15
0.98
3.05
3.37
5.68
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7.5
7.0
6.5
6.0
5.5
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2.5
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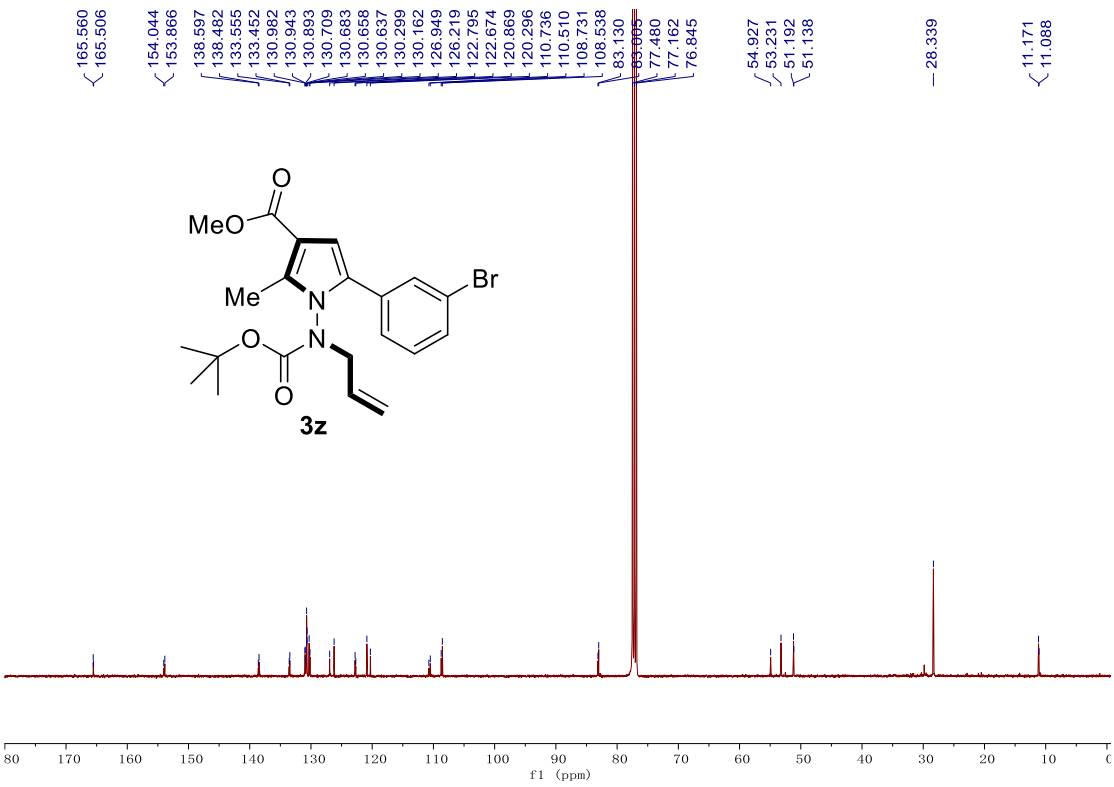
1.0
0.5
0.0
f1 (ppm)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130.162
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126.219
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110.510
108.731
108.538
83.130
83.005
77.480
77.162
76.845
54.927
53.231
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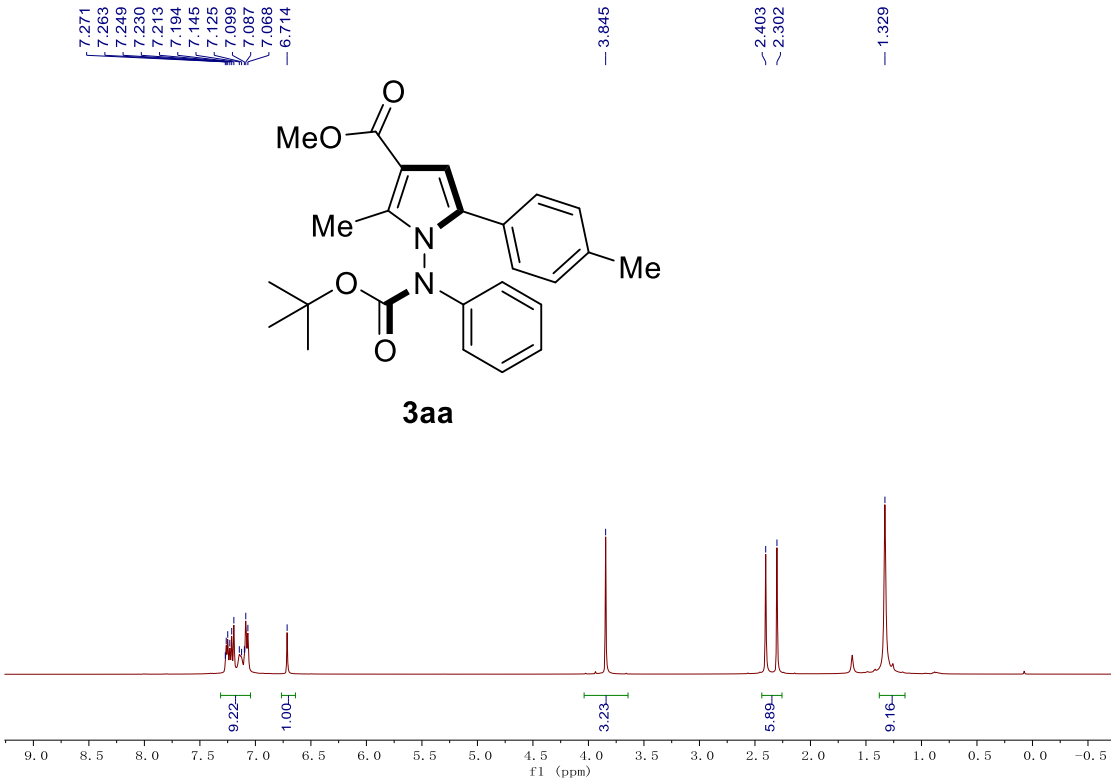
11.171
11.088
MeO
Me
N
N
O
O
O
Br
f1 (ppm)

3z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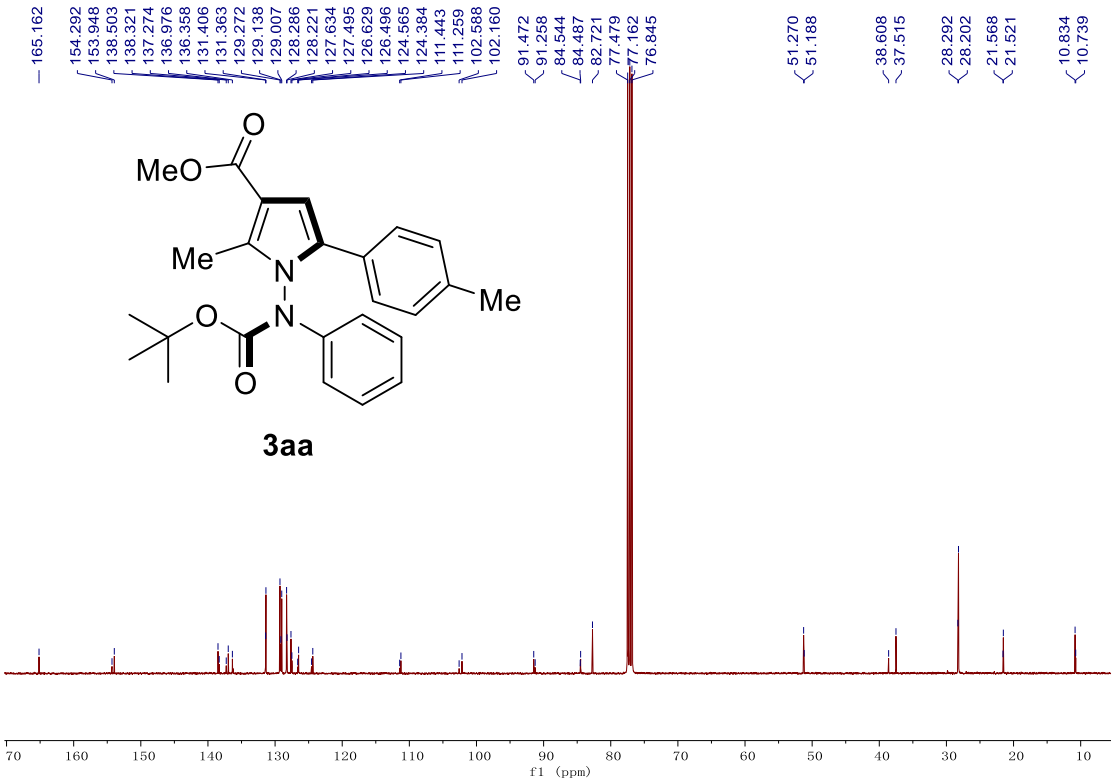
7.125
7.099
7.087
7.068
6.714
3.845
2.403
2.302
1.329
MeO
Me
N
N
O
O
O
Me
9.22
1.00
3.23
5.89
9.16
f1 (ppm)

3aa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128.221
127.634
127.495
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126.496
124.565
124.384
111.443
111.259
102.588
102.160
91.472
91.258
84.544
84.487
82.721
77.479
77.162
76.845
51.270
51.188
38.608
37.515
28.292
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MeO
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N
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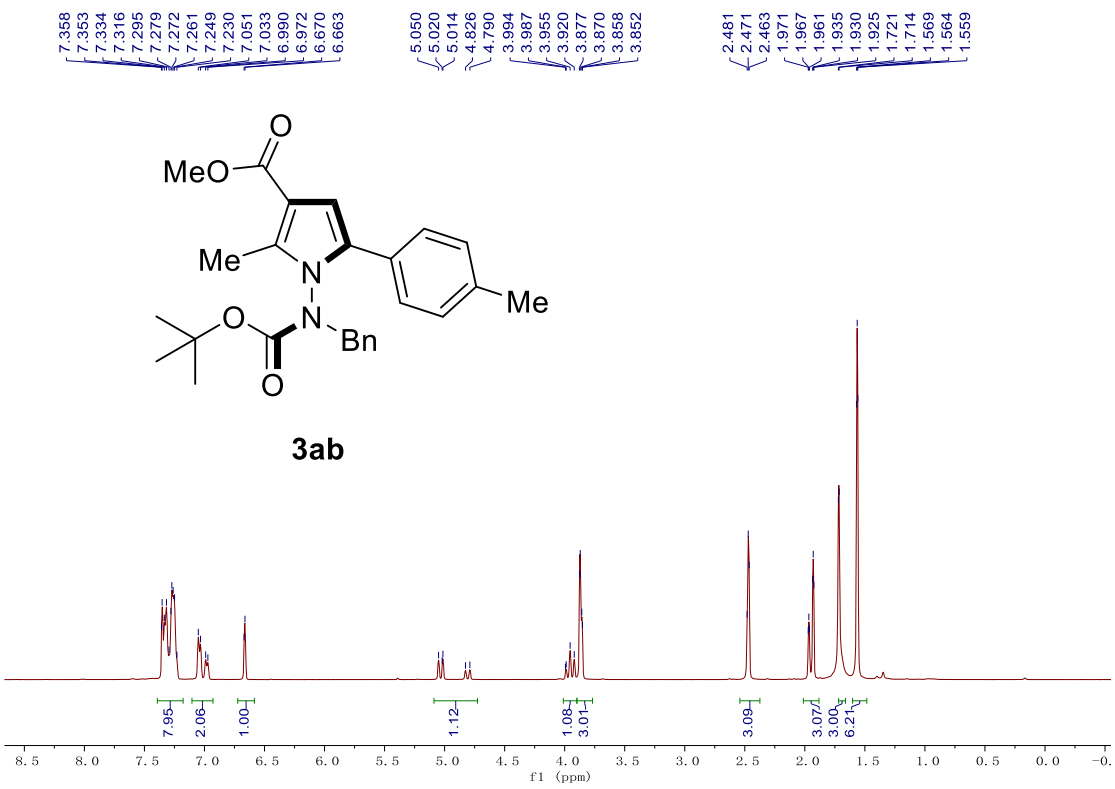
O
Me
f1 (ppm)

3aa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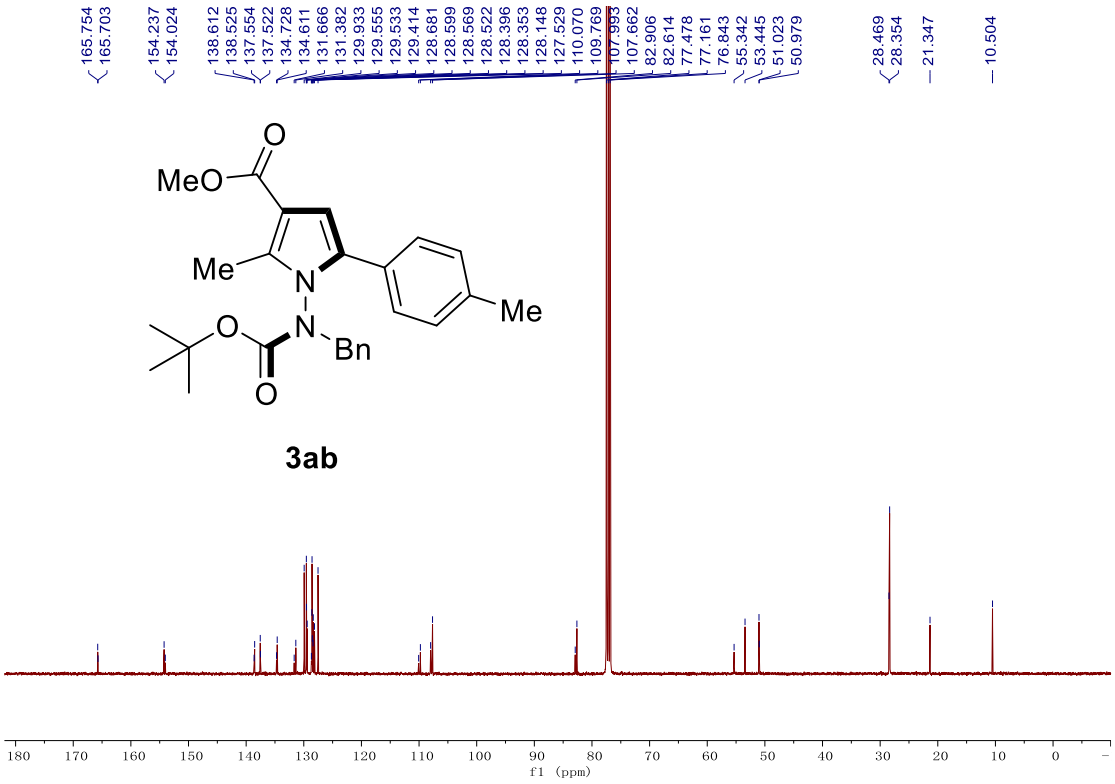
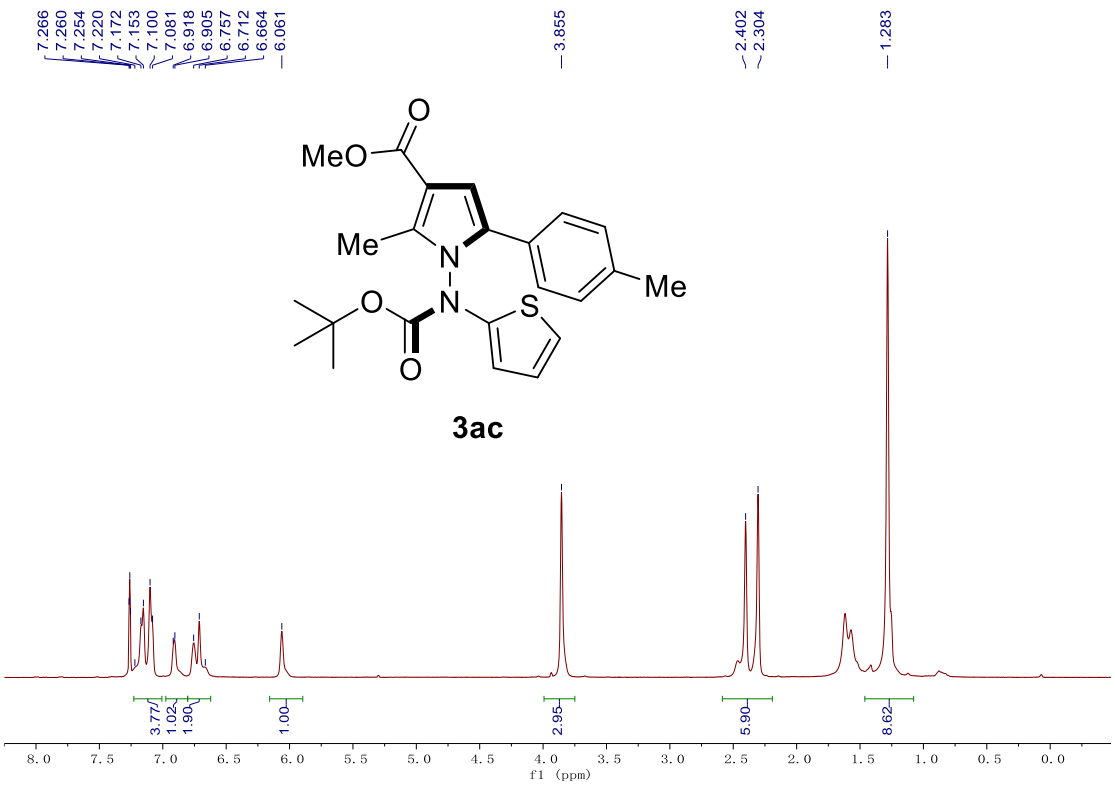
6.972
6.670
6.663
5.050
5.020
5.014
4.826
4.790
3.994
3.987
3.955
3.920
3.877
3.870
3.858
3.852
2.481
2.471
2.463
1.971
1.967
1.961
1.935
1.930
1.925
1.721
1.714
1.569
1.564
1.559
MeO
O
Me
N
N
Bn
O
O
Me
7.95
2.06
1.00
1.12
1.08
3.01
3.09
3.07
3.00
6.21
f1 (ppm)

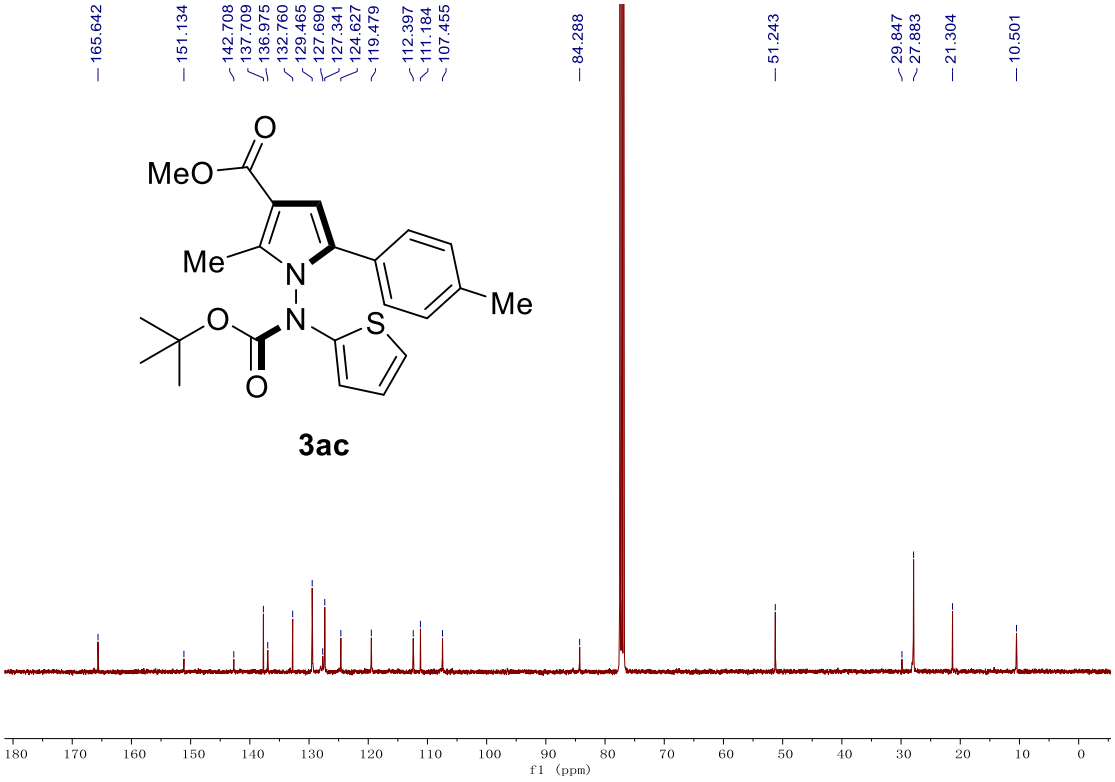
3ab

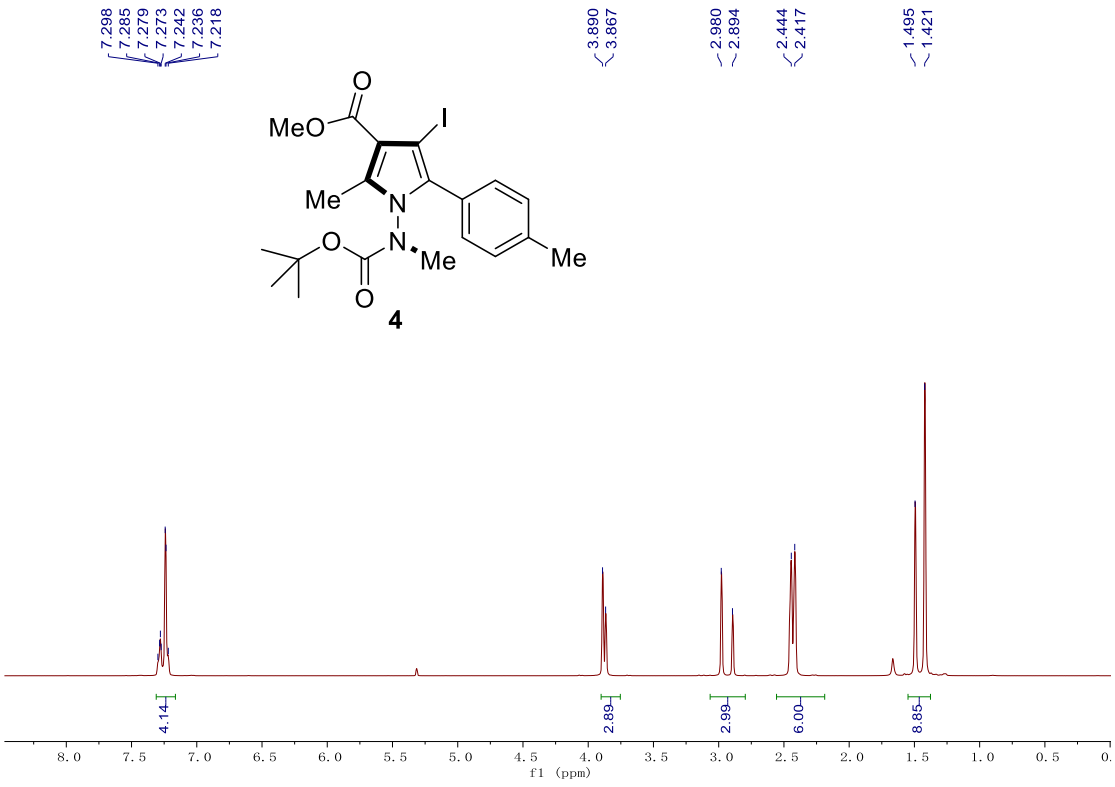

165.754
165.703
154.237
154.024
138.612
138.525
137.554
137.522
134.728
134.611
131.666
131.382
129.933
129.555
129.533
129.414
128.681
128.599
128.569
128.522
128.396
128.353
128.148
127.529
110.070
109.769
107.993
107.662
82.906
82.614
77.478
77.161
76.843
55.342
53.445
51.023
50.979
28.469
28.354
21.347
10.504
MeO
O
Me
N
Me
O
N
Bn
O
O
f1 (ppm)

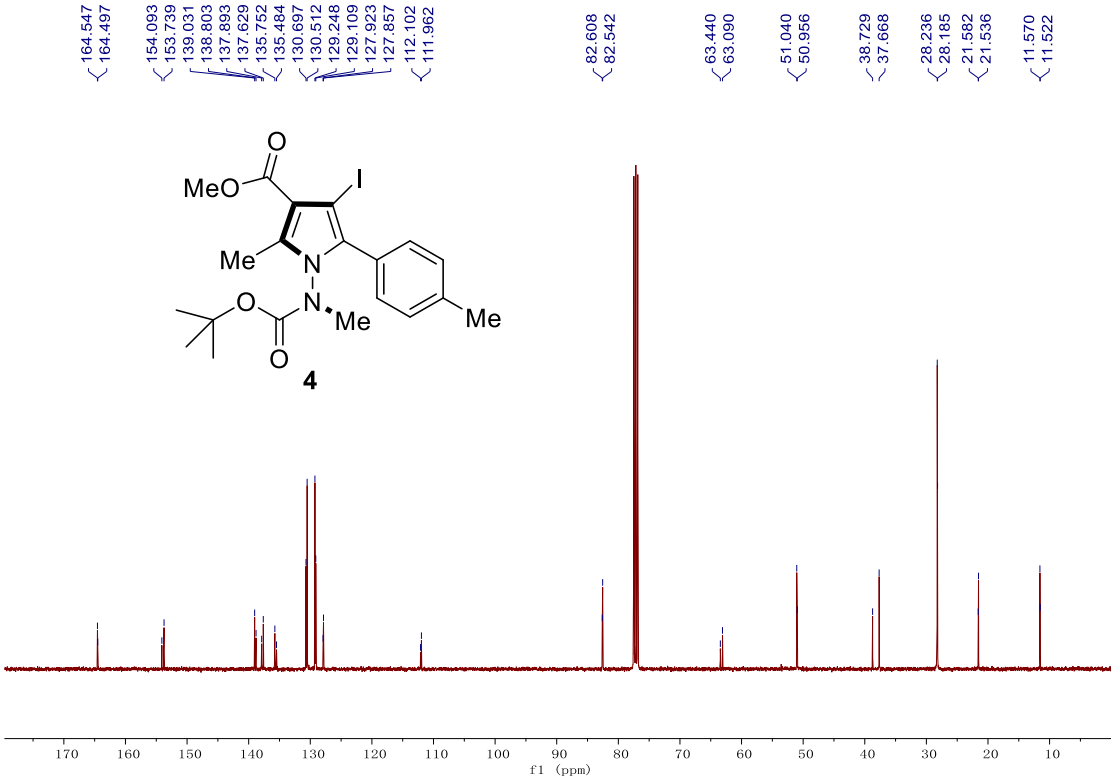
3ab

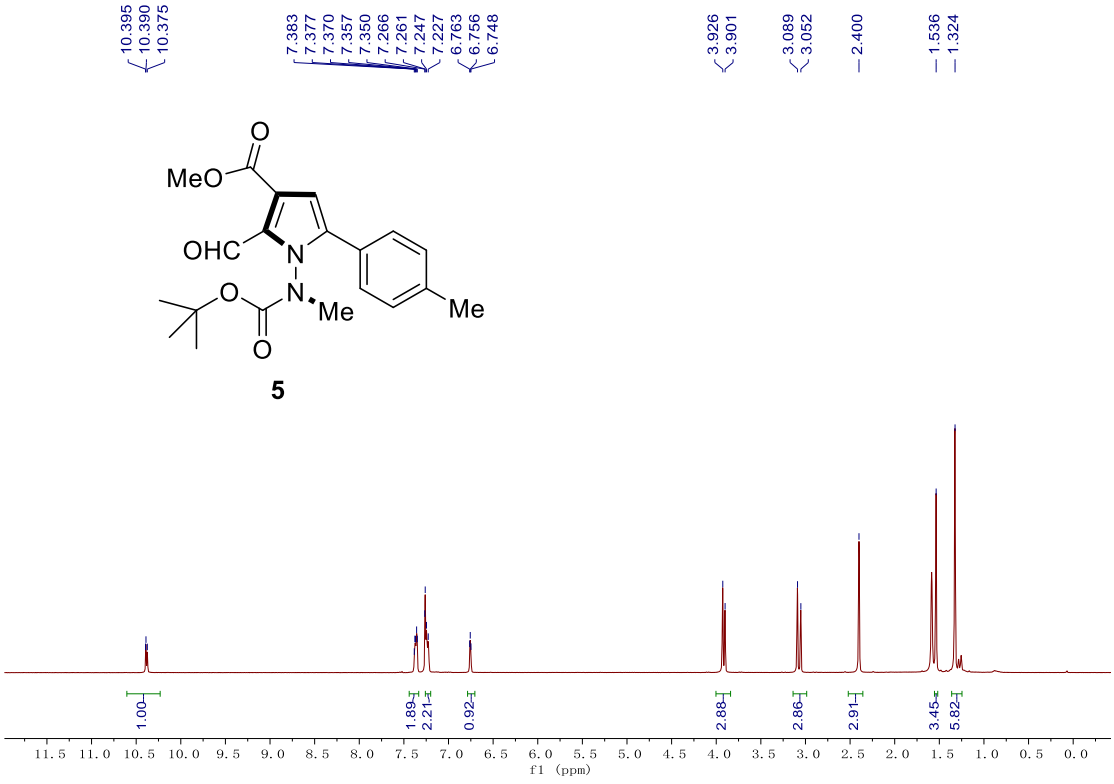

7.266
7.260
7.254
7.220
7.172
7.153
7.100
7.081
6.918
6.905
6.757
6.712
6.664
6.061
3.855
2.402
2.304
1.283
MeO
O
Me
N
Me
O
N
S
O
3.77
1.02
1.90
1.00
2.95
5.90
8.62
f1 (ppm)

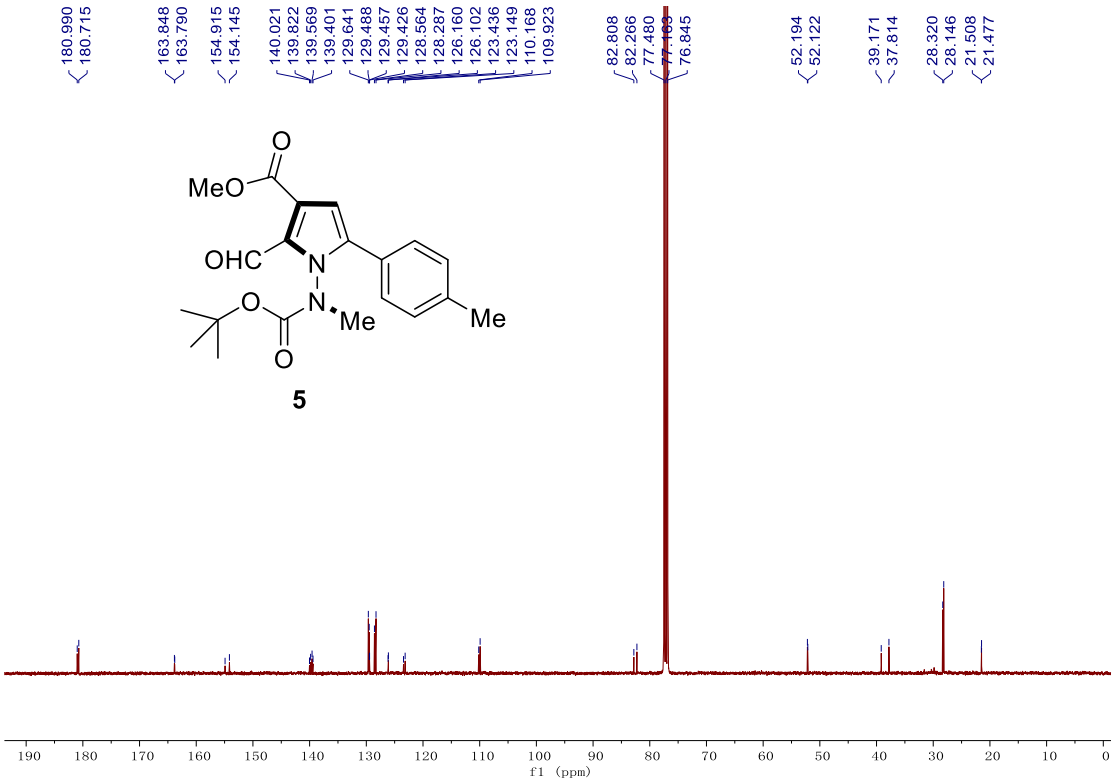
3ac

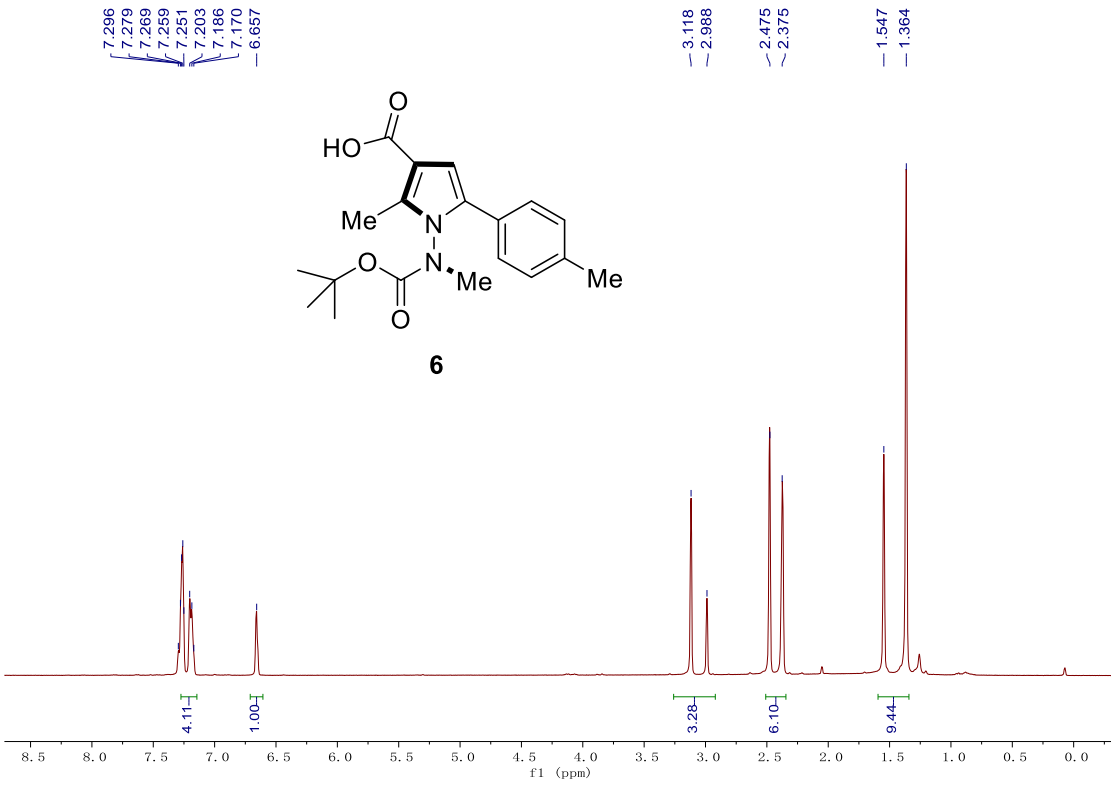

165.642
151.134
142.708
137.709
136.975
132.760
129.465
127.690
127.341
124.627
119.479
112.397
111.184
107.455
84.288
51.243
29.847
27.883
21.304
10.501
MeO
O
Me
N
N
O
O
S
Me
O
3ac
f1 (ppm)

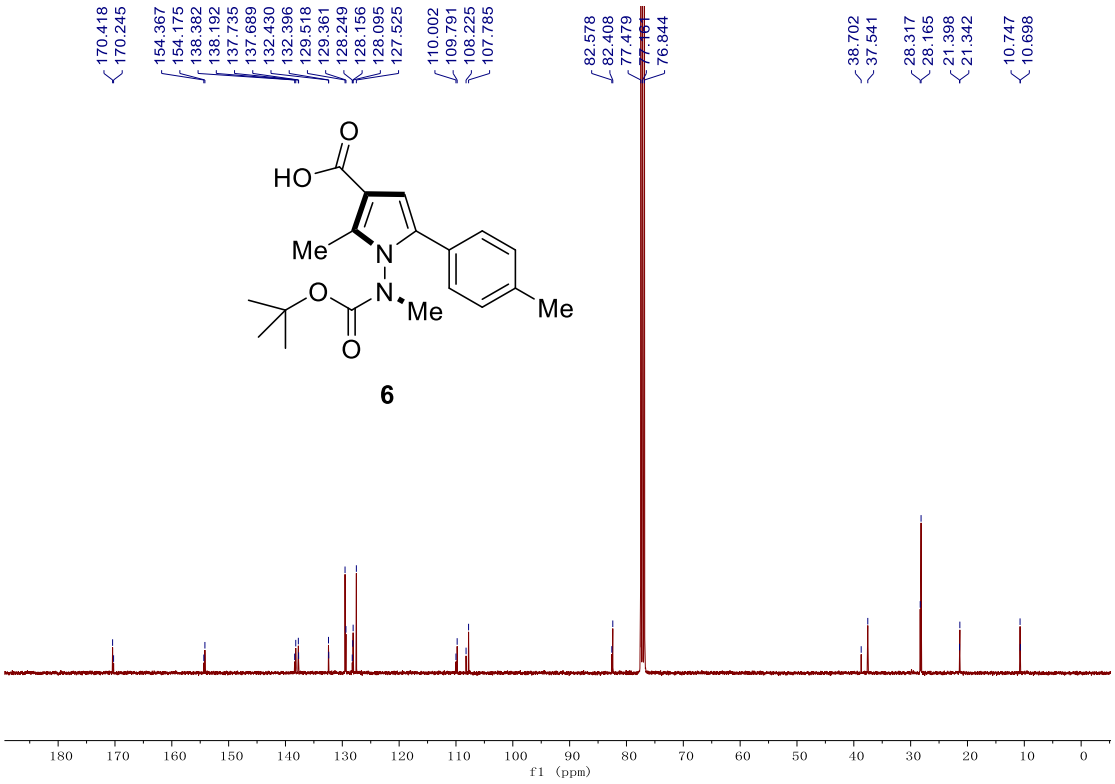

7.298
7.285
7.279
7.273
7.242
7.236
7.218
3.890
3.867
2.980
2.894
2.444
2.417
1.495
1.421
MeO
O
I
Me
N
N
Me
Me
O
O
4
4.14
2.89
2.99
6.00
8.85
f1 (ppm)


164.547
164.497
154.093
153.739
139.031
138.803
137.893
137.629
135.752
135.484
130.697
130.512
129.248
129.109
127.923
127.857
112.102
111.962
82.608
82.542
63.440
63.090
51.040
50.956
38.729
37.668
28.236
28.185
21.582
21.536
11.570
11.522
MeO
O
I
Me
N
N
Me
O
O
O
Me
4
f1 (ppm)

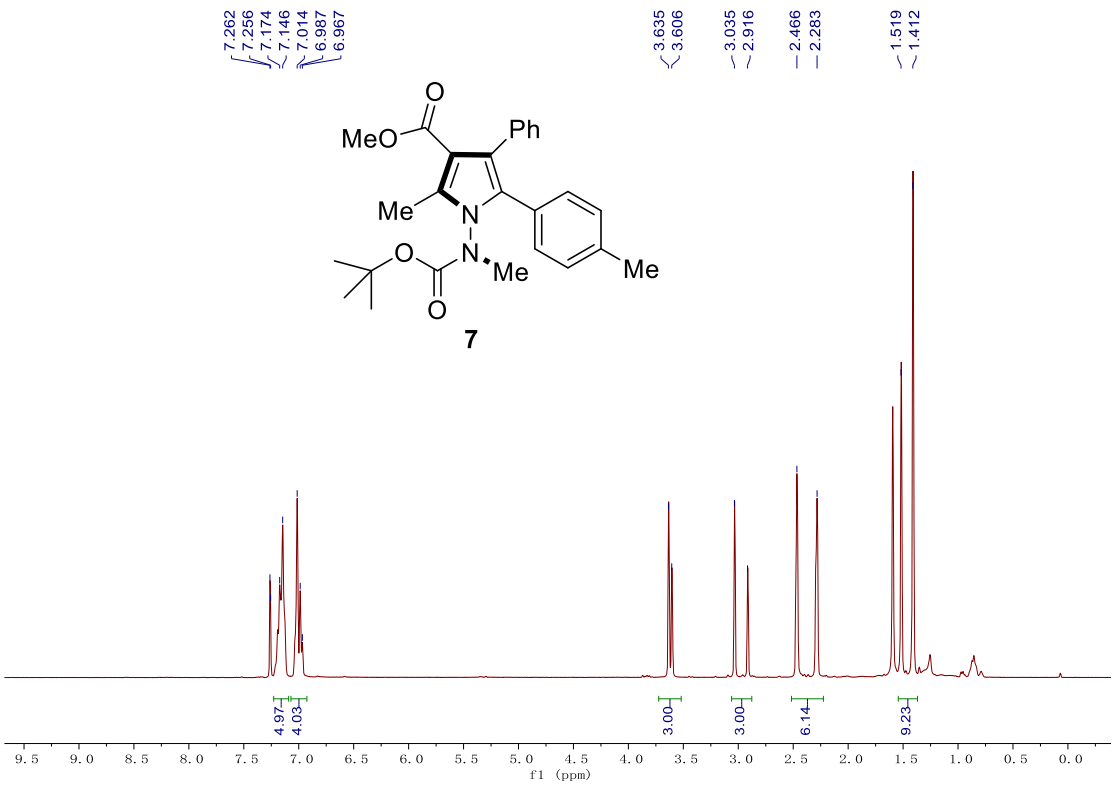

10.395
10.390
10.375
7.383
7.377
7.370
7.357
7.350
7.266
7.261
7.247
7.227
6.763
6.756
6.748
3.926
3.901
3.089
3.052
2.400
1.536
1.324
MeO
O
OHC
N
N
Me
O
O
Me
5
1.00
1.89
2.21
0.92
2.88
2.86
2.91
3.45
5.82
f1 (ppm)


180.990
180.715
163.848
163.790
154.915
154.145
140.021
139.822
139.569
139.401
129.641
129.488
129.457
129.426
128.564
128.287
126.160
126.102
123.436
123.149
110.168
109.923
82.808
82.266
77.480
77.163
76.845
52.194
52.122
39.171
37.814
28.320
28.146
21.508
21.477
MeO
OHC
N
O
N
Me
Me
O
O
5
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

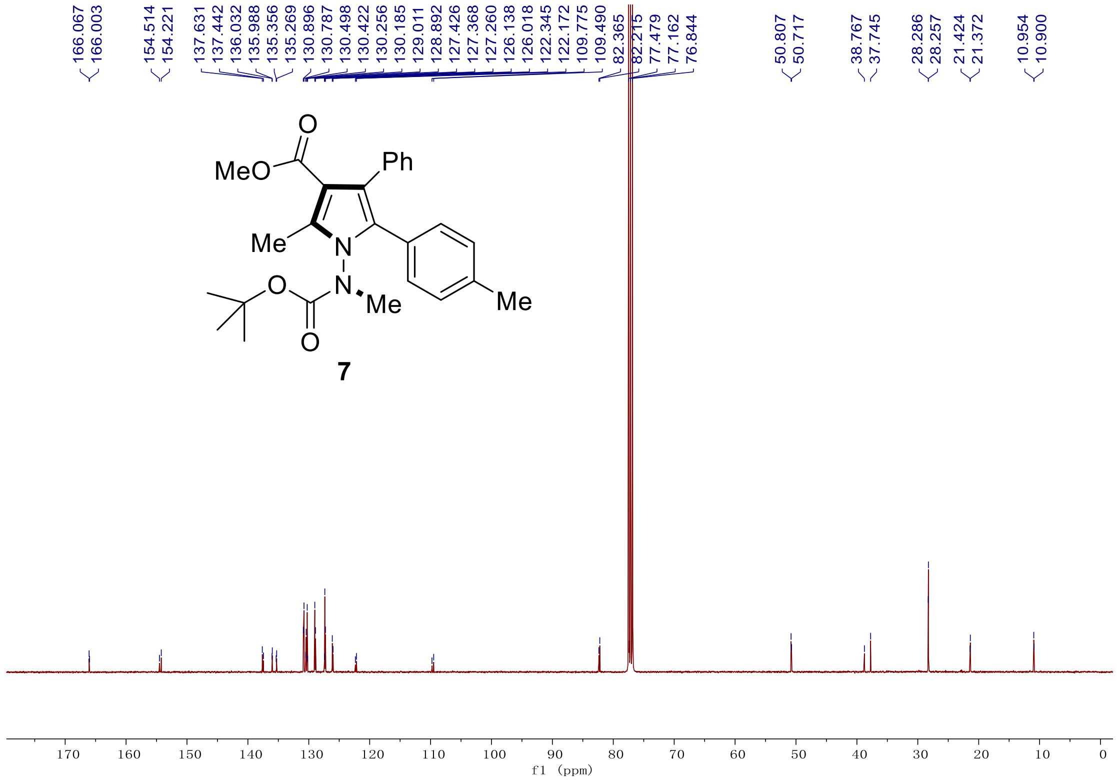

7.296
7.279
7.269
7.259
7.251
7.203
7.186
7.170
6.657
3.118
2.988
2.475
2.375
1.547
1.364
HO
O
Me
N
O
N
Me
Me
O
6
4.11
1.00
3.28
6.10
9.44
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

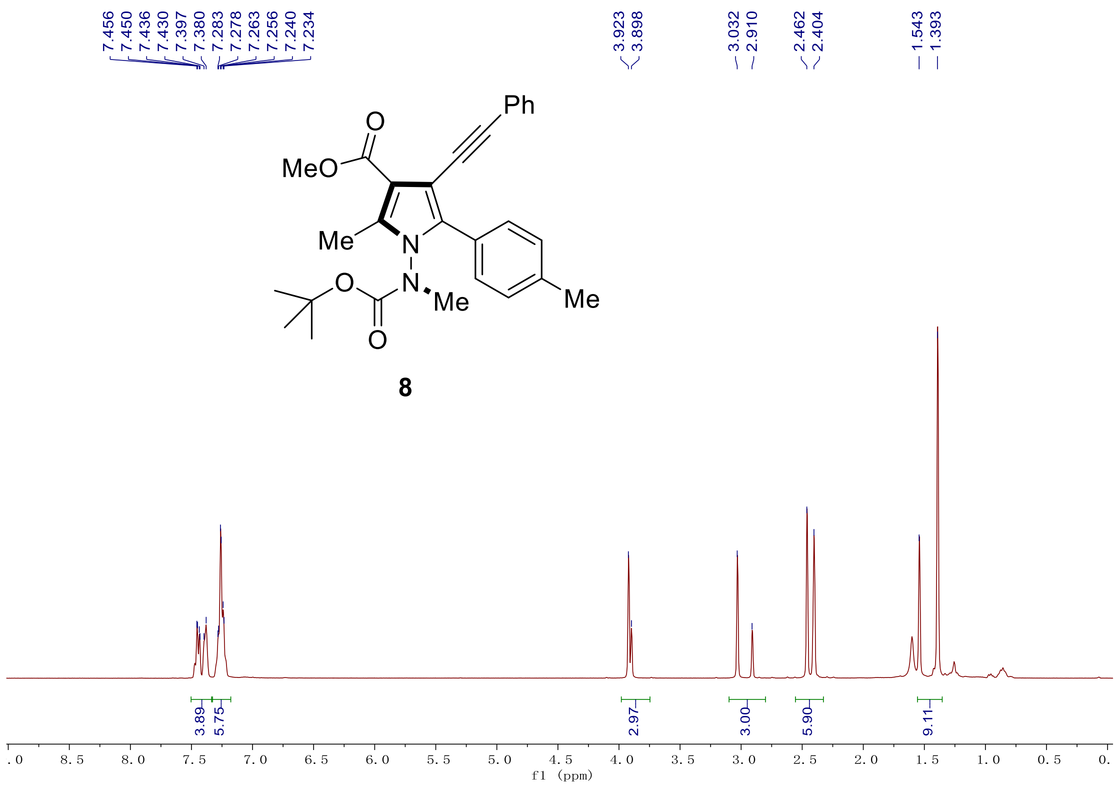

170.418
170.245
154.367
154.175
138.382
138.192
137.735
137.689
132.430
132.396
129.518
129.361
128.249
128.156
128.095
127.525
110.002
109.791
108.225
107.785
82.578
82.408
77.479
77.161
76.844
38.702
37.541
28.317
28.165
21.398
21.342
10.747
10.698
HO
O
Me
N
N
Me
O
O
Me
Me
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

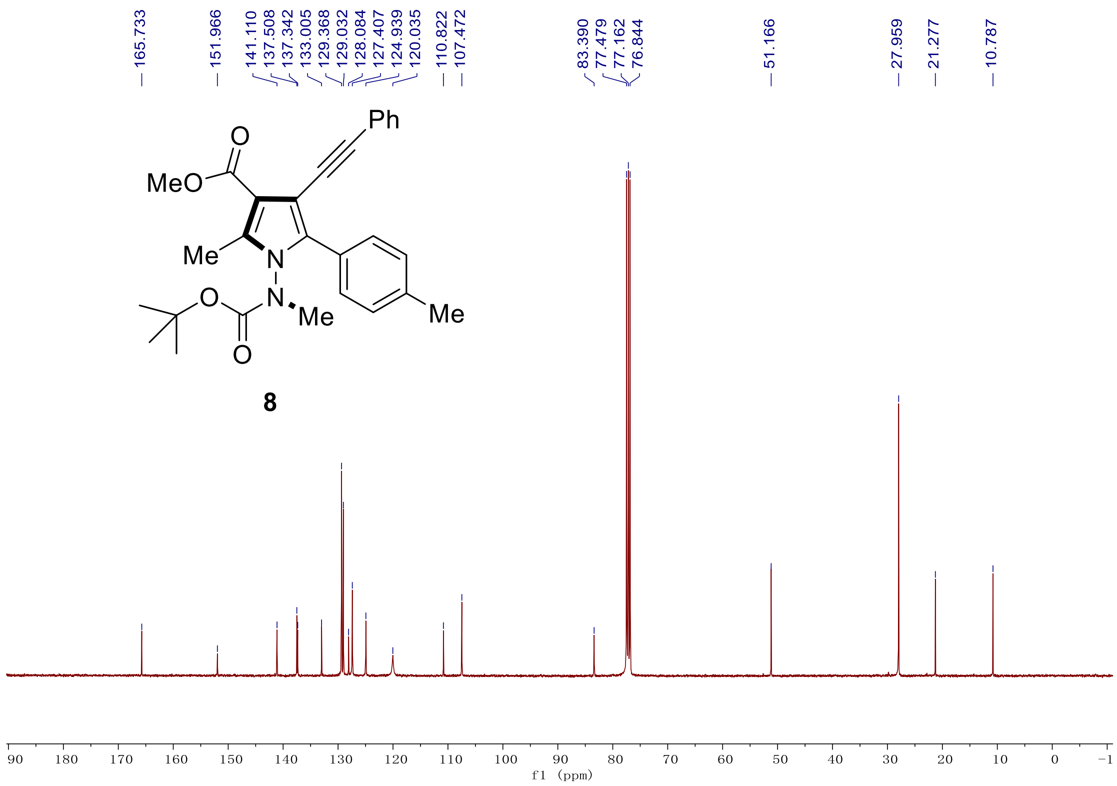
6


7.262
7.256
7.174
7.146
7.014
6.987
6.967
3.635
3.606
3.035
2.916
2.466
2.283
1.519
1.412
MeO
O
Ph
Me
N
N
Me
O
O
Me
4.97
4.03
3.00
3.00
6.14
9.23
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

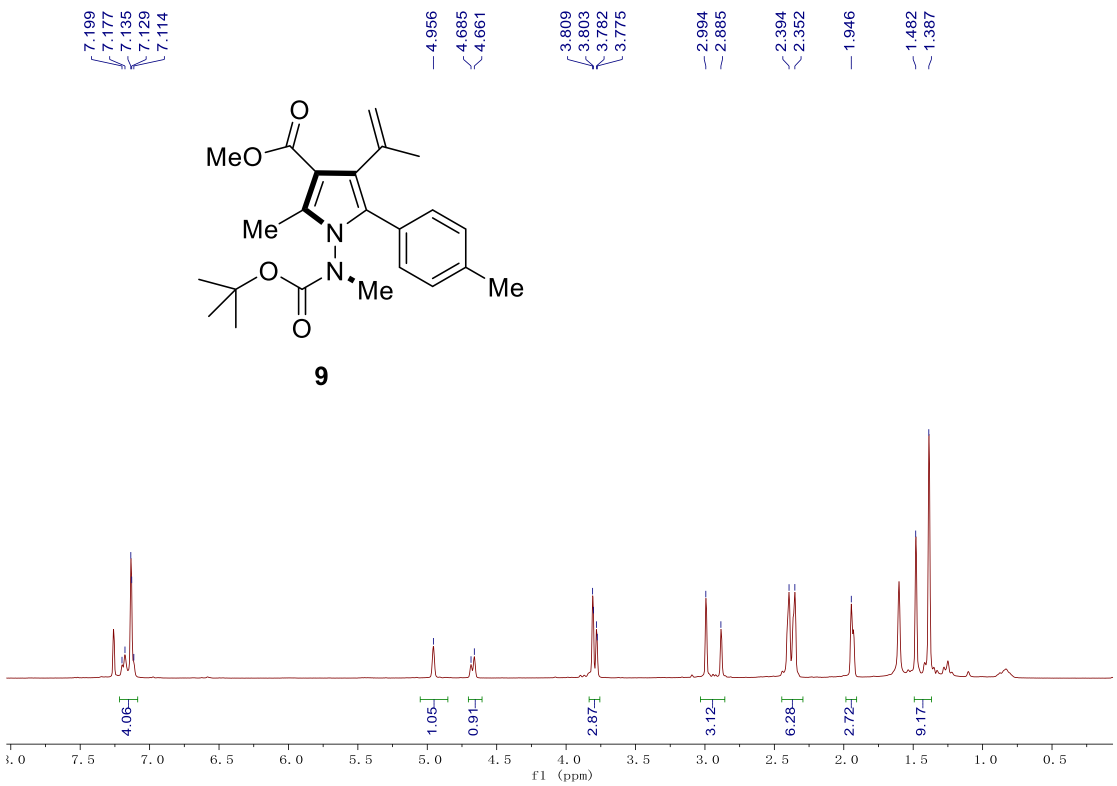
7


166.067
166.003
154.514
154.221
137.631
137.442
136.032
135.988
135.356
135.269
130.896
130.787
130.498
130.422
130.256
130.185
129.011
128.892
127.426
127.368
127.260
126.138
126.018
122.345
122.172
109.775
109.490
82.365
82.215
77.479
77.162
76.844
50.807
50.717
38.767
37.745
28.286
28.257
21.424
21.372
10.954
10.900
MeO
O
Ph
Me
N
N
O
Me
O
Me
7
f1 (ppm)

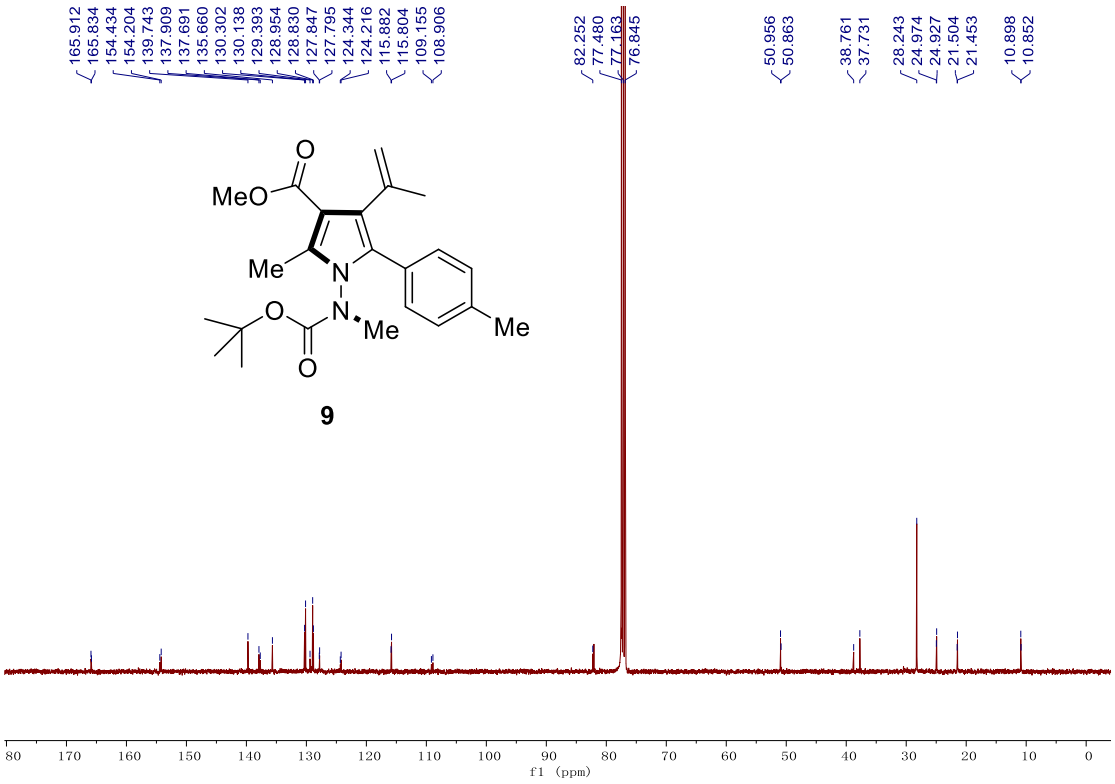

7.456
7.450
7.436
7.430
7.397
7.380
7.283
7.278
7.263
7.256
7.240
7.234
3.923
3.898
3.032
2.910
2.462
2.404
1.543
1.393
O
Ph
MeO
Me
N
N
O
Me
Me
O
8
3.89
5.75
2.97
3.00
5.90
9.11
f1 (ppm)


165.733
151.966
141.110
137.508
137.342
133.005
129.368
129.032
128.084
127.407
124.939
120.035
110.822
107.472
83.390
77.479
77.162
76.844
51.166
27.959
21.277
10.787
Ph
O
MeO
Me
N
N
O
Me
O
Me
f1 (ppm)

8


7.199
7.177
7.135
7.129
7.114
4.956
4.685
4.661
3.809
3.803
3.782
3.775
2.994
2.885
2.394
2.352
1.946
1.482
1.387
O
MeO
Me
N
N
O
Me
O
Me
4.06
1.05
0.91
2.87
3.12
6.28
2.72
9.17
f1 (ppm)

9


165.912
165.834
154.434
154.204
139.743
137.909
137.691
135.660
130.302
130.138
129.393
128.954
128.830
127.847
127.795
124.344
124.216
115.882
115.804
109.155
108.906
82.252
77.480
77.163
76.845
50.956
50.863
38.761
37.731
28.243
24.974
24.927
21.504
21.453
10.898
10.852
MeO
O
Me
N
N
Me
O
O
Me
Me
9
80
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)