Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

Supporting Information

Enantioselective β-Alkylation of Pyrroles under Formation of an All-Carbon Quaternary Stereocenter

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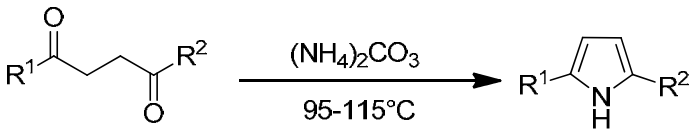
Contents

1. General Information

All reactions were carried out under an atmosphere of argon with magnetic stirring. Catalysis reactions were performed in brown glass vials. Solvents were distilled under argon from calcium hydride (CH_3CN, CH_2Cl_2) or sodium/benzophenone (Et_2O, THF, toluene). The iridium catalyst Λ-**MTC**[1], nitroolefins[1-3], diketones[4] and 2,5-Diphenyl-1*H*-pyrrole **1h**[5] were synthesized according to published procedures. All other reagents were purchased from commercial suppliers and used without further purification. Flash column chromatography was performed with silica gel (300-400 mesh, Yantai Jiangyou Silica Gel Development Co., Ltd). ^1H and ^{13}C NMR spectra were recorded on Bruker AM (400 MHz) or Bruker AM (500 MHz) spectrometer at ambient temperature. NMR standards were used as follows: $CDCl_3$ = 7.26 ppm (^1H NMR) and 77.0 ppm (^{13}C NMR). IR spectra were recorded on a Nicolet Avatar 330 FT-IR spectrophotometer. Chiral HPLC chromatograms were obtained from an Agilent 1260 Series HPLC system. High-resolution mass spectra were recorded on a Bruker En Apex Ultra 7.0 FT-MS instrument using ESI technique. Enantioselectivities were determined by chiral HPLC and the absolute configuration was assigned by single crystal X-ray diffraction of the product (*S*)-**3u**. All other products were assigned accordingly. Optical rotations were measured on a PerkinElmer 341 polarimeter at concentration of 1.0 g /100 mL.

2. Synthesis of Substrates and Racemic References

2.1 Synthesis of 2,5-Disubstiuted 1*H*-Pyrroles

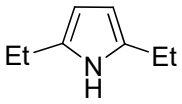


S1b-g

1b (R^1=R^2=Et)
1c (R^1=Et, R^2=Me)
1d (R^1=*n*Pr, R^2=Me)
1e (R^1=*c*Hex, R^2=Me)
1f (R^1=Ph, R^2=Me)
1g (R^1=*o*-MeOPh, R^2=Me)

General Procedure. 2,5-Dimethyl pyrrole **1a** was purchased and used without further purification. Other disubstituted pyrroles **1b-g** were synthesized following a published procedure with slight modifications.[6] Accordingly, a mixture of diketone[4] (8.8 mmol) and ammonium carbonate (17.6 mmol) was stirred at 95 °C for 1.5 h followed by 115 °C (oil bath temperature) for 1 h under continuous bubbling of argon. The reaction mixture was cooled to room temperature, then extracted with dichloromethane (2 x 2 mL). The combined organic layer was dried over anhydrous magnesium sulfate, concentrated in vacuo. The residue was subjected to flash chromatography (EtOAc/*n*-hexane = 1:100) to afford the pure pyrroles **1b-g**.

2,5-Diethyl-1*H*-pyrrole (1b)



Following the general procedure, octane-3,6-dione **S1b** (800.0 mg, 5.6 mmol) was converted to 2,5-diethyl-1*H*-pyrrole **1b** as a colourless oil (300.0 mg, 2.5 mmol, 44%).

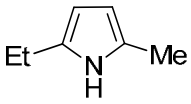
^{1}H NMR (500 MHz, $CDCl_3$): δ (ppm) 7.61 (br s, 1H), 5.80 (d, J = 2.6 Hz, 2H), 2.61 (q, J = 7.5 Hz, 4H), 1.25 (t, J = 7.6 Hz, 6H).

^{13}C NMR (126 MHz, $CDCl_3$): δ (ppm) 132.6, 103.9, 20.8, 13.6.

IR (film): ν (cm^{-1}) 3372, 3107, 2967, 2931, 2875, 2853, 1639, 1590, 1513, 1460, 1415, 1376, 1325, 1179, 1026, 792, 763.

HRMS (ESI, *m*/*z*) calcd for $C_8H_{14}N$ $(M+H)^+$ 124.1126, found: 124.1125.

2-Ethyl-5-methyl-1*H*-pyrrole (1c)



Following the general procedure, heptane-2,5-dione **S1c** (800.0 mg, 6.2 mmol) was converted to 2-ethyl-5-methyl-1*H*-pyrrole **1c** as a colourless oil (271.0 mg, 2.5 mmol, 40%).

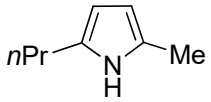
^{1}H NMR (500 MHz, $CDCl_3$): δ (ppm) 7.59 (br s, 1H), 5.79-5.77 (m, 2H), 2.60 (q, J = 7.6 Hz, 2H), 2.25 (s, 3H), 1.24 (t, J = 7.6 Hz, 3H).

^{13}C NMR (126 MHz, $CDCl_3$): δ (ppm) 132.8, 125.9, 105.6, 104.1, 20.8, 13.7, 12.9.

IR (film): ν (cm^{-1}) 3370, 3106, 2968, 2930, 1633, 1592, 1514, 1456, 1422, 1402, 1328, 1256, 1182, 1034, 1006, 765, 696, 666, 564.

HRMS (ESI, m/z) calcd for $C_7H_{12}N$ $(M+H)^+$ 110.0970, found: 110.0968.

2-Methyl-5-propyl-1*H*-pyrrole (1d)



Following the general procedure, octane-2,5-dione **S1d** (800.0 mg, 5.6 mmol) was converted to 2-methyl-5-propyl-1*H*-pyrrole **1d** as a colourless oil (269.0 mg, 2.2 mmol, 39%).

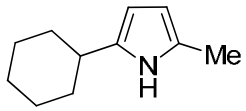
^{1}H NMR (500 MHz, $CDCl_3$): δ (ppm) 7.57 (br s, 1H), 5.78-5.76 (m, 2H), 2.53 (t, J = 7.5 Hz, 2H), 2.25 (s, 3H), 1.67-1.59 (m, 2H), 0.97 (t, J = 7.4 Hz, 3H).

^{13}C NMR (126 MHz, $CDCl_3$): δ (ppm) 131.3, 125.8, 105.5, 104.8, 29.8, 23.0, 13.9, 12.9.

IR (film): ν (cm^{-1}) 3370, 3105, 2959, 2931, 2872, 1592, 1513, 1456, 1423, 1401, 1182, 1034, 767.

HRMS (ESI, m/z) calcd for $C_8H_{14}N$ $(M+H)^+$ 124.1126, found: 124.1128.

2-Cyclohexyl-5-methyl-1*H*-pyrrole (1e)



Following the general procedure, 1-cyclohexylpentane-1,4-dione **S1e** (400.0 mg, 2.2 mmol) was converted to 2-cyclohexyl-5-methyl-1*H*-pyrrole **1e** as a colourless oil (165.0 mg, 1.0 mmol, 46%).

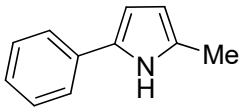
^{1}H NMR (500 MHz, $CDCl_3$): δ (ppm) 7.61 (br s, 1H), 5.77 (d, J = 2.7 Hz, 2H), 2.55-2.49 (m, 1H), 2.25 (s, 3H), 2.00-1.96 (m, 2H), 1.82-1.79 (m, 2H), 1.73-1.70 (m, 1H), 1.41-1.26 (m, 5H).

^{13}C NMR (126 MHz, $CDCl_3$): δ (ppm) 136.9, 125.5, 105.4, 102.8, 36.8, 33.3, 26.3, 26.1, 12.9.

IR (film): ν (cm^{-1}) 3377, 2925, 2852, 1591, 1448, 1401, 1041, 766, 745.

HRMS (ESI, m/z) calcd for $C_{11}H_{18}N$ $(M+H)^+$ 164.1439, found: 164.1436.

2-Methyl-5-phenyl-1*H*-pyrrole (1f)



Following the general procedure, 1-phenylpentane-1,4-dione **S1f** (400.0 mg, 2.3 mmol) was converted to 2-methyl-5-phenyl-1*H*-pyrrole **1f** as a white solid (184.0 mg, 1.2 mmol, 51%).

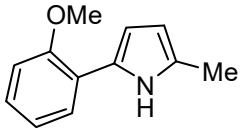
^{1}H NMR (500 MHz, $CDCl_3$): *δ* (ppm) 8.11 (br s, 1H), 7.44-7.42 (m, 2H), 7.36-7.32 (m, 2H), 7.18-7.15 (m, 1H), 6.40 (t, *J* = 3.0 Hz, 1H), 5.96 (t, *J* = 2.5 Hz, 1H), 2.34 (s, 3H).

^{13}C NMR (126 MHz, $CDCl_3$): *δ* (ppm) 132.9, 130.7, 129.0, 128.8, 125.6, 123.3, 107.9, 106.2, 13.2.

IR (film): *v* (cm^{-1}) 3401, 1515, 1475, 1452, 1075, 1039, 900, 774, 752, 687, 628, 569, 553.

HRMS (ESI, *m*/*z*) calcd for $C_{11}H_{12}N$ $(M+H)^+$ 158.0970, found: 158.0964.

2-(2-methoxyphenyl)-5-methyl-1*H*-pyrrole (1g)



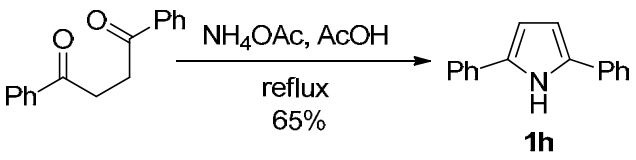
Following the general procedure, 1-(2-methoxyphenyl)pentane-1,4-dione **S1g** (495.0 mg, 2.4 mmol) was converted to 2-(2-methoxyphenyl)-5-methyl-1*H*-pyrrole **1g** as a white solid (262.1 mg, 1.4 mmol, 58%).

^{1}H NMR (500 MHz, $CDCl_3$): δ (ppm) 9.43 (br s, 1H), 7.64-7.62 (m, 1H), 7.15-7.11 (m, 1H), 6.99-6.95 (m, 2H), 6.51 (t, *J* = 3.0 Hz, 1H), 5.96 (s, 1H), 3.97 (s, 3H), 2.36 (s, 3H).

^{13}C NMR (126 MHz, $CDCl_3$): δ (ppm) 154.4, 128.3, 127.8, 126.1, 126.0, 121.4, 121.3, 111.5, 106.8, 106.4, 55.6, 13.3.

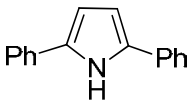
IR (film): *v* (cm^{-1}) 3453, 2937, 2838, 1587, 1511, 1466, 1440, 1315, 274, 1234, 1211, 1180, 1123, 1069, 1053, 1024, 929, 749, 667, 640, 581.

HRMS (ESI, *m*/*z*) calcd for $C_{12}H_{14}NO$ $(M+H)^+$ 188.1075, found: 188.1074.



1h

2,5-Diphenyl-1*H*-pyrrole (1h)



Substrate **1h** was prepared according to a reported literature.[5]

^{1}H NMR (500 MHz, $CDCl_3$): δ (ppm) 8.65 (br s, 1H), 7.51 (d, J = 8.0 Hz, 4H), 7.37 (t, J = 7.7 Hz, 4H), 7.21 (t, J = 7.6 Hz, 2H), 6.57 (s, 2H).

^{13}C NMR (126 MHz, $CDCl_3$): δ (ppm) 133.1, 132.4, 128.9, 126.3, 123.8, 107.9.

All the data are in full accordance with the literature.[5]

2.2 Synthesis of Nitroolefins

Nitroolefins **2a-b, 2d-i, 2k, 2l,**[1] **2c, 2j,**[2] and **2m**[3] were synthesized according to published procedures.

2.3 Synthesis of Racemic Products Used as HPLC References

General Procedure. A solution of pyrroles **1a-h** (0.10 mmol), nitroolefins **2a-m** (0.20 mmol) and the racemic catalyst *rac*-**MTC** (0.0010-0.0040 mmol) in anhydrous toluene (50 or 200 μL) was stirred at 40 °C for 12-40 h under argon atmosphere (monitoring by ^{1}H NMR). The resulting mixture was dried in vacuo and then subjected to flash chromatography (silica gel, eluents: EtOAc/*n*-hexane = 1:50) to afford the racemic products *rac*-**3a-t**, which were used as references to determine enantiomeric excess of the enantioselective β-alkylation of pyrroles.

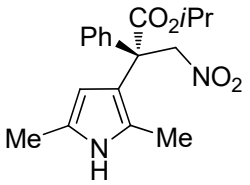
3. Enantioselective β-Alkylation of Pyrroles Catalyzed by Λ-MTC

3.1 Catalytic Reactions

General procedure for catalytic reactions in Table 1. A solution of 2,5-dimethyl 1*H*-pyrrole **1a** (0.050-0.25 mmol), nitroacrylate **2a** (0.050-0.25 mmol) and catalyst Λ-**MTC** (0.00050-0.0010 mmol) in anhydrous toluene (0.025-0.10 mL) was stirred at 20 or 40 °C for the indicated time (monitoring by ^{1}H NMR) under argon atmosphere and reduced light. The resulting mixture was then dried in vacuo. Conversions were determined by ^{1}H NMR spectroscopy of the crude product, and enantiomeric excess established by HPLC on a chiral stationary phase.

General procedure for catalytic reactions in Figures 2 and 3. A solution of pyrroles **1a-h** (0.10 mmol), nitroolefins **2a-m** (0.20 mmol) and catalyst Λ-**MTC** (0.0010-0.0040 mmol) in anhydrous toluene (50 or 200 μL) was stirred at 40 °C for the indicated time (monitoring by ^{1}H NMR) under argon atmosphere and reduced light. The resulting mixture was then dried in vacuo and subjected to flash chromatography (silica gel, eluents: EtOAc/*n*-hexane = 1:50) to afford products **3a-t**. Enantiomeric excess of the pure product was then established by HPLC on a chiral stationary phase.

(*S*)-Isopropyl 2-(2,5-dimethyl-1*H*-pyrrol-3-yl)-3-nitro-2-phenylpropanoate (3a)



A solution of **1a** (9.5 mg, 0.10 mmol), **2a** (47.0 mg, 0.20 mmol) and catalyst Λ-**MTC** (2.23 mg, 0.0010 mmol) in anhydrous toluene (50 μL) was stirred at 40 °C for 30 h under argon atmosphere and reduced light. The mixture was then dried in vacuo and subjected to flash chromatography (silica gel, eluents: EtOAc/*n*-hexane = 1:50) to afford product **3a** as a light green oil (31.4 mg, 0.095 mmol, 95%). Enantiomeric excess was established by HPLC analysis using a Chiralpak AD-H column, ee = 94% (HPLC conditions: AD-H, 254 nm, *n*-hexane/isopropanol = 90:10, flow rate 1.0 mL/min, 25 °C, t_r(major) = 8.6 min, t_r(minor) = 10.4 min); $[a]_D^{20}$ = -46.1° (c = 1.0, $CHCl_3$).

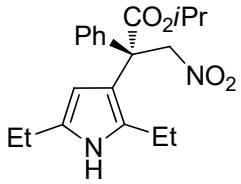
^{1}H NMR (500 MHz, $CDCl_3$): *δ* (ppm) 7.66 (br s, 1H), 7.36 (d, *J* = 7.7 Hz, 2H), 7.28-7.21 (m, 3H), 5.73 (s, 1H), 5.43 (d, *J* = 13.7 Hz, 1H), 5.16-5.08 (m, 2H), 2.17 (s, 3H), 1.64 (s, 3H), 1.22 (q, *J* = 6.3 Hz, 6H).

^{13}C NMR (126 MHz, $CDCl_3$): *δ* (ppm) 170.3, 139.3, 128.4, 127.9, 127.2, 124.6, 124.4, 116.4, 105.8, 81.8, 69.3, 54.4, 21.40, 21.36, 12.8.

IR (film): v (cm^{-1}) 3389, 2963, 2925, 2856, 1724, 1597, 1556, 1496, 1448, 1421, 1375, 1261, 1215, 1183, 1104, 923, 877, 801, 701, 670, 648.

HRMS (ESI, m/z) calcd for $C_{18}H_{22}N_2NaO_4$ $(M+Na)^+$ 353.1477, found: 353.1471.

(*S*)-Isopropyl 2-(2,5-diethyl-1*H*-pyrrol-3-yl)-3-nitro-2-phenylpropanoate (3b)



A solution of **1b** (12.3 mg, 0.10 mmol), **2a** (47.0 mg, 0.20 mmol) and catalyst Λ-**MTC** (2.23 mg, 0.0010 mmol) in anhydrous toluene (50 μL) was stirred at 40 °C for 29 h under argon atmosphere and reduced light. The mixture was then dried in vacuo and subjected to flash chromatography (silica gel, eluents: EtOAc/*n*-hexane = 1:50) to afford **3b** as a light green oil (33.7 mg, 0.094 mmol 94%). Enantiomeric excess was established by HPLC analysis using a Chiralpak AD-H column, ee = 95% (HPLC conditions: AD-H, 254 nm, *n*-hexane/isopropanol = 95:5, flow rate 1.0 mL/min, 25 °C, t_r(major) = 12.4 min, t_r(minor) = 14.3 min); $[a]_D^{20}$ = -41.9° (c=1.0, $CHCl_3$).

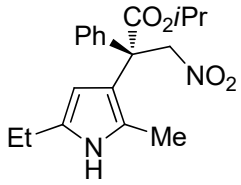
^{1}H NMR (400 MHz, $CDCl_3$): *δ* (ppm) 7.65 (br s, 1H), 7.39-7.37 (m, 2H), 7.29-7.21 (m, 3H), 5.74 (d, *J* = 2.8 Hz, 1H), 5.47(d, *J* = 13.8 Hz, 1H), 5.16-5.09 (m, 2H), 2.57 (q, *J* = 7.6 Hz, 2H), 2.15-1.93 (m, 2H), 1.25-1.19 (m, 9H), 0.85 (t, *J* = 7.6 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): *δ* (ppm) 170.3, 139.7, 131.4, 129.8, 128.4, 127.9, 127.2, 116.0, 103.8, 82.1, 69.3, 54.4, 21.4, 20.7, 19.6, 13.3, 12.8.

IR (film): v (cm^{-1}) 3395, 2965, 2926, 2854, 1723, 1593, 1556, 1493, 1448, 1416, 1375, 1322, 1261, 1211, 1183, 1106, 1023, 865, 799, 702, 668.

HRMS (ESI, m/z) calcd for $C_{20}H_{26}N_2NaO_4$ $(M+Na)^+$ 381.1790, found: 381.1784.

(*S*)-Isopropyl 2-(5-ethyl-2-methyl-1*H*-pyrrol-3-yl)-3-nitro-2-phenylpropanoate (3c)



A solution of **1c** (10.9 mg, 0.10 mmol), **2a** (47.0 mg, 0.20 mmol) and catalyst Λ-**MTC** (2.23 mg, 0.0010 mmol) in anhydrous toluene (50 μL) was stirred at 40 °C for 15 h under argon atmosphere and reduced light. The mixture was then dried in vacuo and subjected to flash chromatography (silica gel, eluents: EtOAc/*n*-hexane = 1:50) to afford a mixture of regioisomers **3c** and **3c'** as a light green oil (33.1 mg, 0.096 mmol, 96%). The regioselectivity was determined as 4:1 (**3c**:**3c'**) by ^{1}H NMR. Enantiomeric excess of **3c** was established as 96% and **3c'** as 93% by HPLC analysis using a Chiralpak AD-H column. (HPLC conditions: AD-H, 254 nm, *n*-hexane/isopropanol = 95:5, flow rate 1.0 mL/min, 25 °C, regioisomer **3c**: t_r(major) = 15.4 min, t_r(minor) = 19.4 min; regioisomer **3c'**: t_r(major) = 13.8 min, t_r(minor) = 17.4 min).

Analytic data of the major regioisomer 3c:

^{1}H NMR (400 MHz, $CDCl_3$): *δ* (ppm) 7.59 (br s, 1H), 7.38-7.36 (m, 2H), 7.27-7.23 (m, 3H), 5.75 (d, *J* =

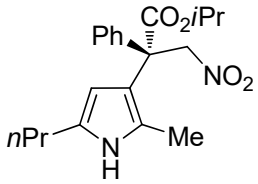
2.6 Hz, 1H), 5.46 (d, *J* = 13.8 Hz, 1H), 5.14-5.10 (m, 2H), 2.54 (q, *J* = 7.5 Hz, 2H), 1.66 (s, 3H), 1.25-1.23 (m, 3H), 1.22-1.18 (m, 6H).

^{13}C NMR (126 MHz, $CDCl_3$): *δ* (ppm) 170.3, 139.3, 131.2, 128.5, 127.9, 127.2, 124.2, 116.3, 104.1, 81.8, 69.3, 54.5, 21.4, 20.6, 13.4, 12.8.

IR (film): *v* (cm^{-1}) 3392, 2964, 1724, 1595, 1556, 1496, 1448, 1375, 1322, 1261, 1107, 923, 801, 701, 594, 568.

HRMS (ESI, *m*/*z*) calcd for $C_{19}H_{24}N_2NaO_4$ $(M+Na)^+$ 367.1634, found: 367.1625.

(*S*)-Isopropyl 2-(2-methyl-5-propyl-1*H*-pyrrol-3-yl)-3-nitro-2-phenylpropanoate (3d)



A solution of **1d** (12.3 mg, 0.10 mmol), **2a** (47.0 mg, 0.20 mmol) and catalyst Λ-**MTC** (2.23 mg, 0.0010 mmol) in anhydrous toluene (50 μL) was stirred at 40 °C for 15 h under argon atmosphere and reduced light. The mixture was then dried in vacuo and subjected to flash chromatography (silica gel, eluents: EtOAc/*n*-hexane = 1:50) to afford a mixture of regioisomers **3d** and **3d'** as a light green oil (35.1 mg, 0.098 mmol 98%). The regioselectivity was determined as 4:1 (**3d**:**3d'**) by ^{1}H NMR. Enantiomeric excess of **3d** was established as 97% and **3d'** as 94% by HPLC analysis using a Chiralpak AD-H column. (HPLC conditions: AD-H, 254 nm, *n*-hexane/isopropanol = 95:5, flow rate 0.8 mL/min, 25 °C, regioisomer **3d**: t_r(major) = 17.3 min, t_r(minor) = 24.2 min; regioisomer **3d'**: t_r(major) = 14.8 min, t_r(minor) = 18.5 min).

Analytic data of the major regioisomer 3d:

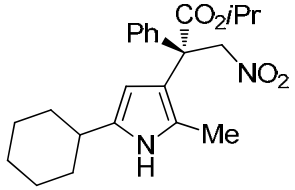
^{1}H NMR (400 MHz, $CDCl_3$): *δ* (ppm) 7.57 (br s, 1H), 7.39-7.36 (m, 2H), 7.29-7.25 (m, 3H), 5.74 (d, *J* = 2.9 Hz, 1H), 5.47 (d, *J* = 13.7 Hz, 1H), 5.14-5.09 (m, 2H), 2.48 (t, *J* = 7.50 Hz, 2H), 1.66 (s, 3H), 1.59 (q, *J* = 7.5 Hz, 2H), 1.24-1.18 (m, 6H), 0.94 (t, *J* = 7.3 Hz, 3H).

^{13}C NMR (126 MHz, $CDCl_3$): *δ* (ppm) 170.2, 139.3, 129.6, 128.5, 127.9, 127.2, 124.2, 116.3, 105.0, 81.9, 69.2, 54.4, 29.6, 22.7, 21.4, 13.7, 12.8.

IR (film): *v* (cm^{-1}) 3390, 2961, 2926, 2855, 1723, 1595, 1556, 1496, 1448, 1417, 1375, 1261, 1212, 1106, 1024, 923, 801, 701, 568.

HRMS (ESI, *m*/*z*) calcd for $C_{20}H_{26}N_2NaO_4$ $(M+Na)^+$ 381.1790, found: 381.1784.

(*S*)-Isopropyl 2-(5-cyclohexyl-2-methyl-1*H*-pyrrol-3-yl)-3-nitro-2-phenyl-propanoate (3e)



A solution of **1e** (16.3 mg, 0.10 mmol), **2a** (47.0 mg, 0.20 mmol) and catalyst Λ-**MTC** (2.23 mg, 0.0010 mmol) in anhydrous toluene (50 μL) was stirred at 40 °C for 16 h under argon atmosphere and reduced light. The mixture was then dried in vacuo and subjected to flash chromatography (silica gel, eluents: EtOAc/*n*-hexane = 1:50) to afford **3e** as a light green oil (36.7 mg, 0.092 mmol, 92%). Enantiomeric excess was established by HPLC analysis using a Chiralpak AD-H column, ee = 97% (HPLC conditions: AD-H, 254 nm, *n*-hexane/isopropanol = 95:5, flow rate 1.0 mL/min, 25 °C, t_r(major) = 11.8 min, t_r(minor) = 14.7 min); $[a]_D^{20}$ = -53.6° (c=1.0, $CHCl_3$).

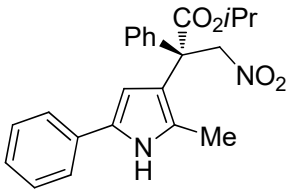
^{1}H NMR (500 MHz, $CDCl_3$): *δ* (ppm) 7.59 (br s, 1H), 7.37 (d, *J* = 7.7 Hz, 2H), 7.28-7.21 (m, 3H), 5.72 (s, 1H), 5.49 (d, *J* = 13.8 Hz, 1H), 5.15-5.07 (m, 2H), 2.49-2.44 (m, 1H), 1.95-1.92 (m, 2H), 1.81-1.78 (m, 2H), 1.71-1.69 (m, 1H), 1.65 (s, 3H), 1.37-1.31 (m, 5H), 1.21 (dd, *J* = 17.2, 6.2 Hz, 6H).

^{13}C NMR (126 MHz, $CDCl_3$): *δ* (ppm) 170.2, 139.3, 135.1, 128.6, 127.9, 127.2, 123.8, 116.1, 102.9, 81.9, 69.2, 54.5, 36.5, 33.0, 26.2, 26.1, 21.4, 12.9.

IR (film): *v* (cm^{-1}) 3393, 2925, 2852, 1724, 1592, 1556, 1493, 1448, 1417, 1375, 1261, 1212, 1105, 1023, 923, 801, 738, 700, 667, 648.

HRMS (ESI, *m*/*z*) calcd for $C_{23}H_{30}N_2NaO_4$ $(M+Na)^+$ 421.2103, found: 421.2097.

(*S*)-Isopropyl 2-(2-methyl-5-phenyl-1*H*-pyrrol-3-yl)-3-nitro-2-phenylpropanoate (3f)



A solution of **1f** (15.7 mg, 0.10 mmol), **2a** (47.0 mg, 0.20 mmol) and catalyst Λ-**MTC** (8.92 mg, 0.0040 mmol) in anhydrous toluene (50 μL) was stirred at 40 °C for 29 h under argon atmosphere and reduced light. The mixture was then dried in vacuo and subjected to flash chromatography (silica gel, eluents: EtOAc/*n*-hexane = 1:50) to afford **3f** as a yellow solid (35.3 mg, 0.090 mmol, 90%). Enantiomeric excess was established by HPLC analysis using a Chiralpak OD-H column, ee = 96% (HPLC conditions: OD-H, 254 nm, *n*-hexane/isopropanol = 90:10, flow rate 1.0 mL/min, 25 °C, t_r(major) = 19.6 min, t_r(minor) = 12.3 min); $[a]_D^{20}$ = -67.5° (c=1.0, $CHCl_3$).

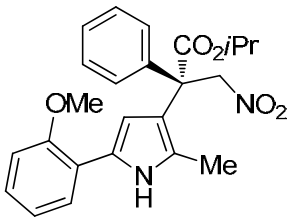
^{1}H NMR (500 MHz, $CDCl_3$): *δ* (ppm) 8.14 (br s, 1H), 7.40 (t, *J* = 6.8 Hz, 4H), 7.36-7.26 (m, 5H), 7.18 (t, *J* = 7.4 Hz, 1H), 6.42 (d, *J* = 2.8 Hz, 1H), 5.49 (d, *J* = 13.7 Hz, 1H), 5.22 (d, *J* = 13.7 Hz, 1H), 5.18-5.13 (m, 1H), 1.78 (s, 3H), 1.24 (dd, *J* = 18.4, 6.2 Hz, 6H).

^{13}C NMR (126 MHz, $CDCl_3$): *δ* (ppm) 170.0, 139.0, 132.1, 129.1, 128.9, 128.4, 128.1, 127.6, 127.5, 126.0, 123.2, 118.8, 106.0, 81.7, 69.6, 54.5, 21.5, 21.4, 13.2.

IR (film): *v* (cm^{-1}) 3387, 2962, 2925, 2854, 1723, 1610, 1581, 1555, 1511, 1464, 1375, 1295, 1260, 1215, 1181, 1105, 1027, 800, 759, 666.

HRMS (ESI, *m*/*z*) calcd for $C_{23}H_{24}N_2NaO_4$ $(M+Na)^+$ 415.1634, found: 415.1627.

(*S*)-Isopropyl 2-(5-(2-methoxyphenyl)-2-methyl-1*H*-pyrrol-3-yl)-3-nitro-2-phenylpropanoate (3g)



A solution of **1g** (18.7 mg, 0.10 mmol), **2a** (47.0 mg, 0.20 mmol) and catalyst Λ-**MTC** (8.90 mg, 0.0040 mmol) in anhydrous toluene (50 μL) was stirred at 40 °C for 29 h under argon atmosphere and reduced light. The mixture was then dried in vacuo and subjected to flash chromatography (silica gel, eluents: EtOAc/*n*-hexane = 1:50) to afford **3g** as a light yellow oil (39.3 mg, 0.093 mmol 93%). Enantiomeric excess was established by HPLC analysis using a Chiralpak OD-H column, ee = 98% (HPLC conditions: OD-H, 254 nm, *n*-hexane/isopropanol = 95:5, flow rate 1.0 mL/min, 25 °C, t_r(major) = 26.9 min, t_r(minor) = 17.5 min); $[a]_D^{20}$ = -65.3° (c=1.0, $CHCl_3$).

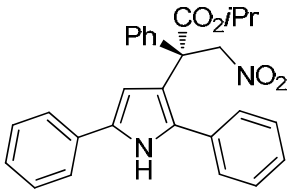
^{1}H NMR (500 MHz, $CDCl_3$): δ (ppm) 9.46 (br s, 1H), 7.59 (d, *J* = 8.2 Hz, 1H), 7.41-7.39 (m, 2H), 7.30-7.23 (m, 3H), 7.15-7.12 (m, 1H), 6.99-6.93 (m, 2H), 6.51 (d, *J* = 2.5 Hz, 1H), 5.54 (d, *J* = 13.8 Hz, 1H), 5.19 (d, *J* = 13.8 Hz, 1H), 5.17-5.12 (m, 1H), 3.94 (s, 3H), 1.78 (s, 3H), 1.25 (d, *J* = 6.3 Hz, 3H), 1.21 (d, *J* = 6.3 Hz, 3H).

^{13}C NMR (126 MHz, $CDCl_3$): δ (ppm) 170.1, 154.5, 139.1, 128.5, 128.0, 127.4, 126.9, 126.5, 126.3, 125.9, 121.4, 120.4, 117.6, 111.5, 106.0, 81.8, 69.4, 55.6, 54.4, 21.4, 13.3.

IR (film): v (cm^{-1}) 3442, 2980, 2931, 1728, 1556, 1508, 1465, 1375, 1237, 1180, 1144, 1106, 1049, 1024, 792, 751, 702, 670.

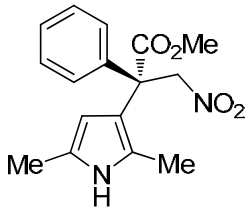
HRMS (ESI, *m*/*z*) calcd for $C_{24}H_{26}N_2NaO_5$ $(M+Na)^+$ 445.1739, found: 445.1738.

(*S*)-Isopropyl 2-(2,5-diphenyl-1*H*-pyrrol-3-yl)-3-nitro-2-phenylpropanoate (3h)



A solution of **1h** (21.9 mg, 0.10 mmol), **2a** (47.0 mg, 0.20 mmol) and catalyst Λ-**MTC** (8.92 mg, 0.0040 mmol) in anhydrous toluene (50 μL) was stirred at 40 °C for 30 h under argon atmosphere and reduced light. TLC and ^{1}H NMR experiments revealed that the desired product **3h** was not formed. 98% of **2a** was recycled.

(*S*)-Methyl 2-(2,5-dimethyl-1*H*-pyrrol-3-yl)-3-nitro-2-phenylpropanoate (3i)



A solution of **1a** (9.5 mg, 0.10 mmol), **2b** (41.4 mg, 0.20 mmol) and catalyst Λ-**MTC** (2.23 mg, 0.0010 mmol) in anhydrous toluene (50 μL) was stirred at 40 °C for 29 h under argon atmosphere and reduced light. The mixture was then dried in vacuo and subjected to flash chromatography (silica gel, eluents: EtOAc/*n*-hexane = 1:50) to afford **3i** as a light green oil (27.8 mg, 0.092 mmol, 92%). Enantiomeric excess was established by HPLC analysis using a Chiralpak AD-H column, ee = 90% (HPLC conditions: AD-H, 254 nm, *n*-hexane/isopropanol = 95:5, flow rate 1.0 mL/min, 25 °C, t_r(major) = 23.3 min, t_r(minor) = 30.1 min); $[a]_D^{20}$ = -43.6° (c=1.0, $CHCl_3$).

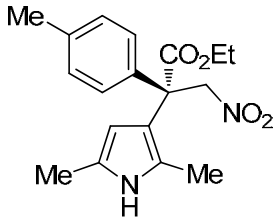
^{1}H NMR (400 MHz, $CDCl_3$): *δ* (ppm) 7.60 (br s, 1H), 7.36-7.33 (m, 2H), 7.30-7.24 (m, 3H), 5.73 (d, *J* = 2.8 Hz, 1H), 5.45 (d, *J* = 13.8 Hz, 1H), 5.12 (d, *J* = 13.8 Hz, 1H), 3.79 (s, 3H), 2.20 (s, 3H), 1.66 (s, 3H).

^{13}C NMR (126 MHz, $CDCl_3$): *δ* (ppm) 171.4, 139.0, 128.3, 128.0, 127.4, 124.8, 124.6, 116.3, 105.7, 82.0, 54.3, 52.7, 12.8, 12.7.

IR (film): *v* (cm^{-1}) 3393, 2924, 2854, 1732, 1666, 1597, 1556, 1496, 1447, 1435, 1401, 1377, 1261, 1212, 1138, 1094, 1052, 1028, 971, 799, 702, 668, 648.

HRMS (ESI, *m*/*z*) calcd for $C_{16}H_{18}N_2NaO_4$ $(M+Na)^+$ 325.1164, found: 325.1156.

(*S*)-Ethyl 2-(2,5-dimethyl-1H-pyrrol-3-yl)-3-nitro-2-(p-tolyl)propanoate (3j)



A solution of **1a** (9.5 mg, 0.10 mmol), **2c** (47.0 mg, 0.20 mmol) and catalyst Λ-**MTC** (2.23 mg, 0.0010 mmol) in anhydrous toluene (50 μL) was stirred at 40 °C for 35 h under argon atmosphere and reduced light. The mixture was then dried in vacuo and subjected to flash chromatography (silica gel, eluents: EtOAc/*n*-hexane = 1:50) to afford **3j** as a light yellow oil (31.0 mg, 0.094 mmol, 94%). Enantiomeric excess was established by HPLC analysis using a Chiralpak AD-H column, ee =95% (HPLC conditions: AD-H, 254 nm, *n*-hexane/isopropanol = 95:5, flow rate 1.0 mL/min, 25 °C, t_r(major) = 18.2 min, tr(minor) = 22.2 min); $[a]_D^{20}$ = -42.5° (c=1.0, $CHCl_3$).

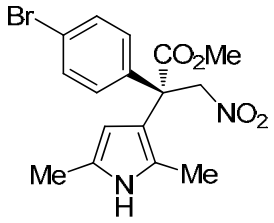
^{1}H NMR (500 MHz, $CDCl_3$): δ (ppm) 7.59 (br s, 1H), 7.23 (d, *J* = 8.2 Hz, 2H), 7.08 (d, *J* = 8.2 Hz, 2H), 5.73 (s, 1H), 5.42 (d, *J* = 13.7 Hz, 1H), 5.12 (d, *J* = 13.7 Hz, 1H), 4.31-4.21 (m, 2H), 2.31 (s, 3H), 2.20 (s, 3H), 1.69 (s, 3H), 1.25 (t, *J* = 7.2 Hz, 3H).

^{13}C NMR (126 MHz, $CDCl_3$): δ (ppm) 171.0, 137.0, 136.1, 128.7, 128.2, 124.6, 124.5, 116.5, 105.9, 81.9, 61.6, 54.1, 20.9, 13.9, 12.9, 12.8.

IR (film): v (cm^{-1}) 3393, 2923, 1728, 1556, 1512, 1426, 1376, 1208, 1139, 1028, 1044, 1020.

HRMS (ESI, *m*/*z*) calcd for $C_{18}H_{22}N_2NaO_4$ $(M+Na)^+$ 353.1477, found: 353.1477.

(*S*)-Methyl 2-(4-bromophenyl)-2-(2,5-dimethyl-1*H*-pyrrol-3-yl)-3-nitro-propanoate (3k)



A solution of **1a** (9.5 mg, 0.10 mmol), **2d** (57.2 mg, 0.20 mmol) and catalyst Λ-**MTC** (2.23 mg, 0.0010 mmol) in anhydrous toluene (50 μL) was stirred at 40 °C for 29 h under argon atmosphere and reduced light. The mixture was then dried in vacuo and subjected to flash chromatography (silica gel, eluents: EtOAc/*n*-hexane = 1:50) to afford **3k** as a light green oil (34.7 mg, 0.091 mmol, 91%). Enantiomeric excess was established by HPLC analysis using a Chiralpak AD-H column, ee = 94% (HPLC conditions: AD-H, 254 nm, *n*-hexane/isopropanol = 95:5, flow rate 1.0 mL/min, 25 °C, t_r(major) = 23.3 min, t_r(minor) = 31.3 min); $[a]_D^{20}$ = -40.4° (c=1.0, $CHCl_3$).

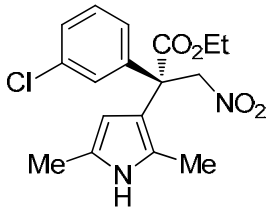
^{1}H NMR (400 MHz, $CDCl_3$): *δ* (ppm) 7.64 (br s, 1H), 7.41-7.38 (m, 2H), 7.27-7.24 (m, 2H), 5.70 (d, *J* = 2.8 Hz, 1H), 5.51 (d, *J* = 13.9 Hz, 1H), 4.99 (d, *J* = 13.9 Hz, 1H), 3.78 (s, 3H), 2.20 (s, 3H), 1.68 (s, 3H).

^{13}C NMR (126 MHz, $CDCl_3$): *δ* (ppm) 170.9, 138.2, 131.1, 130.4, 125.2, 124.5, 121.6, 115.9, 105.3, 81.8, 53.7, 52.8, 12.8, 12.7.

IR (film): *v* (cm^{-1}) 3387, 2962, 2925, 2854, 1723, 1610, 1555, 1511, 1464, 1375, 1260, 1181, 1105, 1027, 923, 880, 800, 759, 694, 666, 560.

HRMS (ESI, *m*/*z*) calcd for $C_{16}H_{17}BrN_2NaO_4$ $(M+Na)^+$ 403.0269, found: 403.0264.

(*S*)-Ethyl 2-(3-chlorophenyl)-2-(2,5-dimethyl-1*H*-pyrrol-3-yl)-3-nitropropanoate (3l)



A solution of **1a** (9.5 mg, 0.10 mmol), **2e** (51.1 mg, 0.20 mmol) and catalyst Λ-**MTC** (4.46 mg, 0.0020 mmol) in anhydrous toluene (200 μL) was stirred at 40 °C for 18 h under argon atmosphere and reduced light. The mixture was then dried in vacuo and subjected to flash chromatography (silica gel, eluents: EtOAc/*n*-hexane = 1:50) to afford **3l** as a light green oil (32.6, 0.093 mmol, 93%).

Enantiomeric excess was established by HPLC analysis using a Chiralpak AD-H column, ee = 86% (HPLC conditions: AD-H, 254 nm, *n*-hexane/isopropanol = 95:5, flow rate 1.0 mL/min, 25 °C, t_r(major) = 17.7 min, t_r(minor) = 20.3 min); $[a]_D^{20}$ = -45.1° (c=1.0, $CHCl_3$).

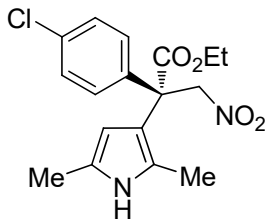
^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 7.61 (br s, 1H), 7.38-7.37 (m, 1H), 7.31-7.28 (m, 1H), 7.25-7.19 (m, 2H), 5.71 (d, *J* = 2.8 Hz, 1H), 5.50 (d, *J* = 13.9 Hz, 1H), 5.03 (d, *J* = 13.9 Hz, 1H), 4.34-4.20 (m, 2H), 2.20 (s, 3H), 1.69 (s, 3H), 1.25 (t, *J* = 7.10 Hz, 3H).

^{13}C NMR (126 MHz, $CDCl_3$): δ (ppm) 170.2, 141.3, 133.9, 129.1, 128.9, 127.6, 126.9, 125.1, 124.5, 115.9, 105.4, 81.7, 61.9, 54.0, 13.9, 12.83, 12.76.

IR (film): *v* (cm^{-1}) 3392, 2963, 2924, 2854, 1727, 1594, 1555, 1476, 1422, 1375, 1261, 1211, 1138, 1094, 1047, 863, 796, 759, 700, 667.

HRMS (ESI, *m*/*z*) calcd for $C_{17}H_{19}ClN_2NaO_4$ $(M+Na)^+$ 373.0931, found: 373.0926.

(*S*)-Ethyl 2-(4-chlorophenyl)-2-(2,5-dimethyl-1*H*-pyrrol-3-yl)-3-nitropropanoate (3m)



A solution of **1a** (9.5 mg, 0.10 mmol), **2f** (51.1 mg, 0.20 mmol) and catalyst Λ-**MTC** (2.23 mg, 0.0010 mmol) in anhydrous toluene (50 μL) was stirred at 40 °C for 30 h under argon atmosphere and reduced light. The mixture was then dried in vacuo and subjected to flash chromatography (silica gel, eluents: EtOAc/*n*-hexane = 1:50) to afford **3m** as a light yellow oil (34.0 mg, 0.097 mmol, 97%). Enantiomeric excess was established by HPLC analysis using a Chiralpak AD-H column, ee = 91% (HPLC conditions: AD-H, 254 nm, *n*-hexane/isopropanol = 95:5, flow rate 1.0 mL/min, 25 °C, t_r(major) = 18.6 min, t_r(minor) = 21.3 min); $[a]_D^{20}$ = -43.1° (c=1.0, $CHCl_3$).

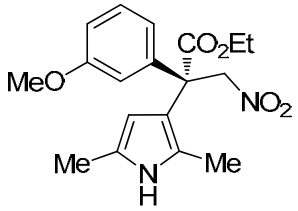
^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 7.61 (br s, 1H), 7.35-7.31 (m, 2H), 7.26-7.22 (m, 2H), 5.71 (d, *J* = 2.8 Hz, 1H), 5.51 (d, *J* = 13.9 Hz, 1H), 5.00 (d, *J* = 13.9 Hz, 1H), 4.33-4.19 (m, 2H), 2.20 (s, 3H), 1.68 (s, 3H), 1.25 (t, *J* = 7.1 Hz, 3H).

^{13}C NMR (126 MHz, $CDCl_3$): δ (ppm) 170.4, 137.8, 133.3, 130.1, 128.1, 125.1, 124.5, 116.1, 105.4, 81.8, 61.8, 53.8, 13.9, 12.8, 12.7.

IR (film): *v* (cm^{-1}) 3395, 2961, 2925, 2854, 1725, 1641, 1597, 1554, 1491, 1464, 1425, 1401, 1377, 1262, 1214, 1138, 1095, 1042, 1014, 798, 759.

HRMS (ESI, *m*/*z*) calcd for $C_{17}H_{19}ClN_2NaO_4$ $(M+Na)^+$ 373.0931, found: 373.0925.

(*S*)-Ethyl 2-(2,5-dimethyl-1*H*-pyrrol-3-yl)-2-(3-methoxyphenyl)-3-nitro-propanoate (3n)



A solution of **1a** (9.5 mg, 0.10 mmol), **2g** (50.3 mg, 0.20 mmol) and catalyst Λ-**MTC** (2.23 mg, 0.0010 mmol) in anhydrous toluene (50 μL) was stirred at 40 °C for 30 h under argon atmosphere and reduced light. The mixture was then dried in vacuo and subjected to flash chromatography (silica gel, eluents: EtOAc/*n*-hexane = 1:50) to afford **3n** as a light green oil (31.5 mg, 0.091 mmol, 91%). Enantiomeric excess was established by HPLC analysis using a Chiralpak AD-H column, ee = 92% (HPLC conditions: AD-H, 254 nm, *n*-hexane/isopropanol = 95:5, flow rate 1.0 mL/min, 25 °C, t_r(major) = 27.7 min, t_r(minor) = 32.3 min); $[a]_D^{20}$ = -39.5° (c=1.0, $CHCl_3$).

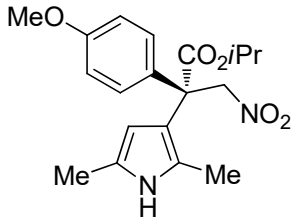
^{1}H NMR (400 MHz, $CDCl_3$): *δ* (ppm) 7.57 (br s, 1H), 7.19 (t, *J* = 7.9 Hz, 1H), 6.95-6.92 (m, 2H), 6.80-6.78 (m, 1H), 5.72 (d, *J* = 2.8 Hz, 1H), 5.40 (d, *J* = 13.7 Hz, 1H), 5.13 (d, *J* = 13.7 Hz, 1H), 4.32-4.22 (m, 2H), 3.75 (s, 3H), 2.19 (s, 3H), 1.70 (s, 3H), 1.25 (t, *J* = 7.1 Hz, 3H).

^{13}C NMR (126 MHz, $CDCl_3$): *δ* (ppm) 170.8, 159.2, 140.8, 128.9, 124.7, 124.5, 120.7, 116.3, 115.0, 112.3, 105.9, 81.9, 61.7, 55.2, 54.3, 13.9, 12.9, 12.8.

IR (film): *v* (cm^{-1}) 3394, 2962, 2925, 2854, 1727, 1600, 1556, 1488, 1434, 1376, 1261, 1214, 1095, 1037, 799, 760, 703.

HRMS (ESI, *m*/*z*) calcd for $C_{18}H_{22}N_2NaO_5$ $(M+Na)^+$ 369.1426, found: 369.1422.

(*S*)-Isopropyl 2-(2,5-dimethyl-1*H*-pyrrol-3-yl)-2-(4-methoxyphenyl)-3-nitro-propanoate (3o)



A solution of **1a** (9.5 mg, 0.10 mmol), **2h** (53.1 mg, 0.20 mmol) and catalyst Λ-**MTC** (2.23 mg, 0.0010 mmol) in anhydrous toluene (50 μL) was stirred at 40 °C for 35 h under argon atmosphere and reduced light. The mixture was then dried in vacuo and subjected to flash chromatography (silica gel, eluents: EtOAc/*n*-hexane = 1:50) to afford **3o** as a light green oil (31.4 mg, 0.087 mmol, 87%). Enantiomeric excess was established by HPLC analysis using a Chiralpak AD-H column, ee = 94% (HPLC conditions: AD-H, 254 nm, *n*-hexane/isopropanol = 95:5, flow rate 1.0 mL/min, 25 °C, t_r(major) = 29.6 min, t_r(minor) = 32.9 min); $[a]_D^{20}$ = -43.4° (c=1.0, $CHCl_3$).

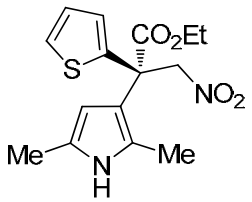
^{1}H NMR (400 MHz, $CDCl_3$): *δ* (ppm) 7.56 (br s, 1H), 7.30-7.26 (m, 2H), 6.81-6.78 (m, 2H), 5.72 (d, *J* = 2.8 Hz, 1H), 5.41 (d, *J* = 13.6 Hz, 1H), 5.14-5.06 (m, 2H), 3.78 (s, 3H), 2.19 (s, 3H), 1.69 (s, 3H), 1.22 (q, *J* = 11.2, 6.3 Hz, 6H).

^{13}C NMR (126 MHz, $CDCl_3$): δ (ppm) 170.5, 158.5, 131.2, 129.6, 124.6, 124.4, 116.7, 113.2, 105.9, 82.0, 69.3, 55.1, 53.8, 21.5, 21.4, 12.9.

IR (film): ν (cm^{-1}) 3387, 2962, 2925, 2854, 1723, 1610, 1555, 1511, 1464, 1375, 1260, 1181, 1105, 1027, 800, 759, 694, 666, 560.

HRMS (ESI, *m*/*z*) calcd for $C_{19}H_{24}N_2NaO_5$ $(M+Na)^+$ 383.1583, found: 383.1578.

(*R*)-Ethyl 2-(2,5-dimethyl-1*H*-pyrrol-3-yl)-3-nitro-2-(thiophen-3-yl)propanoate (3p)



A solution of **1a** (9.5 mg, 0.10 mmol), **2i** (45.4 mg, 0.20 mmol) and catalyst Λ-**MTC** (2.23 mg, 0.0010 mmol) in anhydrous toluene (50 μL) was stirred at 40 °C for 30 h under argon atmosphere and reduced light. The mixture was then dried in vacuo and subjected to flash chromatography (silica gel, eluents: EtOAc/*n*-hexane = 1:50) to afford **3p** as a light yellow oil (31.6 mg, 0.098 mmol, 98%). Enantiomeric excess was established by HPLC analysis using a Chiralpak AD-H column, ee = 95% (HPLC conditions: AD-H, 254 nm, *n*-hexane/isopropanol = 95:5, flow rate 1.0 mL/min, 25 °C, t_r(major) = 23.7 min, t_r(minor) = 29.2 min); $[a]_D^{20}$ = -47.8° (c=1.0, $CHCl_3$).

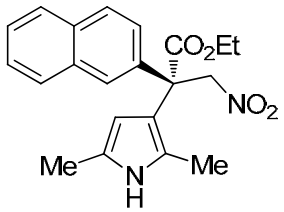
^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 7.65 (br s, 1H), 7.22 (d, *J* = 5.2 Hz, 1H), 7.04 (d, *J* = 3.6 Hz, 1H), 6.92-6.91 (m, 1H), 5.68 (d, *J* = 2.5 Hz, 1H), 5.51 (d, *J* = 13.9 Hz, 1H), 5.08 (d, *J* = 13.9 Hz, 1H), 4.36-4.24 (m, 2H), 2.19 (s, 3H), 1.84 (s, 3H), 1.29 (t, *J* = 7.1 Hz, 3H).

^{13}C NMR (126 MHz, $CDCl_3$): δ (ppm) 170.2, 142.8, 127.2, 126.2, 125.7, 125.0, 124.6, 116.7, 104.7, 82.4, 62.1, 51.7, 13.9, 12.8, 12.5.

IR (film): ν (cm^{-1}) 3387, 2962, 2925, 2854, 1723, 1610, 1555, 1511, 1464, 1375, 1260, 1181, 1105, 1027, 923, 880, 800, 759, 694, 666, 560.

HRMS (ESI, *m*/*z*) calcd for $C_{15}H_{18}N_2NaO_4S$ $(M+Na)^+$ 345.0885, found: 345.0879.

(*S*)-Ethyl 2-(2,5-dimethyl-1*H*-pyrrol-3-yl)-2-(naphthalen-2-yl)-3-nitropropanoate (3q)



A solution of **1a** (9.5 mg, 0.10 mmol), **2j** (54.2 mg, 0.20 mmol) and catalyst Λ-**MTC** (2.23 mg, 0.0010 mmol) in anhydrous toluene (50 μL) was stirred at 40 °C for 28 h under argon atmosphere and reduced light. The mixture was then dried in vacuo and subjected to flash chromatography (silica gel, eluents: EtOAc/*n*-hexane = 1:50) to afford **3q** as a yellow oil (35.2 mg, 0.096 mmol, 96%).

Enantiomeric excess was established by HPLC analysis using a Chiralpak AD-H column, ee = 90% (HPLC conditions: AD-H, 254 nm, *n*-hexane/isopropanol = 90:10, flow rate 0.50 mL/min, 25 °C, t_r(major) = 29.3 min, t_r(minor) = 35.1 min); $[a]_D^{20}$ = -49.4° (c=1.0, $CHCl_3$).

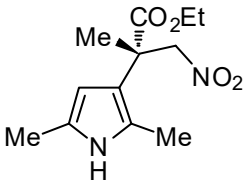
^{1}H NMR (500 MHz, $CDCl_3$): δ (ppm) 7.89 (br s, 1H), 7.81-7.78 (m, 2H), 7.74 (d, *J* = 8.9 Hz, 1H), 7.62 (br s, 1H), 7.49-7.42 (m, 3H), 5.79 (d, *J* = 2.5 Hz, 1H), 5.53 (d, *J* = 13.8 Hz, 1H), 5.27 (d, *J* = 13.8 Hz, 1H), 4.35-4.26 (m, 2H), 2.22 (s, 3H), 1.64 (s, 3H), 1.27 (t, *J* = 7.2 Hz, 3H).

^{13}C NMR (126 MHz, $CDCl_3$): δ (ppm) 170.9, 136.5, 132.7, 132.3, 128.4, 127.7, 127.3, 127.3, 126.4, 126.3, 126.1, 124.9, 124.6, 116.3, 106.0, 81.7, 61.8, 54.4, 13.9, 12.9, 12.8.

IR (film): v (cm^{-1}) 3393, 2924, 1728, 1597, 1555, 1375, 1208, 1125, 1086, 1043, 908, 862, 820, 753, 693, 478.

HRMS (ESI, *m*/*z*) calcd for $C_{21}H_{22}N_2NaO_4$ $(M+Na)^+$ 389.1477, found: 389.1477.

(*S*)-Ethyl 2-(2,5-dimethyl-1*H*-pyrrol-3-yl)-2-methyl-3-nitropropanoate (3r)



A solution of **1a** (9.5 mg, 0.10 mmol), **2k** (31.8 mg, 0.20 mmol) and catalyst Λ-**MTC** (8.92 mg, 0.0040 mmol) in anhydrous toluene (200 μL) was stirred at 40 °C for 12 h under argon atmosphere and reduced light. The mixture was then dried in vacuo and subjected to flash chromatography (silica gel, eluents: EtOAc/*n*-hexane = 1:50) to afford **3r** as a yellow oil (24.4 mg, 0.096 mmol, 96%). Enantiomeric excess was established by HPLC analysis using a Chiralpak AD-H column, ee = 92% (HPLC conditions: AD-H, 254 nm, *n*-hexane/isopropanol = 98:2, flow rate 0.8 mL/min, 25 °C, t_r(major) = 46.3 min, t_r(minor) = 49.6 min); $[a]_D^{20}$ = -52.1° (c=1.0, $CHCl_3$).

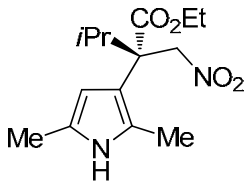
^{1}H NMR (500 MHz, $CDCl_3$): *δ* (ppm) 7.59 (br s, 1H), 5.66 (d, *J* = 2.5 Hz, 1H), 5.11 (d, *J* = 13.2, 1H), 4.62 (d, *J* = 13.2, 1H), 4.22 (q, *J* = 7.1 Hz, 2H), 2.19 (d, *J* = 13.3 Hz, 6H), 1.70 (s, 3H), 1.26 (t, *J* = 7.12 Hz, 3H).

^{13}C NMR (126 MHz, $CDCl_3$): *δ* (ppm) 173.1, 125.1, 122.3, 116.1, 104.9, 81.5, 61.5, 45.6, 21.6, 14.0, 12.8, 12.7.

IR (film): *v* (cm^{-1}) 3386, 2961, 2924, 2854, 1720, 1621, 1598, 1552, 1464, 1371, 1260, 1215, 1095, 1019, 861, 798, 685, 642.

HRMS (ESI, *m*/*z*) calcd for $C_{12}H_{18}N_2NaO_4$ $(M+Na)^+$ 277.1164, found: 277.1156.

(*S*)-Ethyl 2-(2,5-dimethyl-1*H*-pyrrol-3-yl)-3-methyl-2-(nitromethyl)butanoate (3s)



A solution of **1a** (9.5 mg, 0.10 mmol), **2l** (37.4 mg, 0.20 mmol) and catalyst Λ-**MTC** (8.90 mg, 0.0040 mmol) in anhydrous toluene (200 μL) was stirred at 40 °C for 40 h under argon atmosphere and reduced light. The mixture was then dried in vacuo and subjected to flash chromatography (silica gel, eluents: EtOAc/*n*-hexane = 1:50) to afford **3s** as a light yellow oil (21.2 mg, 0.075 mmol, 75%). Enantiomeric excess was established by HPLC analysis using a Chiralpak OD-H column, ee > 99% (HPLC conditions: OD-H, 254 nm, *n*-hexane/isopropanol = 95:5, flow rate 0.5 mL/min, 25 °C, t_r(major) = 39.9 min, t_r(minor) = 48.9 min); $[a]_D^{20}$ = -53.8° (c=1.0, $CHCl_3$).

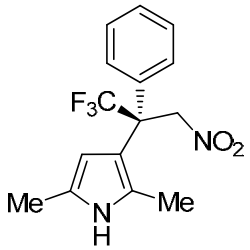
^{1}H NMR (500 MHz, $CDCl_3$): δ (ppm) 7.54 (br s, 1H), 5.60 (s, 1H), 4.99 (d, *J* = 12.7 Hz, 1H), 4.89 (d, *J* = 12.7 Hz, 1H), 4.27 (q, *J* = 7.2 Hz, 2H), 2.61-2.53 (m, 1H), 2.17 (s, 3H), 2.07 (s, 3H), 1.30 (t, *J* = 7.3 Hz, 3H), 1.01 (d, *J* = 7.0 Hz, 3H), 0.97 (d, *J* = 7.0 Hz, 3H).

^{13}C NMR (126 MHz, $CDCl_3$): δ (ppm) 172.4, 124.6, 122.8, 113.7, 106.2, 80.2, 61.3, 53.8, 32.1, 18.7, 18.5, 14.2, 12.9.

IR (film): ν (cm^{-1}) 3396, 2925, 1723, 1599, 1553, 1467, 1376, 1213, 1180, 1072, 861, 785, 696, 644, 557.

HRMS (ESI, *m*/*z*) calcd for $C_{14}H_{22}N_2NaO_4$ $(M+Na)^+$ 305.1477, found: 305.1476.

(*R*)-2,5-dimethyl-3-(1,1,1-trifluoro-3-nitro-2-phenylpropan-2-yl)-1*H*-pyrrole (3t)



A solution of **1a** (9.5 mg, 0.10 mmol), **2m** (43.4 mg, 0.20 mmol) and catalyst Λ-**MTC** (8.90 mg, 0.0040 mmol) in anhydrous toluene (200 μL) was stirred at 40 °C for 30 h under argon atmosphere and reduced light. The mixture was then dried in vacuo and subjected to flash chromatography (silica gel, eluents: EtOAc/*n*-hexane = 1:50) to afford **3t** as a light green oil (29.7 mg, 0.095 mmol, 95%). Enantiomeric excess was established by HPLC analysis using a Chiralpak AD-H column, ee > 99% (HPLC conditions: AD-H, 254 nm, *n*-hexane/isopropanol = 95:5, flow rate 1.0 mL/min, 25 °C, t_r(major) = 13.4 min, t_r(minor) = 25.2 min); $[a]_D^{20}$ = -46.4° (c=1.0, $CHCl_3$).

^{1}H NMR (500 MHz, $CDCl_3$): δ (ppm) 7.63 (br s, 1H), 7.44-7.33 (m, 5H), 5.88 (s, 1H), 5.31 (d, *J* = 12.0 Hz, 1H), 5.20 (d, *J* = 12.0 Hz, 1H), 2.22 (s, 3H), 1.53 (s, 3H).

^{13}C NMR (126 MHz, $CDCl_3$): δ (ppm) 136.1, 128.4, 128.3, 128.1, 125.5, 125.2, 125.0, 113.2, 106.5,

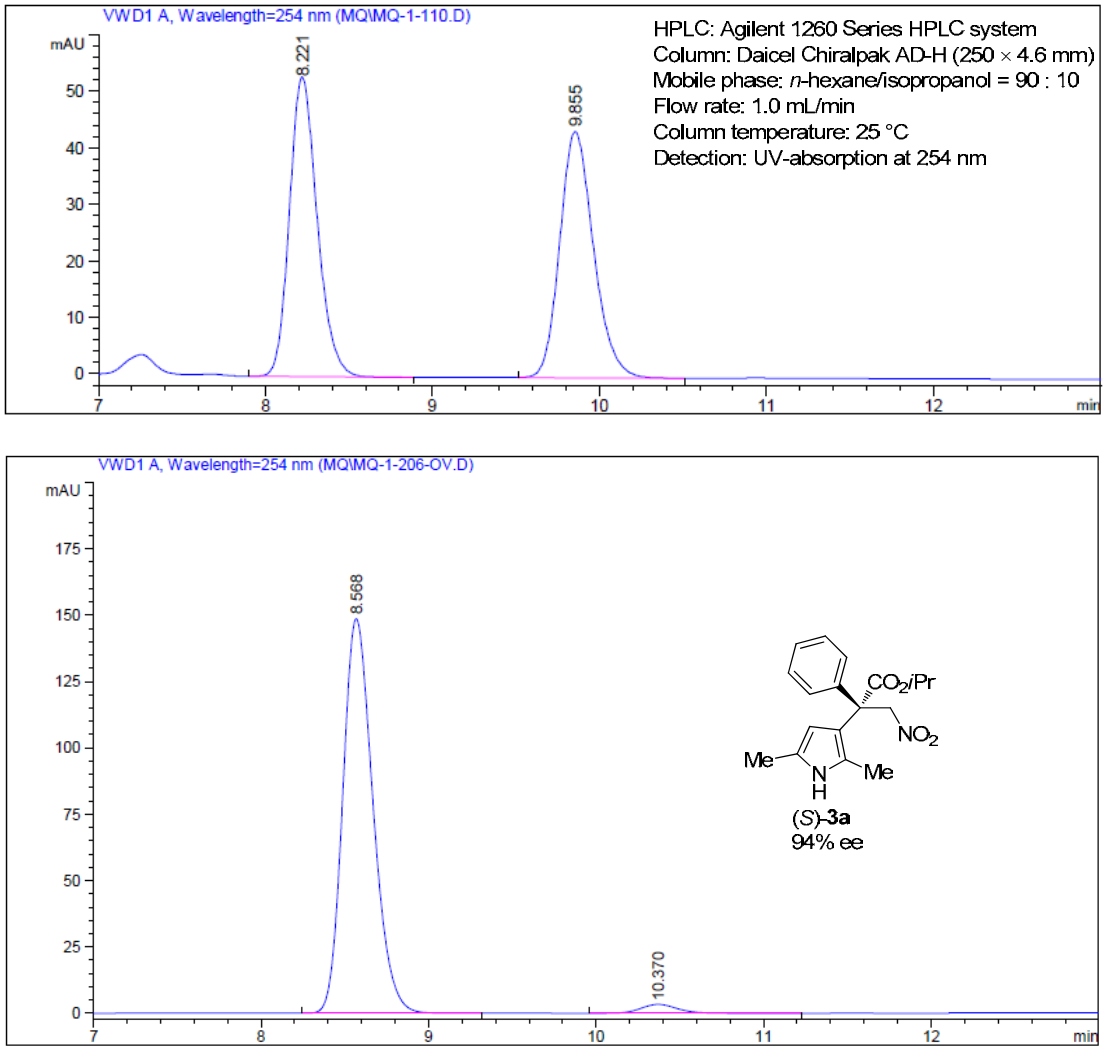
79.3, 54.4, 12.9, 12.8.

IR (film): v (cm^{-1}) 3424, 2924, 1599, 1562, 1500, 1434, 1375, 1334, 1286, 1219, 1146, 1043, 1016, 771, 748, 700, 640, 548.

HRMS (ESI, *m/z*) calcd for $C_{15}H_{15}F_3N_2NaO_2$ $(M+Na)^+$ 335.0983, found: 335.0979.

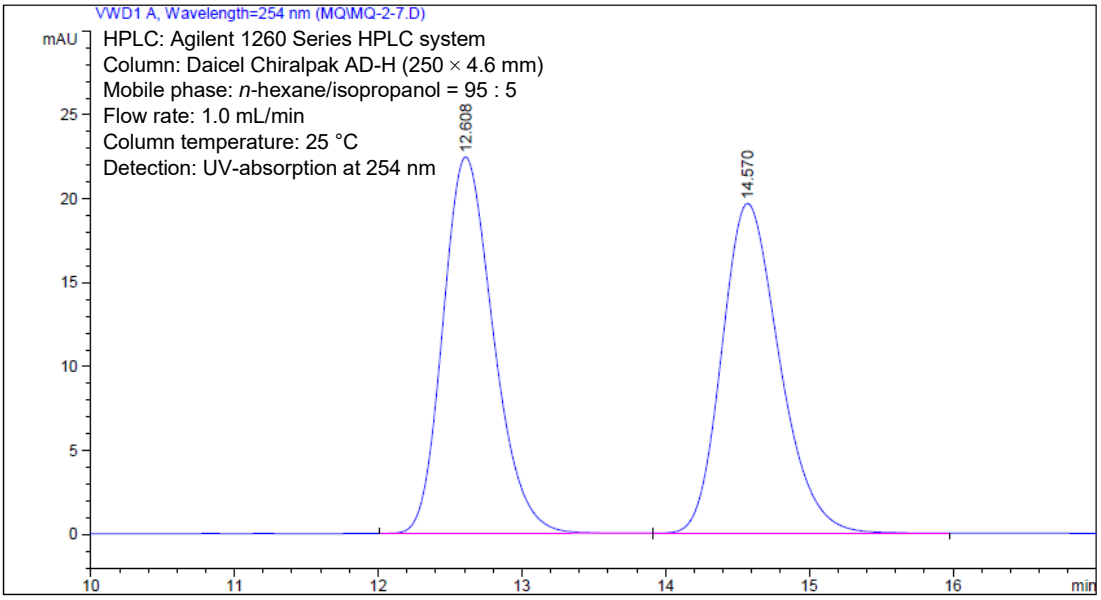
3.2 Determination of Enantioselectivities of the Asymmetric β-Alkylation of Pyrroles

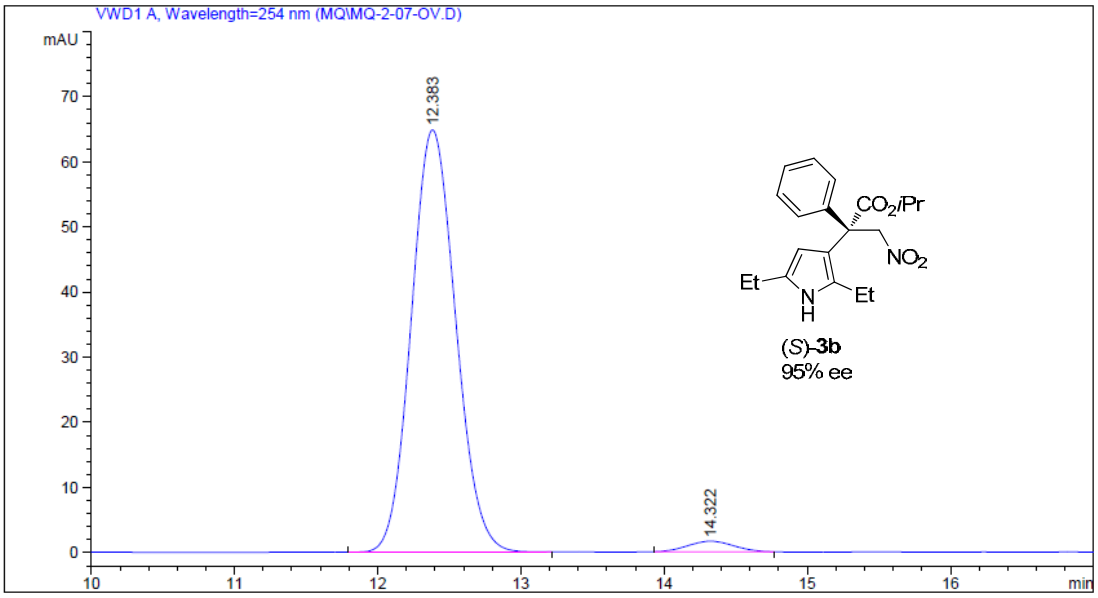
Enantiomeric excess of products were determined with a Daicel Chiralpak AD-H or OD-H column (250 x 4.6 mm) on an Agilent 1260 Series HPLC System using n-hexane/isopropanol as mobile phase, the temperature was 25 °C and UV-absorption was measured at 254 nm.



#	[min]		[min]	[mAU*s]	[mAU]	%
1	8.568	BB	0.1939	1857.79822	148.55951	97.1437
2	10.370	MM R	0.2693	54.62431	3.38075	2.8563

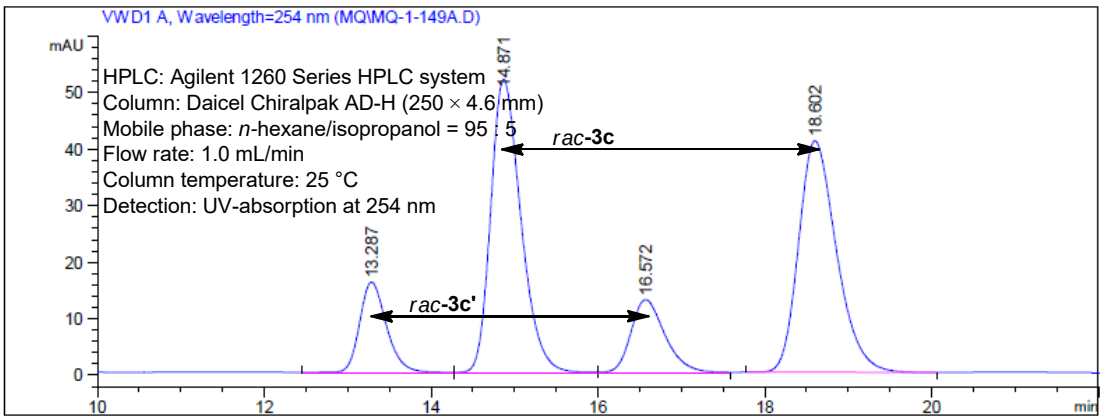
Figure S1. HPLC traces of *rac*-**3a** (reference) and (*S*)-**3a**.

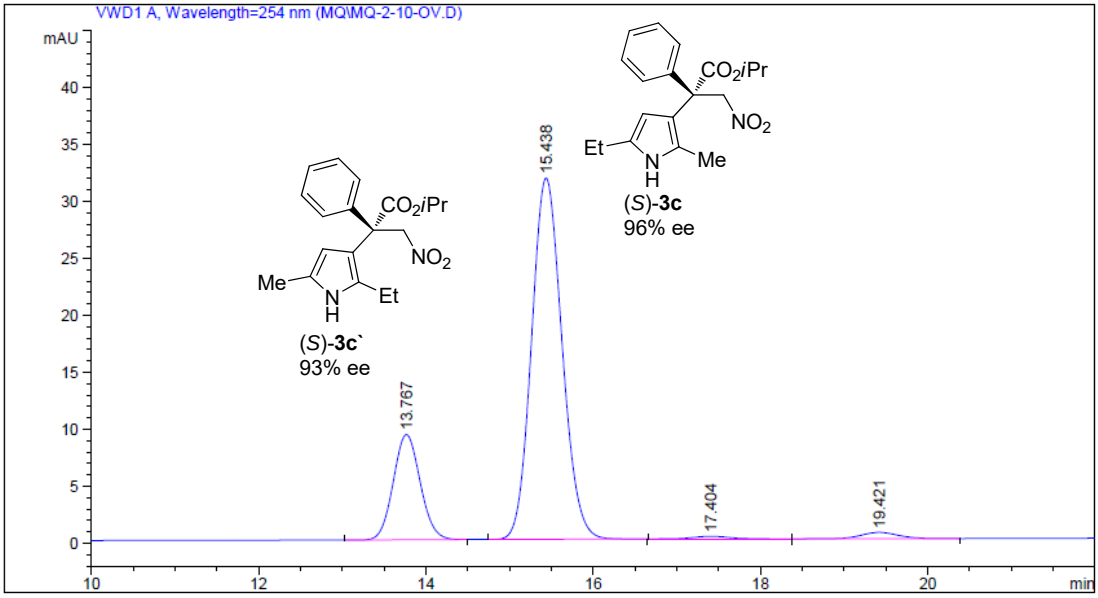




#	[min]		[min]	[mAU*s]	[mAU]	%
1	12.383	BB	0.3373	1396.04517	64.80389	97.4115
2	14.322	MM R	0.3778	37.09658	1.63636	2.5885

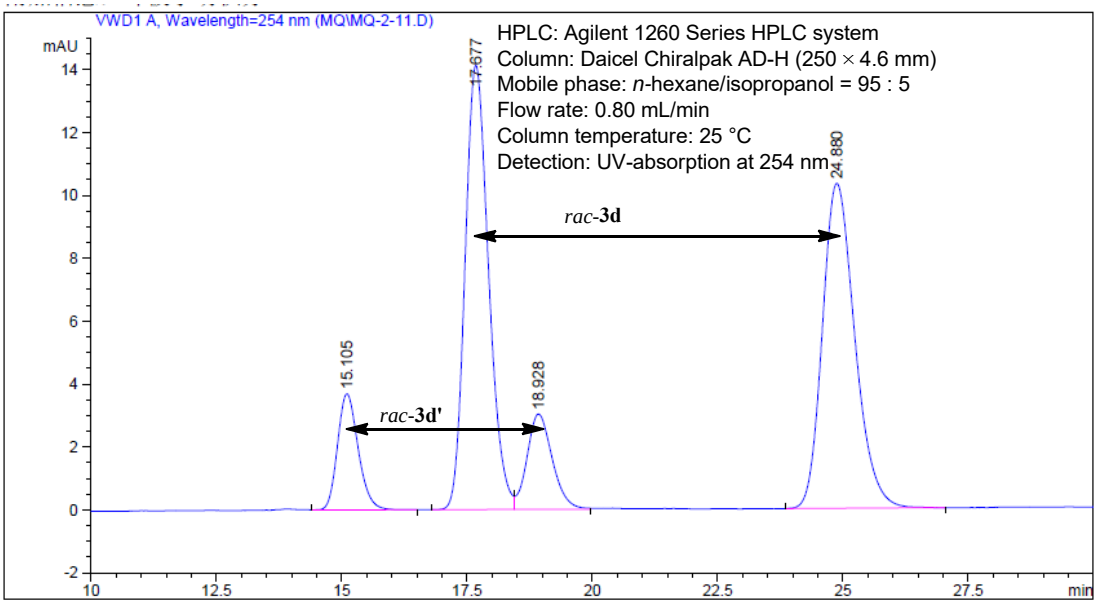
Figure S2. HPLC traces of *rac*-**3b** (reference) and (*S*)-**3b**.

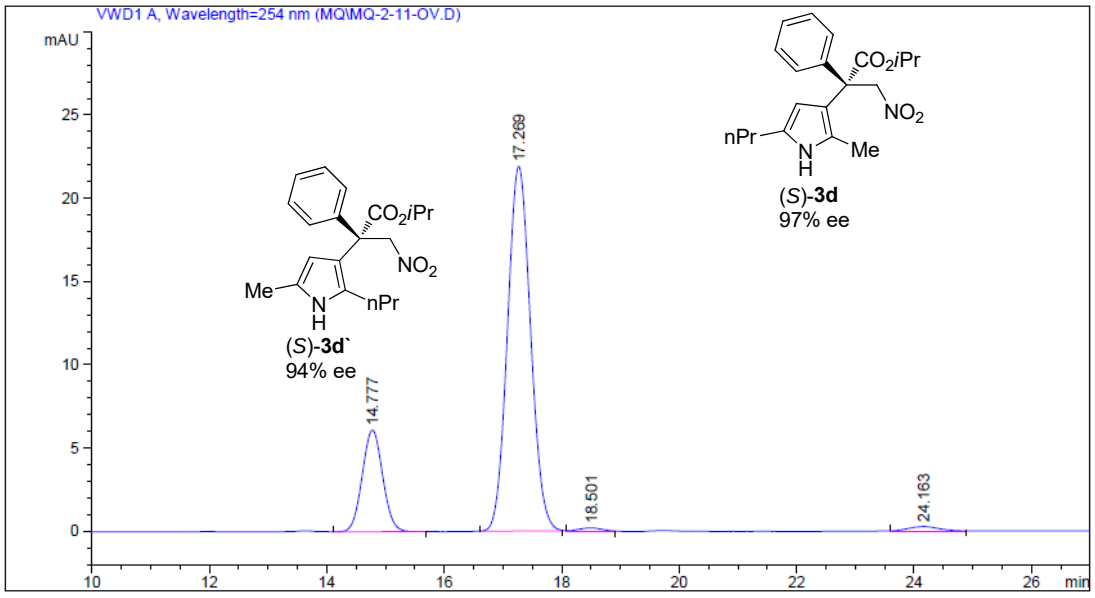




#	[min]		[min]	[mAU*s]	[mAU]	%
1	13.767	BB	0.3495	206.99747	9.23444	20.0164
2	15.438	BB	0.3952	801.93884	31.69345	77.5465
3	17.404	BB	0.4531	7.04565	2.30207e-1	0.6813
4	19.421	BB	0.4994	18.15782	5.58417e-1	1.7558

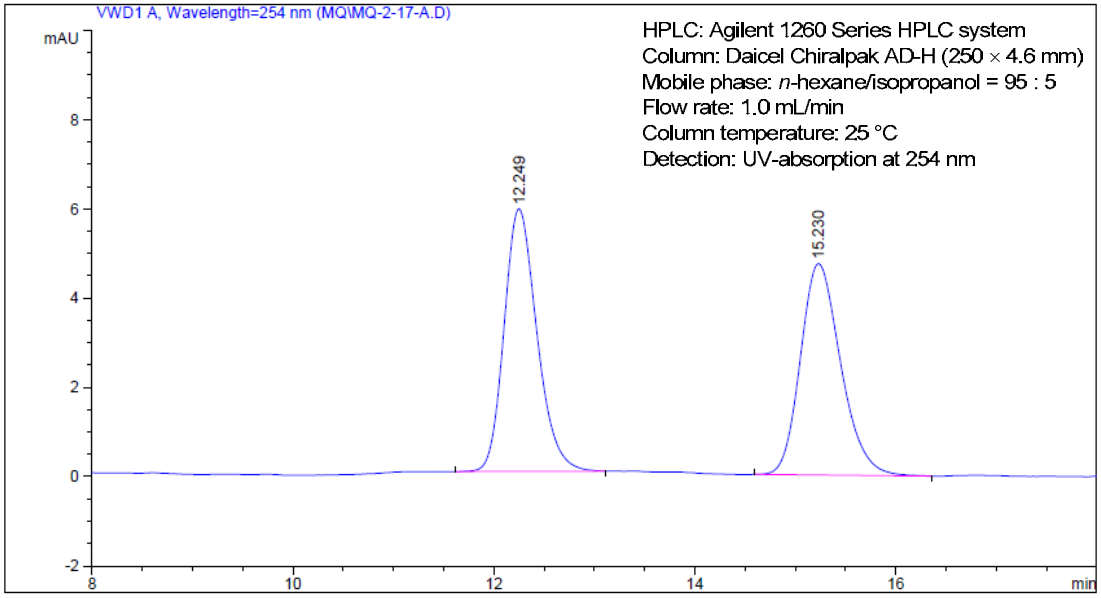
Figure S3. HPLC traces of *rac*-**3c/3c'** (reference) and (*S*)-**3c/3c'**.

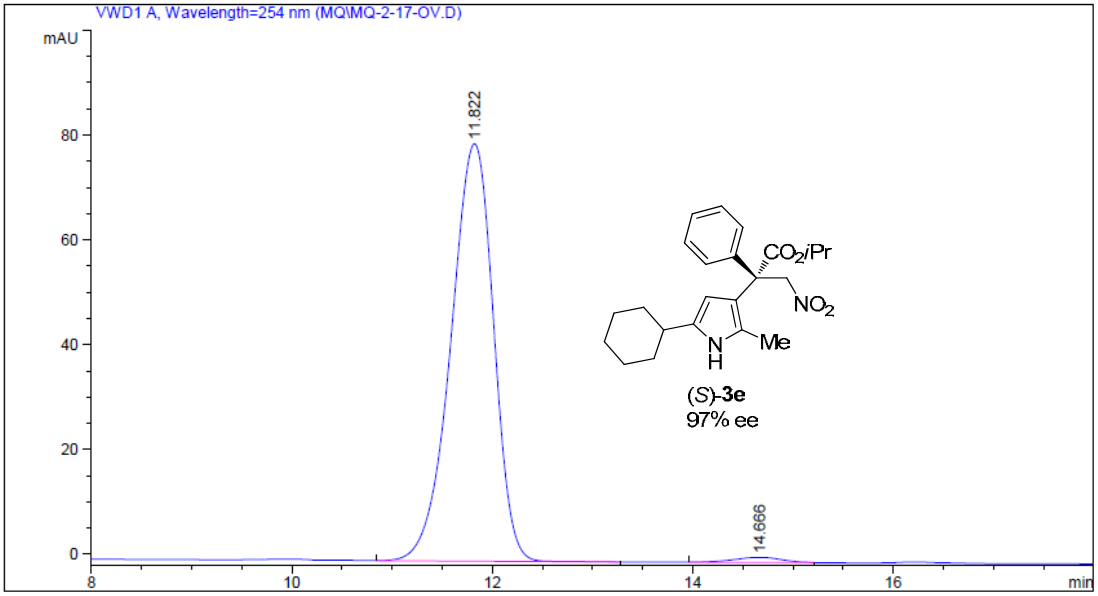




#	[min]		[min]	[mAU*s]	[mAU]	%
1	14.777	BB	0.3778	147.48898	6.10720	19.3974
2	17.269	MM R	0.4544	597.66510	21.92007	78.6034
3	18.501	MM R	0.4365	4.93198	1.88320e-1	0.6486
4	24.163	MM R	0.6214	10.26950	2.75458e-1	1.3506

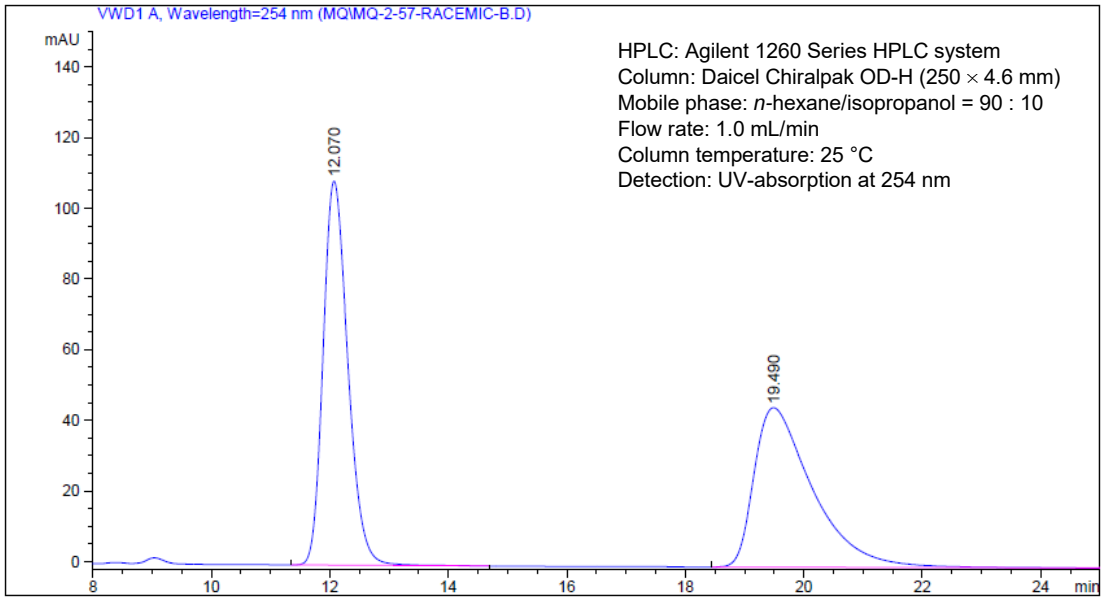
Figure S4. HPLC traces of *rac*-**3d/3d'** (reference) and (*S*)-**3d/3d'.**

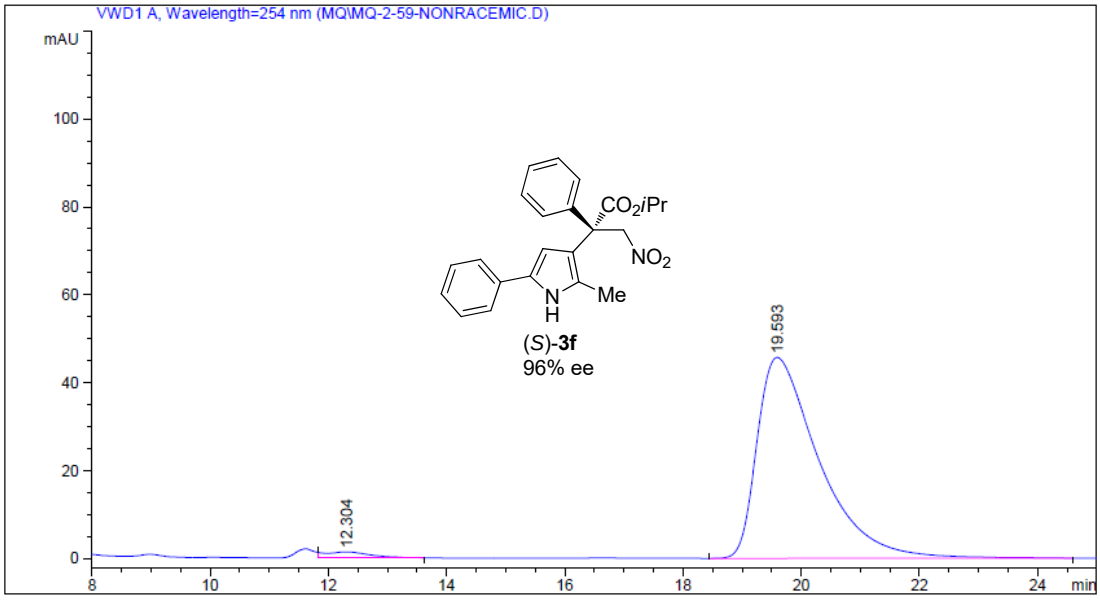




#	[min]		[min]	[mAU*s]	[mAU]	%
1	11.822	VB	0.4609	2354.76563	79.64777	98.7205
2	14.666	MM R	0.5340	30.51943	9.52487e-1	1.2795

Figure S5. HPLC traces of *rac*-**3e** (reference) and (*S*)-**3e**.

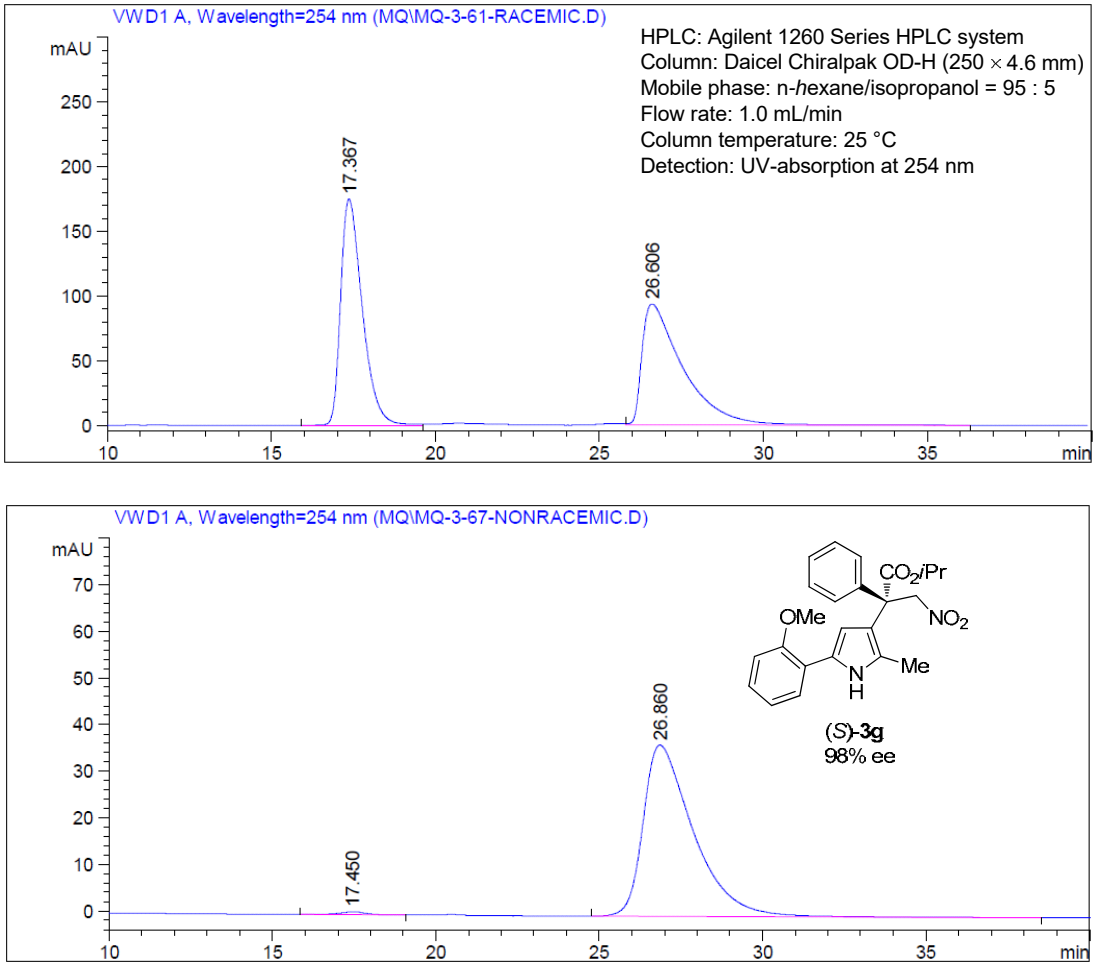




d

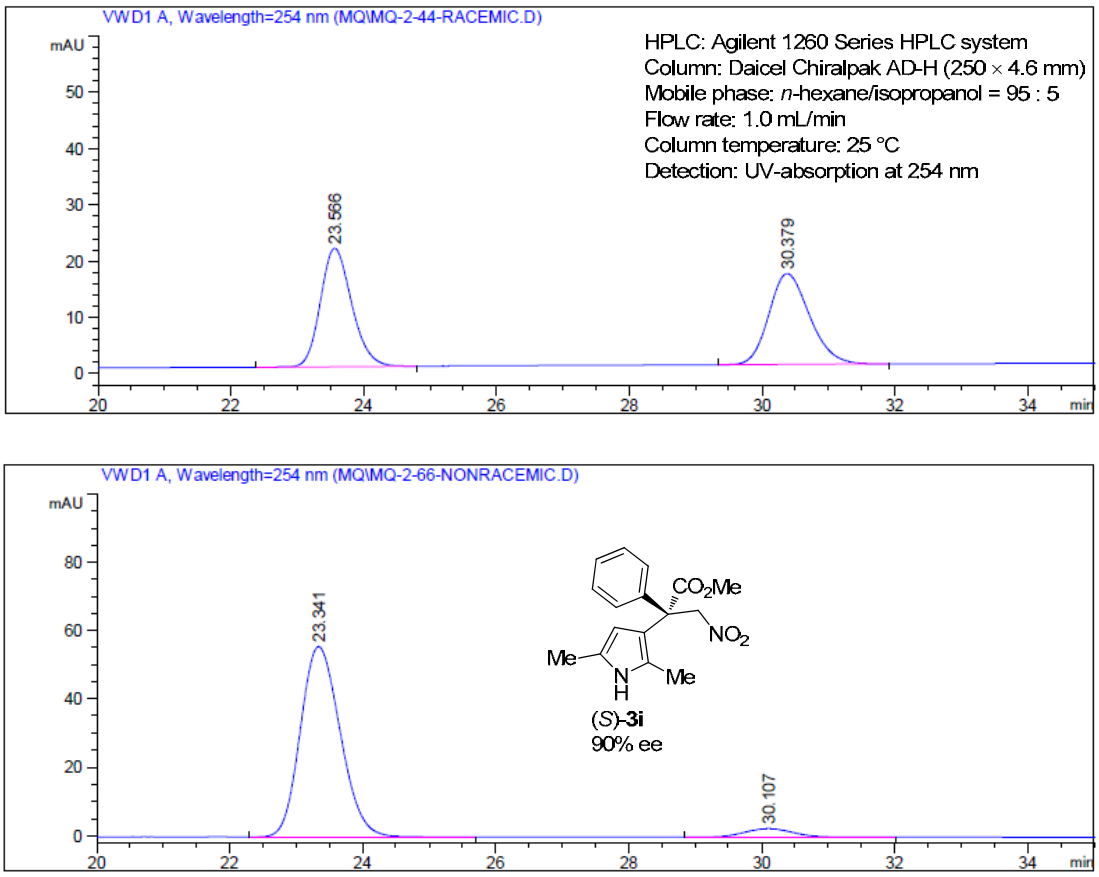
#	[min]		[min]	[mAU*s]	[mAU]	%
1	12.304	MM R	0.8939	73.79144	1.37588	2.1724
2	19.593	BB	1.0753	3322.96118	45.70263	97.8276

Figure S6. HPLC traces of *rac*-**3f** (reference) and (*S*)-**3f**.



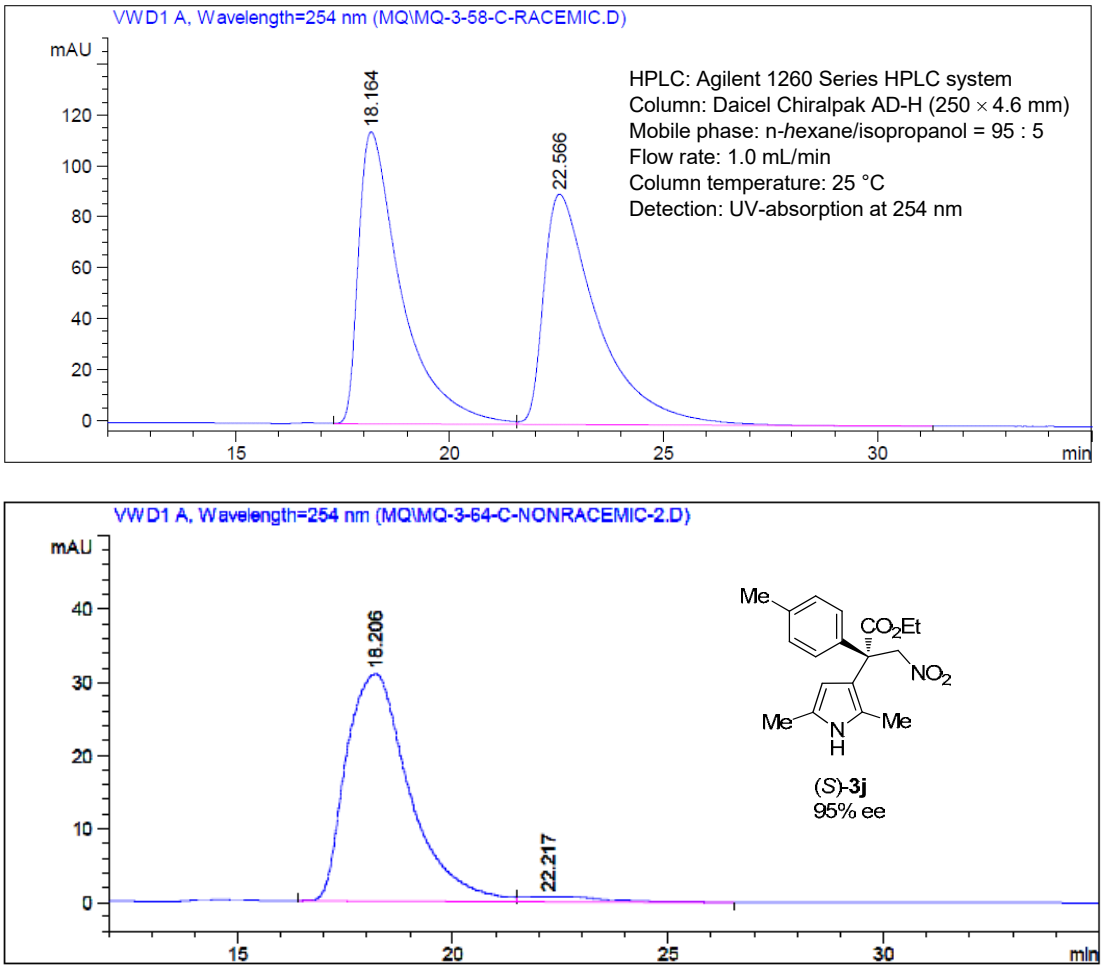
#	[min]		[min]	[mAU*s]	[mAU]	%
1	17.450	BB	0.7788	36.88820	6.05424e-1	0.9281
2	26.860	BB	1.5465	3937.67456	36.73618	99.0719

Figure S7. HPLC traces of *rac*-**3g** (reference) and (*S*)-**3g**.



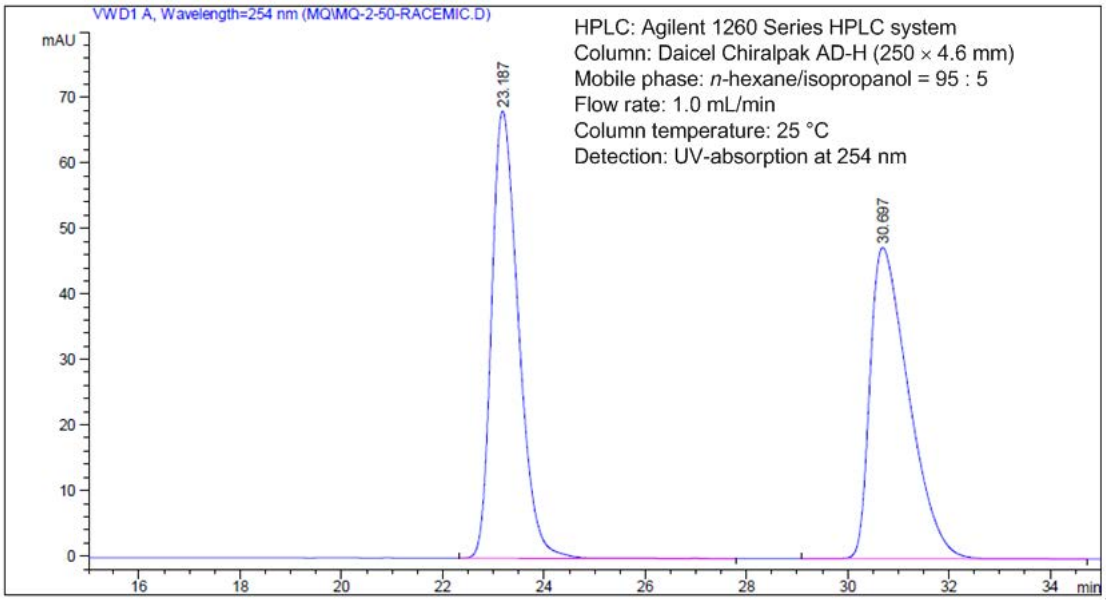
#	[min]		[min]	[mAU*s]	[mAU]	%
1	23.341	BB	0.6561	2319.28442	55.66699	94.8353
2	30.107	BB	0.7924	126.30647	2.50425	5.1647

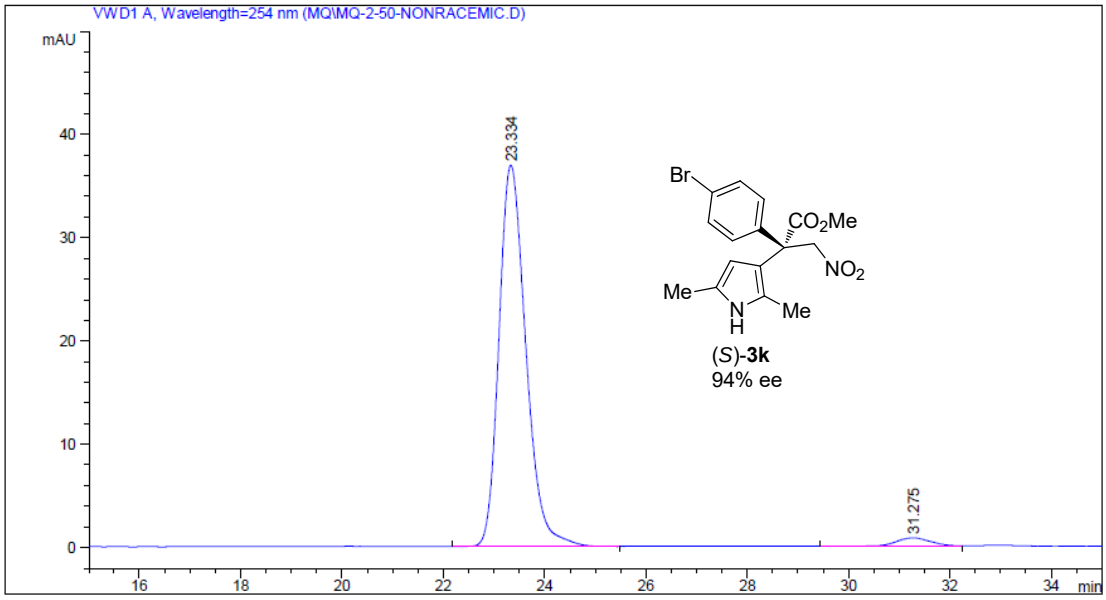
Figure S8. HPLC traces of *rac*-**3i**(reference) and (*S*)-**3i**.



#	[min]		[min]	[mAU*s]	[mAU]	%
1	18.206	BV	1.5921	3163.15991	31.06173	97.2354
2	22.217	VB	1.4758	89.93442	7.26718e-1	2.7646

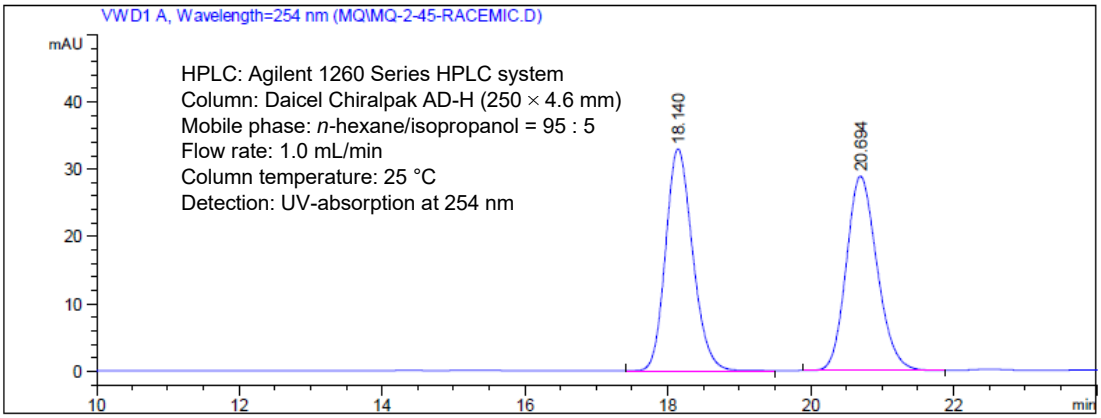
Figure S9. HPLC traces of *rac*-**3j** (reference) and (*S*)-**3j**.

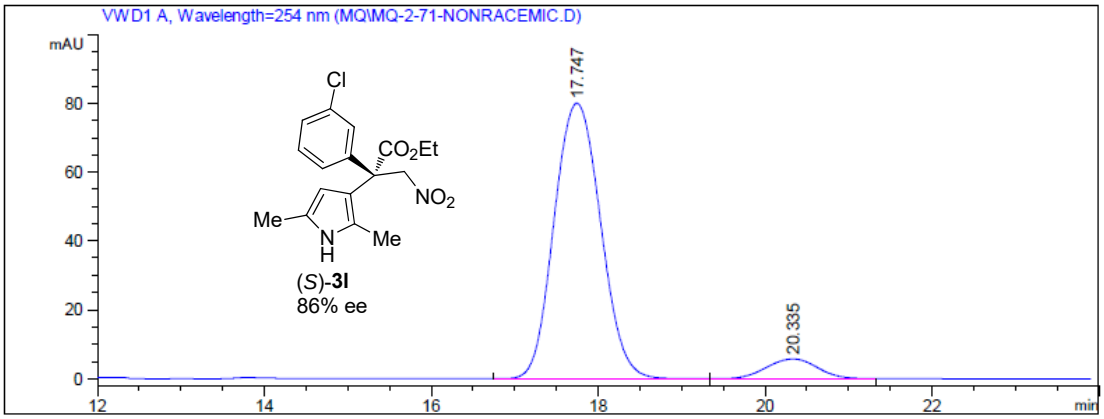




#	[min]		[min]	[mAU*s]	[mAU]	%
1	23.334	BV	0.5748	1361.64600	36.87268	97.1869
2	31.275	BV	0.7293	39.41361	8.07746e-1	2.8131

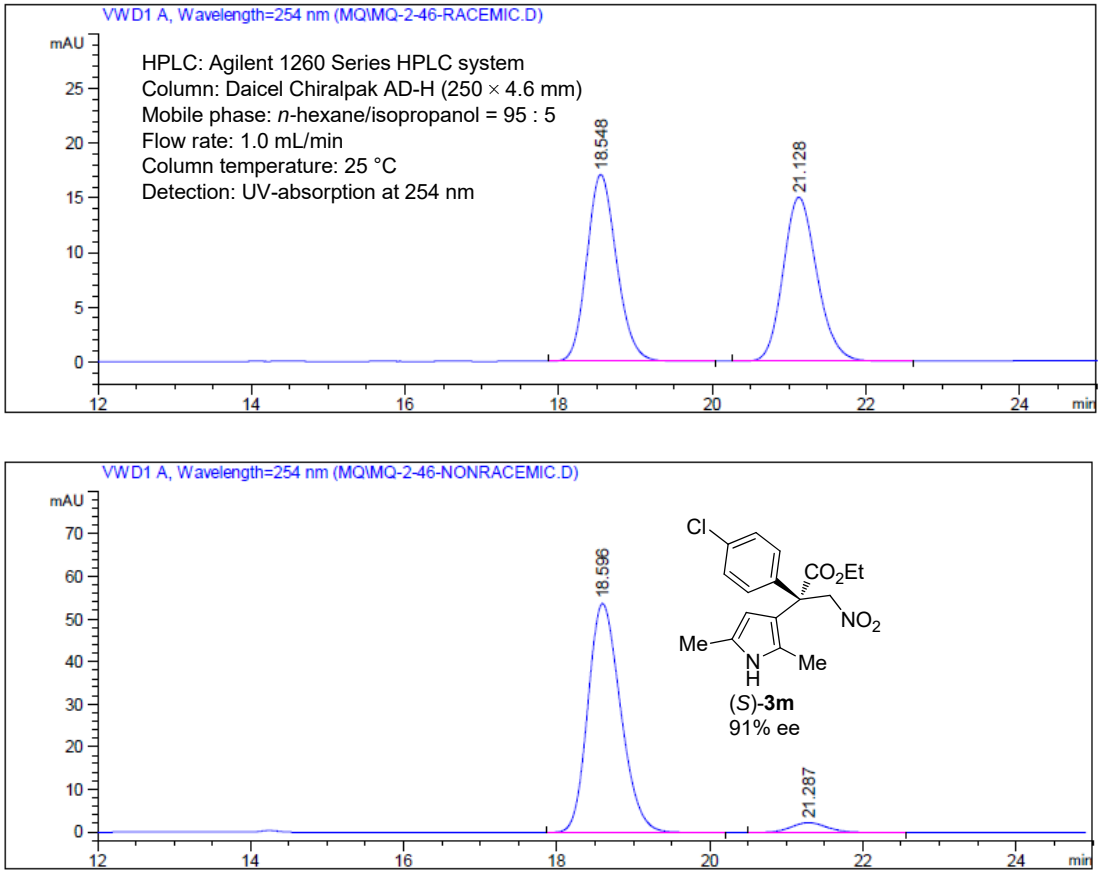
Figure S10. HPLC traces of *rac*-**3k** (reference) and (*S*)-**3k**.





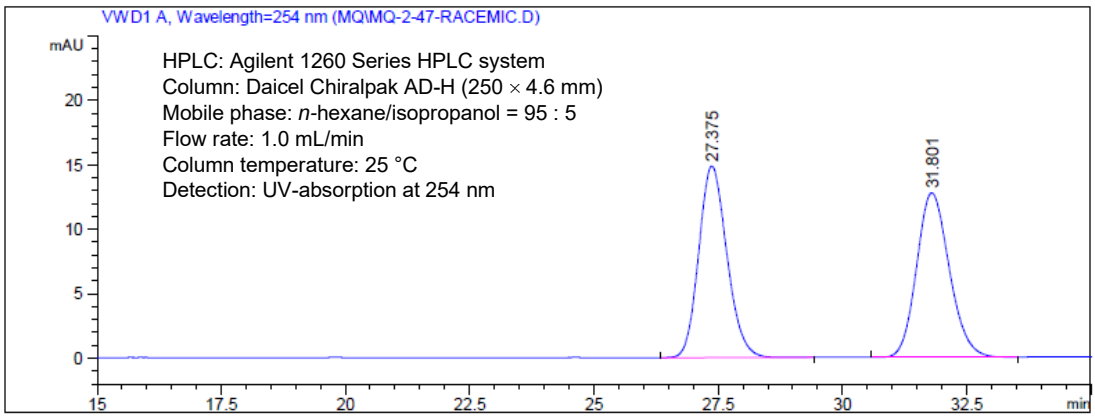
#	[min]		[min]	[mAU*s]	[mAU]	%
1	17.747	BB	0.6213	3099.26367	80.11197	92.7907
2	20.335	BB	0.6809	240.79645	5.67682	7.2093

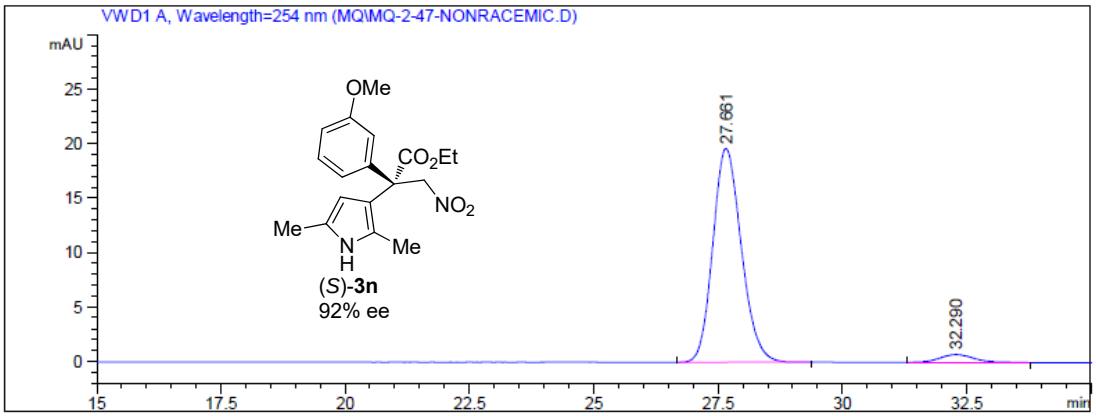
Figure S11. HPLC traces of *rac*-**3l** (reference) and (*S*)-**3l**.



#	[min]		[min]	[mAU*s]	[mAU]	%
1	18.596	BB	0.4587	1588.26563	53.76383	95.4664
2	21.287	BB	0.5069	75.42444	2.29803	4.5336

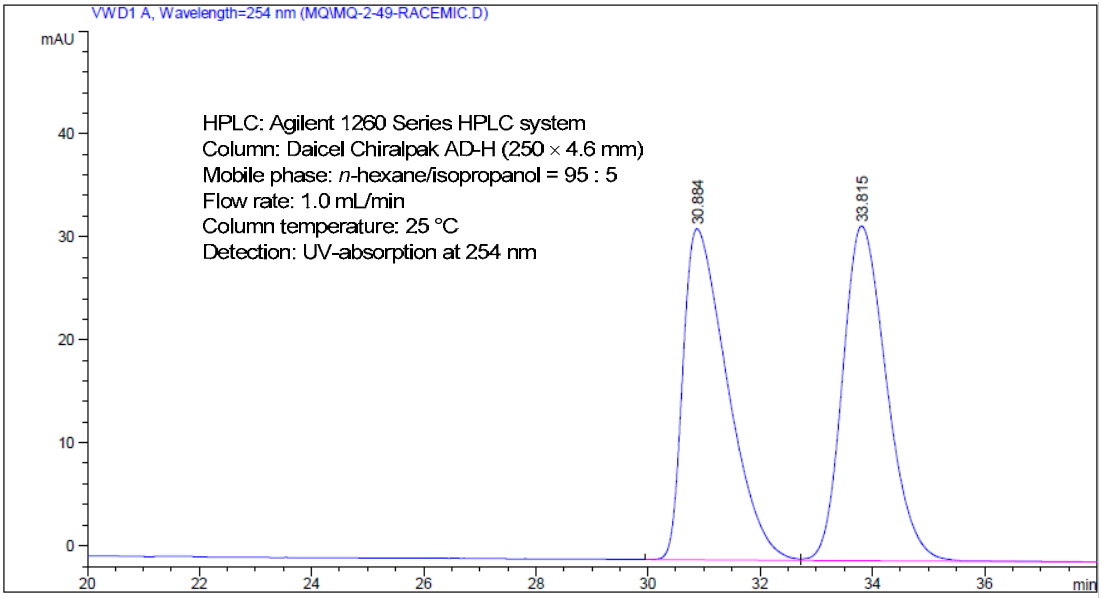
Figure S12. HPLC traces of *rac*-**3m** (reference) and (*S*)-**3m**.

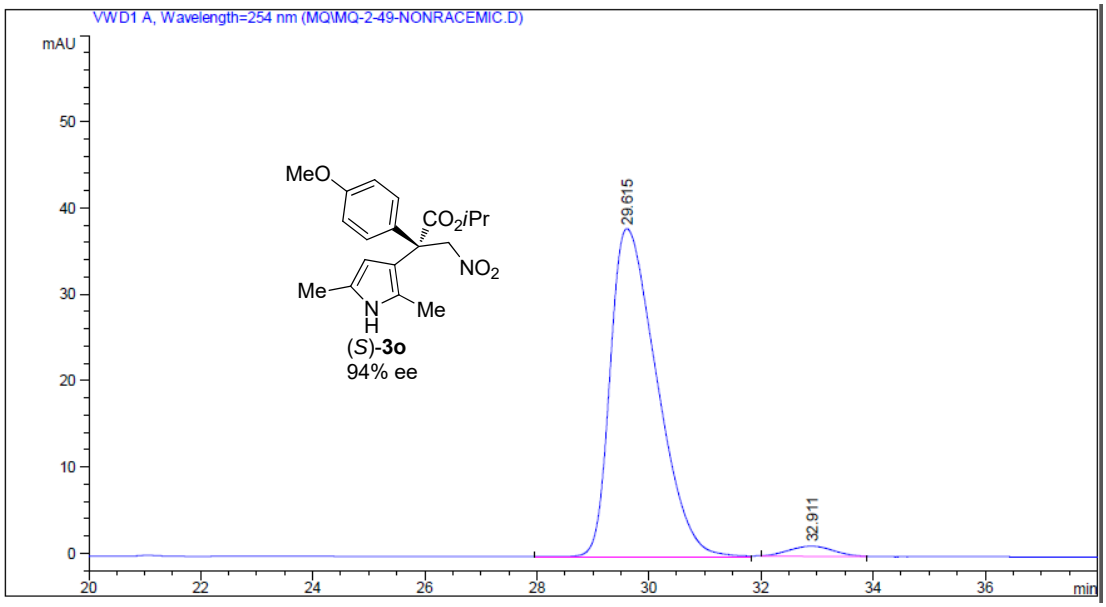




#	[min]		[min]	[mAU*s]	[mAU]	%
1	27.661	BB	0.6175	783.50012	19.63525	95.9647
2	32.290	BB	0.6478	32.94572	7.14660e-1	4.0353

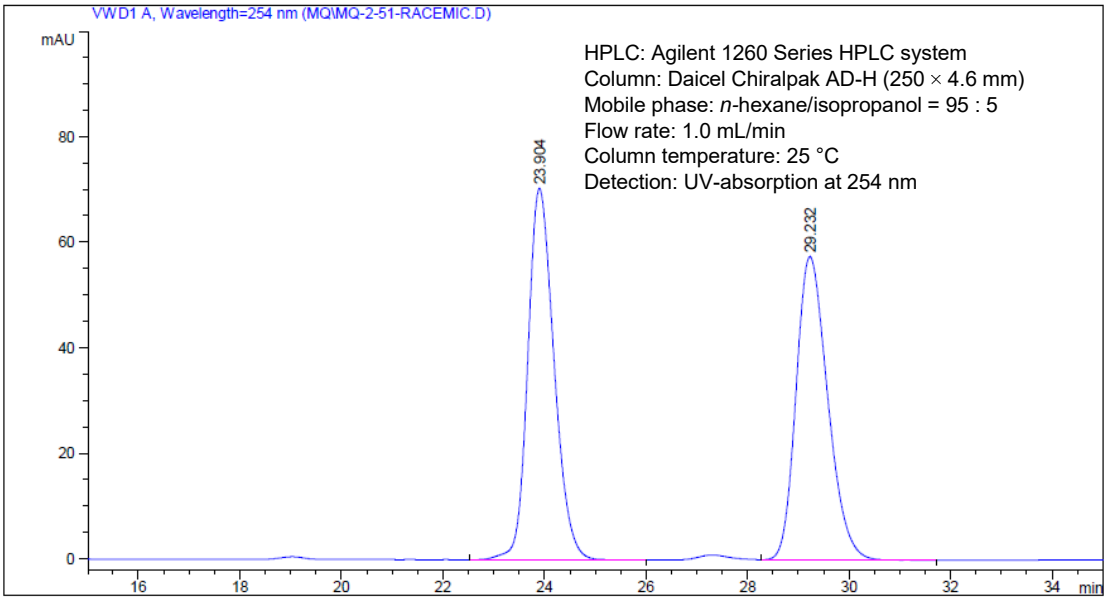
Figure S13. HPLC traces of *rac*-**3n** (reference) and (*S*)-**3n**.

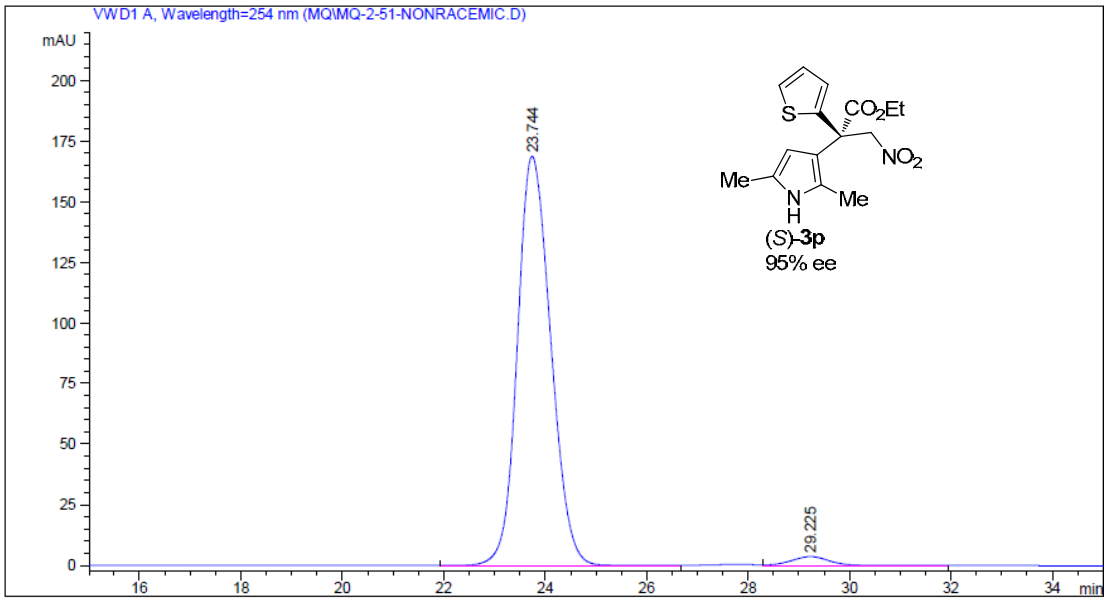




#	[min]		[min]	[mAU*s]	[mAU]	%
1	29.615	BV	0.8794	2187.30347	38.00833	97.1330
2	32.911	MM R	0.9147	64.56089	1.17632	2.8670

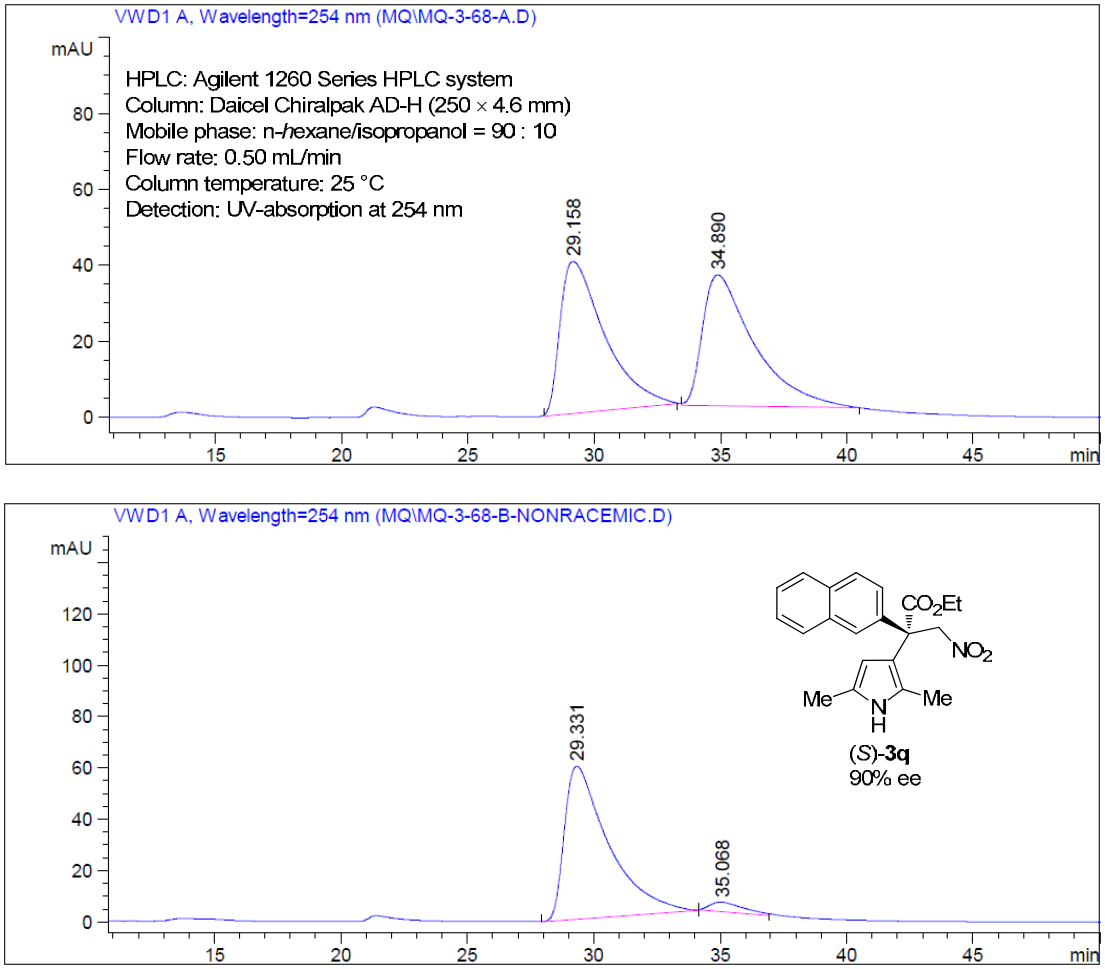
Figure S14. HPLC traces of *rac*-**3o** (reference) and (*S*)-**3o**.





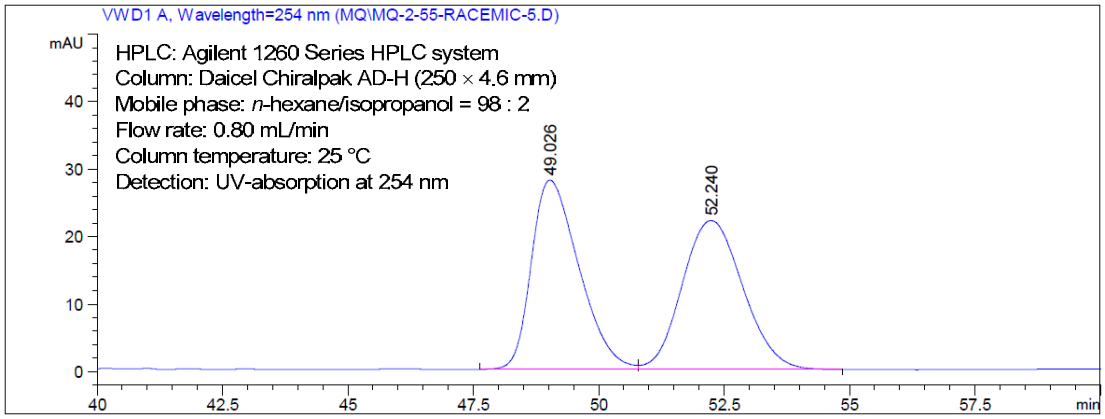
#	[min]		[min]	[mAU*s]	[mAU]	%
1	23.744	BV	0.7167	7698.18994	168.58769	97.6241
2	29.225	VB	0.8113	187.35164	3.62290	2.3759

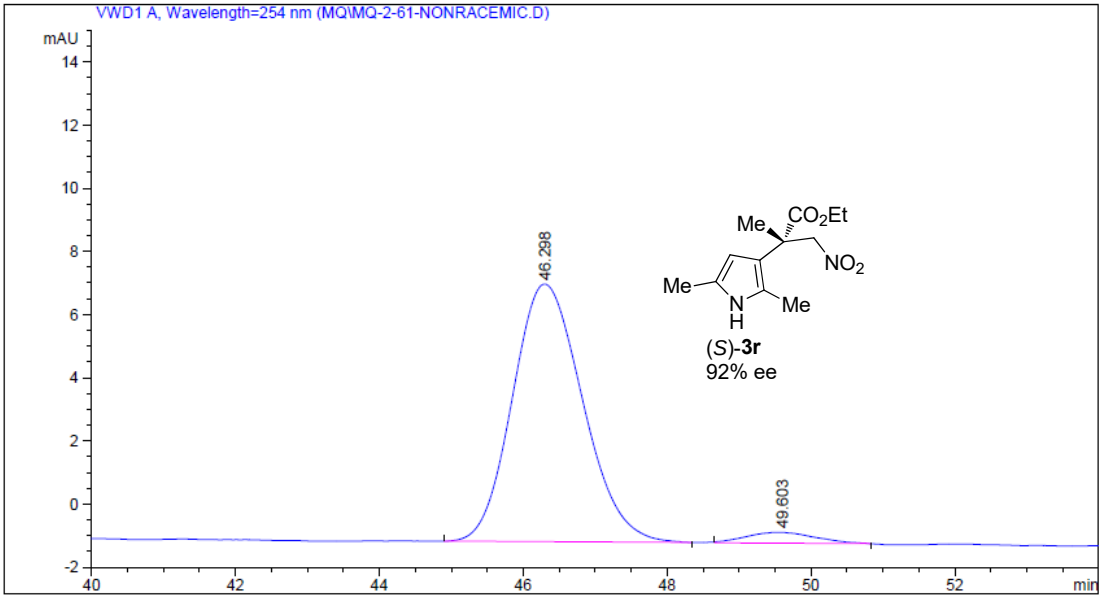
Figure S15. HPLC traces of *rac*-**3p** (reference) and (*S*)-**3p**.



#	[min]		[min]	[mAU*s]	[mAU]	%
1	29.331	MM R	2.0147	7200.12012	59.56320	95.2446
2	35.068	MM R	1.5917	359.49277	3.76415	4.7554

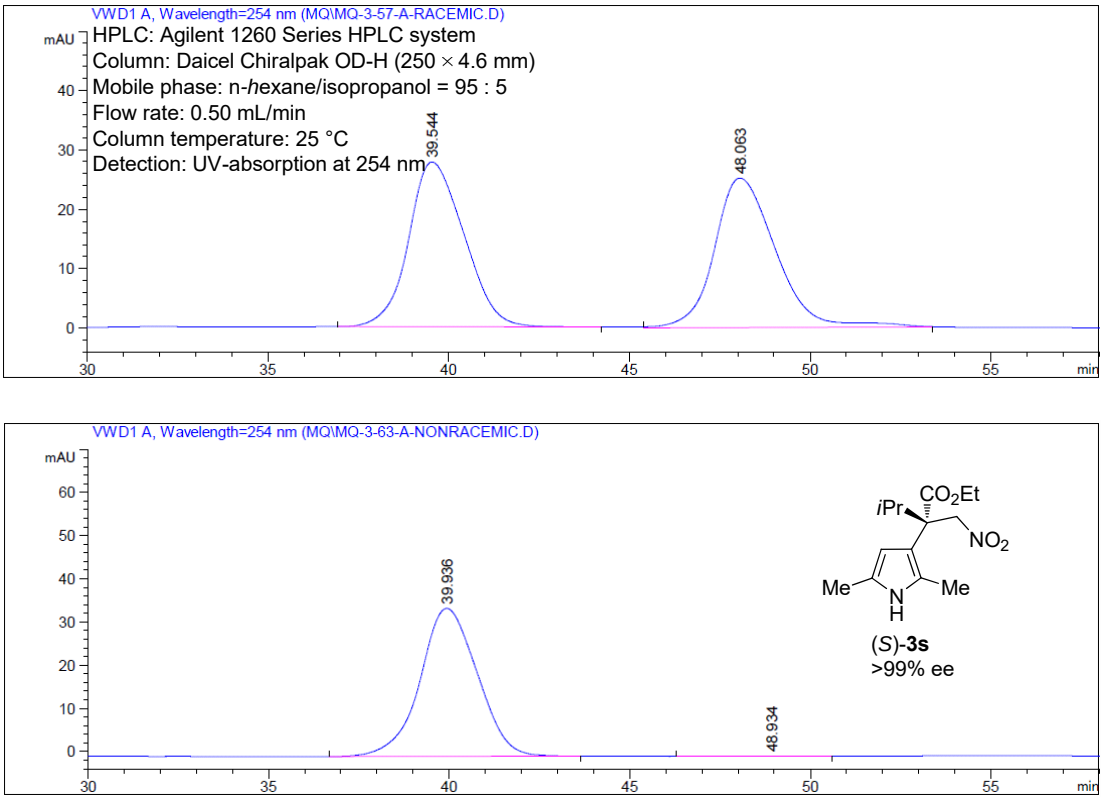
Figure S16. HPLC traces of *rac*-**3q** (reference) and (*S*)-**3q**.





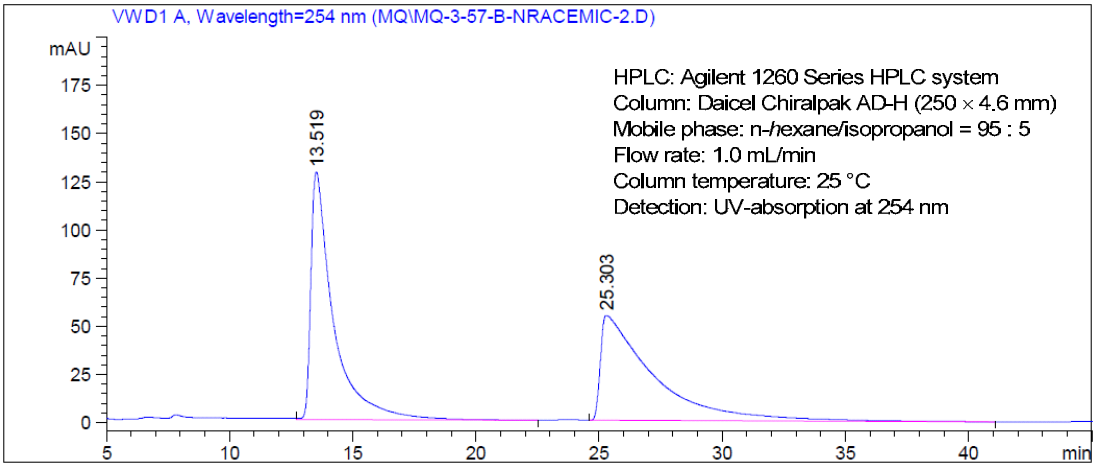
#	[min]		[min]	[mAU*s]	[mAU]	%
1	46.298	BB	1.0141	551.89069	8.15935	95.9804
2	49.603	MM R	1.1239	23.11273	3.42756e-1	4.0196

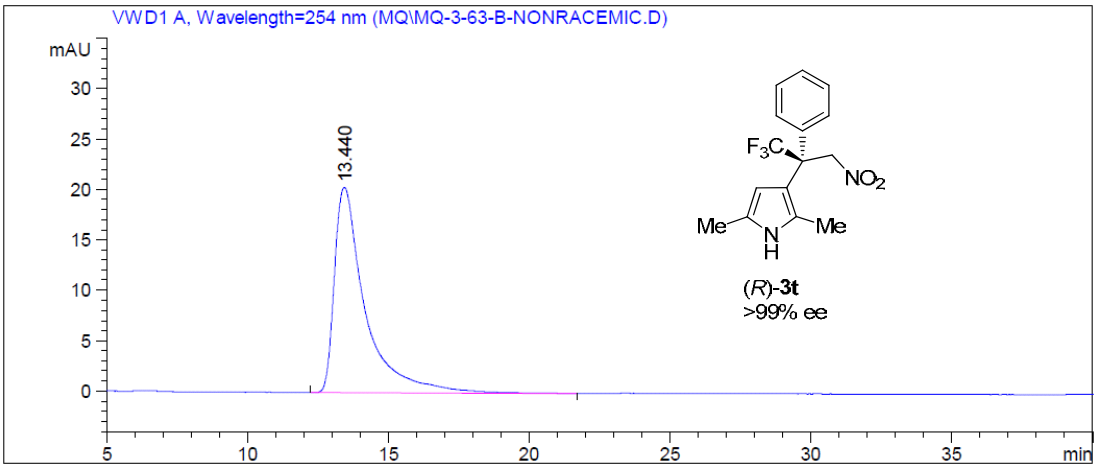
Figure S17. HPLC traces of *rac*-**3r** (reference) and (*S*)-**3r**.



#	[min]		[min]	[mAU*s]	[mAU]	%
1	39.936	BB	1.6878	3780.67041	34.25153	99.8112
2	48.934	MM R	1.9920	7.15227	5.98412e-2	0.1888

Figure S18. HPLC traces of *rac*-**3s** (reference) and (*S*)-**3s**.





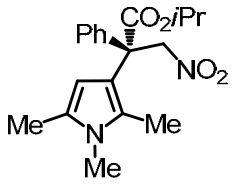
#	[min]		[min]	[mAU*s]	[mAU]	%
1	13.440	BB	1.0948	1555.04626	20.36665	100.0000

Figure S19. HPLC traces of *rac*-**3t** (reference) and (*R*)-**3t**.

4. Control Experiments for Probing the Hydrogen Bond Interactions

General Procedure for Table 2. A solution of **1a** or **1a'** (0.10 mmol), **2a** (47.0 mg, 0.20 mmol), catalyst Λ-**MTC** (0.0010 or 0.0040 mmol) and additives (ethanol, DMF or nitrobenzene as shown in Table 2) in anhydrous toluene (50 μL) was stirred at 40 °C for 20 h under argon atmosphere and reduced light. The crude product was directly diluted by deuterated chloroform (0.5 mL) and used for determination of conversion by ^{1}H NMR and ee value by HPLC analysis on chiral stationary phase.

(*S*)-Isopropyl 3-nitro-2-phenyl-2-(1,2,5-trimethyl-1*H*-pyrrol-3-yl)propanoate (3a')



A solution of **1a'** (10.9 mg, 0.10 mmol), **2a** (47.0 mg, 0.20 mmol) and catalyst Λ-**MTC** (8.92 mg, 0.0040 mmol) in anhydrous toluene (50 μL) was stirred at 40 °C for 36 h under argon atmosphere and reduced light. The mixture was then dried in vacuo and subjected to flash chromatography (silica gel, eluents: EtOAc/*n*-hexane = 1:50) to afford product **3a'** as a light green oil (24.4 mg, 0.071 mmol, 71%). Enantiomeric excess was established by HPLC analysis using a Chiralpak AD-H column, ee = 48% (HPLC conditions: AD-H, 254 nm, *n*-hexane/isopropanol = 98:2, flow rate 0.8 mL/min, 25 °C, t_r(major) = 13.8 min, t_r(minor) = 16.6 min); $[a]_D^{20}$ = -34.2° (c = 1.0, $CHCl_3$).

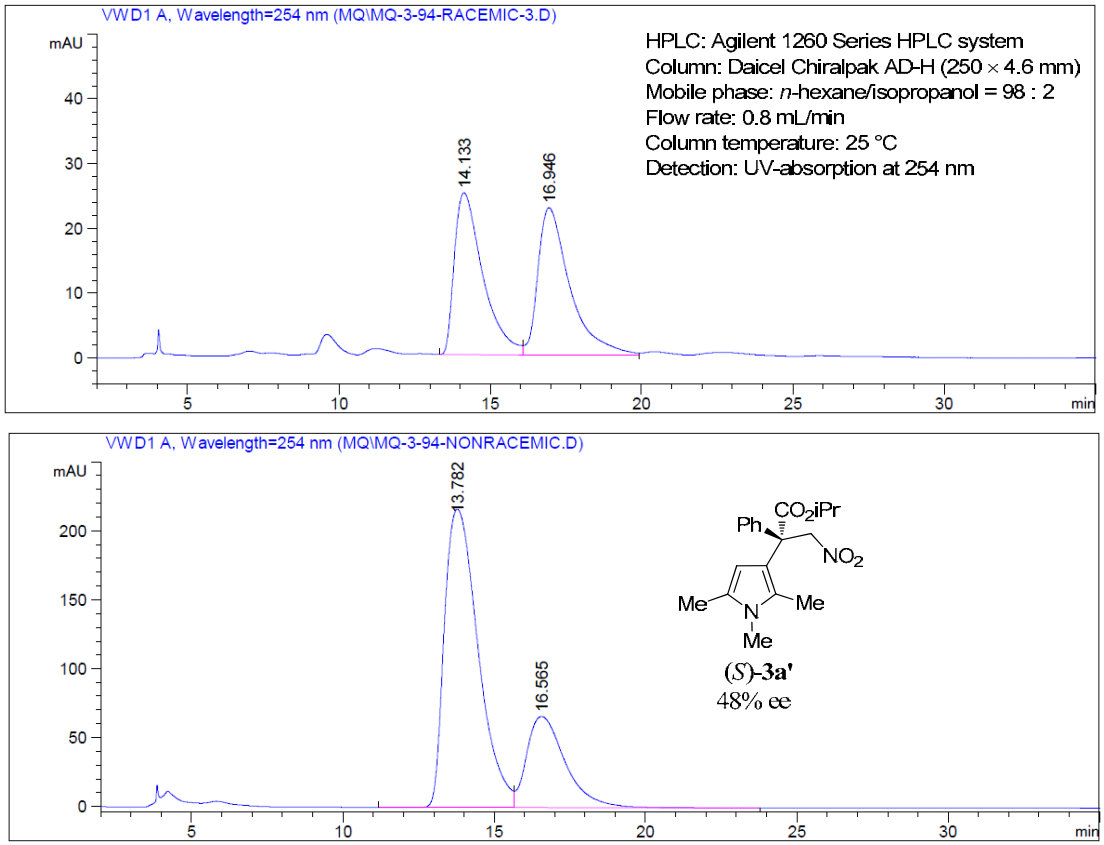
^{1}H NMR (500 MHz, $CDCl_3$): *δ* (ppm) 7.36-7.35 (m, 2H), 7.28-7.21 (m, 3H), 5.75 (s, 1H), 5.44 (d, *J* = 13.9 Hz, 2H), 5.16-5.06 (m, 2H), 3.29 (s, 3H), 2.18 (s, 3H), 1.64 (s, 3H), 1.23 (q, *J* = 6.5 Hz, 6H).

^{13}C NMR (126 MHz, $CDCl_3$): *δ* (ppm) 170.4, 139.6, 128.4, 127.9, 127.2, 126.5, 126.2, 115.7, 104.6, 82.1, 69.3, 54.5, 30.2, 21.5, 12.5, 11.8.

IR (film): v (cm^{-1}) 2980, 2921, 2852, 1728, 1556, 1522, 1496, 1447, 1411, 1375, 1344, 1210, 1145, 1106, 1065, 1023, 735, 701.

HRMS (ESI, m/z) calcd for $C_{19}H_{25}N_2O_4$ $(M+H)^+$ 345.1814, found: 345.1824.

Enantiomeric excess of products were determined with a Daicel Chiralpak AD-H (250 x 4.6 mm) on an Agilent 1260 Series HPLC System using n-hexane/isopropanol as mobile phase, the temperature was 25 °C and UV-absorption was measured at 254 nm.

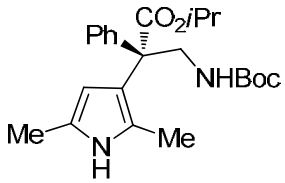


#	[min]		[min]	[mAU*s]	[mAU]	%
1	13.782	BV	1.2252	1.67797e4	216.75374	73.9439
2	16.565	VB	1.3681	5912.79395	66.32346	26.0561

Figure 20. HPLC traces of *rac*-**3a'** (reference) and (*S*)-**3a'**.

5. Further Transformations of Product 3a[7]

5.1 Synthesis of the Transformation Products



4a

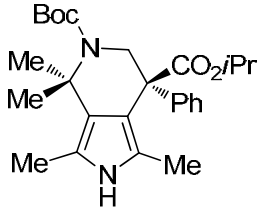
Compound 4a. To a stirred solution of **3a** (88.6 mg, 0.268 mmol) and $NiCl_2{\cdot}6H_2O$ (63.7 mg, 0.268 mmol) in methanol (2.7 mL) was added $NaBH_4$ (121.7 mg, 3.216 mmol) in small portions over a period of 1 h at 0 °C. The solution was stirred for further 30 min and then a saturated solution of NH_4Cl (0.27 mL) was added. The resulting suspension was filtered over a short pad of Celite. Solvents were evaporated under reduced pressure. The residue was redissolved in dichloromethane (10 mL) then washed with water. Organic phase was dried over Na_2SO_4, and concentrated in high vacuo to afford a white semi-solid (the unprotected amine, 73.0 mg, 0.243 mmol), which was then dissolved in a mixed solvent of dichloromethane/H_2O (1:1, 1 mL) at 0 °C. Potassium carbonate (6.7 mg, 0.0486 mmol) and di-*tert*-butyl pyrocarbonate (63.6 mg, 0.292 mmol) were added in portions at this temperature. The mixture was stirred at 25 °C overnight then diluted with dichloromethane (10 mL). Organic phase was separated, dried over Na_2SO_4. Solvents were removed and the residue was purified by silica gel column chromatography to afford the pure product **4a** as a light-yellow foamed solid (81.6 mg, 0.204 mmol, 76%). Enantiomeric excess was established by HPLC analysis using a Chiralpak AD-H column, ee = 94% (HPLC conditions: AD-H, 254 nm, *n*-hexane/isopropanol = 95:5, flow rate 1 mL/min, 25 °C, t_r(major) = 15.7 min, t_r(minor) = 20.2 min); $[a]_D^{20}$ = -24.9° (c=1.0, $CHCl_3$).

^{1}H NMR (500 MHz, $CDCl_3$): δ (ppm) 7.56 (br s, 1H), 7.30-7.19 (m, 5H), 5.74 (s, 1H), 5.07-5.00 (m, 1H), 4.84-4.72 (m, 1H), 3.99-3.90(m, 2H), 2.20 (s, 3H), 1.79 (s, 3H), 1.29 (s, 9H), 1.19 (q, J = 6.2 Hz, 6H).

^{13}C NMR (126 MHz, $CDCl_3$): δ (ppm) 173.8, 155.5, 141.0, 128.4, 127.7, 126.5, 124.4 124.2, 117.8, 106.7, 78.6, 68.6, 56.3, 47.2, 28.3, 21.6, 21.5, 12.9.

IR (film): ν (cm^{-1}) 3387, 2962, 2925, 2854, 1723, 1610, 1581, 1555, 1511, 1464, 1375, 1260, 1251, 1181, 1105, 1027, 800, 759, 666.

HRMS (ESI, *m*/*z*) calcd for $C_{23}H_{32}N_2NaO_4$ $(M+Na)^+$ 423.2260, found: 423.2255.



5a

Compound 5a. To a stirred solution of **3a** (80.0 mg, 0.242 mmol) and $NiCl_2{\cdot}6H_2O$ (57.5 mg, 0.242 mmol) in methanol (2.5 mL) was added $NaBH_4$ (109.8 mg, 2.904 mmol) in small portions over a period of 1 h at 0 °C. The solution was stirred for additional 30 min and then a saturated solution of NH_4Cl

(0.25 mL) was added. The resulting mixture was filtered over a short pad of Celite. Solvents were evaporated under reduced pressure. The residue was redissolved in dichloromethane (10 mL) then washed with water. Organic phase was dried over Na_2SO_4 and concentrated in high vacuo to afford a white semi-solid (the unprotected amine, 70.0 mg, 0.233 mmol), which was then dissolved in a mixed solvents of acetone/H_2O (1:1, 1 mL) at 0 °C. Potassium carbonate (6.4 mg, 0.0466 mmol) and di-*tert*-butyl pyrocarbonate (60.9 mg, 0.279 mmol) were added in portions. The mixture was stirred at 25°C overnight then diluted with dichloromethane (10 mL). Organic phase was separated, washed with brine, dried over Na_2SO_4. Solvents were removed and the residue was purified by silica gel column chromatography to afford the pure product **5a** as a yellow oil (92.8 mg, 0.211 mmol, 87%). Enantiomeric excess was established by HPLC analysis using a Chiralpak OD-H column, ee = 94% (HPLC conditions: OD-H, 254 nm, *n*-hexane/isopropanol = 98:2, flow rate 1 mL/min, 25 °C, t_r(major) = 11.5 min, t_r(minor) = 16.1 min); $[a]_D^{20}$ = +25.8° (c=1.0, $CHCl_3$).

^{1}H NMR (500 MHz, $CDCl_3$): *δ* (ppm) 7.47 (br s, 1H), 7.28-7.19 (m, 5H), 5.18-5.10 (m, 1H), 4.37 (d, *J* = 13.0 Hz, 1H), 3.75 (d, *J* = 13.0 Hz, 1H), 2.28 (s, 3H), 1.72 (s, 6H), 1.61 (s, 3H), 1.43 (s, 9H), 1.29-1.24 (m, 6H).

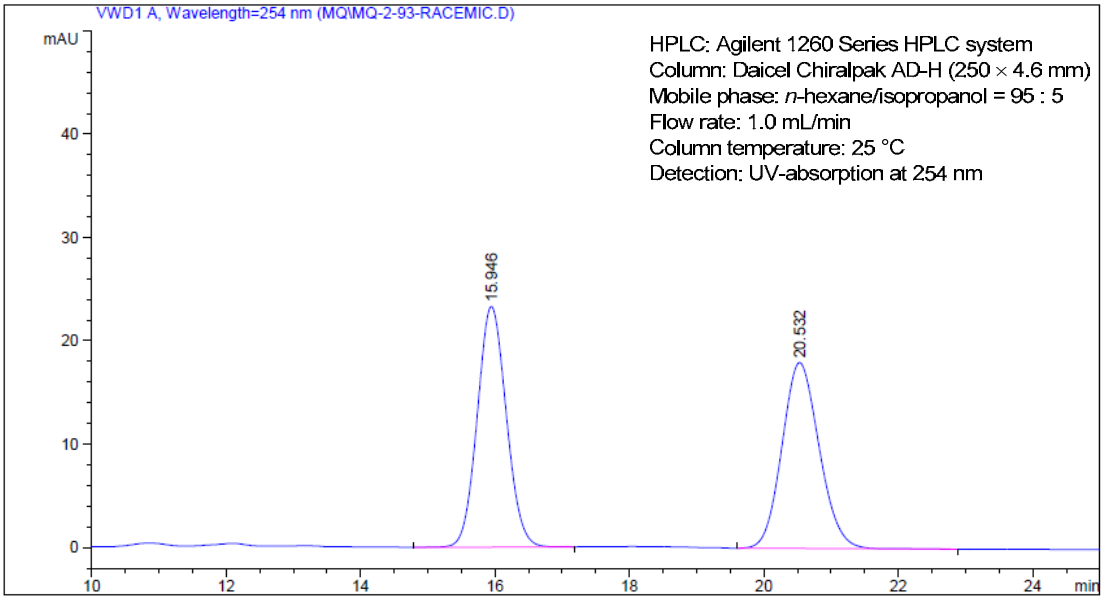
^{13}C NMR (126 MHz, $CDCl_3$): *δ* (ppm) 173.3, 141.3, 128.0, 127.8, 126.6, 124.1, 120.4, 117.5, 116.1, 79.4, 68.5, 57.0, 53.6, 53.4, 52.1, 28.5, 21.8, 21.7, 13.6, 12.1.

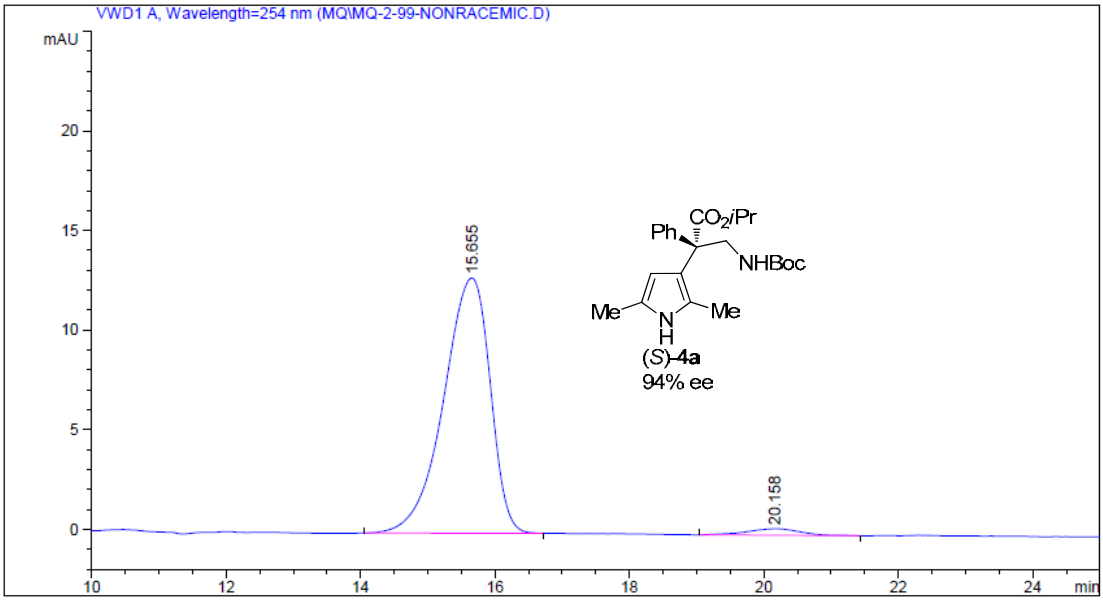
IR (film): *v* (cm^{-1}) 3387, 2962, 2925, 2854, 1723, 1610, 1581, 1555, 1511, 1464, 1375, 1295, 1260, 1215, 1181, 1105, 1027, 800, 759, 666.

HRMS (ESI, *m*/*z*) calcd for $C_{26}H_{36}N_2NaO_4$ $(M+Na)^+$ 463.2573, found: 463.2569.

5.2 Determination of Enantiopurities of the Follow-Up Products

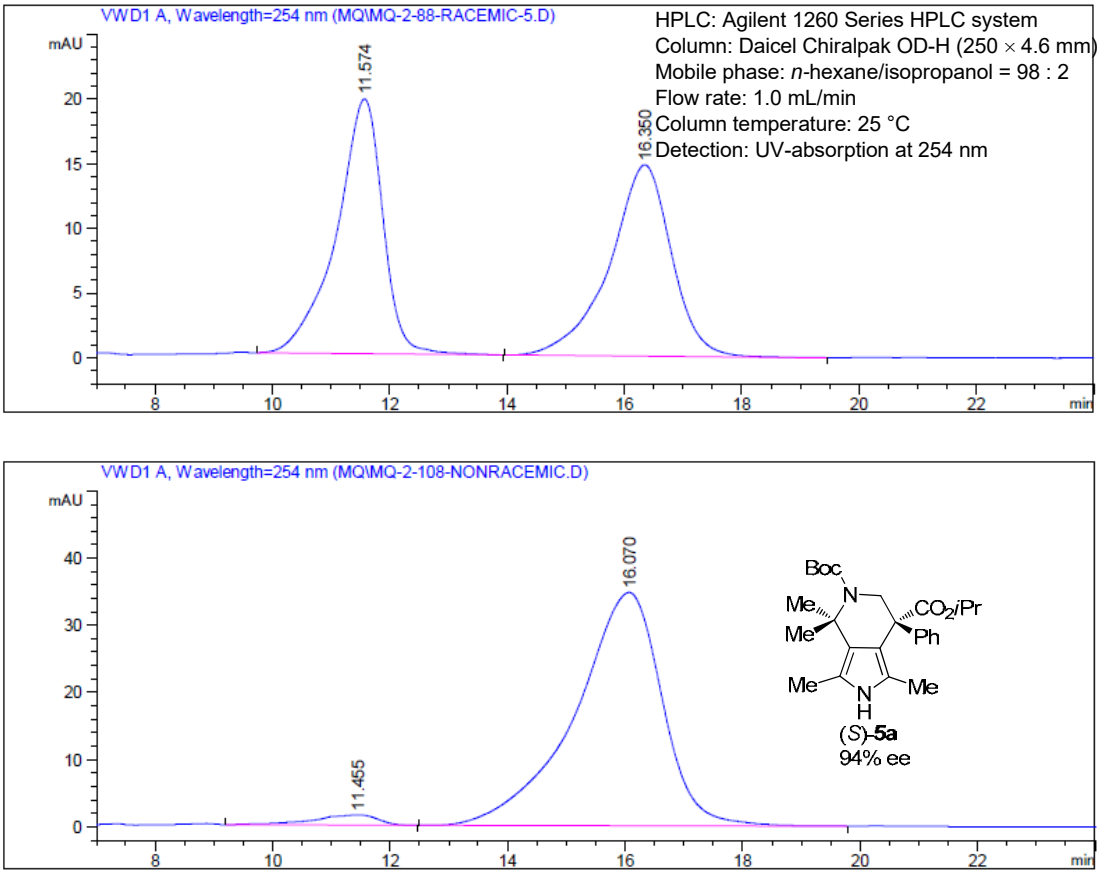
Enantiomeric excess of fellow-up products were determined with a Daicel Chiralpak AD-H or OD-H column (250 x 4.6 mm) on an Agilent 1260 Series HPLC System using n-hexane/isopropanol as mobile phase, the temperature was 25 °C and UV-absorption was measured at 254 nm.





#	[min]		[min]	[mAU*s]	[mAU]	%
1	15.655	BB	0.7492	616.17657	12.80999	97.2197
2	20.158	BB	0.6546	17.62156	3.23971e-1	2.7803

Figure S21. HPLC traces of *rac*-**4a** (reference) and (*S*)-**4a**.



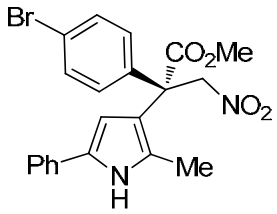
#	[min]		[min]	[mAU*s]	[mAU]	%
1	11.455	BB	1.0339	115.31252	1.51852	3.1211
2	16.070	BB	1.5209	3579.24121	34.71511	96.8789

Figure S22. HPLC traces of *rac*-**5a** (reference) and (*S*)-**5a**.

6. Single Crystal X-Ray Diffraction with Compound (*S*)-3u

6.1 Synthesis of Compound (*S*)-3u

(*S*)-Methyl 2-(4-bromophenyl)-2-(2-methyl-5-phenyl-1*H*-pyrrol-3-yl)-3-nitro-propanoate (3u)



Compound **(*S*)-3u** was synthesized from the enantioselective Friedel-Crafts alkylation of pyrrole **1f** with nitroacrylate **2d** under the standard conditions in the presence of 4 mol% of the non-racemic iridium catalyst. Accordingly, a solution of **1f** (15.7 mg, 0.10 mmol), **2d** (57.2 mg, 0.20 mmol) and catalyst Λ-**MTC** (8.92 mg, 0.0040 mmol) in anhydrous toluene (50 μL) was stirred at 40 °C for 30 h under argon atmosphere and reduced light. The mixture was then dried in vacuo and subjected to flash chromatography (silica gel, eluents: EtOAc/*n*-hexane = 1:50) to afford **3u** as a yellow solid (41.2 mg, 0.093 mmol, 93%). Enantiomeric excess was established by HPLC analysis using a Chiralpak AD-H column, ee = 94% (HPLC conditions: AD-H, 254 nm, *n*-hexane/isopropanol = 92:8, flow rate 1 mL/min, 25 °C, t_r(major) = 29.7 min, t_r(minor) = 43.7 min); $[a]_D^{20}$ = -63.4° (c=1.0, $CHCl_3$).

^{1}H NMR (500.2 MHz, $CDCl_3$): *δ* (ppm) 8.19 (br s, 1H), 7.44-7.40 (m, 4H), 7.37-7.34 (m, 2H), 7.31-7.28 (m, 2H), 7.22-7.19 (m, 1H), 6.36 (d, *J* = 2.9 Hz, 1H), 5.58 (d, *J* = 13.8 Hz, 1H), 5.09 (d, *J* = 13.8 Hz, 1H), 3.81 (s, 3H), 1.81 (s, 3H).

^{13}C NMR (125.8 MHz, $CDCl_3$): *δ* (ppm) 170.7, 137.8, 131.8, 131.3, 130.4, 129.6, 128.9, 127.5, 126.3, 123.3, 121.9, 118.0, 105.2, 81.8, 53.8, 53.0, 13.0.

IR (film): *v* (cm^{-1}) 3387, 2962, 2925, 2854, 1723, 1610, 1581, 1555, 1511, 1464, 1375, 1260, 1215, 1181, 1105, 1027, 800, 759, 694, 666, 560.

HRMS (ESI, *m*/*z*) calcd for $C_{21}H_{19}BrN_2NaO_4$ $(M+Na)^+$ 465.0426, found: 465.0419.

6.2 Crystallography of Compound (*S*)-3u

Crystals of (*S*)-**3u** were obtained by slow diffusion from the solution in $CHCl_3$ layered *n*-hexane. Data were collected on an Oxford Gemini S Ultra detector employing graphite-monochromated Mo-Kα radiation (= 0.71073 Å). The crystal was kept at 173 K during data collection. The structure was solved by SHELXL-97.[8] Refinement was done by full-matrix least squares based on F2 data of one twin domain using SHELXL-97. The absolute configuration was determined. The structure is shown in Figure S24. Crystallographic data for (*S*)-**3u** has been deposited with the Cambridge Crystallographic Data Centre (CCDC) under deposition number 1407324.

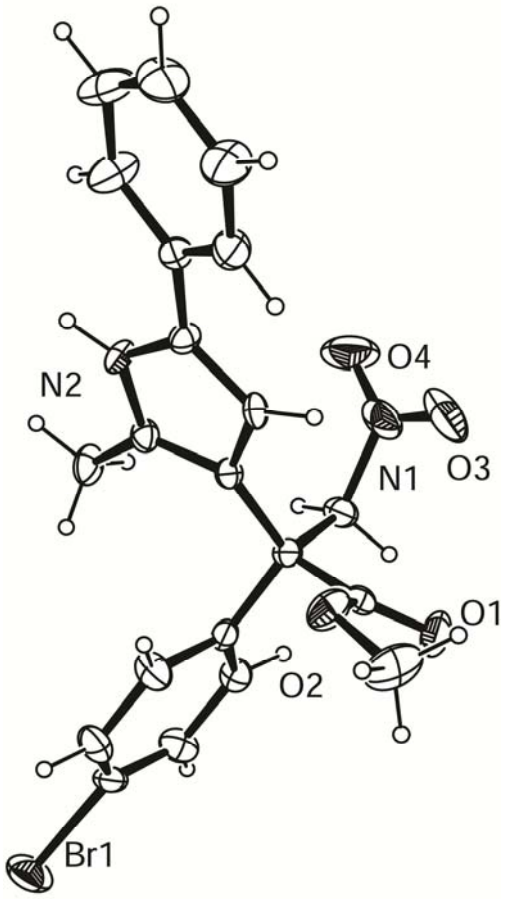


Figure S23. Ortep drawing of (*S*)-**3u** with 50% probability thermal ellipsoids.

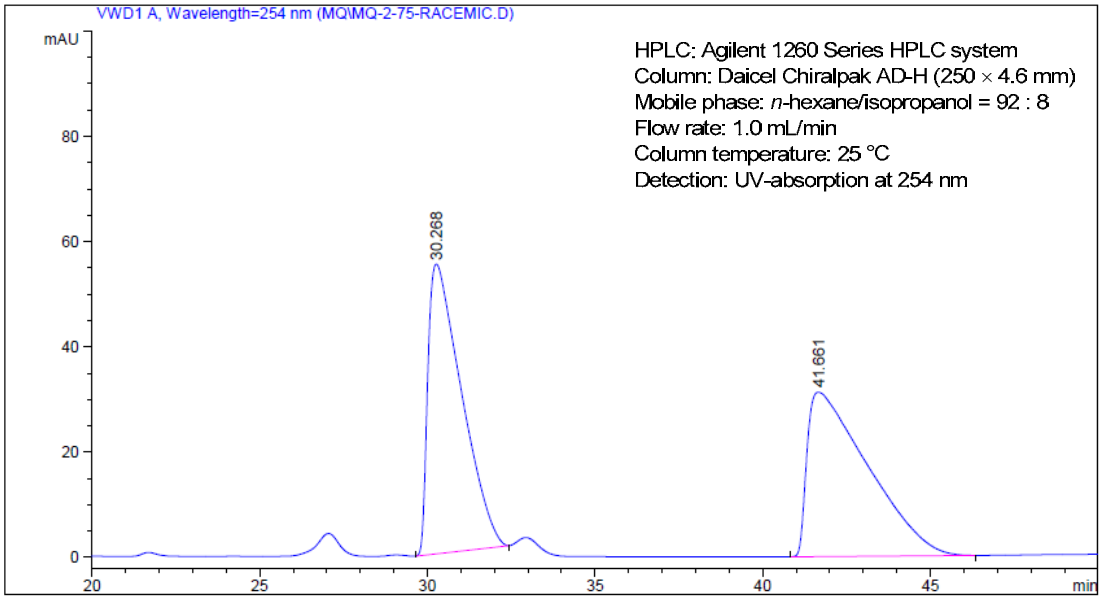
Table S1. Data collection and refinement statistics for the compound (*S*)-**3u.**

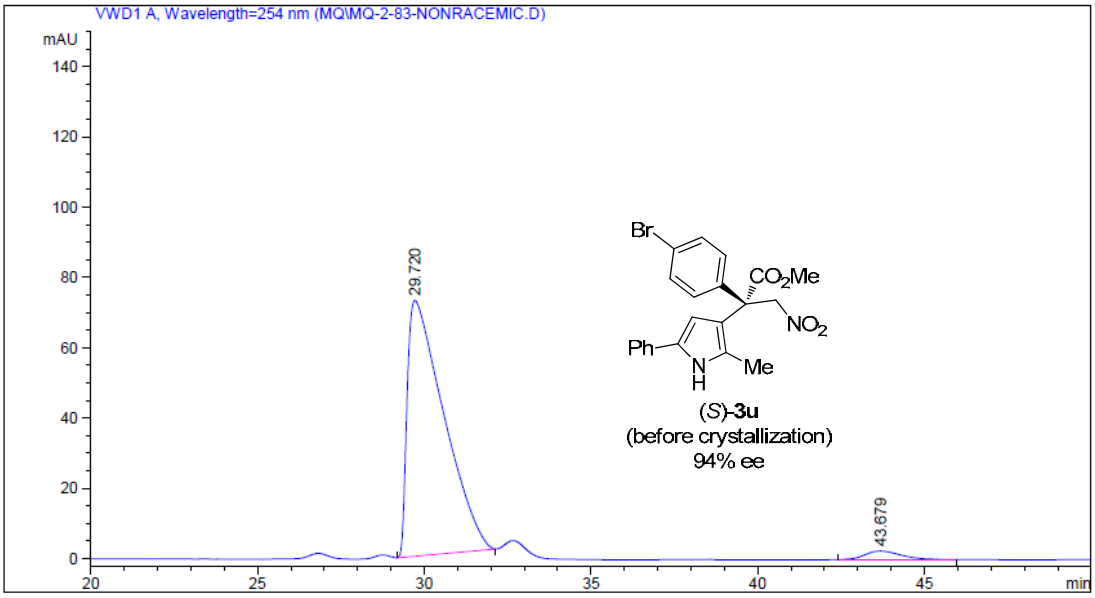
	(*S*)-**3u**
Empirical formula	C_{21} H_{19} Br N_2 O_4
Formula weight	443.29
Temperature (K)	173(2)
Wavelength (Å)	0.71073
Crystal system	Orthorhombic
Space group	P2(1)2(1)2(1)
Cell dimensions	
a, b, c (Å)	8.4058, 10.8659,

	21.9188
α, β, γ (°)	90, 90, 90
Volume ($Å^3$)	2001.99 (13)
Z	4
Density (calculated, mg/m^3)	1.471
Absorption coefficient (mm^{-1})	2.082
F(000)	904
Crystal size (mm^3)	0.20 x 0.20 x 0.10
Theta range for data collection	3.05 to 26.00°
Index ranges	-10<=h<=6, -13<=k<=12, -20<=l<=27
Reflections collected	5801
Independent reflections	3551[R(int) = 0.0368]
Completeness	99.8 %
Absorption correction	Semi-empirical from equivalents
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	3551 / 0 / 253
Goodness-of-fit on F^2	0.999
Final R indices [I>2sigma(I)]	R1 = 0.0449, wR2 = 0.0864
R indices (all data)	R1 = 0.0545, wR2 = 0.0898
Absolute structure parameter	0.018(10)
Largest diff. peak and hole ($e.Å^{-3}$)	0.496 and -0.398

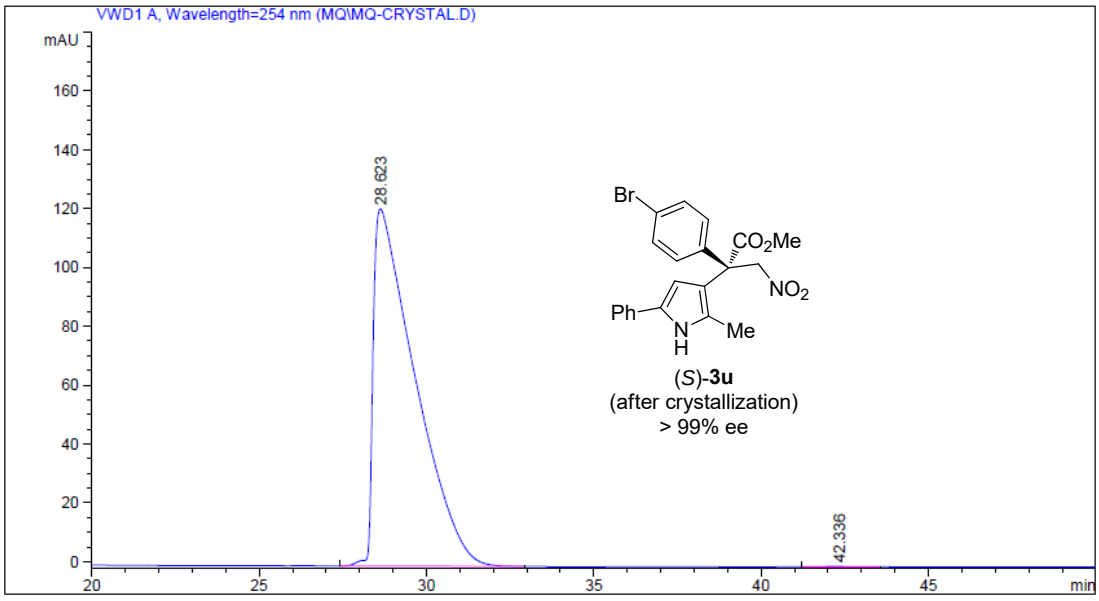
6.3 Determination of Enantiopurities of the crystalline product

Enantiomeric excess of products were determined with a Daicel Chiralpak AD-H column (250 x 4.6 mm) on an Agilent 1260 Series HPLC System using n-hexane/isopropanol as mobile phase, the temperature was 25 °C and UV-absorption was measured at 254 nm.





#	[min]		[min]	[mAU*s]	[mAU]	%
1	29.720	BB	1.1040	5525.35059	72.76025	96.9154
2	43.679	BB	0.8651	175.85672	2.39660	3.0846



#	[min]		[min]	[mAU*s]	[mAU]	%
1	28.623	BB	1.1889	1.05276e4	121.37430	99.9131
2	42.336	MM R	1.1291	9.15141	1.35086e-1	0.0869

Figure S24. HPLC traces of *rac*-**3u** (reference), (*S*)-**3u** (before crystallization) and (*S*)-**3u** (after crystallization).

7. References

[1] L.-A. Chen, X. Tang, J. Xi, W. Xu, L. Gong, E. Meggers, *Angew. Chem. Int. Ed.* **2013**, *52*, 14021–14025.

[2] R. Kastl, H. Wennemers, *Angew. Chem. Int. Ed.* **2013**, *52*, 7228–7232.

[3] J.-R. Gao, H. Wu, B. Xiang, W. Yu, L. Han, and Y. Jia, *J. Am. Chem. Soc.,* **2013,** *135,* 2983–2986.

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[5] J. Xuan, Z. J. Feng, J. R. Chen, L. Q. Lu, and W. J. Xiao, *Chem. Eur. J.* **2014**, *20*, 3045–3049.

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[7] S. Lancianesi, A. Palmieri, M. Petrini, *Adv. Synth. Catal.* **2013**, *355*, 3285–3289.

[8] G. M. Sheldrick, *Acta Cryst.* **2008**, *A64*, 112–122.

8. ^{1}H and ^{13}C NMR Data

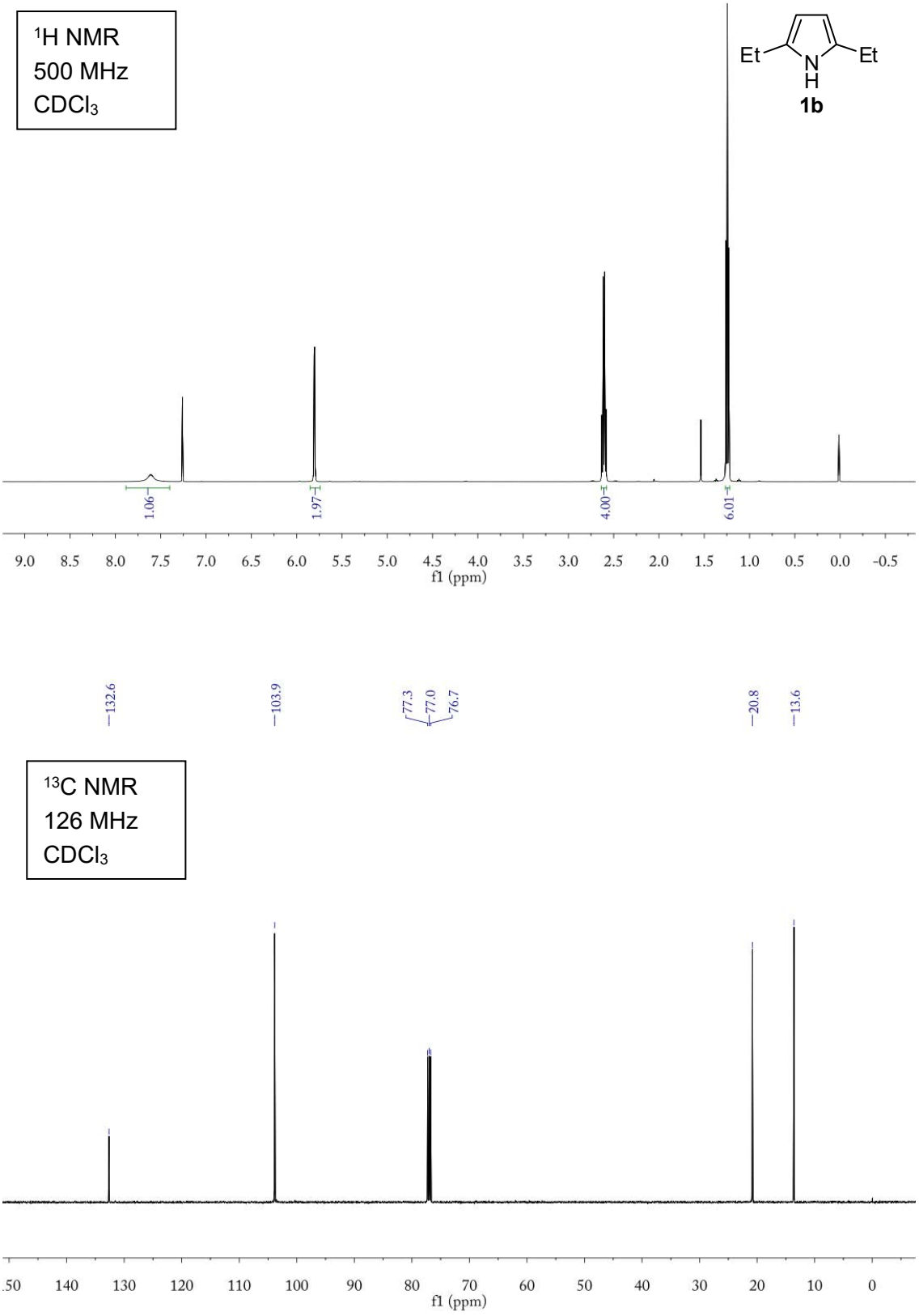
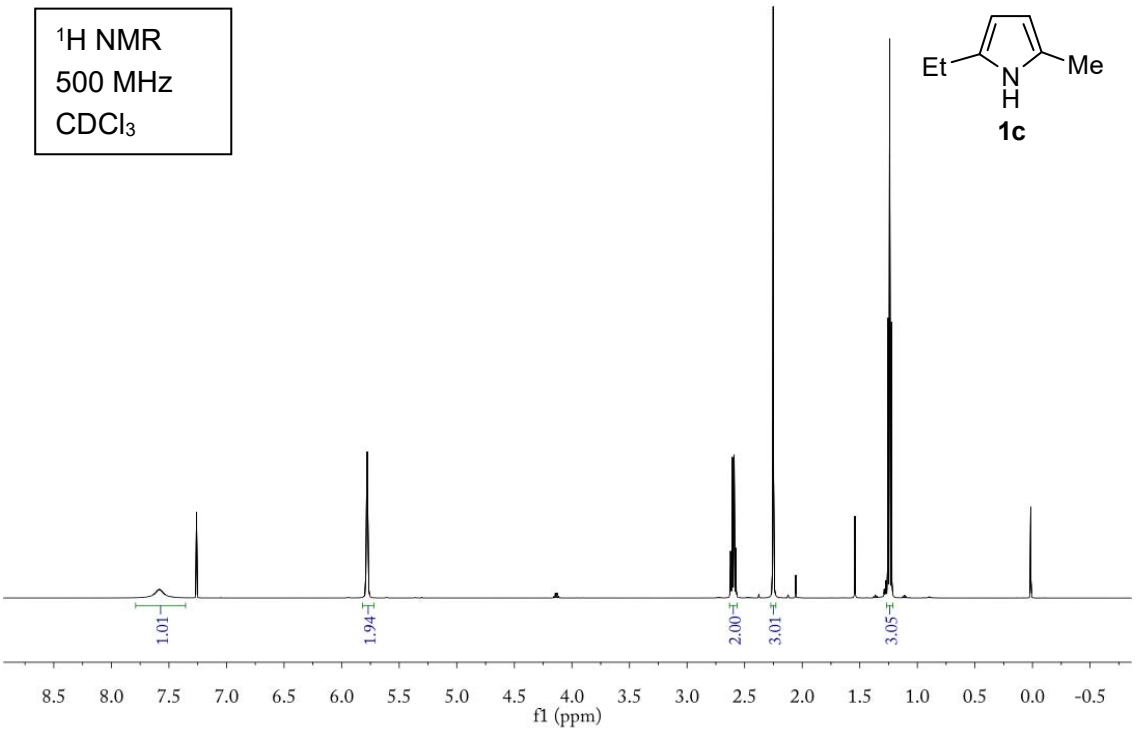


Figure S25. ^{1}H NMR and ^{13}C NMR spectra of **1b**.



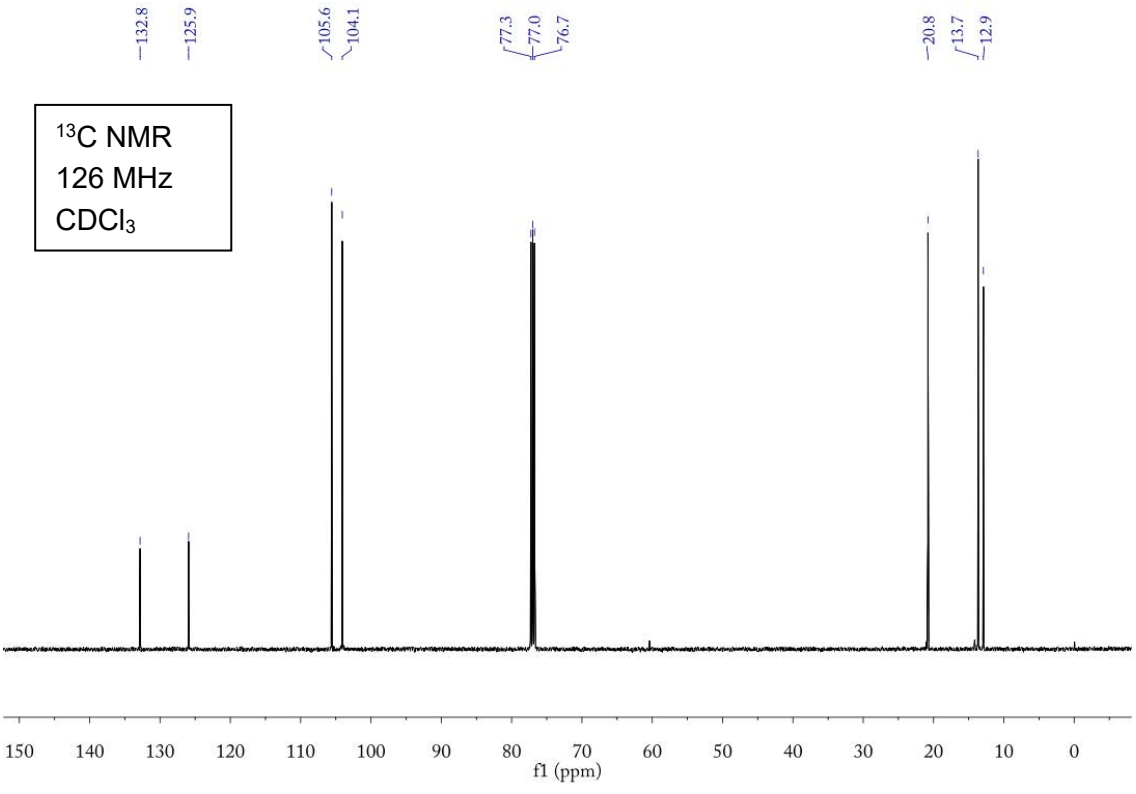
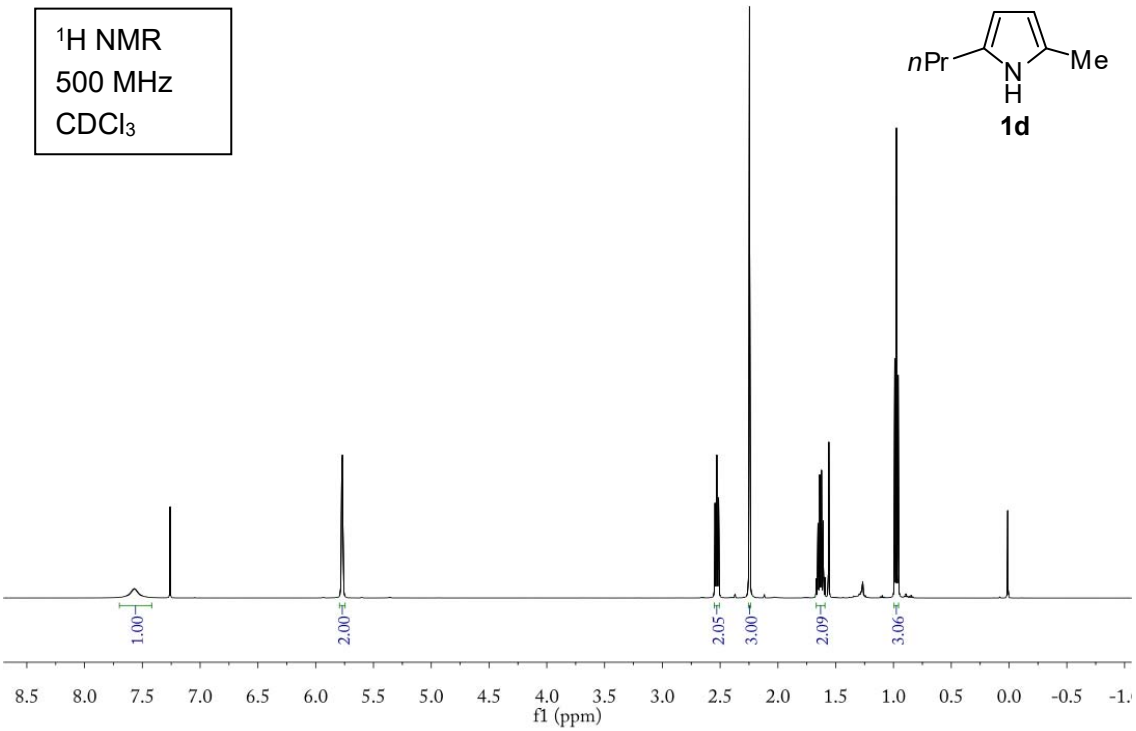


Figure S26. ^{1}H NMR and ^{13}C NMR spectra of **1c**.



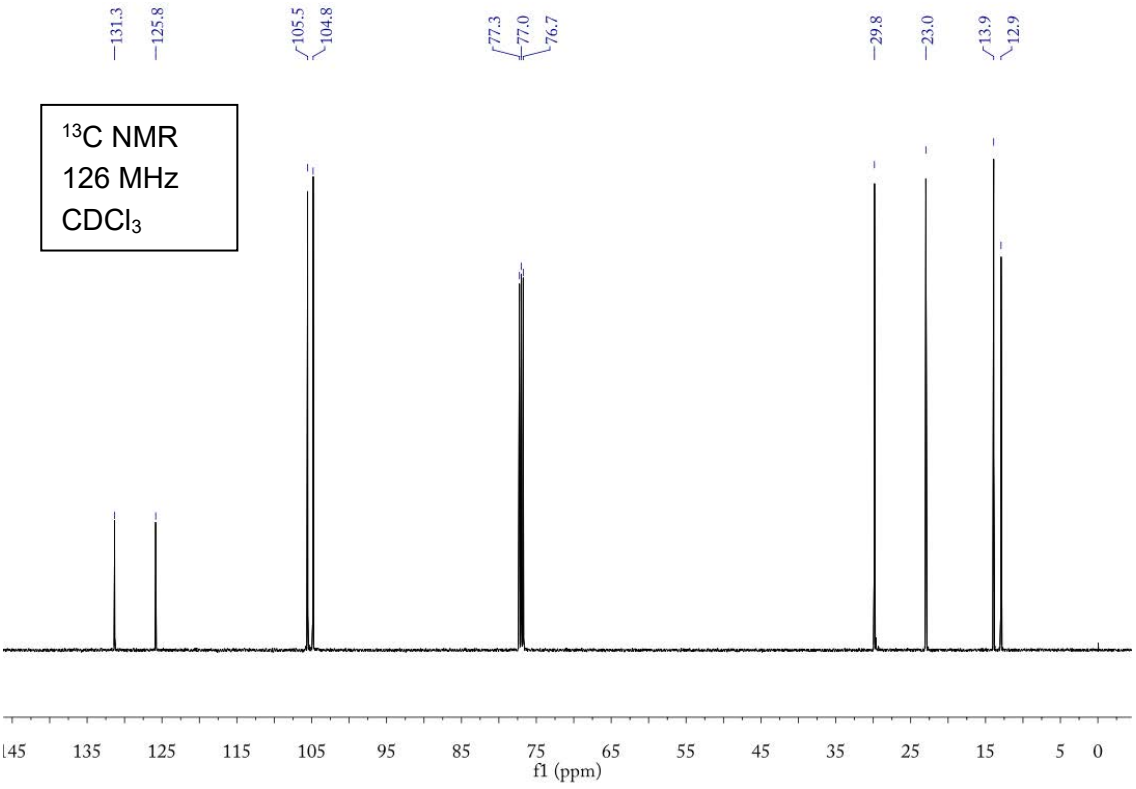


Figure S27. ^{1}H NMR and ^{13}C NMR spectra of **1d**.

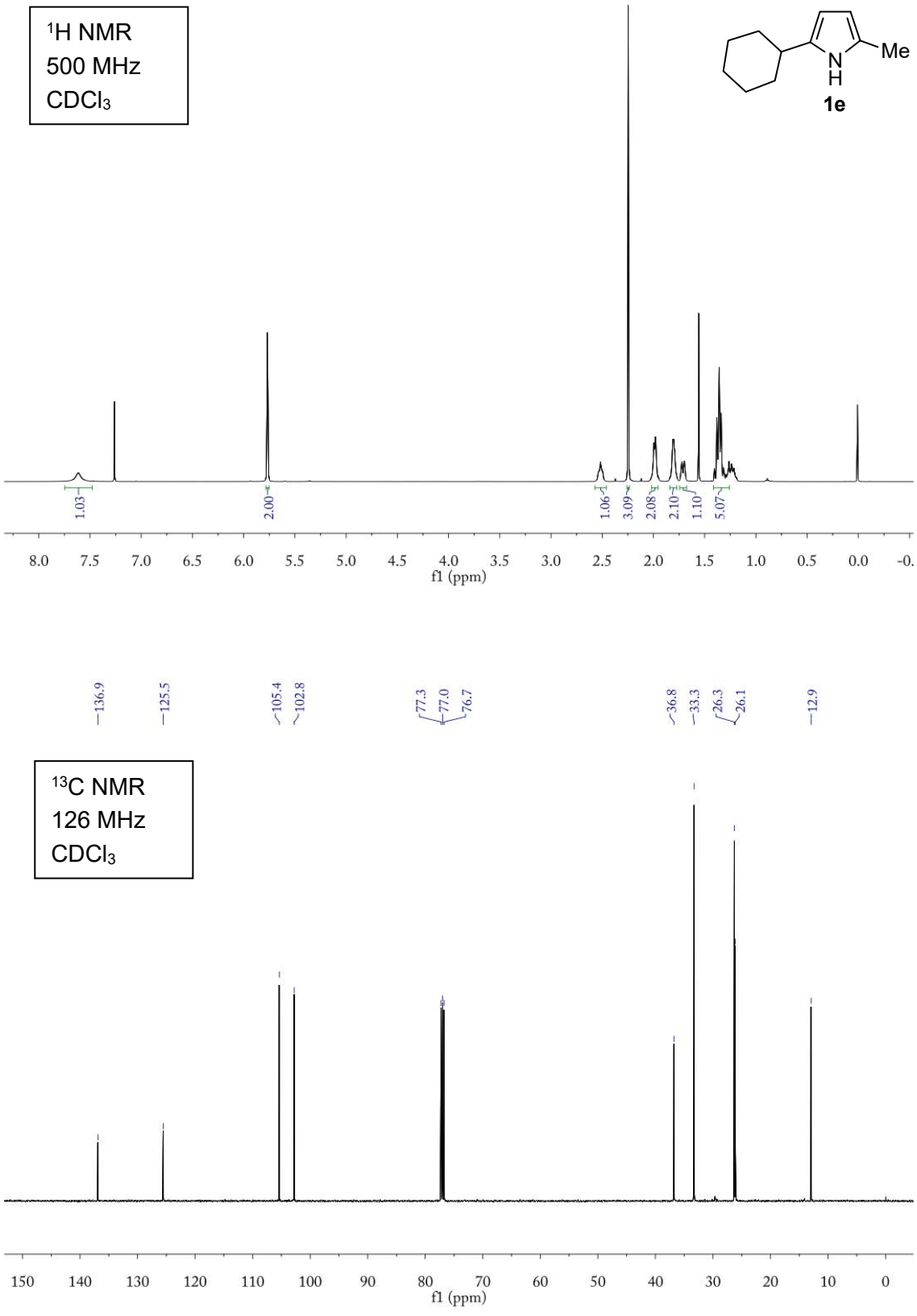


Figure S28. ^{1}H NMR and ^{13}C NMR spectra of **1e**.

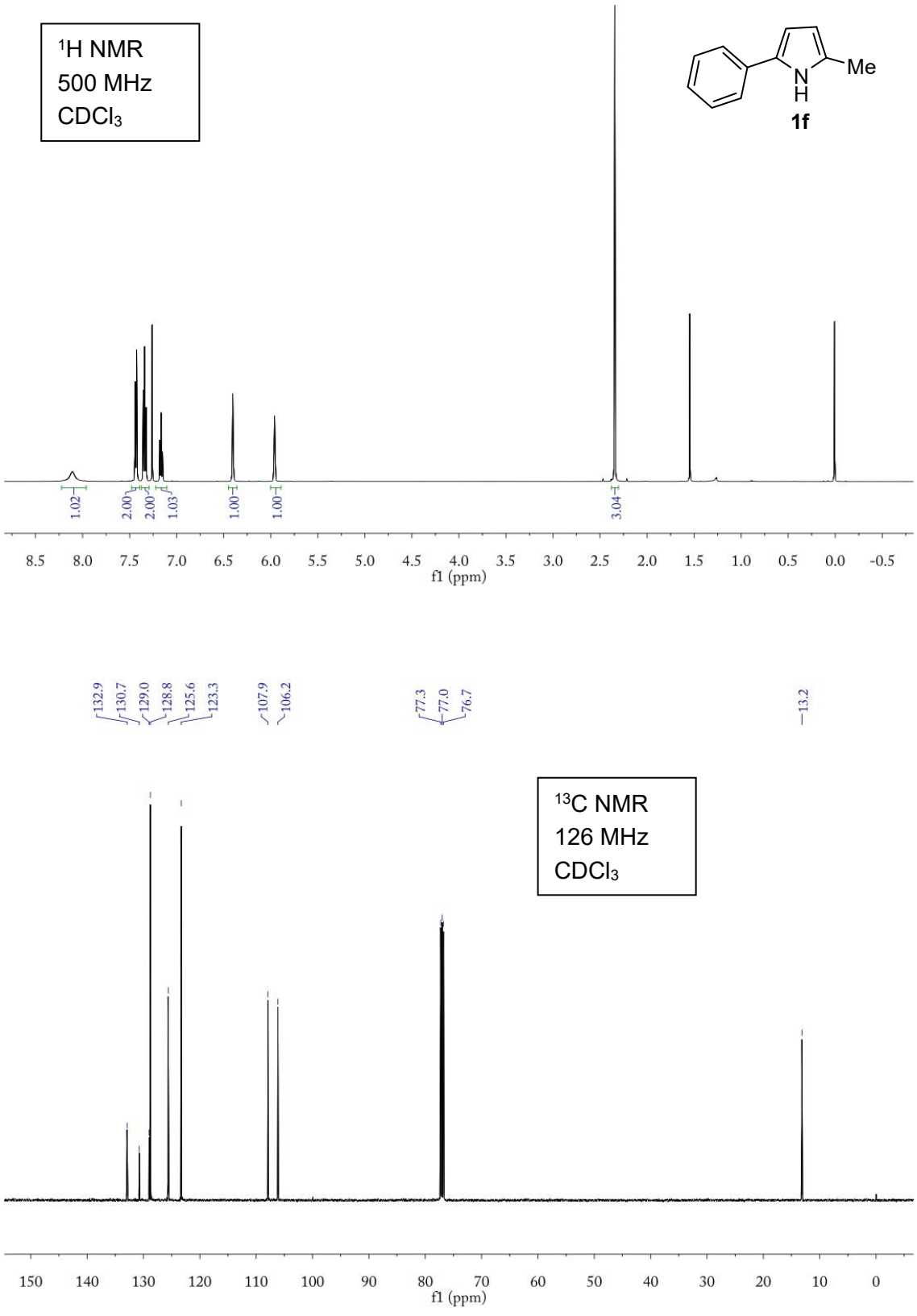


Figure S29. ^{1}H NMR and ^{13}C NMR spectra of **1f**.

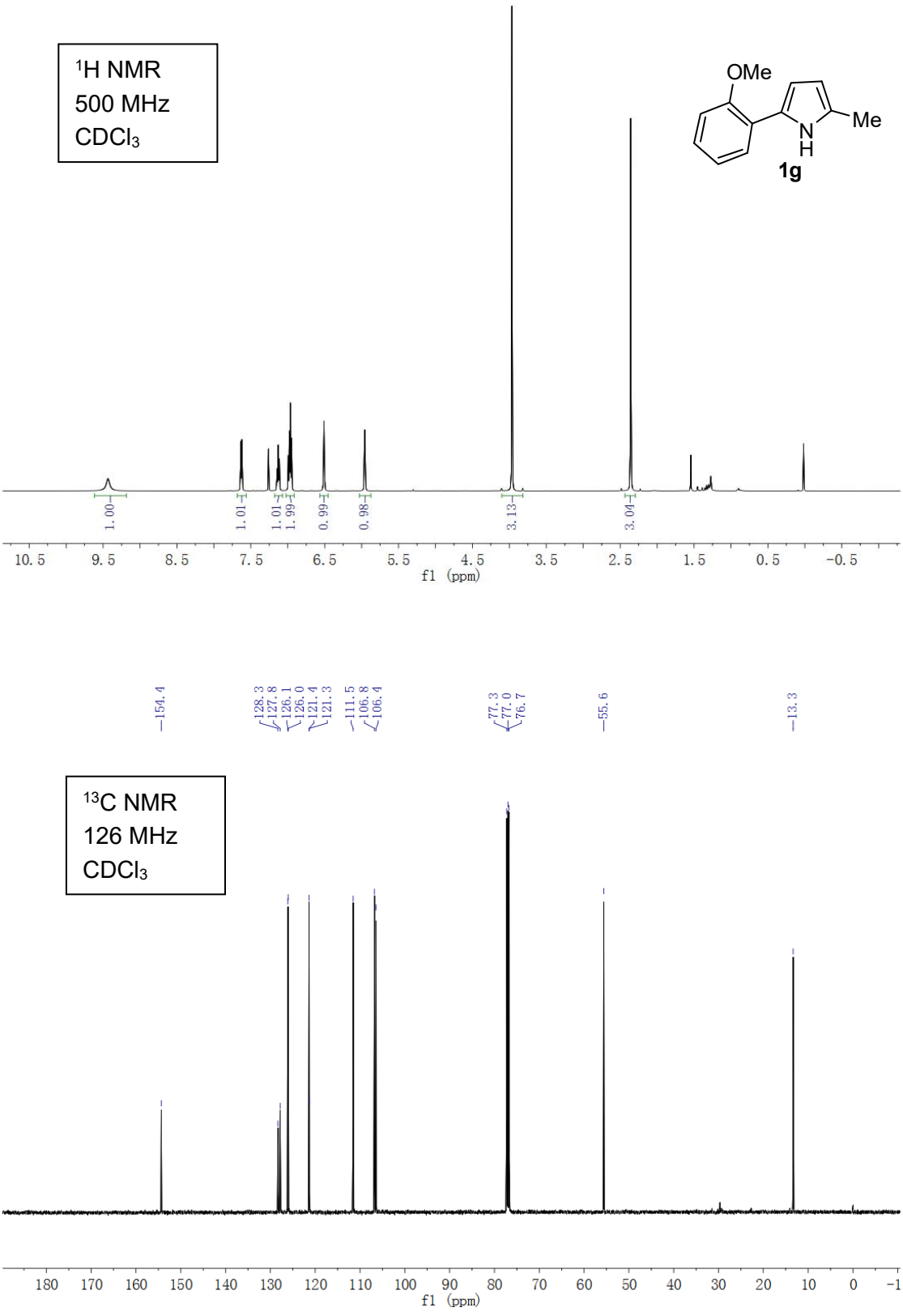


Figure S30. ^{1}H NMR and ^{13}C NMR spectra of **1g**.

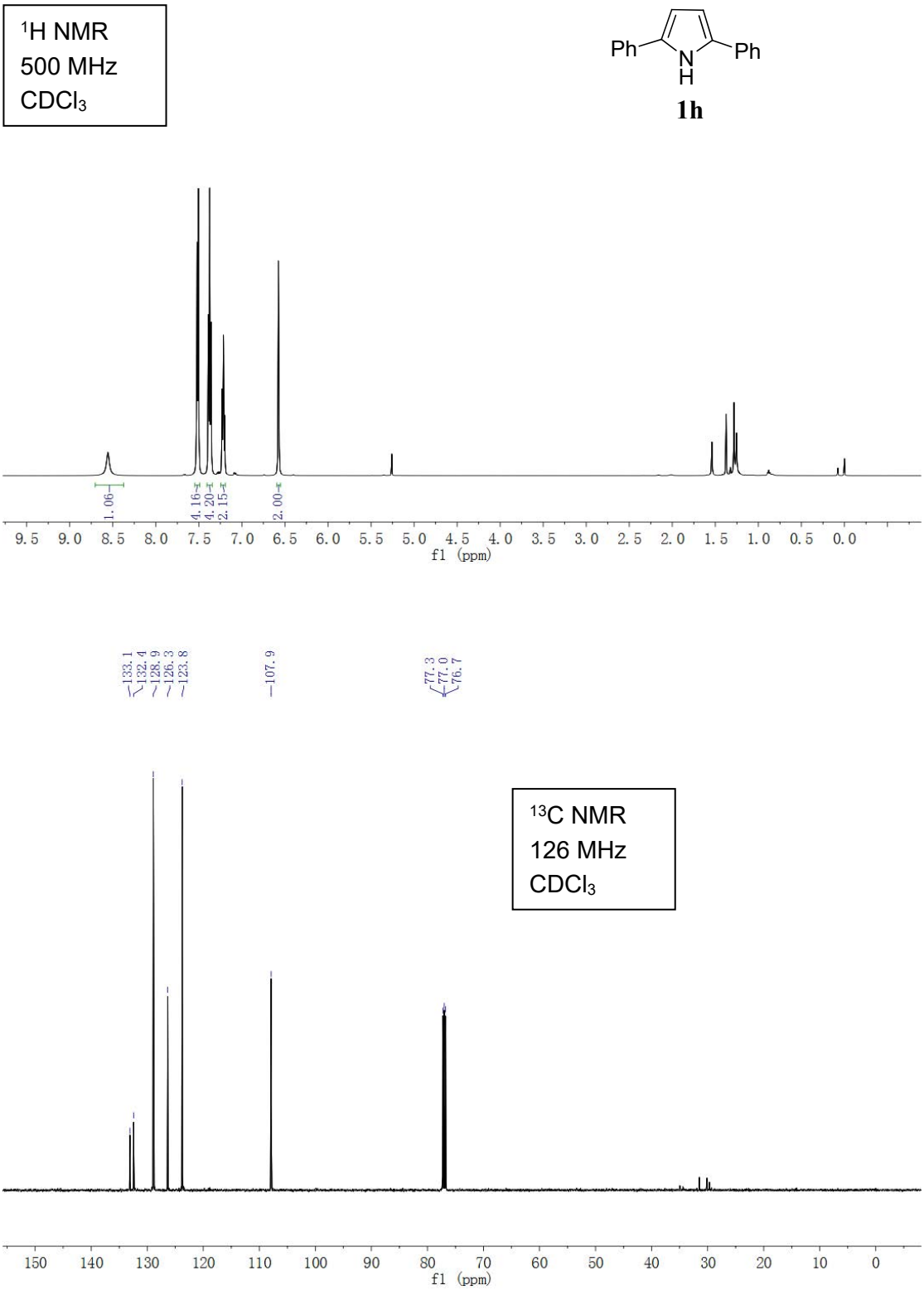


Figure S31. ^{1}H NMR and ^{13}C NMR spectra of **1h**.

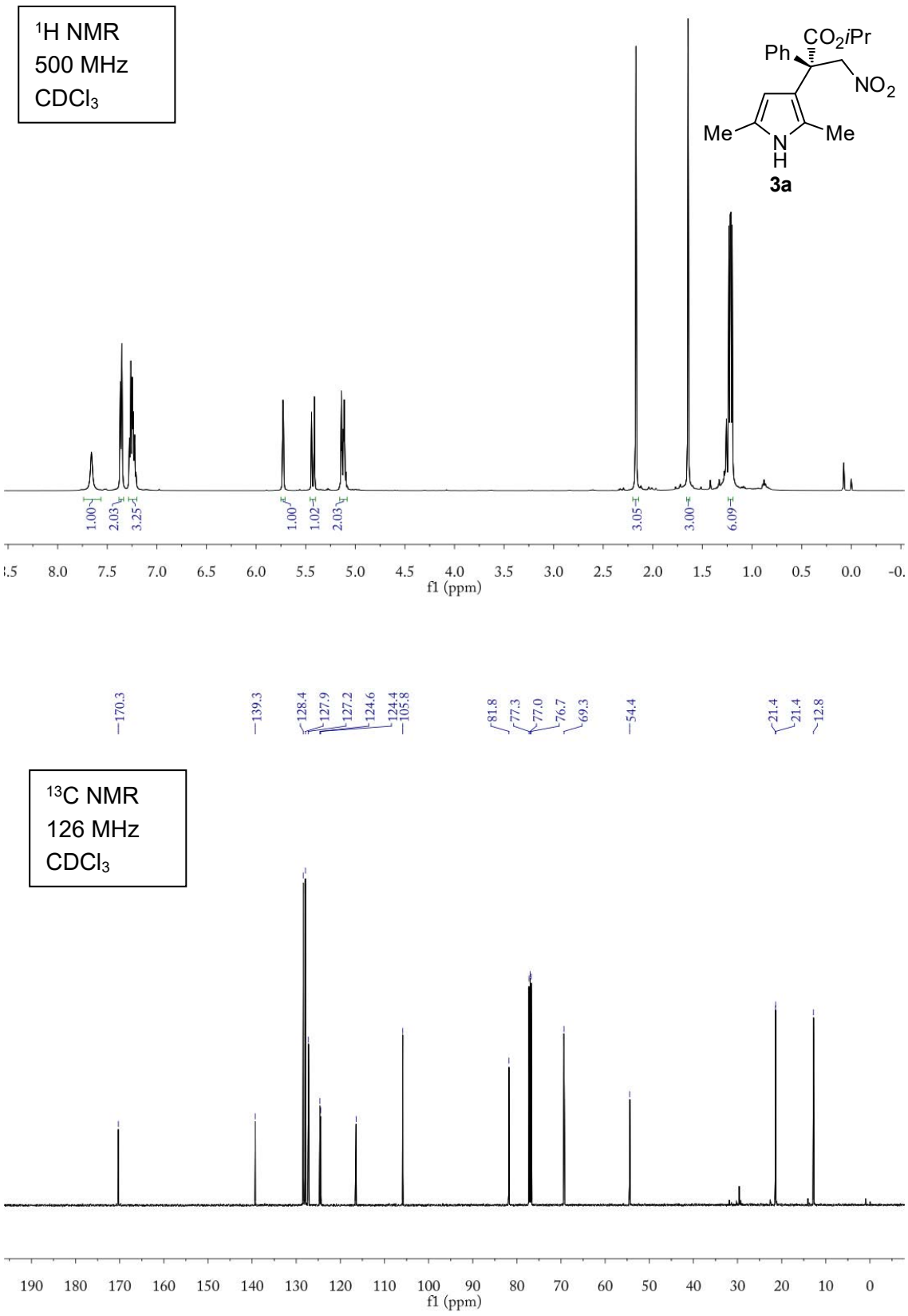


Figure S32. ^{1}H NMR and ^{13}C NMR spectra of **3a**.

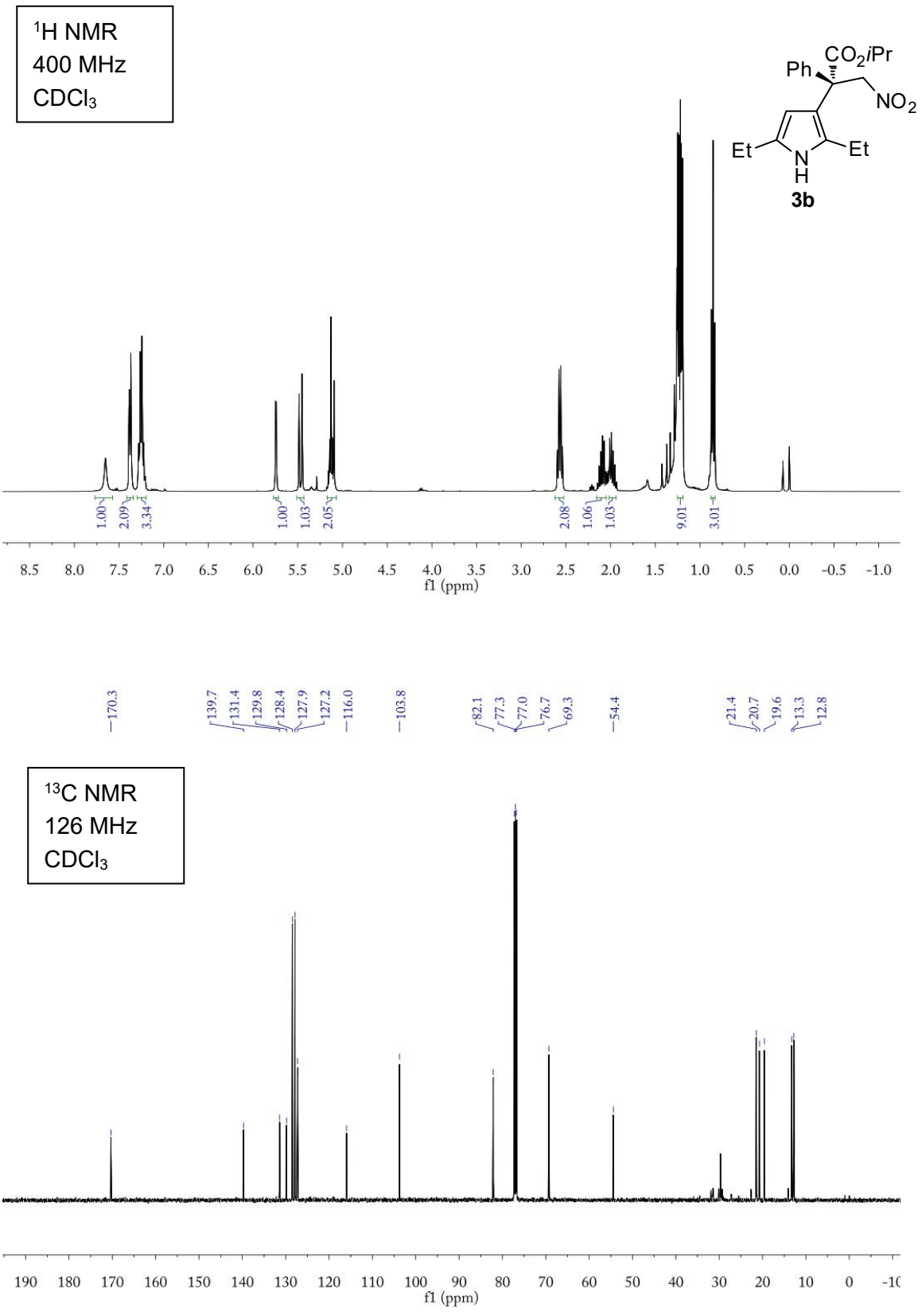


Figure S33. ^{1}H NMR and ^{13}C NMR spectra of **3b**.

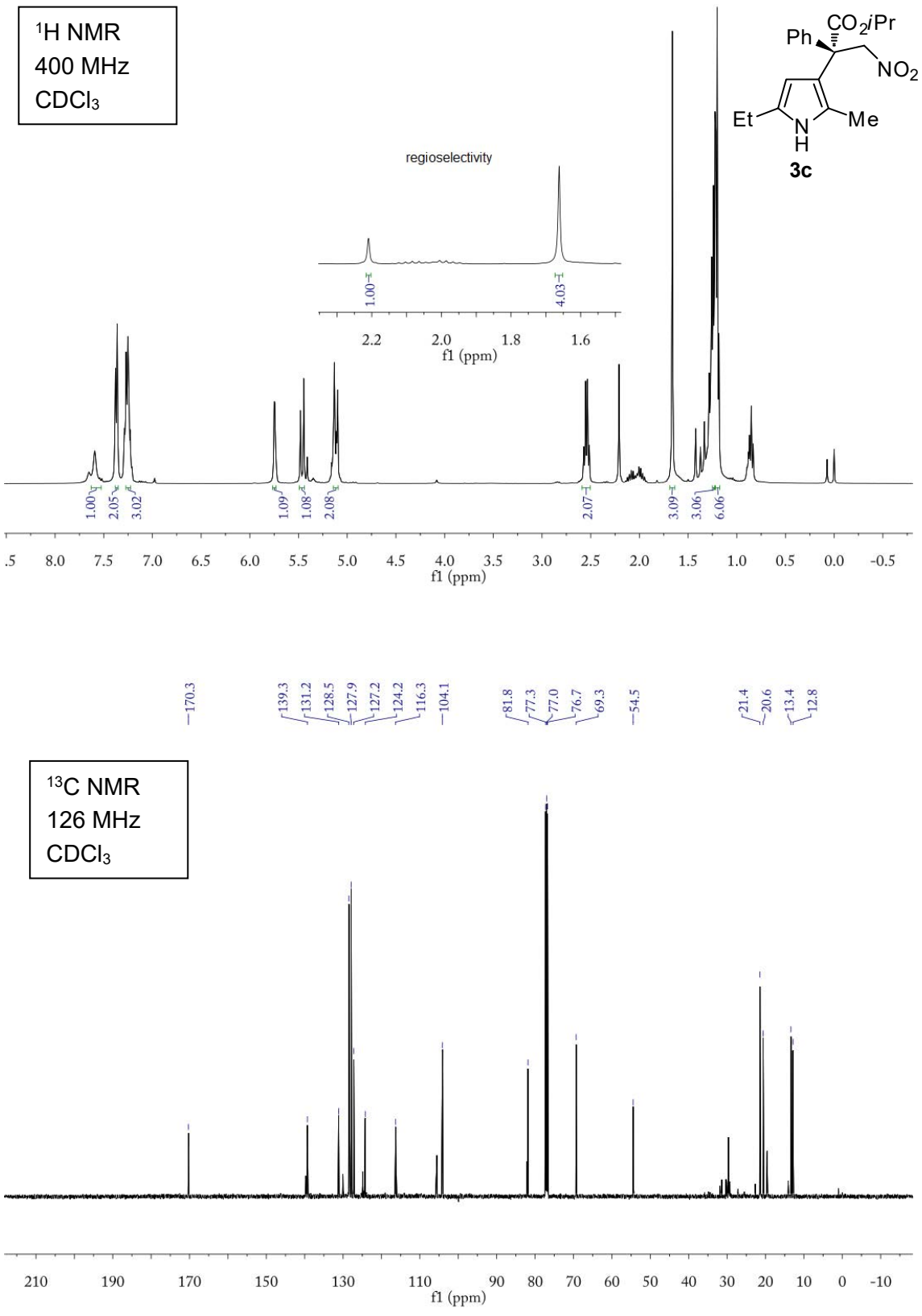


Figure S34. ^{1}H NMR and ^{13}C NMR spectra of **3c**.

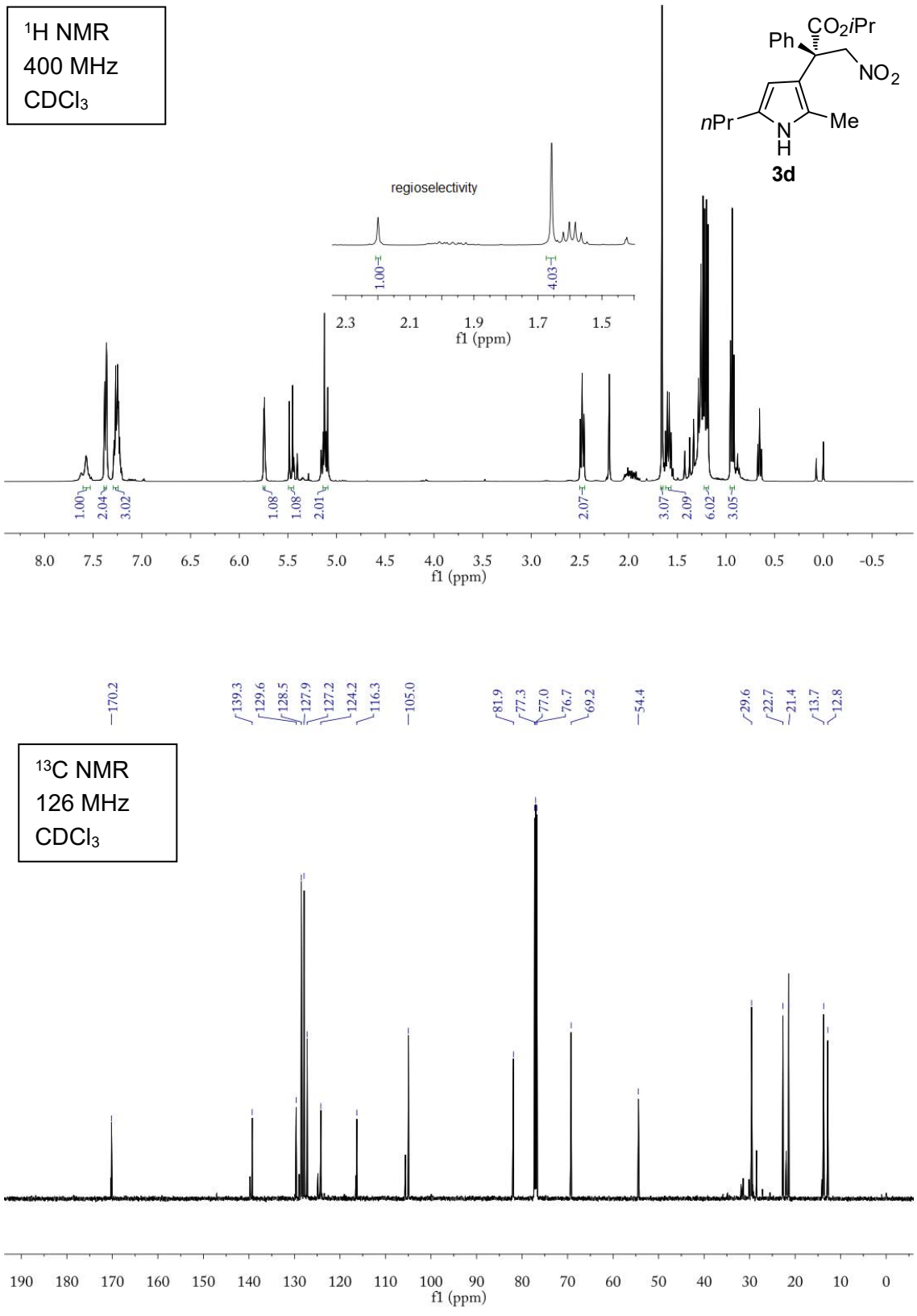


Figure S35. ^{1}H NMR and ^{13}C NMR spectra of **3d**.

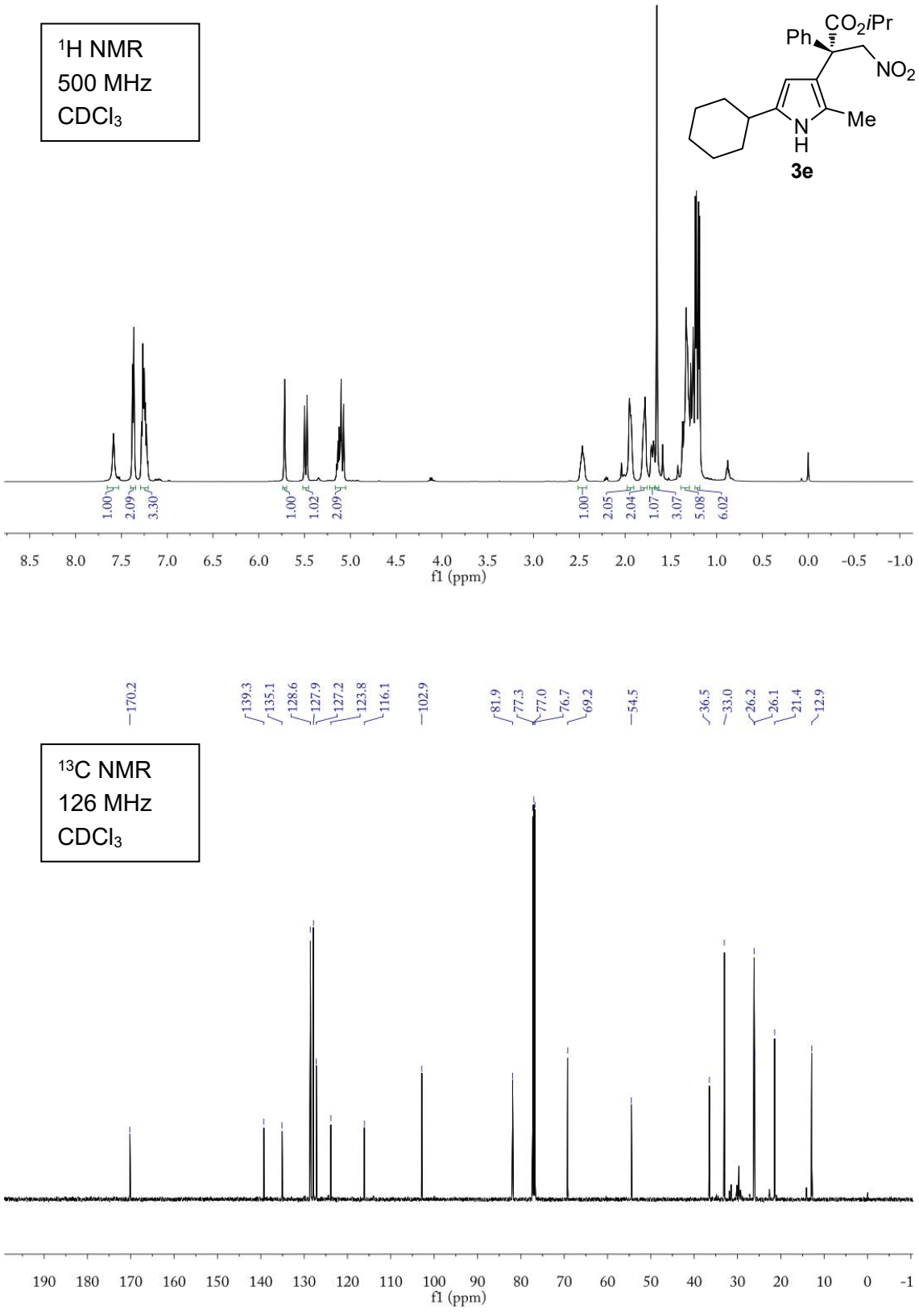
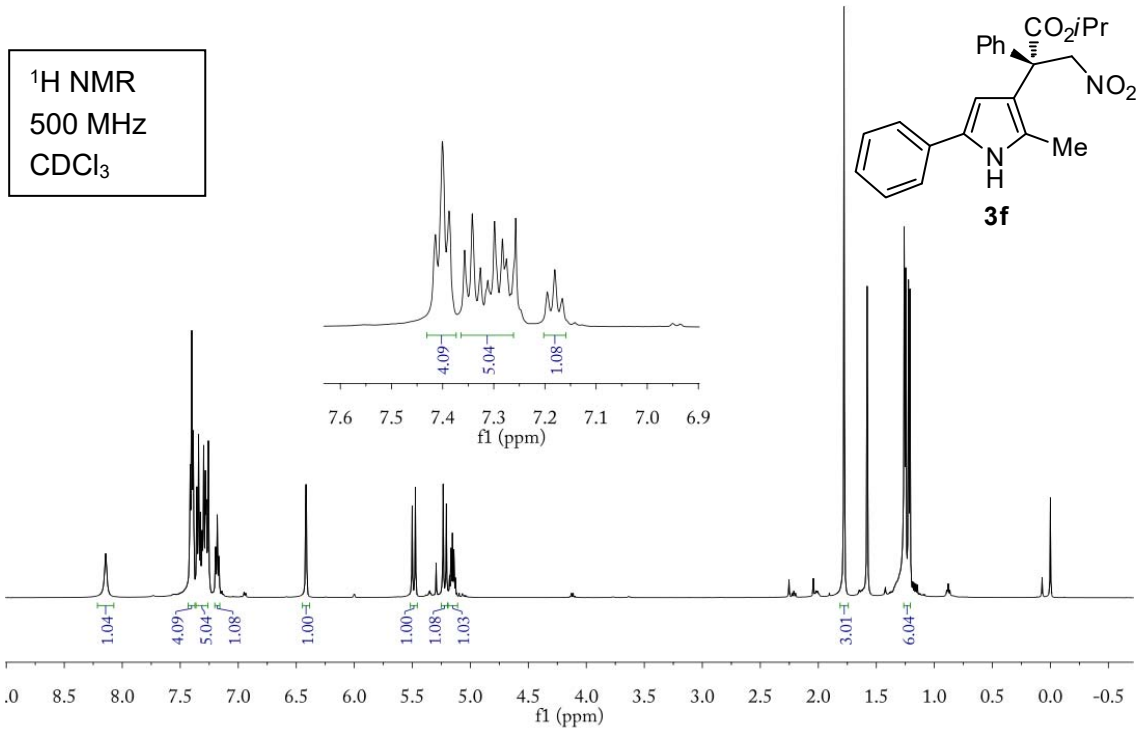


Figure S36. ^{1}H NMR and ^{13}C NMR spectra of **3e**.



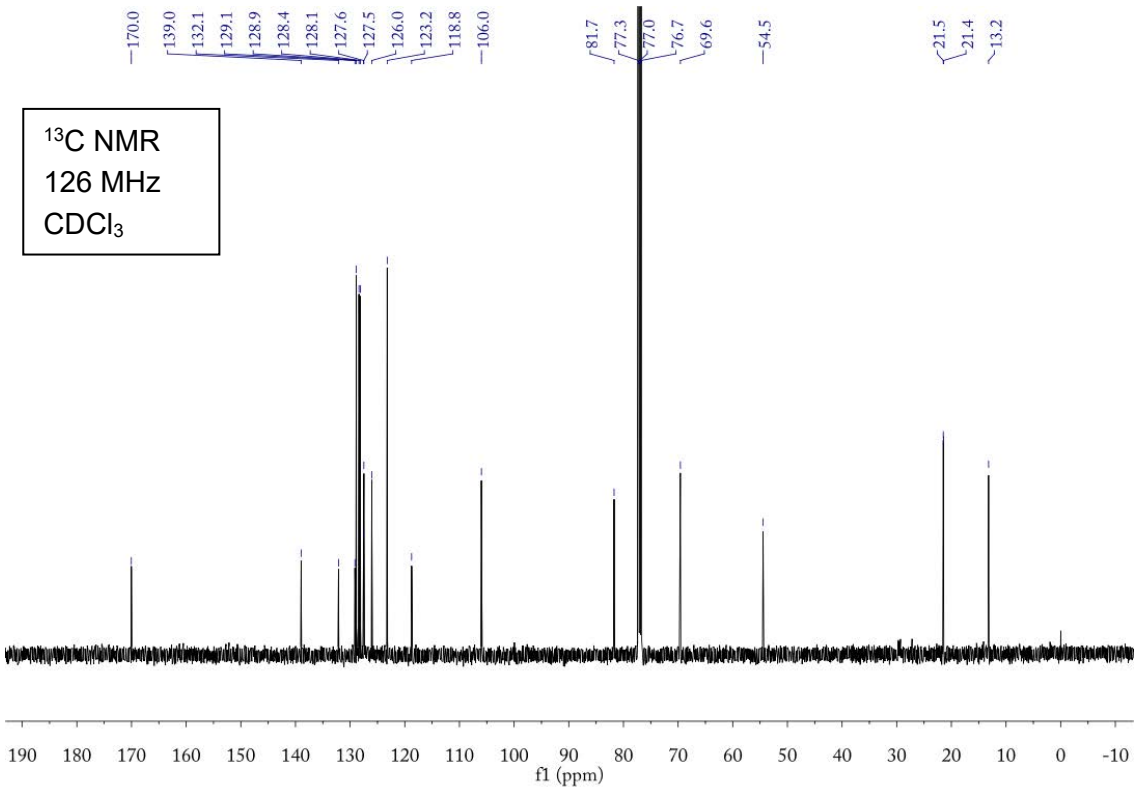


Figure S37. ^{1}H NMR and ^{13}C NMR spectra of **3f**.

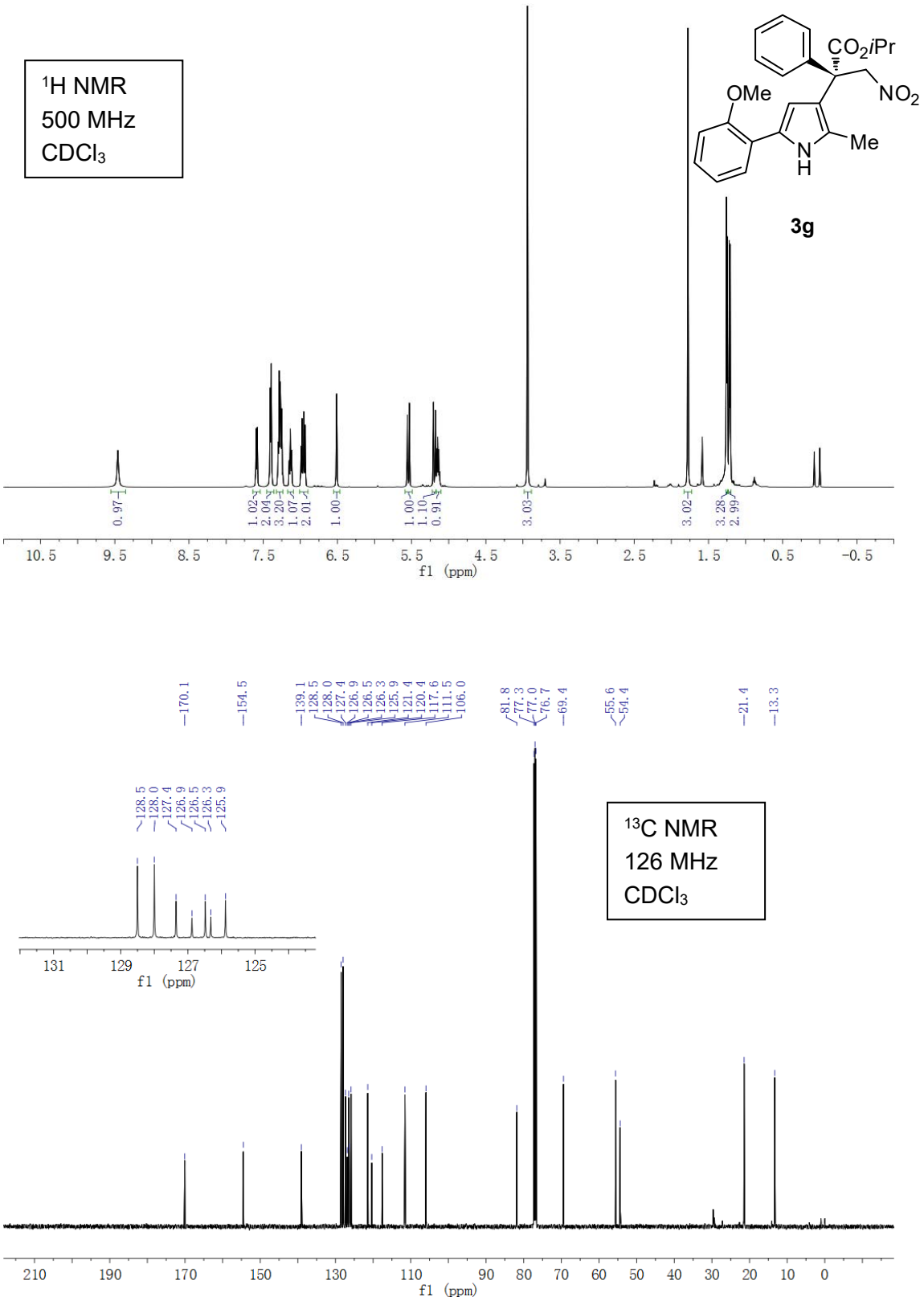


Figure S38. ^{1}H NMR and ^{13}C NMR spectra of **3g**.

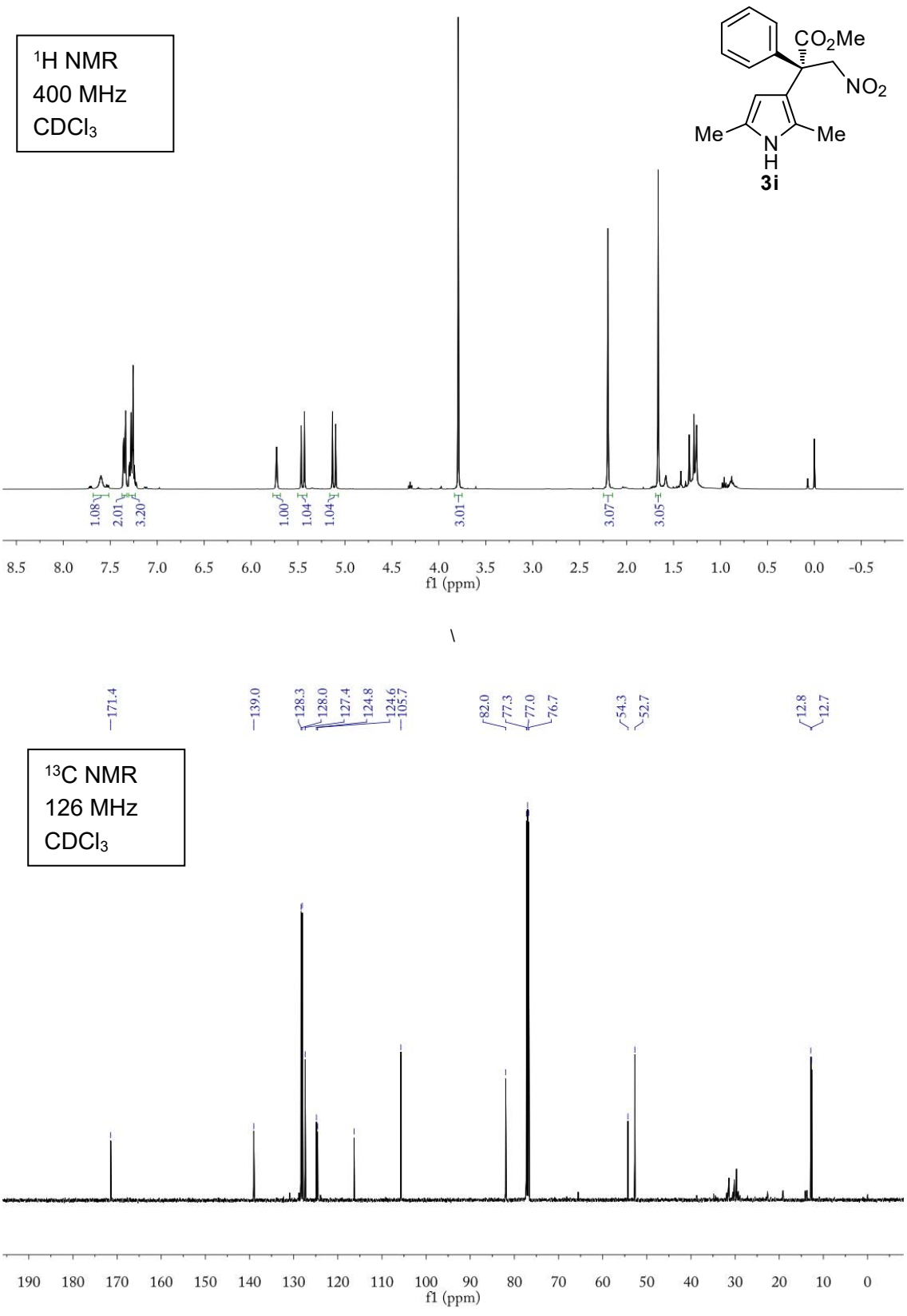


Figure S39. ^{1}H NMR and ^{13}C NMR spectra of **3i**.

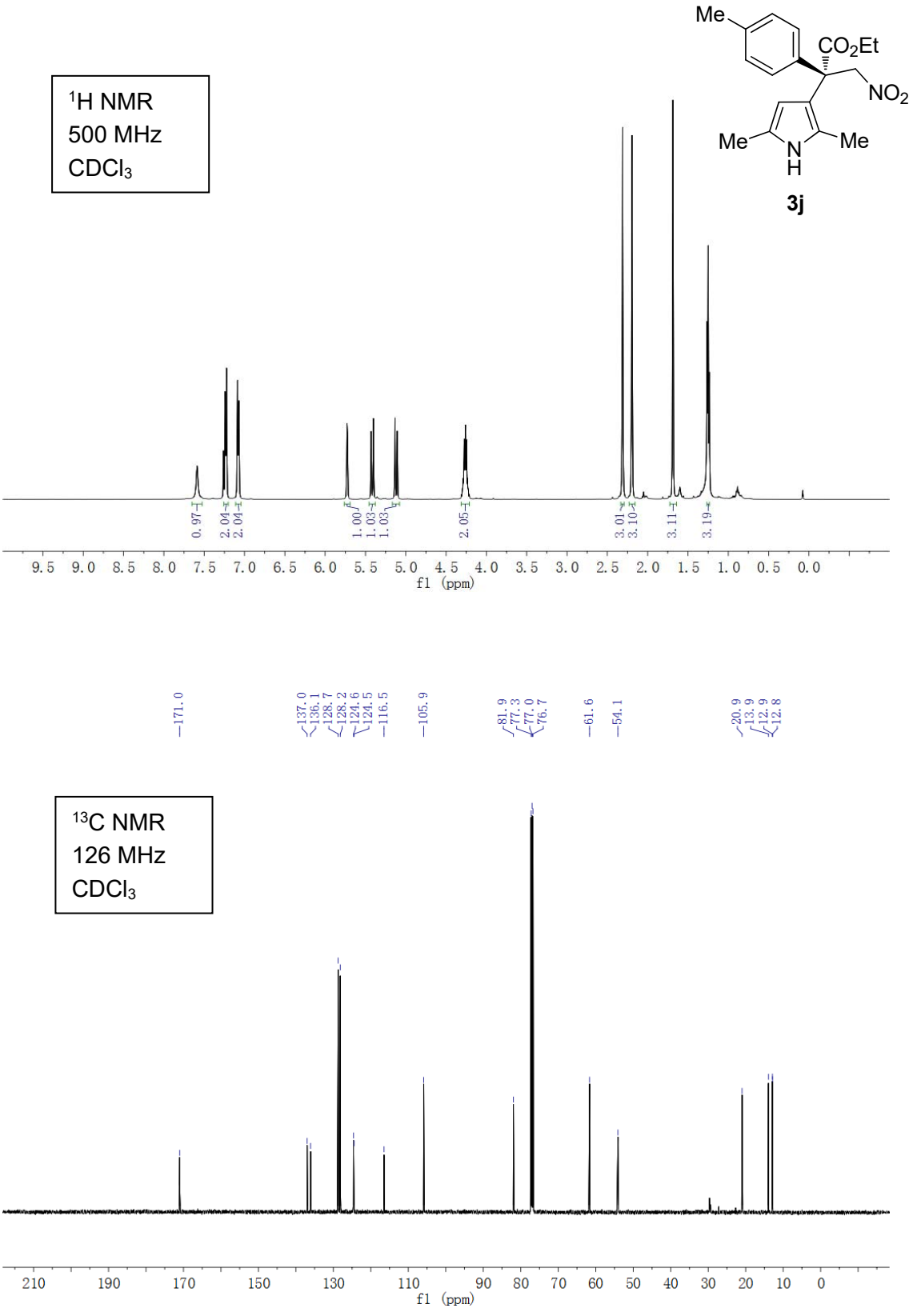


Figure S40. ^{1}H NMR and ^{13}C NMR spectra of **3j**.

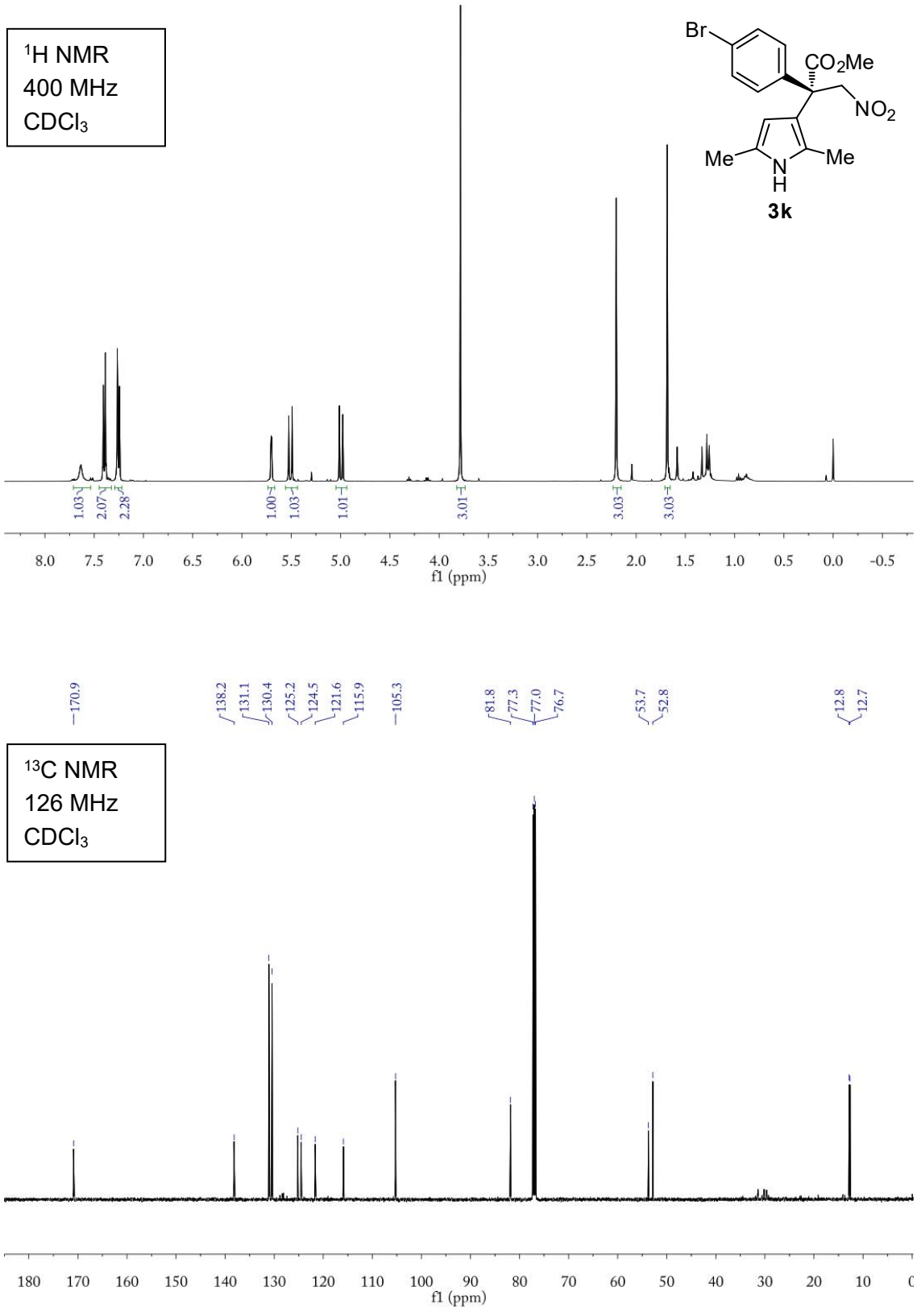


Figure S41. ^{1}H NMR and ^{13}C NMR spectra of **3k**.

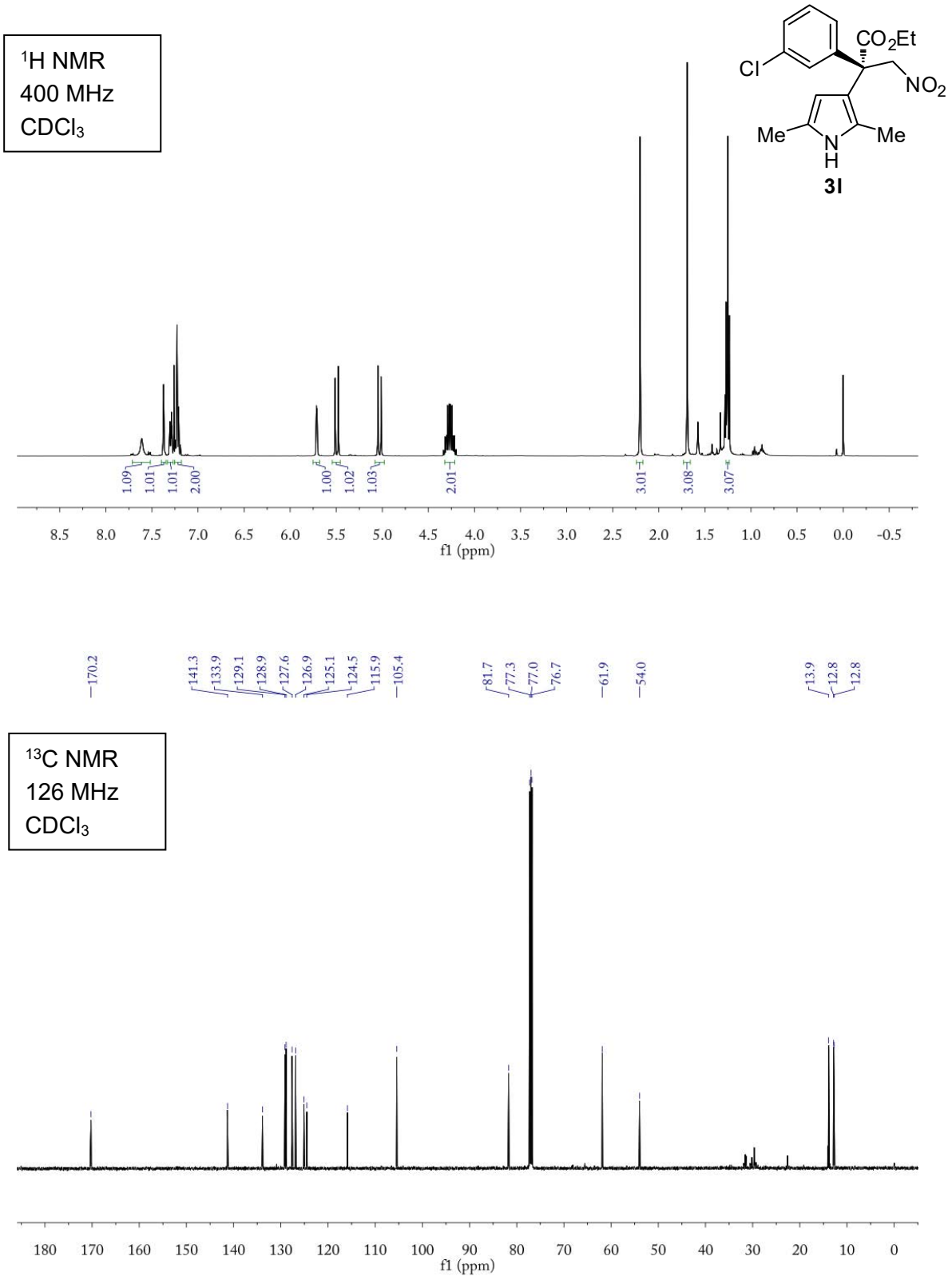


Figure S42. ^{1}H NMR and ^{13}C NMR spectra of **3l**.

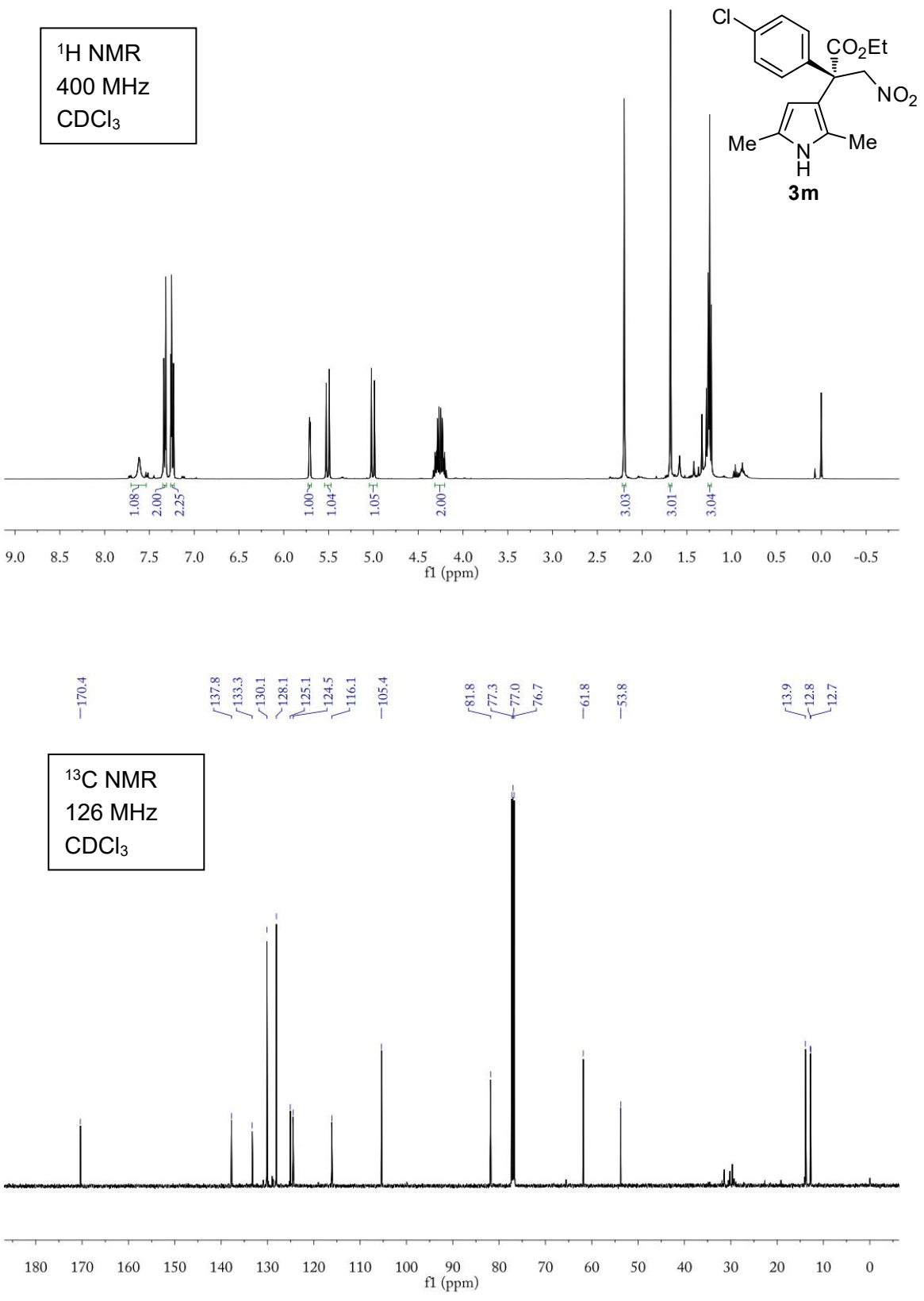


Figure S43. ^{1}H NMR and ^{13}C NMR spectra of **3m**.

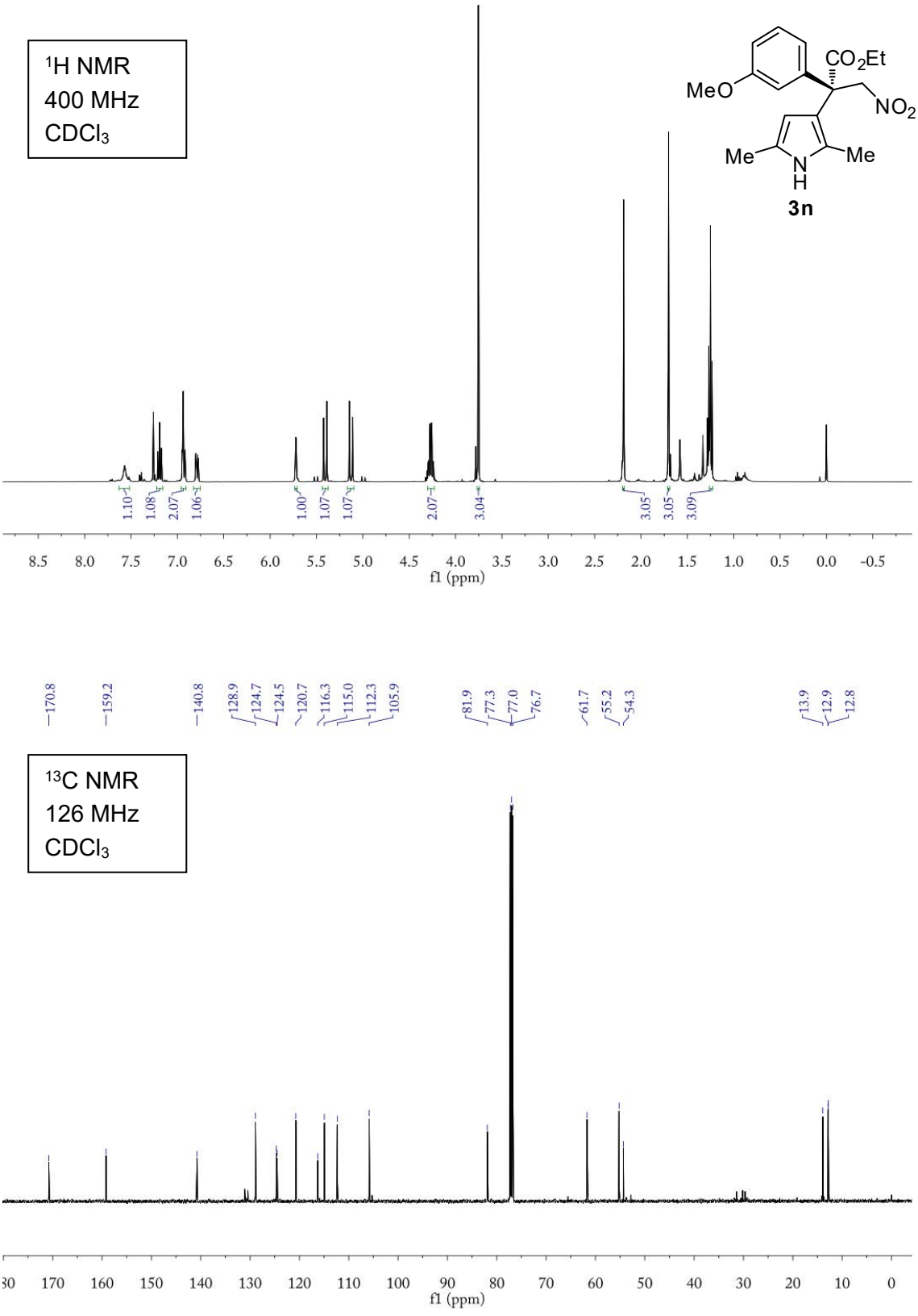


Figure S44. ^{1}H NMR and ^{13}C NMR spectra of **3n**.

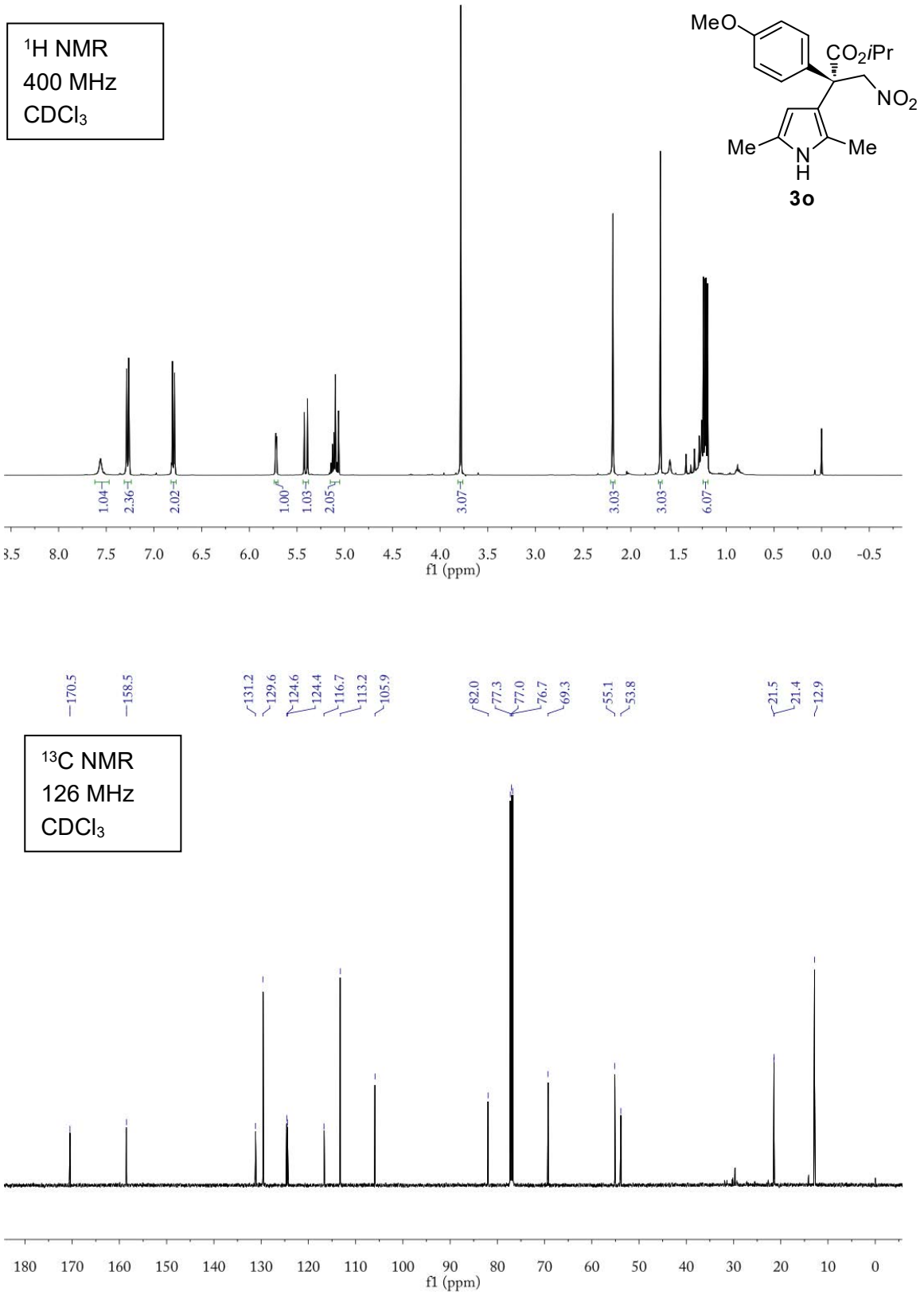


Figure S45. ^{1}H NMR and ^{13}C NMR spectra of **3o**.

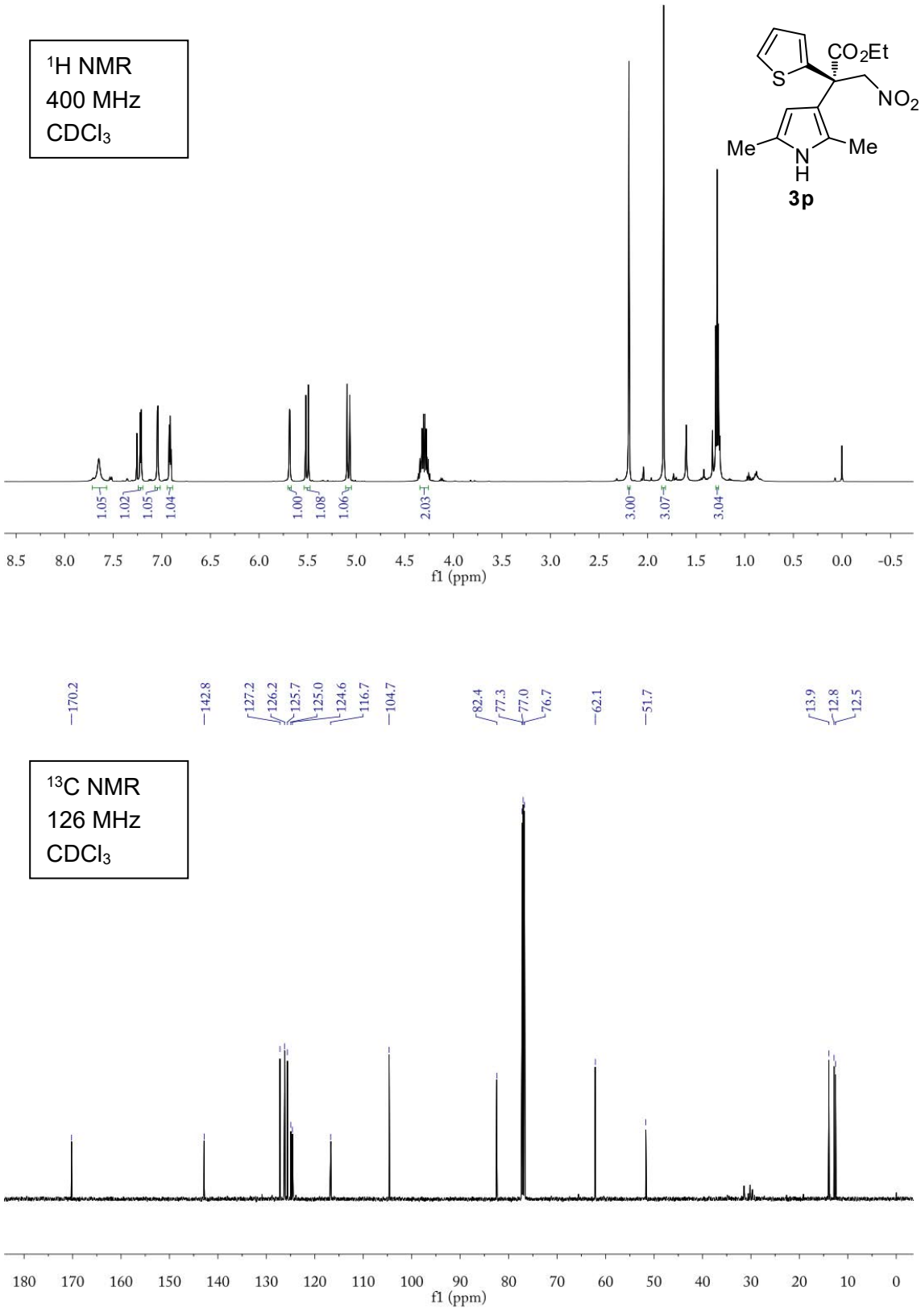


Figure S46. ^{1}H NMR and ^{13}C NMR spectra of **3p**.

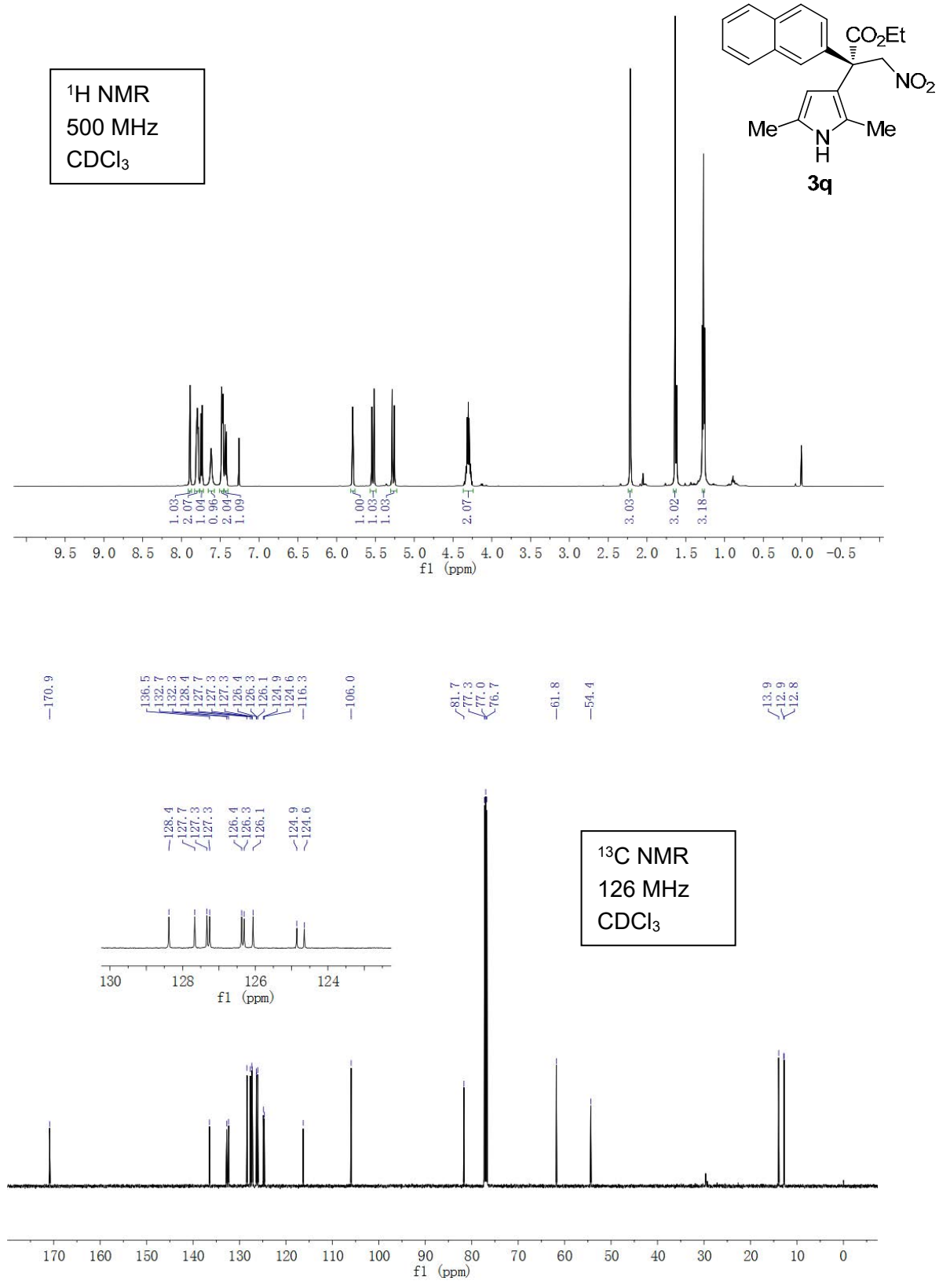


Figure S47. ^{1}H NMR and ^{13}C NMR spectra of **3q**.

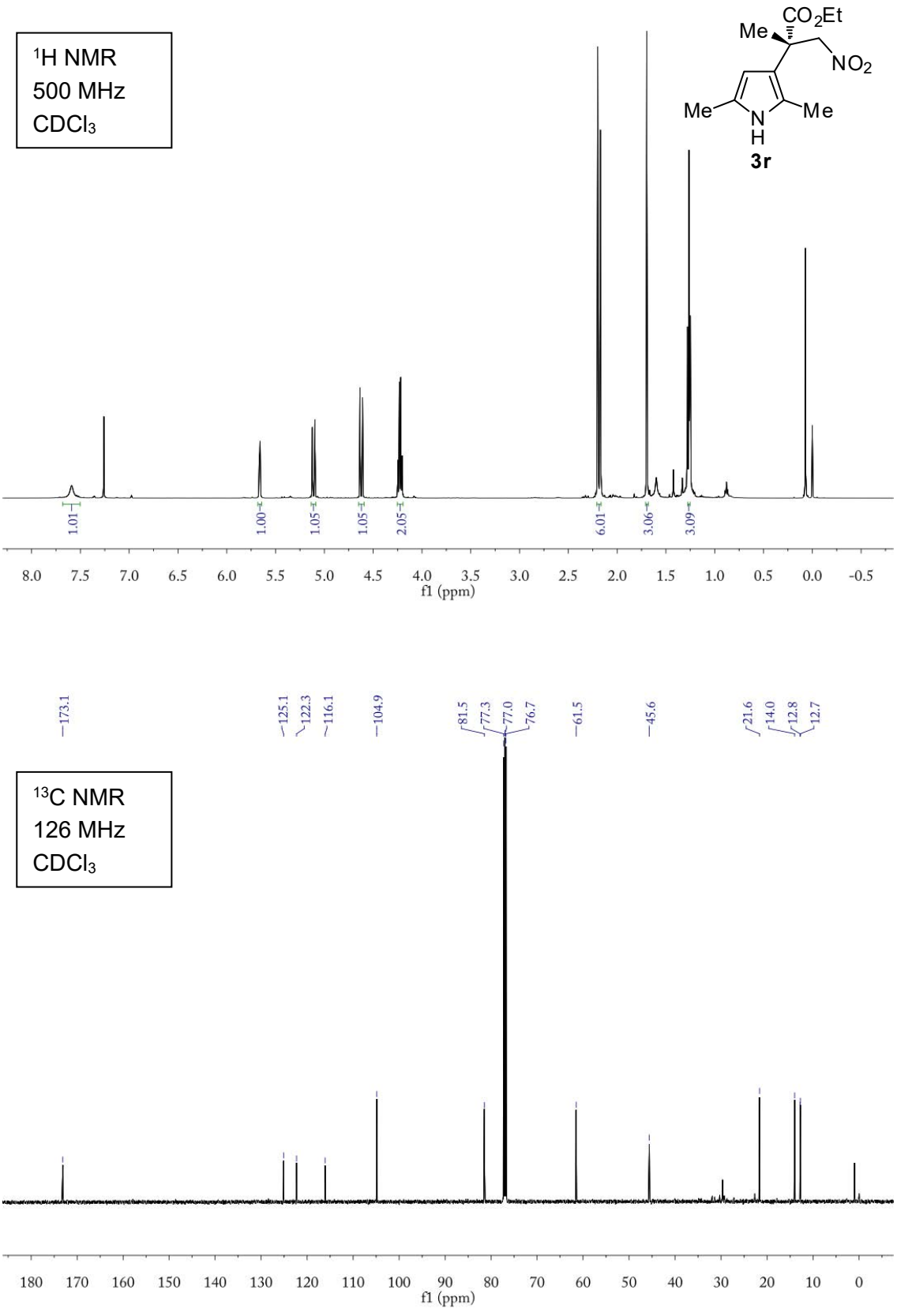


Figure S48. ^{1}H NMR and ^{13}C NMR spectra of **3r**.

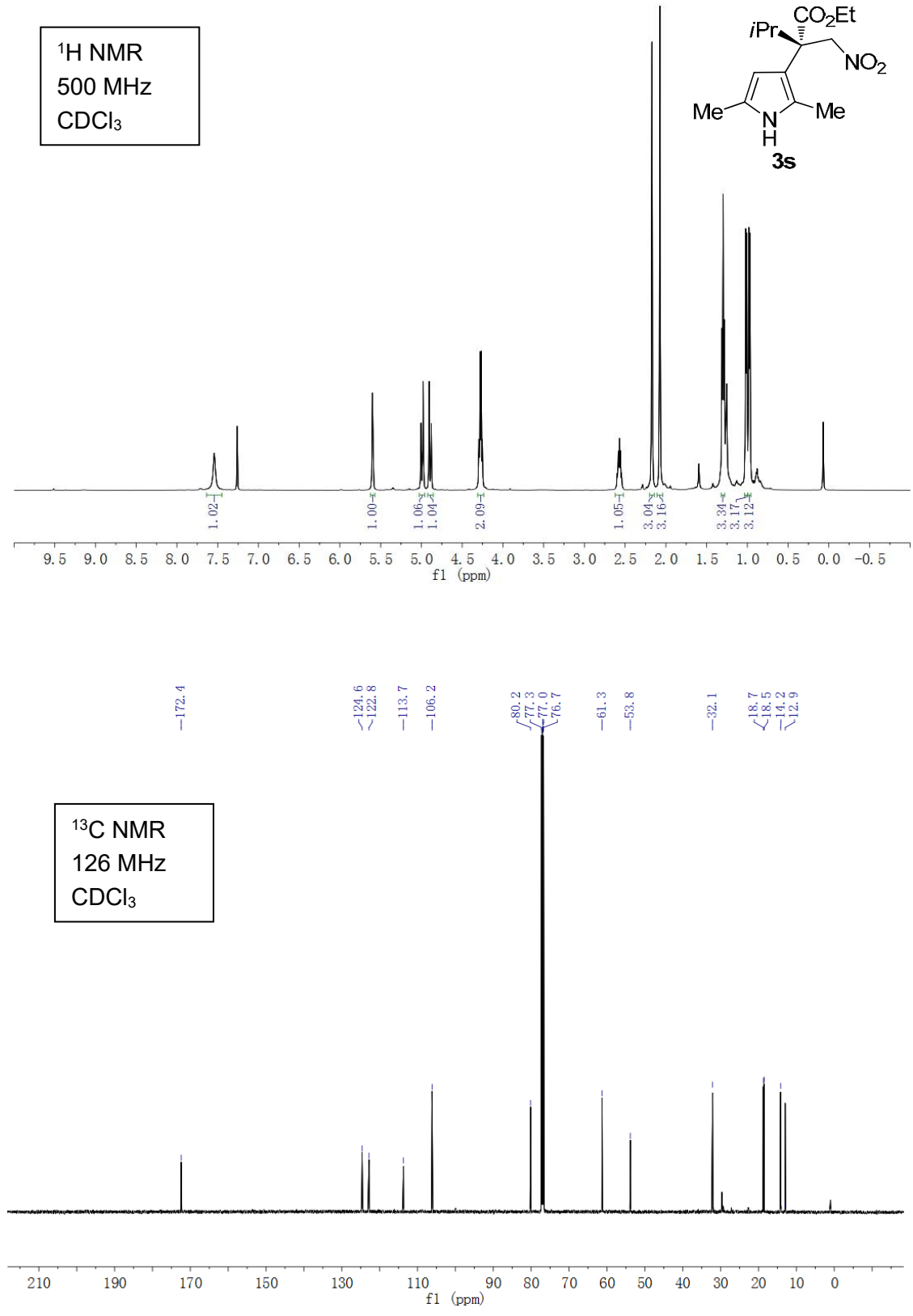


Figure S49. ^{1}H NMR and ^{13}C NMR spectra of **3s**.

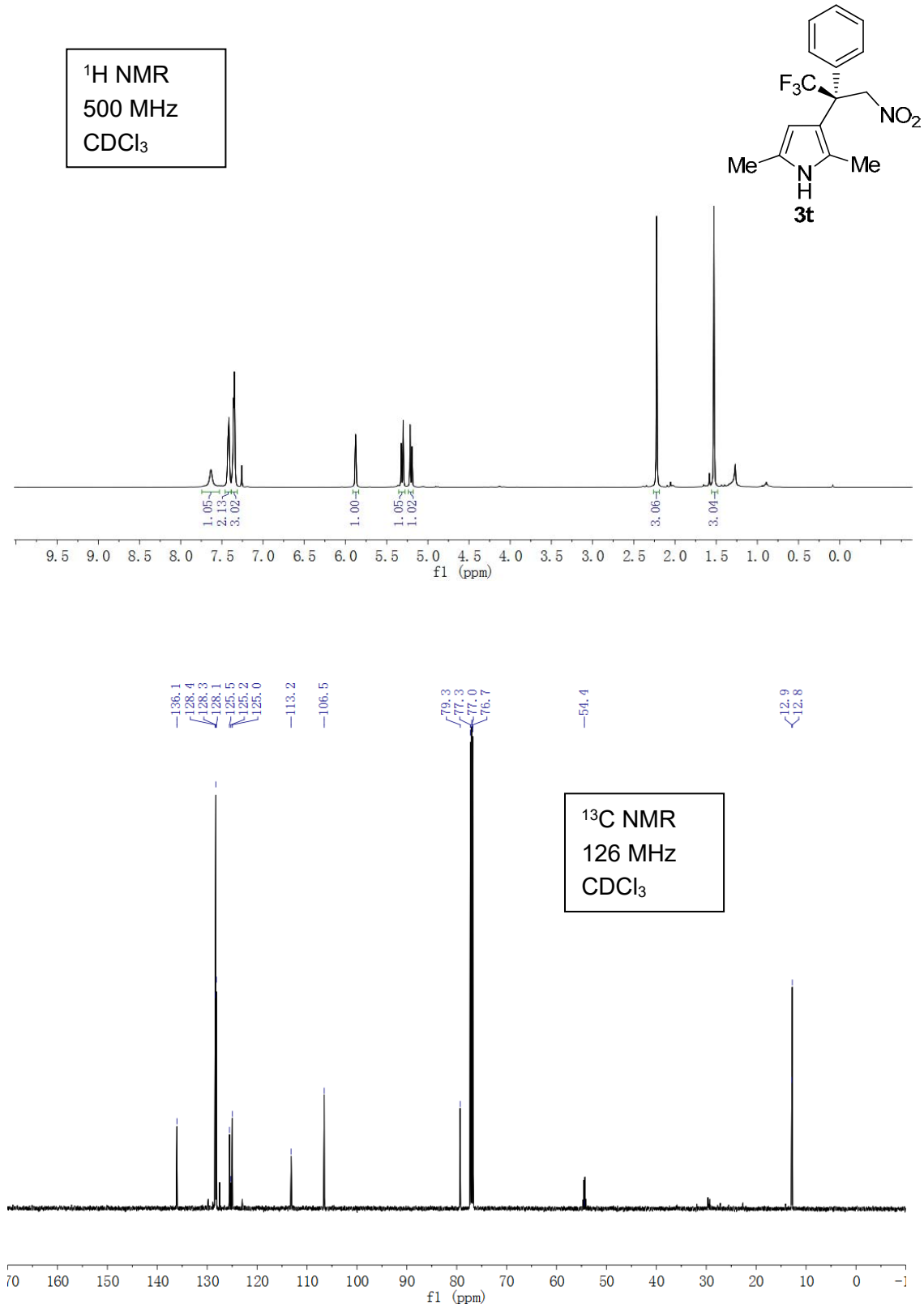


Figure S50. ^{1}H NMR and ^{13}C NMR spectra of **3t**.

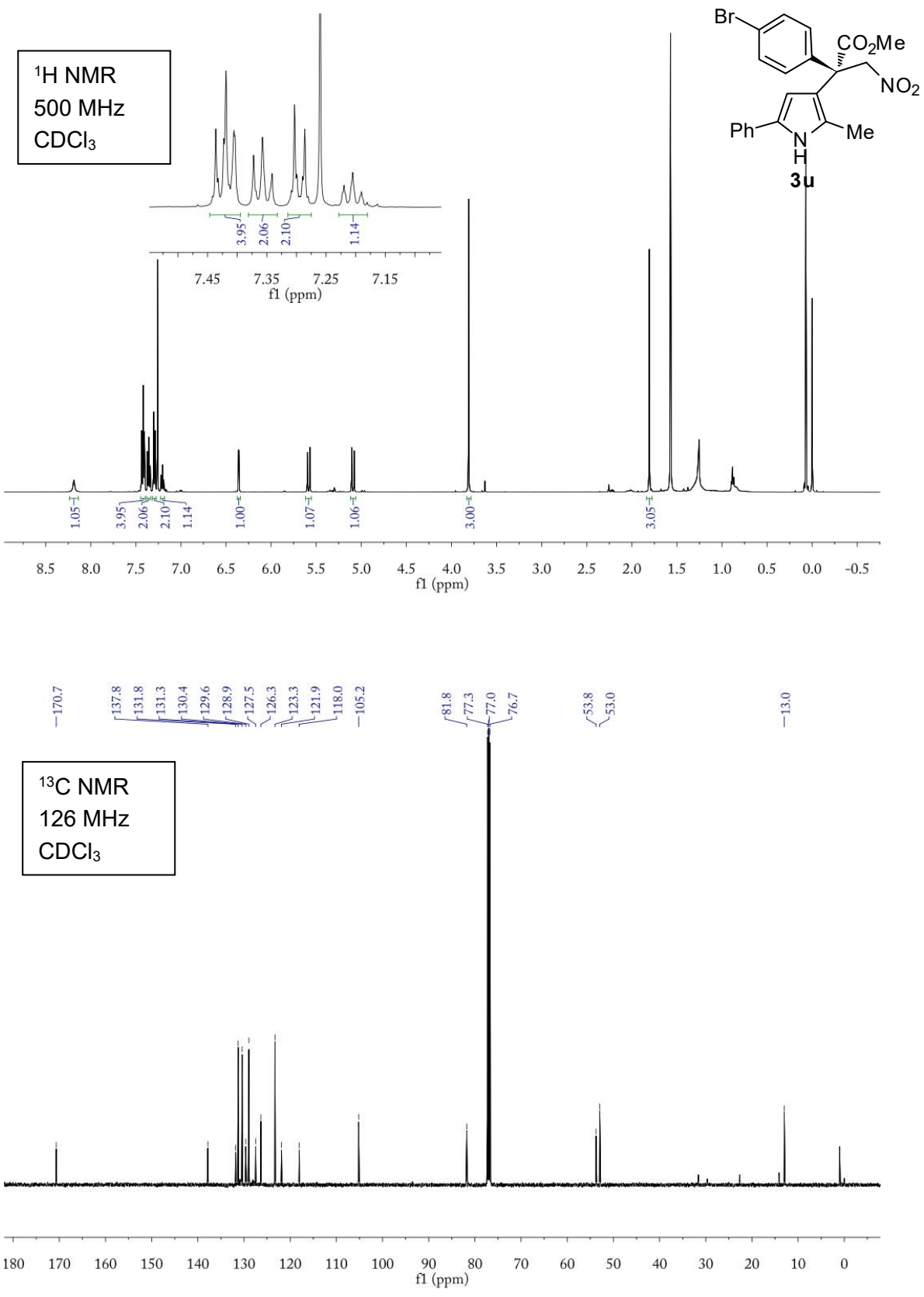


Figure S51. ^{1}H NMR and ^{13}C NMR spectra of **3u**.

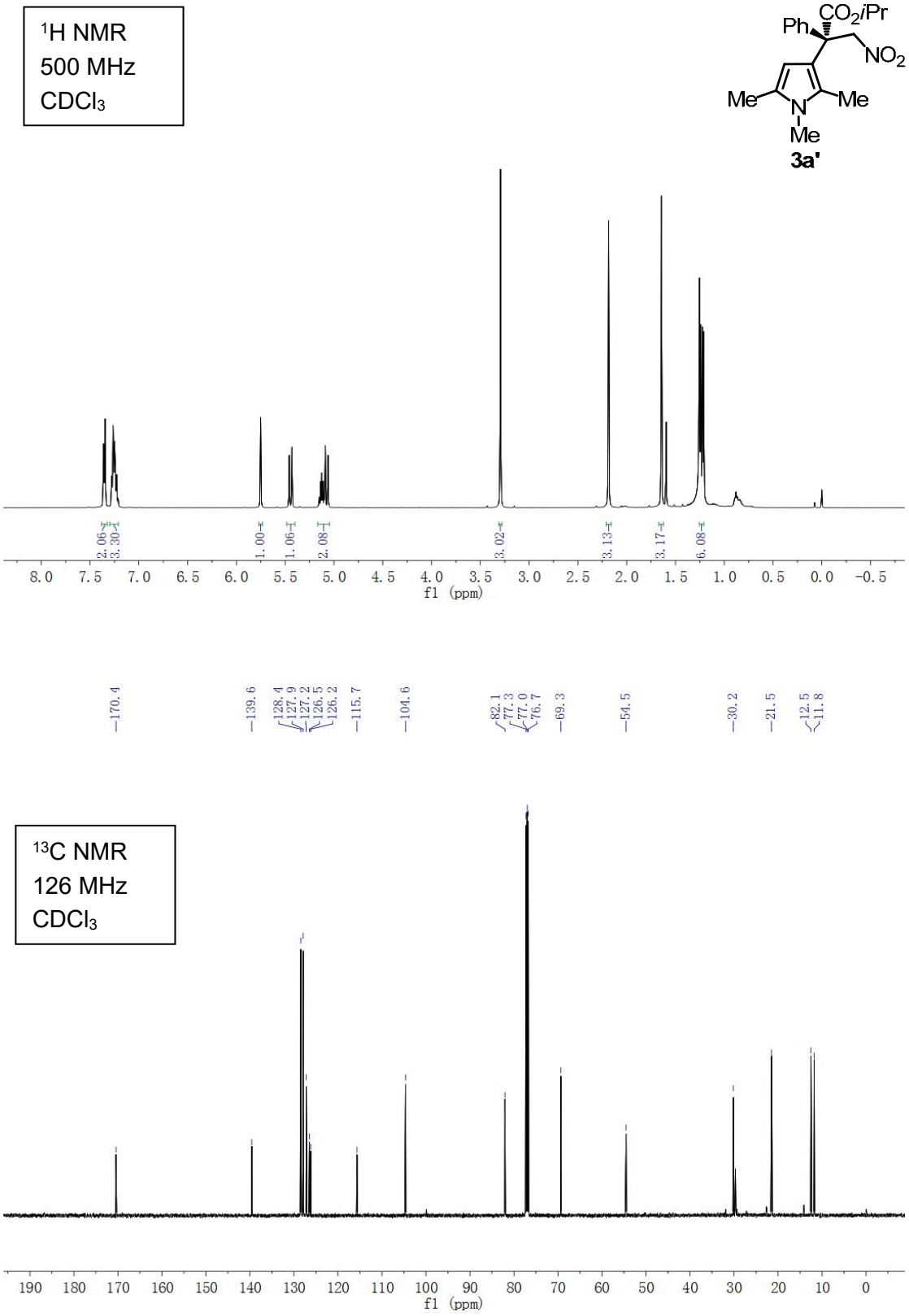


Figure S52. ^{1}H NMR and ^{13}C NMR spectra of **3a'**.

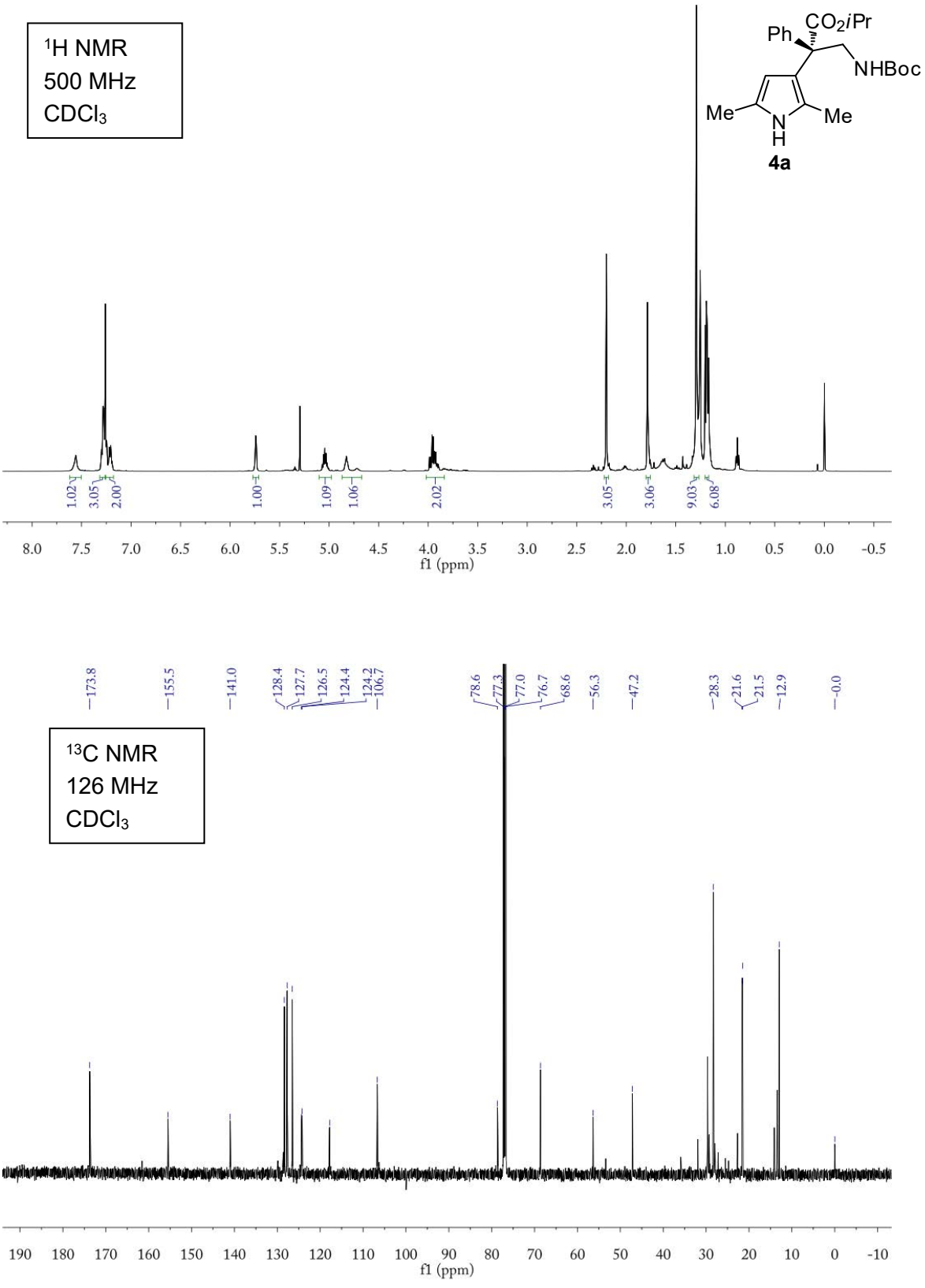


Figure S53. ^{1}H NMR and ^{13}C NMR spectra of **4a**.

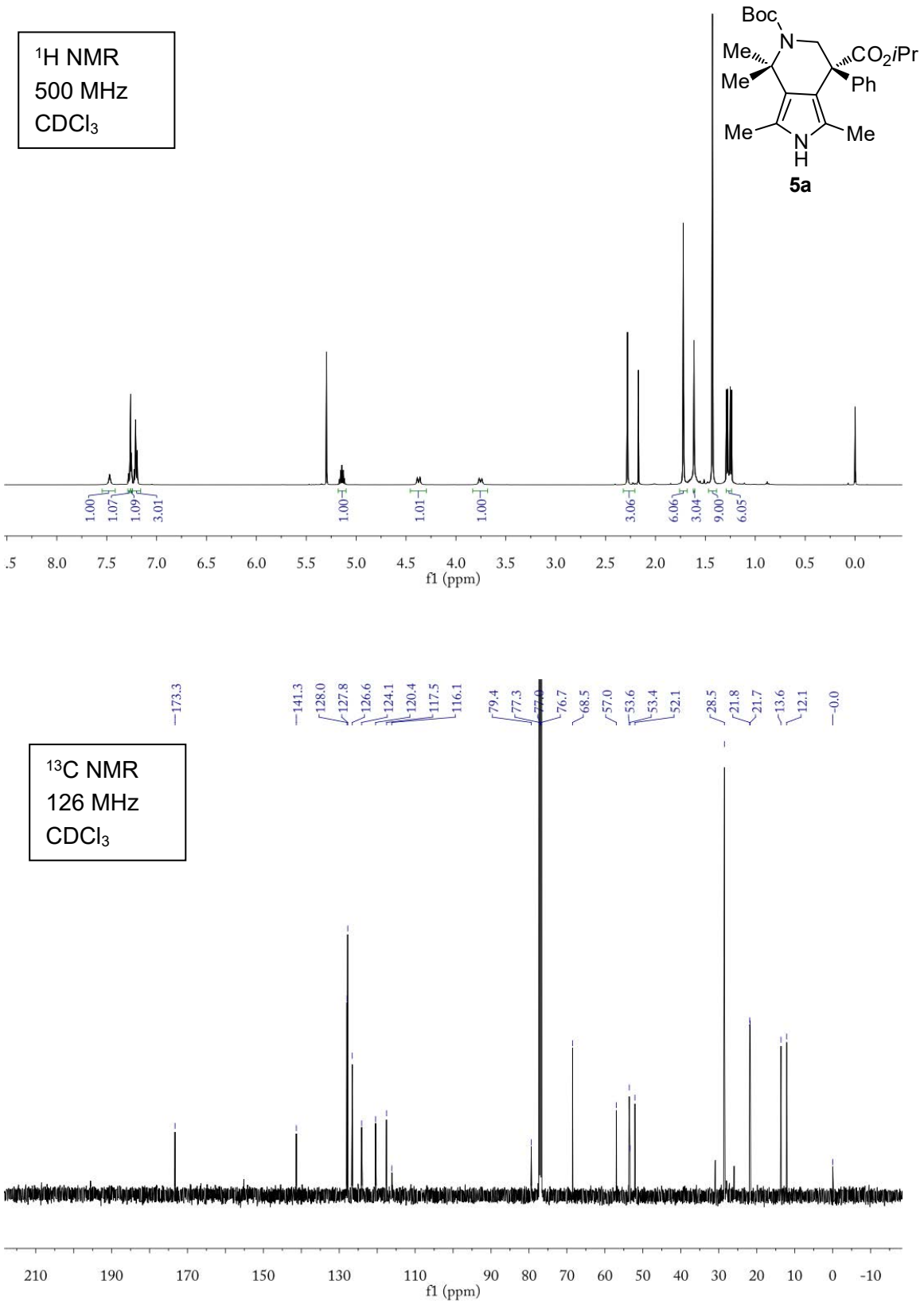


Figure S54. ^{1}H NMR and ^{13}C NMR spectra of **5a**.