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Supporting Information

Synthesis of Chiral γ-Aminophosphonates through Organocatalytic Hydrophosphonylation of Azadienes with Phosphites

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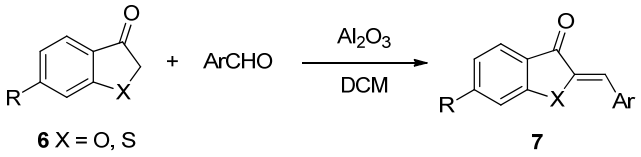
1. General

Commercially available reagents were used without further purification. Solvents were treated prior to use according to the standard methods. ^{1}H NMR and ^{13}C NMR spectra were recorded at room temperature in $CDCl_3$ or DMSO on 400 MHz instrument with tetramethylsilane (TMS) as internal standard. Enantiomeric excess was determined by HPLC analysis, using chiral column described below in detail. Optical rotations were measured by polarimeter. Flash column chromatography was performed on silica gel (200-300 mesh). All reactions were monitored by TLC analysis. The chiral thiourea and squaramide organocatalysts were prepared according to the known methods.[1]

2. General Procedure for Synthesis of Azadienes 1

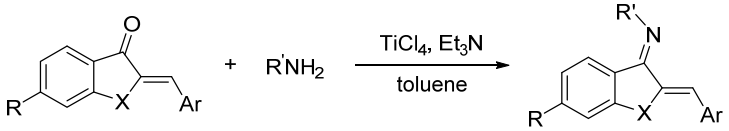
Heterocyclic enones **7** could be conveniently synthesized according to the known literature procedures.[2] Among them, **7a-l** and **7n-p**[2-4] are the known compounds.



6 X = O, S **7**

Aluminium oxide (65.0 g, activated, basic) was added to a solution of ketone **6** (20 mmol) and aldehydes (40 mmol) in dichloromethane (80 mL). The mixture was thoroughly stirred at room temperature under exclusion of light. The progress of the reaction was monitored by TLC analysis. The suspension was filtered off, the residue washed with dichloromethane, and the washes were combined with the filtrate. The solvent was evaporated in *vacuo*. The residue was purified by flash chromatography on silica gel and recrystallized from ethyl acetate/hexanes to give pure enones **7**.

Azadienes could be conveniently synthesized according to the known literature procedures.[5] Among them, **1a-e, 1h-k** and **1n** [5-6] are the known compounds.

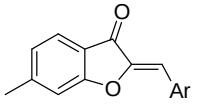


7 X = O, S **1**

Heterocyclic enones **7** (5.0 mmol) and sulfamides (5.0 mmol) were added in a round bottom flask under N_2 in toluene (50 mL) and cooled to 0 ^{o}C. Triethylamine (10.0 mmol) and $TiCl_4$ (5.0 mmol) were then successively added. The reaction mixture was heated for reflux under nitrogen overnight. The solution was then cooled to room temperature, quenched with water and extracted with dichloromethane. The combined organic phase was dried over sodium sulfate and concentrated. The residue was purified by flash chromatography on silica gel and recrystallized from ethyl acetate/ hexanes to give pure azadienes **1**.

N-tosylimine **1q** could be synthesized according to the known literature procedures.[7]

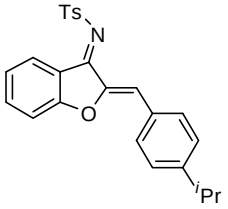
(*Z*)-2-(4-(*tert*-Butyl)benzylidene)-6-methylbenzofuran-3(2*H*)-one (7m): 3.5 mmol scale, 70% yield, pale yellow solid, new compound, mp = 110-112 °C, R_f = 0.60 (hexanes/ethyl acetate = 10/1);



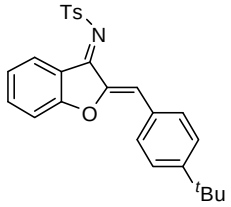
Ar = 4-*t*-BuC_6H_4

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 (d, *J* = 8.3 Hz, 2H), 7.67 (d, *J* = 7.8 Hz, 1H), 7.48 (d, *J* = 8.3 Hz, 2H), 7.11 (s, 1H), 7.01 (d, *J* = 7.8 Hz, 1H), 6.86 (s, 1H), 2.48 (s, 3H), 1.35 (s, 9H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 184.5, 166.7, 153.5, 149.0, 147.2, 131.4, 129.7, 126.0, 124.9, 124.4, 119.5, 113.2, 112.8, 35.1, 31.3, 22.8; HRMS (ESI) *m/z* Calculated for $C_{20}H_{21}O_2$ $[M+H]^+$ 293.1536, found 293.1538.

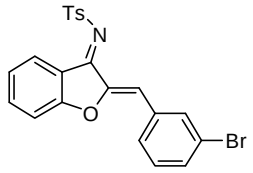
***N*-((*E*)-2-((*Z*)-4-Isopropylbenzylidene)benzofuran-3(2*H*)-ylidene)-4-methylbenzenesulfonamide (1f):** 3.0 mmol scale**,** 45% yield, new compound, yellow solid, mp = 123-124 °C, R_f = 0.65 (hexanes/ethyl acetate = 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.77 (d, *J* = 8.0 Hz, 1H), 8.00 (d, *J* = 8.2 Hz, 2H), 7.82 (d, *J* = 8.2 Hz, 2H), 7.71-7.60 (m, 1H), 7.37 (d, *J* = 8.1 Hz, 2H), 7.33-7.23 (m, 4H), 7.11 (s, 1H), 3.00-2.86 (m, 1H), 2.46 (s, 3H), 1.26 (d, *J* = 6.9 Hz, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.2, 164.8, 152.0, 149.3, 143.4, 139.2, 137.6, 132.0, 131.1, 130.1, 129.6, 127.3, 127.1, 123.8, 118.6, 116.3, 112.4, 34.3, 23.8, 21.7. HRMS (ESI) *m/z* Calculated for $C_{25}H_{24}NO_3S$ $[M+H]^+$ 418.1471, found 418.1470.



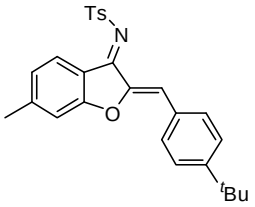
***N*-((*E*)-2-((*Z*)-4-(*tert*-butyl)benzylidene)benzofuran-3(2*H*)-ylidene)-4-methylbenzenesulfonamide (1g)**: 3.0 mmol scale, 37% yield, new compound, yellow solid, mp = 171-173 °C, R_f = 0.65 (hexanes/ethyl acetate = 5/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.78 (d, *J* = 8.0 Hz, 1H), 8.00 (d, *J* = 8.2 Hz, 2H), 7.82 (d, *J* = 8.4 Hz, 2H), 7.66 (t, *J* = 7.4 Hz, 1H), 7.45 (d, *J* = 8.4 Hz, 2H), 7.37 (d, *J* = 8.1 Hz, 2H), 7.30 (d, *J* = 8.3 Hz, 1H), 7.26 (t, *J* = 7.9 Hz, 1H), 7.12 (s, 1H), 2.46 (s, 3H), 1.33 (s, 9H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.2, 164.8, 154.2, 149.4, 143.4, 139.2, 137.6, 131.8, 131.1, 129.7, 129.6, 127.1, 126.1, 123.8, 118.5, 116.2, 112.4, 35.1, 31.2, 21.7. HRMS (ESI) *m/z* Calculated for $C_{26}H_{26}NO_3S$ $[M+H]^+$ 432.1628, found 432.1628.



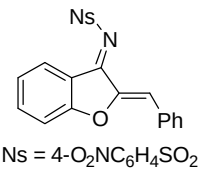
***N*-((*E*)-2-((*Z*)-3-Bromobenzylidene)benzofuran-3(2*H*)-ylidene)-4-methylbenzenesulfonamide (1l):** 43% yield, new compound, yellow solid, mp = 183-185 °C, R_f = 0.50 (hexanes/ethyl acetate = 3/1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.76 (d, *J* = 7.8 Hz, 1H), 8.00-7.98 (m, 3H), 7.75 (d, *J* = 7.7 Hz, 1H), 7.68 (t, *J* = 7.6 Hz, 1H), 7.47 (d, *J* = 7.8 Hz, 1H), 7.37 (d, *J* = 8.0 Hz, 2H), 7.32 (d, *J* = 8.4 Hz, 1H), 7.30-7.25 (m, 2H), 6.95 (s, 1H), 2.46 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.0, 164.8, 150.3, 143.7, 138.8, 138.0, 134.4, 134.0, 133.0, 131.2, 130.4, 130.1, 129.6, 127.2, 124.1, 123.1, 118.2, 113.4, 112.5, 21.8; HRMS (ESI) *m/z* Calculated for $C_{22}H_{17}BrNO_3S$ $[M+H]^+$ 454.0107, found 454.0107.



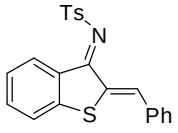
***N*-((*E*)-2-((*Z*)-4-(*tert*-Butyl)benzylidene)-6-methylbenzofuran-3(2*H*)-ylidene)-4-methylbenzenesulfonamide (1m):** 2.0 mmol scale, 17% yield, new compound, yellow solid, mp = 226-228 °C, R_f = 0.60 (hexanes/ethyl acetate = 5/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.63 (d, *J* = 8.3 Hz, 1H), 8.00 (d, *J* = 8.2 Hz, 2H), 7.81 (d, *J* = 8.4 Hz, 2H), 7.45 (d, *J* = 8.5 Hz, 2H), 7.36 (d, *J* = 8.1 Hz, 2H), 7.11-7.06 (m, 3H), 2.50 (s, 3H), 2.46 (s, 3H), 1.34 (s, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.4, 164.9, 153.9, 150.1, 149.8, 143.2, 139.3, 131.6, 130.6, 129.8, 129.4, 127.0, 126.0, 125.2, 116.2, 115.6, 112.4, 35.0, 31.1, 22.7, 21.6. HRMS (ESI) *m/z* Calculated for $C_{27}H_{28}NO_3S$ $[M+H]^+$ 446.1784, found 446.1779.



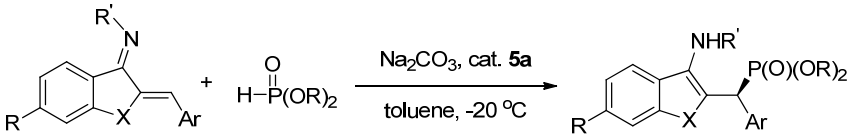
***N*-((*E*)-2-((*Z*)-Benzylidene)benzofuran-3(2*H*)-ylidene)-4-nitrobenzenesulfonamide (1o):** 3.0 mmol scale, 21% yield, new compound, yellow solid, mp = 197-199 °C, R_f = 0.75 (hexanes/ethyl acetate = 3/1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.69 (d, *J* = 8.0 Hz, 1H), 8.46-8.37 (m, 2H), 8.34-8.24 (m, 2H), 7.91-7.88 (m, 2H), 7.76-7.70 (m, 1H), 7.49-7.39 (m, 3H), 7.36 (d, *J* = 8.4 Hz, 1H), 7.34-7.29 (m, 1H), 7.12 (s, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.2, 165.1, 150.1, 149.5, 147.5, 138.5, 132.1, 132.1, 131.0, 130.8, 129.2, 128.5, 124.3, 124.2, 118.4, 117.4, 112.7; HRMS (ESI) *m/z* Calculated for $C_{21}H_{15}N_2O_5S$ $[M+H]^+$ 407.0696, found 407.0696.



***N*-((*E*)-2-((*Z*)-Benzylidene)benzo[b]thiophen-3(2*H*)-ylidene)-4-methylbenzenesulfonamide (1p):** 2.5 mmol scale, 21% yield, new compound, red solid, mp = 160-162 °C, R_f = 0.35 (hexanes/ethyl acetate = 7/1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.94 (d, *J* = 8.2 Hz, 1H), 8.17 (s, 1H), 8.01 (d, *J* = 8.3 Hz, 2H), 7.65 (d, *J* = 7.3 Hz, 2H), 7.61-7.54 (m, 1H), 7.50-7.32 (m, 7H), 2.48 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 170.5, 147.6, 143.2, 140.1, 136.1, 135.5, 134.6, 132.7, 132.3, 131.3, 130.6, 129.6, 129.2, 128.7, 126.8, 126.0, 123.5, 21.8; HRMS (ESI) *m/z* Calculated for $C_{22}H_{18}NO_2S_2$ $[M+H]^+$ 392.0773, found 392.0776.

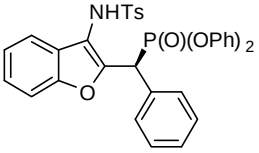


3. General Procedure for Hydrophosphonylation of Azadienes 1

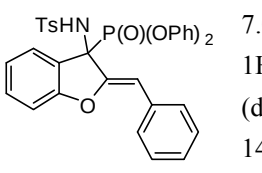


To a solution of azadienes **1** (0.15 mmol), sodium carbonate (7.9 mg, 0.075 mmol) and quinine (2.4 mg, 7.5 μmol) in toluene (1.0 mL), phosphorus nucleophiles **2** (0.45 mmol) was added at -20 °C and stirred for 1-8 days. Water was added to the reaction mixture, and aqueous layer was extracted with dichloromethane. The combined organic extracts were dried over sodium sulfate, filtered, and concentrated under reduced pressure to give the crude product, followed by purification with chromatography using hexanes/ethyl acetate as eluent to give the chiral products **3**.

(*S*)-(-)-Diphenyl((3-((4-methylphenyl)sulfonamido)benzofuran-2-yl)(phenyl)methyl)phosphonate (3aa): 89 mg, 97% yield, 91% ee, $[\alpha]^{20}_D$ = -50.00 (*c* 0.89, $CHCl_3$), new compound, white solid, m.p. = 91-92 °C, R_f = 0.20 (hexanes/ethyl acetate = 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.55-7.53 (m, 3H), 7.43-7.40 (m, 2H), 7.33-7.31 (m, 4H), 7.26 (d, *J* = 7.9 Hz, 1H), 7.21-7.16 (m, 3H), 7.14-7.03 (m, 5H), 7.00 (d, *J* = 8.2 Hz, 2H), 6.89 (d, *J* = 8.4 Hz, 2H), 6.83 (d, *J* = 8.4 Hz, 2H), 4.82 (d, *J* = 26.8 Hz, 1H), 2.31 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.6 (d, *J* = 1.0 Hz), 150.2 (d, *J* = 9.9 Hz), 150.1 (d, *J* = 9.4 Hz), 146.4 (d, *J* = 11.9 Hz), 143.7, 136.7, 131.3 (d, *J* = 6.8 Hz), 130.3 (d, *J* = 7.1 Hz), 129.7, 129.6, 129.6, 128.6 (d, *J* = 1.8 Hz), 128.1 (d, *J* = 2.5 Hz), 127.4, 125.7 (d, *J* = 2.6 Hz), 125.4, 125.3, 124.9, 123.3, 120.5 (d, *J* = 4.4 Hz), 120.3 (d, *J* = 4.3 Hz), 119.9, 116.1 (d, *J* = 10.1 Hz), 111.5, 43.1 (d, *J* = 139.4 Hz), 21.5; ^{13}C DEPT-45° NMR (101 MHz, $CDCl_3$) δ 130.3 (d, *J* = 7.1 Hz), 129.7, 129.6, 129.6, 128.6 (d, *J* = 1.8 Hz), 128.2 (d, *J* = 2.6 Hz), 127.4, 125.4, 125.3, 124.9, 123.3, 120.5 (d, *J* = 4.4 Hz), 120.3 (d, *J* = 4.3 Hz), 119.9, 111.5, 43.1 (d, *J* = 139.4 Hz), 21.5; ^{31}P NMR (162 MHz, $CDCl_3$) δ 14.2. HPLC: Chiralcel IC column, 220 nm, 30 °C, *n*-hexane/*i*-propanol = 70/30, flow = 0.7 mL/min, retention time 14.3 min and 15.5 min (maj). HRMS Calculated for $C_{34}H_{29}NO_6PS$ $[M+H]^+$ 610.1448, found 610.1449.

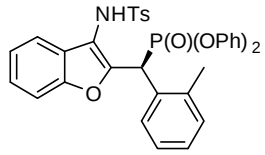


(Z)-Diphenyl(2-benzylidene-3-((4-methylphenyl)sulfonamido)-2,3-dihydrobenzofuran-3-yl)phosphonate (4aa): new compound, white solid, m.p. = 190-191 °C, R_f = 0.25 (hexanes/ethyl acetate = 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.55 (d, *J* = 7.7 Hz, 1H), 7.43-7.35 (m, 3H), 7.34-7.06 (m, 12H), 7.04-6.98 (m, 4H), 6.93 (d, *J* = 8.1 Hz, 2H), 6.87 (d, *J* = 8.3 Hz, 2H), 6.33-6.32 (m, 1H), 5.90 (d, *J* = 5.7 Hz, 1H), 2.15 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 158.2 (d, *J* = 8.2 Hz), 150.2 (d, *J* = 10.1 Hz), 150.1 (d, *J* = 9.7 Hz), 149.4 (d, *J* = 2.0 Hz), 143.8 (s), 138.0 (d, *J* = 1.8 Hz), 133.7 (d, *J* = 4.7 Hz), 131.4 (d, *J* = 2.9 Hz), 129.8 (d, *J* = 0.6 Hz), 129.6, 129.3, 128.9 (d, *J* = 1.8 Hz), 128.2 (d, *J* = 3.5 Hz), 128.1, 127.5, 127.0 (d, *J* = 0.9 Hz), 125.7 (d, *J* = 0.8 Hz), 125.6 (d, *J* = 0.9 Hz), 122.4 (d, *J* = 2.9 Hz), 120.5 (d, *J* = 4.1 Hz), 120.3 (d, *J* = 4.2 Hz), 120.0 (d, *J* = 8.7 Hz), 110.3 (d, *J* = 2.0 Hz), 108.2 (d, *J* = 8.6 Hz), 65.9 (d, *J* = 171.5 Hz), 21.4;

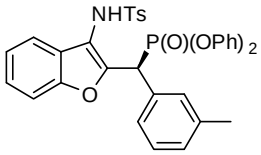


^{13}C DEPT-45^{o} NMR (101 MHz, $CDCl_3$) δ 131.4 (d, *J* = 2.9 Hz), 129.8 (d, *J* = 0.8 Hz), 129.6 (d, *J* = 0.5 Hz), 129.3, 128.9 (d, *J* = 1.8 Hz), 128.2 (d, *J* = 3.5 Hz), 128.1, 127.5, 127.0 (d, *J* = 0.9 Hz), 125.7 (d, *J* = 0.9 Hz), 125.6 (d, *J* = 0.8 Hz), 122.4 (d, *J* = 2.9 Hz), 120.5 (d, *J* = 4.1 Hz), 120.3 (d, *J* = 4.2 Hz), 110.3 (d, *J* = 2.0 Hz), 108.2 (d, *J* = 8.6 Hz), 21.4; ^{31}P NMR (162 MHz, $CDCl_3$) δ 6.2. HRMS Calculated for $C_{34}H_{32}N_2O_6PS$ $[M+NH_4]^+$ 627.1713, found 627.1711.

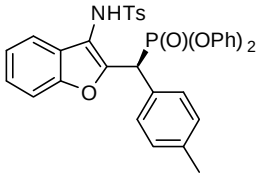
(-)-Diphenyl((3-((4-methylphenyl)sulfonamido)benzofuran-2-yl)(*o*-tolyl)methyl)phosphonate (3ba): 89 mg, 95% yield, 92% ee, $[\alpha]^{20}_D$ = -11.98 (*c* 0.86, $CHCl_3$), new compound, white solid, m.p. = 202-203 ^{o}C, R_f = 0.35 (hexanes/ethyl acetate = 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.03-7.94 (m, 1H), 7.57 (d, *J* = 8.3 Hz, 2H), 7.41 (s, 1H), 7.33 (d, *J* = 8.3 Hz, 1H), 7.24-7.06 (m, 9H), 7.06-6.98 (m, 5H), 6.90 (d, *J* = 8.3 Hz, 2H), 6.80 (d, *J* = 8.3 Hz, 2H), 5.53 (d, *J* = 27.3 Hz, 1H), 2.30 (s, 3H), 2.24 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.5, 150.4 (d, *J* = 9.8 Hz), 150.3 (d, *J* = 9.7 Hz), 147.3 (d, *J* = 11.6 Hz), 143.8, 137.3 (d, *J* = 8.8 Hz), 137.1, 130.8 (d, *J* = 1.7 Hz), 130.6 (d, *J* = 4.7 Hz), 130.3 (d, *J* = 6.4 Hz), 129.7, 129.7, 129.6, 128.2 (d, *J* = 2.7 Hz), 127.5, 126.4 (d, *J* = 2.7 Hz), 125.5 (d, *J* = 2.0 Hz), 125.4, 125.2, 124.9, 123.2, 120.6 (d, *J* = 4.4 Hz), 120.4 (d, *J* = 4.3 Hz), 119.8, 116.1 (d, *J* = 10.2 Hz), 111.6, 38.9 (d, *J* = 141.0 Hz), 21.6, 20.0; ^{31}P NMR (162 MHz, $CDCl_3$) δ 15.0. HPLC: Chiralcel IC column, 220 nm, 30 ^{o}C, *n*-hexane/*i*-propanol = 70/30, flow = 0.7 mL/min, retention time 9.8 min and 13.6 min (maj). HRMS Calculated for $C_{35}H_{31}NO_6PS$ $[M+H]^+$ 624.1604, found 624.1605.



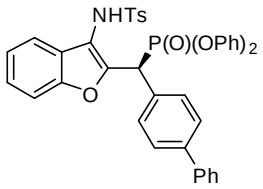
(-)-Diphenyl((3-((4-methylphenyl)sulfonamido)benzofuran-2-yl)(*m*-tolyl)methyl)phosphonate (3ca): 93 mg, 99% yield, 92% ee, $[\alpha]^{20}_D$ = -62.74 (*c* 0.91, $CHCl_3$), new compound, white solid, m.p. = 139-140 ^{o}C, R_f = 0.35 (hexanes/ ethyl acetate = 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57 (d, *J* = 8.2 Hz, 2H), 7.45 (s, 1H), 7.33 (d, *J* = 8.4 Hz, 2H), 7.26-7.17 (m, 5H), 7.15-7.09 (m, 6H), 7.07-7.00 (m, 3H), 6.90 (d, *J* = 8.1 Hz, 2H), 6.84 (d, *J* = 8.1 Hz, 2H), 4.65 (d, *J* = 26.9 Hz, 1H), 2.33 (s, 3H), 2.33 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.7 (d, *J* = 1.1 Hz)., 150.2 (d, *J* = 9.9 Hz), 150.2 (d, *J* = 9.1 Hz), 146.3 (d, *J* = 11.6 Hz), 143.7, 138.3 (d, *J* = 1.8 Hz), 137.0, 131.1 (d, *J* = 7.6 Hz), 131.0 (d, *J* = 6.8 Hz), 129.8, 129.7, 129.6, 129.1 (d, *J* = 2.6 Hz), 128.6 (d, *J* = 1.8 Hz), 127.5, 127.5 (d, *J* = 7.4 Hz), 125.9 (d, *J* = 2.7 Hz), 125.4, 125.3, 125.0, 123.4, 120.6 (d, *J* = 4.4 Hz), 120.3 (d, *J* = 4.3 Hz), 120.0, 116.1 (d, *J* = 10.0 Hz), 111.6, 43.2 (d, *J* = 138.9 Hz), 21.6, 21.6; ^{31}P NMR (162 MHz, $CDCl_3$) δ 14.4. HPLC: Chiralcel IC column, 220 nm, 30 ^{o}C, *n*-hexane/*i*-propanol = 70/30, flow = 0.7 mL/min, retention time 13.6 min and 15.2 min (maj). HRMS Calculated for $C_{35}H_{31}NO_6PS$ $[M+H]^+$ 624.1604, found 624.1602.



(-)-Diphenyl((3-((4-methylphenyl)sulfonamido)benzofuran-2-yl)(*p*-tolyl)methyl)phosphonate (3da): 90 mg, 96% yield, 91% ee, $[\alpha]^{20}_D$ = -56.58 (*c* 0.85, $CHCl_3$), new compound, white solid, m.p. = 171-172 ^{o}C, R_f = 0.35 (hexanes/ethyl acetate = 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.55 (d, *J* = 8.2 Hz, 2H), 7.43 (s, 1H), 7.32 (d, *J* = 8.4 Hz, 2H), 7.29-7.17 (m, 5H), 7.17-7.08 (m, 6H), 7.06-7.02 (m, 3H), 6.91 (d, *J* = 8.0 Hz, 2H), 6.85 (d, *J* = 8.1 Hz, 2H), 4.62 (d, *J* = 26.9 Hz, 1H), 2.36 (s, 3H), 2.34 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.7 (d, *J* = 1.1 Hz), 150.2 (d, *J* = 10.0 Hz), 150.2 (d, *J* = 9.2 Hz), 146.4 (d, *J* = 11.4 Hz), 143.8, 138.1 (d, *J* = 2.7 Hz), 136.9, 130.3 (d, *J* = 7.2 Hz), 129.8, 129.7, 129.4 (d, *J* = 1.7 Hz), 128.0 (d, *J* = 6.9 Hz), 127.5, 125.9 (d, *J* = 2.7 Hz), 125.5, 125.4, 124.9, 123.4, 120.6 (d, *J* = 4.4 Hz), 120.4 (d, *J* = 4.3 Hz), 120.0, 116.0 (d, *J* = 10.0 Hz), 111.6, 42.9 (d, *J* = 139.4 Hz), 21.6, 21.3; ^{31}P NMR (162 MHz, $CDCl_3$) δ 14.6. HPLC: Chiralcel IC column, 220 nm, 30 ^{o}C, *n*-hexane/*i*-propanol = 70/30, flow = 0.7 mL/min, retention time 15.0 min and 16.7 min (maj). HRMS Calculated for $C_{35}H_{31}NO_6PS$ $[M+H]^+$ 624.1604, found 624.1603.

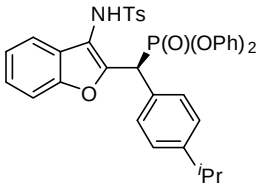


(-)-Diphenyl([1,1'-biphenyl]-4-yl(3-((4-methylphenyl)sulfonamido)benzofuran-2-yl)methyl)phosphonate (3ea): 102 mg, 99% yield, 91% ee, $[\alpha]^{20}_D$ = -29.10 (*c* 1.00, $CHCl_3$), new compound, white solid, m.p. = 85-87 °C, R_f = 0.25 (hexanes/ethyl acetate = 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ



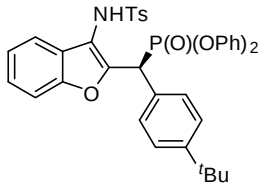
7.61-7.43 (m, 11H), 7.40-7.32 (m, 2H), 7.28-6.99 (m, 11H), 6.95-6.86 (m, 4H), 4.87 (d, *J* = 26.8 Hz, 1H), 2.30 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.7, 150.3 (d, *J* = 9.8 Hz), 150.2 (d, *J* = 9.4 Hz), 146.5 (d, *J* = 11.9 Hz), 143.9, 141.1 (d, *J* = 2.7 Hz), 140.5, 136.8, 130.8 (d, *J* = 7.1 Hz), 130.3 (d, *J* = 6.9 Hz), 129.8, 129.74 (s), 129.7, 129.0, 127.7, 127.5, 127.3 (d, *J* = 1.3 Hz), 127.2, 125.8 (d, *J* = 2.4 Hz), 125.5, 125.4, 125.0, 123.5, 120.5 (d, *J* = 4.3 Hz), 120.4 (d, *J* = 4.3 Hz), 119.9, 116.2 (d, *J* = 10.0 Hz), 111.6, 42.9 (d, *J* = 139.4 Hz), 21.6; ^{31}P NMR (162 MHz, $CDCl_3$) δ 14.1. HPLC: IC column, 220 nm, 30 °C, *n*-hexane/*i*-propanol = 70/30, flow = 0.7 mL/min, retention time 16.6 min and 18.5 min (maj). HRMS Calculated for $C_{40}H_{33}NO_6PS$ $[M+H]^+$ 686.1761, found 686.1760.

(-)-Diphenyl((4-isopropylphenyl)(3-((4-methylphenyl)sulfonamido)benzofuran-2-yl)methyl)phosphonate(3fa): 94 mg, 96% yield, 93% ee, $[\alpha]^{20}_D$ = -38.48 (*c* 0.92, $CHCl_3$), new compound, white solid, m.p. = 73-75 °C, R_f = 0.35 (hexanes/ethyl acetate = 4/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ



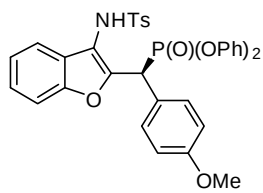
7.58 (d, *J* = 7.3 Hz, 2H), 7.42-7.02 (m, 17H), 6.89-6.79 (m, 4H), 4.67 (d, *J* = 26.8 Hz, 1H), 3.00-2.83 (m, 1H), 2.35 (s, 3H), 1.26 (d, *J* = 6.2 Hz, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.7, 150.3 (d, *J* = 9.8 Hz), 150.2 (d, *J* = 9.3 Hz), 149.0 (d, *J* = 2.7 Hz), 146.5 (d, *J* = 11.6 Hz), 143.8, 136.9, 130.4 (d, *J* = 7.2 Hz), 129.8, 129.72 (s), 129.6, 128.2 (d, *J* = 6.9 Hz), 127.5, 126.8 (d, *J* = 1.0 Hz), 125.9 (d, *J* = 2.4 Hz), 125.4, 125.3, 124.9, 123.4, 120.6 (d, *J* = 4.2 Hz), 120.3 (d, *J* = 4.2 Hz), 119.9, 116.0 (d, *J* = 10.0 Hz), 111.6, 42.9 (d, *J* = 139.3 Hz), 33.9, 24.1, 21.6; ^{31}P NMR (162 MHz, $CDCl_3$) δ 14.5. HPLC: Chiralcel IA column, 220 nm, 30 °C, *n*-hexane/*i*-propanol = 70/30, flow = 1.0 mL/min, retention time 24.1 min and 45.6 min (maj). HRMS Calculated for $C_{37}H_{35}NO_6PS$ $[M+H]^+$ 652.1917, found 652.1917.

(-)-Diphenyl((4-(tert-butyl)phenyl)(3-((4-methylphenyl)sulfonamido)benzofuran-2-yl)methyl)phosphonate (3ga): 99 mg, 99% yield, 93% ee, $[\alpha]^{20}_D$ = -35.77 (*c* 0.97, $CHCl_3$), new compound, white solid, m.p. = 74-76 °C, R_f = 0.40 (hexanes/ ethyl acetate = 4/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ



7.59 (d, *J* = 8.1 Hz, 2H), 7.36-7.30 (m, 7H), 7.24-7.20 (m, 3H), 7.16-7.00 (m, 7H), 6.89 (d, *J* = 8.0 Hz, 2H), 6.79 (d, *J* = 8.0 Hz, 2H), 4.64 (d, *J* = 26.8 Hz, 1H), 2.37 (s, 3H), 1.33 (s, 9H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.7 (d, *J* = 1.0 Hz), 151.3 (d, *J* = 2.7 Hz), 150.3 (d, *J* = 9.9 Hz), 150.2 (d, *J* = 9.4 Hz), 146.5 (d, *J* = 11.4 Hz), 143.9, 137.0, 130.2 (d, *J* = 7.2 Hz), 129.8, 129.8, 129.6, 127.8 (d, *J* = 6.9 Hz), 127.5, 125.9 (d, *J* = 2.7 Hz), 125.7 (d, *J* = 1.7 Hz), 125.5, 125.3, 125.0, 123.5, 120.6 (d, *J* = 4.4 Hz), 120.3 (d, *J* = 4.3 Hz), 119.9, 115.9 (d, *J* = 10.1 Hz), 111.7, 42.9 (d, *J* = 139.3 Hz), 34.7, 31.4, 21.7; ^{31}P NMR (162 MHz, $CDCl_3$) δ 14.4. HPLC: Chiralcel IA column, 220 nm, 30 °C, *n*-hexane/*i*-propanol = 70/30, flow = 1.0 mL/min, retention time 17.5 min and 35.8 min (maj). HRMS Calculated for $C_{38}H_{37}NO_6PS$ $[M+H]^+$ 666.2074, found 666.2073.

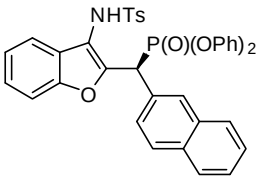
(-)-Diphenyl((4-methoxyphenyl)(3-((4-methylphenyl)sulfonamido)benzofuran-2-yl)methyl)phosphonate (3ha): 95 mg, 99% yield, 92% ee, $[\alpha]^{20}_D$ = -45.00 (*c* 0.94, $CHCl_3$), new compound, white solid, m.p. = 162-163 °C, R_f = 0.20 (hexanes/ethyl acetate = 3/1). ^{1}H



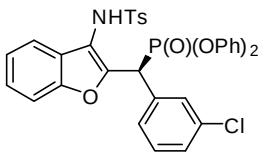
NMR (400 MHz, $CDCl_3$) δ 7.55 (d, *J* = 8.1 Hz, 2H), 7.42 (s, 1H), 7.35-7.26 (m, 4H), 7.24-7.02 (m, 10H), 6.92 (d, *J* = 8.2 Hz, 2H), 6.87-6.84 (m, 4H), 4.68 (d, *J* = 26.9 Hz, 1H), 3.81 (s, 3H), 2.34 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 159.6 (d, *J* = 2.4 Hz), 153.6, 150.2 (d, *J* = 10.0 Hz), 150.2 (d, *J* = 9.3 Hz),

146.7 (d, *J* = 11.0 Hz), 143.8, 136.9, 131.6 (d, *J* = 7.3 Hz), 129.8, 129.7, 127.5, 125.9 (d, *J* = 2.8 Hz), 125.5, 125.4, 124.9, 123.4, 123.1 (d, *J* = 6.8 Hz), 120.6 (d, *J* = 4.4 Hz), 120.4 (d, *J* = 4.3 Hz), 119.9, 115.9 (d, *J* = 9.9 Hz), 114.1 (d, *J* = 1.5 Hz), 111.6, 55.4, 42.4 (d, *J* = 139.8 Hz), 21.6; ^{31}P NMR (162 MHz, $CDCl_3$) δ 14.6. HPLC: Chiralcel IC column, 220 nm, 30 ^{o}C, *n*-hexane/*i*-propanol = 70/30, flow = 0.7 mL/min, retention time 17.8 min and 20.1 min (maj). HRMS Calculated for $C_{35}H_{31}NO_7PS$ $[M+H]^+$ 640.1553, found 640.1551.

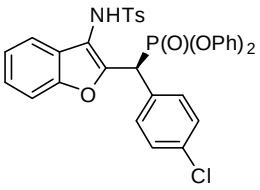
(-)-Diphenyl((3-((4-methylphenyl)sulfonamido)benzofuran-2-yl)(naphthalen-2-yl)methyl)phosphonate (3ia): 97 mg, 98% yield, 90% ee, $[\alpha]^{20}_D$ = -48.92 (*c* 0.93, $CHCl_3$), new compound, white solid, m.p. = 211-212 ^{o}C, R_f = 0.25 (hexanes/ethyl acetate = 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86-7.74 (m, 4H), 7.63 (s, 1H), 7.59 (d, *J* = 8.7 Hz, 1H), 7.52-7.48 (m, 4H), 7.35-7.32 (m, 2H), 7.24 – 7.19 (m, 1H), 7.17-7.00 (m, 7H), 6.90-6.86 (m, 6H), 5.02 (d, *J* = 26.9 Hz, 1H), 2.17 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.7 (d, *J* = 0.9 Hz), 150.2 (d, *J* = 9.9 Hz), 150.1 (d, *J* = 9.4 Hz), 146.2 (d, *J* = 11.9 Hz), 143.7, 136.6, 133.2 (d, *J* = 2.0 Hz), 132.8 (d, *J* = 1.8 Hz), 129.6, 129.6, 129.5, 129.5 (d, *J* = 9.4 Hz), 128.9 (d, *J* = 7.0 Hz), 128.2 (d, *J* = 1.1 Hz), 128.1, 127.7, 127.6 (d, *J* = 7.4 Hz), 127.4, 126.5, 126.4, 125.8 (d, *J* = 2.5 Hz), 125.4, 125.3, 125.0, 123.4, 120.4 (d, *J* = 4.4 Hz), 120.3 (d, *J* = 4.3 Hz), 120.1, 116.4 (d, *J* = 10.0 Hz), 111.5, 43.2 (d, *J* = 139.2 Hz), 21.4; ^{31}P NMR (162 MHz, $CDCl_3$) δ 14.2. HPLC: Chiralcel IC column, 220 nm, 30 ^{o}C, *n*-hexane/*i*-propanol = 70/30, flow = 0.7 mL/min, retention time 15.9 min and 18.0 min (maj). HRMS Calculated for $C_{38}H_{31}NO_6PS$ $[M+H]^+$ 660.1604, found 660.1608.



(-)-Diphenyl((3-chlorophenyl)(3-((4-methylphenyl)sulfonamido)benzofuran-2-yl)methyl)phosphonate (3ja): 95 mg, 98% yield, 88% ee, $[\alpha]^{20}_D$ = -45.50 (*c* 0.89, $CHCl_3$), new compound, white solid, m.p. = 69-70 ^{o}C, R_f = 0.30 (hexanes/ethyl acetate = 4/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 (s, 1H), 7.52 (d, *J* = 7.8 Hz, 2H), 7.44 (d, *J* = 6.5 Hz, 1H), 7.34-7.05 (m, 13H), 7.00 (d, *J* = 7.6 Hz, 2H), 6.92-6.87 (m, 4H), 4.82 (d, *J* = 26.8 Hz, 1H), 2.32 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.7, 150.1 (d, *J* = 9.6 Hz), 150.0 (d, *J* = 8.9 Hz), 145.6 (d, *J* = 12.8 Hz), 143.9, 136.6, 134.3, 133.4 (d, *J* = 6.7 Hz), 130.3 (d, *J* = 7.4 Hz), 129.9 (d, *J* = 1.5 Hz), 129.8, 129.7, 128.5 (d, *J* = 7.0 Hz), 128.4 (d, *J* = 2.2 Hz), 127.4, 125.6 (d, *J* = 4.4 Hz), 125.6, 125.5, 125.2, 123.5, 120.4 (d, *J* = 4.4 Hz), 120.3 (d, *J* = 4.2 Hz), 120.1, 116.6 (d, *J* = 10.0 Hz), 111.6, 42.7 (d, *J* = 139.4 Hz), 21.6; ^{31}P NMR (162 MHz, $CDCl_3$) δ 13.3. HPLC: Chiralcel IC column, 220 nm, 30 ^{o}C, *n*-hexane/*i*-propanol = 70/30, flow = 0.7 mL/min, retention time 11.6 min and 14.2 min (maj). HRMS Calculated for $C_{34}H_{28}ClNO_6PS$ $[M+H]^+$ 644.1058, found 644.1059.

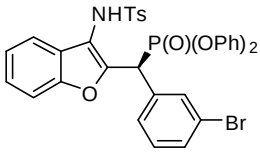


(-)-Diphenyl((4-chlorophenyl)(3-((4-methylphenyl)sulfonamido)benzofuran-2-yl)methyl)phosphonate (3ka): 94 mg, 97% yield, 87% ee, $[\alpha]^{20}_D$ = -22.89 (*c* 0.90, $CHCl_3$), new compound, white solid, m.p. = 193-194 ^{o}C, R_f = 0.65 (hexanes/ethyl acetate = 6/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54 (s, 1H), 7.49 (d, *J* = 7.9 Hz, 2H), 7.41 (d, *J* = 7.4 Hz, 2H), 7.31-7.28 (m, 3H), 7.21-7.01 (m, 9H), 7.00-6.82 (m, 6H), 4.99 (d, *J* = 26.7 Hz, 1H), 2.30 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.6, 150.2 (d, *J* = 9.9 Hz), 150.1 (d, *J* = 9.5 Hz), 146.3 (d, *J* = 12.1 Hz), 143.9, 136.6, 134.2 (d, *J* = 3.3 Hz), 131.6 (d, *J* = 6.9 Hz), 130.3 (d, *J* = 6.7 Hz), 129.8, 129.7, 129.6, 128.8 (d, *J* = 1.6 Hz), 127.5, 125.5, 125.4, 125.1, 123.4, 120.4 (d, *J* = 4.7 Hz), 120.4 (d, *J* = 4.6 Hz), 119.9, 116.4 (d, *J* = 10.1 Hz), 111.6, 42.4 (d, *J* = 139.9 Hz), 21.6; ^{31}P NMR (162 MHz, $CDCl_3$) δ 13.4. HPLC: Chiralcel IA column, 220 nm, 30 ^{o}C, *n*-hexane/*i*-propanol = 60/40, flow = 1.0 mL/min, retention time 51.1 min and 95.9

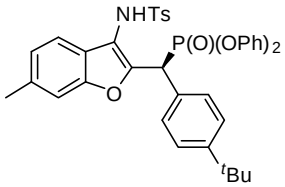


min (maj). HRMS Calculated for $C_{34}H_{28}ClNO_6PS$ $[M+H]^+$ 644.1058, found 644.1058.

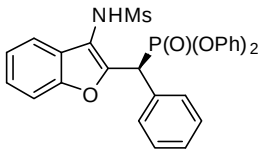
(-)-Diphenyl((3-bromophenyl)(3-((4-methylphenyl)sulfonamido)benzofuran-2-yl)methyl)phosphonate (3la): 93 mg, 90% yield, 89% ee, $[\alpha]^{20}_D$ = -46.20 (*c* 0.87, $CHCl_3$), new compound, white solid, m.p. = 65-67 °C, R_f = 0.30 (hexanes/ethyl acetate = 4/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54 (d, *J* = 8.1 Hz, 2H), 7.52-7.41 (m, 3H), 7.34-7.32 (m, 3H), 7.25-7.22 (m, 4H), 7.20-7.00 (m, 7H), 6.93-6.87 (m, 4H), 4.67 (d, *J* = 26.7 Hz, 1H), 2.35 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.7 (d, *J* = 1.0 Hz), 150.1 (d, *J* = 9.8 Hz), 150.0 (d, *J* = 9.1 Hz), 145.4 (d, *J* = 12.1 Hz), 144.0, 136.8, 133.4 (d, *J* = 6.7 Hz), 133.2 (d, *J* = 7.9 Hz), 131.4 (d, *J* = 2.6 Hz), 130.2 (d, *J* = 2.0 Hz), 129.9, 129.8, 129.8, 129.0 (d, *J* = 6.5 Hz), 127.5, 125.8 (d, *J* = 2.7 Hz), 125.7, 125.5, 125.2, 123.6, 122.5 (d, *J* = 1.8 Hz), 120.5 (d, *J* = 4.4 Hz), 120.3 (d, *J* = 4.4 Hz), 120.1, 116.5 (d, *J* = 9.9 Hz), 111.6, 42.7 (d, *J* = 139.0 Hz), 21.8; ^{31}P NMR (162 MHz, $CDCl_3$) δ 13.4. HPLC: Chiralcel IC column, 220 nm, 30 °C, *n*-hexane/*i*-propanol = 70/30, flow = 0.7 mL/min, retention time 11.8 min and 14.9 min (maj). HRMS Calculated for $C_{34}H_{28}BrNO_6PS$ $[M+H]^+$ 688.0553, found 688.0550.



(-)-Diphenyl((4-(tert-butyl)phenyl)(6-methyl-3-((4-methylphenyl)sulfonamido)benzofuran-2-yl)methyl)phosphonate (3ma): 83 mg, 81% yield, 94% ee, $[\alpha]^{20}_D$ = -44.02 (*c* 0.72, $CHCl_3$), new compound, white solid, m.p. = 85-87 °C, R_f = 0.60 (hexanes/ethyl acetate = 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57 (d, *J* = 8.1 Hz, 2H), 7.44 (s, 1H), 7.37- 7.29 (m, 4H), 7.20-6.99 (m, 10H), 6.90 (d, *J* = 8.2 Hz, 1H), 6.87 (d, *J* = 8.1 Hz, 2H), 6.78 (d, *J* = 8.1 Hz, 2H), 4.76 (d, *J* = 26.8 Hz, 1H), 2.38 (s, 3H), 2.33 (s, 3H), 1.32 (s, 9H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 154.1 (d, *J* = 0.9 Hz), 151.1 (d, *J* = 2.9 Hz), 150.3 (d, *J* = 10.0 Hz), 150.2 (d, *J* = 9.5 Hz), 145.8 (d, *J* = 11.8 Hz), 143.7, 136.9, 135.2 (d, *J* = 1.0 Hz), 130.0 (d, *J* = 7.1 Hz), 129.7, 129.7, 129.6, 128.1 (d, *J* = 6.7 Hz), 127.5, 125.6 (d, *J* = 1.6 Hz), 125.3, 125.2, 124.8, 123.3 (d, *J* = 2.5 Hz), 120.6 (d, *J* = 4.3 Hz), 120.4 (d, *J* = 4.3 Hz), 119.4, 115.9 (d, *J* = 10.2 Hz), 111.8, 42.7 (d, *J* = 139.7 Hz), 34.6, 31.4, 21.7, 21.6; ^{31}P NMR (162 MHz, $CDCl_3$) δ 14.5. HPLC: Chiralcel IC column, 220 nm, 30 °C, *n*-hexane/*i*-propanol = 70/30, flow = 0.7 mL/min, retention time 12.4 min (maj) and 14.8 min. HRMS Calculated for $C_{39}H_{39}NO_6PS$ $[M+H]^+$ 680.2230, found 680.2234.

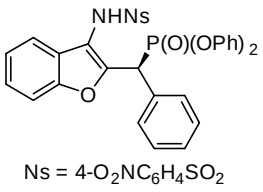


(-)-Diphenyl ((3-(methylsulfonamido)benzofuran-2-yl)(phenyl)methyl)phosphonate (3na): 78 mg, 98% yield, 87% ee, $[\alpha]^{20}_D$ = -4.17 (*c* 0.36, $CHCl_3$), new compound, white solid, m.p. = 211-212 °C, R_f = 0.20 (hexanes/ethyl acetate = 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82-7.73 (m, 2H), 7.56 (d, *J* = 7.7 Hz, 1H), 7.46-7.28 (m, 5H), 7.25-7.14 (m, 5H), 7.12-7.05 (m, 2H), 6.97-6.94 (m, 3H), 6.92-6.87 (m, 2H), 5.47 (d, *J* = 26.6 Hz, 1H), 2.80 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.8 (d, *J* = 1.0 Hz), 150.4 (d, *J* = 9.9 Hz), 150.2 (d, *J* = 9.6 Hz), 147.7 (d, *J* = 10.9 Hz), 132.1 (d, *J* = 5.9 Hz), 130.3 (d, *J* = 7.3 Hz), 129.8, 129.8, 129.1 (d, *J* = 1.5 Hz), 128.5 (d, *J* = 2.3 Hz), 125.5, 125.4 (d, *J* = 2.5 Hz), 123.9, 120.5 (d, *J* = 4.4 Hz), 120.4 (d, *J* = 4.4 Hz), 119.5, 115.9 (d, *J* = 9.9 Hz), 112.1, 43.4 (d, *J* = 141.1 Hz), 40.1.; ^{31}P NMR (162 MHz, $CDCl_3$) δ 13.7. HPLC: Chiralcel IC column, 220 nm, 30 °C, *n*-hexane/*i*-propanol = 80/20, flow = 0.7 mL/min, retention time 21.9 min (maj) and 24.2 min. HRMS Calculated for $C_{28}H_{25}NO_6PS$ $[M+H]^+$ 534.1135, found 534.1136.

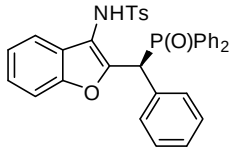


(-)-Diphenyl ((3-((4-nitrophenyl)sulfonamido)benzofuran-2-yl)(phenyl)methyl)phosphonate (3oa): 90 mg, 94% yield, 87% ee, $[\alpha]^{20}_D$ = -0.62 (*c* 0.80, $CHCl_3$), new compound, white solid, m.p. = 126-127 °C, R_f = 0.35 (hexanes/ethyl acetate = 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.59 (s, 1H), 7.72 (d, *J* = 8.5 Hz, 2H), 7.52 (d, *J* = 8.6 Hz, 2H), 7.35-7.07 (m, 14H), 7.05-6.99 (m, 1H), 6.97-6.84 (m, 4H),

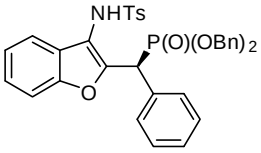
5.24 (d, J = 27.3 Hz, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.7, 150.4 (d, J = 10.1 Hz), 150.0 (d, J = 10.3 Hz), 149.8, 145.9 (d, J = 13.0 Hz), 144.8, 132.1 (d, J = 7.4 Hz), 129.9, 129.8, 129.5 (d, J = 6.0 Hz), 128.6 (d, J = 2.2 Hz), 128.5, 128.3 (d, J = 2.9 Hz), 125.8, 125.6, 125.6, 124.9 (d, J = 1.3 Hz), 123.8, 123.5, 120.7 (d, J = 4.2 Hz), 120.5 (d, J = 4.3 Hz), 120.4, 116.5 (d, J = 10.5 Hz), 111.4, 42.7 (d, J = 139.2 Hz).; ^{31}P NMR (162 MHz, $CDCl_3$) δ 14.3. HPLC: Chiralcel IC column, 220 nm, 30 °C, *n*-hexane/*i*-propanol = 70/30, flow = 0.7 mL/min, retention time 12.6 min and 28.6 min (maj). HRMS Calculated for $C_{33}H_{26}N_2O_8PS$ $[M+H]^+$ 641.1142, found 641.1143.



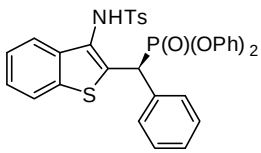
(+)-*N*-(2-((Diphenylphosphoryl)(phenyl)methyl)benzofuran-3-yl)-4-methylbenzenesulfonamide (3ab): 69 mg, 80% yield, 66% ee, $[\alpha]^{20}_D$ = +9.36 (*c* 0.63, $CHCl_3$), new compound, white solid, m.p. = 210-212 °C, R_f = 0.40 (hexanes/ethyl acetate = 1/1). ^{1}H NMR (400 MHz, DMSO) δ 9.79 (s, 1H), 7.86-7.69 (m, 4H), 7.57-7.33 (m, 7H), 7.27 (d, J = 8.2 Hz, 2H), 7.25 -7.07 (m, 7H), 7.04-6.99 (m, 3H), 5.69 (d, J = 11.6 Hz, 1H), 2.18 (s, 3H); ^{13}C NMR (101 MHz, DMSO) δ 153.2, 148.3 (d, J = 9.6 Hz), 143.6, 136.4, 133.7 (d, J = 4.9 Hz), 132.8 (d, J = 36.6 Hz), 132.4 (d, J = 2.4 Hz), 132.2 (d, J = 2.5 Hz), 131.8 (d, J = 36.5 Hz), 131.5 (d, J = 8.8 Hz), 131.0 (d, J = 9.2 Hz), 130.2 (d, J = 4.8 Hz), 129.8, 129.0 (d, J = 11.5 Hz), 128.7 (d, J = 11.6 Hz), 128.4, 127.4 (d, J = 1.2 Hz), 127.0, 125.1, 124.8, 123.1, 120.3, 116.3 (d, J = 7.1 Hz), 111.6, 44.5 (d, J = 61.9 Hz), 21.4; ^{31}P NMR (162 MHz, DMSO) δ 28.1. HPLC: Chiralcel IC column, 220 nm, 30 °C, *n*-hexane/*i*-propanol = 70/30, flow = 0.7 mL/min, retention time 18.1 min and 27.1 min (maj). HRMS Calculated for $C_{34}H_{29}NO_4PS$ $[M+H]^+$ 578.1549, found 578.1550.



(-)-Dibenzyl((3-((4-methylphenyl)sulfonamido)benzofuran-2-yl)(phenyl)methyl)phosphonate (3ac): 77 mg, 80% yield, 80% ee, $[\alpha]^{20}_D$ = -34.32 (*c* 0.74, $CHCl_3$), new compound, white solid, m.p. = 61-63 °C, R_f = 0.15 (hexanes/ethyl acetate = 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54 (d, J = 8.2 Hz, 2H), 7.51-7.43 (m, 1H), 7.33 (d, J = 8.5 Hz, 2H), 7.30-7.11 (m, 13H), 7.10-6.93 (m, 6H), 4.93-4.71 (m, 4H), 4.51-4.38 (m, 1H), 2.32 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.6, 147.1 (d, J = 11.6 Hz), 143.7, 136.9, 135.8 (d, J = 5.7 Hz), 135.8 (d, J = 5.9 Hz), 131.8 (d, J = 6.4 Hz), 130.2 (d, J = 6.8 Hz), 129.7, 128.6, 128.6, 128.5, 128.5, 127.9, 127.9, 127.5, 125.9 (d, J = 2.6 Hz), 124.8, 123.4, 120.2, 115.8 (d, J = 9.6 Hz), 111.6, 68.9 (d, J = 7.1 Hz), 68.6 (d, J = 7.1 Hz), 43.3 (d, J = 137.7 Hz), 21.6; ^{31}P NMR (162 MHz, $CDCl_3$) δ 22.6. HPLC: Chiralcel IA column, 220 nm, 30 °C, *n*-hexane/*i*-propanol = 60/40, flow = 1.0 mL/min, retention time 22.2 min and 60.6 min (maj). HRMS Calculated for $C_{36}H_{33}NO_6PS$ $[M+H]^+$ 638.1761, found 638.1763.

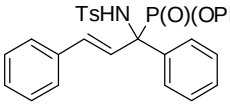


(-)-Diphenyl((3-((4-methylphenyl)sulfonamido)benzo[b]thiophen-2-yl)(phenyl)methyl)phosphonate (3pa): 88 mg, 94% yield, 87% ee, $[\alpha]^{20}_D$ = -153.11 (*c* 0.77, $CHCl_3$), new compound, pale yellow solid, m.p. = 80-82 °C, R_f = 0.20 (hexanes/ethyl acetate = 5/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.46 (s, 1H), 7.85 (d, J = 7.5 Hz, 1H), 7.63-7.58 (m, 3H), 7.40-7.24 (m, 7H), 7.22-7.01 (m, 8H), 6.87 (d, J = 8.0 Hz, 2H), 6.80 (d, J = 8.1 Hz, 2H), 4.44 (d, J = 25.4 Hz, 1H), 2.38 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 149.9 (d, J = 10.4 Hz), 149.8 (d, J = 8.4 Hz), 143.8, 138.05 (s), 137.2 (d, J = 3.5 Hz), 136.8 (d, J = 1.9 Hz), 134.1 (d, J = 9.6 Hz), 133.4 (d, J = 6.3 Hz), 129.9, 129.8 (d, J = 8.3 Hz), 129.8, 129.7, 129.0, 128.7 (d, J = 1.4 Hz), 127.4, 126.5 (d, J = 9.6 Hz), 125.7, 125.5, 125.2 (d, J = 1.0 Hz), 124.7, 123.4, 121.9 (d, J = 1.1 Hz), 120.7 (d, J = 4.3 Hz), 120.2 (d, J = 4.3 Hz), 44.2 (d, J = 138.8 Hz), 21.5; ^{31}P NMR (162 MHz, $CDCl_3$) δ 17.1. HPLC: Chiralcel IC column, 220 nm, 30 °C, *n*-hexane/*i*-propanol = 70/30, flow = 0.7 mL/min, retention time 13.7 min and 18.5 min (maj). HRMS Calculated for $C_{34}H_{29}NO_5PS_2$



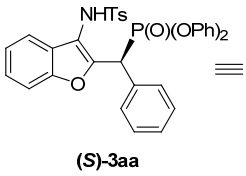
$[M+H]^+$ 626.1219, found 626.1216.

(*E*)-Diphenyl (1-((4-methylphenyl)sulfonamido)-1,3-diphenylallyl)phosphonate (3qa): 10 mg, 11% yield, new compound, white solid, m.p. = 61-63 °C, R_f = 0.10 (hexanes/ethyl acetate = 7/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89-7.76 (m, 2H), 7.52 (d, *J* = 8.1 Hz, 2H), 7.38-7.25 (m, 6H), 7.24-7.06 (m, 8H), 7.00 (d, *J* = 8.0 Hz, 2H), 6.90 (d, *J* = 8.0 Hz, 2H), 6.87-6.74 (m, 3H), 6.56-6.49 (m, 1H), 6.04 (d, *J* = 7.0 Hz, 1H), 2.31 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 150.4 (d, *J* = 10.6 Hz), 150.3 (d, *J* = 10.4 Hz), 143.1, 139.5, 137.8 (d, *J* = 11.6 Hz), 135.7 (d, *J* = 3.0 Hz), 134.5 (d, *J* = 2.8 Hz), 129.7, 129.7, 129.4 (d, *J* = 5.5 Hz), 129.2, 128.5, 128.5, 128.2 (d, *J* = 2.5 Hz), 127.4, 127.0 (d, *J* = 1.2 Hz), 125.4, 122.6 (d, *J* = 10.0 Hz), 120.4 (d, *J* = 4.3 Hz), 120.3 (d, *J* = 4.2 Hz), 67.1 (d, *J* = 154.5 Hz), 21.5; ^{13}C DEPT-45° NMR (101 MHz, $CDCl_3$) δ 137.8 (d, *J* = 11.5 Hz), 129.7, 129.7, 129.4 (d, *J* = 5.5 Hz), 129.2, 128.5, 128.5, 128.2 (d, *J* = 2.5 Hz), 127.4, 127.0 (d, *J* = 1.2 Hz), 125.4, 122.6 (d, *J* = 10.0 Hz), 120.4 (d, *J* = 4.3 Hz), 120.3 (d, *J* = 4.2 Hz), 21.5; ^{31}P NMR (162 MHz, $CDCl_3$) δ 11.5. HRMS Calculated for $C_{34}H_{30}KNO_5PS$ $[M+K]^+$ 634.1214, found 634.1217.



4. Determination of the Absolute Configuration of (-)-3aa

The absolute configuration of product diphenyl ((3-((4-methyl- phenyl)sulfonamido)benzofuran-2-yl)(phenyl)methyl)phosphonate (-)-**3aa** was assigned as (*S*) based on the X-ray diffraction analysis after recrystallization from mixture solvent ethyl acetate/*n*-hexane to upgrade ee to > 99%. The configurations of the other chiral products are assigned by analogy. The CCDC number is 1588669. These details can be obtained free of charge via www.ccdc.com. ac.uk/data_request/cif from the Cambridge Crystallographic Data Centre.



(*S*)-3aa

≡

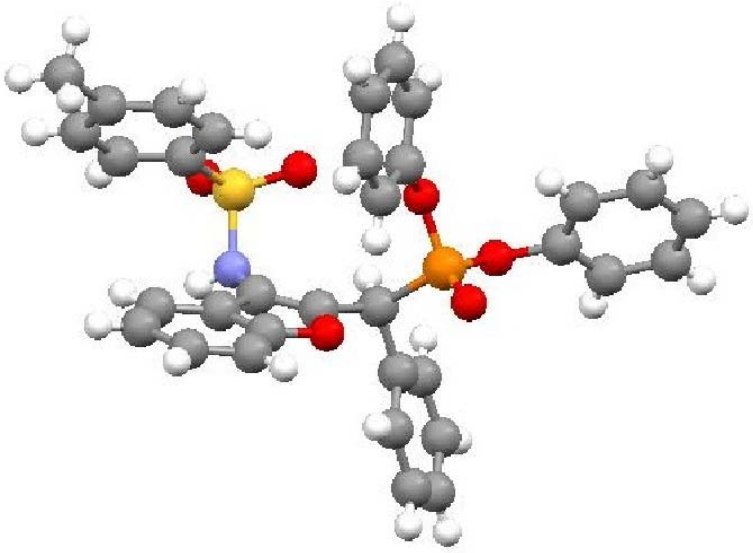


Figure S1. X-ray Single Crystal Structure of (-)-**3aa**

5. References

[1] (*a*) W. Yang and D.-M. Du, *Org. Lett.*, 2010, **12**, 5450; (*b*) H. Y. Bae, S. Some, J. H. Lee, J.-Y. Kim, M. J. Song, S. Lee, Y. J. Zhang and C. E. Song, *Adv. Synth. Catal.*, 2011, **353**, 3196; (*c*) K. Asano and S. Matsubara, *Org. Lett.*, 2012, **14**, 1620.

[2] (*a*) R. Löser, M. Chlupacova, A. Marecek, V. Opletalova and M. Gütschow, *Helv. Chim. Acta*, 2004, **87**, 2597; (*b*) M. Morimoto, H. Fukumoto, T. Nozoe, A. Hagiwara and K. Komai, *J. Agric. Food Chem.*, 2007, **55**, 700.

[3] (*a*) T. Patonay, R. Bognár and G. Litkei, *Tetrahedron*, 1984, **40**, 2555; (*b*) J. Liu, M. Liu, Y. Yue, N. Zhang, Y. Zhang and K. Zhuo, *Tetrahedron Lett.*, 2013, **54**, 1802; (*c*) C. Liu, Z. Zhang, J. Zhang, X. Liu and M. Xie, *Chin. J. Chem.*, 2014, **32**, 1233; (*d*) Y. Weng, Q. Chen and W. Su, *J. Org. Chem.*, 2014, **79**, 4218; (*e*) M. P. Carrasco, A. S. Newton, L. Gonçalves, A. Góis, M. Machado, J. Gut, F. Nogueira, T. Hänscheid, R. C. Guedes, D. J.V.A. dos Santos, P. J. Rosenthal and R. Moreira, *Eur. J. Med. Chem.*, 2014, **80**, 523; (*f*) S. Li, F.Jin, M. Viji, H. Jo, J. Sim, H. S. Kim, H. Lee and J.-K. Jung, *Tetrahedron Lett.*, 2017, **58**, 1417; (*g*) K. M.Taylor, Z. E.Taylor and S. T. Handy, *Tetrahedron Lett.*, 2017, **58**, 240; (*h*) V. N. Badavath, C. Nath, N. M. Ganta, G. Ucar, B. N. Sinha and V. Jayaprakash, *Chinese Chem. Lett.*, 2017, **28**, 1528.

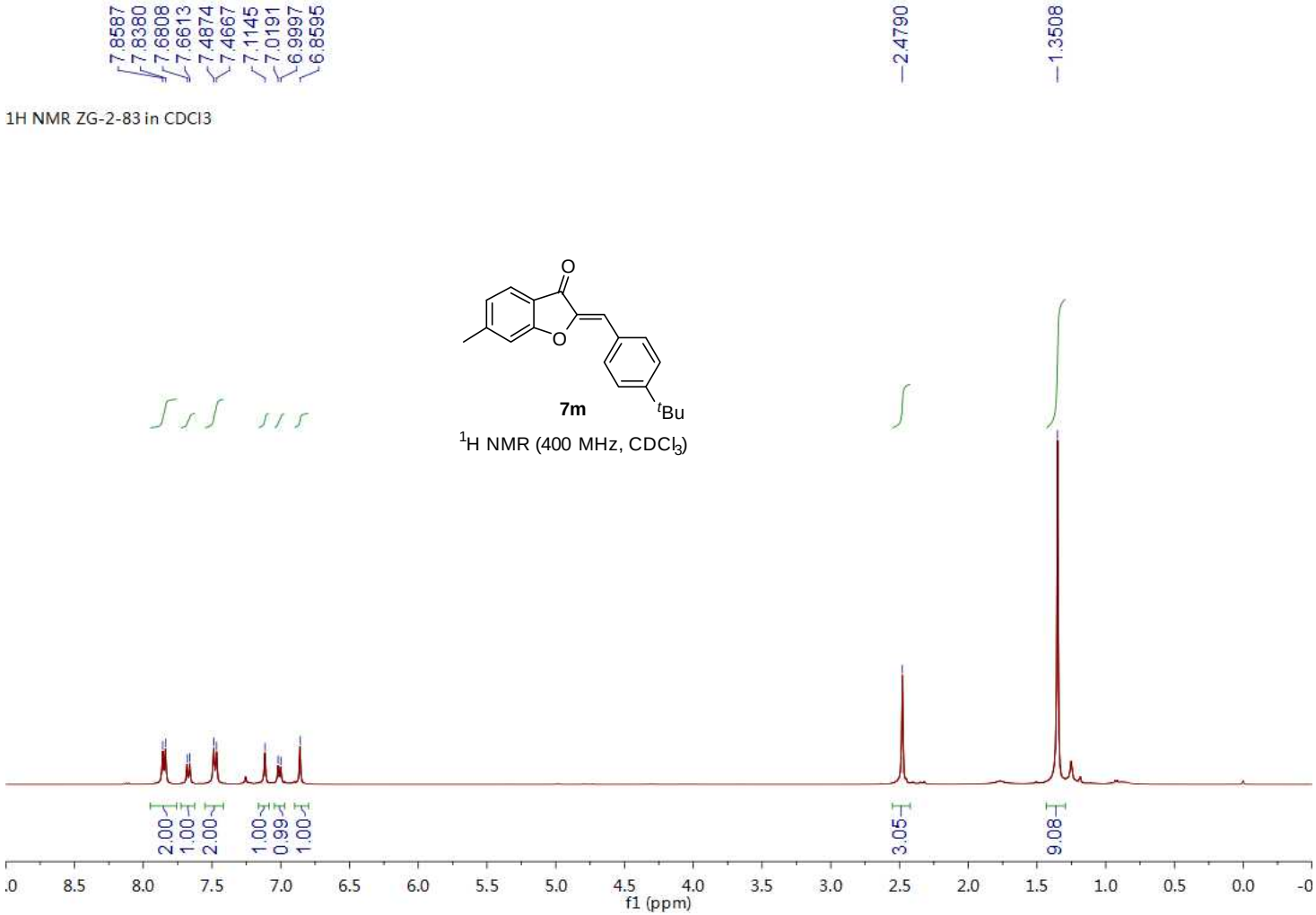
[4] J. E. Zweig and T. R. Newhouse, *J. Am. Chem. Soc.*, 2017, **139**, 10956.

[5] Z.-Q. Rong, M. Wang, C. H. E. Chow and Y. Zhao, *Chem. Eur. J.*, 2016, **22**, 9483.

[6] H. Ni, X. Tang, W. Zheng, W. Yao, N. Ullah and Y. Lu, *Angew. Chem. Int. Ed.*, 2017, **56**, 14222.

[7] C. Simal, T. Lebl, A. M. Z. Slawin and A. D. Smith, *Angew. Chem. Int. Ed.*, 2012, **51**, 3653.

6. Copy of NMR and HPLC for the Compounds



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166.74
153.46
148.99
147.23
131.44
129.74
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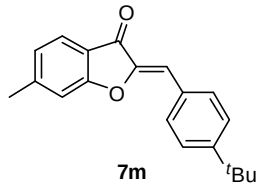
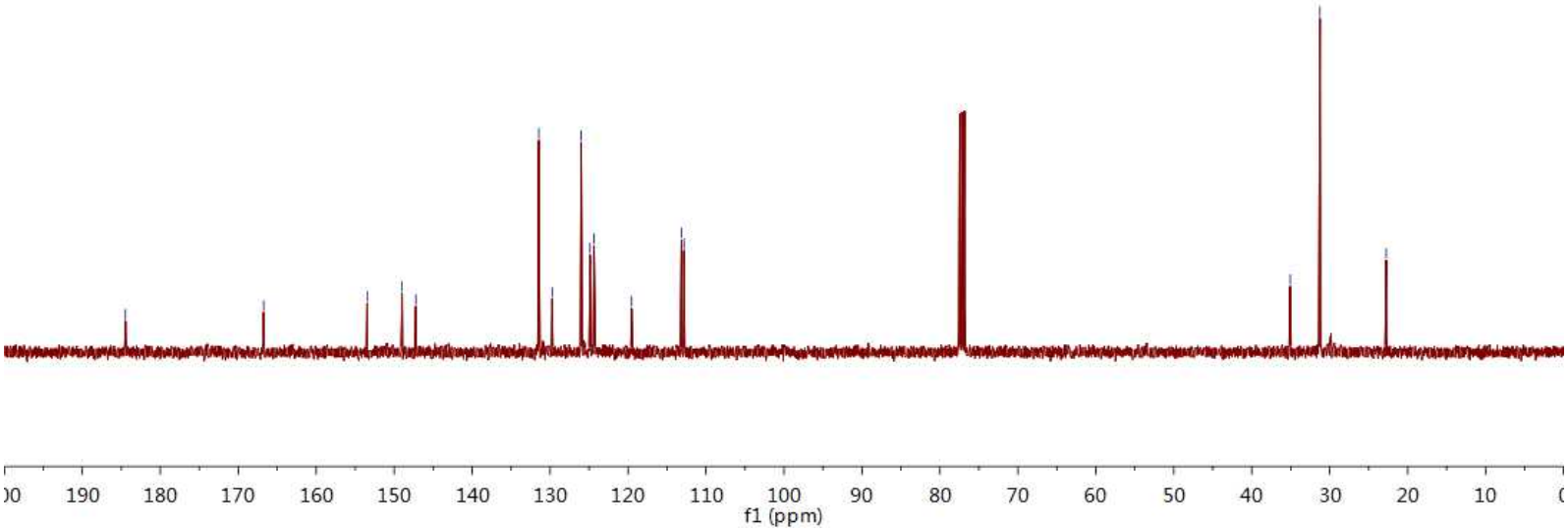
112.83
35.06
31.26
22.76

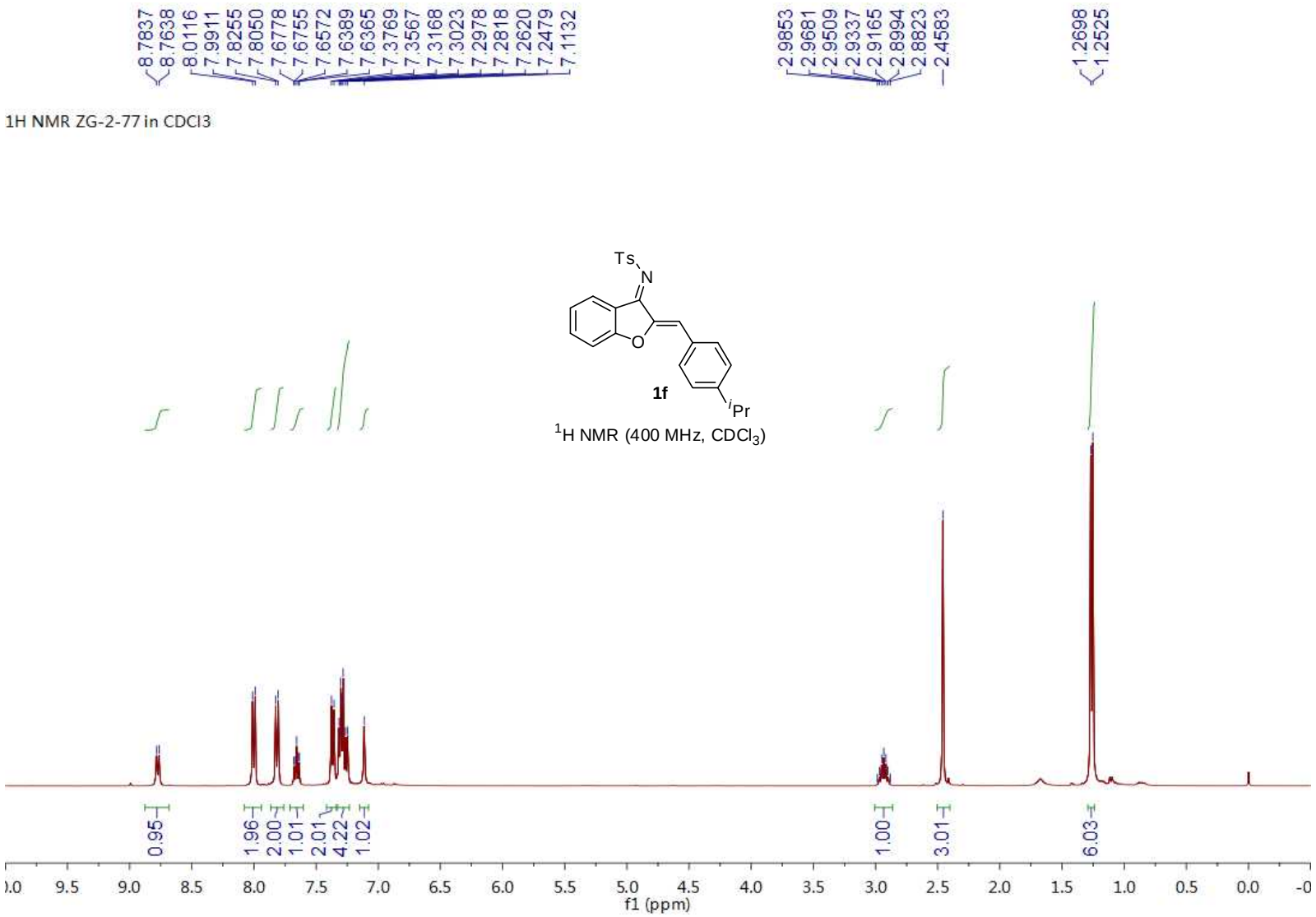
13C NMR ZG-2-83 in CDCl3



7m

^{13}C NMR (101 MHz, $CDCl_3$)

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7.3567
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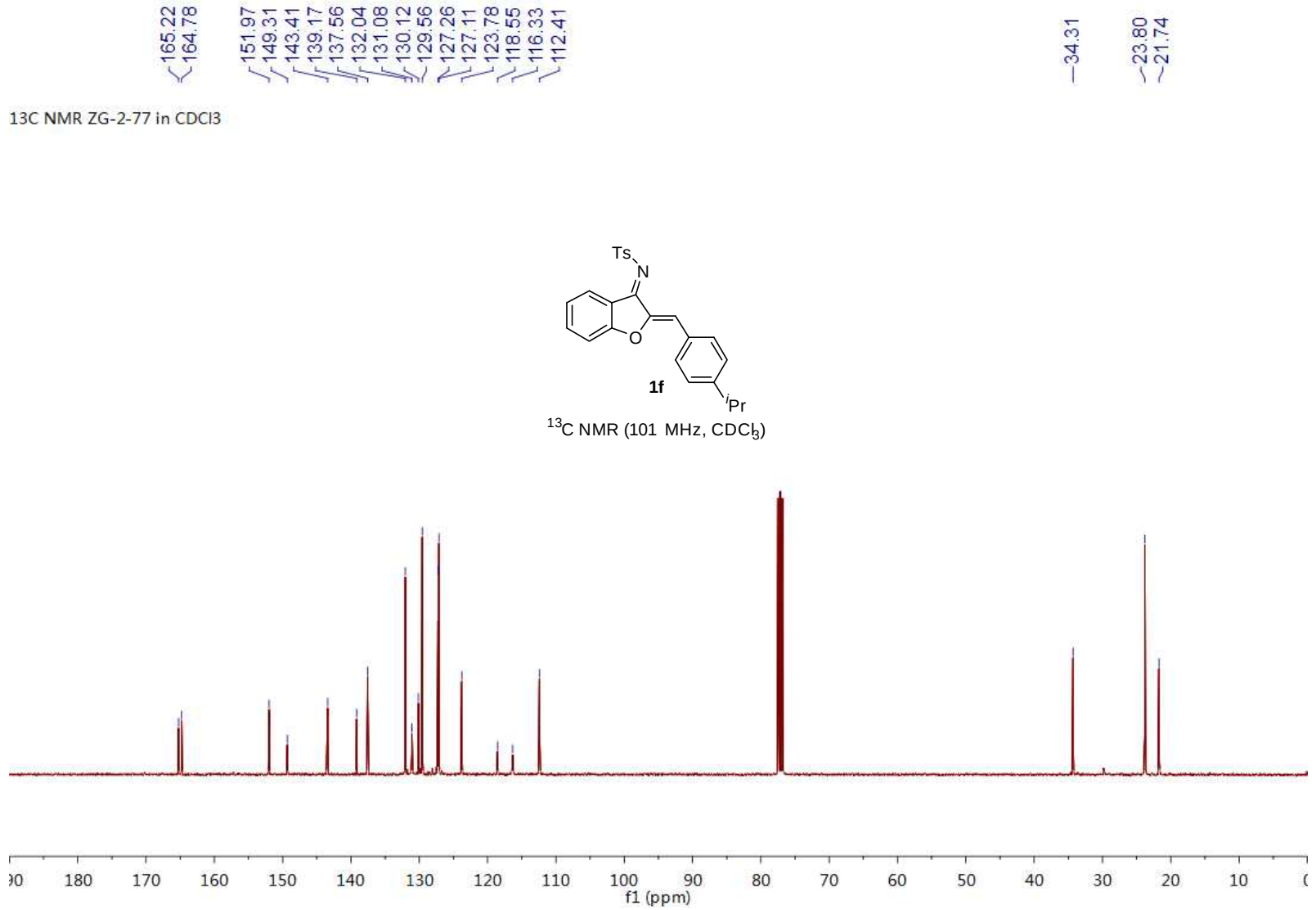
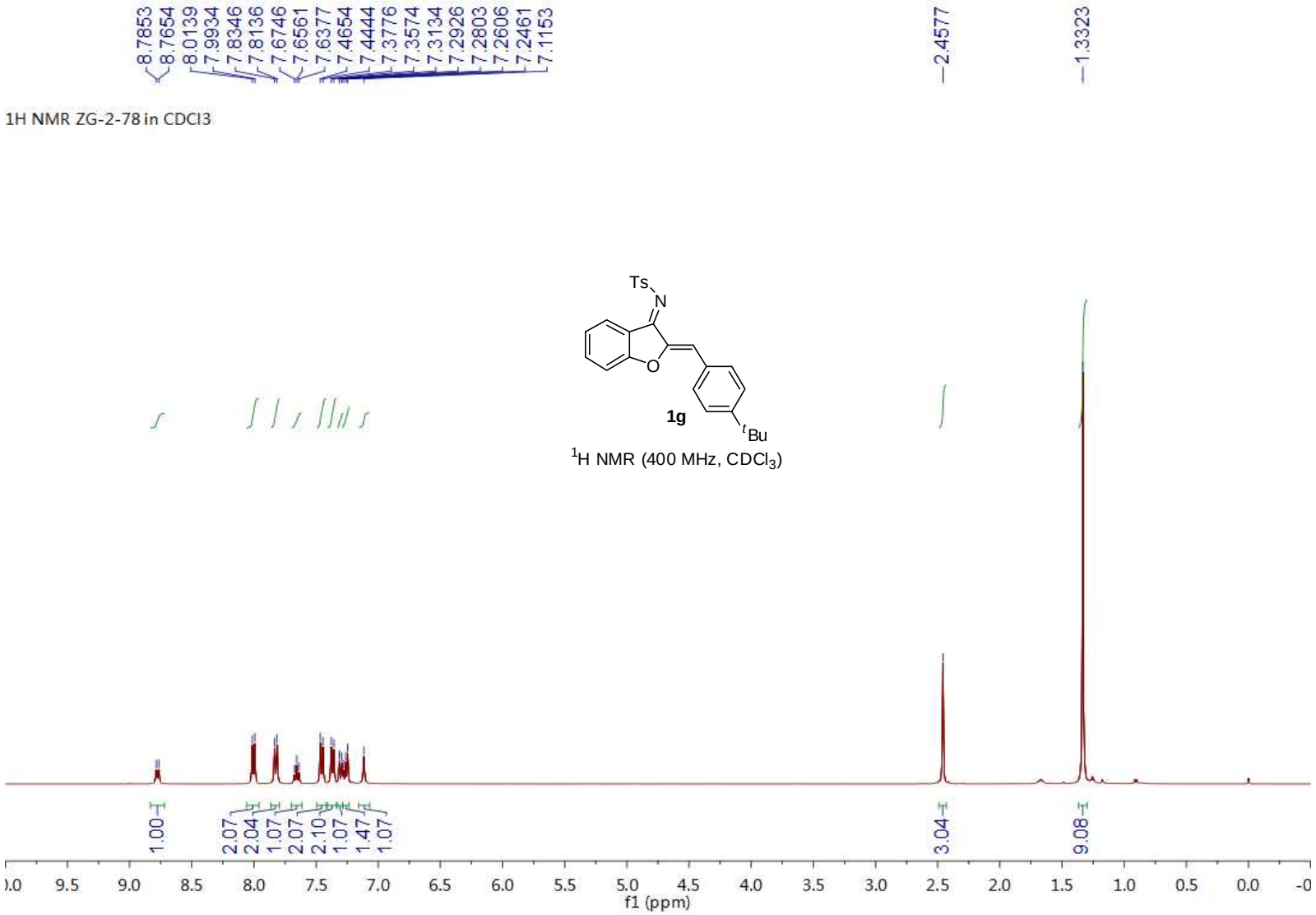
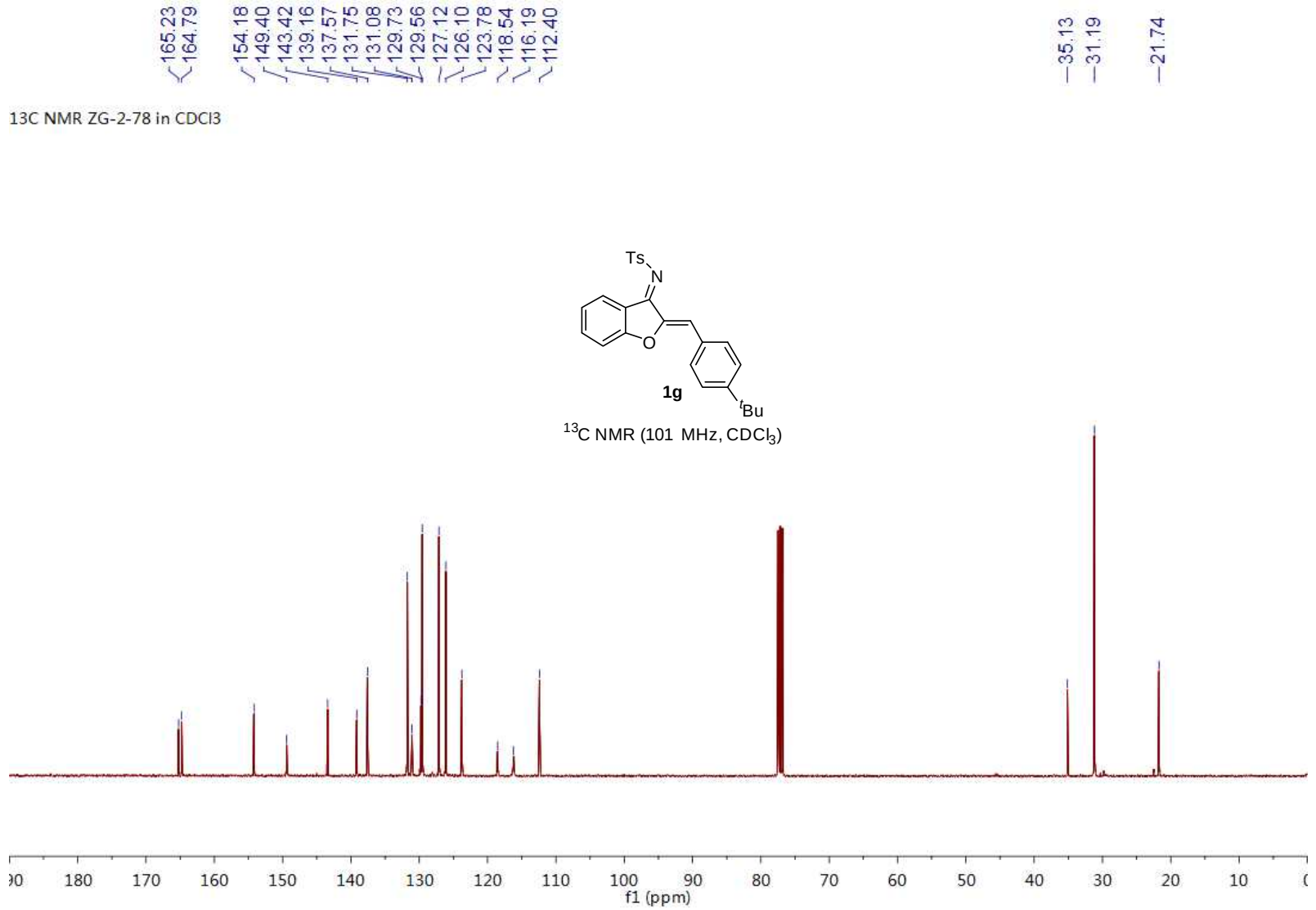
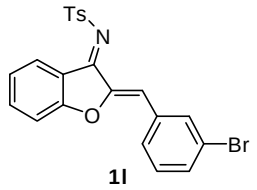
7.2620
7.2479
7.1132
2.9853
2.9681
2.9509
2.9337
2.9165
2.8994
2.8823
2.4583
1.2698
1.2525
1H NMR ZG-2-77 in CDCl3
Ts
N
O
1f
iPr
1H NMR (400 MHz, CDCl3)
0.95
1.96
2.00
1.01
2.01
4.22
1.02
1.00
3.01
6.03
f1 (ppm)


165.22
164.78
151.97
149.31
143.41
139.17
137.56
132.04
131.08
130.12
129.56
127.26
127.11
123.78
118.55
116.33
112.41
34.31
23.80
21.74
13C NMR ZG-2-77 in CDCl3
Ts
N
O
1f
iPr
13C NMR (101 MHz, CDCl3)
f1 (ppm)


8.7853
8.7654
8.0139
7.9934
7.8346
7.8136
7.6746
7.6561
7.6377
7.4654
7.4444
7.3776
7.3574
7.3134
7.2926
7.2803
7.2606
7.2461
7.1153
2.4577
1.3323
1H NMR ZG-2-78 in CDCl3
Ts
N
O
1g
tBu
1H NMR (400 MHz, CDCl3)
1.00
2.07
2.04
1.07
2.07
2.10
1.07
1.47
1.07
3.04
9.08
f1 (ppm)

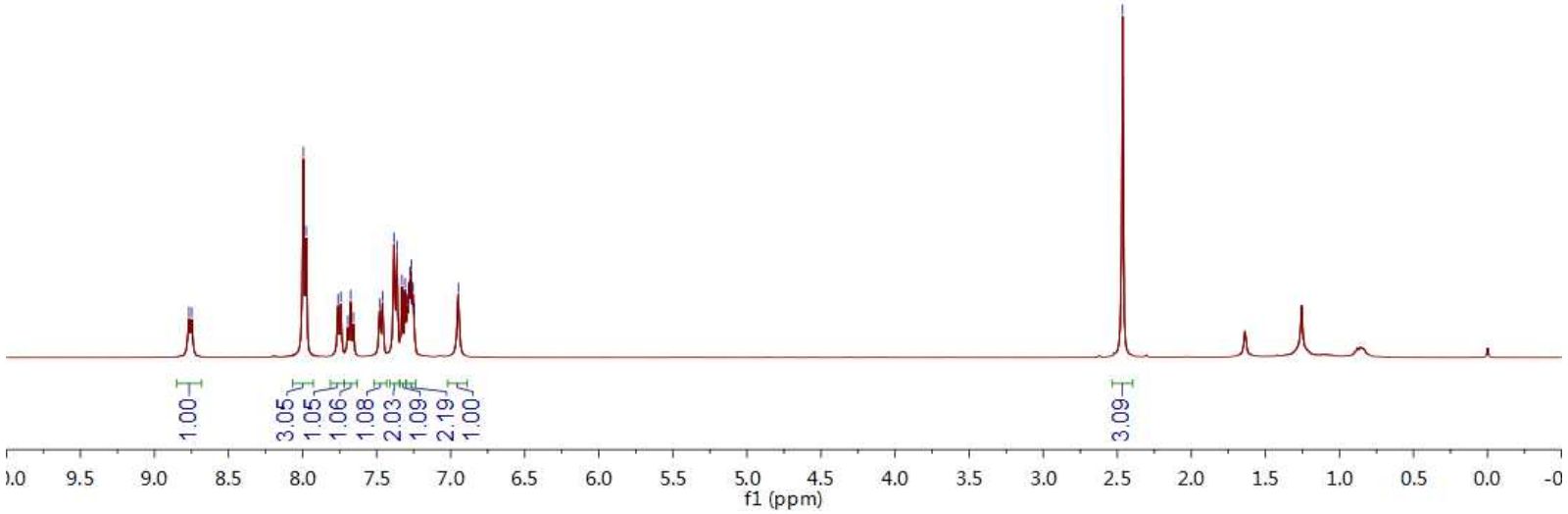

165.23
164.79
154.18
149.40
143.42
139.16
137.57
131.75
131.08
129.73
129.56
127.12
126.10
123.78
118.54
116.19
112.40
35.13
31.19
21.74
13C NMR ZG-2-78 in CDCl3
Ts
N
O
1g
tBu
13C NMR (101 MHz, CDCl3)
f1 (ppm)

1H NMR ZG-2-55 in CDCl3

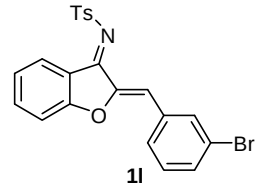


1l

^{1}H NMR (400 MHz, $CDCl_3$)

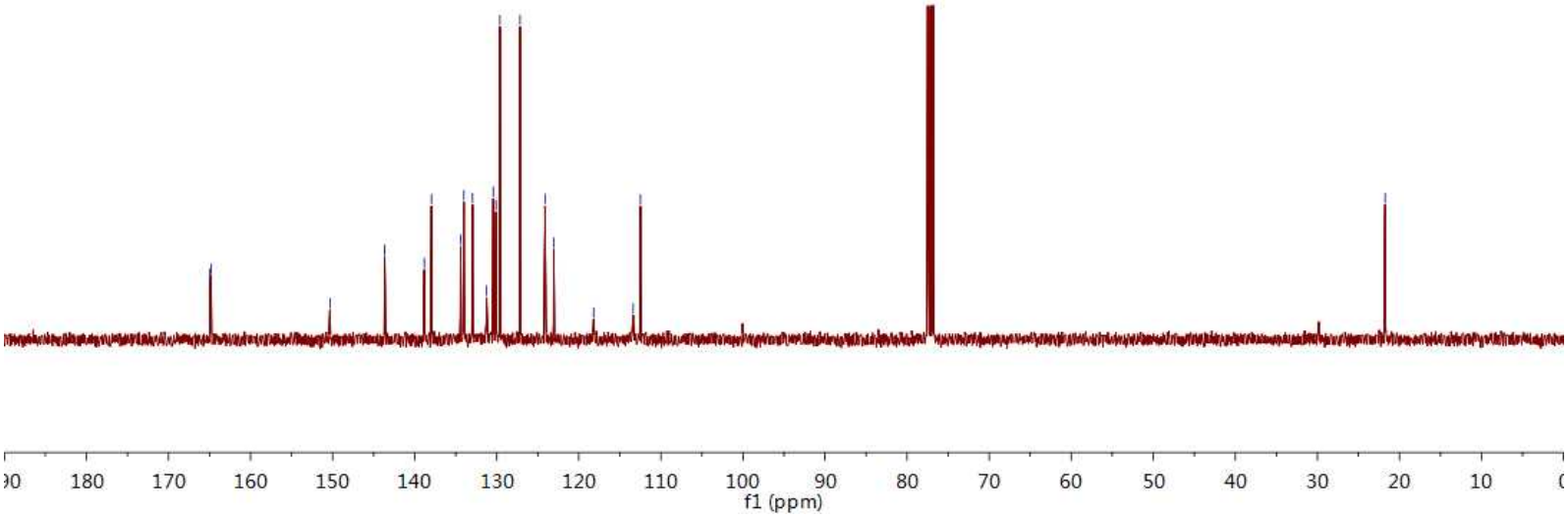


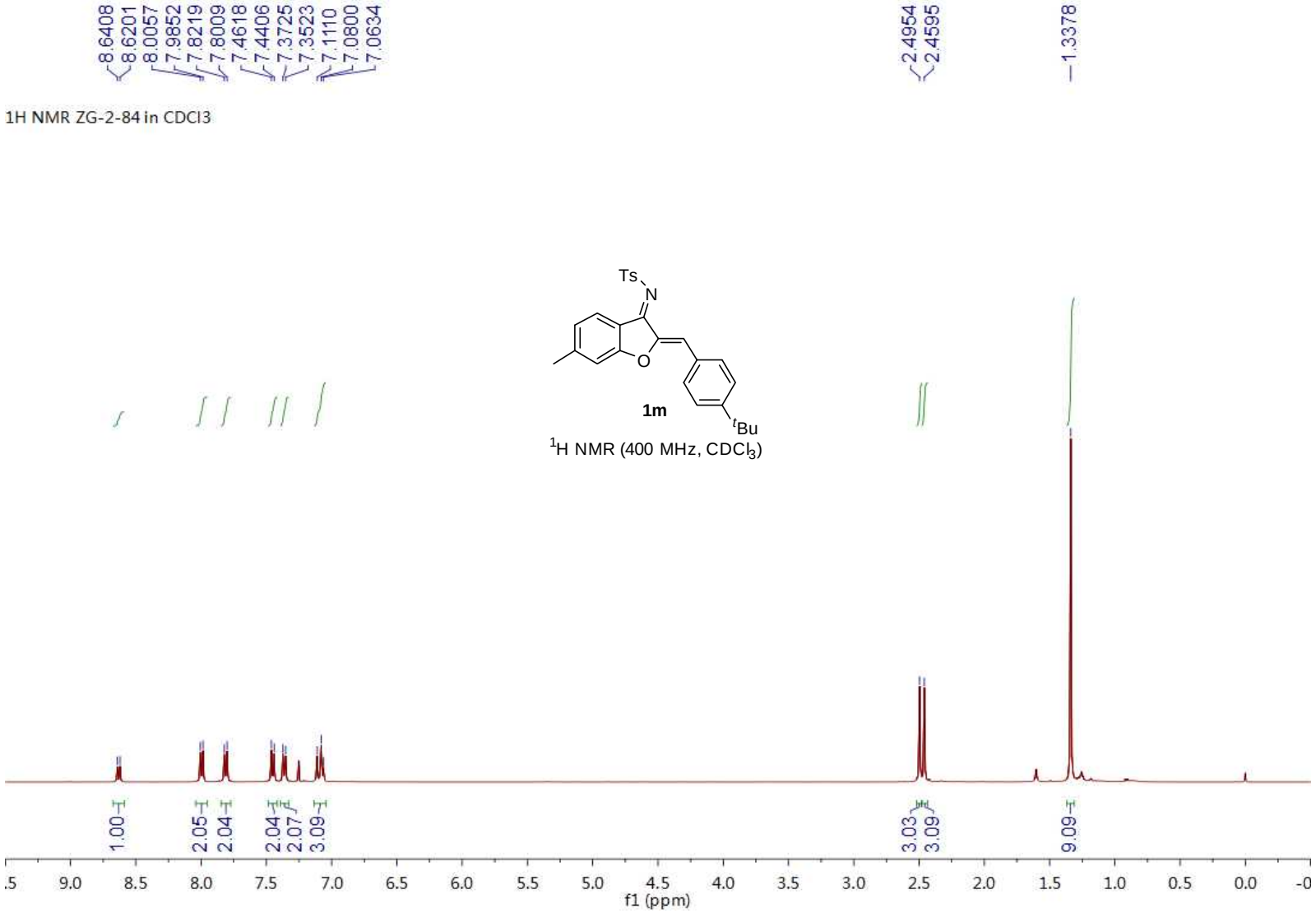
13C NMR ZG-2-55 in CDCl3



1l

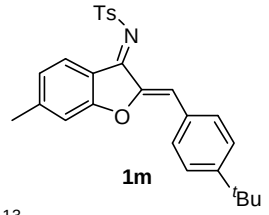
^{13}C NMR (101 MHz, $CDCl_3$)



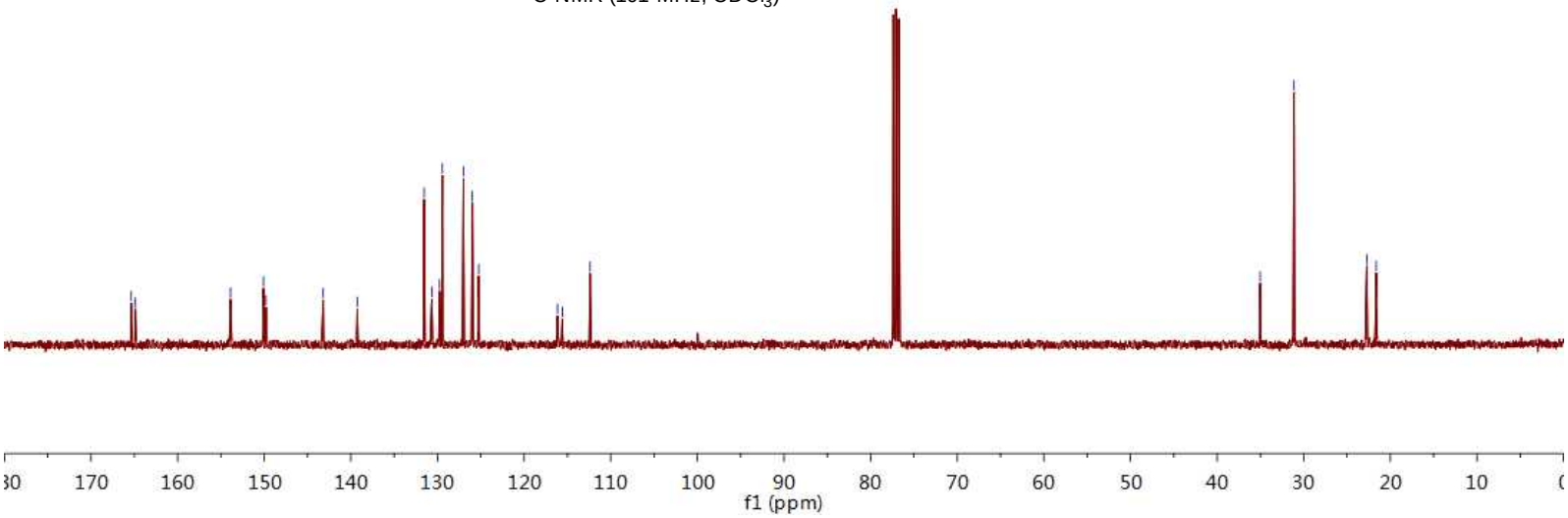

8.6408
8.6201
8.0057
7.9852
7.8219
7.8009
7.4618
7.4406
7.3725
7.3523
7.1110
7.0800
7.0634
2.4954
2.4595
1.3378
1H NMR ZG-2-84 in CDCl3
Ts
N
O
1m
tBu
1H NMR (400 MHz, CDCl3)
1.00
2.05
2.04
2.04
2.07
3.09
3.03
3.09
9.09
f1 (ppm)

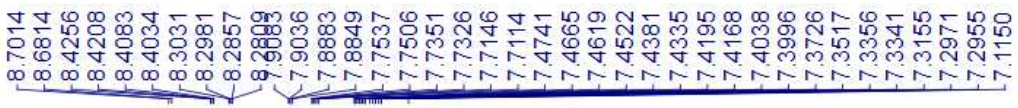
165.36
164.88
153.89
150.08
149.79
143.19
139.26
131.55
129.76
129.44
127.01
125.98
125.24
116.15
115.59
112.39
35.03
31.12
22.72
21.64

13C NMR ZG-2-84 in CDCl3

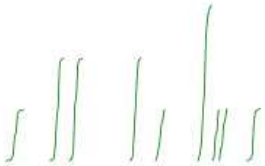


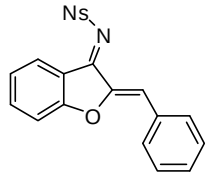
^{13}C NMR (101 MHz, $CDCl_3$)





1H NMR ZG-2-68 in CDCl3

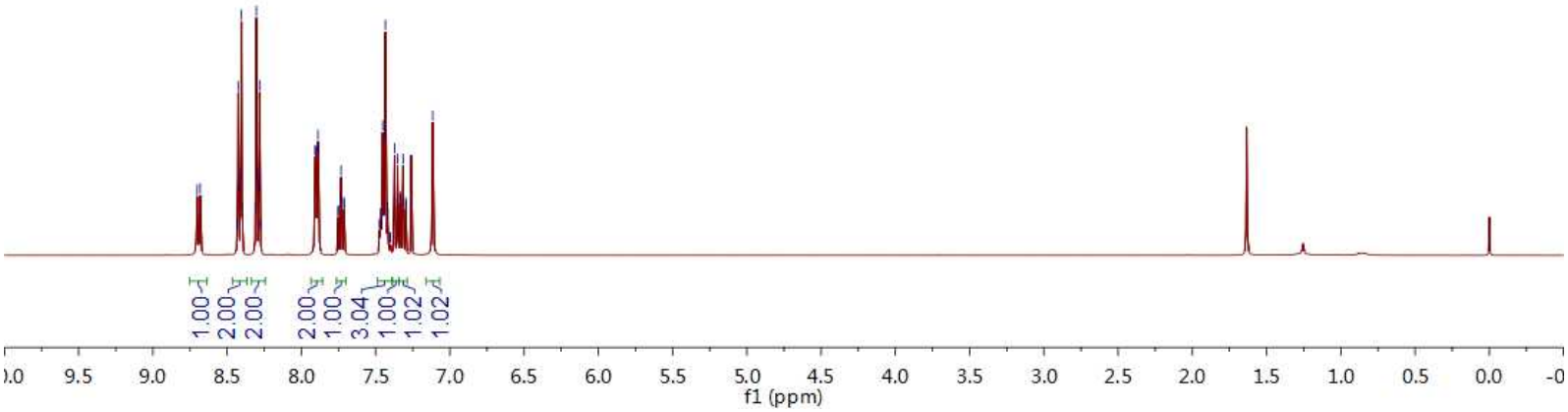




Ns = 4-$NO_2C_6H_4SO_2$

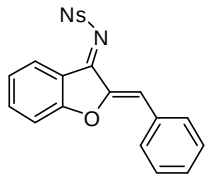
1o

^{1}H NMR (400 MHz, $CDCl_3$)



166.16
165.10
150.11
149.48
147.49
138.49
132.12
132.10
130.98
130.80
129.18
128.47
124.28
124.20
118.36
117.42
112.71

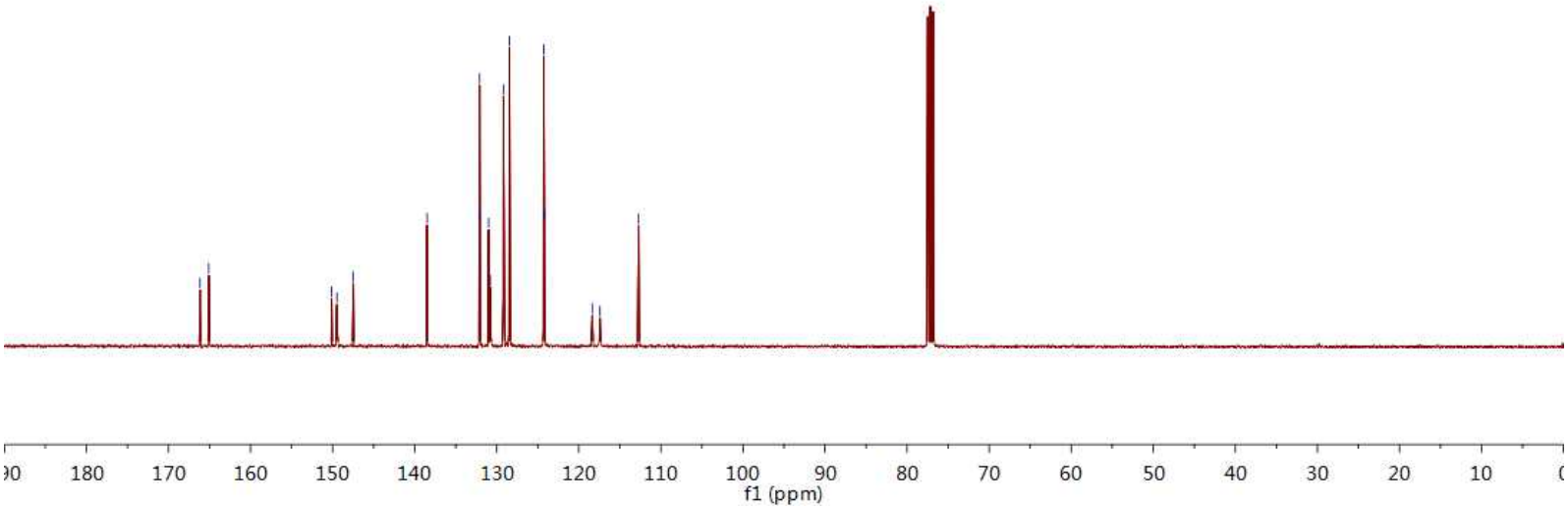
13C NMR ZG-2-68 in CDCl3



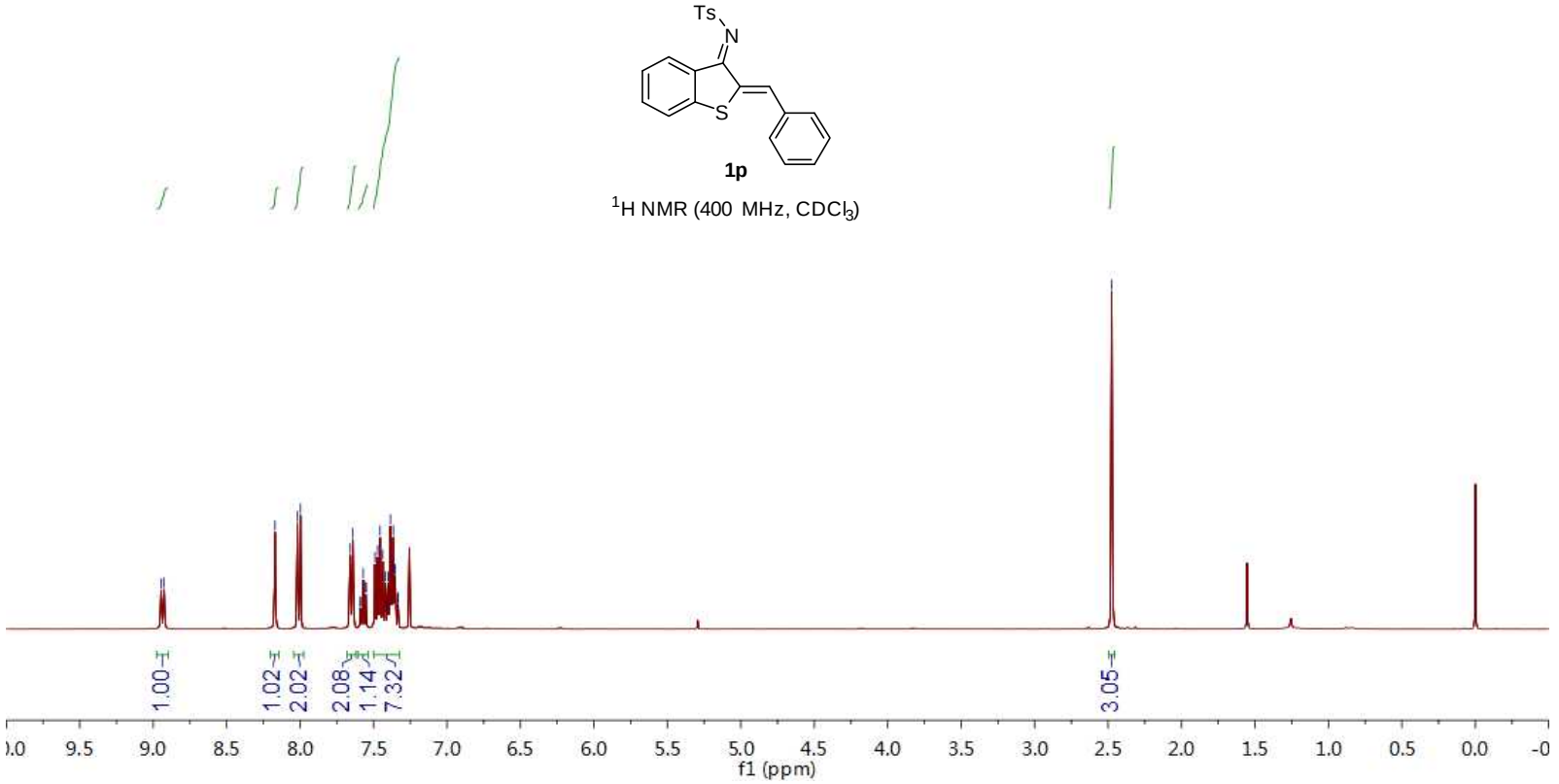
Ns = 4-$NO_2C_6H_4SO_2$

1o

^{13}C NMR (101 MHz, $CDCl_3$)



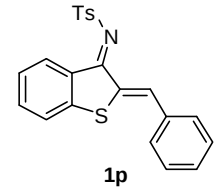
1H NMR ZG-3-35 in CDCl3



1p

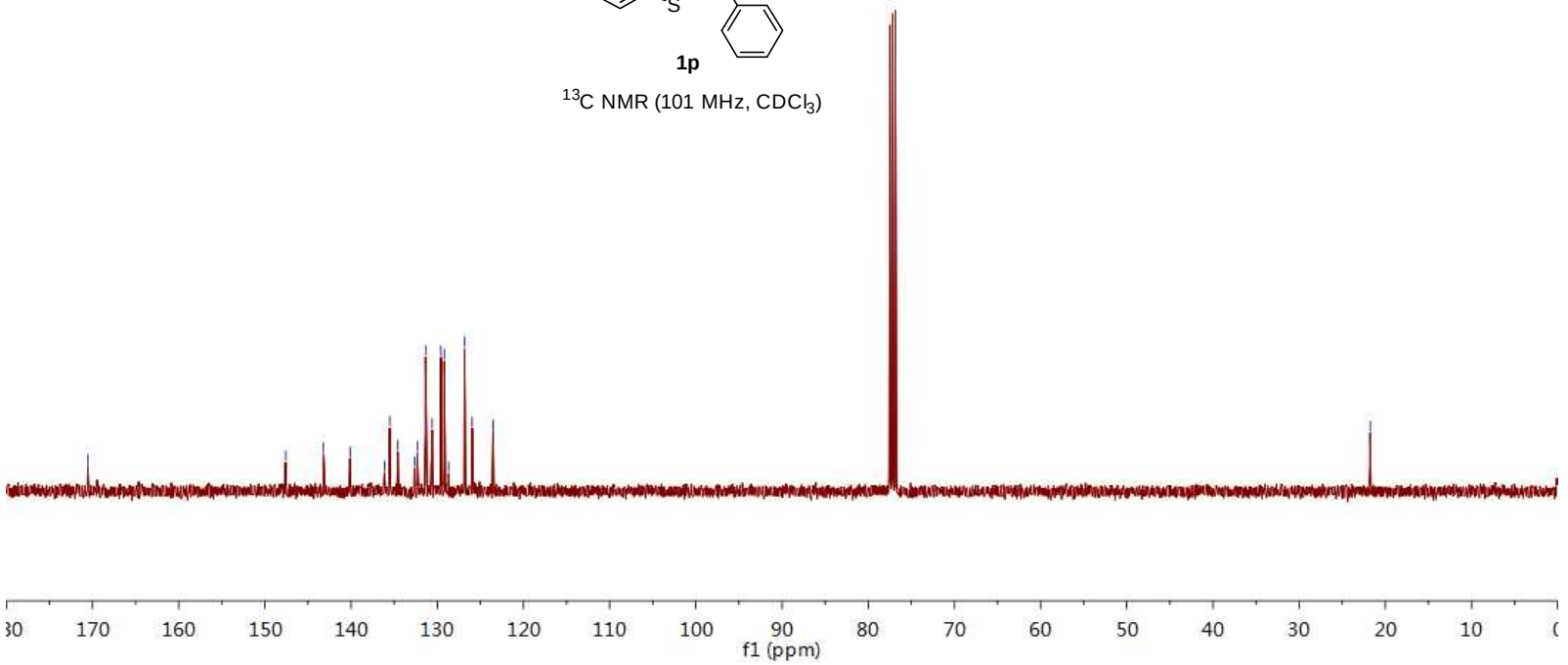
^{1}H NMR (400 MHz, $CDCl_3$)

13C NMR ZG-3-35 in CDCl3

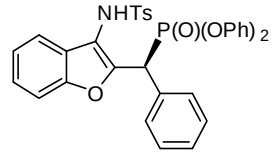


1p

^{13}C NMR (101 MHz, $CDCl_3$)

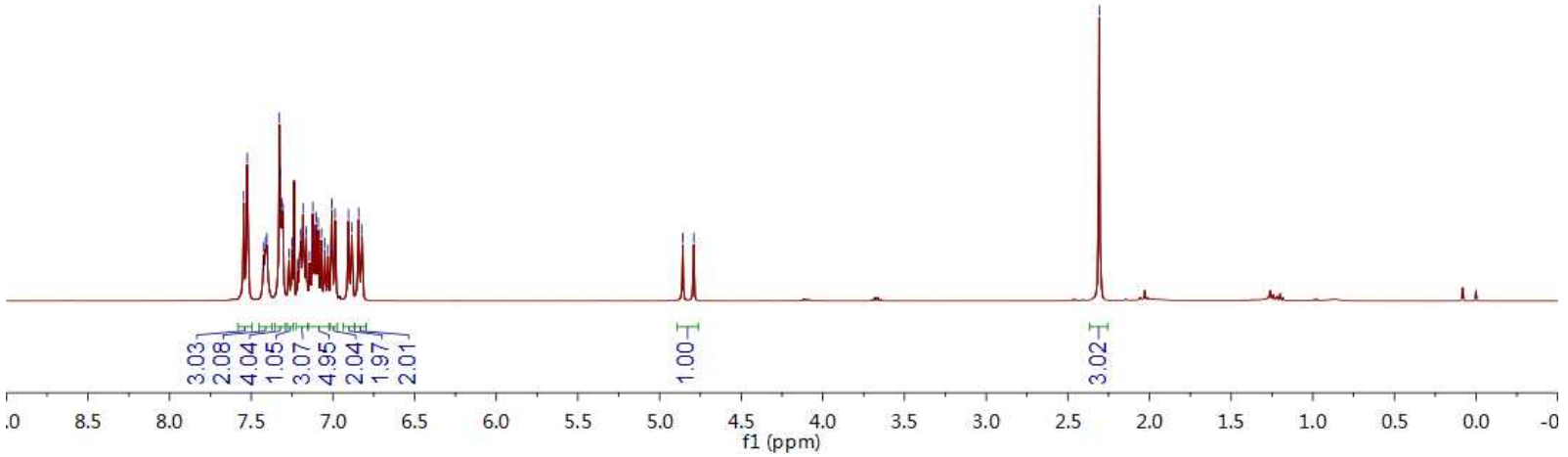


1H NMR ZG-2-61A in CDCl3

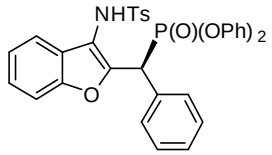


3aa

^{1}H NMR (400 MHz, $CDCl_3$)

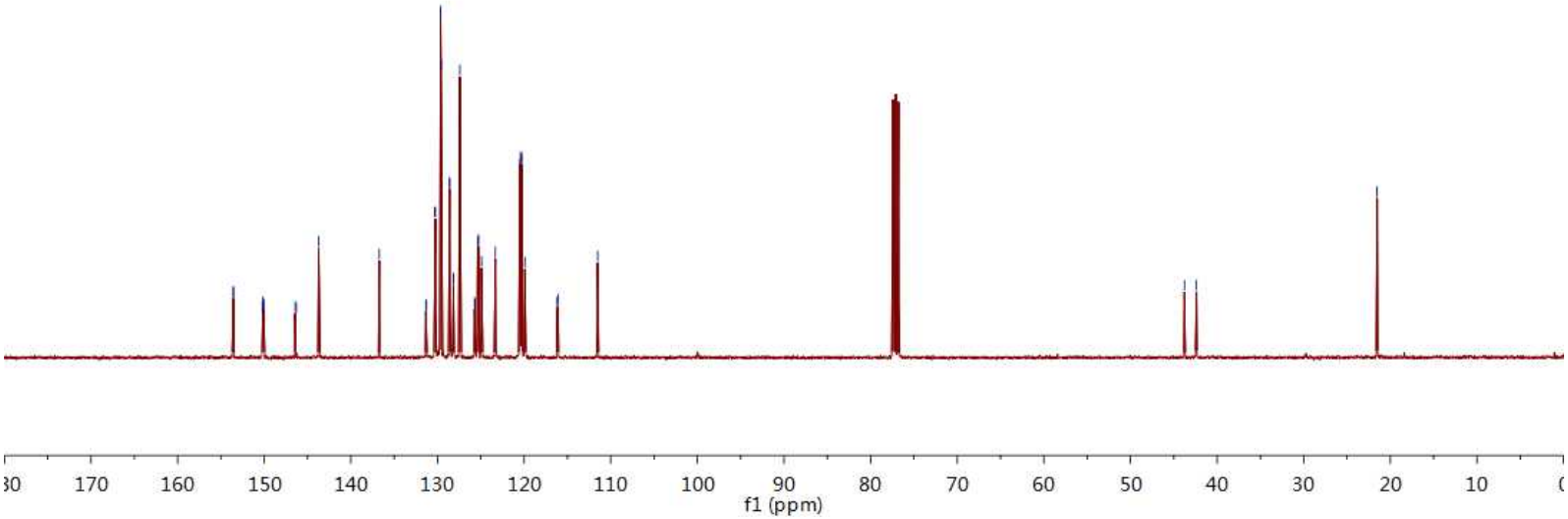


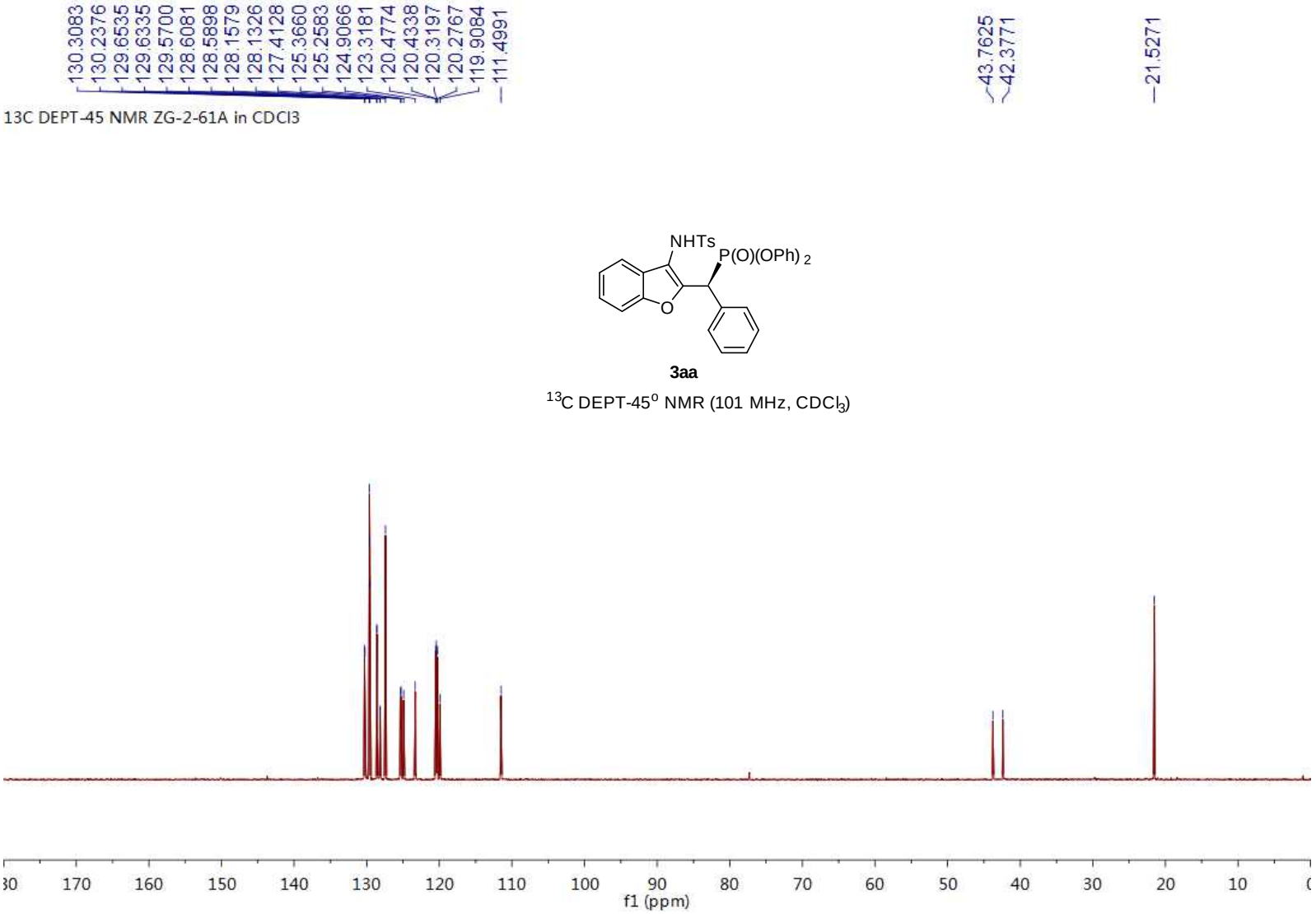
13C NMR ZG-2-61A in CDCl3



3aa

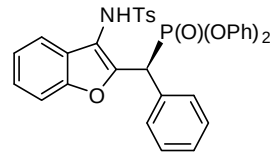
^{13}C NMR (101 MHz, $CDCl_3$)




130.3083
130.2376
129.6535
129.6335
129.5700
128.6081
128.5898
128.1579
128.1326
127.4128
125.3660
125.2583
124.9066
123.3181
120.4774
120.4338
120.3197
120.2767
119.9084
111.4991
43.7625
42.3771
21.5271
13C DEPT-45 NMR ZG-2-61A in CDCl3
NHTs
P(O)(OPh) 2
O
3aa
13C DEPT-45o NMR (101 MHz, CDCl3)
f1 (ppm)

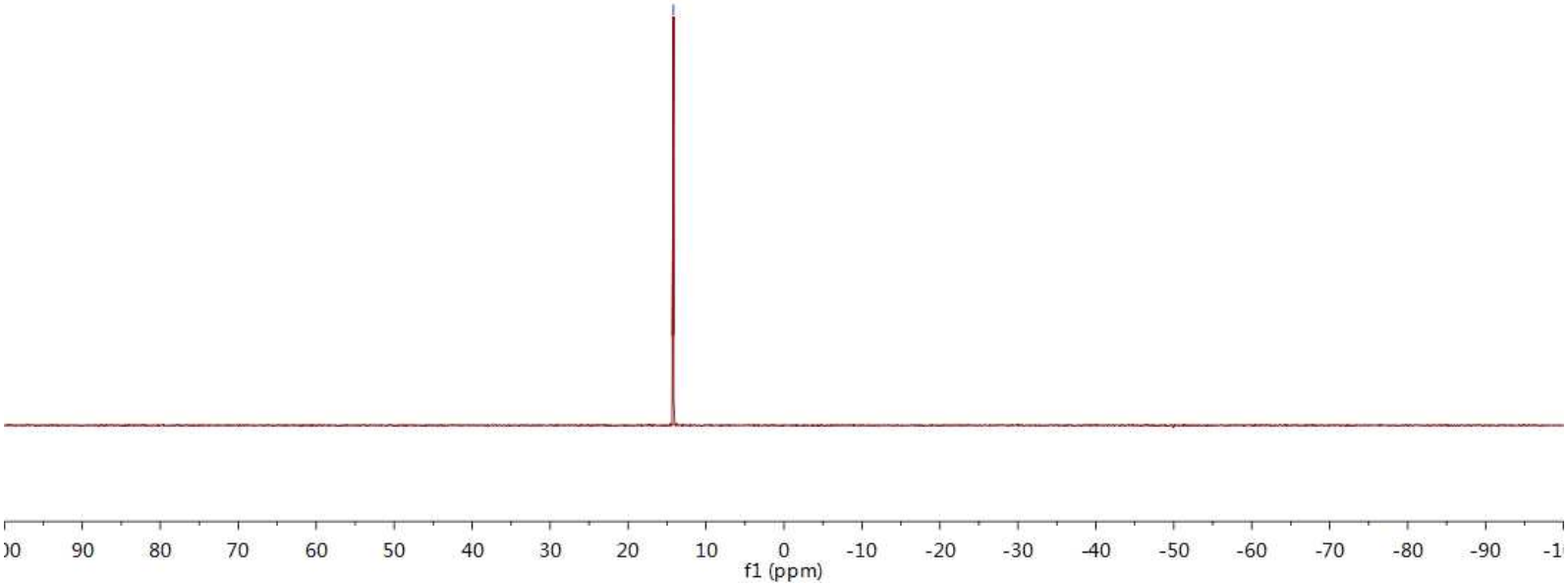
14.19

31P NMR ZG-2-61A in CDCl3

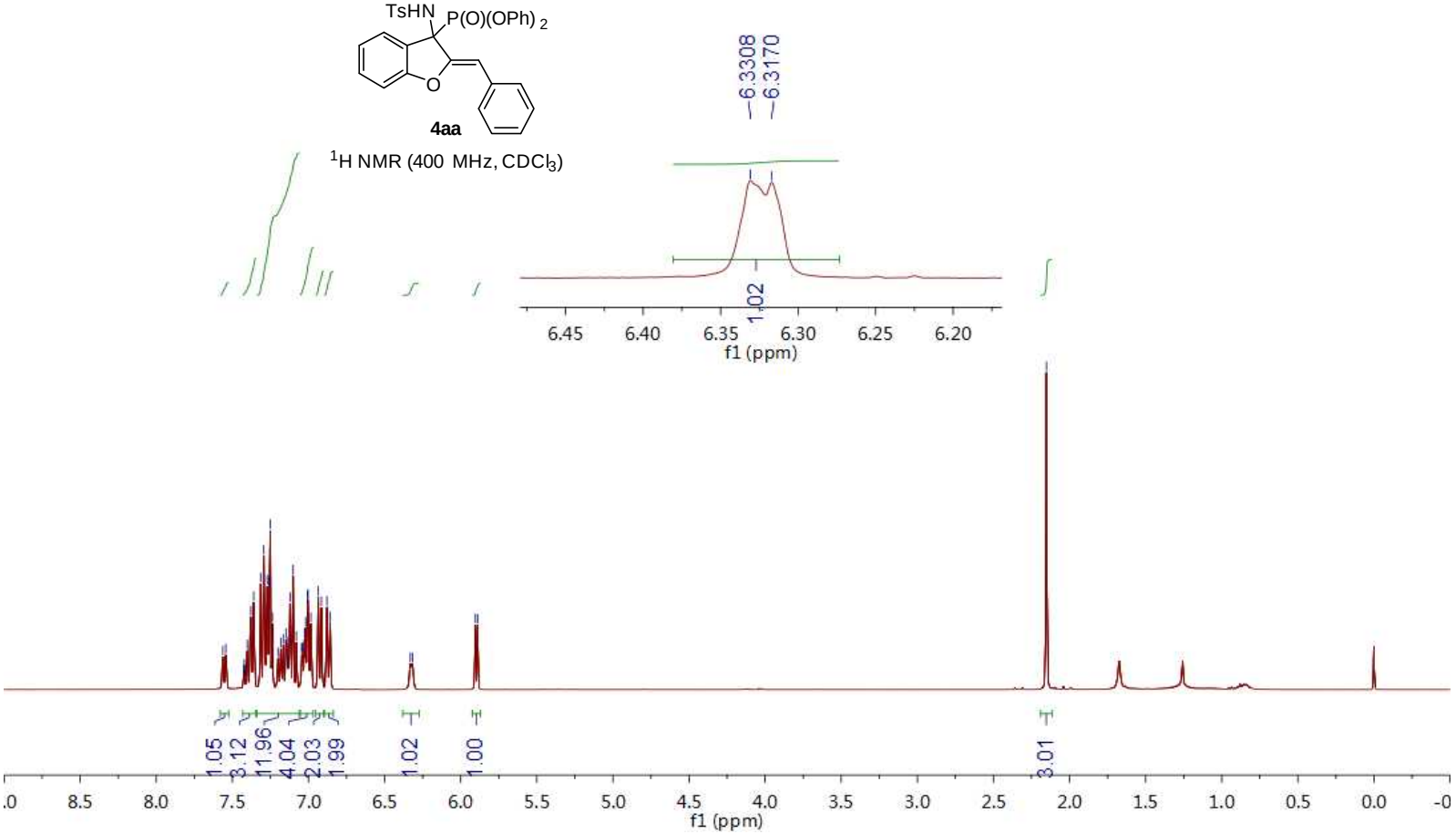


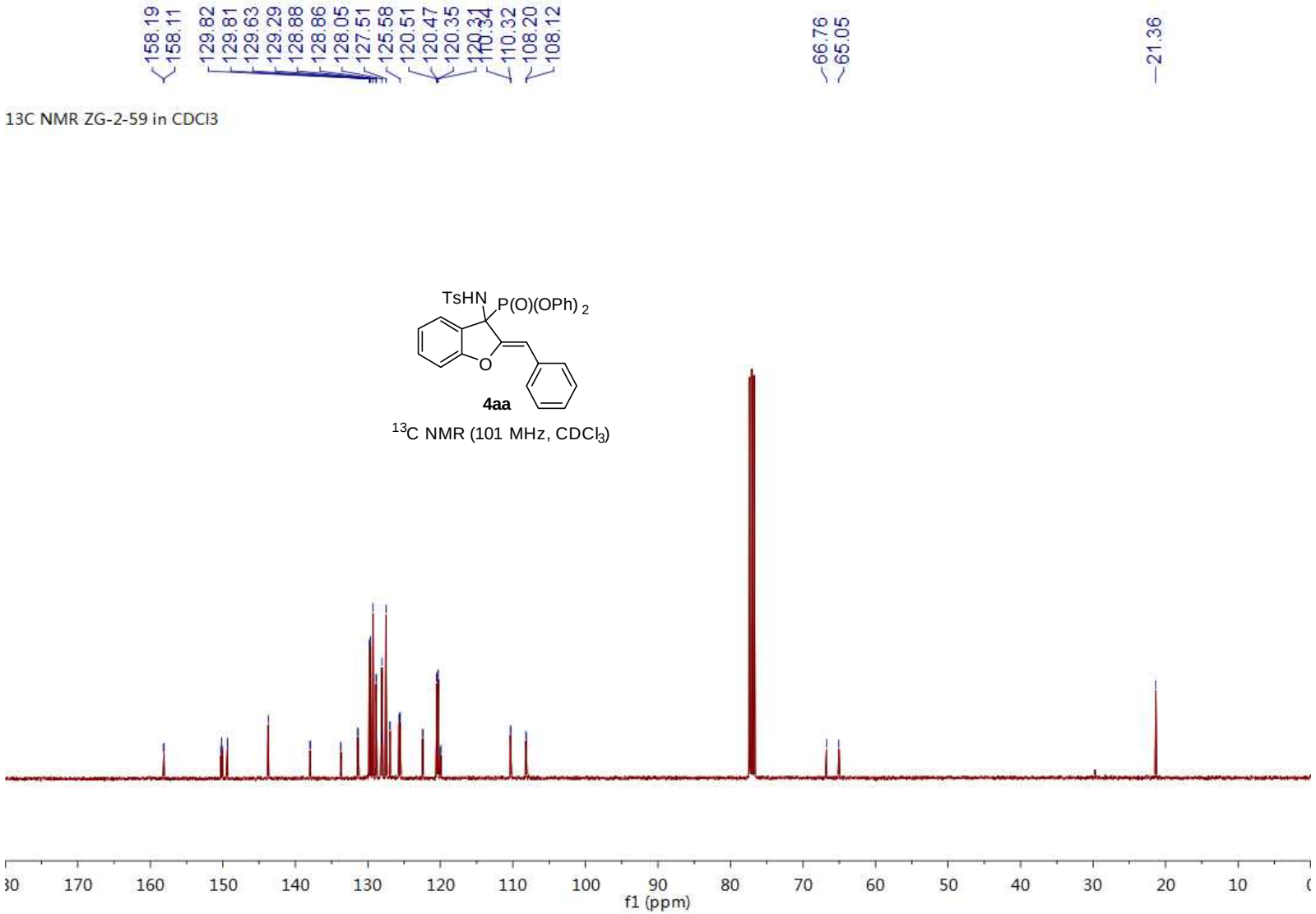
3aa

^{31}P NMR (162 MHz, $CDCl_3$)

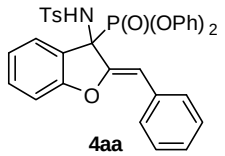


1H NMR ZG-2-59 in CDCl3



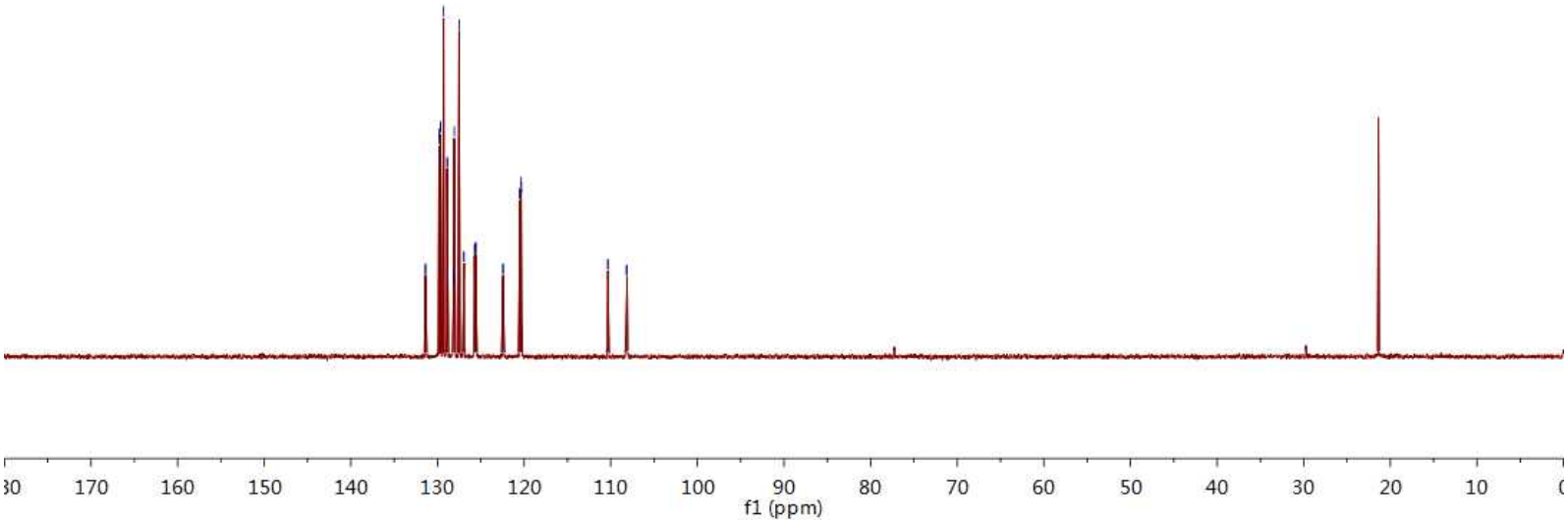

158.19
158.11
129.82
129.81
129.63
129.29
128.88
128.86
128.05
127.51
125.58
120.51
120.47
120.35
120.31
110.34
110.32
108.20
108.12
66.76
65.05
21.36
13C NMR ZG-2-59 in CDCl3
TsHN
P(O)(OPh)2
O
4aa
13C NMR (101 MHz, CDCl3)
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

13C DEPT-45 NMR ZG-2-59 in CDCl3

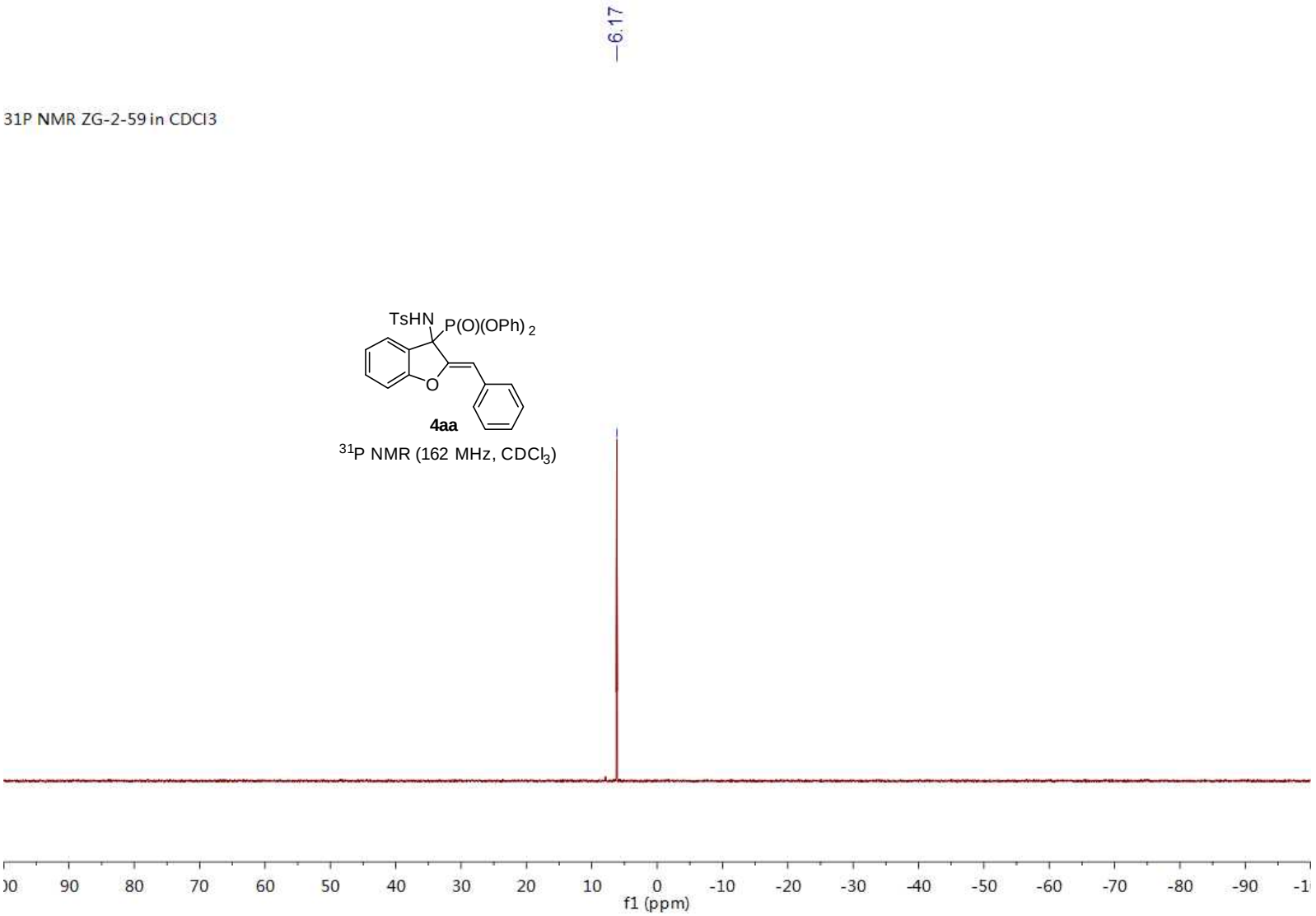


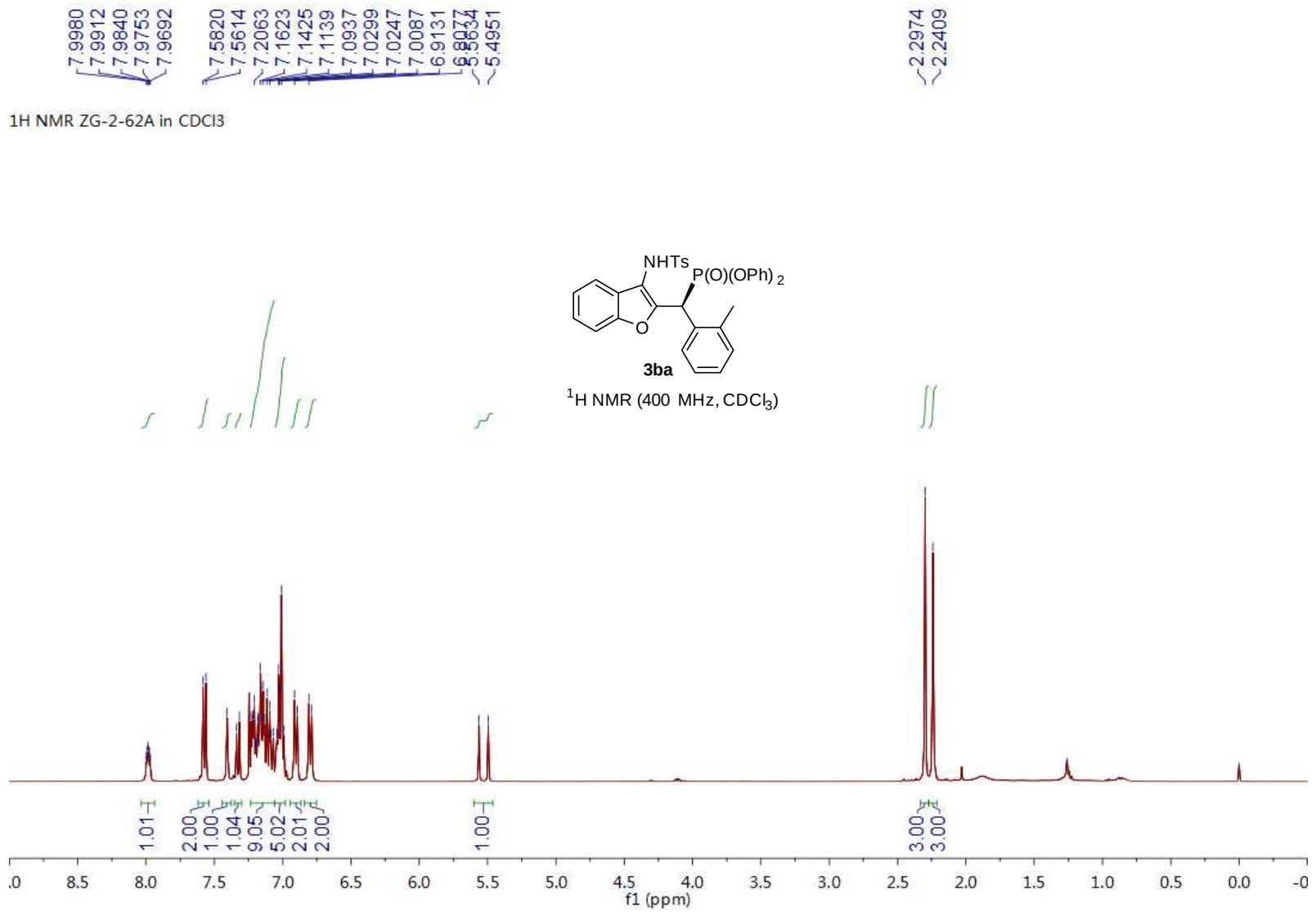
4aa

^{13}C DEPT-45^{o} NMR (101 MHz, $CDCl_3$)

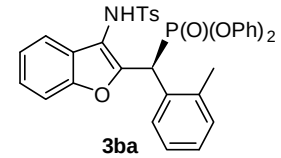


31P NMR ZG-2-59 in CDCl3



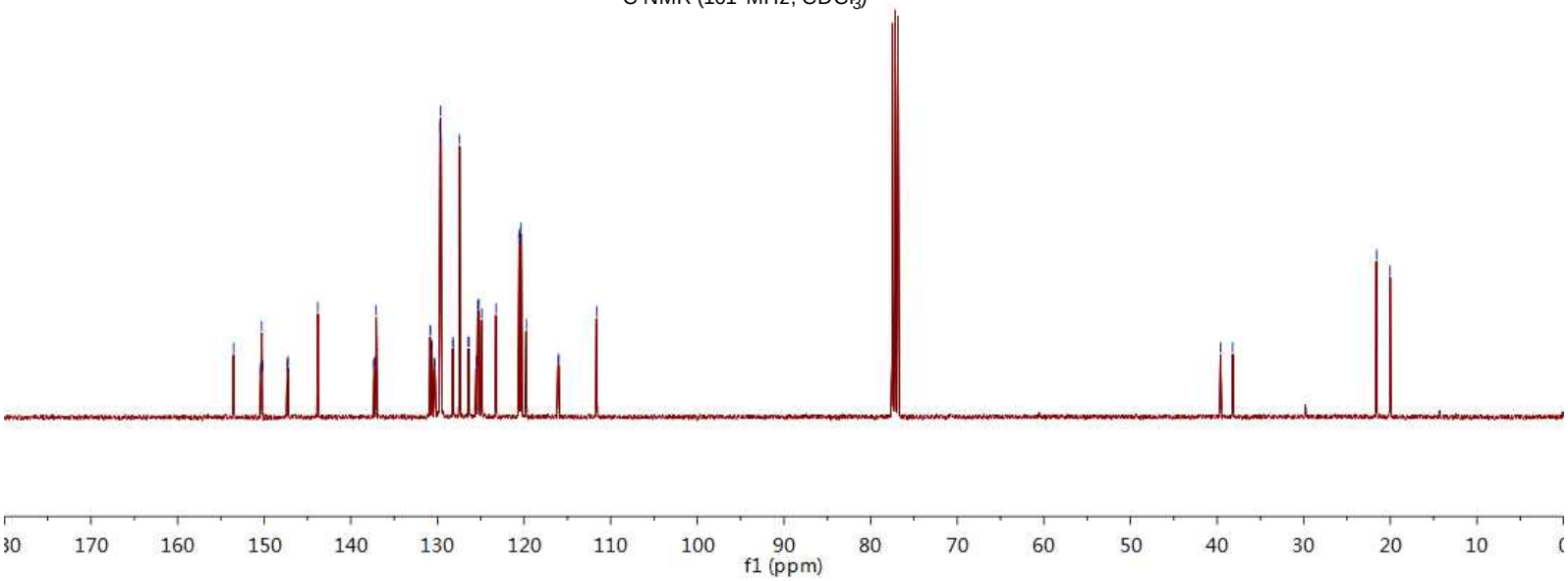

7.9980
7.9912
7.9840
7.9753
7.9692
7.5820
7.5614
7.2063
7.1623
7.1425
7.1139
7.0937
7.0299
7.0247
7.0087
6.9131
5.4951
2.2974
2.2409
1H NMR ZG-2-62A in CDCl3
NHTs
P(O)(OPh) 2
O
3ba
1H NMR (400 MHz, CDCl3)
1.01
2.00
1.00
1.04
9.05
5.02
2.01
2.00
1.00
3.00
3.00
f1 (ppm)

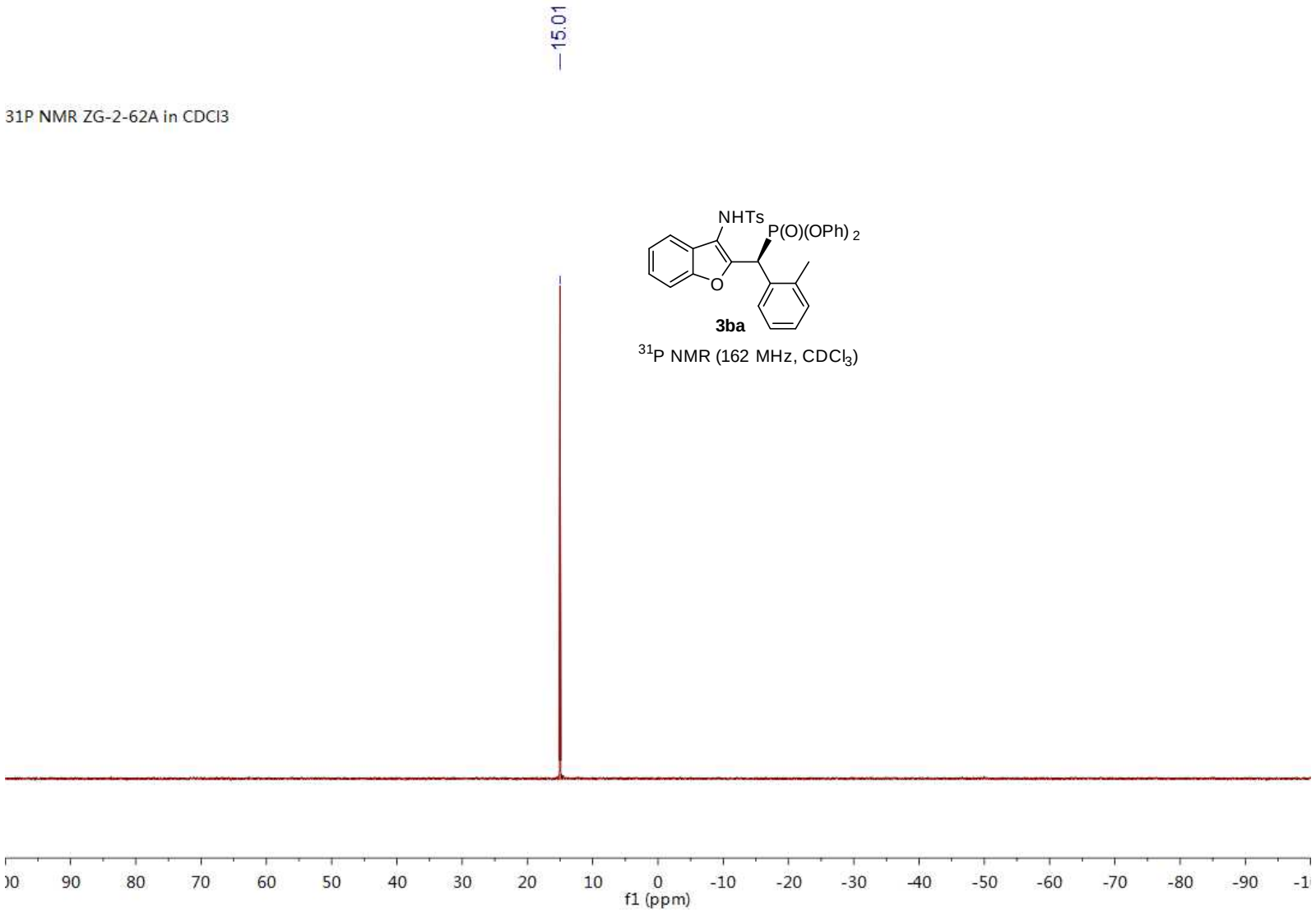
13C NMR ZG-2-62A in CDCl3

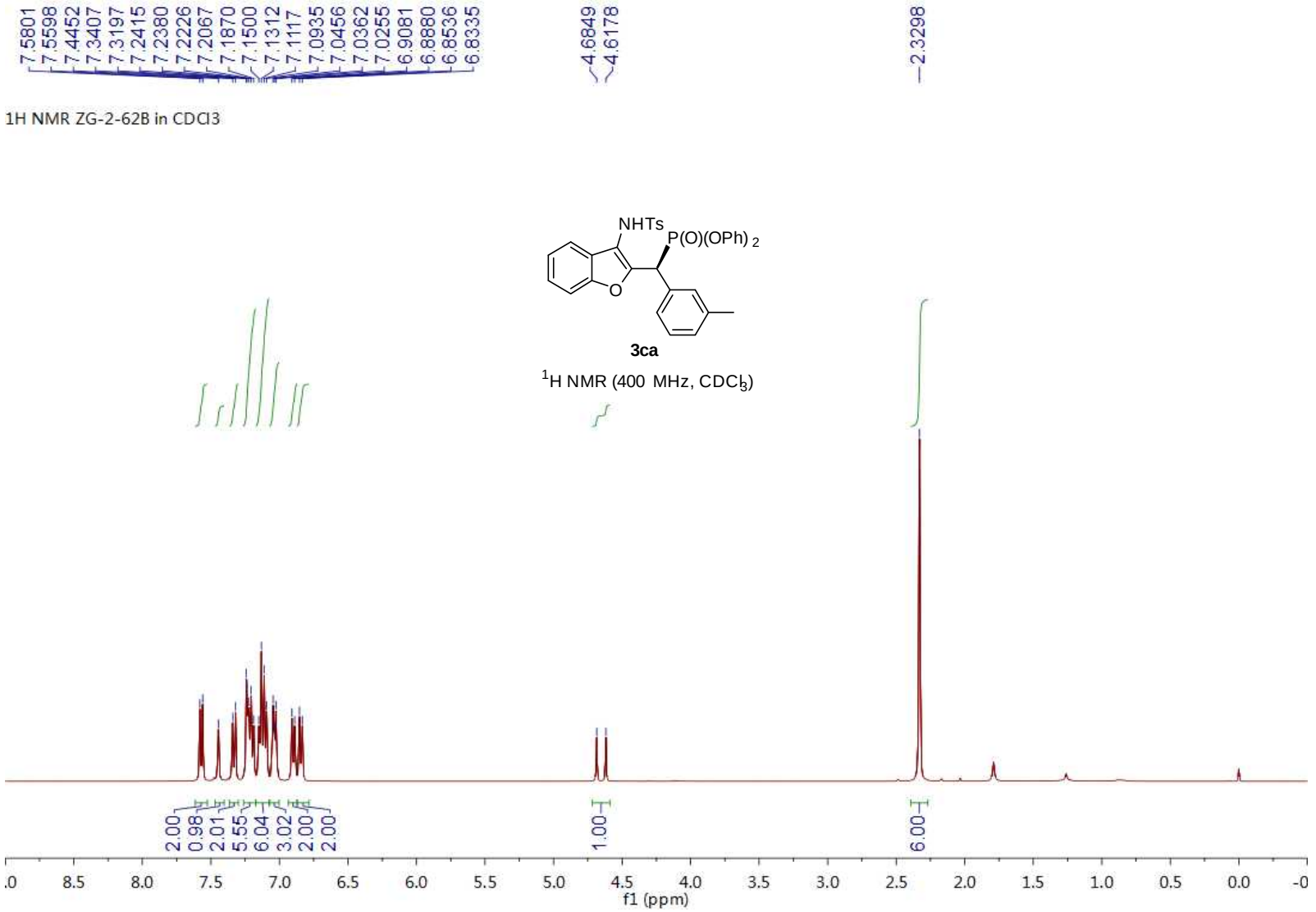


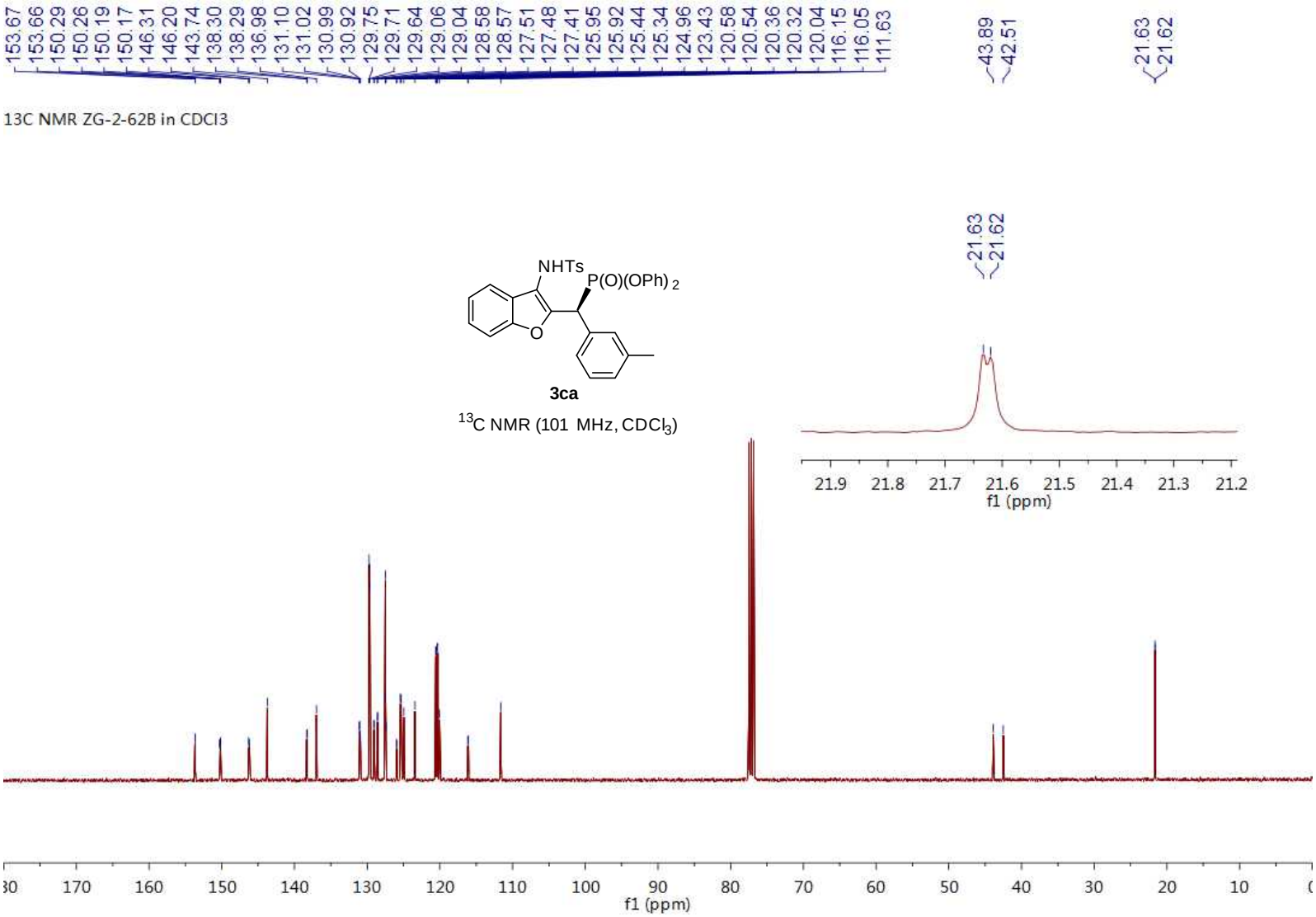
3ba

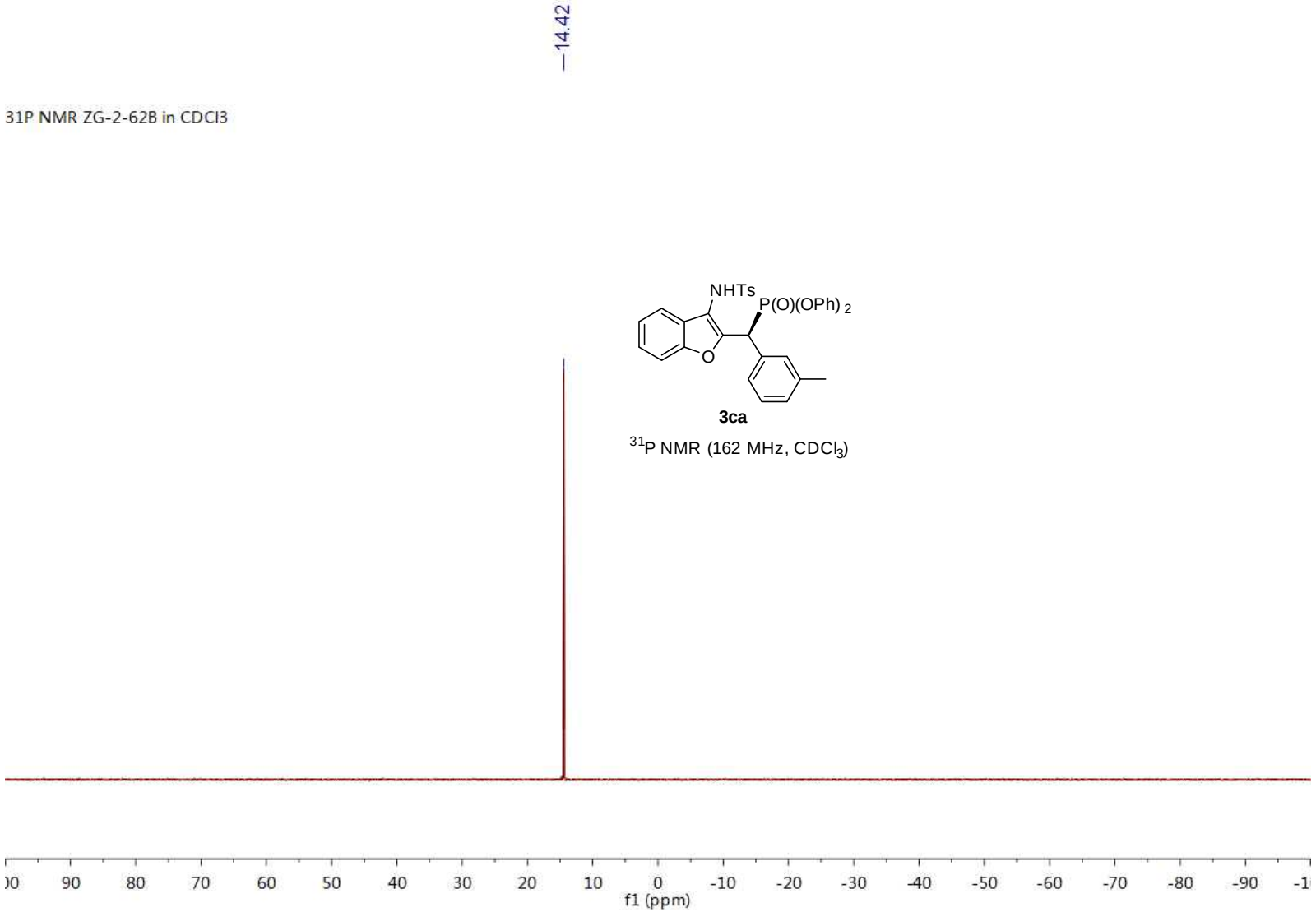
^{13}C NMR (101 MHz, $CDCl_3$)

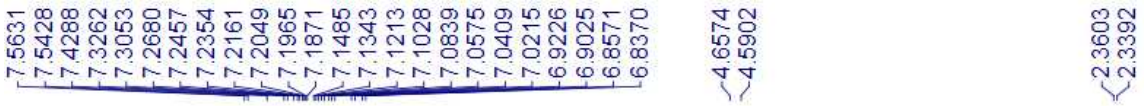



15.01
31P NMR ZG-2-62A in CDCl3
NHTs
P(O)(OPh)2
O
3ba
31P NMR (162 MHz, CDCl3)
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
f1 (ppm)

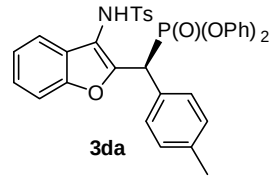

7.5801
7.5598
7.4452
7.3407
7.3197
7.2415
7.2380
7.2226
7.2067
7.1870
7.1500
7.1312
7.1117
7.0935
7.0456
7.0362
7.0255
6.9081
6.8880
6.8536
6.8335
4.6849
4.6178
2.3298
1H NMR ZG-2-62B in CDCl3
NHTs
P(O)(OPh) 2
O
3ca
1H NMR (400 MHz, CDCl3)
2.00
0.98
2.01
5.55
6.04
3.02
2.00
2.00
1.00
6.00
f1 (ppm)


153.67
153.66
150.29
150.26
150.19
150.17
146.31
146.20
143.74
138.30
138.29
136.98
131.10
131.02
130.99
130.92
129.75
129.71
129.64
129.06
129.04
128.58
128.57
127.51
127.48
127.41
125.95
125.92
125.44
125.34
124.96
123.43
120.58
120.54
120.36
120.32
120.04
116.15
116.05
111.63
43.89
42.51
21.63
21.62
13C NMR ZG-2-62B in CDCl3
NHTs
P(O)(OPh)2
O
3ca
13C NMR (101 MHz, CDCl3)
21.63
21.62
21.9
21.8
21.7
21.6
21.5
21.4
21.3
21.2
f1 (ppm)
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)


14.42
31P NMR ZG-2-62B in CDCl3
NHTs
P(O)(OPh)2
O
3ca
31P NMR (162 MHz, CDCl3)
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
f1 (ppm)

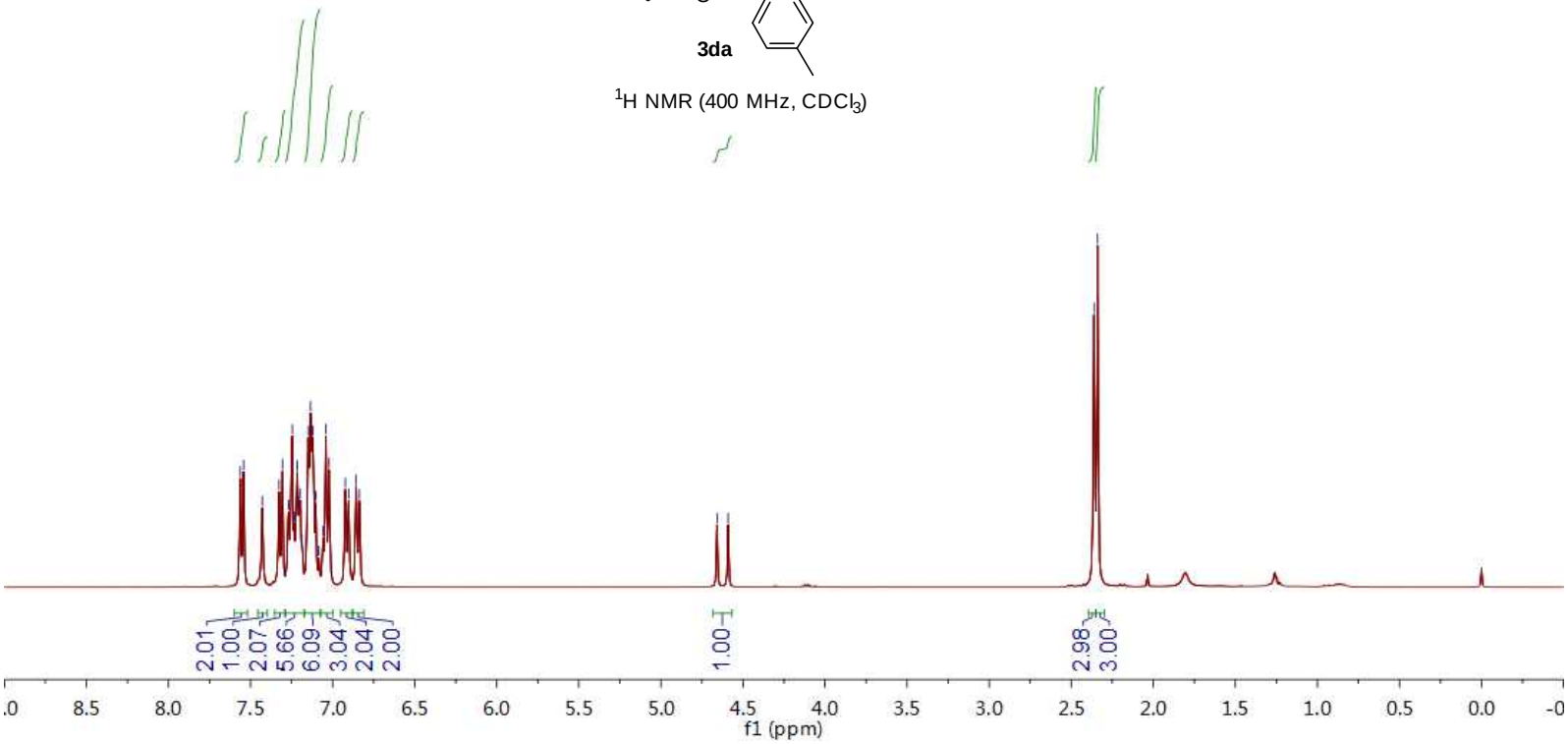


1H NMR ZG-2-62C in CDCl3

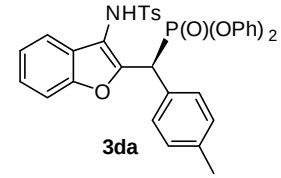


3da

^{1}H NMR (400 MHz, $CDCl_3$)

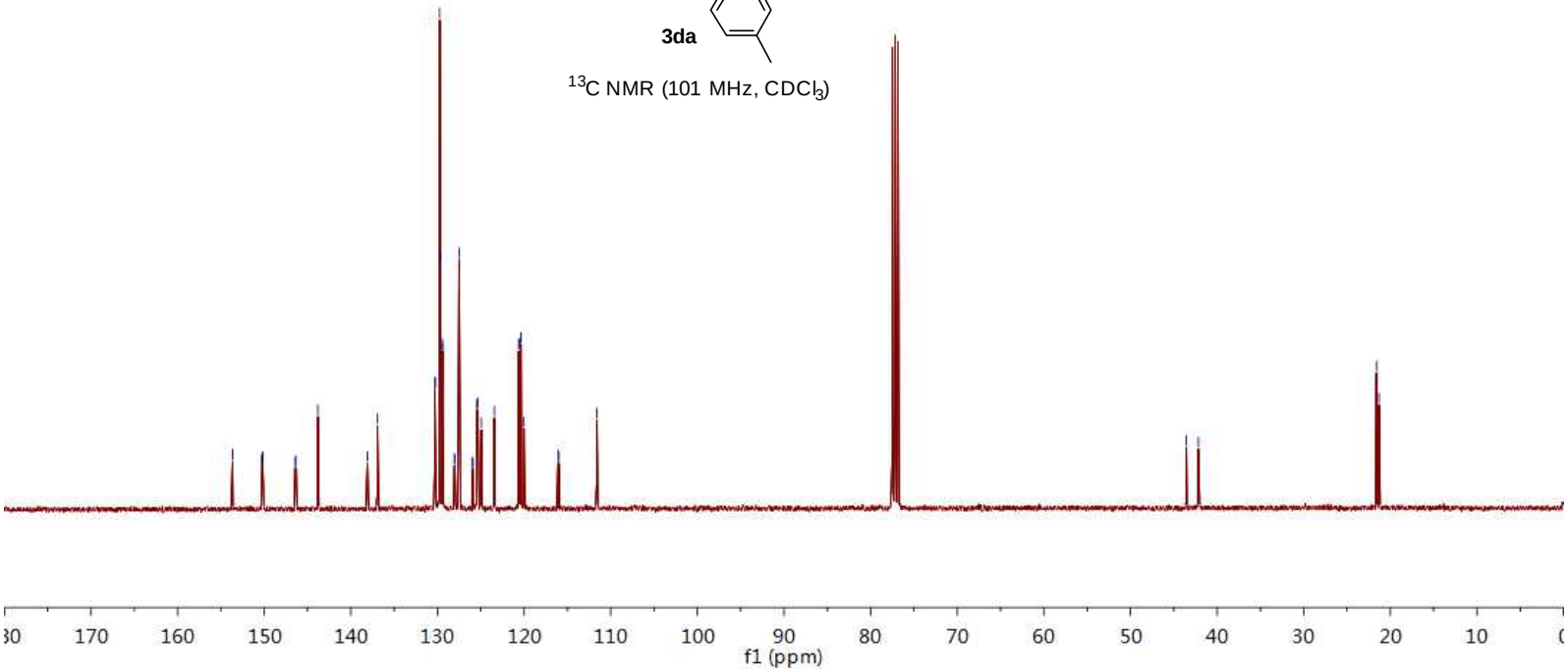


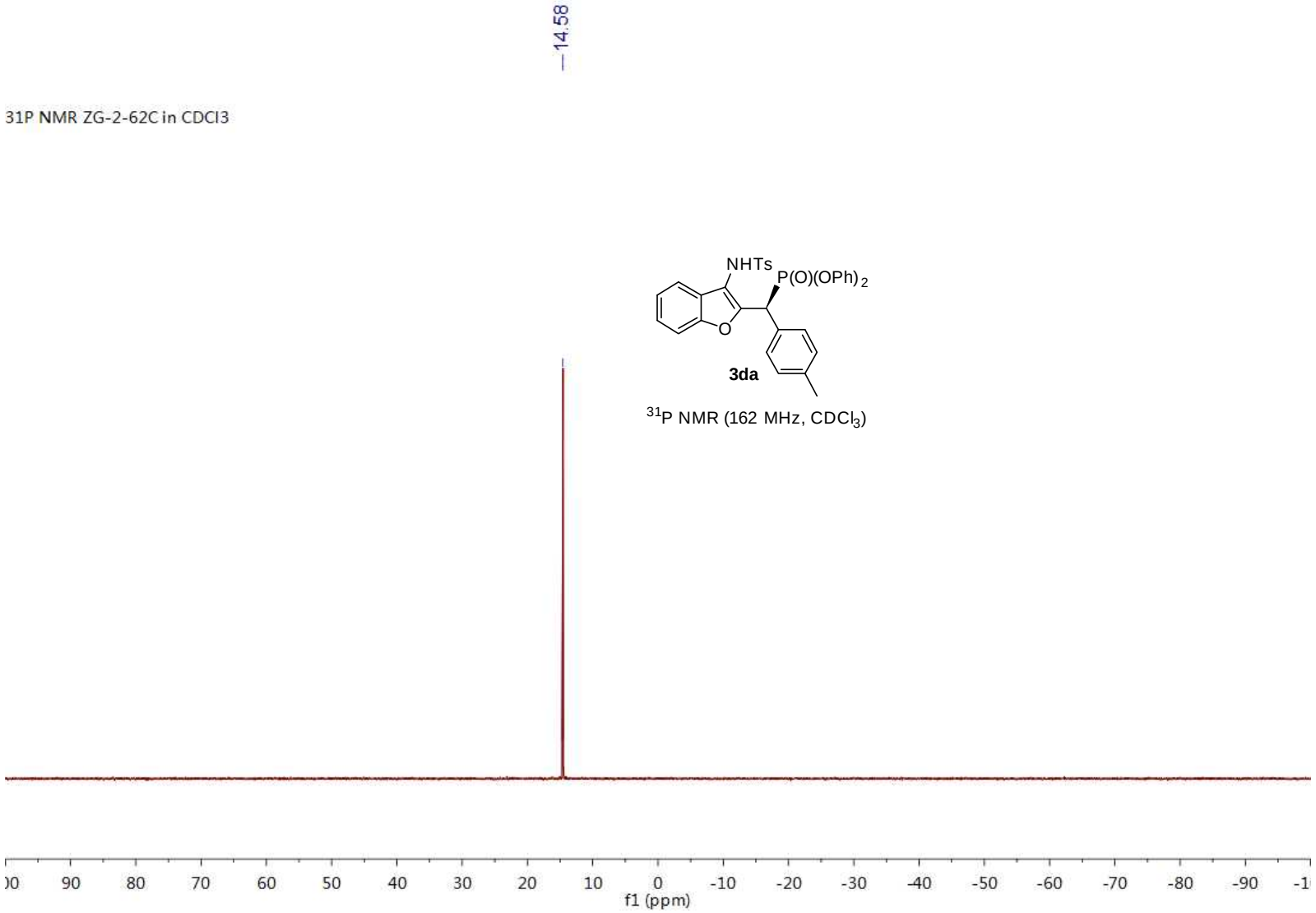
13C NMR ZG-2-62C in CDCl3

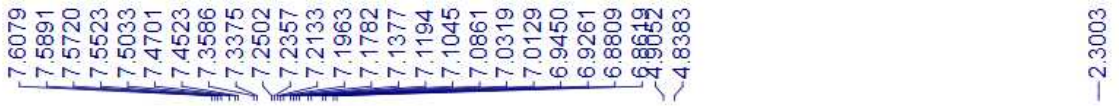


3da

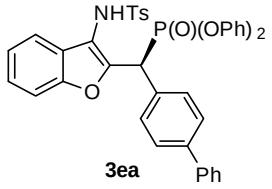
^{13}C NMR (101 MHz, $CDCl_3$)




14.58
31P NMR ZG-2-62C in CDCl3
NHTs
P(O)(OPh)2
O
3da
31P NMR (162 MHz, CDCl3)
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
f1 (ppm)

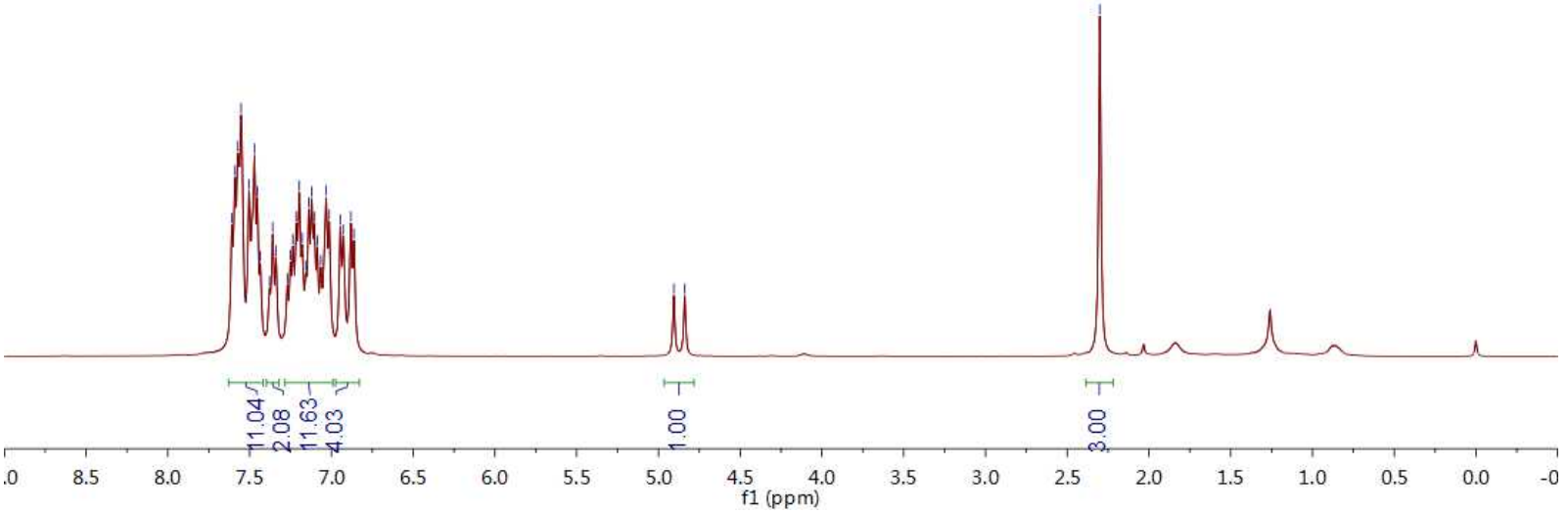


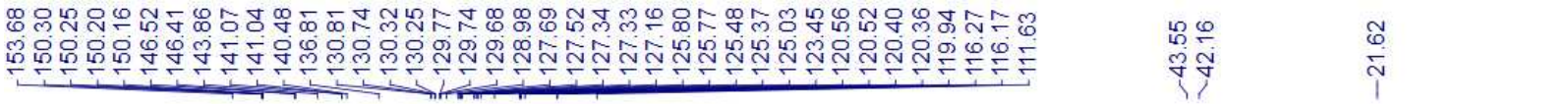
1H NMR ZG-2-79A in CDCl3



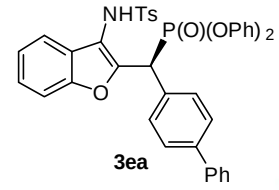
3ea

^{1}H NMR (400 MHz, $CDCl_3$)



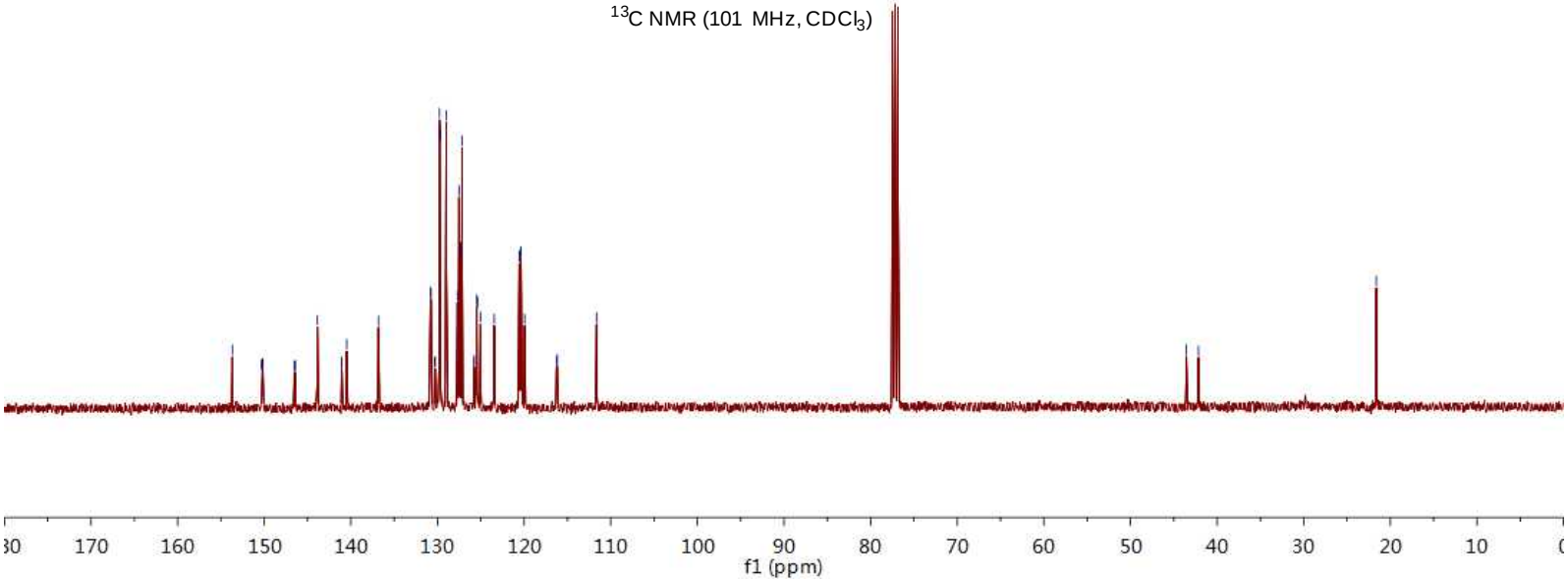


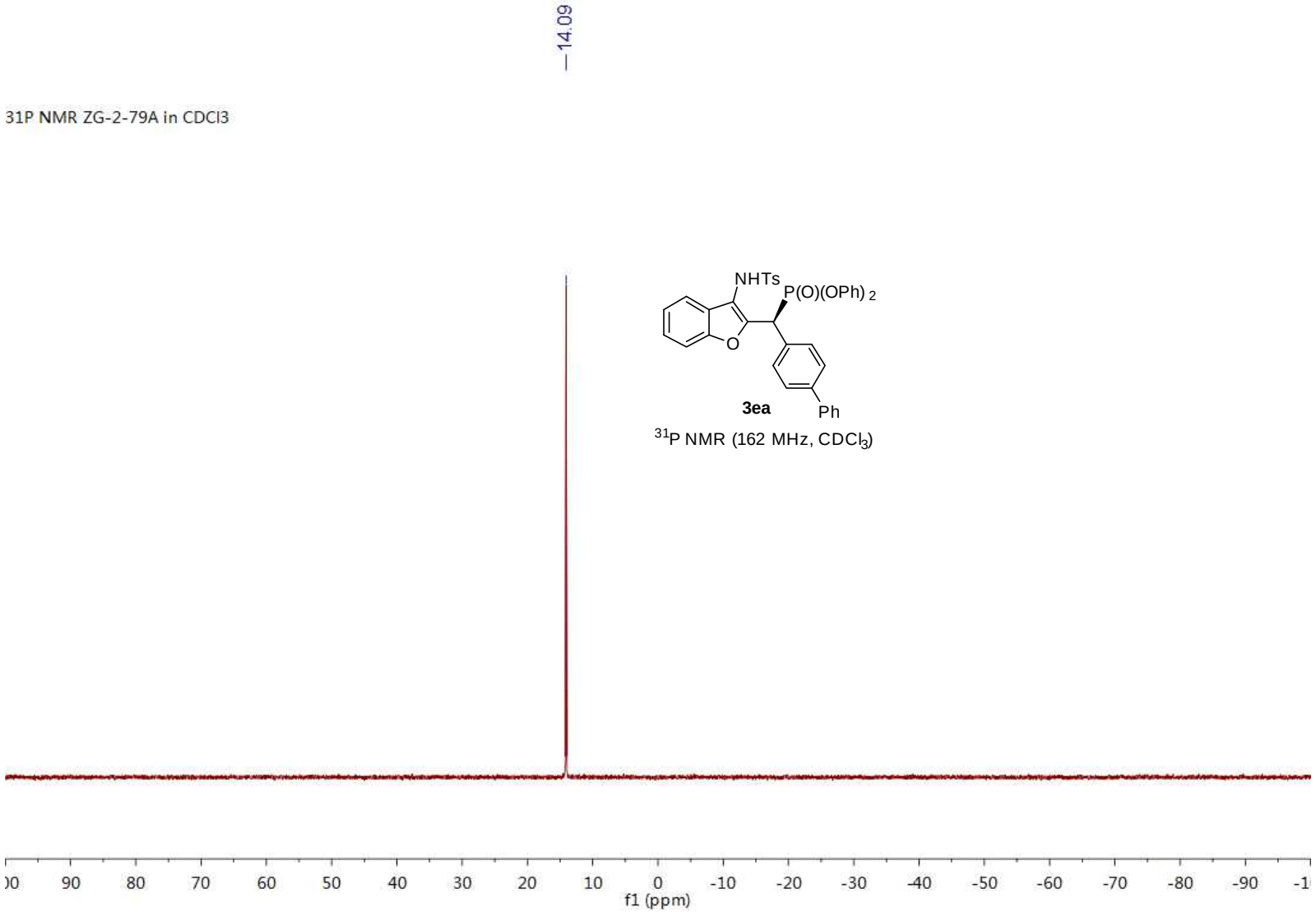
13C NMR ZG-2-79A in CDCl3

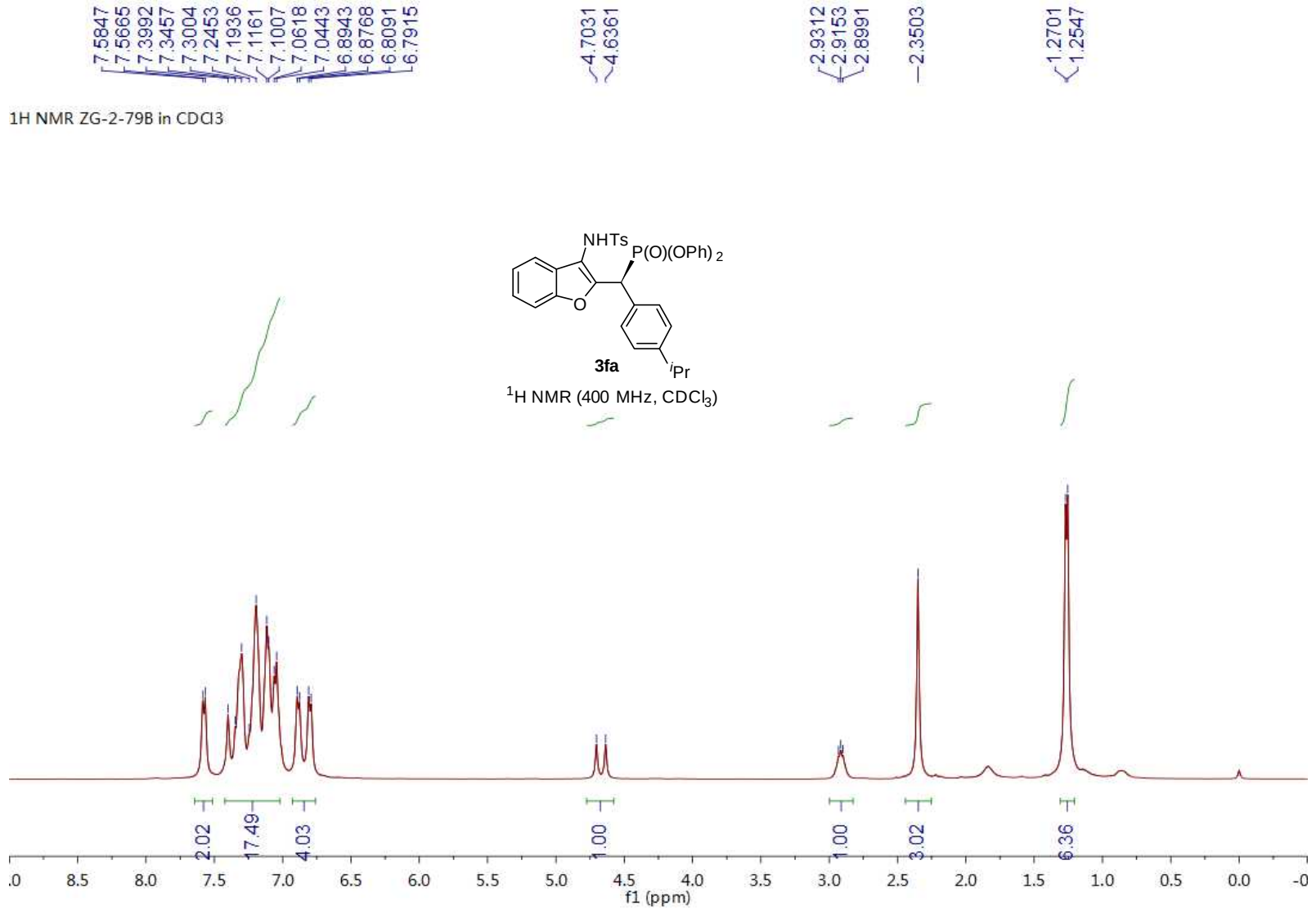


3ea

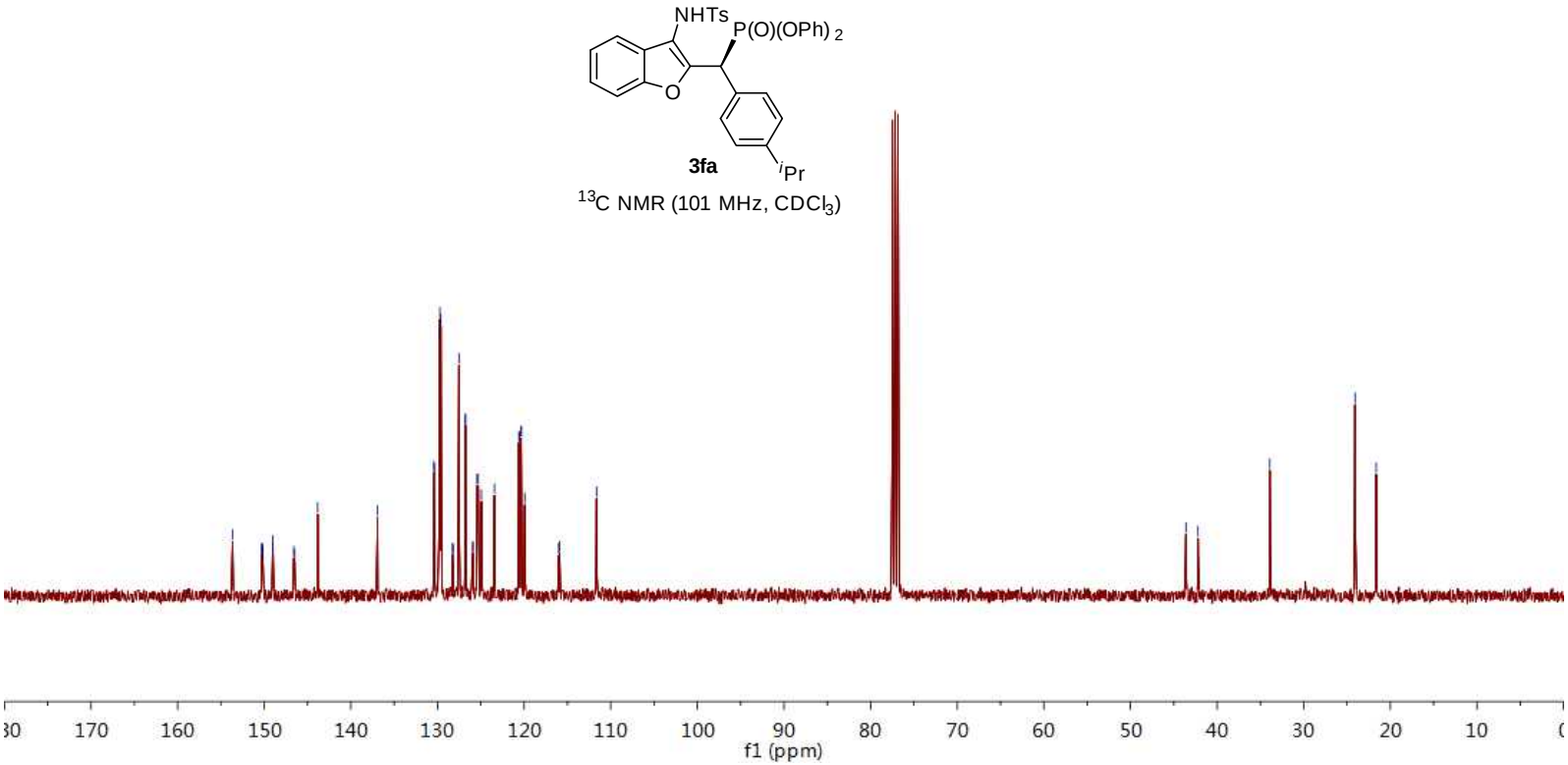
^{13}C NMR (101 MHz, $CDCl_3$)

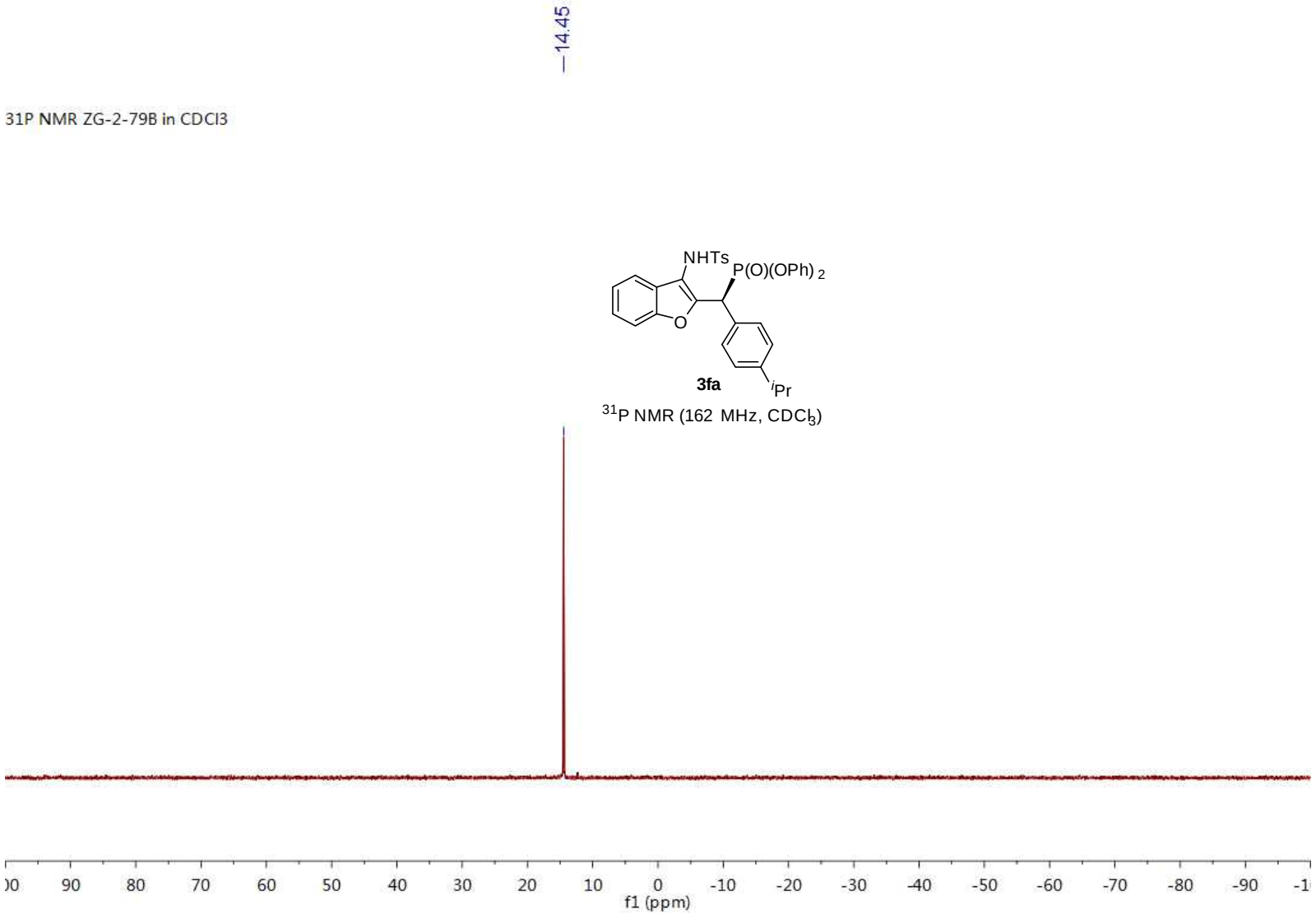


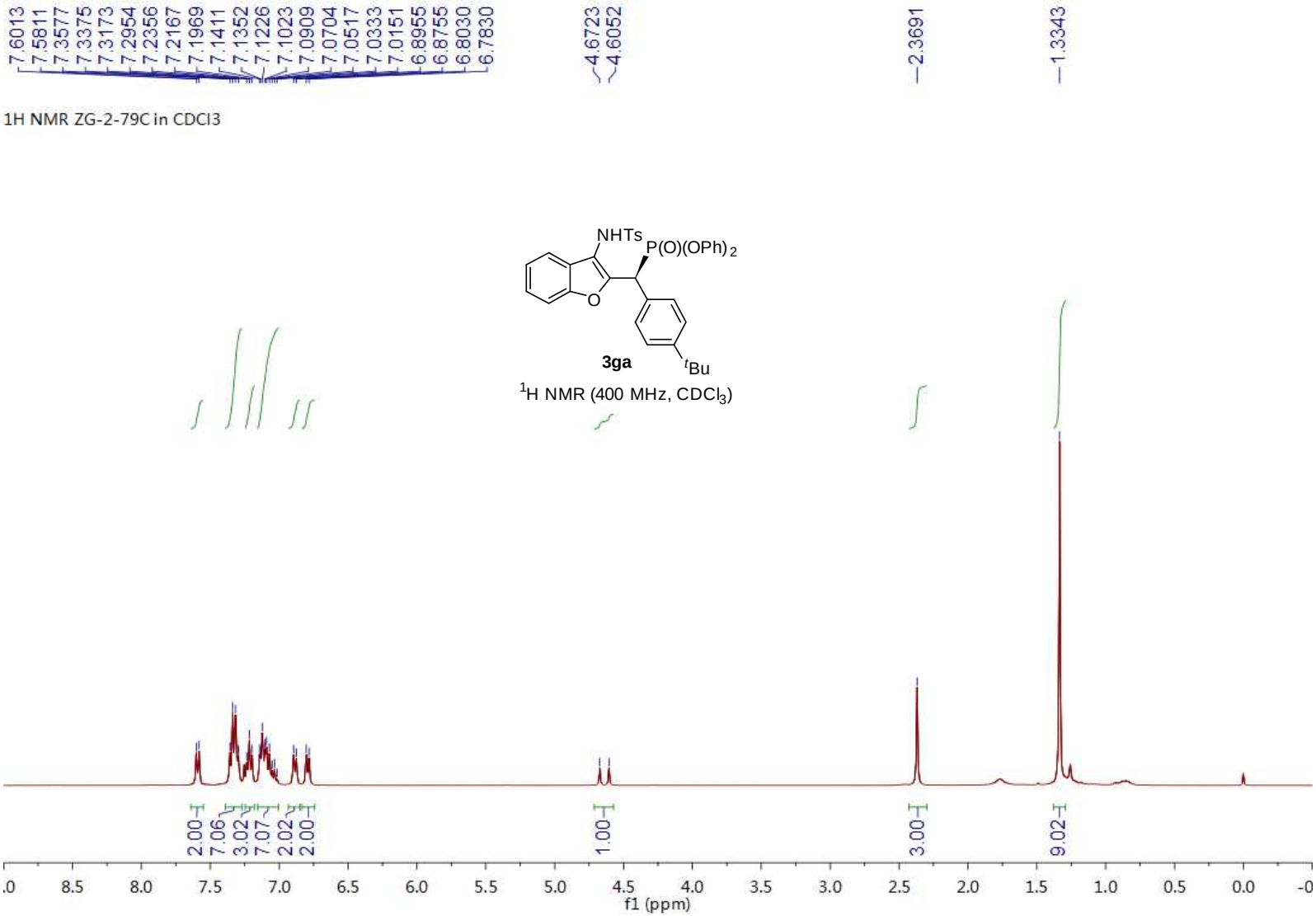

14.09
31P NMR ZG-2-79A in CDCl3
NHTs
P(O)(OPh)2
O
3ea
Ph
31P NMR (162 MHz, CDCl3)
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
f1 (ppm)


7.5847
7.5665
7.3992
7.3457
7.3004
7.2453
7.1936
7.1161
7.1007
7.0618
7.0443
6.8943
6.8768
6.8091
6.7915
4.7031
4.6361
2.9312
2.9153
2.8991
2.3503
1.2701
1.2547
1H NMR ZG-2-79B in CDCl3
NHTs
P(O)(OPh)2
O
3fa
iPr
1H NMR (400 MHz, CDCl3)
2.02
17.49
4.03
1.00
1.00
3.02
6.36
f1 (ppm)

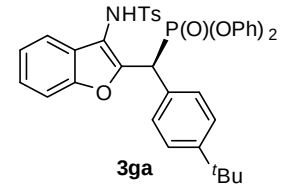
13C NMR ZG-2-79B in CDCl3



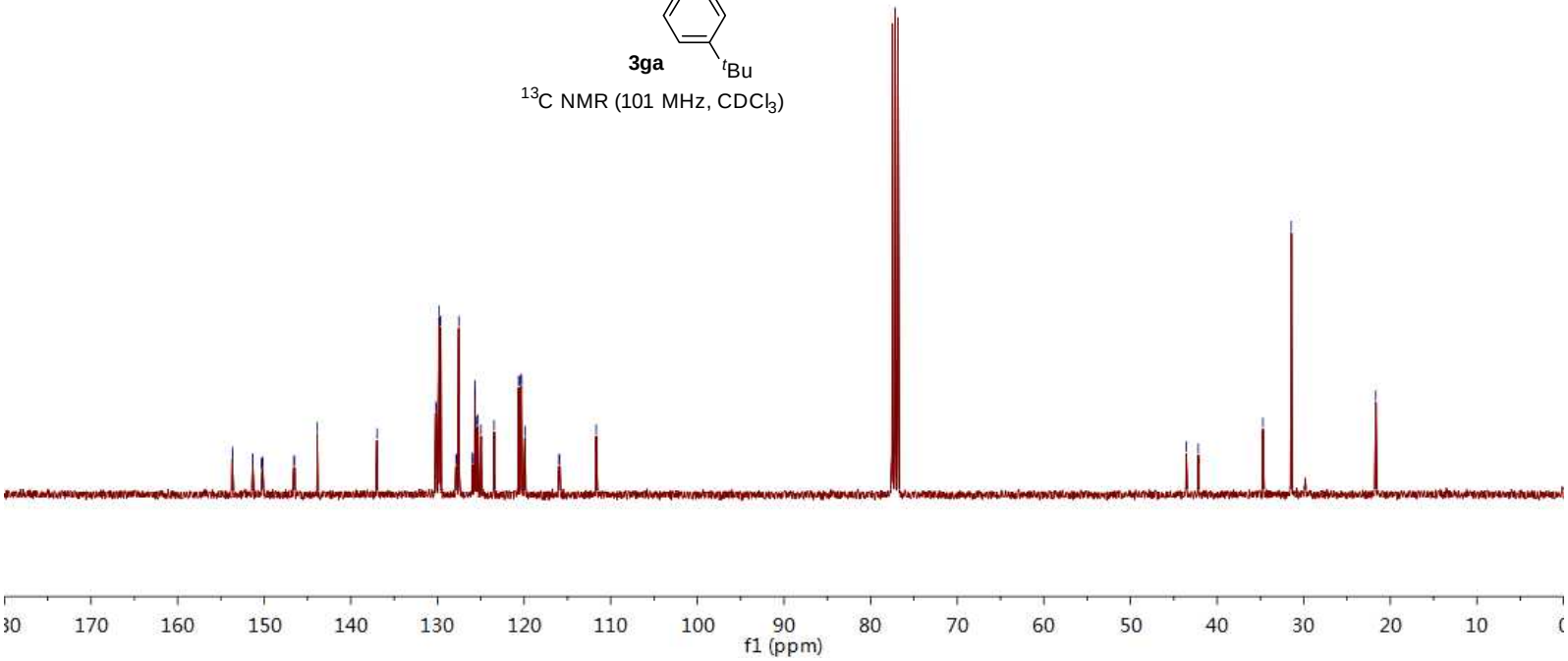

14.45
31P NMR ZG-2-79B in CDCl3
NHTs
P(O)(OPh) 2
O
3fa
iPr
31P NMR (162 MHz, CDCl3)
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
f1 (ppm)

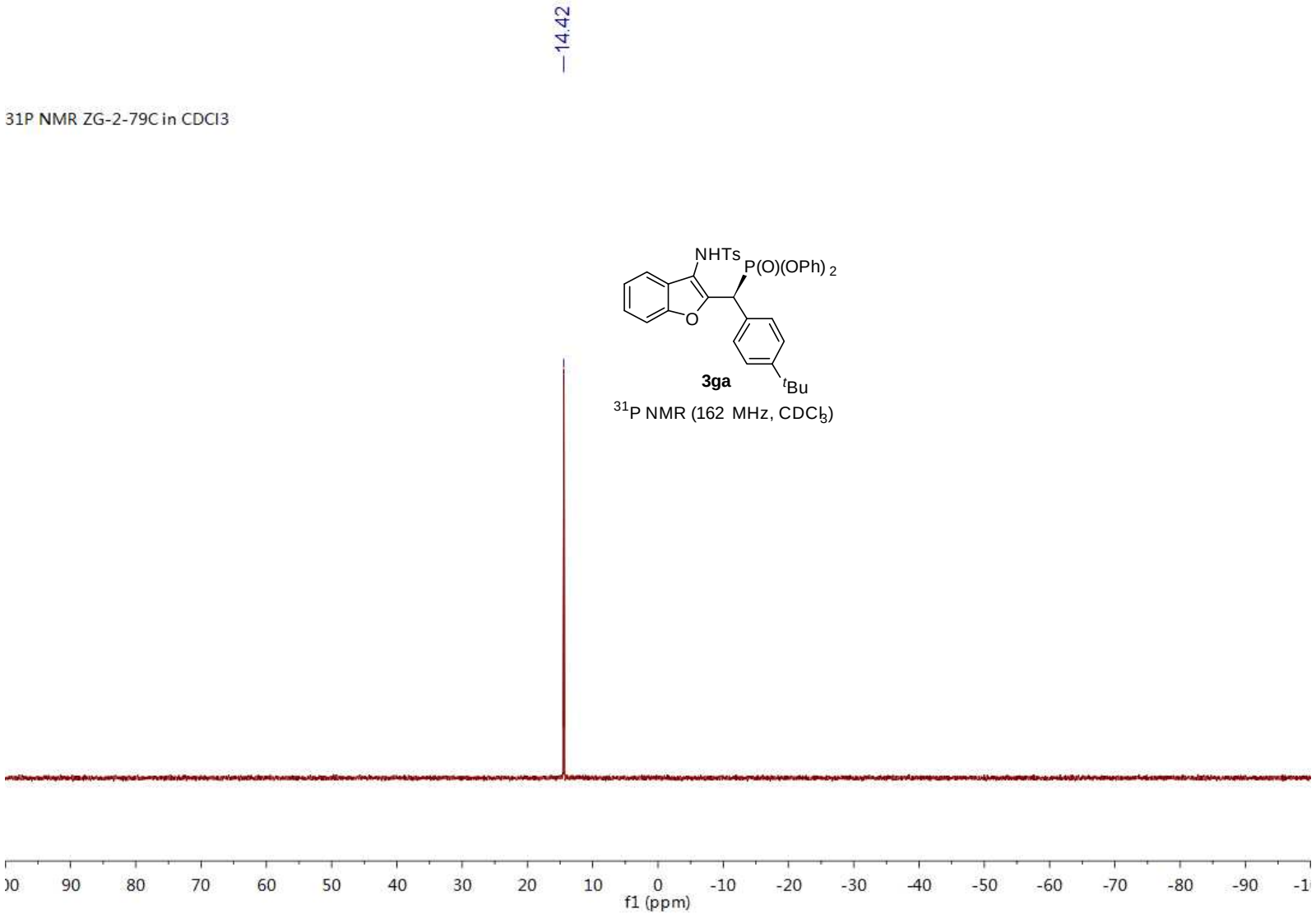

7.6013
7.5811
7.3577
7.3375
7.3173
7.2954
7.2356
7.2167
7.1969
7.1411
7.1352
7.1226
7.1023
7.0909
7.0704
7.0517
7.0333
7.0151
6.8955
6.8755
6.8030
6.7830
4.6723
4.6052
2.3691
1.3343
1H NMR ZG-2-79C in CDCl3
NHTs
P(O)(OPh)2
O
3ga
tBu
1H NMR (400 MHz, CDCl3)
2.00
7.06
3.02
7.07
2.02
2.00
1.00
3.00
9.02
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)

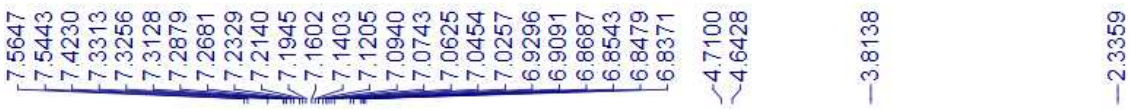
13C NMR ZG-2-79C in CDCl3



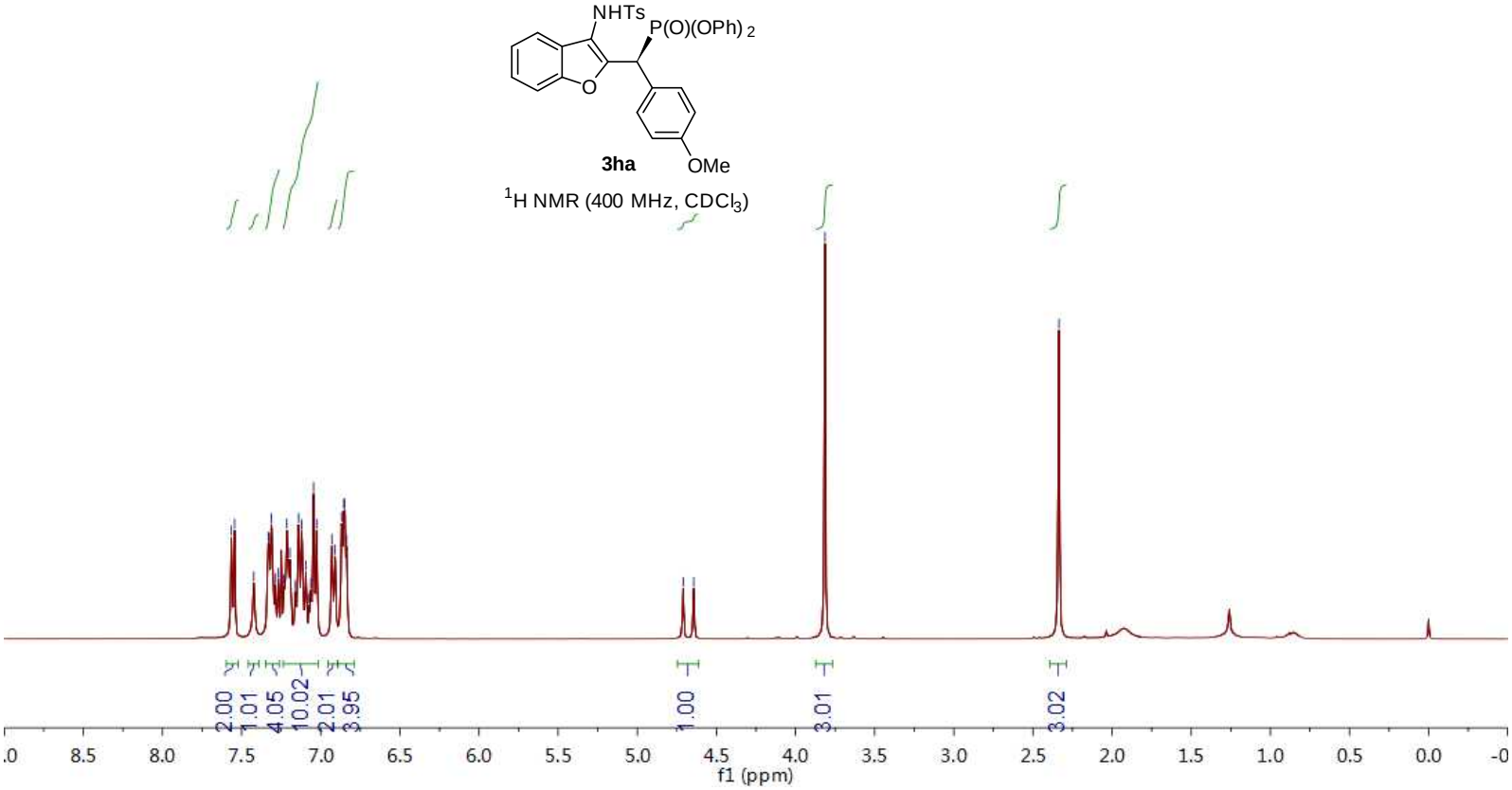
^{13}C NMR (101 MHz, $CDCl_3$)



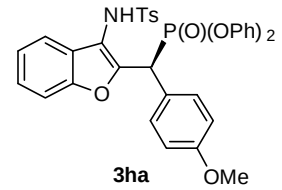

14.42
31P NMR ZG-2-79C in CDCl3
NHTs
P(O)(OPh)2
O
3ga
tBu
31P NMR (162 MHz, CDCl3)
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
f1 (ppm)



1H NMR ZG-2-64A in CDCl3

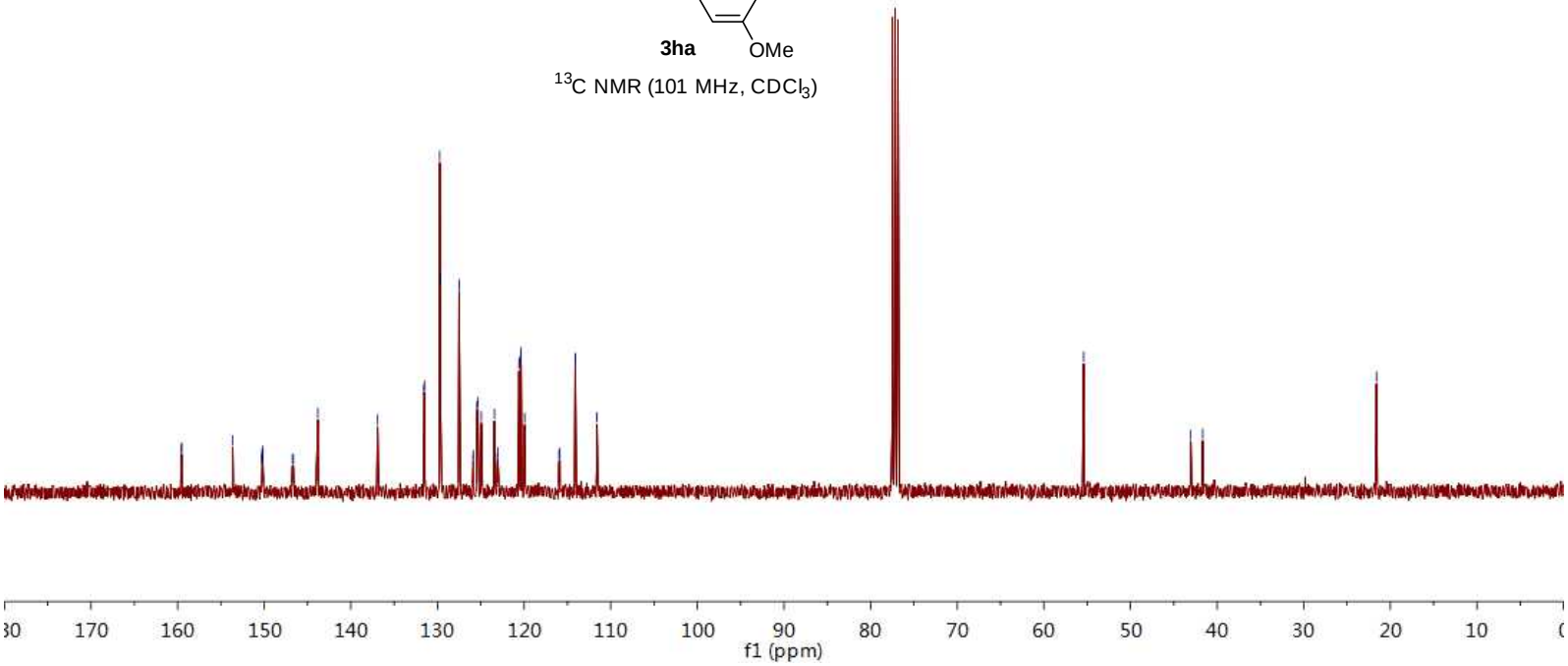


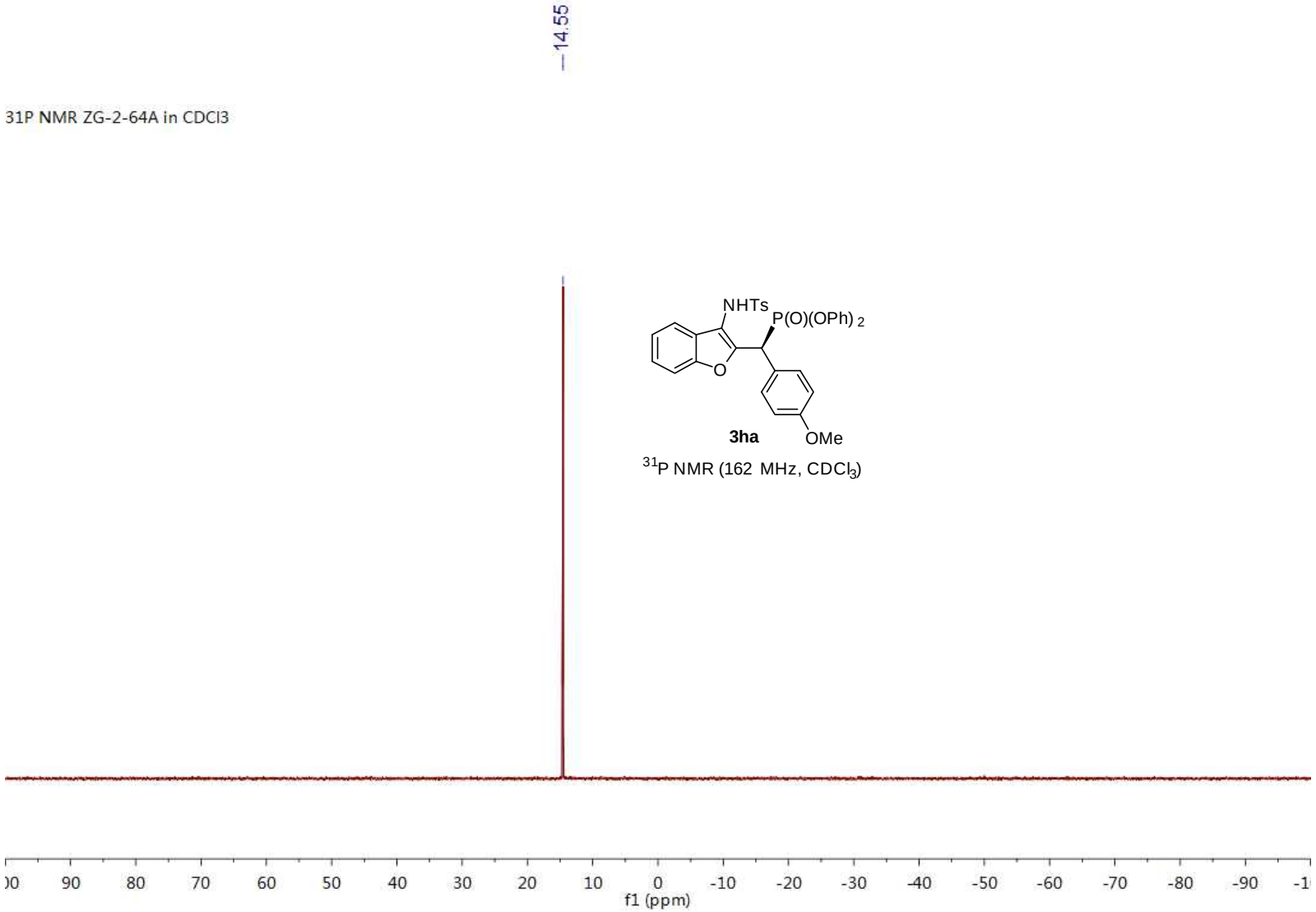
13C NMR ZG-2-64A in CDCl3

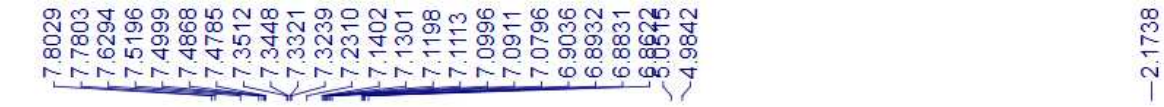


3ha

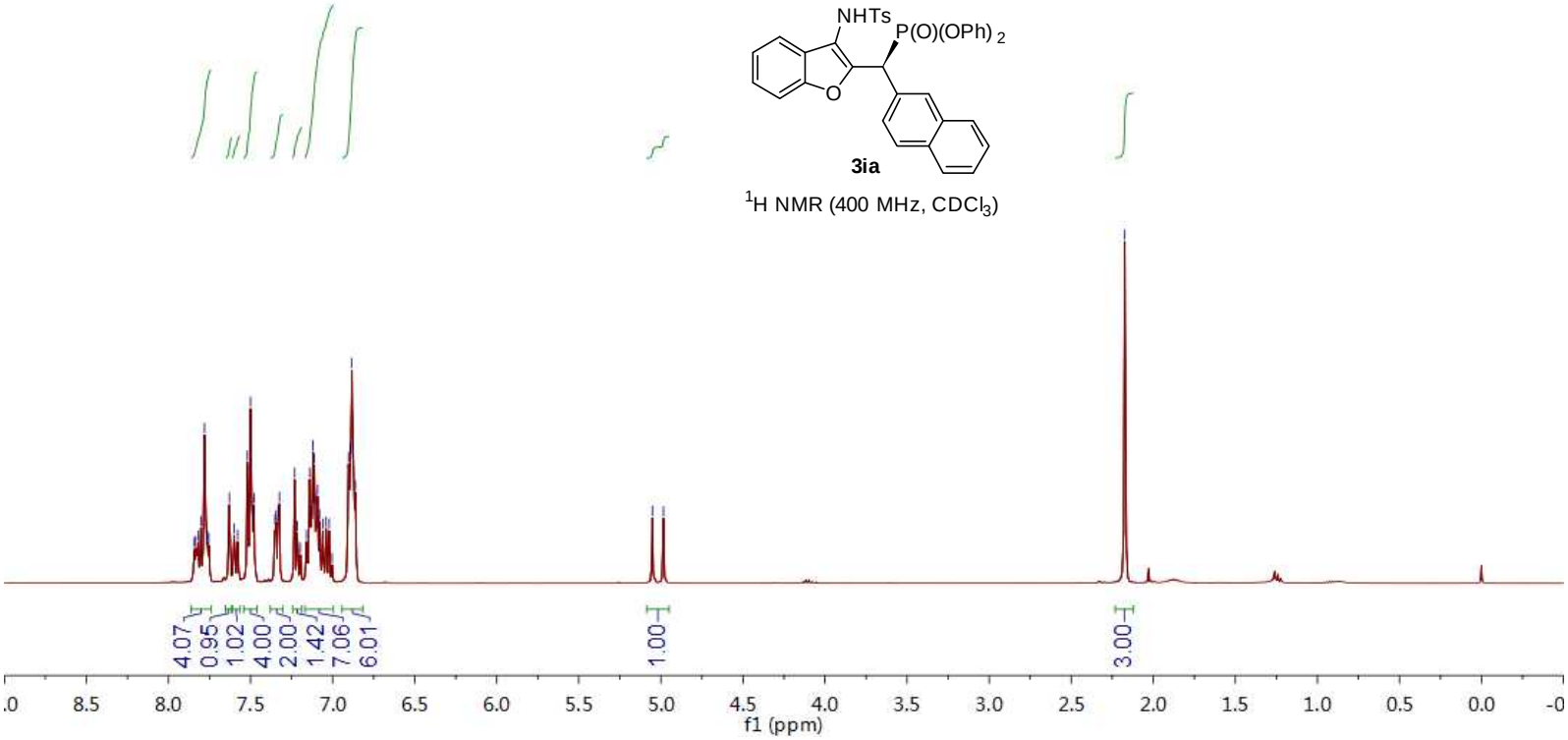
^{13}C NMR (101 MHz, $CDCl_3$)




14.55
31P NMR ZG-2-64A in CDCl3
NHTs
P(O)(OPh) 2
O
3ha
OMe
31P NMR (162 MHz, CDCl3)
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
f1 (ppm)

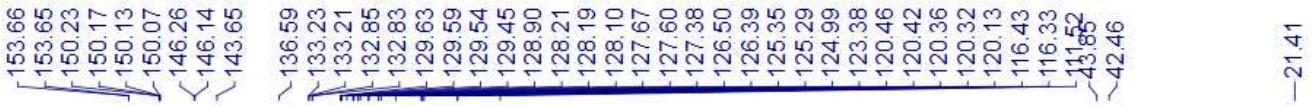


1H NMR ZG-2-64B in CDCl3

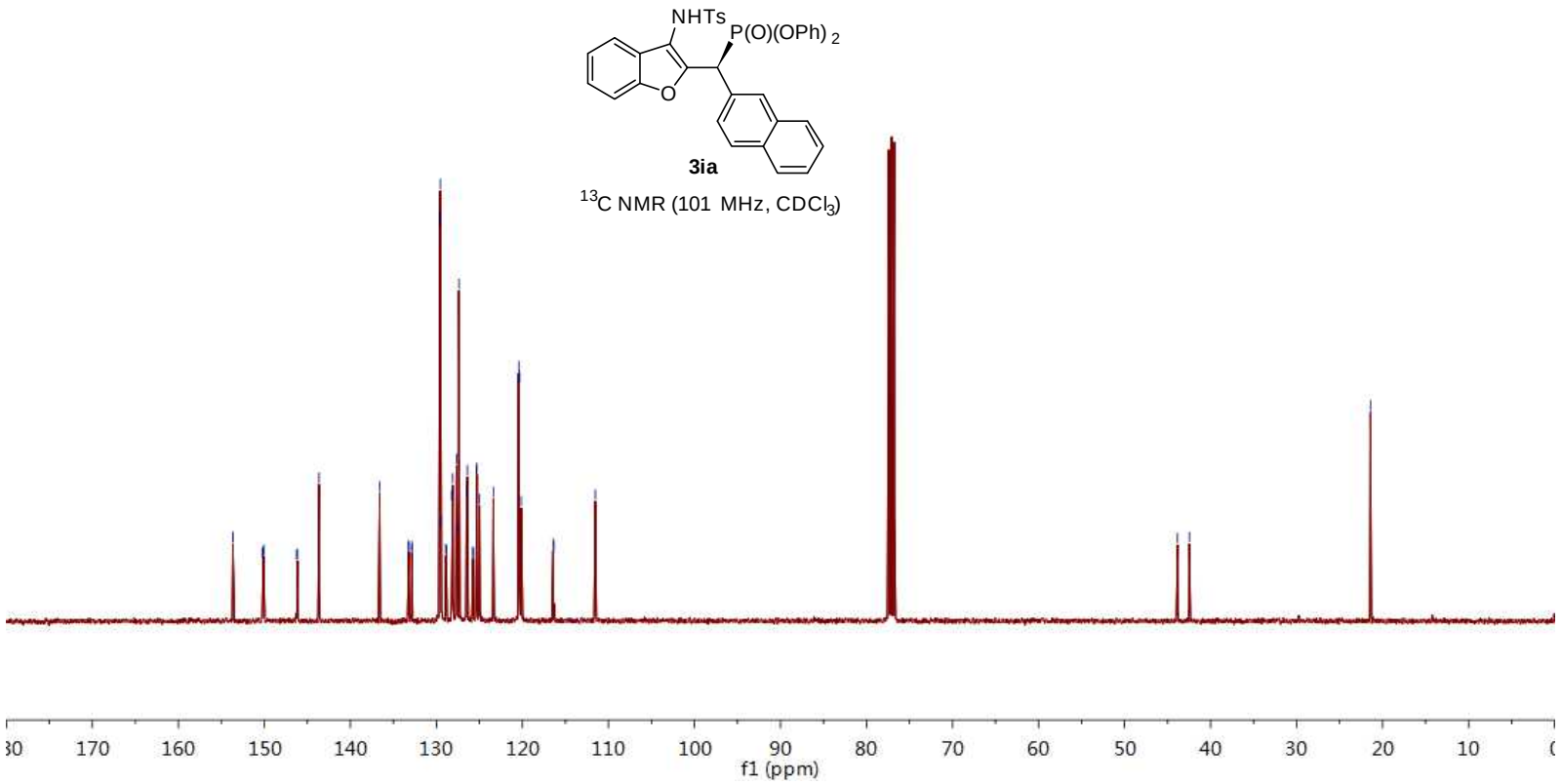


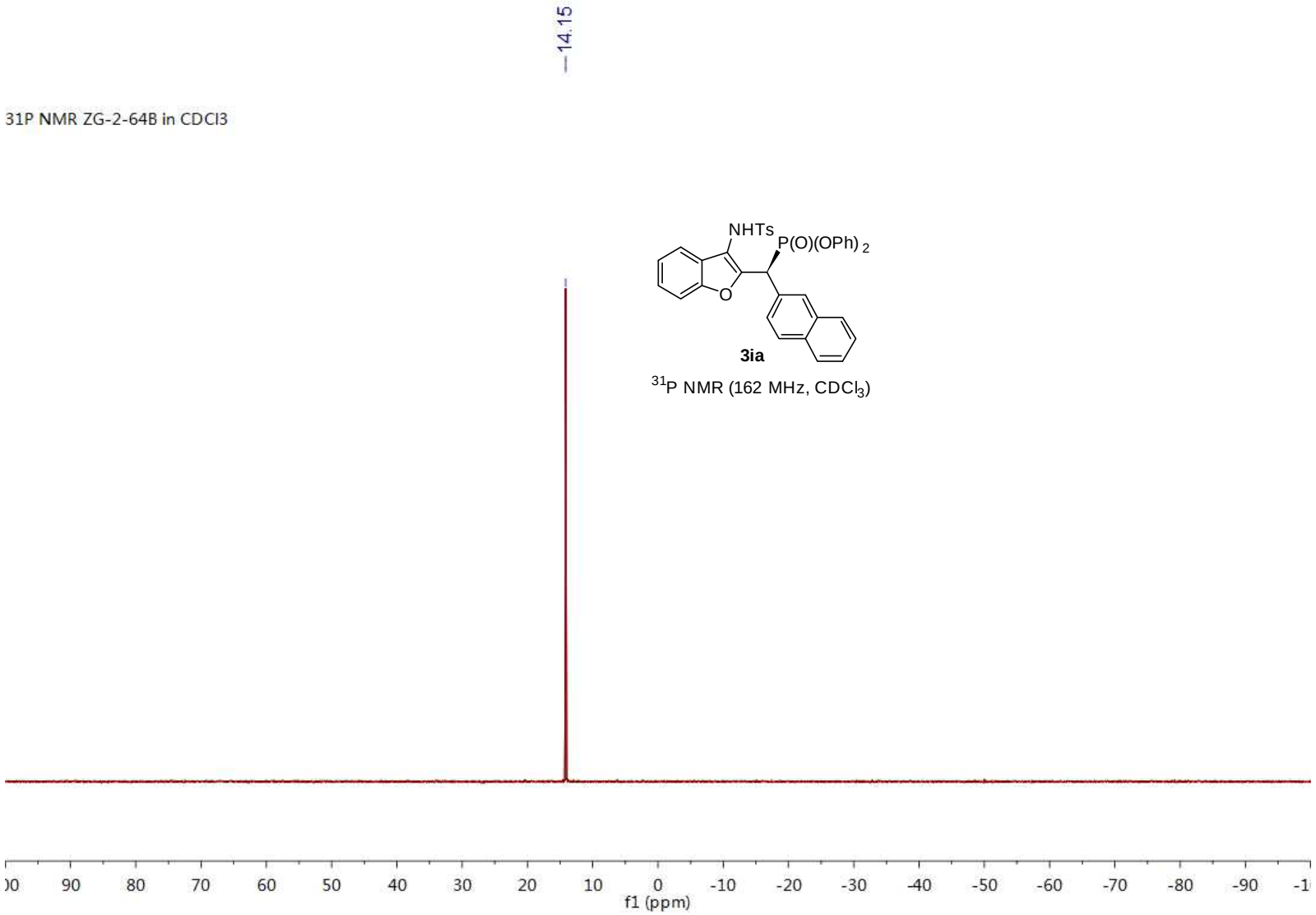
3ia

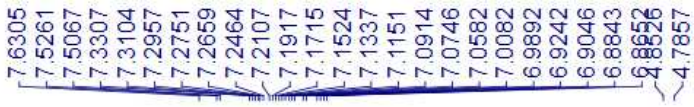
^{1}H NMR (400 MHz, $CDCl_3$)



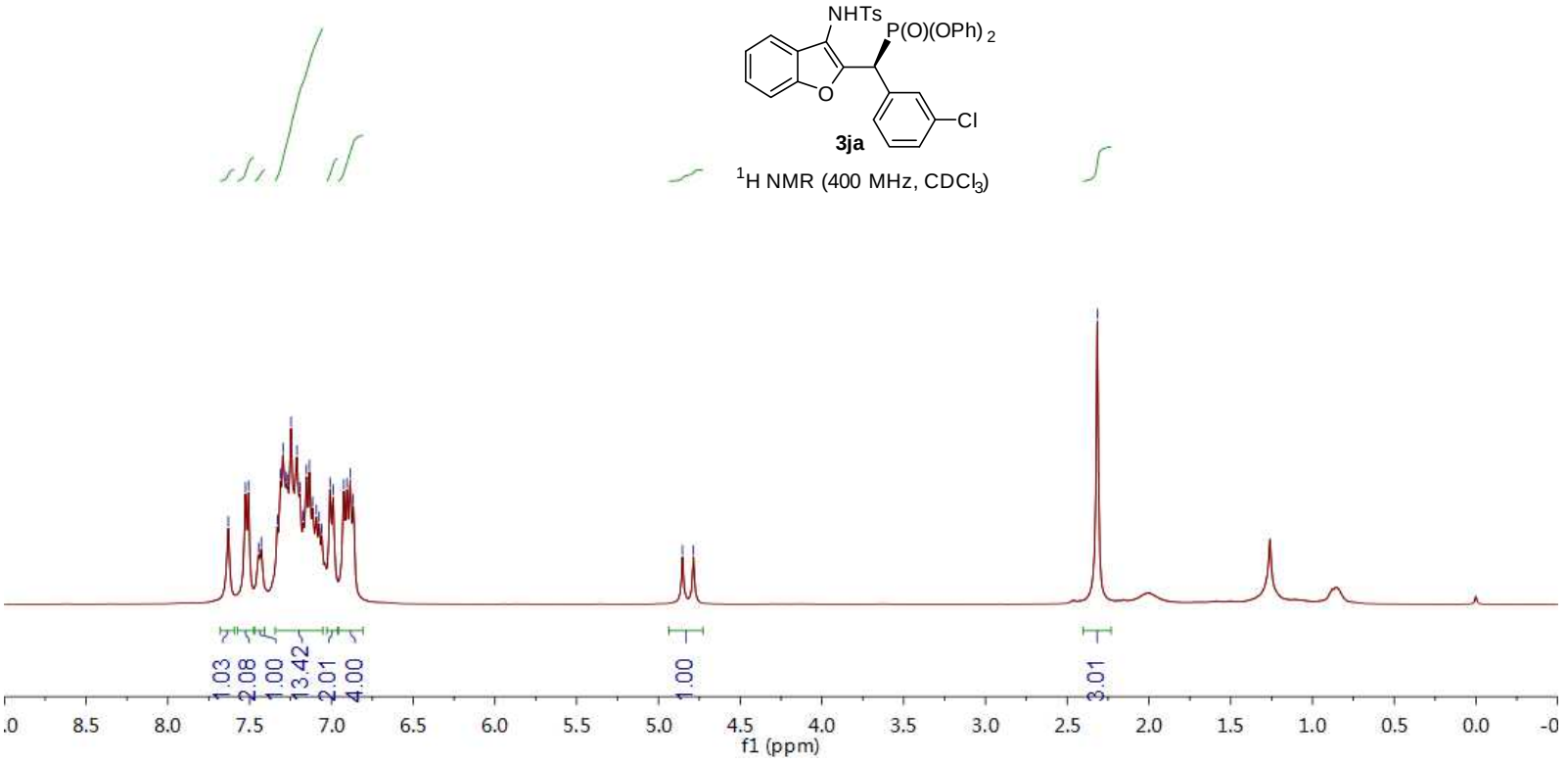
13C NMR ZG-2-64B in CDCl3




14.15
31P NMR ZG-2-64B in CDCl3
NHTs
P(O)(OPh)2
O
3ia
31P NMR (162 MHz, CDCl3)
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
f1 (ppm)



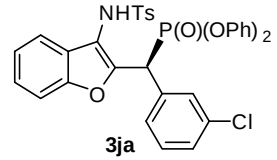
1H NMR ZG-2-71A in CDCl3



3ja

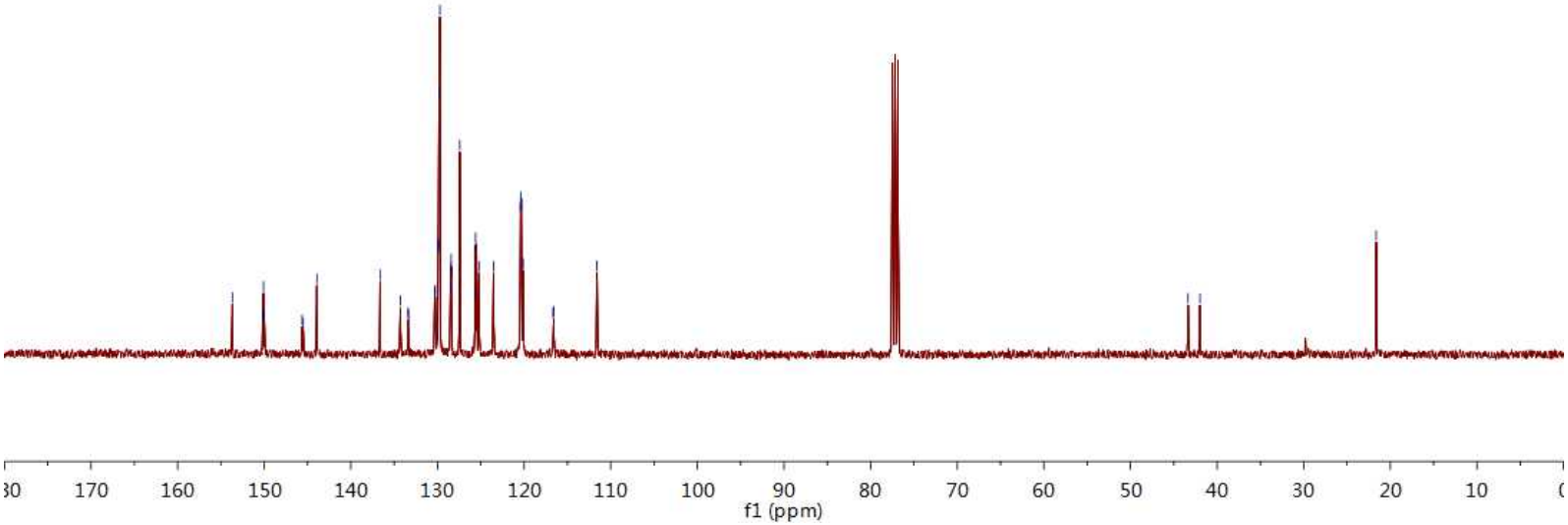
^{1}H NMR (400 MHz, $CDCl_3$)

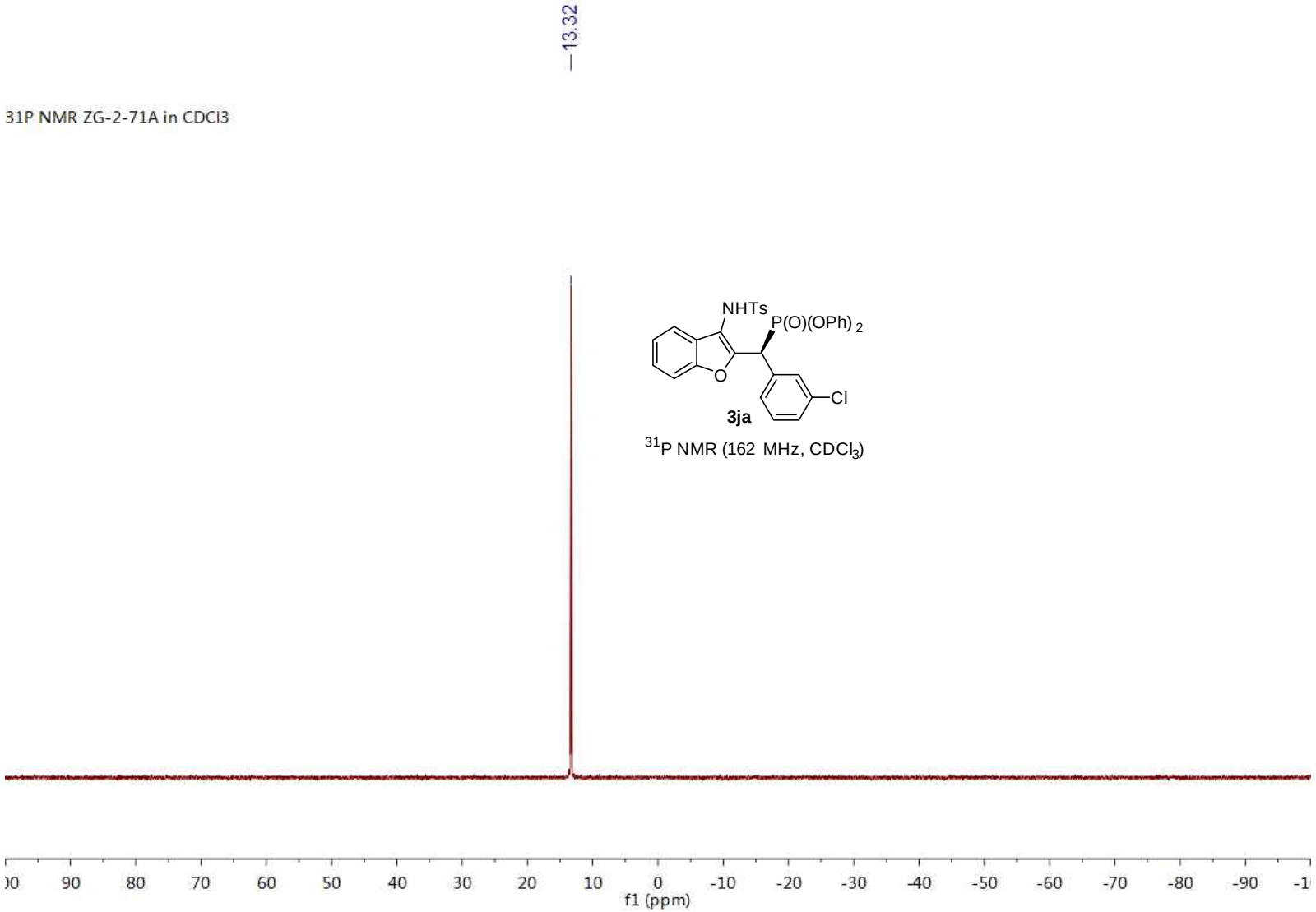
13C NMR ZG-2-71A in CDCl3

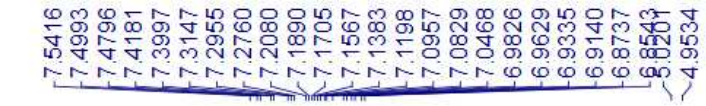


3ja

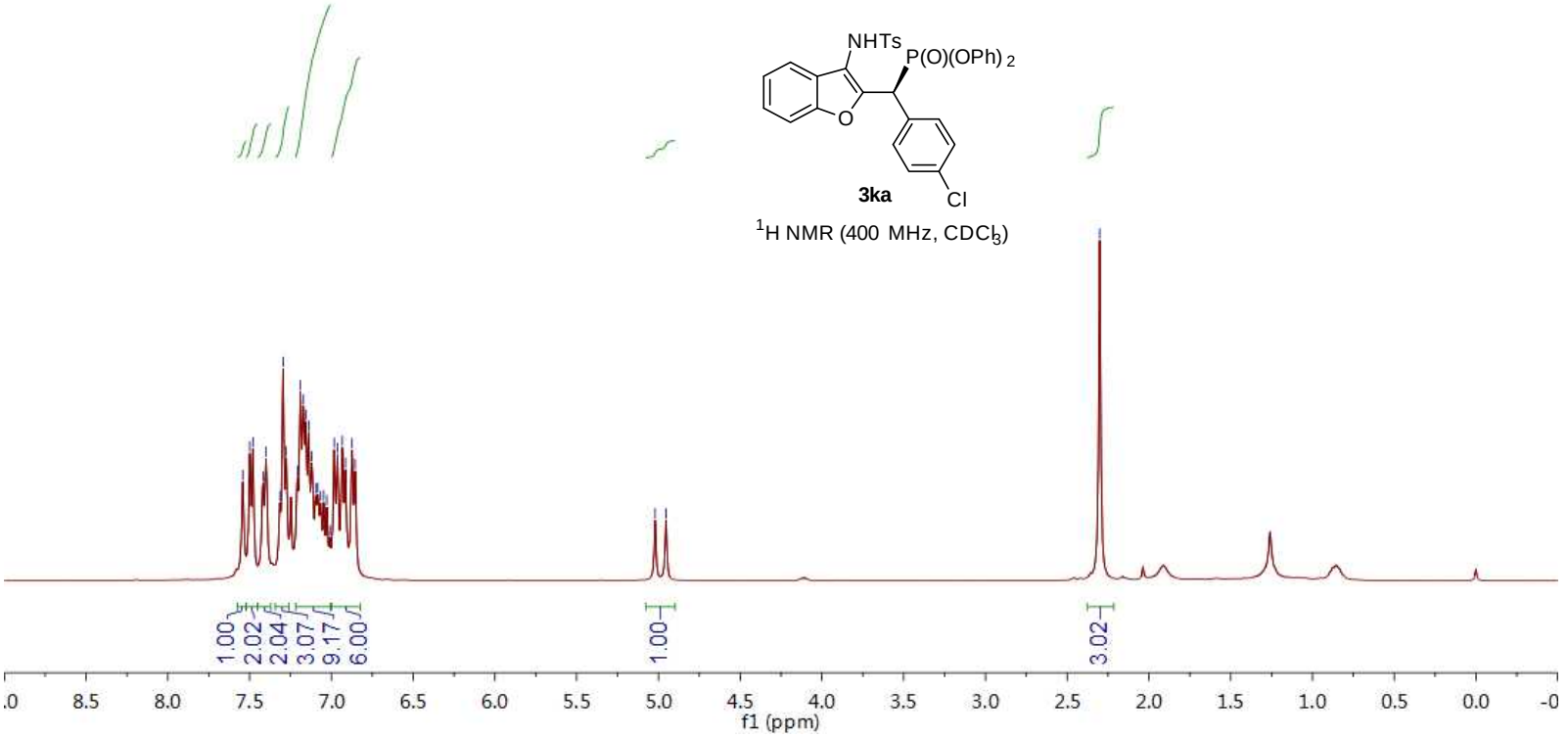
^{13}C NMR (101 MHz, $CDCl_3$)




13.32
31P NMR ZG-2-71A in CDCl3
NHTs
P(O)(OPh)2
O
Cl
3ja
31P NMR (162 MHz, CDCl3)
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
f1 (ppm)



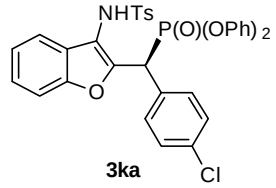
1H NMR ZG-2-71B in CDCl3



3ka

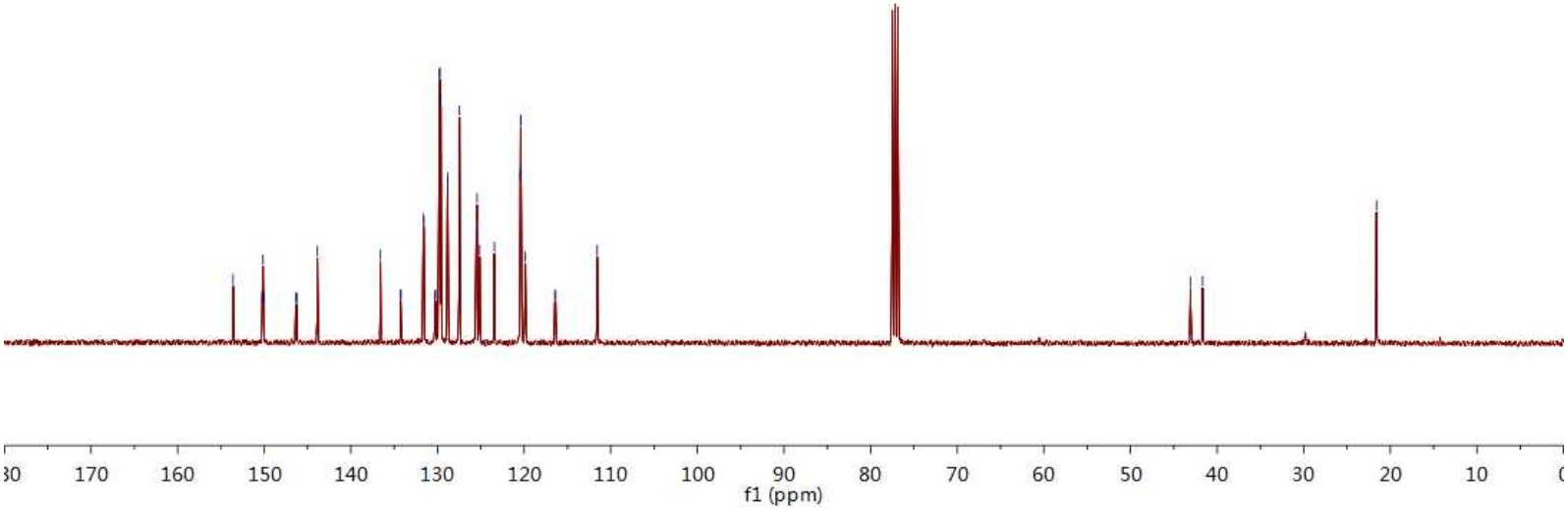
^{1}H NMR (400 MHz, $CDCl_3$)

13C NMR ZG-2-71B in CDCl3



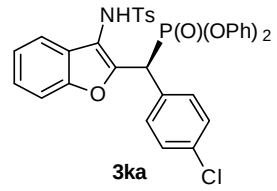
3ka

^{13}C NMR (101 MHz, $CDCl_3$)



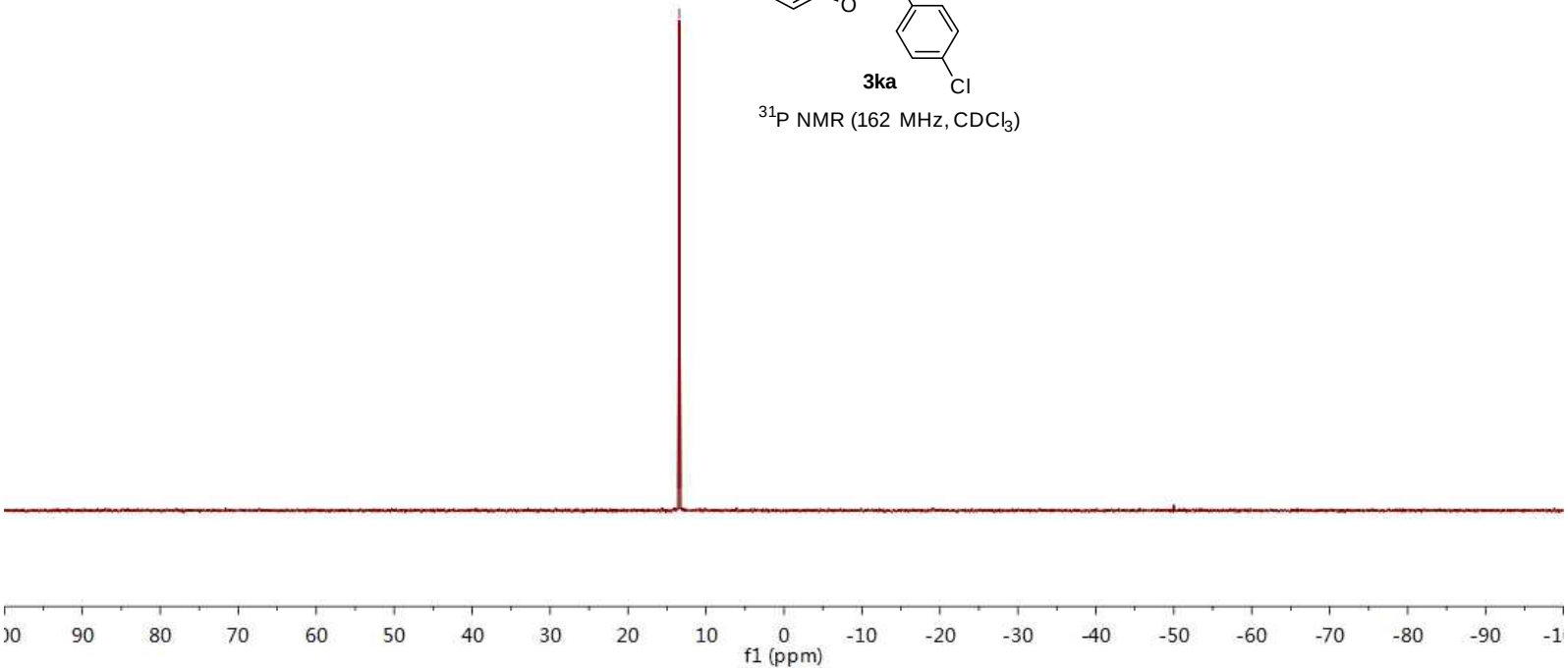
13.42

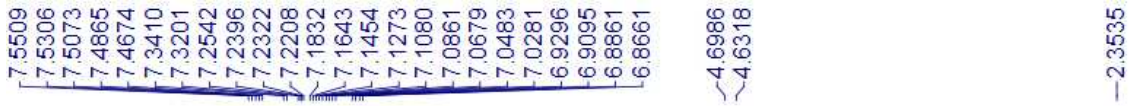
31P NMR ZG-2-71B in CDCl3



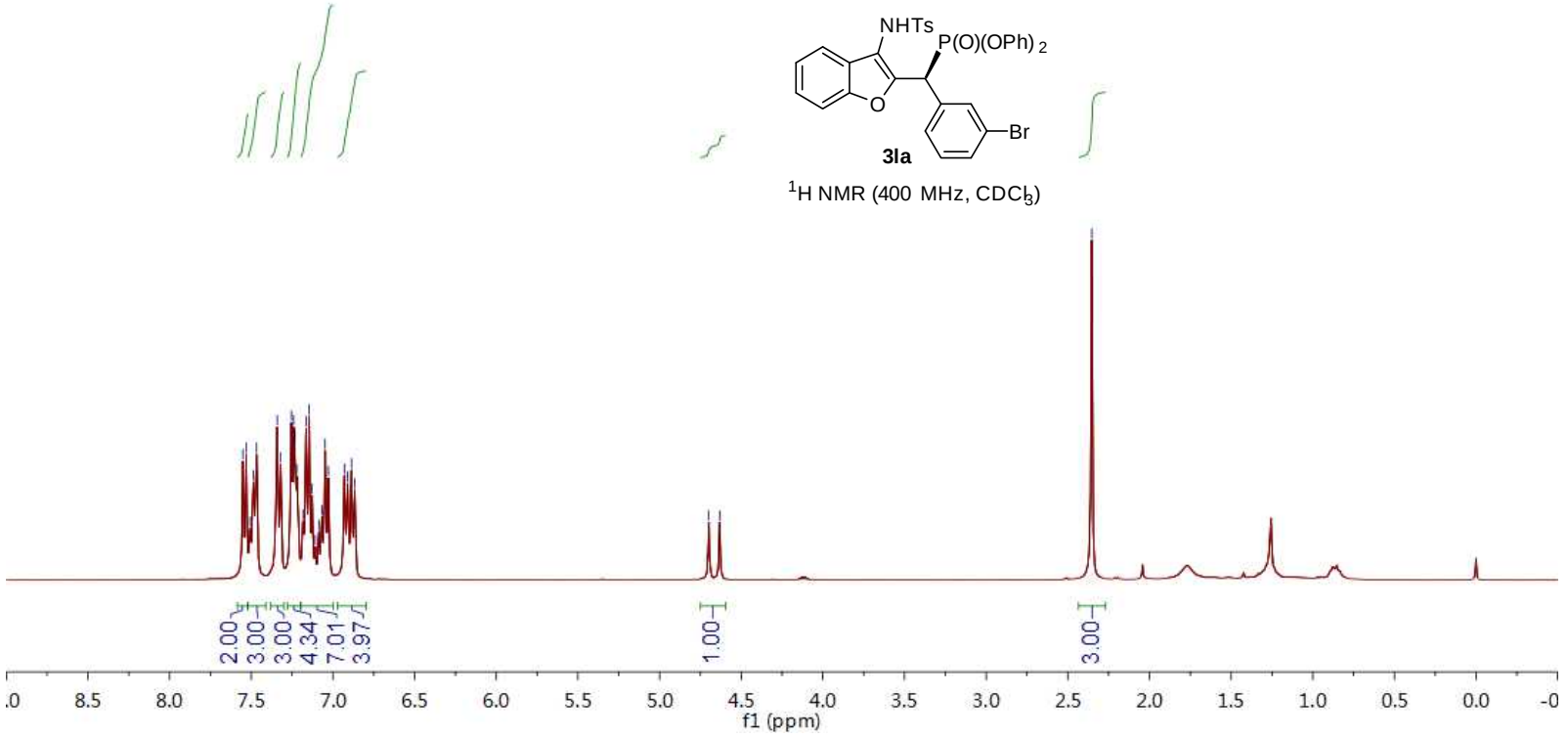
3ka

^{31}P NMR (162 MHz, $CDCl_3$)





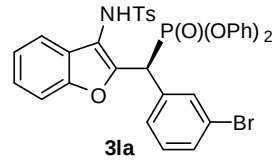
1H NMR ZG-2-71C in CDCl3



3la

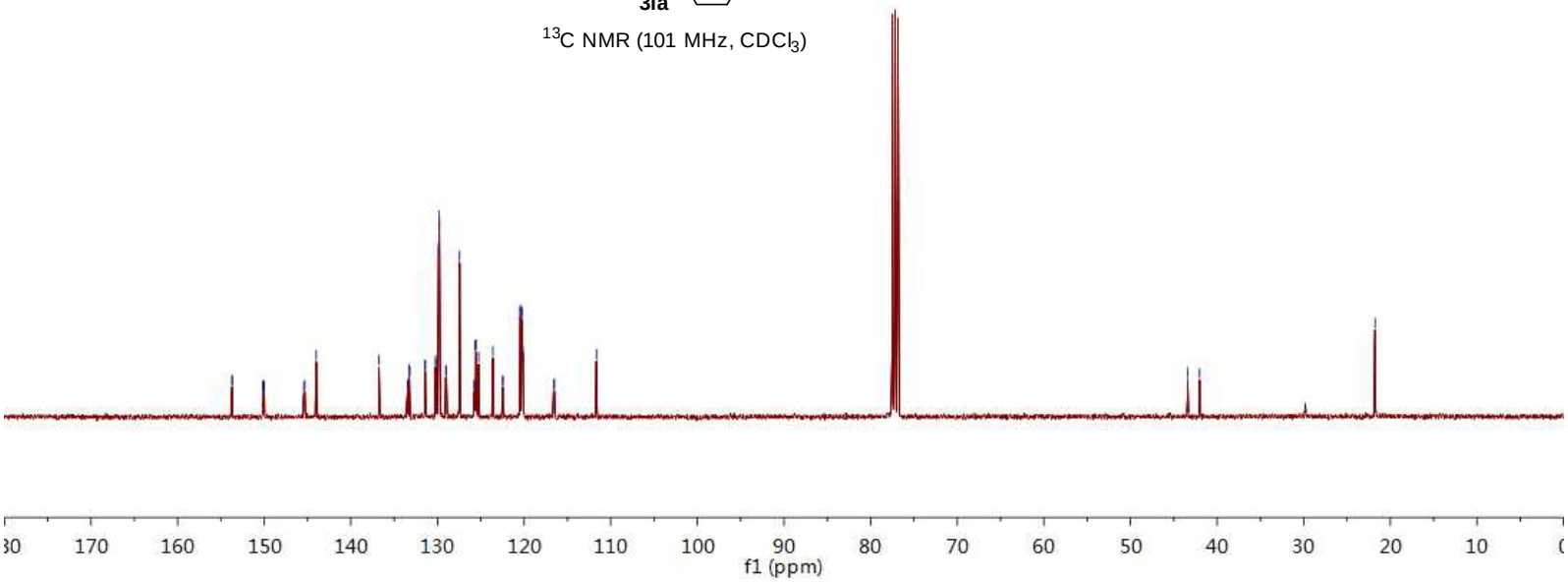
^{1}H NMR (400 MHz, $CDCl_3$)

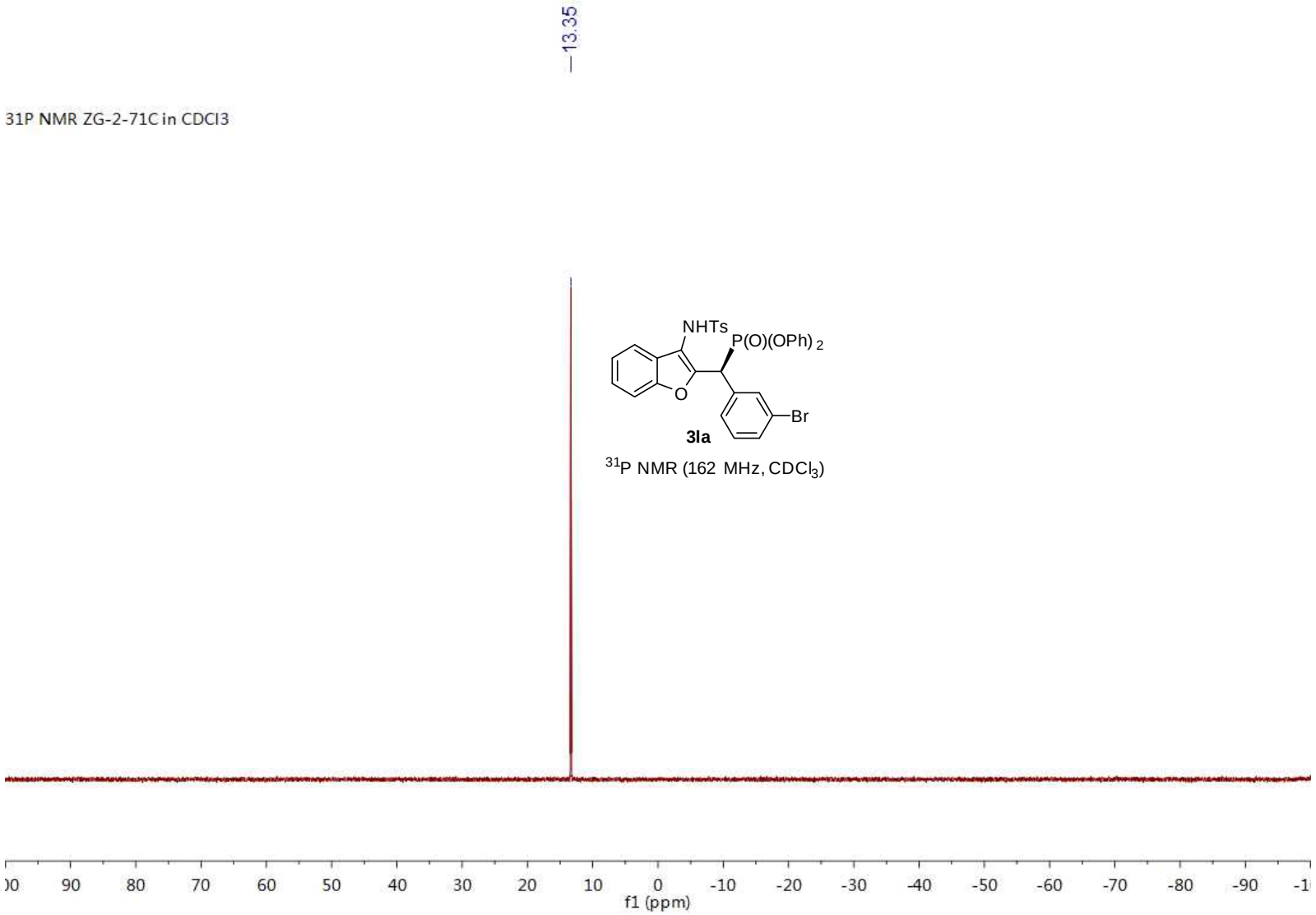
13C NMR ZG-2-71C in CDCl3

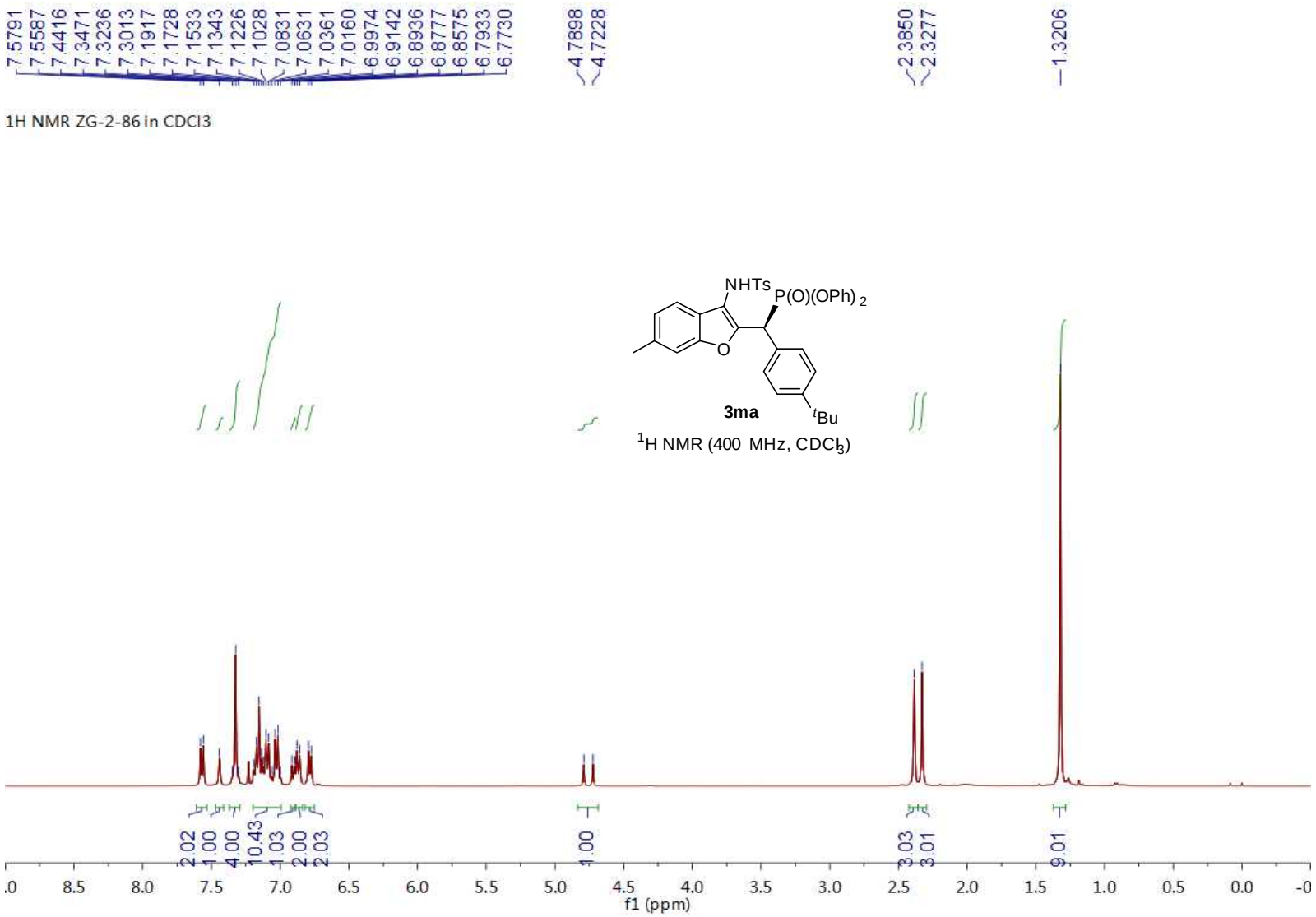


3la

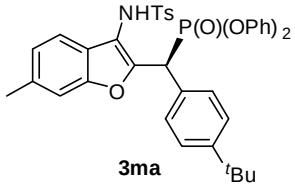
^{13}C NMR (101 MHz, $CDCl_3$)




13.35
31P NMR ZG-2-71C in CDCl3
NHTs
P(O)(OPh)2
O
Br
3la
31P NMR (162 MHz, CDCl3)
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
f1 (ppm)

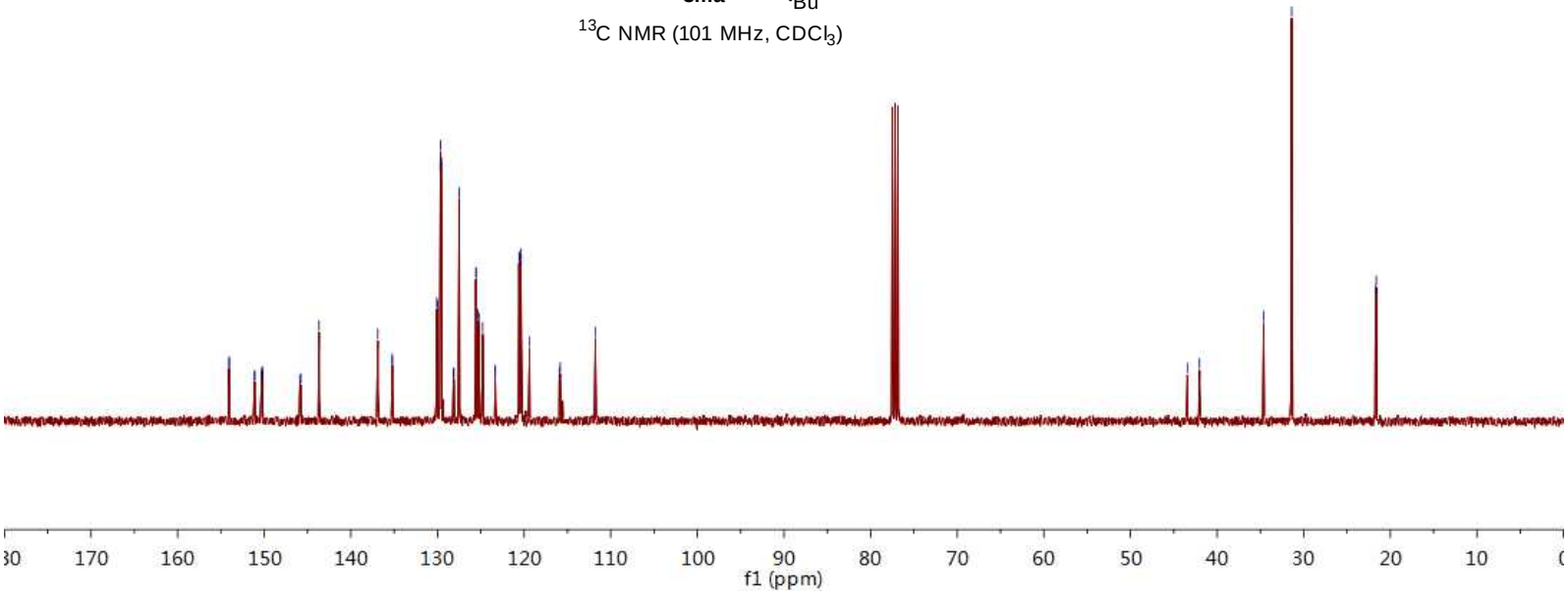

7.5791
7.5587
7.4416
7.3471
7.3236
7.3013
7.1917
7.1728
7.1533
7.1343
7.1226
7.1028
7.0831
7.0631
7.0361
7.0160
6.9974
6.9142
6.8936
6.8777
6.8575
6.7933
6.7730
4.7898
4.7228
2.3850
2.3277
1.3206
1H NMR ZG-2-86 in CDCl3
NHTs
P(O)(OPh)2
O
3ma
tBu
1H NMR (400 MHz, CDCl3)
2.02
1.00
4.00
10.43
1.03
2.00
2.03
1.00
3.03
3.01
9.01
f1 (ppm)

13C NMR ZG-2-86 in CDCl3



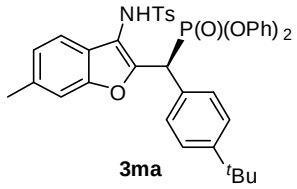
3ma

^{13}C NMR (101 MHz, $CDCl_3$)



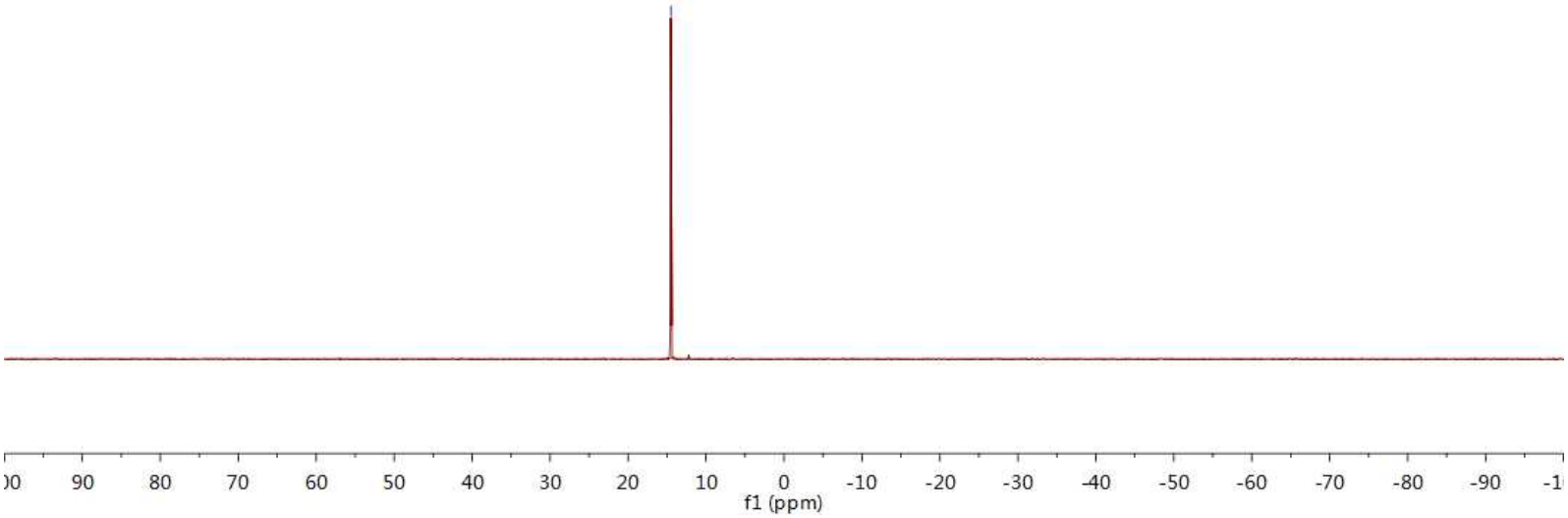
14.50

31P NMR ZG-2-86 in CDCl3

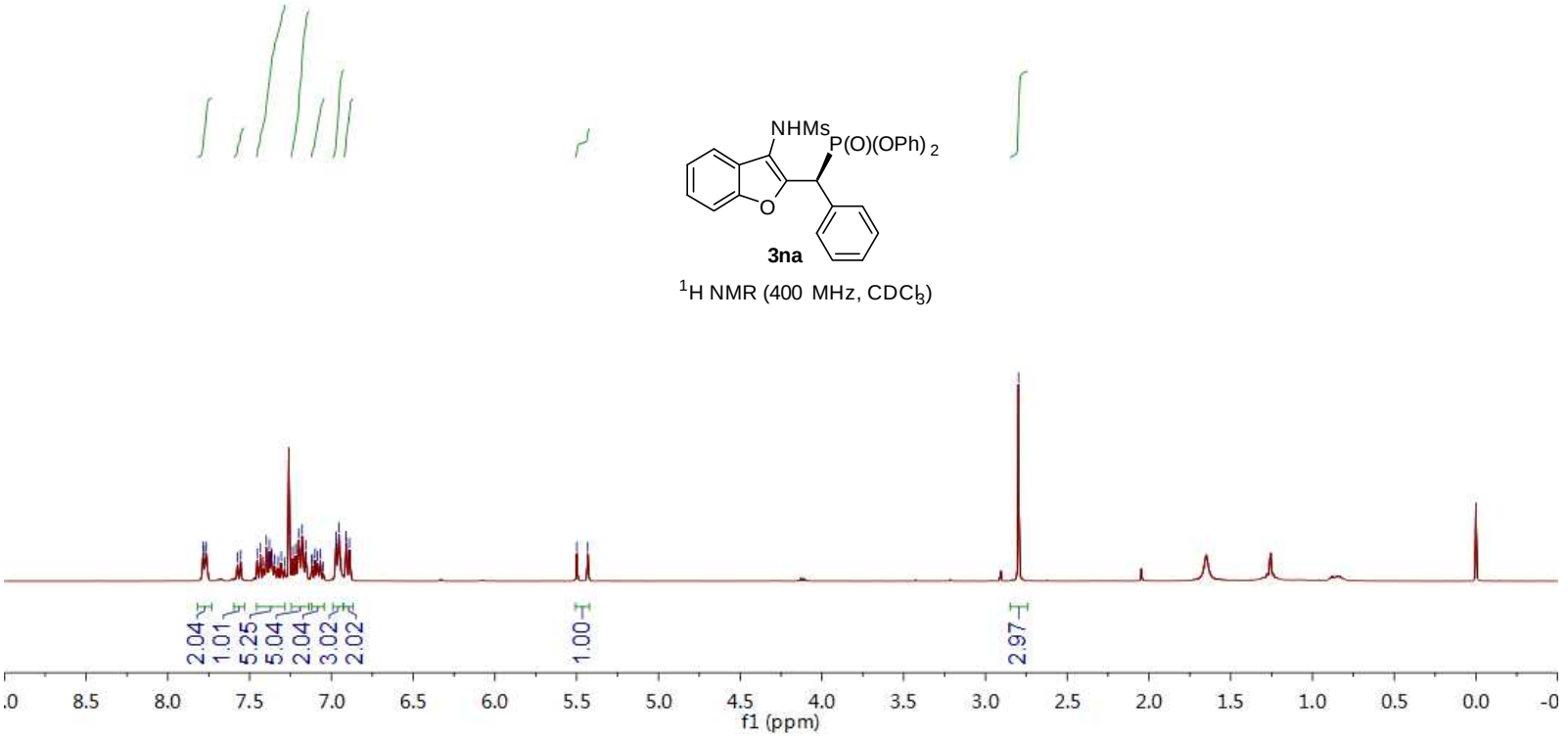


3ma

^{31}P NMR (162 MHz, $CDCl_3$)



1H NMR ZG-2-69B in CDCl3



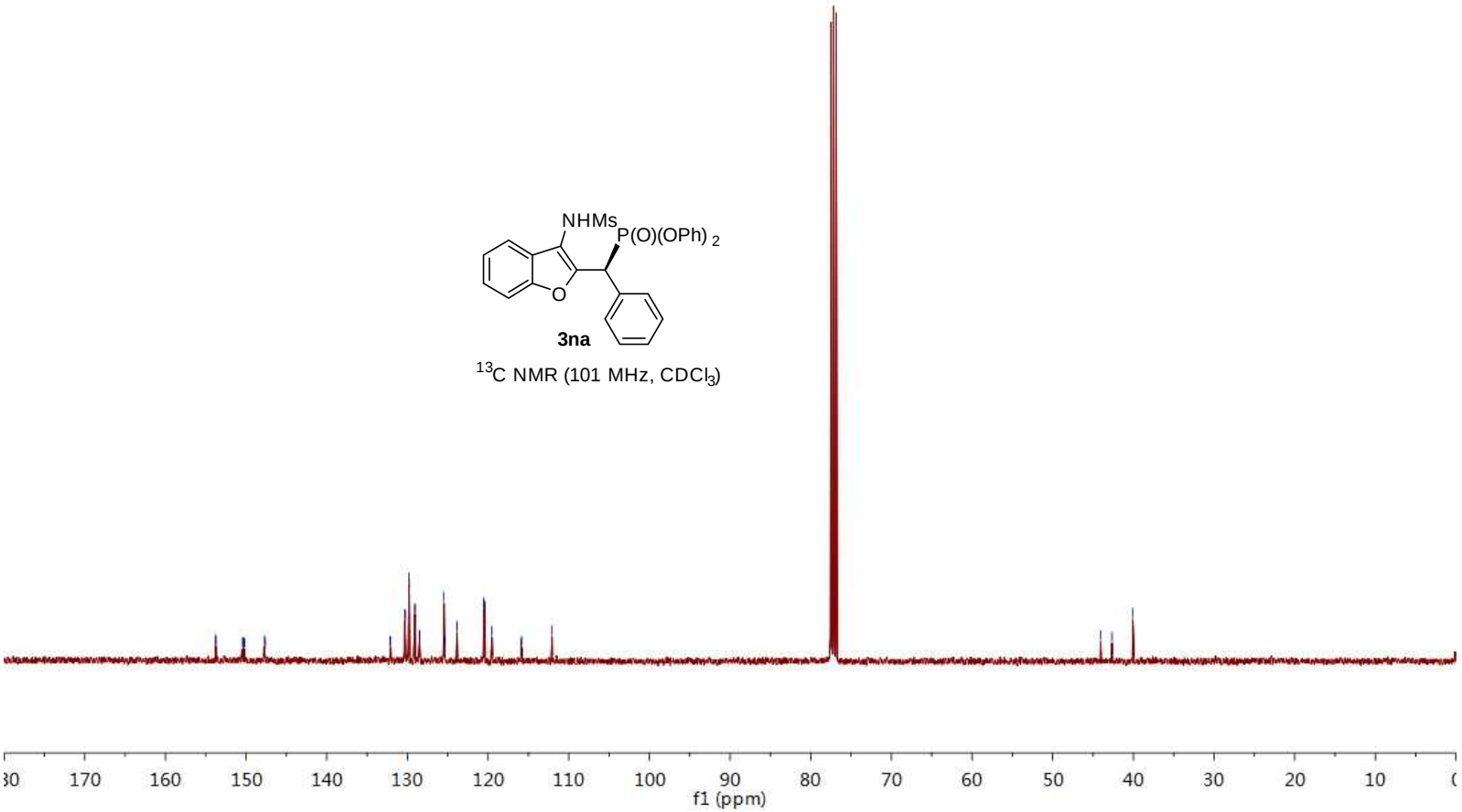
3na

^{1}H NMR (400 MHz, $CDCl_3$)

153.76
153.75
150.43
150.33
150.29
150.19
147.73
147.62
132.15
132.10
130.33
130.26
129.80
129.77
129.08
129.06
128.50
128.48
125.48
125.42
125.39
123.85
120.53
120.49
120.44
120.39
119.52
115.92
115.82
112.07

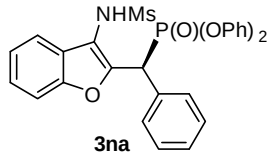
44.05
42.65
40.08

13C NMR ZG-2-69B in CDCl3



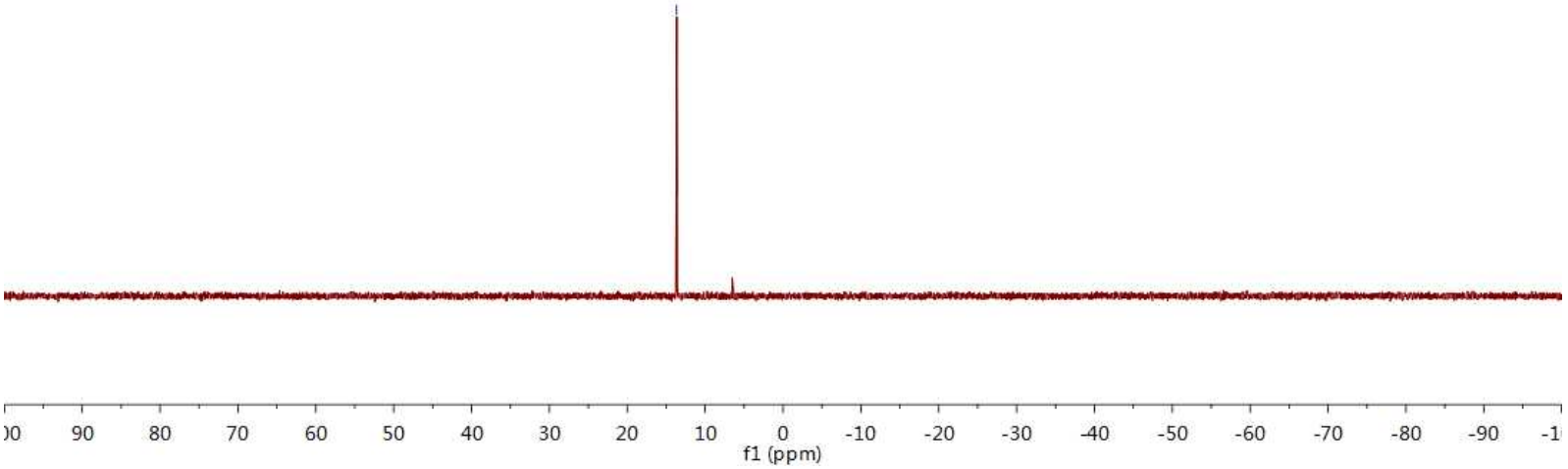
13.66

31P NMR ZG-2-69B in CDCl3

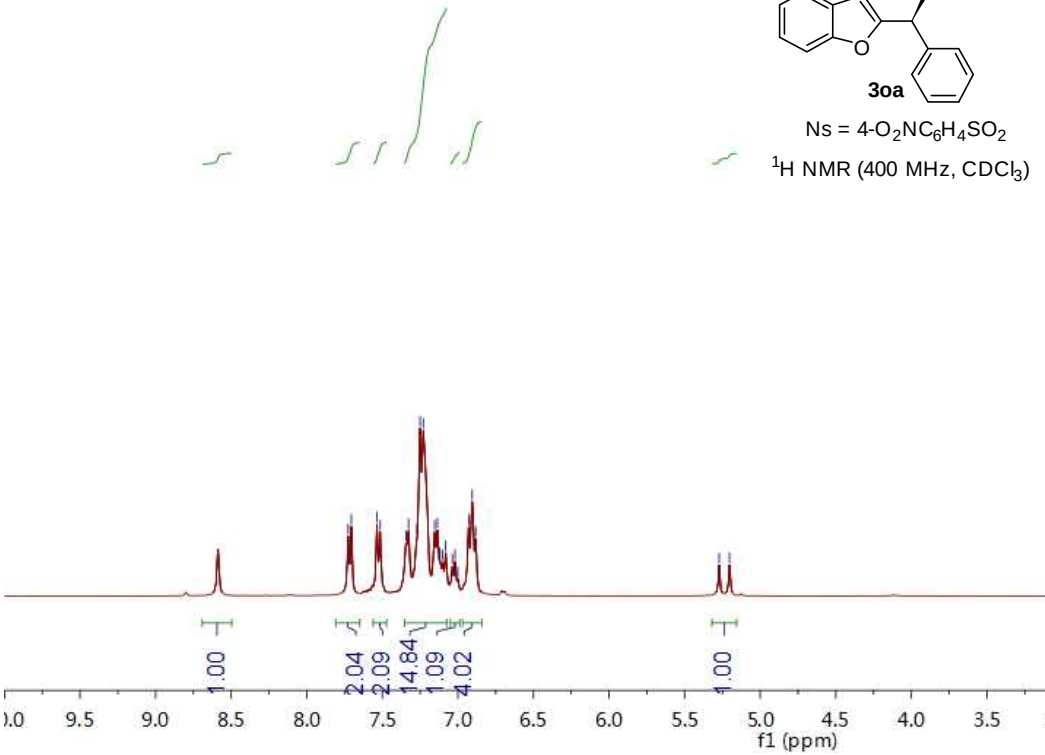


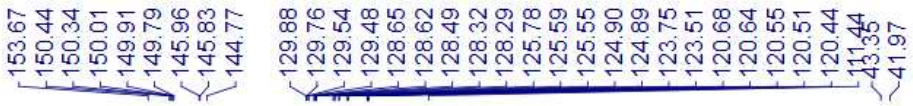
3na

^{31}P NMR (162 MHz, $CDCl_3$)

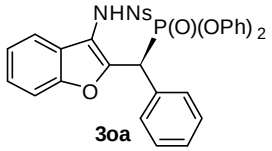


1H NMR ZG-2-69C in CDCl3





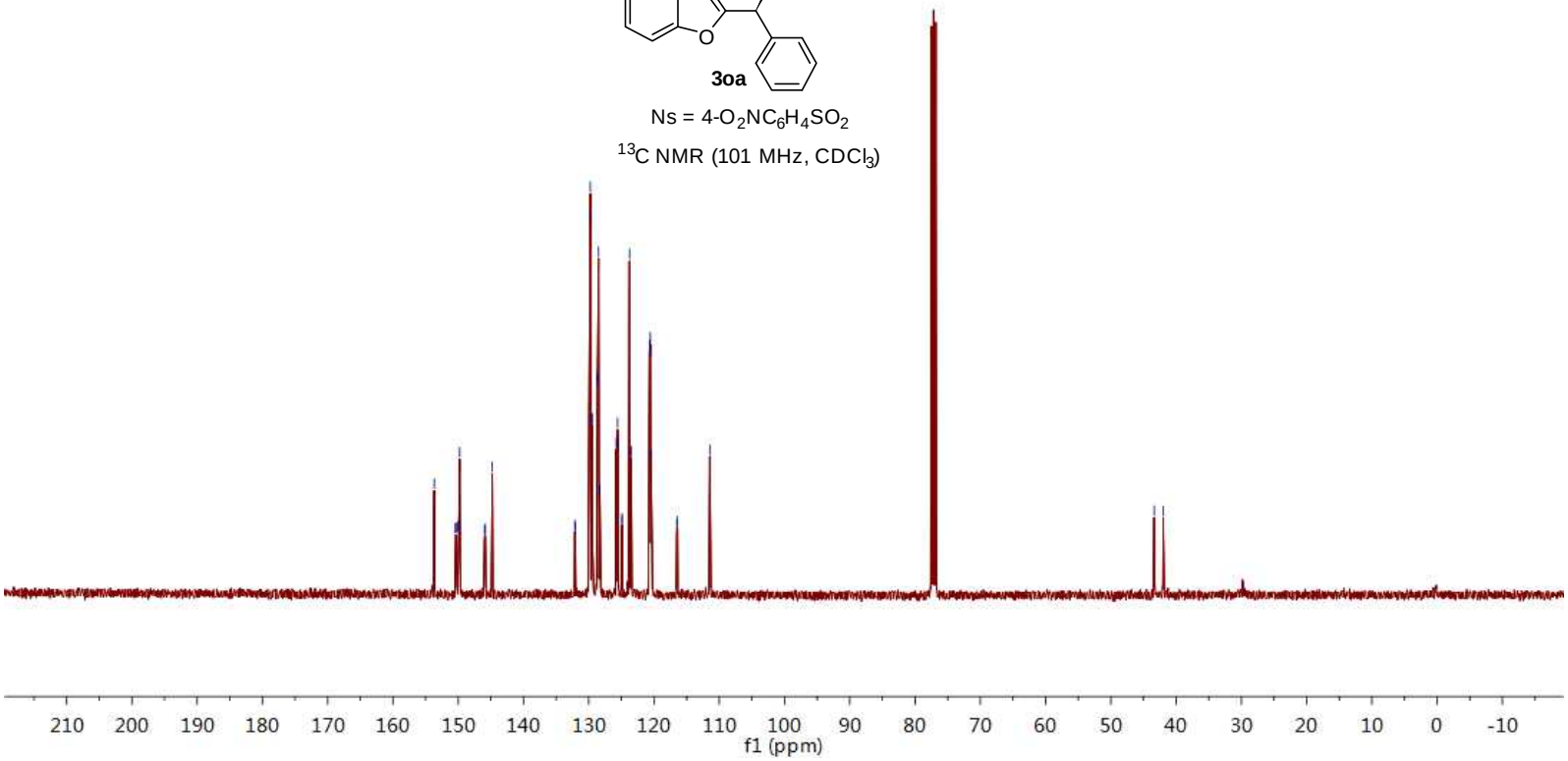
13C NMR ZG-2-69C in CDCl3



3oa

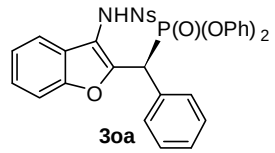
Ns = 4-$O_2NC_6H_4SO_2$

^{13}C NMR (101 MHz, $CDCl_3$)



14.30

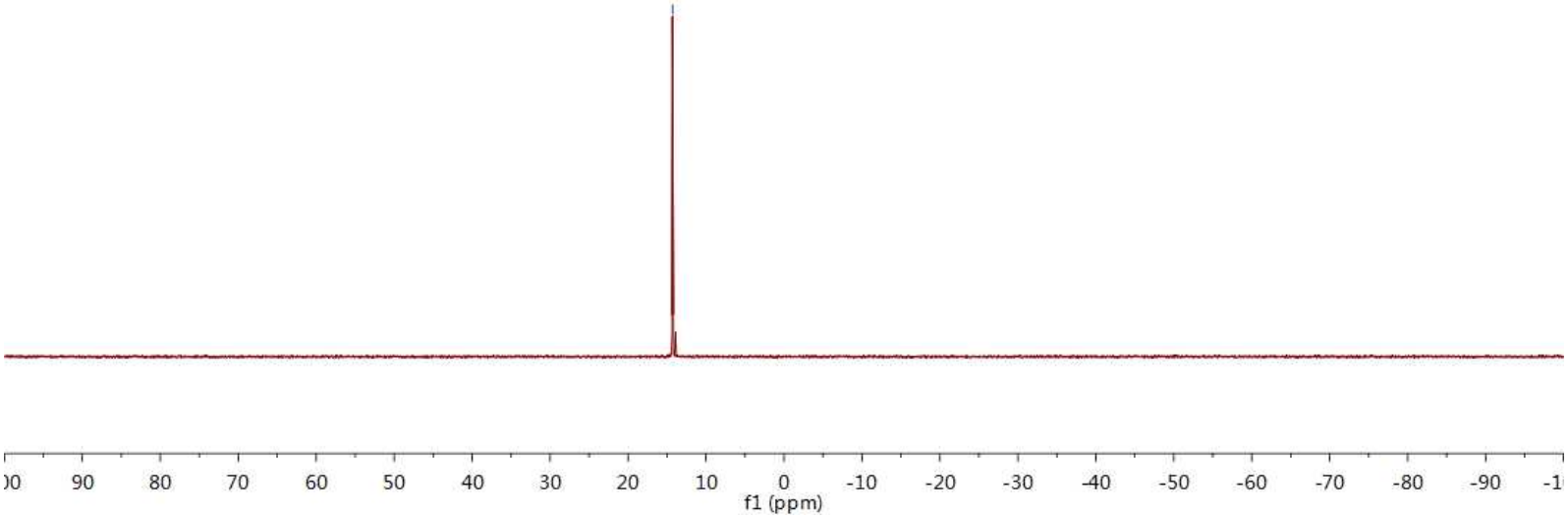
31P NMR ZG-2-69C in CDCl3

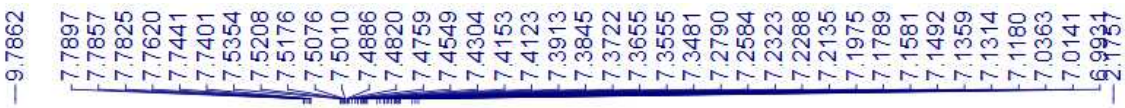


3oa

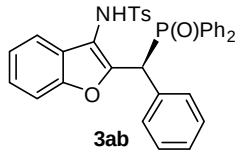
Ns = 4-$O_2NC_6H_4SO_2$

^{31}P NMR (162 MHz, $CDCl_3$)



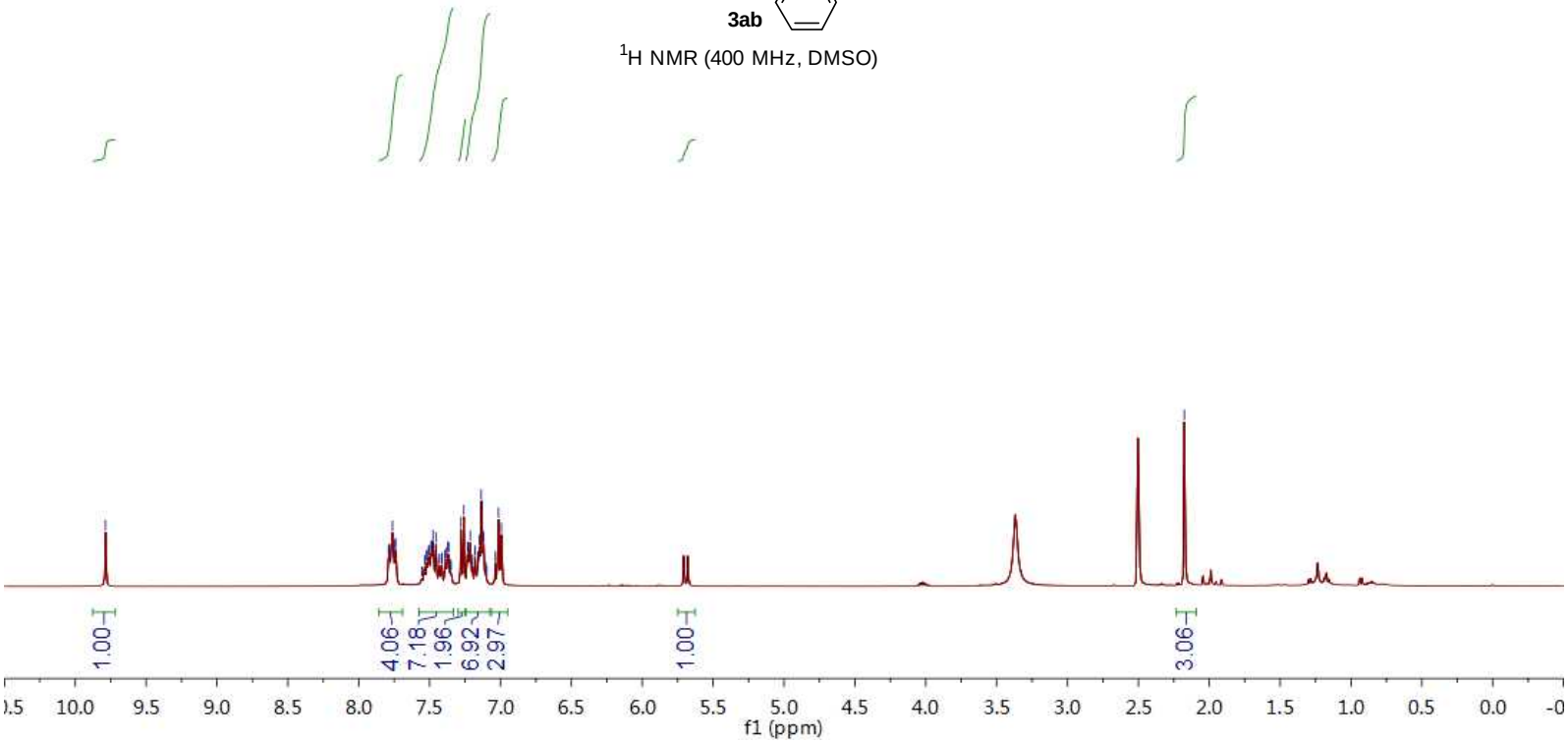


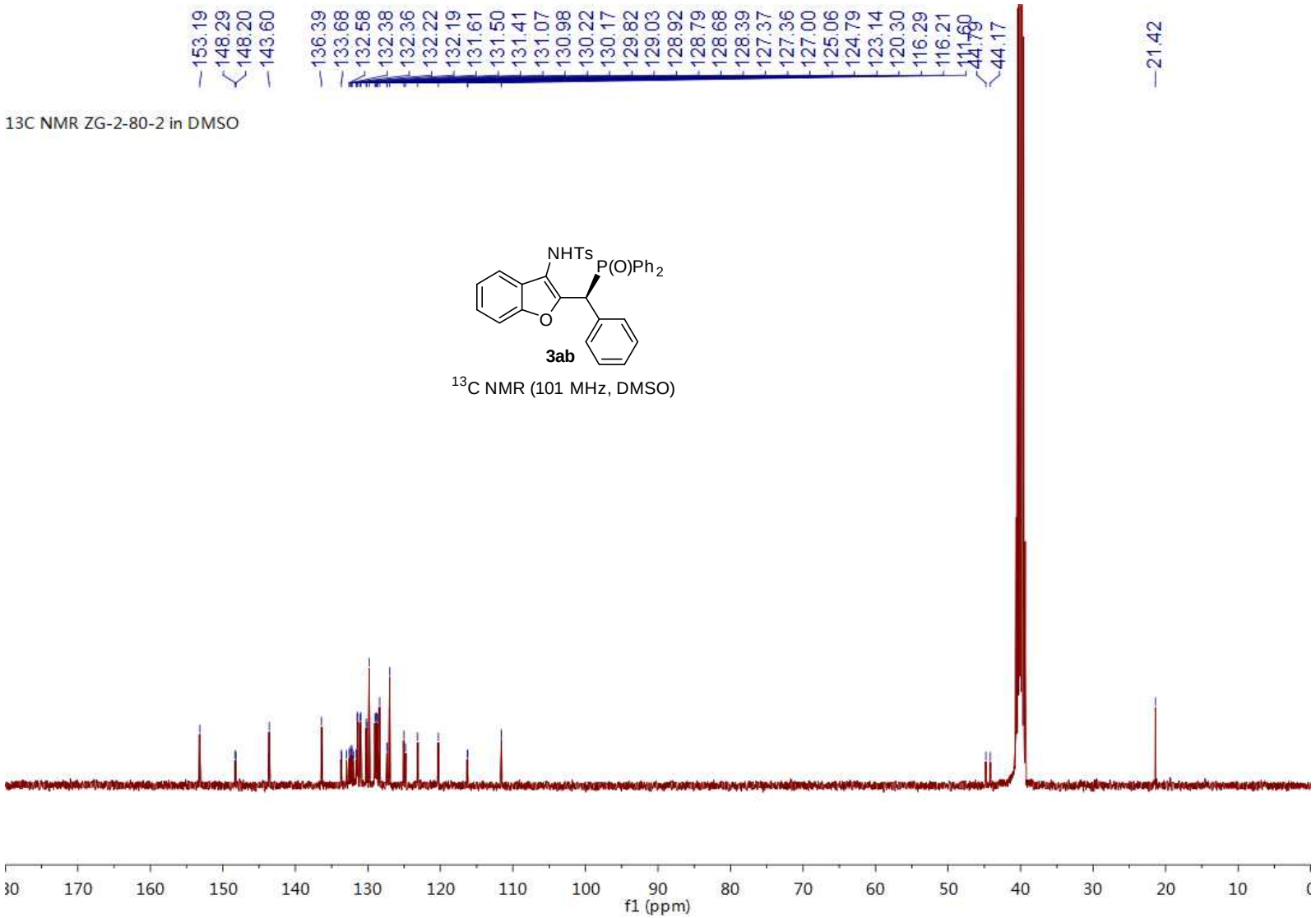
1H NMR ZG-2-80-2 in DMSO

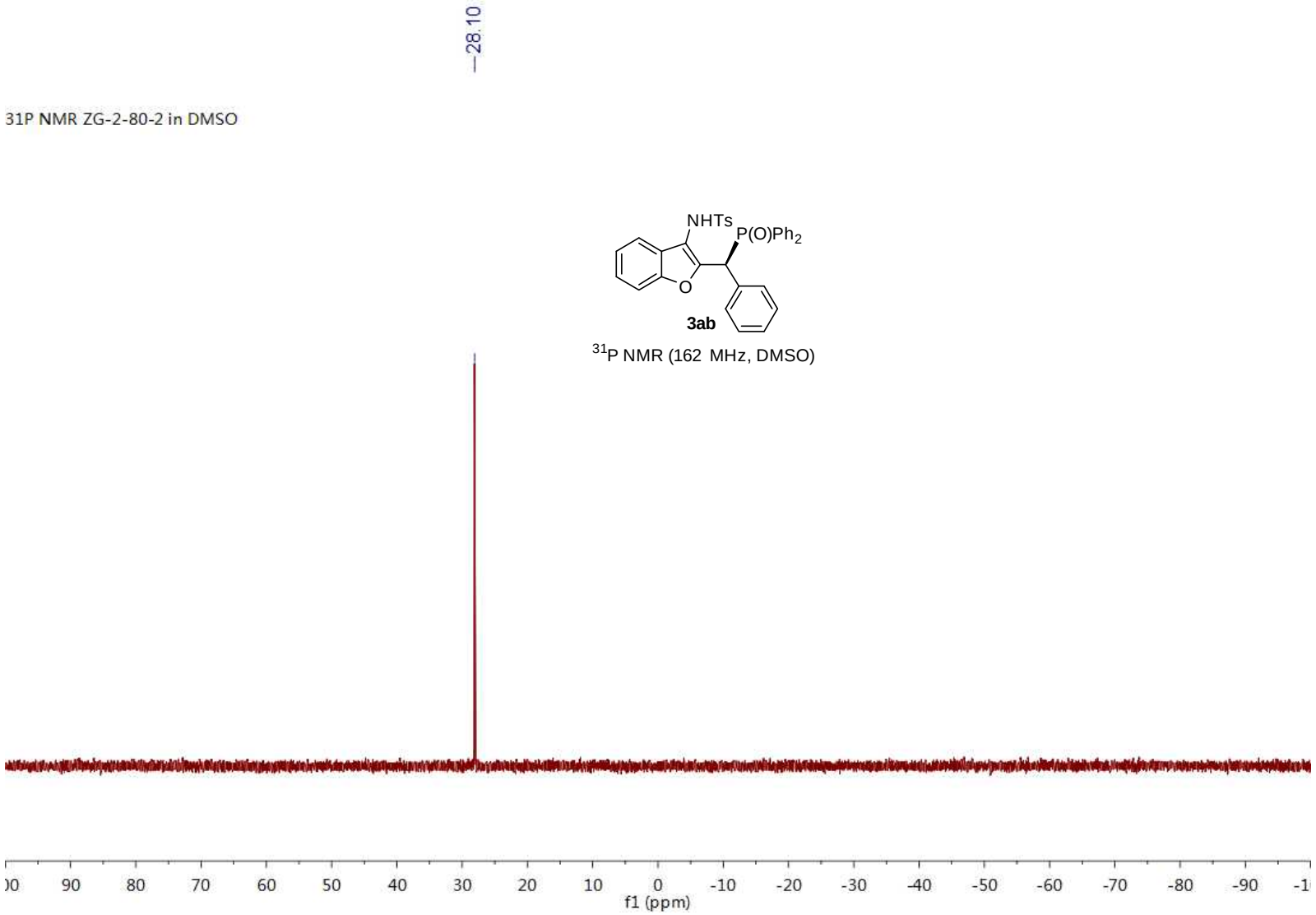


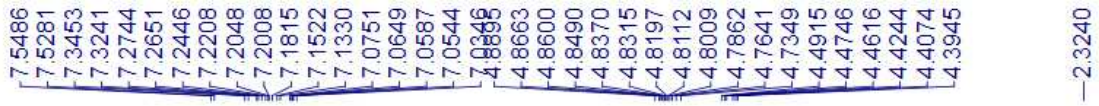
3ab

^{1}H NMR (400 MHz, DMSO)

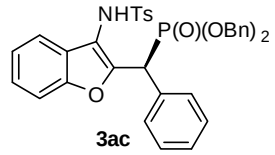



153.19
148.29
148.20
143.60
136.39
133.68
132.58
132.38
132.36
132.22
132.19
131.61
131.50
131.41
131.07
130.98
130.22
130.17
129.82
129.03
128.92
128.79
128.68
128.39
127.37
127.36
127.00
125.06
124.79
123.14
120.30
116.29
116.21
111.60
44.79
44.17
21.42
13C NMR ZG-2-80-2 in DMSO
NHTs
P(O)Ph2
O
3ab
13C NMR (101 MHz, DMSO)
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)


28.10
31P NMR ZG-2-80-2 in DMSO
NHTs
P(O)Ph2
O
3ab
31P NMR (162 MHz, DMSO)
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
f1 (ppm)

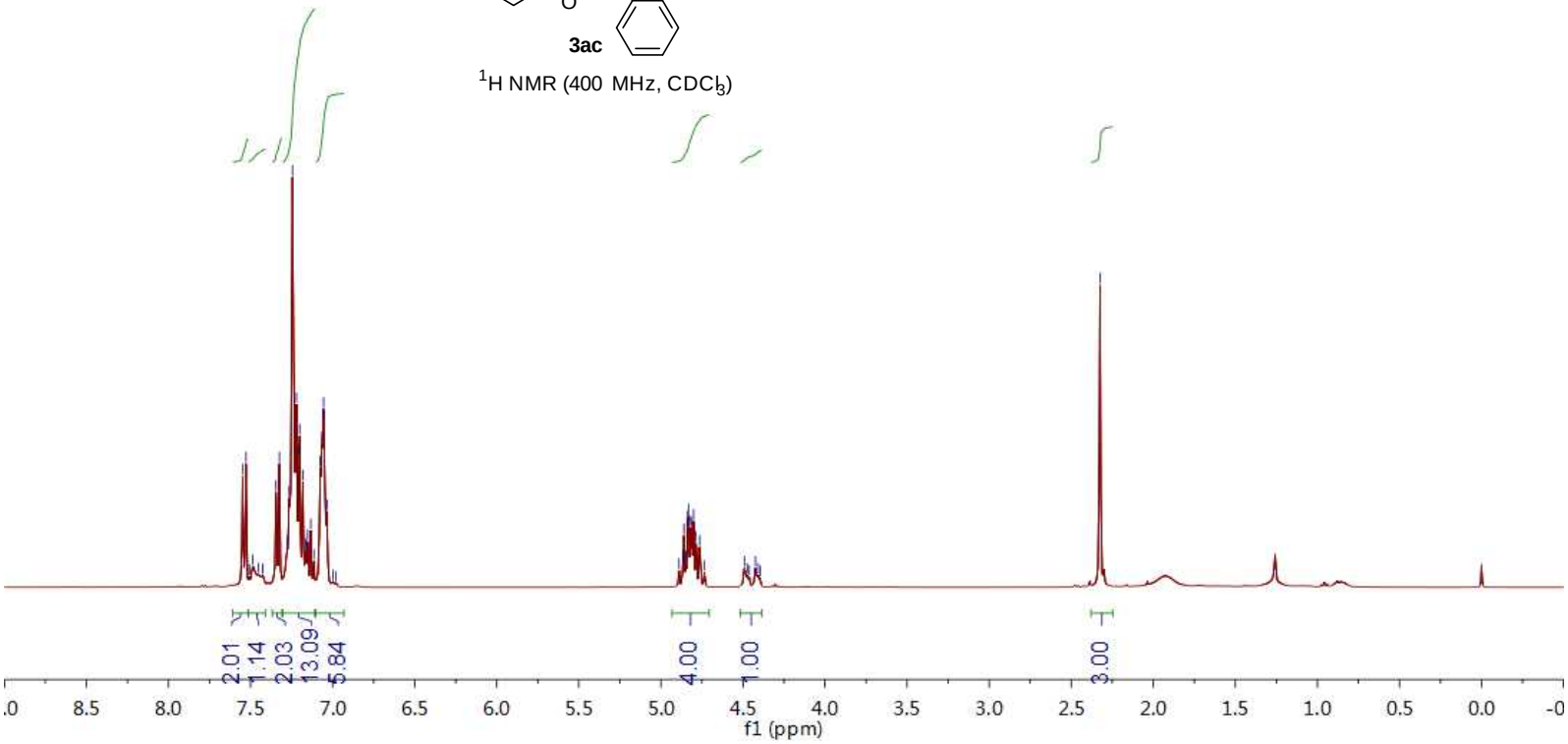


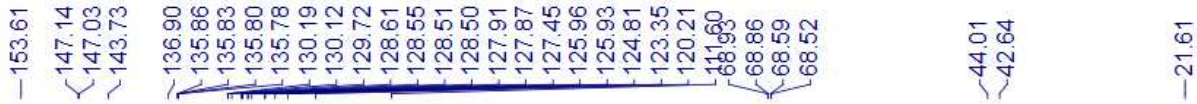
1H NMR ZG-2-61B in CDCl3



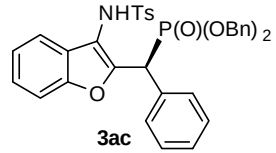
3ac

^{1}H NMR (400 MHz, $CDCl_3$)



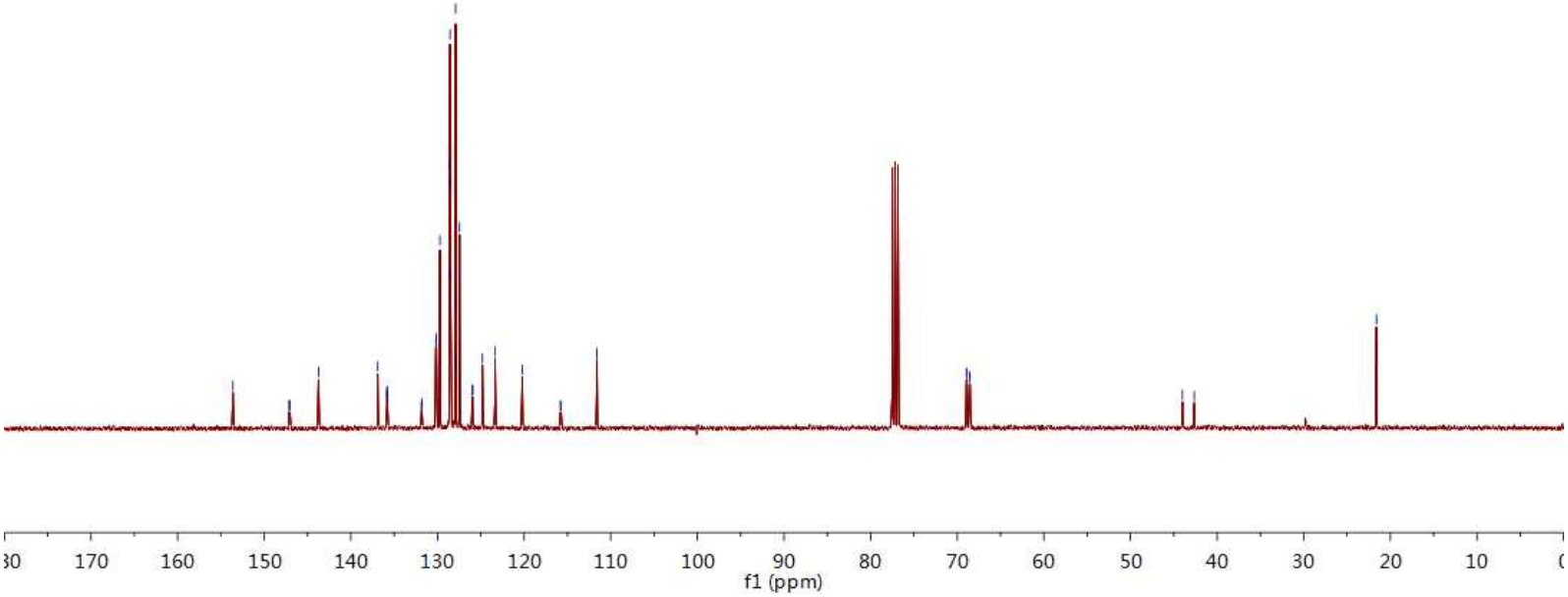


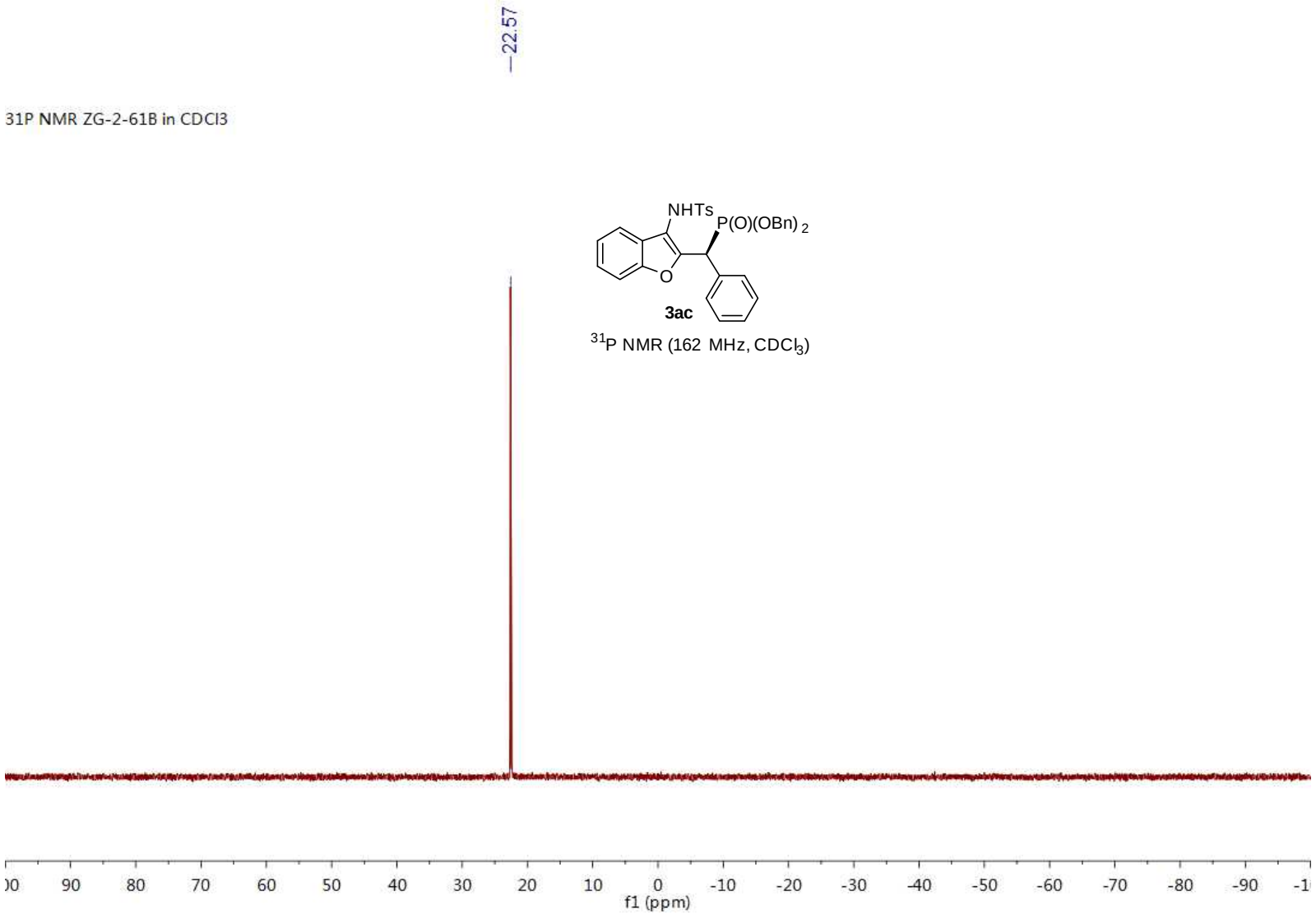
13C NMR ZG-2-61B in CDCl3



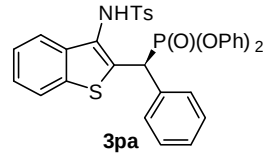
3ac

^{13}C NMR (101 MHz, $CDCl_3$)



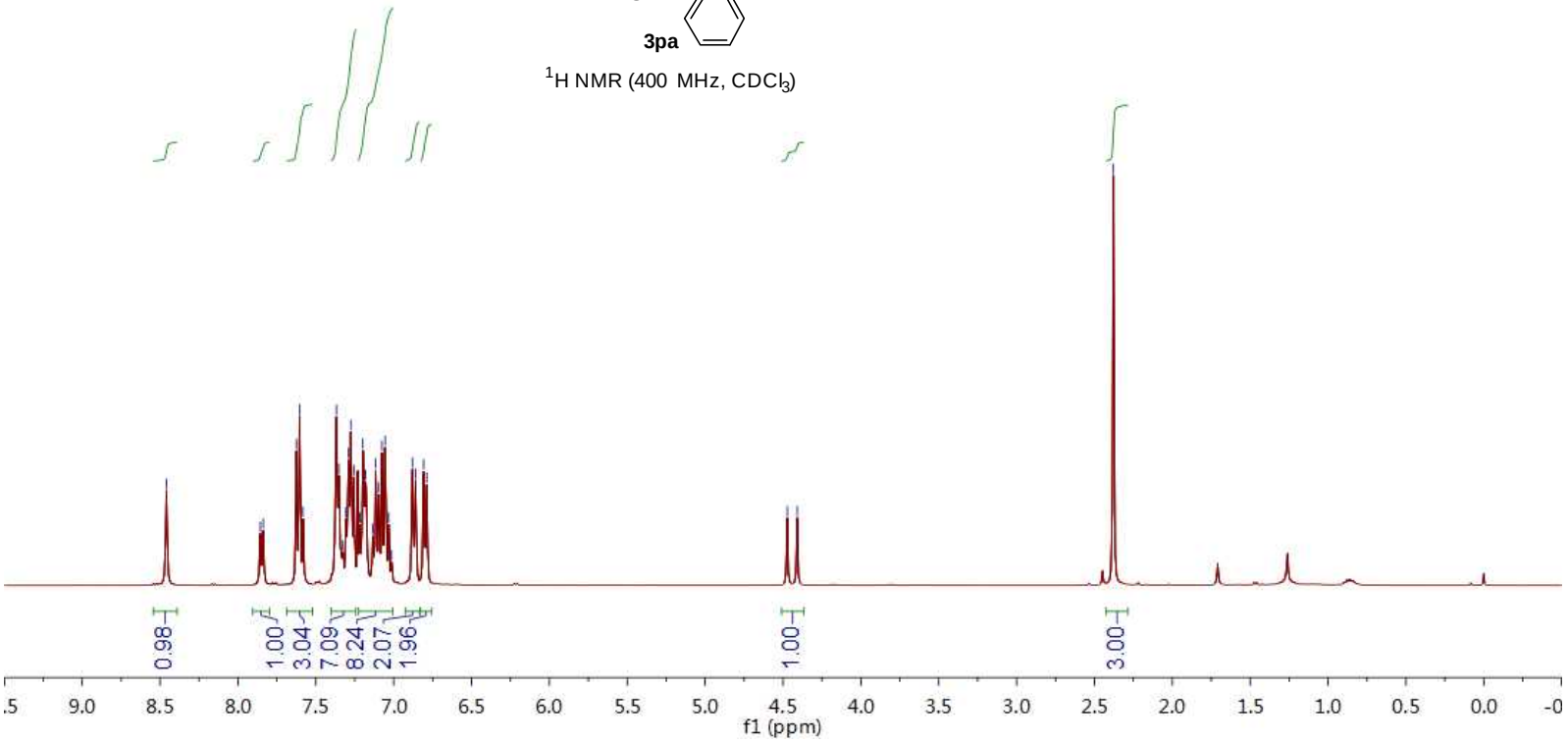

-22.57
31P NMR ZG-2-61B in CDCl3
NHTs
P(O)(OBn)2
O
3ac
31P NMR (162 MHz, CDCl3)
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
f1 (ppm)

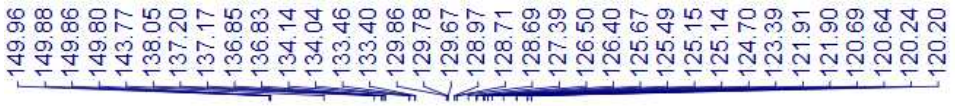
1H NMR ZG-3-36A in CDCl3



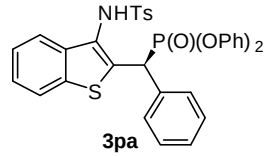
3pa

^{1}H NMR (400 MHz, $CDCl_3$)



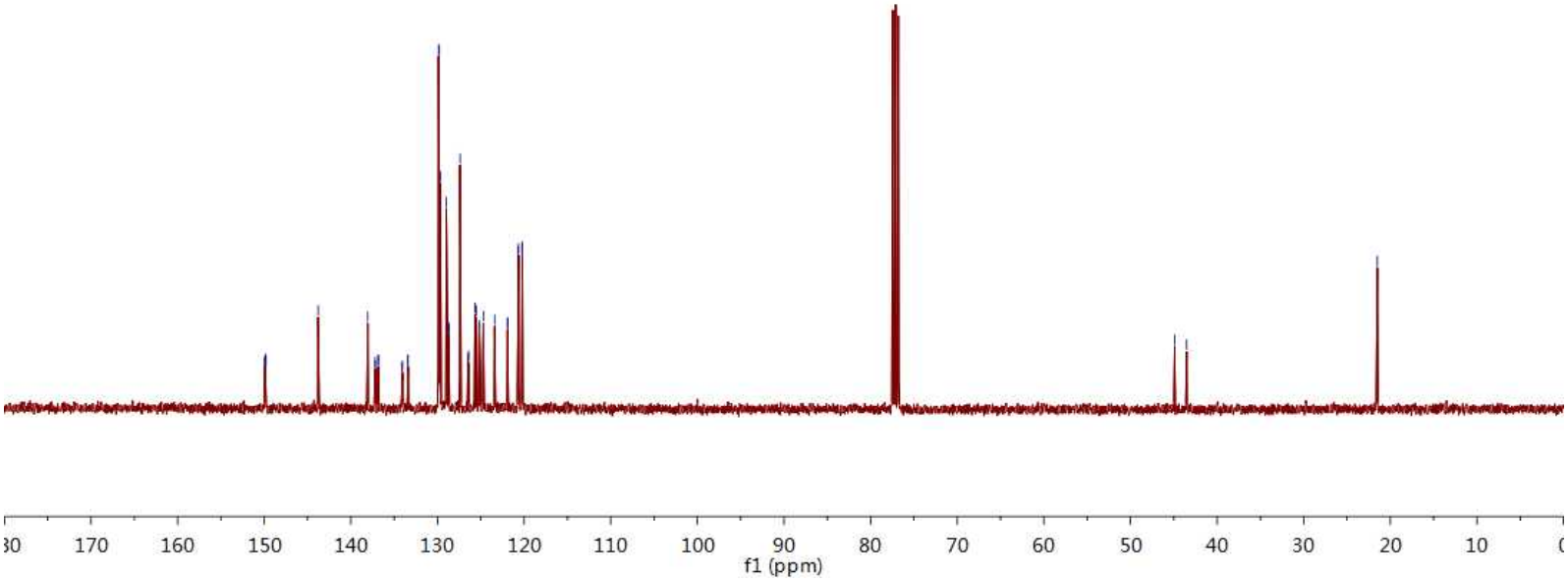


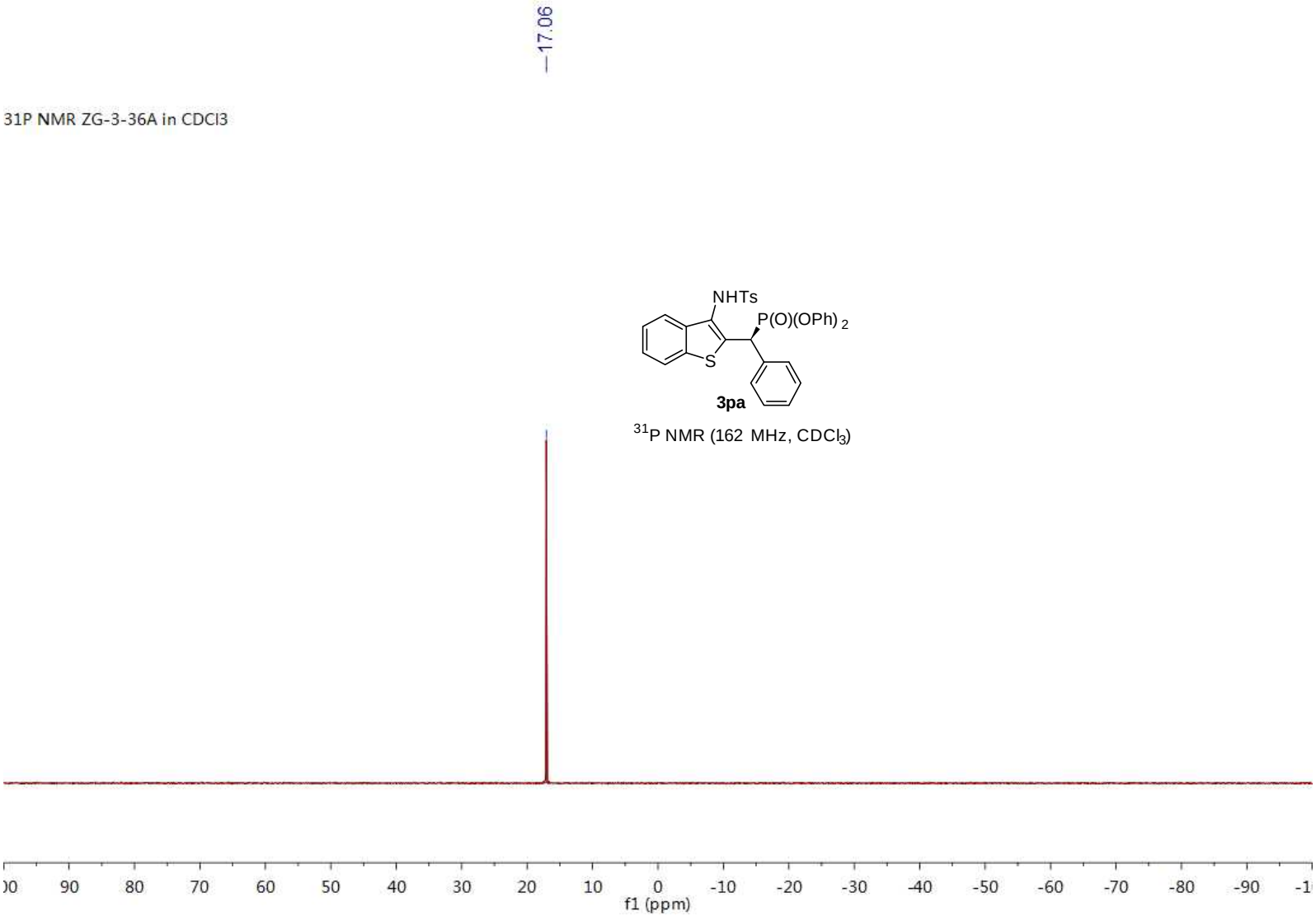
13C ZG-3-36A in CDCl3

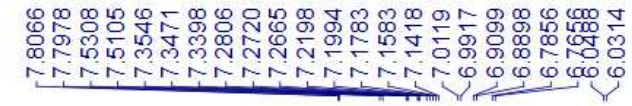


3pa

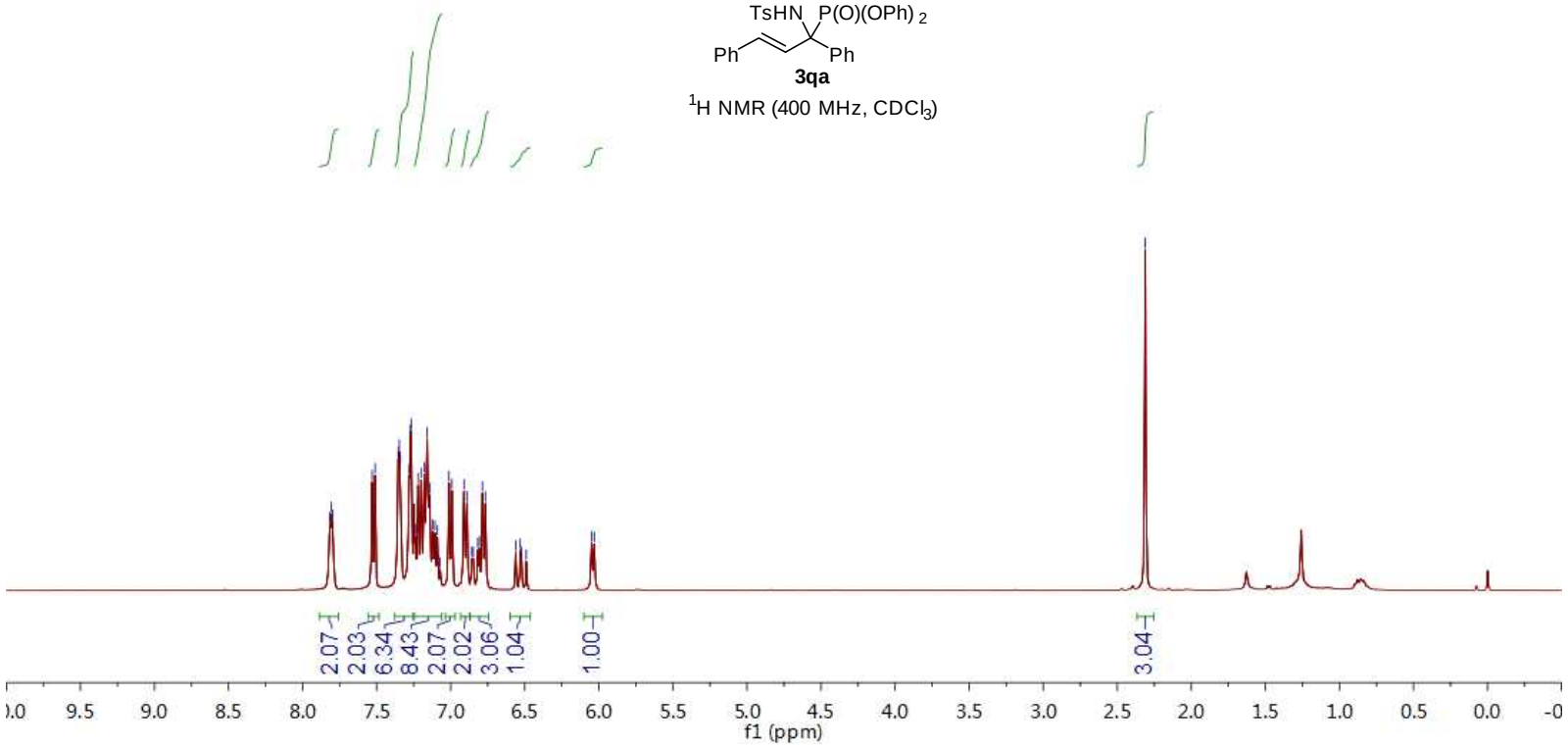
^{13}C NMR (101 MHz, $CDCl_3$)



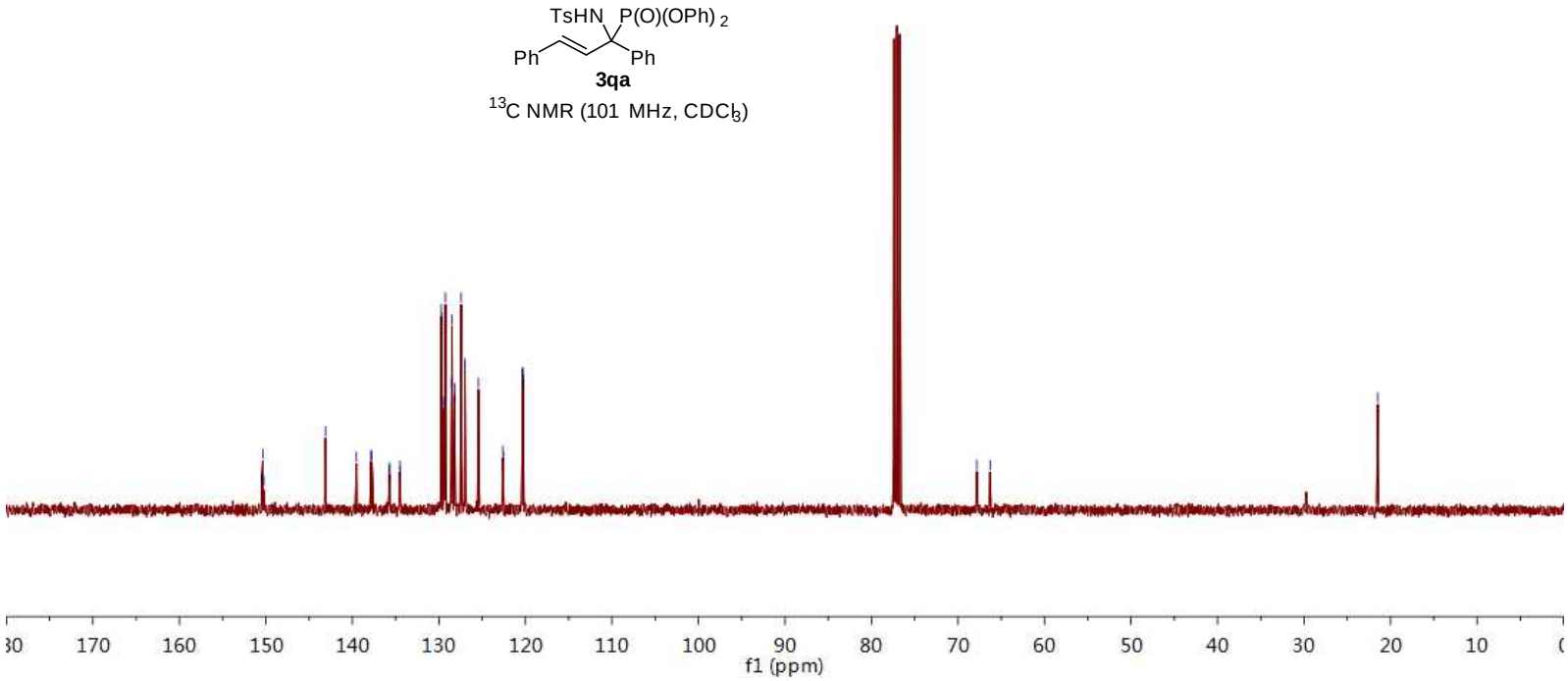

17.06
31P NMR ZG-3-36A in CDCl3
NHTs
P(O)(OPh)2
S
3pa
31P NMR (162 MHz, CDCl3)
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
f1 (ppm)

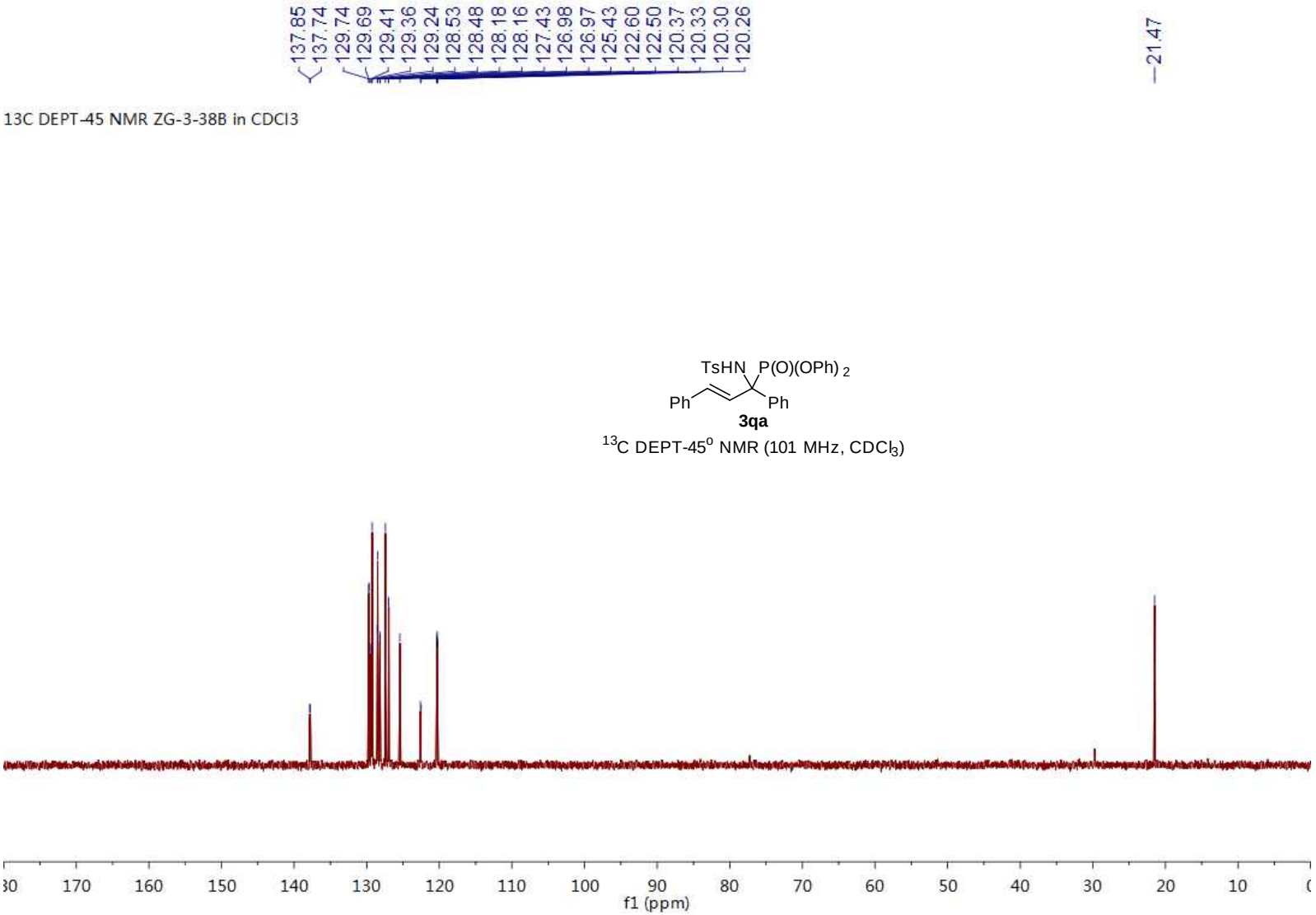


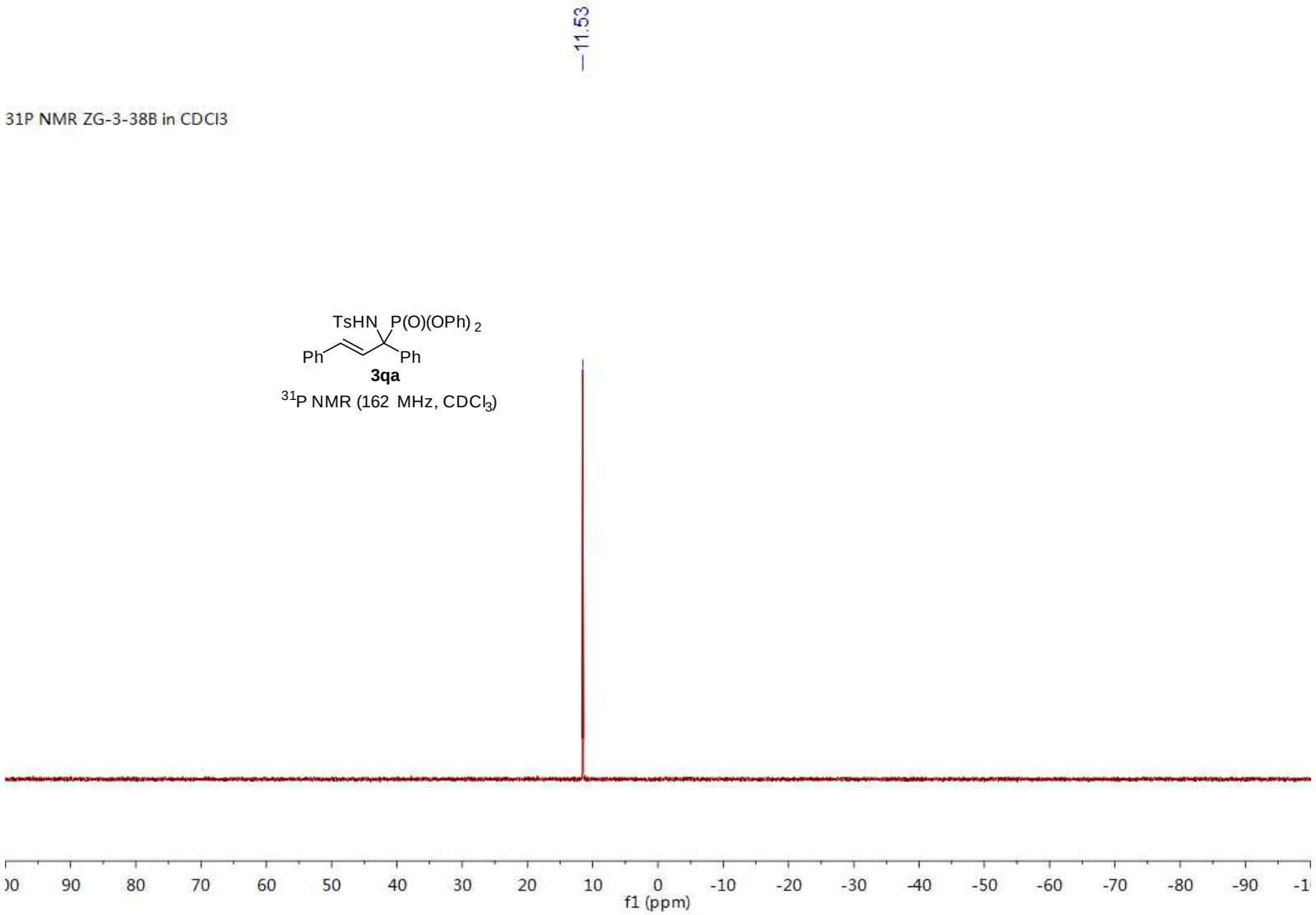
1H NMR ZG-3-38B in CDCl3



13C NMR ZG-3-38B in CDCl3




137.85
137.74
129.74
129.69
129.41
129.36
129.24
128.53
128.48
128.18
128.16
127.43
126.98
126.97
125.43
122.60
122.50
120.37
120.33
120.30
120.26
21.47
13C DEPT-45 NMR ZG-3-38B in CDCl3
TsHN
P(O)(OPh) 2
Ph
Ph
3qa
13C DEPT-45o NMR (101 MHz, CDCl3)
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)


11.53
31P NMR ZG-3-38B in CDCl3
TsHN
P(O)(OPh)2
Ph
Ph
3qa
31P NMR (162 MHz, CDCl3)
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
f1 (ppm)

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004505.D
Sample Name: ZG-2-61A(+/-)

```
==========================================================================
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 6/19/2017 12:00:08 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 6/19/2017 10:34:53 AM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 8:36:17 PM
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 70/30, 0.7 mL/min,  30 oC, 220 nm
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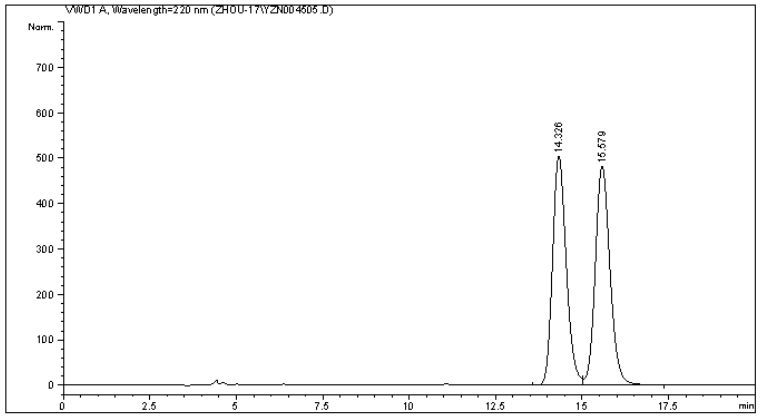



```
==========================================================================
                        Area Percent Report
==========================================================================

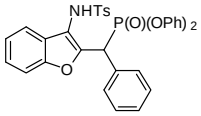
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|-------|---------|---------|-------|
   1  14.326 BV    0.4261 1.39347e4   503.79327  49.3796
   2  15.579 VB    0.4547 1.42849e4   482.31406  50.6204

Totals :                 2.82196e4   986.10733

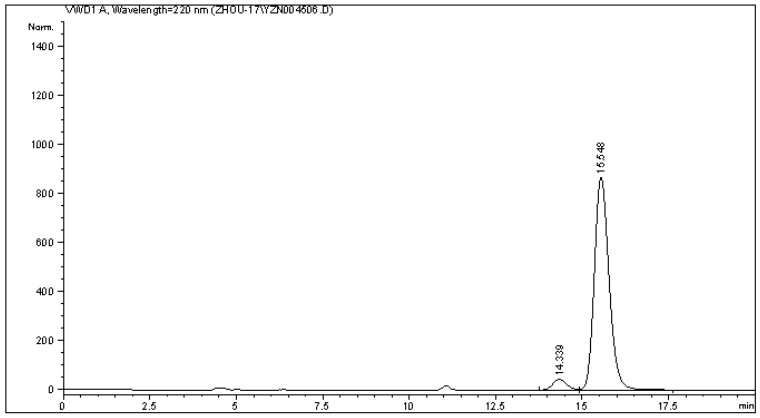
==========================================================================
                        *** End of Report ***
```



(+/-)-3aa

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004506.D
Sample Name: ZG-2-61A

```
==========================================================================
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 6/19/2017 12:26:04 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 6/19/2017 12:21:40 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 8:37:53 PM
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 70/30, 0.7 mL/min,  30 oC, 220 nm
```




```
==========================================================================
                        Area Percent Report
==========================================================================

Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|-------|---------|---------|-------|
   1  14.339 BV    0.4300 1214.60071   43.77455   4.5298
   2  15.548 VB    0.4556 2.55990e4   869.39563  95.4702

Totals :                 2.68136e4   913.17018

==========================================================================
                        *** End of Report ***
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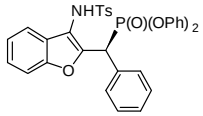

(*S*)-(-)-3aa

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004533.D
Sample Name: ZG-2-62A(+/-)

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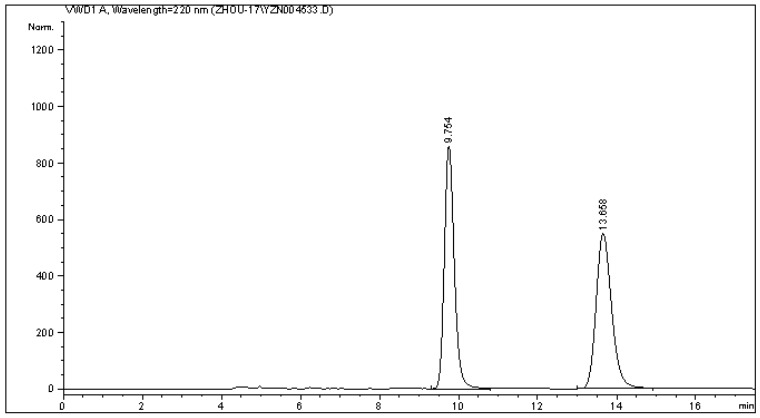
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 6/21/2017 9:02:51 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 6/21/2017 8:22:30 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 8:44:17 PM
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 70/30, 0.7 mL/min,  30 oC, 220 nm
```




```
==================================================================
                        Area Percent Report
==================================================================

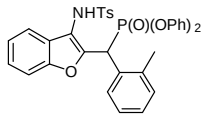
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|-------|----------|----------|--------|
   1   9.754 VV    0.2696 1.50305e4   859.36847  49.9391
   2  13.658 BB    0.4218 1.50672e4   549.60809  50.0609

Totals :                 3.00977e4  1408.97656

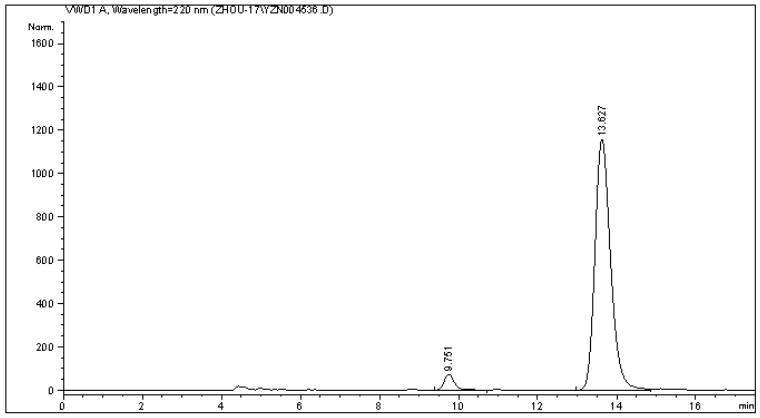
==================================================================
                        *** End of Report ***
```



(+/-)-3ba

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004536.D
Sample Name: ZG-2-62A

```
==================================================================
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 6/21/2017 10:34:01 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 6/21/2017 10:28:51 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 8:45:41 PM
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 70/30, 0.7 mL/min,  30 oC, 220 nm
```




```
==================================================================
                        Area Percent Report
==================================================================

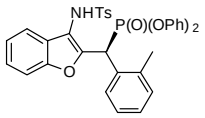
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|-------|----------|----------|--------|
   1   9.751 BV    0.2796 1317.13318   71.77303   3.9725
   2  13.627 BV    0.4243 3.18394e4  1157.30908  96.0275

Totals :                 3.31566e4  1229.08211

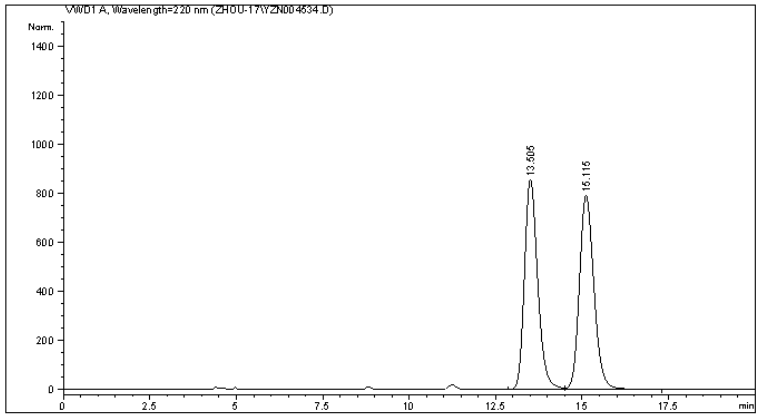
==================================================================
                        *** End of Report ***
```



(*S*)-(-)-3ba

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004534.D
Sample Name: ZG-2-62B(+/-)

```
==================================================================
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 6/21/2017 9:31:52 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 6/21/2017 9:26:35 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 8:47:12 PM
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 70/30, 0.7 mL/min,  30 oC, 220 nm
```




```
==================================================================
                      Area Percent Report
==================================================================

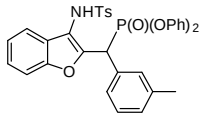
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|-------|----------|----------|--------|
   1  13.505 BV    0.4100 2.28368e4   856.71838  49.6412
   2  15.115 VB    0.4516 2.31670e4   792.64319  50.3588

Totals :                 4.60038e4  1649.36157

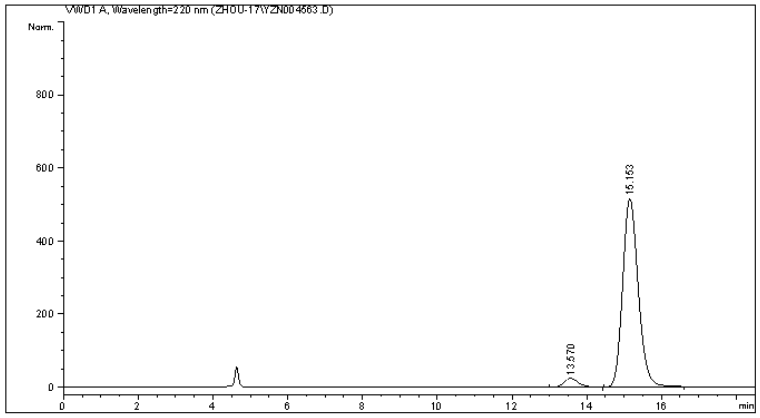
==================================================================
                      *** End of Report ***
```



(+/-)-3ca

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004563.D
Sample Name: ZG-2-62B

```
==================================================================
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 6/24/2017 1:20:05 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 6/24/2017 1:15:30 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 8:48:53 PM
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 70/30, 0.7 mL/min,  30 oC, 220 nm
```




```
==================================================================
                      Area Percent Report
==================================================================

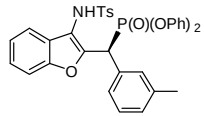
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|-------|----------|----------|--------|
   1  13.570 BB    0.4118  635.46277   23.81252   4.1004
   2  15.153 BB    0.4461 1.48620e4   514.63782  95.8996

Totals :                 1.54975e4   538.45034

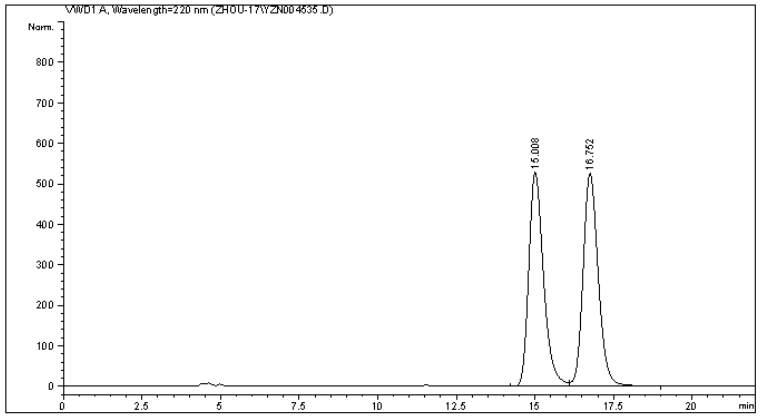
==================================================================
                      *** End of Report ***
```



(*S*)-(-)-3ca

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004535.D
Sample Name: ZG-2-62C(+/-)

```
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 6/21/2017 10:02:03 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 6/21/2017 9:57:33 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 8:50:15 PM
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 70/30, 0.7 mL/min,  30 oC, 220 nm
```




```
                          Area Percent Report

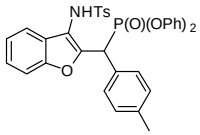
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|-------|---------|---------|-------|
   1  15.008 VV    0.4990 1.72618e4   528.54193  49.4916
   2  16.752 VB    0.5178 1.76165e4   525.51593  50.5084

Totals :                 3.48783e4  1054.05786

                          *** End of Report ***
```

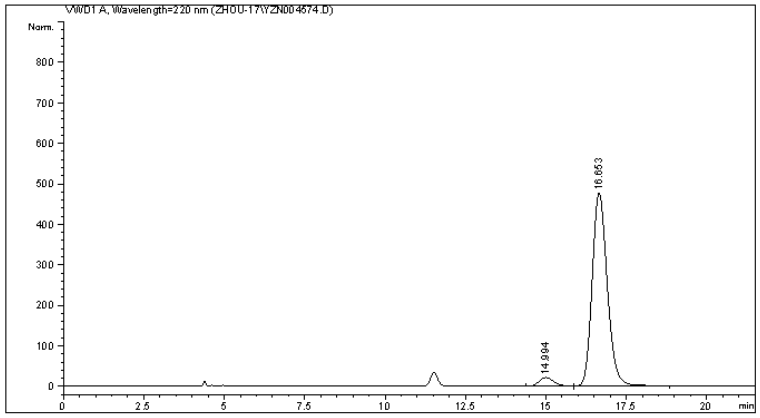


(+/-)-3da

Instrument 1 11/3/2017 8:51:14 PM Page 1 of 1

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004574.D
Sample Name: ZG-2-62C

```
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 6/25/2017 11:38:22 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 6/25/2017 11:08:59 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 8:52:36 PM
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 70/30, 0.7 mL/min,  30 oC, 220 nm
```




```
                          Area Percent Report

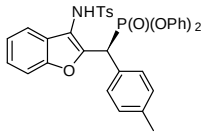
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|-------|---------|---------|-------|
   1  14.994 BV    0.5045  724.97223   21.96547   4.4257
   2  16.653 VB    0.5046 1.56561e4   477.71994  95.5743

Totals :                 1.63810e4   499.68541

                          *** End of Report ***
```

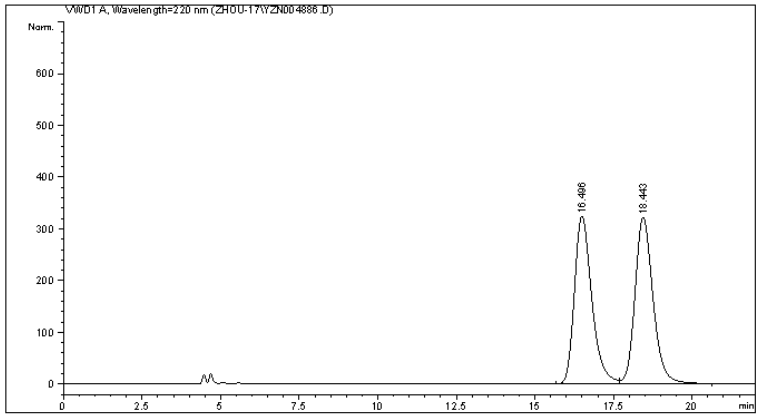


(*S*)-(-)-3da

Instrument 1 11/3/2017 8:52:43 PM Page 1 of 1

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004886.D
Sample Name: ZG-2-79A(+/-)

```
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 7/20/2017 8:41:29 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 7/20/2017 8:12:36 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 9:49:15 PM
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 70/30, 0.7 mL/min,  30 oC, 220 nm,
```



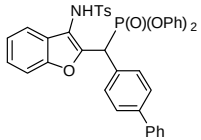

```
                          Area Percent Report

Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|------|---------|---------|-------|
   1  16.496 BV    0.5911 1.24889e4   323.85489  49.3376
   2  18.443 VB    0.6145 1.28243e4   321.07635  50.6624

Totals :                  2.53131e4   644.93124
```

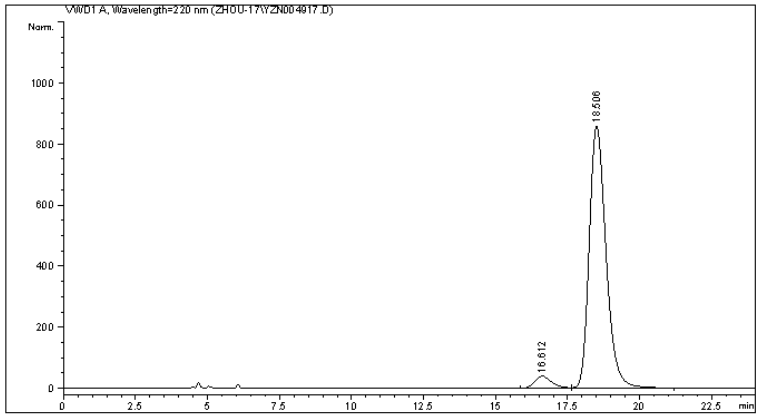


(+/-)-3ea

```
                          *** End of Report ***
```


Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004917.D
Sample Name: ZG-2-79A

```
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 7/23/2017 10:36:02 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 7/23/2017 10:27:36 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 9:50:41 PM
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 70/30, 0.7 mL/min,  30 oC, 220 nm
```



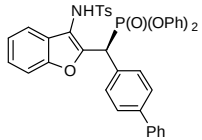

```
                          Area Percent Report

Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|------|---------|---------|-------|
   1  16.612 BV    0.6190 1605.08569   39.67850   4.4112
   2  18.506 VB    0.6222 3.47813e4   859.33435  95.5888

Totals :                  3.63864e4   899.01285
```

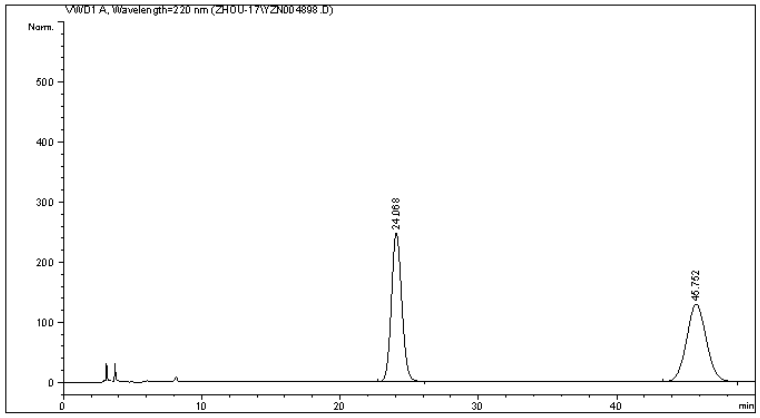


(*S*)-(-)-3ea

```
                          *** End of Report ***
```

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004898.D
Sample Name: ZG-2-79B(+/-)

```
==================================================================
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 7/21/2017 3:37:43 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 7/21/2017 3:20:33 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 9:53:09 PM
                  (modified after loading)
Sample Info     : IA, Hexane/i-PrOH = 70/30, 1.0 mL/min,  30 oC, 220 nm,
```




```
==================================================================
                      Area Percent Report
==================================================================

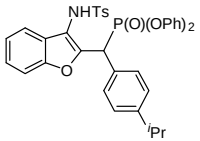
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|------|---------|---------|--------|
   1  24.068 BB    0.8035 1.2901le4   247.97955  50.1460
   2  45.752 BB    1.5342 1.2826oe4   129.15497  49.8540

Totals :                 2.5727le4   377.13452

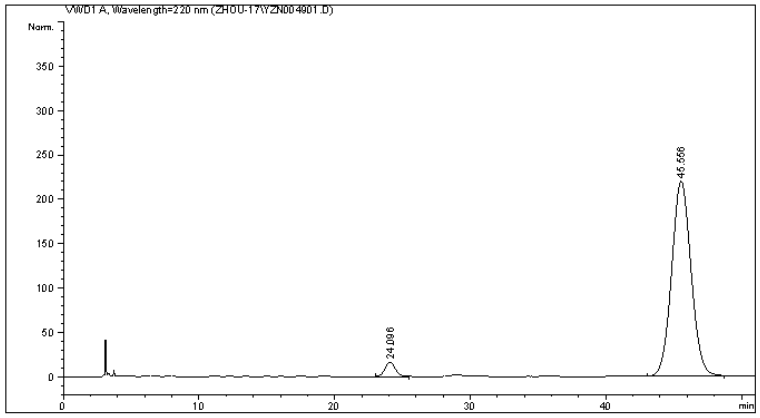
==================================================================
                      *** End of Report ***
```



(+/-)-3fa

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004901.D
Sample Name: ZG-2-79B

```
==================================================================
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 7/21/2017 9:22:16 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 7/21/2017 8:33:40 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 9:54:45 PM
                  (modified after loading)
Sample Info     : IA, Hexane/i-PrOH = 70/30, 1.0 mL/min,  30 oC, 220 nm,
```




```
==================================================================
                      Area Percent Report
==================================================================

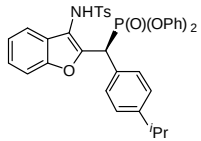
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|------|---------|---------|--------|
   1  24.096 BB    0.8014  848.53790   16.28780   3.7395
   2  45.556 BB    1.5357 2.18428e4   219.66837  96.2605

Totals :                 2.26914e4   235.95617

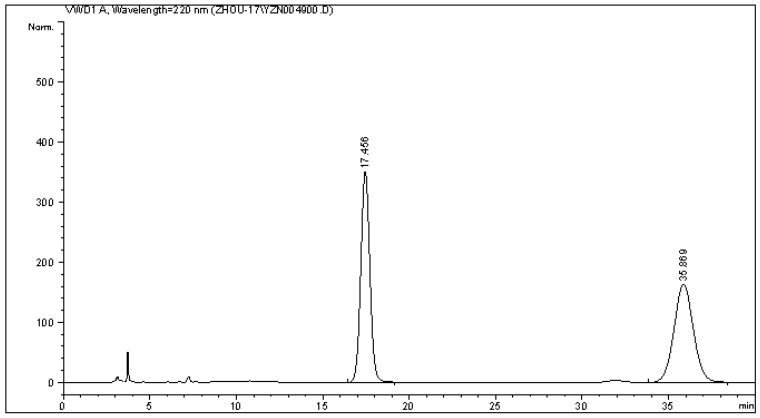
==================================================================
                      *** End of Report ***
```



(*S*)-(-)-3fa

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004900.D
Sample Name: ZG-2-79C(+/-)

```
==================================================================
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 7/21/2017 5:18:27 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 7/21/2017 5:14:28 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 9:56:00 PM
                  (modified after loading)
Sample Info     : IA, Hexane/i-PrOH = 70/30, 1.0 mL/min,  30 oC, 220 nm,
```




```
==================================================================
                      Area Percent Report
==================================================================

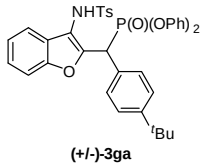
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|-------|----------|----------|--------|
   1  17.456 BB    0.5598 1.27732e4   351.17429  50.0633
   2  35.869 BB    1.1959 1.27409e4   163.78157  49.9367

Totals :                 2.55141e4   514.95586

==================================================================
                      *** End of Report ***
```

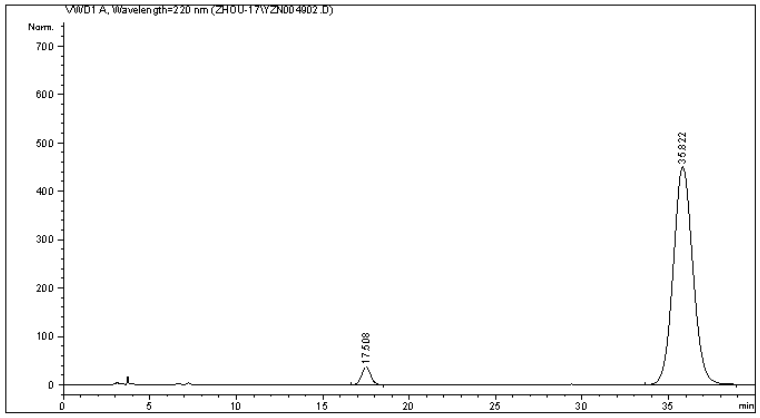


(+/-)-3ga

Instrument 1 11/3/2017 9:56:07 PM Page 1 of 1

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004902.D
Sample Name: ZG-2-79C

```
==================================================================
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 7/21/2017 10:20:16 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 7/21/2017 10:14:25 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 9:57:38 PM
                  (modified after loading)
Sample Info     : IA, Hexane/i-PrOH = 70/30, 1.0 mL/min,  30 oC, 220 nm,
```




```
==================================================================
                      Area Percent Report
==================================================================

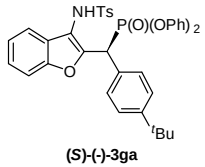
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|-------|----------|----------|--------|
   1  17.508 BB    0.5624 1305.03015   35.90367   3.5574
   2  35.822 BB    1.2127 3.53803e4   450.05505  96.4426

Totals :                 3.66854e4   485.95872

==================================================================
                      *** End of Report ***
```

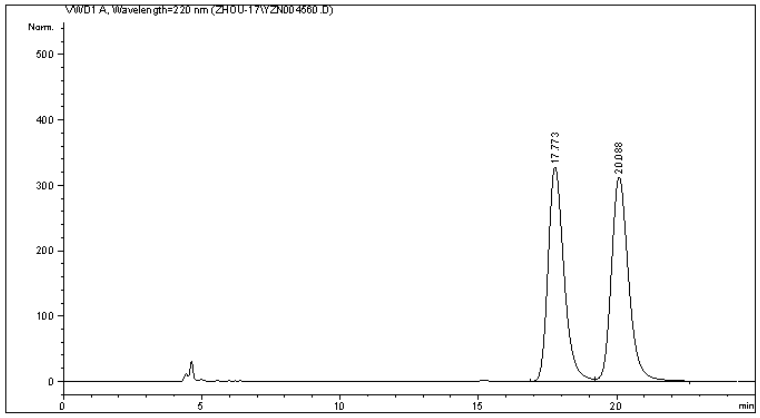


(S)-(-)-3ga

Instrument 1 11/3/2017 9:57:42 PM Page 1 of 1

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004560.D
Sample Name: ZG-2-64A(+/-)

```
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 6/24/2017 11:42:51 AM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 6/24/2017 11:24:57 AM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 8:53:47 PM
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 70/30, 0.7 mL/min,  30 oC, 220 nm
```




```
                          Area Percent Report

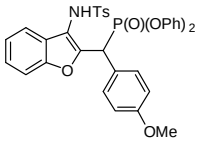
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #  [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|------|---------|---------|-------|
   1  17.773 BV    0.6093 1.30803e4   328.06274  49.3512
   2  20.088 VB    0.6565 1.34242e4   312.77750  50.6488

Totals :                 2.65045e4   640.84024

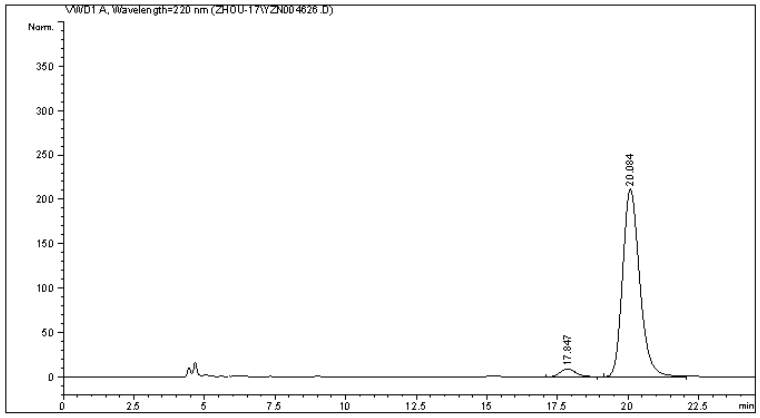
                          *** End of Report ***
```



(+/-)-3ha

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004626.D
Sample Name: ZG-2-64A

```
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 6/30/2017 8:10:27 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 6/30/2017 7:43:45 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 8:55:07 PM
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 70/30, 0.7 mL/min,  30 oC, 220 nm
```




```
                          Area Percent Report

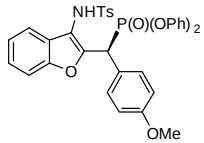
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #  [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|------|---------|---------|-------|
   1  17.847 BB    0.6106  354.34619    8.94556   3.8561
   2  20.084 BB    0.6430 8834.94531  211.56477  96.1439

Totals :                 9189.29150  220.51033

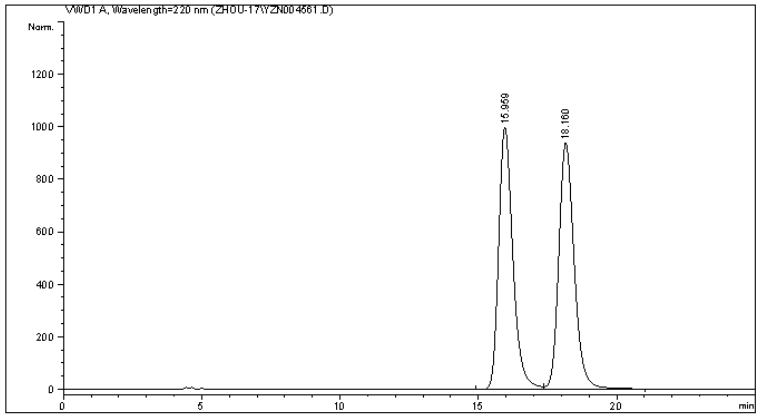
                          *** End of Report ***
```



(*S*)-(-)-3ha

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004561.D
Sample Name: ZG-2-64B(+/-)

```
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 6/24/2017 12:24:38 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 6/24/2017 12:16:40 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 8:57:07 PM
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 70/30, 0.7 mL/min,  30 oC, 220 nm
```




```
                          Area Percent Report

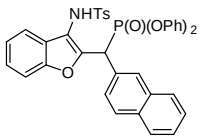
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|-------|----------|----------|--------|
   1  15.959 VV    0.5472 3.55877e4   997.78674  49.6116
   2  18.160 VB    0.5920 3.61449e4   938.58997  50.3884

Totals :                  7.17327e4  1936.37671

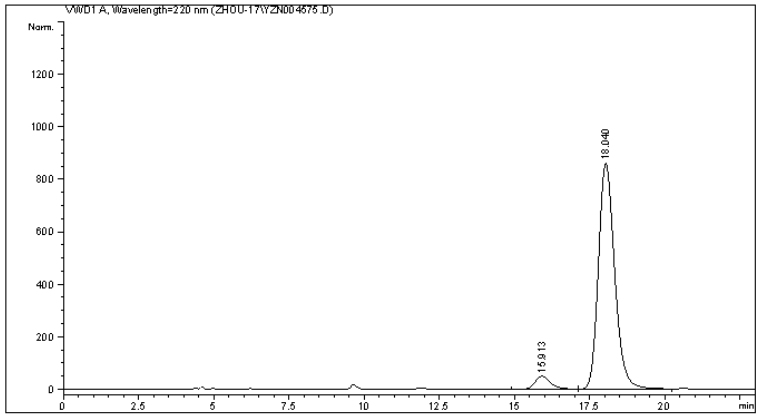
                          *** End of Report ***
```



(+/-)-3ia

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004575.D
Sample Name: ZG-2-64B

```
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 6/26/2017 12:07:19 AM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 6/26/2017 12:00:03 AM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 8:58:17 PM
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 70/30, 0.7 mL/min,  30 oC, 220 nm
```




```
                          Area Percent Report

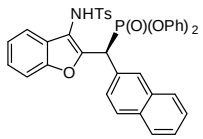
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|-------|----------|----------|--------|
   1  15.913 VV    0.5497 1779.83215   49.42228   5.1928
   2  18.040 VB    0.5814 3.24954e4   861.20795  94.8072

Totals :                  3.42753e4   910.63022

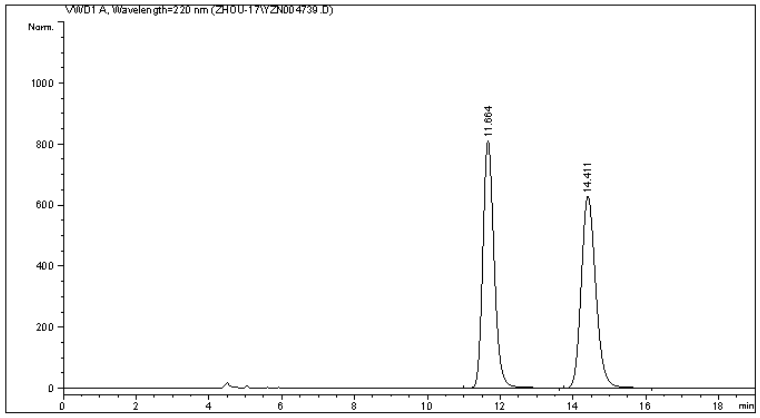
                          *** End of Report ***
```



(*S*)-(-)-3ia

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004739.D
Sample Name: ZG-2-71A(+/-)

```
==================================================================
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 7/10/2017 3:39:50 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 7/10/2017 3:08:26 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 9:12:09 PM
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 70/30, 0.7 mL/min,  30 oC, 220 nm
```




```
==================================================================
                      Area Percent Report
==================================================================

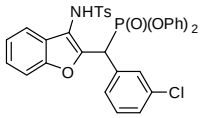
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|------|---------|---------|-------|
   1  11.664 BB    0.3329 1.74468e4   809.70868  49.9776
   2  14.411 BB    0.4289 1.74625e4   628.57990  50.0224

Totals :                 3.49093e4  1438.28857

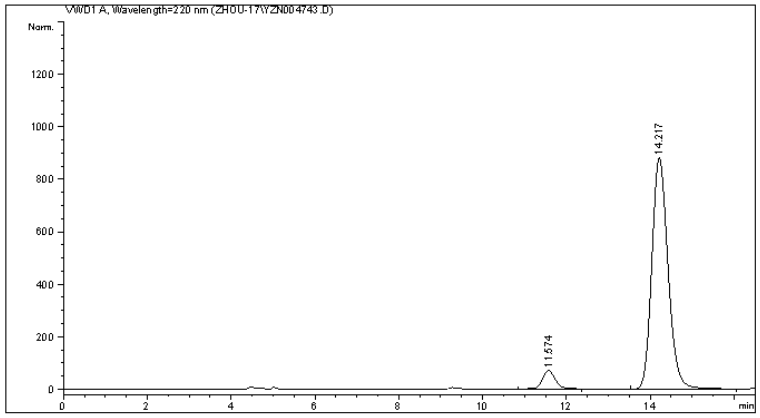
==================================================================
                      *** End of Report ***
```



(+/-)-3ja

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004743.D
Sample Name: ZG-2-71A

```
==================================================================
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 7/10/2017 9:17:55 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 7/10/2017 8:44:27 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 9:13:26 PM
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 70/30, 0.7 mL/min,  30 oC, 220 nm
```




```
==================================================================
                      Area Percent Report
==================================================================

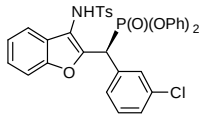
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|------|---------|---------|-------|
   1  11.574 BB    0.3282 1502.81543   70.23960   5.9586
   2  14.217 BB    0.4158 2.37182e4   881.69421  94.0414

Totals :                 2.52211e4   951.93382

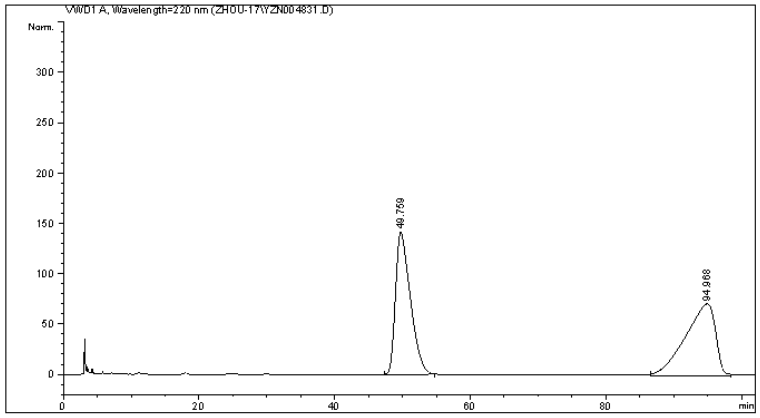
==================================================================
                      *** End of Report ***
```



(*S*)-(-)-3ja

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004831.D
Sample Name: ZG-2-71B(+/-)

```
==================================================================
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 7/16/2017 10:53:18 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 7/16/2017 10:47:43 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 9:15:52 PM
                  (modified after loading)
Sample Info     : IA, Hexane/i-PrOH = 60/40, 1.0 mL/min,  30 oC, 220nm
```




```
==================================================================
                      Area Percent Report
==================================================================

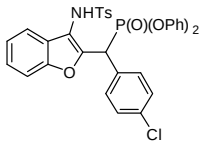
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|------|----------|----------|--------|
   1  49.759 BB    2.2621 2.15155e4   141.47208  49.4385
   2  94.968 MM R  5.1479 2.20042e4    71.23990  50.5615

Totals :                 4.35197e4   212.71198

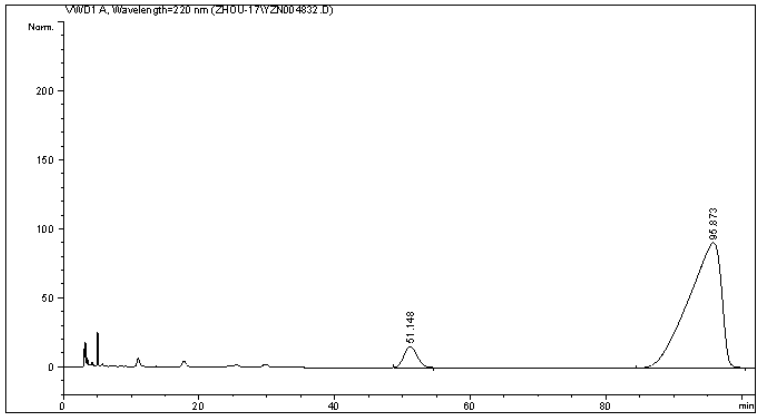
==================================================================
                      *** End of Report ***
```



(+/-)-3ka

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004832.D
Sample Name: ZG-2-71B

```
==================================================================
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 7/17/2017 12:41:22 AM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 7/17/2017 12:36:20 AM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 9:42:02 PM
                  (modified after loading)
Sample Info     : IA, Hexane/i-PrOH = 60/40, 1.0 mL/min,  30 oC, 220nm
```




```
==================================================================
                      Area Percent Report
==================================================================

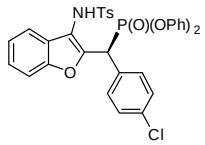
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|------|----------|----------|--------|
   1  51.148 BB    1.9269 2067.80786   15.33591   6.3255
   2  95.873 MM R  5.6323 3.06225e4    90.61561  93.6745

Totals :                 3.26903e4   105.95151

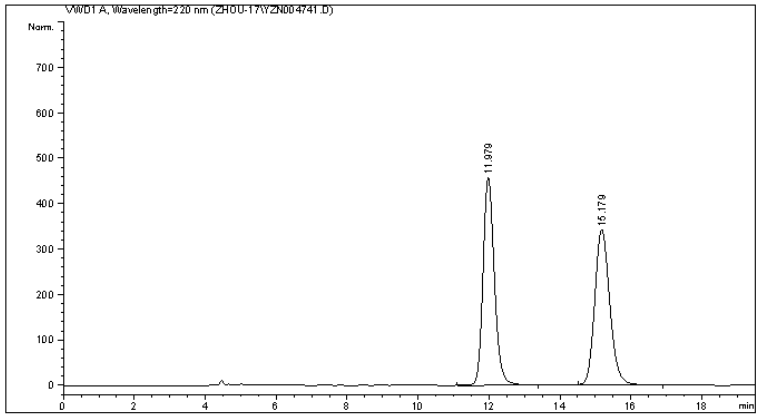
==================================================================
                      *** End of Report ***
```



(*S*)-(-)-3ka

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004741.D
Sample Name: ZG-2-71C(+/-)

```
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 7/10/2017 4:34:22 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 7/10/2017 4:24:43 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 9:45:30 PM
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 70/30, 0.7 mL/min,  30 oC, 220 nm
```




```
                          Area Percent Report

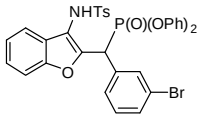
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s    [mAU   ]      %
----|-------|----|-------|----------|----------|--------|
   1  11.979 BB    0.3428 1.01968e4   457.83871  50.1759
   2  15.179 VB    0.4553 1.01254e4   342.79211  49.8241

Totals :                 2.03222e4   800.63083

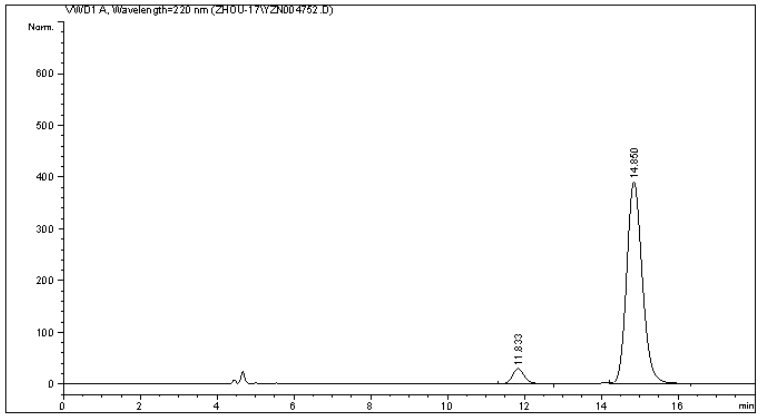
                          *** End of Report ***
```



(+/-)-3la

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004752.D
Sample Name: ZG-2-71C

```
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 7/11/2017 4:41:13 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 7/11/2017 4:37:58 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 9:46:43 PM
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 70/30, 0.7 mL/min,  30 oC, 220 nm
```




```
                          Area Percent Report

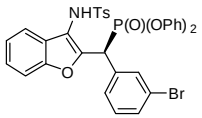
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s    [mAU   ]      %
----|-------|----|-------|----------|----------|--------|
   1  11.833 BB    0.3392  664.41431   29.91925   5.6947
   2  14.850 VB    0.4352 1.10028e4   390.23569  94.3053

Totals :                 1.16672e4   420.15494

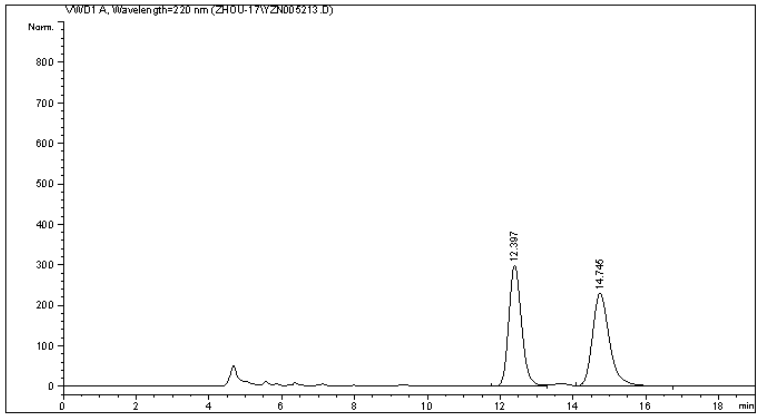
                          *** End of Report ***
```



(*S*)-(-)-3la

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN005213.D
Sample Name: ZG-2-86(+/-)

```
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 8/23/2017 11:01:54 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 8/23/2017 10:42:02 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 10:07:57 PM
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 70/30, 0.7 mL/min,  30 oC, 220 nm
```



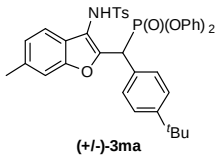

```
                          Area Percent Report

Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #  [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|------|---------|---------|-------|
   1  12.397 VV    0.3755 7269.55176  298.86407  49.3350
   2  14.745 VB    0.4958 7465.53662  229.62669  50.6650

Totals :                 1.47351e4   528.49077
```

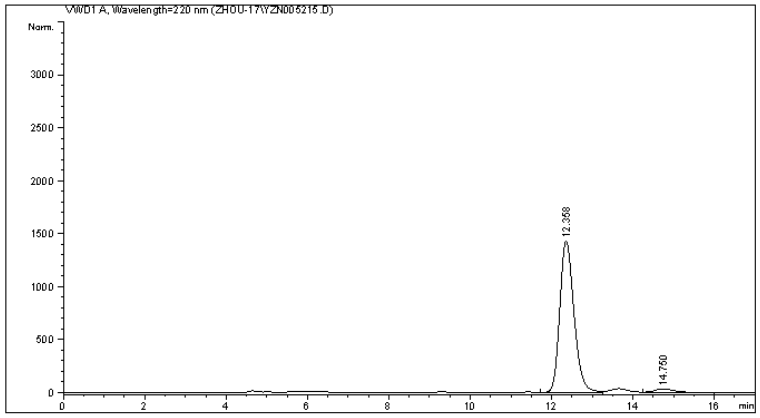


(+/-)-3ma

Instrument 1 11/3/2017 10:08:04 PM Page 1 of 1

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN005215.D
Sample Name: ZG-2-86

```
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 8/24/2017 12:00:02 AM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 8/23/2017 11:57:15 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 10:12:26 PM
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 70/30, 0.7 mL/min,  30 oC, 220 nm
```



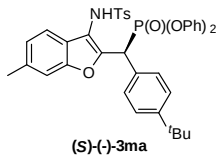

```
                          Area Percent Report

Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #  [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|------|---------|---------|-------|
   1  12.358 VV    0.3728 3.46924e4  1432.46265  96.8427
   2  14.750 VB    0.5051 1131.06177   33.95209   3.1573

Totals :                 3.58234e4  1466.41474
```

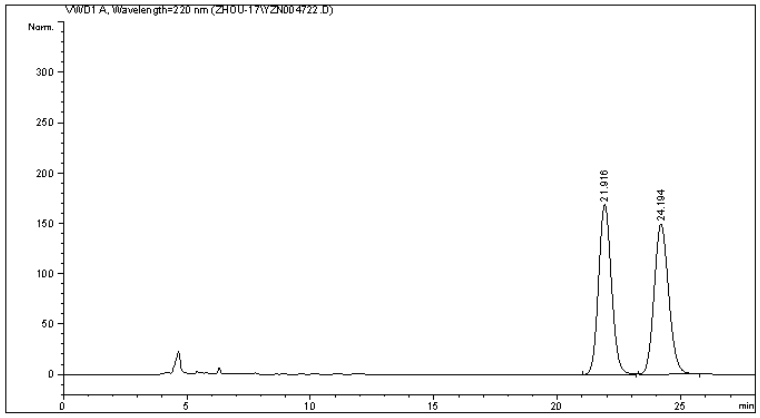


(S)-(-)-3ma

Instrument 1 11/3/2017 10:12:36 PM Page 1 of 1

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004722.D
Sample Name: ZG-2-69B(+/-)

```
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 7/7/2017 7:27:18 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 7/7/2017 7:09:57 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 9:04:58 PM
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 80/20, 0.7 mL/min,  30 oC, 220 nm
```




```
                          Area Percent Report

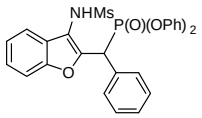
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|-------|----------|----------|--------|
   1  21.916 BB    0.5617 6100.78271  168.71190  50.0207
   2  24.194 BB    0.6362 6095.72852  148.92819  49.9793

Totals :                 1.21965e4   317.64009

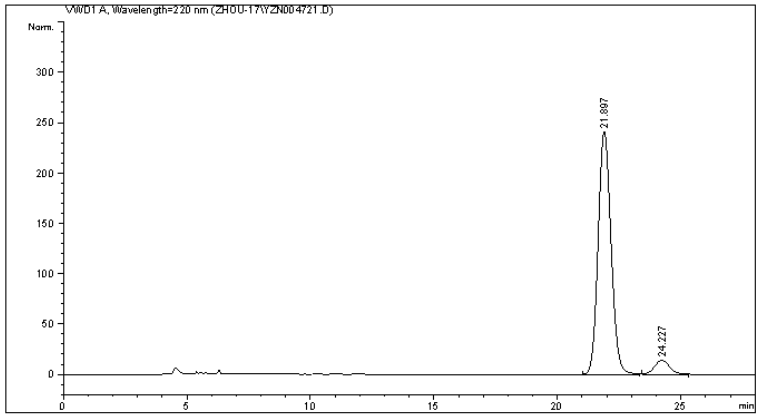
                          *** End of Report ***
```



(+/-)-3na

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004721.D
Sample Name: ZG-2-69B

```
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 7/7/2017 6:33:29 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 7/7/2017 6:16:57 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 12/3/2017 9:20:36 PM
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 80/20, 0.7 mL/min,  30 oC, 220 nm
```




```
                          Area Percent Report

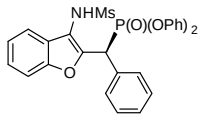
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|-------|----------|----------|--------|
   1  21.897 BB    0.5653 8761.41895  241.01743  93.6586
   2  24.227 BB    0.6576  593.21368   13.95498   6.3414

Totals :                 9354.63263  254.97241

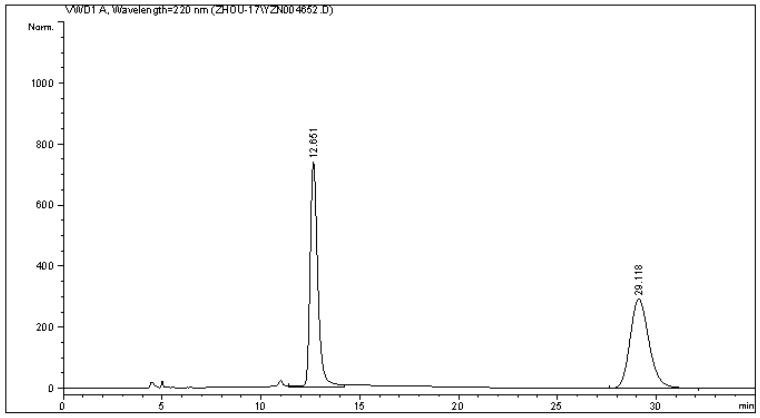
                          *** End of Report ***
```



(*S*)-(-)-3na

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004652.D
Sample Name: ZG-2-69C(+/-)

```
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 7/3/2017 5:44:36 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 7/3/2017 5:41:47 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 9:08:28 PM
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 70/30, 0.7 mL/min,  30 oC, 220 nm
```



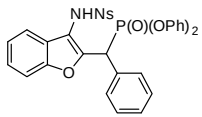

```
                          Area Percent Report

Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|-------|----------|----------|--------|
   1  12.651 VV    0.4072 1.98057e4   735.85510  50.3692
   2  29.118 BB    1.0295 1.95153e4   293.35913  49.6308

Totals :                 3.93210e4  1029.21423
```



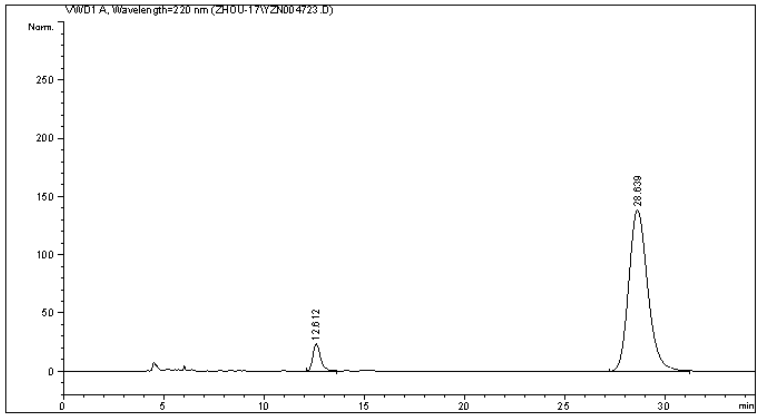
(+/-)-3oa

Ns = 4-$NO_2C_6H_4SO_2$

```
                          *** End of Report ***
```


Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004723.D
Sample Name: ZG-2-69C

```
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 7/7/2017 8:22:57 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 7/7/2017 7:58:58 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 9:10:25 PM
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 70/30, 0.7 mL/min,  30 oC, 220 nm
```



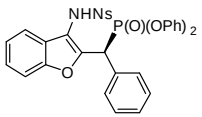

```
                          Area Percent Report

Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|-------|----------|----------|--------|
   1  12.612 BB    0.4104  629.26440   23.35532   6.4788
   2  28.639 BB    1.0064 9083.40137  138.58795  93.5212

Totals :                 9712.66577  161.94327
```



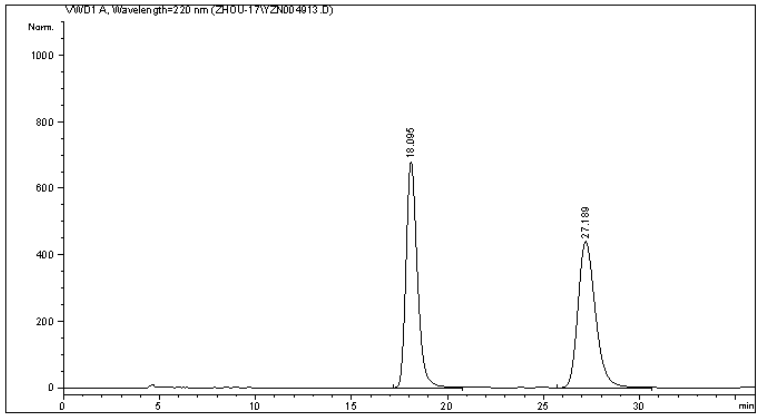
(*S*)-(-)-3oa

Ns = 4-$NO_2C_6H_4SO_2$

```
                          *** End of Report ***
```

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004913.D
Sample Name: ZG-2-80-2(+/-)

```
==================================================================
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 7/23/2017 7:22:00 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 7/23/2017 7:14:35 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 10:00:26 PM
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 70/30, 0.7 mL/min,  30 oC, 220 nm
```




```
==================================================================
                        Area Percent Report
==================================================================

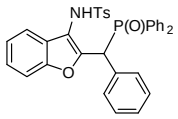
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]      [min]  mAU   *s    [mAU   ]      %
----|-------|----|------|---------|---------|-------|
   1  18.095 BB    0.6291 2.77871e4   678.72095  50.0669
   2  27.189 VB    0.9682 2.77129e4   439.74289  49.9331

Totals :                 5.55000e4  1118.46384

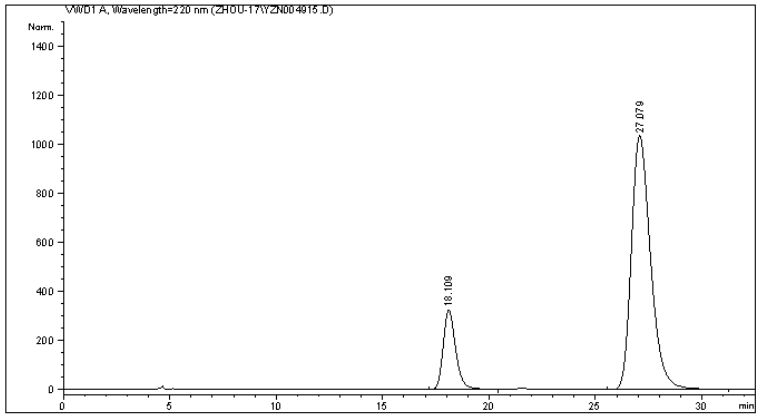
==================================================================
                        *** End of Report ***
```



(+/-)-3ab

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004915.D
Sample Name: ZG-2-80-2

```
==================================================================
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 7/23/2017 9:15:41 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 7/23/2017 9:10:47 PM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 10:01:50 PM
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 70/30, 0.7 mL/min,  30 oC, 220 nm
```




```
==================================================================
                        Area Percent Report
==================================================================

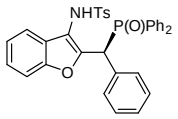
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]      [min]  mAU   *s    [mAU   ]      %
----|-------|----|------|---------|---------|-------|
   1  18.109 BB    0.6256 1.32833e4   324.84781  16.9888
   2  27.079 VB    0.9631 6.49052e4  1035.09045  83.0112

Totals :                 7.81885e4  1359.93826

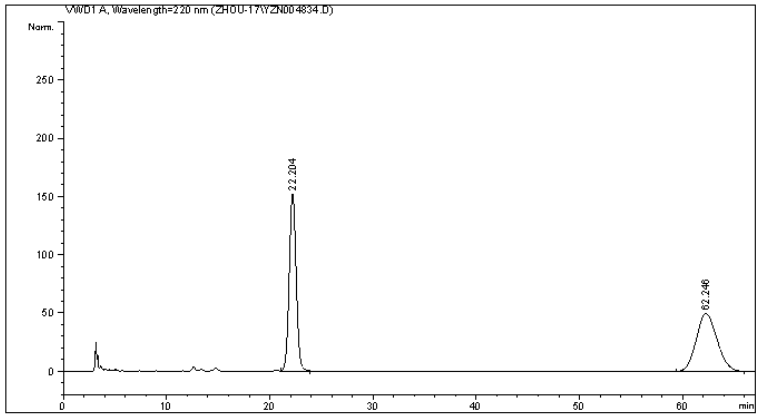
==================================================================
                        *** End of Report ***
```



(*S*)-(+)-3ab

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004834.D
Sample Name: ZG-2-61B(+/-)

```
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 7/17/2017 4:16:27 AM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 7/17/2017 4:13:00 AM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 8:40:12 PM
                  (modified after loading)
Sample Info     : IA, Hexane/i-PrOH = 60/40, 1.0 mL/min,  30 oC, 220nm
```




```
                          Area Percent Report

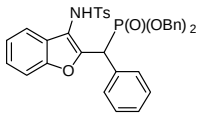
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|-------|----------|----------|--------|
   1  22.204 BB    0.7184 7087.72754  152.50095  50.1958
   2  62.246 BB    2.0746 7032.43213   49.96262  49.8042

Totals :                 1.41202e4   202.46357

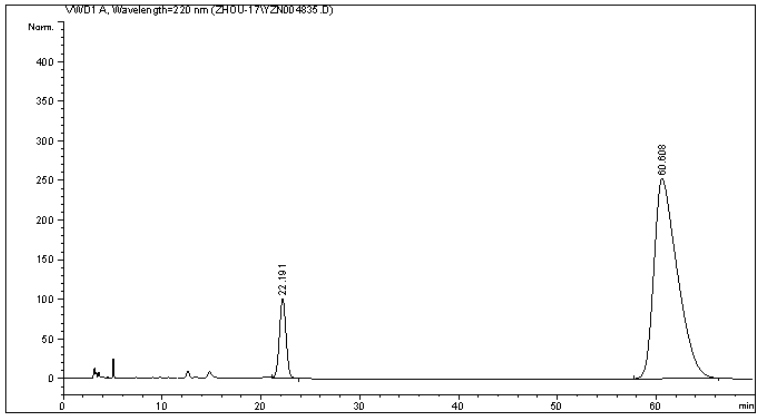
                          *** End of Report ***
```



(+/-)-3ac

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN004835.D
Sample Name: ZG-2-61B

```
Acq. Operator   :
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 7/17/2017 5:28:01 AM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 7/17/2017 5:24:25 AM by
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed    : 11/3/2017 8:42:10 PM
                  (modified after loading)
Sample Info     : IA, Hexane/i-PrOH = 60/40, 1.0 mL/min,  30 oC, 220nm
```




```
                          Area Percent Report

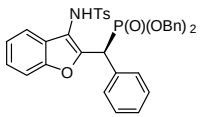
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|-------|----------|----------|--------|
   1  22.191 VB    0.7181 4683.87158  100.83031  10.1725
   2  60.608 BB    2.4110 4.13605e4   252.23161  89.8275

Totals :                 4.60443e4   353.06192

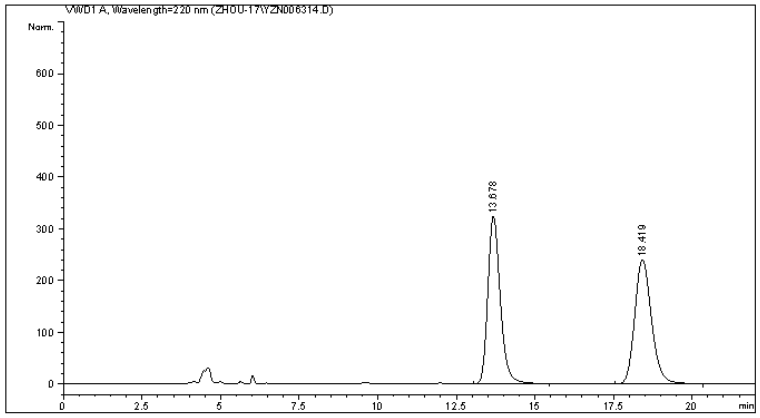
                          *** End of Report ***
```



(*S*)-(-)-3ac

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN006314.D
Sample Name: ZG-3-36A(+/-)

```
==========================================================================
Acq. Operator   : mc-
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 11/22/2017 6:42:11 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 11/22/2017 5:48:44 PM by mc-
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 12/1/2017 2:51:56 PM by hx-
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 70/30, 0.7 mL/min, 30 oC, 220 nm
```




```
==========================================================================
                        Area Percent Report
==========================================================================

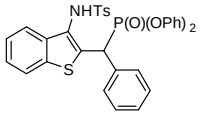
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|-------|----------|----------|--------|
   1  13.678 BB    0.4215 8926.28906  324.38126  50.0338
   2  18.419 BB    0.5713 8914.24316  240.19218  49.9662

Totals :                 1.78405e4   564.57344

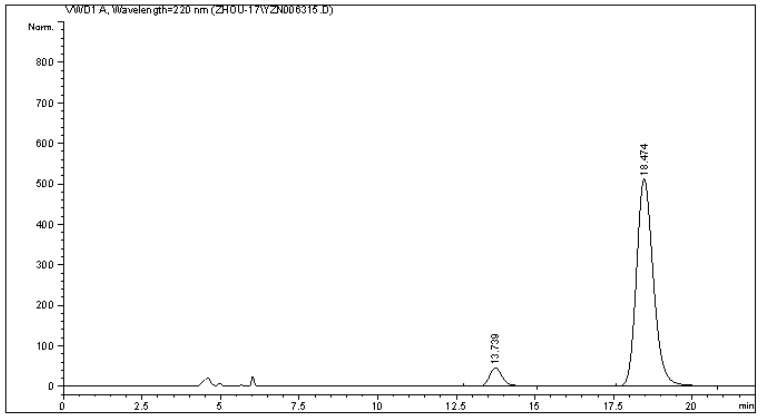
==========================================================================
                        *** End of Report ***
```



(+/-)-3pa

Data File C:\CHEM32\1\DATA\ZHOU-17\YZN006315.D
Sample Name: ZG-3-36A

```
==========================================================================
Acq. Operator   : mc-
Acq. Instrument : Instrument 1                    Location : Vial 1
Injection Date  : 11/22/2017 7:17:22 PM
Acq. Method     : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 11/22/2017 7:05:10 PM by mc-
                  (modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF LC.M
Last changed    : 12/1/2017 2:54:50 PM by hx-
                  (modified after loading)
Sample Info     : IC, Hexane/i-PrOH = 70/30, 0.7 mL/min, 30 oC, 220 nm
```




```
==========================================================================
                        Area Percent Report
==========================================================================

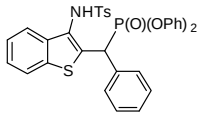
Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=220 nm

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]  mAU   *s   [mAU   ]      %
----|-------|----|-------|----------|----------|--------|
   1  13.739 BB    0.4387 1317.66174   45.64960   6.4537
   2  18.474 BB    0.5752 1.90994e4   511.75677  93.5463

Totals :                 2.04170e4   557.40637

==========================================================================
                        *** End of Report ***
```



(*S*)-(-)-3pa