Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

Palladium-catalyzed 1,4-addition of secondary alkylphenylphosphines to α,β-unsaturated carbonyl compounds for the synthesis of phosphorus- and carbon-stereogenic compounds

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Supporting Information

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General Methods

All air- and moisture-sensitive manipulations were carried out with standard Schlenk techniques under nitrogen or in a glove box under nitrogen. ^{1}H, ^{13}C and ^{31}P NMR spectra were recorded on a Varian instrument (400 MHz, 100 MHz and 162 MHz, respectively). ^{1}H, ^{13}C NMR chemical shifts are reported vs tetramethylsilane signal or residual protio solvent signals.

Toluene and THF were distilled over sodium benzophenone ketyl under nitrogen. Dichloromethane and DMF were distilled over CaH_2 under nitrogen.

The catalysts **4**,[1] phenylalkylphosphine,[2] enones,[3] and N-acylpyrrole[4] were synthesized following the literature procedures. All other chemicals and solvents were purchased from commercial company and used as received.

Experimental Details and Characterization Data

Generanl Procedure for Table 2.

A mixture of catalyst (*S*,*S*)-**5a** (7.62 mg, 0.01 mmol; 5 mol%) and KOAc (9.8 mg, 0.1 mmol) in toluene (2.5 mL) was stirred at room temperature for 1 h. Then the temperature was reduced to −5 °C (realized with a refrigerated bath circulator), alkylphenylphosphine (0.20 mmol) and α,β-unsaturated carbonyl compound (0.30 mmol) were added into it, and the resulting solution was stirred for 24 h at −5 °C. Then 0.3 mL $Me_2S{\cdot}BH_3$ (2 M in THF) was added into it and the resulting solution was stirred for 1.5 h. The excess borane was reacted with H_2O and the mixture was dried over $MgSO_4$, filtered and concentrated under vacuum. The residue was purified by silica gel chromatography with hexane/EtOAc = 4/1 to afford the product as a white solid.

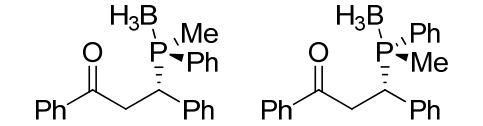


Table 2, entry 1. White solid. 98% yield, dr = 1.1/1. The ee was determined on a Daicel Chiralcel OZ-3 column with hexane/2-propanol = 95/5, flow = 0.8 mL/min. Retention times: 11.3 min [(R_c,R_p)-diastereomer], 13.5 min [(S_c,S_p)-diastereomer], 14.8 min [(R_c,S_p)-diastereomer], 22.3 min [(S_c,R_p)-diastereomer]. 87% ee (major diastereomer), 96% ee (minor diastereomer). The absolute configuration was assigned by analogy with Table 2, entries 9 and 17.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.89-7.87 (m, 1H), 7.82-7.76 (m, 2H), 7.56-7.20 (m, 10H), 7.15-7.09 (m, 1H), 6.90-6.84 (m, 1H), 4.10-3.95 (m, 1H), 3.92-3.76 (m, 1H), 3.55 (ddd, J = 17.6, 10.0 and 4.0 Hz, 0.47H), 3.23 (ddd, J = 17.6, 10.4 and 2.8 Hz, 0.52H), 1.54 (d, J = 9.6 Hz, 1.38H), 1.34 (d, J = 10.0 Hz, 1.68H), 1.30-0.30 (m, 3H). ^{31}P{^{1}H} NMR (162 MHz, $CDCl_3$): δ 18.1 (m).

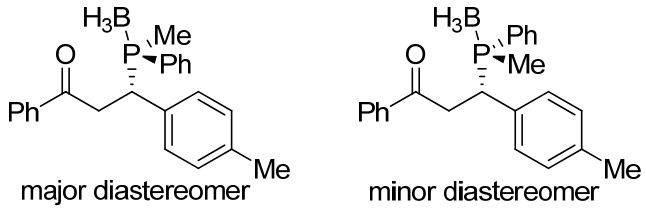
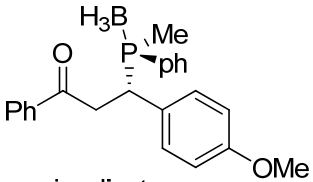
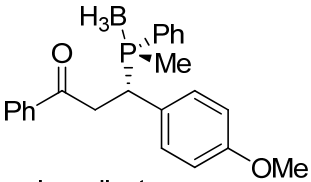


Table 2, entry 2. White solid. 97% yield, dr = 1.1/1. The ee was determined on a Daicel Chiralcel OZ-3 column with hexane/2-propanol = 95/5, flow = 1.0 mL/min. Retention times: 10.4 min [(R_c,R_p)-diastereomer], 12.7 min [(S_c,S_p)-diastereomer], 14.3 min [(R_c,S_p)-diastereomer], 22.2 min [(S_c,R_p)-diastereomer]. 88% ee (major diastereomer), 95% ee (minor diastereomer). The absolute configuration was assigned by analogy with Table 2, entries 9 and 17.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.88 (d, J = 7.6 Hz, 1H), 7.78 (t, J = 8.0 Hz, 2H), 7.54-7.34 (m, 7H), 7.21 (d, J = 6.8 Hz, 1H), 7.08 (d, J = 7.6 Hz, 1H), 6.93 (d, J = 7.6 Hz, 1H), 6.74 (d, J = 6.8 Hz, 1H), 4.08-3.92 (m, 1H), 3.90-3.75 (m, 1H), 3.50 (ddd, J = 17.6, 10.0 and 6.8 Hz, 0.47H), 3.20 (ddd, J = 17.6, 10.4 and 2.8 Hz, 0.52H), 2.25 (s, 1.51H), 2.22 (s, 1.40H), 1.52 (d, J = 9.6 Hz, 1.41H), 1.33 (d, J = 10.0 Hz, 1.63H), 1.30-0.30 (m, 3H). ^{31}P{^{1}H} NMR (162 MHz, $CDCl_3$): δ 18.5 (m).



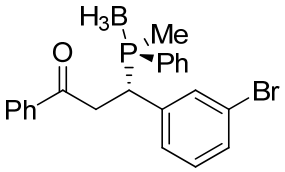
major diastereomer



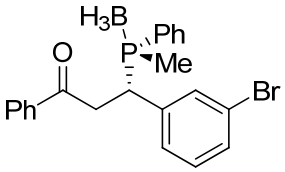
minor diastereomer

Table 2, entry 3. White solid. 92% yield, dr = 1.2/1. The ee was determined on a Daicel Chiralcel OZ-3 column with hexane/2-propanol = 95/5, flow = 1.0 mL/min. Retention times: 16.6 min [(R_c,R_p)-diastereomer], 19.6 min [(S_c,S_p)-diastereomer], 22.6 min [(R_c,S_p)-diastereomer], 40.0 min [(S_c,R_p)-diastereomer]. 89% ee (major diastereomer), 95% ee (minor diastereomer). The absolute configuration was assigned by analogy with Table 2, entries 9 and 17.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.89-7.85 (m, 1H), 7.82-7.75 (m, 2H), 7.55-7.35 (m, 7H), 7.28-7.23 (m, 1H), 6.85-6.76 (m, 2H), 6.65 (d, *J* = 8.8 Hz, 1H), 4.05-3.90 (m, 1H), 3.87-3.76 (m, 1H), 3.73 (s, 1.7H), 3.72 (s, 1.3H), 3.49 (ddd, *J* = 17.6, 10.4 and 7.2 Hz, 0.45H), 3.20 (ddd, *J* = 18.0, 6.4 and 3.2 Hz, 0.53H), 1.53 (d, *J* = 9.6 Hz, 1.27H), 1.34 (d, *J* = 10.0 Hz, 1.64H), 1.30-0.30 (m, 3H). ^{31}P{^{1}H} NMR (162 MHz, $CDCl_3$): δ 18.5 (m).



major diastereomer



minor diastereomer

Table 2, entry 4. White solid. 94% yield, dr = 1.1/1. The ee was determined on a Daicel Chiralcel OZ-3 column with hexane/2-propanol = 98/2, flow = 0.8 mL/min. Retention times: 18.3 min [(R_c,R_p)-diastereomer], 24.5 min [(S_c,S_p)-diastereomer], 26.5 min [(R_c,S_p)-diastereomer], 38.7 min [(S_c,R_p)-diastereomer]. 87% ee (major diastereomer), 96% ee (minor diastereomer). The absolute configuration was assigned by analogy with Table 2, entries 9 and 17.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.90 (d, *J* = 7.2 Hz, 1H), 7.83-7.35 (m, 2H), 7.60-7.36 (m, 8H), 7.32-7.24 (m, 1H), 7.16 (t, *J* = 8.0 Hz, 0.50H), 7.01 (t, *J* = 8.0 Hz, 0.43H), 6.91-6.85 (m, 1H), 4.05-3.90 (m, 1H), 3.87-3.75 (m, 1H), 3.49 (ddd, *J* = 17.6, 10.0

and 7.2 Hz, 0.47H), 3.20 (ddd, J = 18.0, 6.4 and 2.8 Hz, 0.55H), 1.56 (d, J = 9.6 Hz, 1.36H), 1.37 (d, J = 9.6 Hz, 1.65H), 1.30-0.30 (m, 3H). $^{31}P\{^{1}H\}$ NMR (162 MHz, $CDCl_3$): δ 19.4 (m).

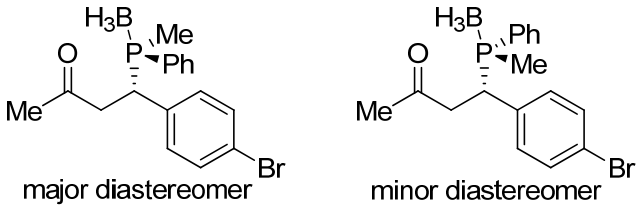


Table 2, entry 5. White solid. 86% yield, dr = 1.1/1. The ee was determined on a Daicel Chiralpak AD-H column with hexane/2-propanol = 95/5, flow = 0.8 mL/min. Retention times: 24.1 min [(S_c,R_p)-diastereomer], 34.7 min [(S_c,S_p)-diastereomer], 48.0 min [(R_c,S_p)-diastereomer], 81.6 min [(R_c,R_p)-diastereomer]. 83% ee (major diastereomer), 96% ee (minor diastereomer). The absolute configuration was assigned by analogy with Table 2, entries 9 and 17.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.88 (d, J = 7.2 Hz, 1H), 7.81-7.74 (m, 2H), 7.58-7.35 (m, 8H), 7.26-7.20 (m, 2H), 6.75 (dd, J = 8.8 and 2.0 Hz, 1H), 4.05-3.92 (m, 1H), 3.86-3.75 (m, 1H), 3.54 (ddd, J = 17.6, 10.4 and 7.2 Hz, 0.46H), 3.19 (ddd, J = 17.6, 9.6 and 2.8 Hz, 0.54H), 1.56 (d, J = 9.6 Hz, 1.39H), 1.35 (d, J = 9.6 Hz, 1.73H), 1.30-0.30 (m, 3H). $^{31}P\{^{1}H\}$ NMR (162 MHz, $CDCl_3$): δ 18.7 (m).

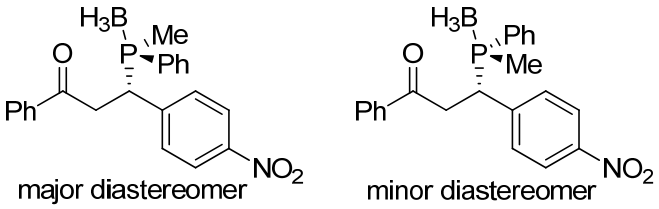


Table 2, entry 6. White solid. 86% yield, dr = 1.2/1. The ee was determined on a Daicel Chiralcel OZ-3 column with hexane/2-propanol = 95/5, flow = 1.0 mL/min. Retention times: 44.9 min [(R_c,R_p)-diastereomer], 52.7 min [(S_c,S_p)-diastereomer], 59.6 min [(R_c,S_p)-diastereomer], 65.0 min [(S_c,R_p)-diastereomer]. 87% ee (major diastereomer), 97% ee (minor diastereomer). The absolute configuration was assigned by analogy with Table 2, entries 9 and 17.

^{1}H NMR (400 MHz, $CDCl_3$): δ 8.15 (d, J = 8.4 Hz, 1H), 7.99-7.89 (m, 2H), 7.82-7.76

(m, 2H), 7.60-7.38 (m, 8H), 7.12-7.06 (dd, J = 8.8 and 1.6 Hz, 1H), 4.20-4.09 (m, 1H), 3.94-3.80 (m, 1H), 3.70 (ddd, J = 17.2, 10.0 and 7.2 Hz, 0.44H), 3.27 (ddd, J = 18.0, 9.6 and 2.8 Hz, 0.54H), 1.65 (d, J = 9.6 Hz, 1.31H), 1.40 (d, J = 10.0 Hz, 1.73H), 1.30-0.30 (m, 3H). $^{31}P\{^{1}H\}$ NMR (162 MHz, $CDCl_3$): δ 19.6 (m).

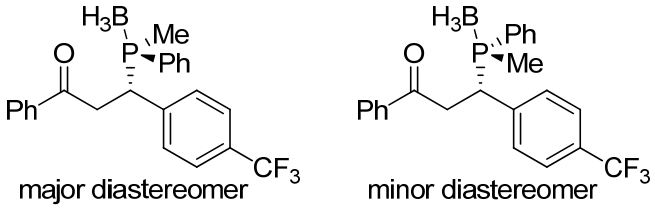
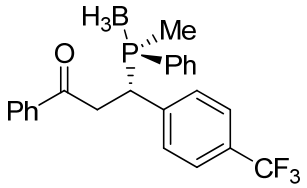
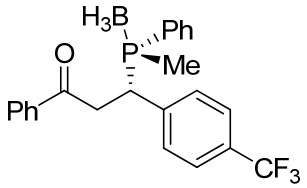


Table 2, entry 7. 86% yield, dr = 1.3/1. The ee was determined on a Daicel Chiralpak AD-H column with hexane/2-propanol = 95/5, flow = 1.0 mL/min. Retention times: 13.2 min [(S_c,R_p)-diastereomer], 25.7 min [(R_c,S_p)-diastereomer]; 17.3 min [(S_c,S_p)-diastereomer], 43.9 min [(R_c,R_p)-diastereomer]. 81% ee (major diastereomer), 97% ee (minor diastereomer). The absolute configuration was assigned by analogy with Table 2, entries 9 and 17.



Major diastereomer, white solid. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.84-7.75 (m, 4H), 7.58-7.44 (m, 8H), 7.40 (t, J = 7.6 Hz, 2H), 4.11 (ddd, J = 14.0, 11.8 and 2.8 Hz, 1H), 3.88 (ddd, J = 18.0, 11.2 and 4.2 Hz, 1H), 3.23 (ddd, J = 18.0, 10.0 and 3.2 Hz, 1H), 1.36 (d, J = 10.0 Hz, 3H). 1.30-0.30 (m, 3H). $^{31}P\{^{1}H\}$ NMR (162 MHz, $CDCl_3$): δ 18.8 (m). $[\alpha]^{20}_{D}$ = −80.7 (c 1.10, $CHCl_3$). HRMS (ESI) calcd for $C_{23}H_{23}BF_3OP$ $(M)^+$ 413.1568, found 413.1561.



Minor diastereomer, white solid. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.90 (d, J = 7.2 Hz,

2H), 7.60-7.35 (m, 10H), 7.01 (d, *J* = 7.6 Hz, 2H), 4.05 (ddd, *J* = 13.6, 10.0 and 3.6 Hz, 1H), 3.83 (ddd, *J* = 16.0, 10.0 and 4.0 Hz, 1H), 3.63 (ddd, *J* = 17.6, 9.6 and 6.8 Hz, 1H), 1.59 (d, *J* = 9.6 Hz, 3H), 1.30-0.30 (m, 3H). $^{31}P\{^{1}H\}$ NMR (162 MHz, $CDCl_3$): δ 20.0 (m). $[\alpha]^{20}_{D}$ = −69.7 (c 1.45, $CHCl_3$). HRMS (ESI) calcd for $C_{23}H_{23}BF_3OP$ $(M)^+$ 413.1568, found 413.1560.

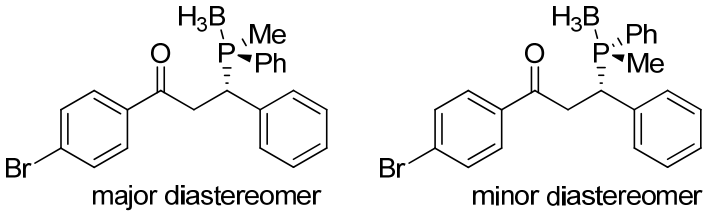


Table 2, entry 8. White solid. 88% yield, dr = 1.2/1. The ee was determined on a Daicel Chiralpak IC column with hexane/2-propanol = 98/2, flow = 1.0 mL/min. Retention times: 22.6 min (major diastereomer), 26.9 min (major diastereomer), 38.3 min (minor diastereomer), 40.1 min (minor diastereomer). 89% ee (major diastereomer), 94% ee (minor diastereomer). The absolute configuration was assigned by analogy with Table 2, entries 9 and 17.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.78-7.73 (m, 2H), 7.65 (d, *J* = 8.4 Hz, 1H), 7.57 (d, *J* = 8.4 Hz, 1H), 7.53-7.37 (m, 5H), 7.30-7.24 (m, 38H), 7.14-7.08 (m, 1H), 6.85-6.81 (m, 1H), 4.04-3.91 (m, 1H), 3.83-3.74 (m, 1H), 3.48 (ddd, *J* = 17.6, 10.0 and 7.2 Hz, 0.52H), 3.21 (ddd, *J* = 17.6, 10.4 and 3.2 Hz, 0.51H), 1.54 (d, *J* = 9.6 Hz, 1.56H), 1.33 (d, *J* = 10.0 Hz, 1.49H), 1.30-0.30 (m, 3H). $^{31}P\{^{1}H\}$ NMR (162 MHz, $CDCl_3$): δ 18.9 (m).

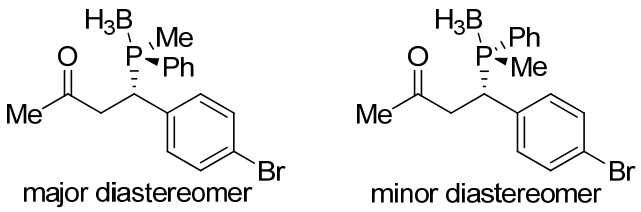
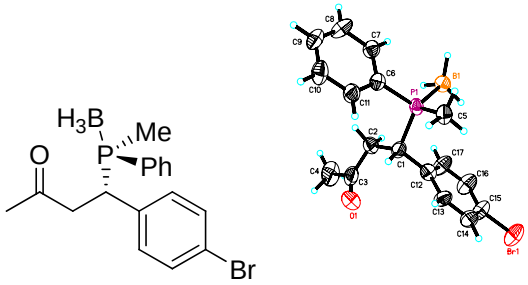
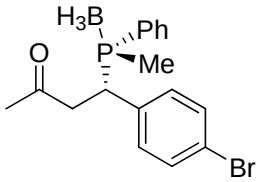


Table 2, entry 9. White solid. 98% yield, dr = 1.7/1. The ee was determined on a Daicel Chiralcel OZ-3 column with hexane/2-propanol = 95/5, flow = 1.0 mL/min. Retention times: 15.2 min [(R_c,R_p)-diastereomer], 17.0 min [(S_c,S_p)-diastereomer],

23.3 min [(R_c,S_p)-diastereomer], 32.8 min [(S_c,R_p)-diastereomer]. 89% ee (major diastereomer), 94% ee (minor diastereomer). The absolute configuration of the major diastereomer was determined to be S_c,S_p by X-ray crystal analysis. The absolute configuration of the minor diastereomer was assigned by analogy with Table 2, entry 17.

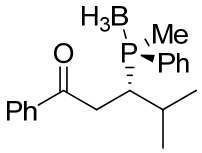


Major diastereomer: ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.73 (t, J = 9.2 Hz, 2H), 7.55-7.42 (m, 5H), 7.13 (d, J = 8.4 Hz, 2H), 3.78 (ddd, J = 14.4, 10.4 and 3.2 Hz, 1H), 3.17 (ddd, J = 17.6, 10.8 and 6.4 Hz, 1H), 2.72 (ddd, J = 18.0, 10.4 and 3.6 Hz, 1H), 1.97 (s, 3H), 1.31 (d, J = 9.6 Hz, 3H). 1.30-0.30 (m, 3H). ^{13}C NMR ($CDCl_3$): δ 204.6 (d, J_{CP} = 12.2 Hz), 135.2 (d, J_{CP} = 2.6 Hz), 132.0 (d, J_{CP} = 8.7 Hz), 131.8 (d, J_{CP} = 2.2 Hz), 131.6 (d, J_{CP} = 2.3 Hz), 130.7 (d, J_{CP} = 4.1 Hz), 128.9 (d, J_{CP} = 9.5 Hz), 128.3 (d, J_{CP} = 51.3 Hz), 121.6 (d, J_{CP} = 3.4 Hz), 43.4 (d, J_{CP} = 5.7 Hz), 38.9 (d, J_{CP} = 32.3 Hz), 30.4 (d, J_{CP} = 1.2 Hz), 9.1 (d, J_{CP} = 38.7 Hz). ^{31}P{^{1}H} NMR (162 MHz, $CDCl_3$): δ 18.0 (m). $[\alpha]^{20}_{D}$ = −103 (c 0.250, $CHCl_3$). HRMS (ESI) calcd for $C_{17}H_{22}BBrOP$ $(M+H)^+$ 362.0716, found 362.0716.

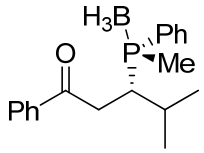


Minor diastereomer. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.51-7.38 (m, 10H), 7.26 (t, J = 4.0 Hz, 2H), 6.80 (d, J = 7.2 Hz, 2H), 3.75-3.69 (m, 1H), 3.24 (ddd, J = 18.0, 14.0 and 4.0 Hz, 1H), 2.95 (ddd, J = 17.6, 10.0 and 7.2 Hz, 1H), 2.09 (s, 3H), 1.52 (d, J = 9.6 Hz, 3H), 1.30-0.30 (m, 3H). ^{31}P{^{1}H} NMR (162 MHz, $CDCl_3$): δ 19.0 (m). $[\alpha]^{20}_{D}$ =

−103 (c 0.250, $CHCl_3$). HRMS (ESI) calcd for $C_{17}H_{22}BBrOP$ $(M+H)^+$ 362.0716, found 362.0714.



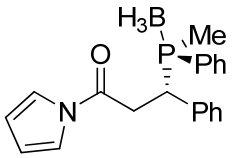
major diastereomer



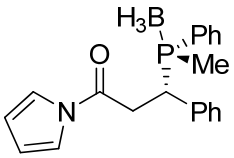
minor diastereomer

Table 2, entry 10. White solid. 91% yield, dr = 2.6/1. The ee was determined on a Daicel Chiralcel OZ-3 column with hexane/2-propanol = 95/5, flow = 1.0 mL/min. Retention times: 10.5 min [(S_c,R_p)-diastereomer], 11.3 min [(R_c,R_p)-diastereomer], 11.8 min [(R_c,S_p)-diastereomer], 12.6 min [(S_c,S_p)-diastereomer]. 72% ee (major diastereomer), 85% ee (minor diastereomer). The absolute configuration was assigned by analogy with Table 2, entries 9 and 17.

^{1}H NMR (300 MHz, $CDCl_3$): δ 7.80-7.65 (m, 4H), 7.55-7.30 (m, 6H), 3.15-2.90 (m, 3H), 2.40-2.20 (m, 1H), 1.67 (d, J = 10.2 Hz, 3H), 1.02 (d, J = 6.6 Hz, 6H), 1.30-0.30 (m, 3H). ^{31}P{^{1}H} NMR (162 MHz, $CDCl_3$): δ 17.7 (m).



major diastereomer



minor diastereomer

Table 2, entry 11. White solid. 84% Yield, dr = 1.2/1. The ee was determined on a Daicel Chiralpak IC column with hexane/2-propanol = 95/5, flow = 1.0 mL/min. Retention times: 9.4 min [(R_c,R_p)-diastereomer], 10.1 min [(S_c,S_p)-diastereomer], 16.0 min [(S_c,R_p)-diastereomer], 16.9 min [(R_c,S_p)-diastereomer]. 86% ee (major diastereomer), 93% ee (minor diastereomer). The absolute configuration was assigned by analogy with Table 2, entries 9 and 17.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.79 (t, J = 6.4 Hz, 1H), 7.55-7.12 (m, 10H), 6.85 (d, J = 6.0 Hz, 1H), 6.23 (dt, J = 20.4 and 2.0 Hz, 2H), 4.03-3.85 (m, 1H), 3.76-3.55 (m, 1H), 3.31 (ddd, J = 17.2, 10.4 and 6.8 Hz, 0.47H), 3.13 (ddd, J = 17.6, 10.0 and 3.2 Hz, 0.53H), 1.56 (d, J = 9.6 Hz, 1.49H), 1.33 (d, J = 10.0 Hz, 1.76H), 1.30-0.30 (m,

3H). $^{31}P\{^{1}H\}$ NMR (162 MHz, $CDCl_3$): δ 18.3 (m).

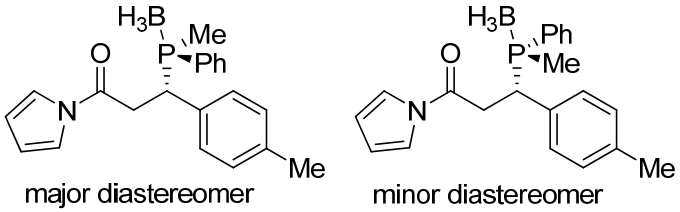


Table 2, entry 12. White solid. 97% yield, dr = 1.2/1. The ee was determined on a Daicel Chiralpak IC column with hexane/2-propanol = 95/5, flow = 1.0 mL/min. Retention times: 8.4 min [(S_c,S_p)-diastereomer], 9.5 min [(R_c,R_p)-diastereomer], 15.3 min [(S_c,R_p)-diastereomer], 16.3 min [(R_c,S_p)-diastereomer]. 84% ee (major diastereomer), 93% ee (minor diastereomer). The absolute configuration was assigned by analogy with Table 2, entries 9 and 17.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.79 (t, J = 8.0 Hz, 1H), 7.55-7.36 (m, 4H), 7.26-7.20 (m, 2H), 7.17-7.09 (m, 2H), 6.95 (d, J = 7.6 Hz, 1H), 6.73 (d, J = 6.8 Hz, 1H), 6.26-6.18 (m, 2H), 3.97-3.81 (m, 1H), 3.70 (ddd, J = 17.2, 9.2 and 3.6 Hz, 0.48H), 3.59 (ddd, J = 17.2, 11.2 and 6.4 Hz, 0.54H), 3.25 (ddd, J = 17.2, 10.8 and 6.4 Hz, 0.47H), 3.09 (ddd, J = 17.2, 9.6 and 3.2 Hz, 0.53H), 2.30 (s, 1.57H), 2.24 (s, 1.37H), 1.53 (d, J = 9.6 Hz, 1.35H), 1.32 (d, J = 10.0 Hz, 1.67H), 1.30-0.30 (m, 3H). $^{31}P\{^{1}H\}$ NMR (162 MHz, $CDCl_3$): δ 18.7 (m).

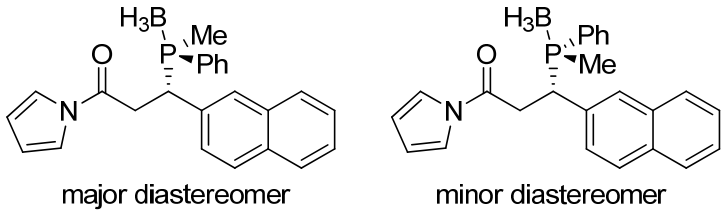


Table 2, entry 13. White solid. 91% yield, dr = 1.2/1. The ee was determined on a Daicel Chiralpak AD-H column with hexane/2-propanol = 95/5, flow = 1.0 mL/min. Retention times: 20.0 min [(S_c,S_p)-diastereomer], 31.1 min [(R_c,R_p)-diastereomer], 34.7 min [(S_c,R_p)-diastereomer], 46.8 min [(R_c,S_p)-diastereomer]. 85% ee (major diastereomer), 93% ee (minor diastereomer). The absolute configuration was assigned by analogy with Table 2, entries 9 and 17.

^{1}H NMR (300 MHz, $CDCl_3$): δ 7.87-7.73 (m, 4H), 7.66-6.95 (m, 11H), 6.26-6.21 (m, 2H), 4.19-4.00 (m, 1H), 3.88-3.68 (m, 1H), 3.37 (ddd, *J* = 17.1, 10.5 and 6.0 Hz, 0.45H), 3.20 (ddd, *J* = 17.1, 9.3 and 2.4 Hz, 0.54H), 1.56 (d, *J* = 9.6 Hz, 1.66H), 1.34 (d, *J* = 10.2 Hz, 1.74H), 1.30-0.30 (m, 3H). ^{31}P{^{1}H} NMR (121 MHz, $CDCl_3$): δ 18.1 (m).

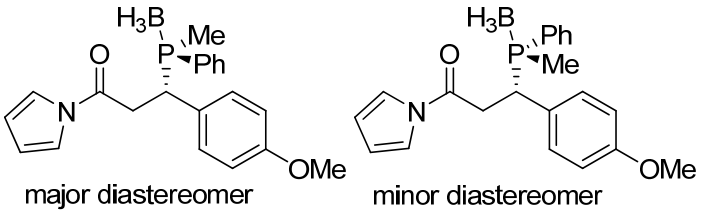


Table 2, entry 14. White solid. 95% yield, dr = 1.1/1. The ee was determined on a Daicel Chiralpak IC column with hexane/2-propanol = 95/5, flow = 1.0 mL/min. Retention times: 15.6 min [(S_c,S_p)-diastereomer], 17.6 min [(R_c,R_p)-diastereomer], 29.2 min [(S_c,R_p)-diastereomer], 32.5 min [(R_c,S_p)-diastereomer]. 83% ee (major diastereomer), 92% ee (minor diastereomer). The absolute configuration was assigned by analogy with Table 2, entries 9 and 17.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.78 (t, *J* = 8.8 Hz, 1H), 7.51-7.15 (m, 7H), 6.84 (d, *J* = 8.4 Hz, 1H), 6.77 (d, *J* = 7.2 Hz, 1H), 6.68 (d, *J* = 8.4 Hz, 1H), 6.26-6.20 (m, 2H), 3.94-3.71 (m, 1H), 3.76 (s, 1.51H), 3.71 (s, 1.40H), 3.58-3.51 (m, 1H), 3.24 (ddd, *J* = 17.2, 10.8 and 2.4 Hz, 0.48H), 3.08 (ddd, *J* = 17.2, 9.2 and 2.8 Hz, 0.52H), 1.54 (d, *J* = 9.6 Hz, 1.35H), 1.33 (d, *J* = 10.4 Hz, 1.67H), 1.30-0.30 (m, 3H). ^{31}P{^{1}H} NMR (121 MHz, $CDCl_3$): δ 18.1 (m).

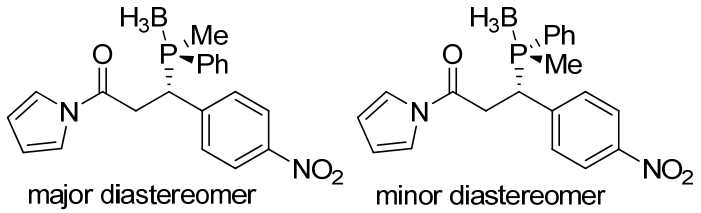


Table 2, entry 15. White solid. 97% yield, dr = 1.1/1. The ee was determined on a Daicel Chiralcel OZ-H column with hexane/2-propanol = 95/5, flow = 0.8 mL/min. Retention times: 47.9 min [(S_c,S_p)-diastereomer], 60.7 min [(R_c,R_p)-diastereomer],

72.0 min [(R_c,S_p)-diastereomer], 97.9 min [(S_c,R_p)-diastereomer]. 85% ee (major diastereomer), 93% ee (minor diastereomer). The absolute configuration was assigned by analogy with Table 2, entries 9 and 17.

^{1}H NMR (300 MHz, $CDCl_3$): δ 8.20 (d, J = 8.7 Hz, 1H), 7.99 (d, J = 8.4 Hz, 1H), 7.80 (t, J = 8.4 Hz, 1H), 7.61-7.38 (m, 5H), 7.26 (s, 1H), 7.14 (s, 1H), 7.08 (d, J = 7.8 Hz, 1H), 6.34-6.20 (m, 2H), 4.13-3.97 (m, 1H), 3.80-3.56 (m, 1H), 3.45 (ddd, J = 17.4, 10.8 and 6.9 Hz, 0.44H), 3.13 (ddd, J = 17.4, 8.7 and 3.0 Hz, 0.50H), 1.66 (d, J = 9.3 Hz, 1.99H), 1.39 (d, J = 9.9 Hz, 1.78H), 1.30-0.30 (m, 3H). ^{31}P{^{1}H} NMR (121 MHz, $CDCl_3$): δ 18.9 (m).

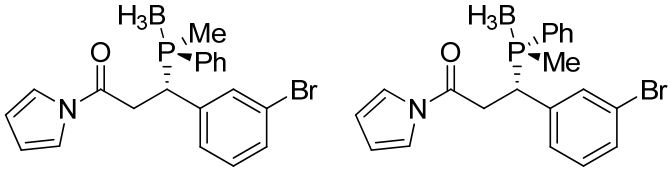


Table 2, entry 16. White solid. 98% yield, dr = 1.2/1. The ee was determined on a Daicel Chiralcel OZ-H column with hexane/2-propanol = 95/5, flow = 0.8 mL/min. Retention times: 10.8 min [(R_c,R_p)-diastereomer], 11.6 min [(S_c,S_p)-diastereomer], 15.5 min [(R_c,S_p)-diastereomer], 22.2 min [(S_c,R_p)-diastereomer]. 84% ee (major diastereomer), 95% ee (minor diastereomer). The absolute configuration was assigned by analogy with Table 2, entries 9 and 17.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.77 (t, J = 7.6 Hz, 1H), 7.60-6.84 (m, 10H), 6.27-6.22 (m, 2H), 3.97-3.80 (m, 1H), 3.78-3.48 (m, 1H), 3.32-3.20 (m, 0.46H), 3.18-3.06 (m, 0.51H), 1.58 (d, J = 9.6 Hz, 1.42H), 1.36 (d, J = 9.6 Hz, 1.64H), 1.30-0.30 (m, 3H). ^{31}P{^{1}H} NMR (162 MHz, $CDCl_3$): δ 19.4 (m).

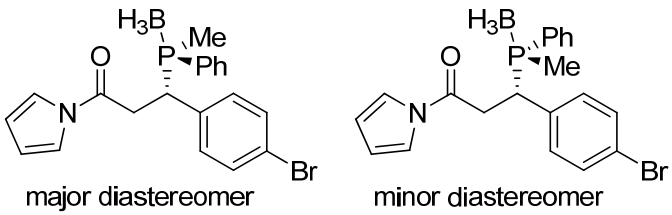
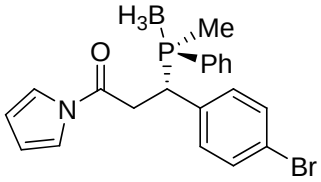
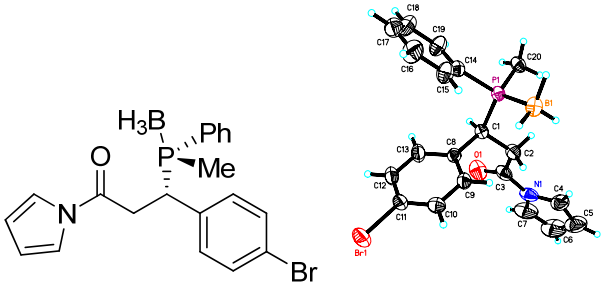


Table 2, entry 17. White solid. 98% yield, dr = 1.2/1. The ee was determined on a

Daicel Chiralcel OZ-H column with hexane/2-propanol = 95/5, flow = 0.8 mL/min. Retention times: 15.3 min [(S_c,S_p)-diastereomer], 18.1 min [(R_c,R_p)-diastereomer], 22.9 min [(R_c,S_p)-diastereomer], 33.8 min [(S_c,R_p)-diastereomer]. 86% ee (major diastereomer), 96% ee (minor diastereomer). The absolute configuration of the major diastereomer was assigned by analogy with Table 2, entry 9. The absolute configuration of the minor diastereomer was was determined to be S_c,R_p by X-ray crystal analysis.



Major diastereomer. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.79 (t, J = 8.8 Hz, 1H), 7.58-7.44 (m, 5H), 7.25-7.15 (m, 4H), 6.23 (s, 2H), 3.95-3.85 (m, 1H), 3.54 (ddd, J = 17.6, 11.2 and 5.2 Hz, 1H), 3.08 (ddd, J = 17.6, 9.2 and 2.8 Hz, 1H), 1.35 (d, J = 10.0 Hz, 3H), 1.30-0.30 (m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.3 (d, J_{CP} = 15.9 Hz), 134.5 (d, J_{CP} = 2.3 Hz), 132.1 (d, J_{CP} = 2.3 Hz), 132.0 (d, J_{CP} = 8.7 Hz), 131.8 (d, J_{CP} = 1.9 Hz), 130.6 (d, J_{CP} = 3.8 Hz), 129.1 (d, J_{CP} = 9.9 Hz), 128.0 (d, J_{CP} = 51.3 Hz), 121.9 (d, J_{CP} = 3.4 Hz), 118.8, 113.5, 39.8 (d, J_{CP} = 32.3 Hz), 35.0 (d, J_{CP} = 8.4 Hz), 9.3 (d, J_{CP} = 39.0 Hz). ^{31}P{^{1}H} NMR (162 MHz, $CDCl_3$): δ 19.4 (m). $[\alpha]^{20}_{D}$ = −75.4 (c 0.60, $CHCl_3$).



Minor diastereomer. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.55-7.21 (m, 9H), 6.74 (d, J = 7.2 Hz, 2H), 6.28 (s, 2H), 3.91-3.82 (m, 1H), 3.71-3.65 (m, 1H), 3.32-3.21 (m, 1H), 3.08 (ddd, J = 17.6, 9.2 and 2.8 Hz, 1H), 1.58 (d, J = 9.6 Hz, 3H), 1.30-0.30 (m, 3H).

^{13}C NMR (100 MHz, $CDCl_3$): δ 167.4 (d, J_{CP} = 15.2 Hz), 134.4 (d, J_{CP} = 5.7 Hz), 132.4 (d, J_{CP} = 9.2 Hz), 132.0 (d, J_{CP} = 2.2 Hz), 131.3 (d, J_{CP} = 1.9 Hz), 130.2 (d, J_{CP} = 4.2 Hz), 128.6 (d, J_{CP} = 9.9 Hz), 125.9 (d, J_{CP} = 52.3 Hz), 121.6 (d, J_{CP} = 3.0 Hz), 118.9, 113.6, 39.9 (d, J_{CP} = 30.4 Hz), 34.9 (d, J_{CP} = 7.6 Hz), 9.0 (d, J_{CP} = 39.5 Hz). ^{31}P{^{1}H} NMR (162 MHz, $CDCl_3$): δ 19.6 (m). $[\alpha]^{20}_D$ = −43.5 (c 1.00, $CHCl_3$).

Generanl Procedure for Table 3.

Isopropylphenylphosphine **2d** (30.4 mg, 0.20 mmol) was added to a solution of (*S*,*S*)-**4** (2.7 mg, 4 μmol Pd) and α,β-unsaturated carbonyl compound **1** (0.30 mmol) in toluene (2.5 mL) at −5 °C (realized with a refrigerated bath circulator), then the resulting solution was stirred for 24 h at the same temperature. Then 0.3 mL $Me_2S{\cdot}BH_3$ (2 M in THF) was added into it and the resulting solution was stirred for 1.5 h. The excess borane was reacted with H_2O and the mixture was dried over $MgSO_4$, filtered and concentrated under vacuum. The residue was purified by silica gel chromatography with hexane/EtOAc = 4/1 to afford the product as a white solid.

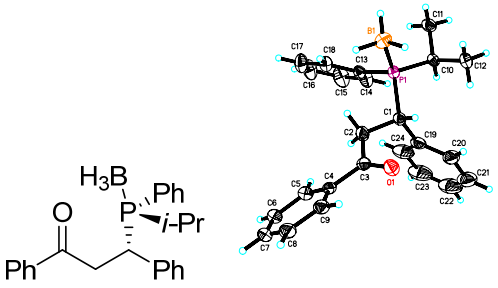


Table 3, entry 1. White solid. 80% yield, dr> 10/1. The ee was determined on a Daicel Chiralcel OZ-3 column with hexane/2-propanol = 95/5, flow = 1.0 mL/min. Retention times: 8.7 min [(R_c,S_p)-diastereomer], 18.5 min [(S_c,R_p)-diastereomer]. 98% ee. $[\alpha]^{20}_D$ = −11.1 (c 0.750, $CHCl_3$). The absolute configuration was determined to be S_c,R_p by X-ray crystal analysis.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.85 (d, J = 7.6 Hz, 2H), 7.54-7.35 (m, 8H), 7.14-7.12 (m, 3H), 6.80-6.76 (m, 1H), 4.24-4.15 (m, 1H), 3.84 (ddd, J = 18.0, 9.2 and 2.8 Hz, 1H), 3.43 (ddd, J = 16.8, 11.2 and 4.0 Hz, 1H), 2.27-2.19 (m, 1H), 1.43 (dd, J = 15.6

and 6.8 Hz, 3H), 0.98 (dd, J = 15.6 and 7.2 Hz, 3H), 1.30-0.30 (m, 3H). ^{13}C NMR ($CDCl_3$): δ 196.6 (d, J_{CP} = 13.3 Hz), 136.5 (d, J_{CP} = 1.1 Hz), 136.2 (d, J_{CP} = 7.3 Hz), 133.9 (d, J_{CP} = 2.2 Hz), 133.2, 131.5 (d, J_{CP} = 2.7 Hz), 128.8 (d, J_{CP} = 3.8 Hz), 128.5, 128.1 (d, J_{CP} = 6.5 Hz), 128.0 (d, J_{CP} = 0.8 Hz), 127.9, 127.1 (d, J_{CP} = 2.3 Hz), 124.5 (d, J_{CP} = 48.2 Hz), 39.1 (d, J_{CP} = 6.1 Hz), 36.1 (d, J_{CP} = 28.5 Hz), 20.5 (d, J_{CP} = 36.1 Hz), 16.8 (d, J_{CP} = 1.9 Hz). ^{31}P{^{1}H} NMR (162 MHz, $CDCl_3$): δ 34.6 (m). HRMS (ESI) calcd for $C_{24}H_{29}BO_2P$ $(M+H)^+$ 374.2080, found 374.2075.

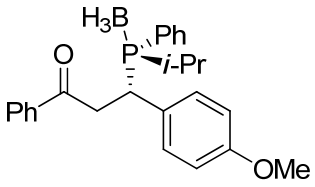


Table 3, entry 2. White solid. 84% yield, dr> 10/1. The ee was determined on a Daicel Chiralcel OZ-3 column with hexane/2-propanol = 95/5, flow = 1.0 mL/min. Retention times: 13.2 min [(R_c,S_p)-diastereomer], 42.5 min [(S_c,R_p)-diastereomer]. 98% ee. $[\alpha]^{20}_D$ = −25.0 (c 2.00, $CHCl_3$). The absolute configuration was assigned by analogy with Table 3, entry 1.

^{1}H NMR (300 MHz, $CDCl_3$): δ 7.84 (d, J = 7.5 Hz, 2H), 7.54-7.38 (m, 8H), 6.79 (d, J = 8.1 Hz, 2H), 7.84 (d, J = 8.7 Hz, 2H), 4.18-4.09 (m, 1H), 3.82 (ddd, J = 17.7, 9.0 and 3.0 Hz, 1H), 3.36 (ddd, J = 17.1, 11.4 and 5.1 Hz, 1H), 2.30-2.16 (m, 1H), 1.40 (dd, J = 15.6 and 6.6 Hz, 3H), 1.00 (dd, J = 15.6 and 6.9 Hz, 3H), 1.30-0.30 (m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 196.7 (d, J_{CP} = 13.6 Hz), 158.4 (d, J_{CP} = 1.9 Hz), 136.4 (d, J_{CP} = 1.5 Hz), 134.0 (d, J_{CP} = 7.6 Hz), 133.1, 131.4 (d, J_{CP} = 2.2 Hz), 129.8 (d, J_{CP} = 3.8 Hz), 128.5, 128.1 (d, J_{CP} = 9.1 Hz), 127.89, 127.87 (d, J_{CP} = 6.2 Hz), 124.5 (d, J_{CP} = 48.5 Hz), 113.4 (d, J_{CP} = 1.9 Hz), 55.0, 39.1 (d, J_{CP} = 6.5 Hz), 35.4 (d, J_{CP} = 29.6 Hz), 20.4 (d, J_{CP} = 36.1 Hz), 16.8 (d, J_{CP} = 1.9 Hz). ^{31}P{^{1}H} NMR (162 MHz, $CDCl_3$): δ 35.2 (m). HRMS (ESI) calcd for $C_{25}H_{31}BO_2P$ $(M+H)^+$ 404.2186, found 404.2187.

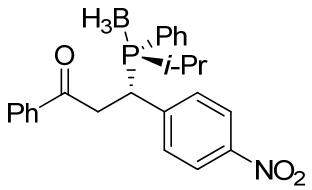


Table 3, entry 3. White solid. 85% yield, dr> 10/1. The ee was determined on a Daicel Chiralcel OZ-3 column with hexane/2-propanol = 95/5, flow = 1.0 mL/min. Retention times: 33.3 min [(R_c,S_p)-diastereomer], 39.9 min [(S_c,R_p)-diastereomer]. 99% ee. $[\alpha]^{20}_D$ = −34.4 (c 1.73, $CHCl_3$). The absolute configuration was assigned by analogy with Table 3, entry 1.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.97 (d, J = 8.4 Hz, 2H), 7.86 (d, J = 8.8 and 1.6 Hz, 2H), 7.57 (t, J = 7.6 Hz, 1H), 7.54-7.36 (m, 7H), 7.10 (dd, J = 8.8 and 1.6 Hz, 2H), 4.32 (td, J = 10.8 and 2.8 Hz, 1H), 3.90 (ddd, J = 18.0, 8.4 and 2.4 Hz, 1H), 3.58 (ddd, J = 18.1, 11.2 and 4.4 Hz, 1H), 2.34-2.21 (m, 1H), 1.40 (dd, J = 15.6 and 6.8 Hz, 3H), 1.07 (dd, J = 15.2 and 6.8 Hz, 3H), 1.30-0.30 (m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 195.9 (d, J_{CP} = 12.5 Hz), 146.6 (d, J_{CP} = 2.3 Hz), 144.7 (d, J_{CP} = 6.4 Hz), 135.9 (d, J_{CP} = 1.2 Hz), 133.6 (d, J_{CP} = 1.1 Hz), 133.5, 132.0 (d, J_{CP} = 2.2 Hz), 129.7 (d, J_{CP} = 3.8 Hz), 128.7, 128.5 (d, J_{CP} = 9.5 Hz), 127.9, 123.8 (d, J_{CP} = 48.6 Hz), 123.1 (d, J_{CP} = 1.5 Hz), 39.3 (d, J_{CP} = 5.3 Hz), 36.2 (d, J_{CP} = 27.3 Hz), 21.3 (d, J_{CP} = 34.5 Hz), 16.9 (d, J_{CP} = 1.9 Hz). ^{31}P{^{1}H} NMR (162 MHz, $CDCl_3$): δ 35.8 (m). HRMS (ESI) calcd for $C_{24}H_{28}BNO_3P$ $(M+H)^+$ 419.1931, found 419.1930.

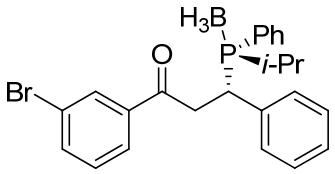


Table 3, entry 4. White solid. 88% yield, dr> 10/1. The ee was determined on a Daicel Chiralcel OZ-3 column with hexane/2-propanol = 95/5, flow = 1.0 mL/min. Retention times: 8.0 min [(R_c,S_p)-diastereomer], 13.8 min [(S_c,R_p)-diastereomer]. 99% ee. $[\alpha]^{20}_D$ = −30.4 (c 3.00, $CHCl_3$). The absolute configuration was assigned by analogy with Table 3, entry 1.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.86 (d, J = 7.2 Hz, 2H), 7.56-7.36 (m, 8H), 7.28-7.25

(m, 1H), 7.03 (t, J = 7.6 Hz, 1H), 6.92 (d, J = 7.6 Hz, 1H), 6.85-6.81 (m, 1H), 4.17-4.11 (m, 1H), 3.86 (ddd, J = 18.0, 9.2 and 2.8 Hz, 1H), 3.38 (ddd, J = 17.6, 10.8 and 4.8 Hz, 1H), 2.28-2.19 (m, 1H), 1.42 (dd, J = 16.0 and 6.8 Hz, 3H), 1.03 (dd, J = 15.6 and 6.8 Hz, 3H), 1.30-0.30 (m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 196.1 (d, J_{CP} = 12.3 Hz), 138.8 (d, J_{CP} = 7.0 Hz), 136.2 (d, J_{CP} = 1.6 Hz), 133.8 (d, J_{CP} = 7.8 Hz), 133.3, 131.8 (d, J_{CP} = 2.4 Hz), 131.5 (d, J_{CP} = 3.7 Hz), 130.2 (d, J_{CP} = 1.5 Hz), 129.5 (d, J_{CP} = 1.7 Hz), 128.6, 128.2 (d, J_{CP} = 9.1 Hz), 127.9, 127.6 (d, J_{CP} = 3.7 Hz), 124.0 (d, J_{CP} = 48.6 Hz), 122.1 (d, J_{CP} = 2.0 Hz), 39.0 (d, J_{CP} = 5.8 Hz), 35.8 (d, J_{CP} = 28.1 Hz), 20.5 (d, J_{CP} = 35.5 Hz), 16.8, 16.7 (d, J_{CP} = 2.4 Hz). ^{31}P{^{1}H} NMR (162 MHz, $CDCl_3$): δ 35.0 (m). HRMS (ESI) calcd for $C_{24}H_{28}BBrOP$ $(M+H)^+$ 452.1185, found 452.1162.

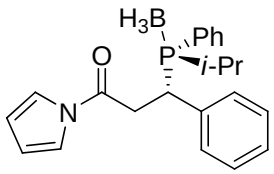


Table 3, entry 5. White solid. 83% yield, dr = 7/1. The ee was determined on a Daicel Chiralcel OZ-3 column with hexane/2-propanol = 95/5, flow = 1.0 mL/min. Retention times: 8.5 min [(R_c,S_p)-diastereomer], 14.6 min [(S_c,R_p)-diastereomer]. 98% ee. $[\alpha]^{20}_D$ = −8.32 (c 2.40, $CHCl_3$). The absolute configuration was assigned by analogy with Table 3, entry 1.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.51-7.48 (m, 1H), 7.47-7.36 (m, 4H), 7.22-7.13 (m, 5H), 6.89-6.85 (m, 2H), 6.24 (d, J = 2.4 Hz, 2H), 4.10 (ddd, J = 11.2, 9.6 and 2.8 Hz, 1H), 3.78 (ddd, J = 17.2, 8.4 and 2.8 Hz, 1H), 3.17 (ddd, J = 17.2, 11.6 and 4.8 Hz, 1H), 2.31-2.19 (m, 1H), 1.44 (dd, J = 15.6 and 6.8 Hz, 3H), 1.01 (dd, J = 15.6 and 6.8 Hz, 3H), 1.30-0.30 (m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.7 (d, J_{CP} = 16.4 Hz), 135.4 (d, J_{CP} = 9.6 Hz), 133.9 (d, J_{CP} = 8.0 Hz), 131.7 (d, J_{CP} = 2.7 Hz), 128.7 (d, J_{CP} = 3.8 Hz), 128.22, 128.17 (d, J_{CP} = 6.8 Hz), 127.5 (d, J_{CP} = 2.3 Hz), 123.9 (d, J_{CP} = 48.6 Hz), 118.9, 113.2, 36.7 (d, J_{CP} = 28.8 Hz), 35.3 (d, J_{CP} = 6.8 Hz), 20.4 (d, J_{CP} = 36.0 Hz), 16.8 (d, J_{CP} = 2.2 Hz). ^{31}P{^{1}H} NMR (162 MHz, $CDCl_3$): δ 35.3 (m).

HRMS (ESI) calcd for $C_{22}H_{31}BBrN_2OP$ $(M+NH_4)^+$ 380.2298, found 380.2295.

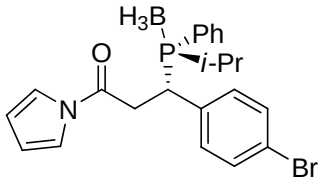


Table 3, entry 6. White solid. 80% yield, dr = 5/1. The ee was determined on a Daicel Chiralcel OZ-3 column with hexane/2-propanol = 95/5, flow = 1.0 mL/min. Retention times: 10.7 min [(R_c,S_p)-diastereomer], 15.7 min [(S_c,R_p)-diastereomer]. 99.6% ee. $[\alpha]^{20}_D$ = −78 (c 0.15, $CHCl_3$). The absolute configuration was assigned by analogy with Table 3, entry 1.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.51-7.48 (m, 1H), 7.47-7.36 (m, 4H), 7.22-7.13 (m, 4H), 6.75 (d, J = 7.6 Hz, 2H), 6.24 (t, J = 2.0 Hz, 2H), 4.09-4.03 (m, 1H), 3.76 (ddd, J = 17.2, 8.0 and 2.4 Hz, 1H), 3.13 (ddd, J = 17.2, 12.0 and 4.4 Hz, 1H), 2.28-2.19 (m, 1H), 1.41 (dd, J = 16.0 and 6.8 Hz, 3H), 1.03 (dd, J = 15.6 and 6.8 Hz, 3H), 1.30-0.30 (m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.4 (d, J_{CP} = 16.0 Hz), 134.7 (d, J_{CP} = 7.0 Hz), 133.8 (d, J_{CP} = 7.8 Hz), 131.9 (d, J_{CP} = 2.6 Hz), 131.3 (d, J_{CP} = 1.1 Hz), 130.3 (d, J_{CP} = 3.7 Hz), 128.4 (d, J_{CP} = 9.3 Hz), 123.6 (d, J_{CP} = 48.3 Hz), 121.4 (d, J_{CP} = 2.6 Hz), 118.8, 113.4, 36.3 (d, J_{CP} = 28.6 Hz), 35.4 (d, J_{CP} = 6.7 Hz), 20.7 (d, J_{CP} = 35.3 Hz), 16.8 (d, J_{CP} = 2.2 Hz). ^{31}P{^{1}H} NMR (162 MHz, $CDCl_3$): δ 34.7 (m). HRMS (ESI) calcd for $C_{22}H_{30}BBrN_2OP$ $(M+NH_4)^+$ 458.1403, found.458.1400.

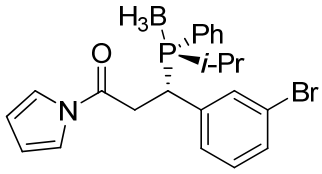


Table 3, entry 7. White solid. 81% yield, dr = 6/1. The ee was determined on a Daicel Chiralcel OZ-3 column with hexane/2-propanol = 95/5, flow = 1.0 mL/min. Retention times: 8.0 min [(R_c,S_p)-diastereomer], 13.0 min [(S_c,R_p)-diastereomer]. 99% ee. $[\alpha]^{20}_D$ = −10.0 (c 2.60, $CHCl_3$). The absolute configuration was assigned by analogy with Table 3, entry 1.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.51-7.44 (m, 1H), 7.47-7.36 (m, 4H), 7.31 (d, *J* = 8.8 Hz, 1H), 7.22 (t, *J* = 2.0 Hz, 2H), 7.06 (t, *J* = 8.0 Hz, 1H), 6.90 (d, *J* = 8.8 Hz, 1H),, 6.88-6.82 (m, 1H), 6.27 (t, *J* = 2.4 Hz, 2H), 4.05 (ddd, *J* = 11.6, 9.6 and 2.8 Hz, 1H), 3.78 (ddd, *J* = 17.6, 8.4 and 2.8 Hz, 1H), 3.12 (ddd, *J* = 17.2, 12.0 and 4.8 Hz, 1H), 2.27-2.17 (m, 1H), 1.42 (dd, *J* = 16.0 and 6.8 Hz, 3H), 1.03 (dd, *J* = 15.6 and 6.8 Hz, 3H), 1.30-0.30 (m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.4 (d, J_{CP} = 15.9 Hz), 138.0 (d, J_{CP} = 7.6 Hz), 133.8 (d, J_{CP} = 7.9 Hz), 132.0 (d, J_{CP} = 2.2 Hz), 131.4 (d, J_{CP} = 3.4 Hz), 130.5 (d, J_{CP} = 1.6 Hz), 129.7 (d, J_{CP} = 1.5 Hz), 128.4 (d, J_{CP} = 8.5 Hz), 127.5 (d, J_{CP} = 3.8 Hz), 123.5 (d, J_{CP} = 48.6 Hz), 122.3 (d, J_{CP} = 1.5 Hz), 118.8, 113.4, 36.4 (d, J_{CP} = 27.7 Hz), 35.3 (d, J_{CP} = 7.2 Hz), 20.4 (d, J_{CP} = 35.7 Hz), 16.75, 16.69 (d, J_{CP} = 1.9 Hz). ^{31}P{^{1}H} NMR (162 MHz, $CDCl_3$): δ 35.9 (m). HRMS (ESI) calcd for $C_{22}H_{30}BBrN_2OP$ $(M+NH_4)^+$ 458.1403, found 458.1397.

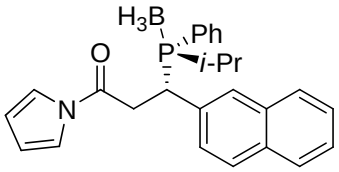


Table 3, entry 8. White solid. 78% yield, dr = 5/1. The ee was determined on a Daicel Chiralcel OZ-3 column with hexane/2-propanol = 95/5, flow = 1.0 mL/min. Retention times: 8.0 min [(R_c,S_p)-diastereomer], 13.0 min [(S_c,R_p)-diastereomer]. 99% ee. $[\alpha]^{20}_D$ = −61.1 (c 1.90, $CHCl_3$). The absolute configuration was assigned by analogy with Table 3, entry 1.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.78-7.75 (m, 1H), 7.67 (d, *J* = 8.8 Hz, 1H), 7.59-7.56 (m, 1H), 7.52-7.48 (m, 1H), 7.46-7.32 (m, 6H), 7.24-7.18 (m, 3H), 7.05 (d, *J* = 8.4 Hz, 1H), 6.23 (t, *J* = 2.0 Hz, 2H), 4.27 (ddd, *J* = 11.6, 9.2 and 2.4 Hz, 1H), 3.88 (ddd, *J* = 17.2, 8.4 and 2.8 Hz, 1H), 3.26 (ddd, *J* = 17.6, 11.6 and 4.4 Hz, 1H), 2.28-2.14 (m, 1H), 1.49 (dd, *J* = 15.6 and 6.4 Hz, 3H), 0.99 (dd, *J* = 15.6 and 6.8 Hz, 3H), 1.30-0.30 (m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.6 (d, J_{CP} = 16.2 Hz), 134.0 (d, J_{CP} = 7.7 Hz), 132.8 (d, J_{CP} = 7.7 Hz), 132.7 (d, J_{CP} = 1.6 Hz), 132.5 (d, J_{CP} = 1.6 Hz), 131.8 (d, J_{CP} = 2.5 Hz), 128.2 (d, J_{CP} = 9.3 Hz), 127.9 (d, J_{CP} = 1.2 Hz), 127.63 (d, J_{CP} = 0.8

Hz), 127.57, 127.52 (d, J_{CP} = 0.8 Hz), 126.8 (d, J_{CP} = 3.2 Hz), 126.3 (d, J_{CP} = 0.8 Hz), 126.1 (d, J_{CP} = 0.8 Hz), 123.9 (d, J_{CP} = 48.4 Hz), 118.9, 113.3, 36.9 (d, J_{CP} = 28.2 Hz), 35.5 (d, J_{CP} = 7.3 Hz), 20.2 (d, J_{CP} = 16.3 Hz), 16.8 (d, J_{CP} = 2.4 Hz), 16.7 (d, J_{CP} = 1.3 Hz). $^{31}P\{^{1}H\}$ NMR (162 MHz, $CDCl_3$): δ 36.0 (m). HRMS (ESI) calcd for $C_{26}H_{33}BN_2OP$ $(M+NH_4)^+$ 430.2454, found 430.2452.

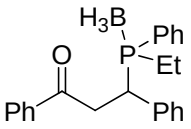


Table 1, entry 6. White solid. 96% yield, dr = 11/1. The ee was determined on a Daicel Chiralcel OZ-3 column with hexane/2-propanol = 95/5, flow = 0.8 mL/min. Retention times: 11.3 min (minor diastereomer), 12.4 min (minor diastereomer), 13.8 min (major diastereomer), 26.1 min (major diastereomer). 86% ee (major diastereomer), 65% ee (minor diastereomer).

Major diastereomer: ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.89-7.87 (m, 2H), 7.58-7.52 (m, 1H), 7.48-7.35 (m, 7H), 7.14-7.08 (m, 3H), 6.90-6.84 (m, 2H), 4.03 (td, *J* = 10.4 and 3.2 Hz, 1H), 3.84 (ddd, *J* = 17.6, 9.6 and 3.2 Hz, 1H), 3.51 (ddd, *J* = 17.2, 10.0 and 6.8 Hz, 1H), 1.96-1.81 (m, 2H), 1.11 (dt, *J* = 16.8 and 7.6 Hz, 3H), 1.30-0.30 (m, 3H). $^{31}P\{^{1}H\}$ NMR (121 MHz, $CDCl_3$): δ 27.2 (m).

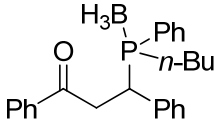
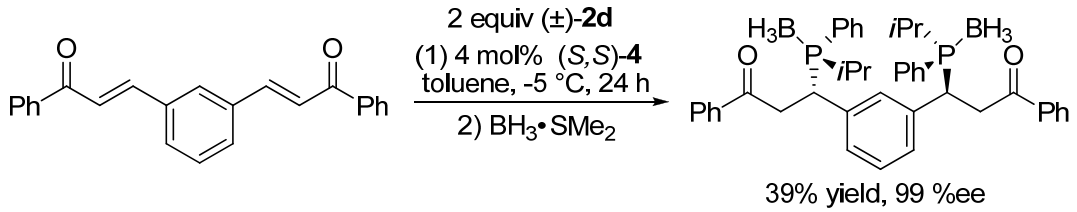


Table 1, entry 7. White solid. 96% yield, dr = 4.7/1. The ee was determined on a Daicel Chiralcel OZ-3 column with hexane/2-propanol = 95/5, flow = 0.8 mL/min. Retention times: 8.4 min (minor diastereomer), 9.7 min (major diastereomer), 13.9 min (minor diastereomer), 16.0 min (major diastereomer). 58% ee (major diastereomer), 86% ee (minor diastereomer).

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.89-7.76 (m, 2H), 7.58-6.84 (m, 13H), 4.09 (ddd, *J* = 15.2, 10.2 and 2.8 Hz, 0.25H), 4.02 (td, *J* = 10.8 and 2.8 Hz, 0.75H), 3.90 (ddd, *J* = 17.6, 10.2 and 4.8 Hz, 0.25H), 3.83 (ddd, *J* = 17.6, 9.6 and 3.6 Hz, 0.75H), 3.52 (ddd, *J* = 17.2, 10.4 and 6.8 Hz, 0.74H), 3.11 (ddd, *J* = 17.6, 10.0 and 2.8 Hz, 0.26H),

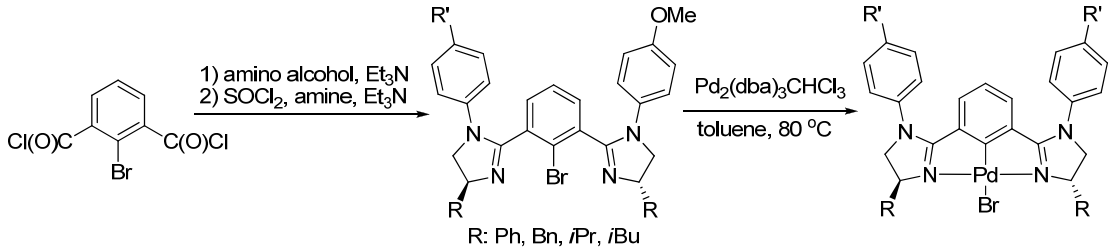
1.90-1.71 (m, 2H), 1.41-1.15 (m, 4H), 0.86 (t, J = 7.2 Hz, 2.25H), 0.73 (t, J = 6.8 Hz, 0.75H), 1.30-0.30 (m, 3H). $^{31}P\{^{1}H\}$ NMR (121 MHz, $CDCl_3$): δ 24.2 (m).

Application for a P-Chiral Bisphosphine Synthesis



White solid. 62% yield. The ee was determined on a Daicel Chiralcel OZ-3 column with hexane/2-propanol = 90/10, flow = 1.0 mL/min. Retention times: 8.1 min [(R_c,S_p)-diastereomer], 12.0 min [(S_c,R_p)-diastereomer]. 99% ee.^{1}H NMR (400 MHz, $CDCl_3$): δ 7.96 (d, J = 7.2 Hz, 4H), 7.56 (t, J = 7.2 Hz, 2H), 7.44 (t, J = 7.2 Hz, 4H), 7.26 (t, J = 7.6 Hz, 2H), 7.20-7.07 (m, 9H), 6.66 (t, J = 8.0 Hz, 1H), 6.46 (d, J = 7.2 Hz, 2H), 4.18 (td, J = 10.8 and 2.8 Hz, 2H), 3.75 (ddd, J = 17.6, 9.6 and 2.4 Hz, 2H), 3.39 (ddd, J = 17.6, 10.4 and 6.4 Hz, 2H), 2.25-2.18 (m, 2H), 1.36 (dd, J = 16.0 and 7.2 Hz, 6H), 0.98 (dd, J = 15.2 and 7.2 Hz, 6H), 1.30-0.30 (m, 6H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 196.7 (d, J_{CP} = 12.2 Hz), 137.23 (d, J_{CP} = 1.5 Hz), 137.18 (d, J_{CP} = 1.5 Hz), 136.5 (d, J_{CP} = 1.5 Hz), 133.7 (d, J_{CP} = 7.8 Hz), 133.3, 131.2 (d, J_{CP} = 2.3 Hz), 130.2 (m), 128.6, 128.0, 127.98 (d, J_{CP} = 9.6 Hz), 127.6 (m), 124.6 (d, J_{CP} = 49.7 Hz), 39.8 (d, J_{CP} = 5.9 Hz), 35.7 (d, J_{CP} = 29.6 Hz), 21.8 (d, J_{CP} = 35.1 Hz), 17.01 (d, J_{CP} = 6.4 Hz), 17.00 (d, J_{CP} = 4.1 Hz). $^{31}P\{^{1}H\}$ NMR (162 MHz, $CDCl_3$): δ 35.9 (m).

General Procedure for the Preparation of Catalyst[5]

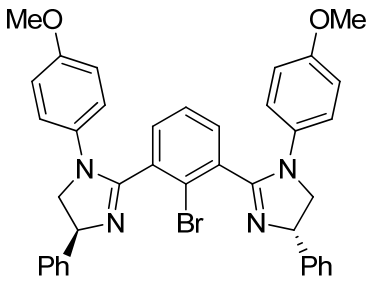


To a solution of amino alcohol (16.0 mmol) and triethyl amine (16.0 mmol) in dichloromethane (30 mL) at 0 °C was added dropwisely a solution of diacyl chloride (8.0 mmol) in dichloromethane, and the resulting mixture was stirred at room

temperature for 24 h. The mixture was filtered and washed with dichloromethane to afford the desired amide for the next step without further purification.

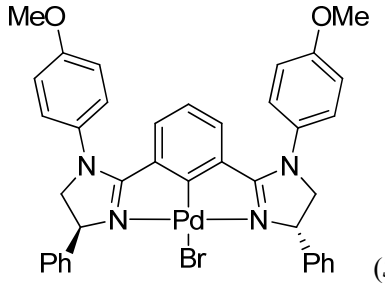
The obtained amide (1.5 mmol) was refluxed with $SOCl_2$ (8 mL) for 8 h, and the excess $SOCl_2$ was removed and the residue was dissolved with dichloromethane (5 mL). Then, it was added to a solution of anilines (3.3 mmol) and triethylamine (9 mmol) in dichloromethane (10 mL), and the resulting mixture was stirred at room temperature for 24 h. After addition of aqueous NaOH solution, the mixture was extracted with dichloromethane, and the organic phase was dried over $MgSO_4$, filtered and evaporated under vacumm. The residue was purified by silica gel chromatography to afford product as a solid.

The obtained oxazoline (0.2 mmol) was stirred with $Pd_2(dba)_3{\cdot}CHCl_3$ (0.1 mmol) in toluene at 80 °C for 16 h. After cooling to room temperature, the mixture was filtered over celite and washed with dichloromethane, and the filtrate was concentrated under vacuum. The residue was purified by silica gel chromatography to afford product as a yellow solid.



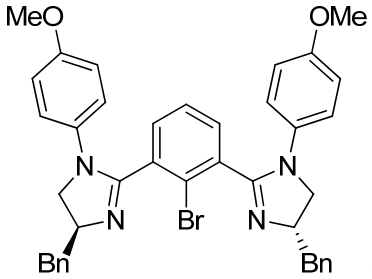
(*S*,*S*)-**Ia**

White solid. 70% yield. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.53-7.40 (m, 6H), 7.38-7.20 (m, 7H), 6.72-6.60 (m, 8H), 5.32 (t, *J* = 10.0 Hz, 2H), 4.27 (t, *J* = 10.0 Hz, 2H), 3.84 (t, *J* = 9.6 Hz, 2H), 3.64 (s, 6H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$): δ 160.9, 155.6, 143.5, 134.5, 133.5, 131.3, 128.2, 126.9, 126.8, 126.6, 126.5, 122.5, 113.8, 67.4, 60.0, 54.9.



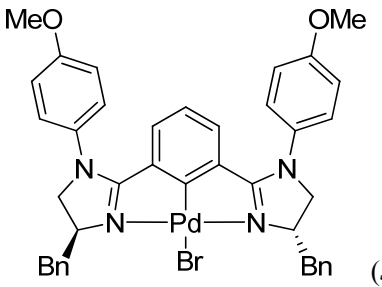
(*S*,*S*)-**5a**

Yellow solid. 85% yield. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.46 (d, *J* = 7.6 Hz, 4H), 7.31 (t, *J* = 7.2 Hz, 4H), 7.28-7.15 (m, 6H), 6.92 (d, *J* = 8.8 Hz, 4H), 6.61 (t, *J* = 7.6 Hz, 1H), 6.35 (d, *J* = 7.6 Hz, 2H), 5.44 (dd, *J* = 10.8 and 4.0 Hz, 2H), 4.39 (t, *J* = 10.4 Hz, 2H), 3.96 (dd, *J* = 9.6 and 3.6 Hz, 2H), 3.83 (s, 6H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$): δ 174.6, 170.2, 159.1, 142.8, 132.9, 132.1, 128.4, 128.1, 127.3, 126.9, 126.7, 122.0, 114.8, 64.8, 63.8, 55.5. $[\alpha]^{20}_{D}$ = −150 (c 1.00, $CHCl_3$). HRMS (ESI) calcd for $C_{38}H_{32}N_4O_2Pd$ $(M\text{-}HBr)^+$ 678.1581, found 678.1564.



(*S*,*S*)-**Ib**

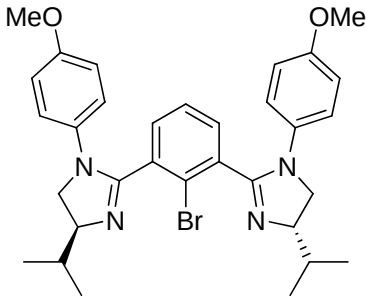
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.25-7.08 (m, 13H), 6.53 (d, *J* = 9.2 Hz, 4H), 6.46 (d, *J* = 8.8 Hz, 4H), 4.51-4.45 (m, 2H), 3.89 (t, *J* = 10.0 Hz, 2H), 3.60 (s, 6H), 3.60-3.56 (m, 2H), 3.19 (dd, *J* = 13.6 and 4.8 Hz, 2H), 2.84 (dd, *J* = 13.6 and 8.4 Hz, 2H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$): δ 160.0, 155.5, 137.8, 134.1, 133.2, 131.1, 129.1, 127.9, 126.7, 125.8, 122.5, 121.3, 113.5, 64.8, 56.1, 54.8, 41.3.



(*S*,*S*)-**5b**

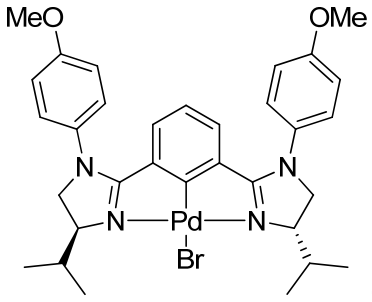
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.47 (d, *J* = 6.0 Hz, 4H), 7.26-7.16 (m, 6H), 6.83 (d, *J*

= 8.0 Hz, 4H), 6.43 (d, *J* = 8.0 Hz, 1H), 6.10 (d, *J* = 7.6 Hz, 2H), 4.72-4.65 (m, 2H), 4.08 (t, *J* = 10.4 Hz, 2H), 3.80 (s, 6H), 3.35 (d, *J* = 4.8 Hz, 4H). $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$): δ 173.3, 169.1, 158.8, 137.0, 132.8, 131.4, 130.0, 127.8, 127.6, 126.3, 126.1, 121.8, 114.4, 62.6, 58.0, 55.3, 40.5. $[\alpha]^{20}_{D}$ = 249 (c 1.00, $CHCl_3$). HRMS (ESI) calcd for $C_{40}H_{36}N_4O_2Pd$ $(M\text{-}HBr)^+$ 706.1894, found 706.1875.



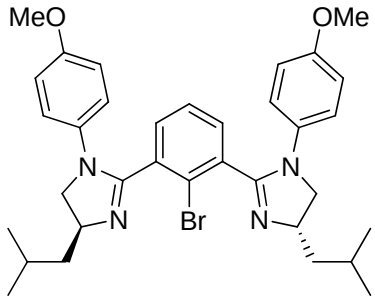
(*S*,*S*)-**Ic**

^{1}H NMR (300 MHz, $CDCl_3$): δ 7.37-7.25 (m, 4H), 6.76-6.63 (m, 7H), 4.09-4.01 (m, 2H), 3.93 (t, *J* = 9.3 Hz, 2H), 3.73 (s, 6H), 3.65 (t, *J* = 9.3 Hz, 2H), 2.01-1.90 (m, 2H), 1.03 (d, *J* = 6.6 Hz, 6H), 0.98 (d, *J* = 6.6 Hz, 6H). $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$): δ 159.3, 155.0, 134.3, 133.3, 130.7, 126.5, 122.0, 121.0, 113.3, 69.3, 54.4, 53.9, 32.1, 18.2. 17.4.



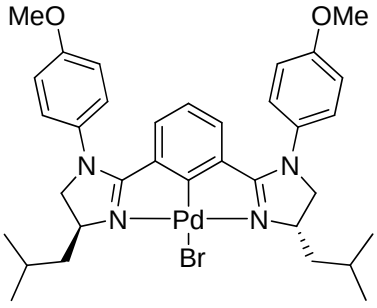
(*S*,*S*)-**5c**

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.12 (d, *J* = 8.8 Hz, 4H), 6.89 (d, *J* = 8.4 Hz, 4H), 6.49 (d, *J* = 7.6 Hz, 1H), 6.20 (d, *J* = 7.6 Hz, 2H), 4.35-4.29 (m, 2H), 3.94 (t, *J* = 10.0 Hz, 2H), 3.81 (s, 6H), 3.80-3.75 (m, 2H), 2.93-2.84 (m, 2H), 0.89 (d, *J* = 6.8 Hz, 6H), 0.85 (d, *J* = 6.4 Hz, 6H). $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$): δ173.2, 168.8, 158.9, 133.0, 132.4, 127.8, 126.4, 121.9, 114.7, 66.7, 55.5, 54.8, 30.2, 18.5, 14.2. $[\alpha]^{20}_{D}$ = −144 (c 1.00, $CHCl_3$). HRMS (ESI) calcd for $C_{32}H_{36}N_4O_2Pd$ $(M\text{-}HBr)^+$ 610.1894, found 610.1878.



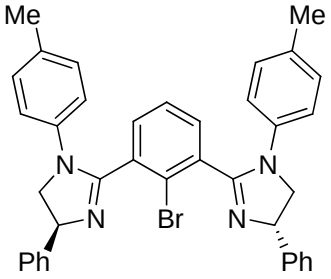
(*S*,*S*)-**Id**

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.32-7.20 (m, 4H), 6.76-6.63 (m, 7H), 4.30-4.20 (m, 2H), 4.03 (t, *J* = 9.0 Hz, 2H), 3.72 (s, 6H), 3.54 (t, *J* = 8.4 Hz, 2H), 1.89-1.73 (m, 4H), 1.48-1.33 (m, 2H), 0.98 (d, *J* = 6.6 Hz, 6H), 0.96 (d, *J* = 6.6 Hz, 6H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$): δ 158.9, 154.9, 134.1, 133.2, 130.6, 126.3, 121.7, 121.3, 113.2, 61.9, 57.3, 54.3, 45.1, 24.2, 22.2, 22.0.



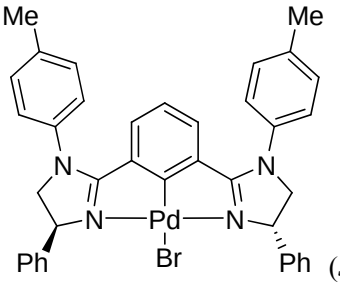
(*S*,*S*)-**5d**

^{1}H NMR (300 MHz, $CDCl_3$): δ 7.18 (d, *J* = 8.7 Hz, 4H), 6.92 (d, *J* = 9.0 Hz, 4H), 6.50 (d, *J* = 7.5 Hz, 1H), 6.23 (d, *J* = 7.8 Hz, 2H), 4.45-4.34 (m, 2H), 4.08 (t, *J* = 9.9 Hz, 2H), 3.85 (s, 6H), 3.77 (dd, *J* = 9.3 and 5.1 Hz, 2H), 1.85-1.42 (m, 6H), 1.04 (d, *J* = 6.3 Hz, 6H), 0.98 (d, *J* = 6.6 Hz, 6H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$): δ 173.3, 168.7, 158.8, 133.1, 132.4, 127.7, 126.2, 121.7, 114.6, 60.9, 60.3, 55.4, 44.2, 25.0, 23.8, 21.5. $[\alpha]^{20}_D$ = −157 (c 1.00, $CHCl_3$). HRMS (ESI) calcd for $C_{34}H_{40}N_4O_2Pd$ $(M\text{-}HBr)^+$ 638.2207, found 638.2185.



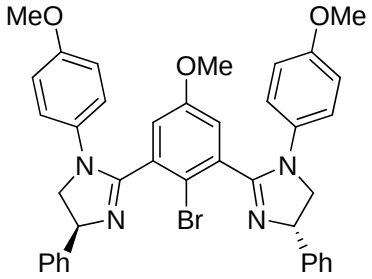
(*S*,*S*)-**Ie**

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.49 (d, *J* = 7.6 Hz, 2H), 7.42 (d, *J* = 7.2 Hz, 4H), 7.32 (m, 5H), 7.24 (t, *J* = 7.2 Hz, 2H), 6.87 (d, *J* = 8.0 Hz, 4H), 6.57 (d, *J* = 8.0 Hz, 4H), 5.32 (t, *J* = 10.0 Hz, 2H), 4.30 (t, *J* = 10.0 Hz, 2H), 3.90 (t, *J* = 9.2 Hz, 2H), 2.21 (s, 6H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$): δ 160.4, 143.4, 137.7, 134.8, 132.3, 131.5, 129.2, 128.3, 127.2, 127.0, 126.7, 121.7, 120.0, 67.3, 59.4, 20.5.



(*S*,*S*)-**5e**

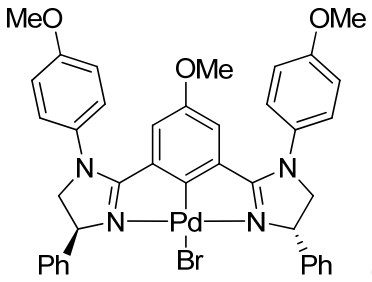
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.46 (d, *J* = 6.8 Hz, 4H), 7.29-7.11 (m, 14H), 6.62 (t, *J* = 7.6 Hz, 1H), 6.44 (d, *J* = 7.6 Hz, 2H), 5.45 (d, *J* = 7.6 Hz, 2H), 4.43 (t, *J* = 9.6 Hz, 2H), 3.96 (d, *J* = 6.8 Hz, 2H), 2.39 (s, 6H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$): δ 174.6, 169.7, 142.7, 137.9, 136.7, 132.8, 130.2, 128.3, 127.2, 126.9, 126.7, 126.2, 121.9, 64.7, 63.5, 21.0. $[\alpha]^{20}_D$ = −179 (c 1.00, $CHCl_3$). HRMS (ESI) calcd for $C_{38}H_{32}N_4Pd$ $(M\text{-}HBr)^+$ 646.1683, found 646.1669.



(*S*,*S*)-**If**

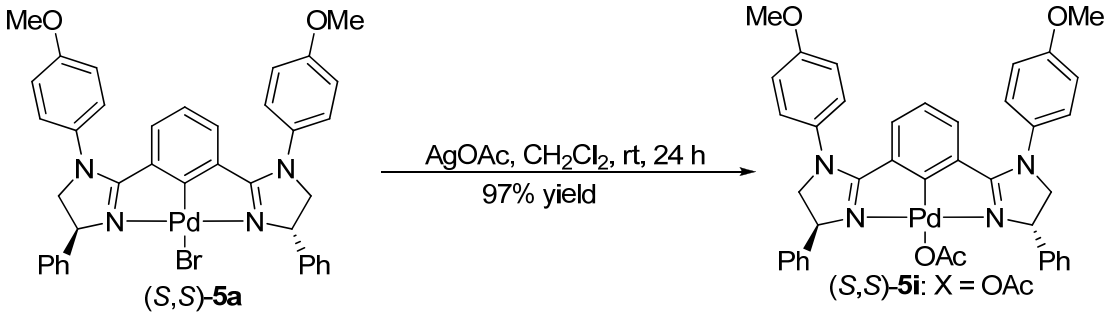
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.45-7.26 (m, 10H), 7..03 (s, 2H), 6.70-6.64 (m, 8H), 5.34 (t, *J* = 9.6 Hz, 2H), 4.32 (t, *J* = 9.1 Hz, 2H), 3.89 (d, *J* = 9.0 Hz, 1H), 3.76 (s, 3H), 3.72 (s, 6H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$): δ 160.7, 158.0, 155.5, 143.2, 135.1,

133.2, 128.1, 126.7, 126.4, 122.3, 117.1, 113.7, 111.7, 67.1, 59.8, 55.2, 54.8.



(*S*,*S*)-**5f**

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.51-7.42 (m, 4H), 7.32-7.15 (m, 10H), 6.92 (d, *J* = 8.8 Hz, 4H), 5.99 (s, 2H), 5.43-5.33 (m, 2H), 4.38 (t, *J* = 7.6 Hz, 2H), 3.99-3.92 (m, 2H), 3.82 (s, 6H), 3.26 (s, 3H). $^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$): δ 169.9, 159.2, 154.9, 142.8, 132.8, 131.9, 128.4, 128.1, 127.3, 126.8, 126.7, 114.7, 113.3, 64.8, 63.7, 55.5, 55.1. $[\alpha]^{20}_D$ = 137 (c 1.10, $CHCl_3$). HRMS (ESI) calcd for $C_{39}H_{34}N_4O_3Pd$ $(M\text{-}HBr)^+$ 708.1687, found 708.1660.

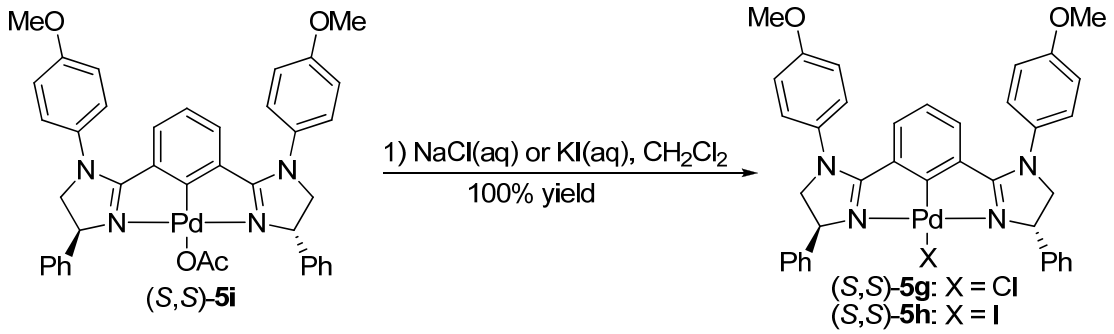


(*S*,*S*)-**5a**

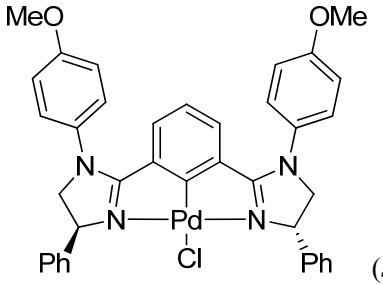
(*S*,*S*)-**5i**: X = OAc

A mixture of (*S*,*S*)-**5a** (110 mg, 0.144 mmol) and AgOAc (29 mg, 0.17 mmol) in dichloromethane (17 mL) was stirred at room temperature for 24 h, the mixture was filtered over celite and concentrated to afford the product (*S*,*S*)-**5i** (104 mg, 0.140 mmol; 97% yield).

^{1}H NMR (300 MHz, $CDCl_3$): δ 7.42-7.25 (m, 14H), 6.93 (d, *J* = 9.0 Hz, 4H), 6.55 (d, *J* = 6.0 Hz, 1H), 6.29 (d, *J* = 7.8 Hz, 2H), 5.50-5.30 (m, 2H), 4.42 (t, *J* = 7.8 Hz, 2H), 3.88 (t, *J* = 6.3 Hz, 2H), 3.84 (s, 6H), 2.00 (s, 3H). MS (ESI): 681.2 $(M\text{-}HOAc)^+$.

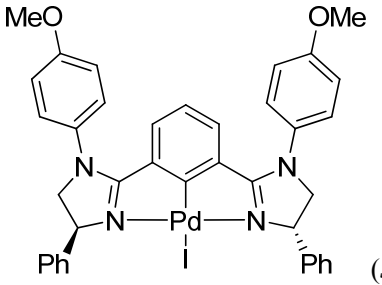


A solution of (*S*,*S*)-**5i** (0.02 mmol) in dichloromethane (8 mL) and aqueous solution of NaCl or KI (0.20 mmol in 6 mL H_2O) was stirred at room temperature for 1 h. The organic phase was dried over $MgSO_4$, filtered, and concentrated to afford the desired products (*S*,*S*)-**5g** and (*S*,*S*)-**5h** in quantitative yield.



(*S*,*S*)-**5g**

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.50 (d, *J* = 7.6 Hz, 4H), 7.34 (d, *J* = 7.2 Hz, 4H), 7.28-7.18 (m, 6H), 6.93 (d, *J* = 9.2 Hz, 4H), 6.58 (d, *J* = 8.0 Hz, 1H), 6.33 (d, *J* = 8.0 Hz, 2H), 5.39 (dd, *J* = 10.8 and 4.4 Hz, 2H), 4.39 (t, *J* = 10.4 Hz, 2H), 4.02 (dd, *J* = 9.6 and 4.4 Hz, 2H), 3.85 (s, 6H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$): δ 174.4, 169.9, 159.2, 142.7, 133.2, 132.3, 128.5, 128.1, 127.5, 126.94, 126.88, 121.9, 114.9, 64.5, 63.6, 55.5. $[\alpha]^{20}_D$ = 60 (c 0.70, $CHCl_3$). HRMS (ESI) calcd for $C_{38}H_{32}N_4O_2Pd$ $(M\text{-}HCl)^+$ 678.1581, found 678.1573.



(*S*,*S*)-**5h**

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.43 (d, *J* = 6.4 Hz, 4H), 7.34 (t, *J* = 6.4 Hz, 4H), 7.28-7.22 (m, 2H), 7.20 (d, *J* = 8.4 Hz, 4H), 6.93 (d, *J* = 8.4 Hz, 4H), 6.63 (t, *J* = 8.0

Hz, 1H), 6.37 (d, J = 7.6 Hz, 2H), 5.53 (dd, J = 10.8 and 4.0 Hz, 2H), 4.37 (t, J = 10.4 Hz, 2H), 3.96 (dd, J = 10.0 and 4.0 Hz, 2H), 3.84 (s, 6H). $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$): δ 175.2, 170.8, 159.3, 143.0, 132.8, 132.1, 128.6, 128.2, 127.4, 127.1, 126.8, 122.2, 114.9, 66.1, 64.1, 55.6. $[\alpha]^{20}_{D}$ = 65 (c 0.55, $CHCl_3$). HRMS (ESI) calcd for $C_{38}H_{32}N_4O_2Pd$ $(M\text{-}HI)^+$ 678.1581, found 678.1572.

References:

(1) Feng.; J.-J.; Chen, X.-F.; Shi, M.; Duan, W.-L. *J. Am. Chem. Soc*. **2010**, *132*, 5562.

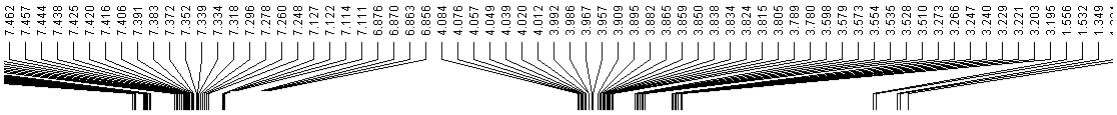
(2) Shadakshari, U.; Nayak, S. K. *Tetrahedron* **2001**, *57*, 8185.

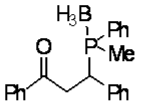
(3) Yamagiwa, N.; Qin, H.; Matsunaga, S.; Shibasaki, M. *J. Am. Chem. Soc. 2005*, **127**, 13419.

(4) Tsvetkov, E. N.; Bondarenko, N. A.; Malakhova, I.G.; Kabachnik, M. I. *Synthesis* **1986**, 198.

(5) a) Ma, K.; You, J. *Chem.–Eur. J*. **2008**, *14*, 7108. b) Bugarin, A.; Connell, B. T. *Organometallics* **2008**, *27*, 4357.

NMR Spectra

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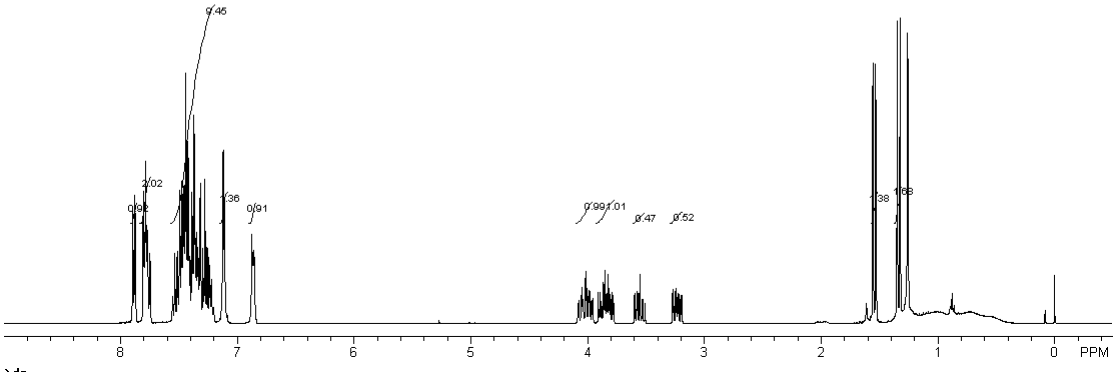
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4
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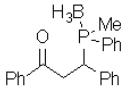
0
PPM


18.129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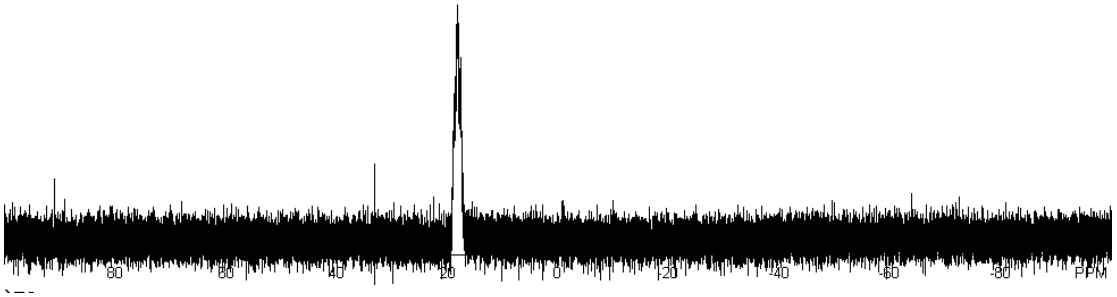
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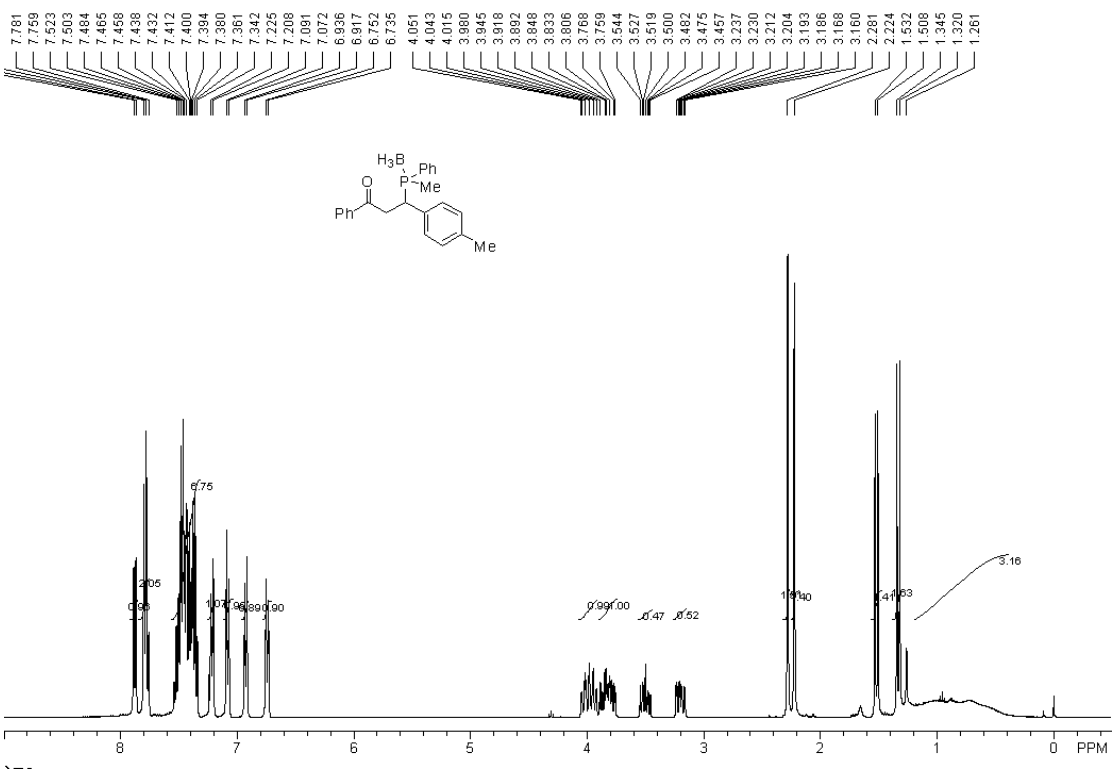
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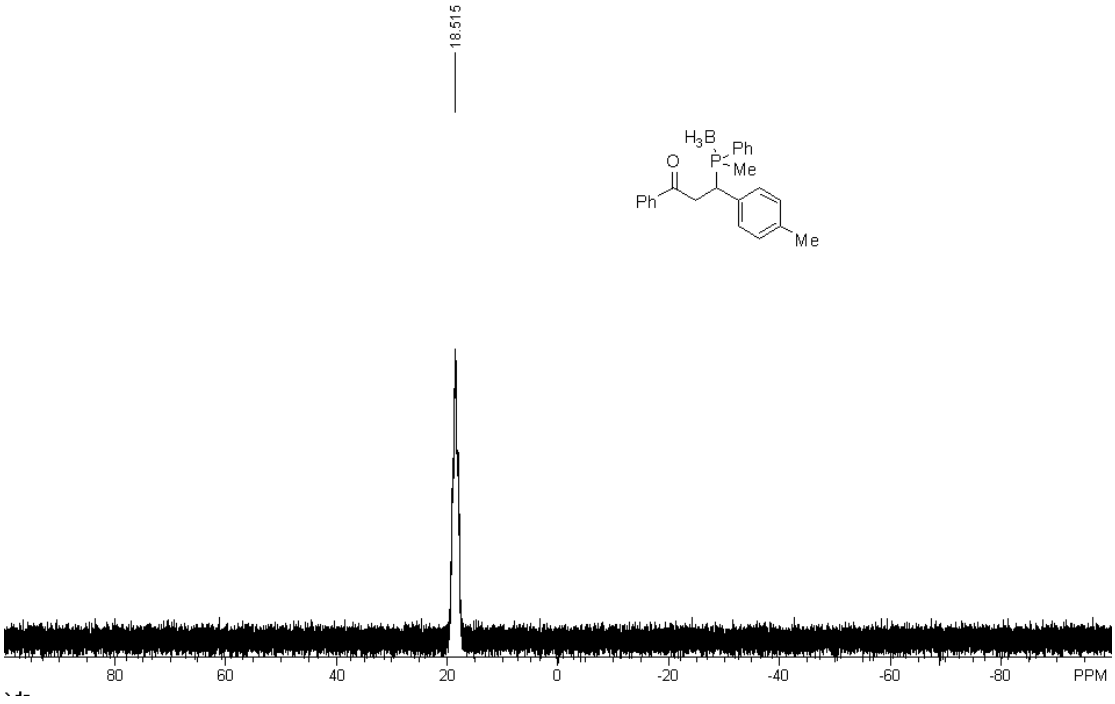
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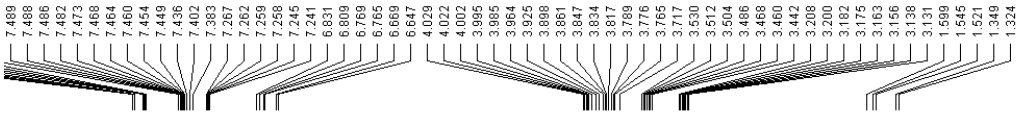
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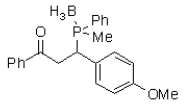
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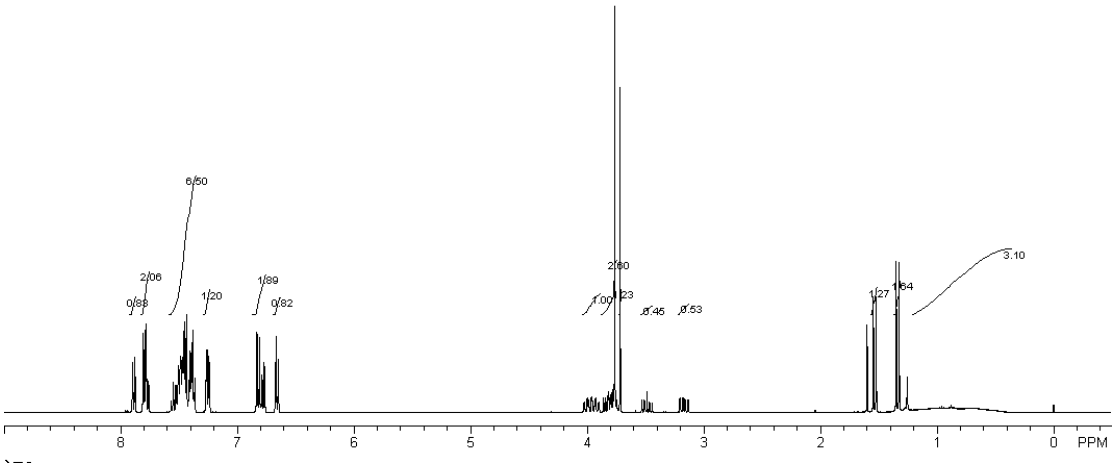
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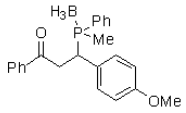
18.491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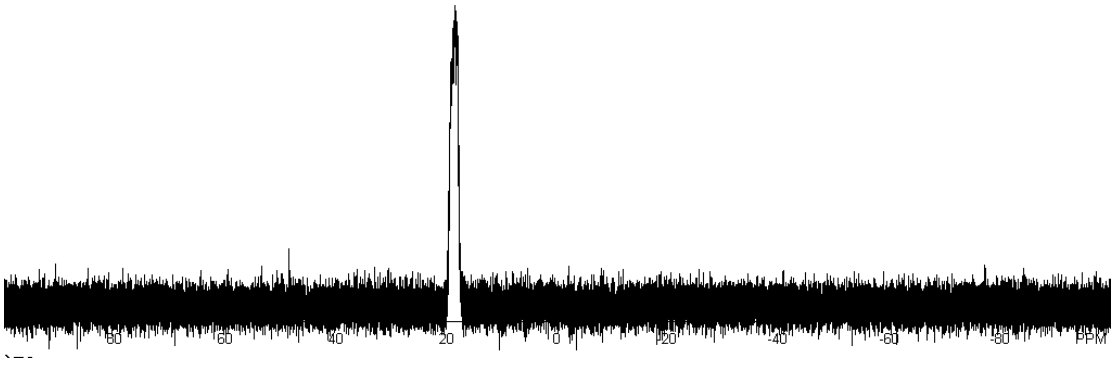
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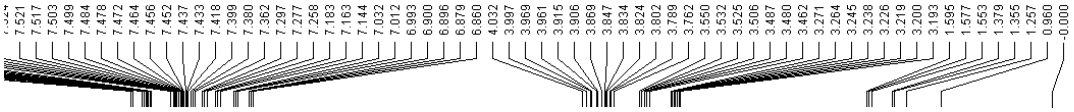

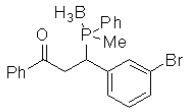
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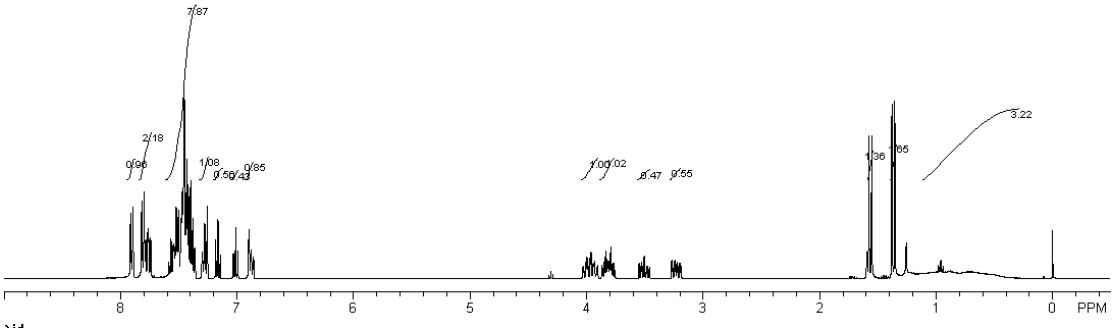
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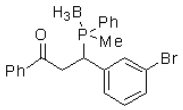
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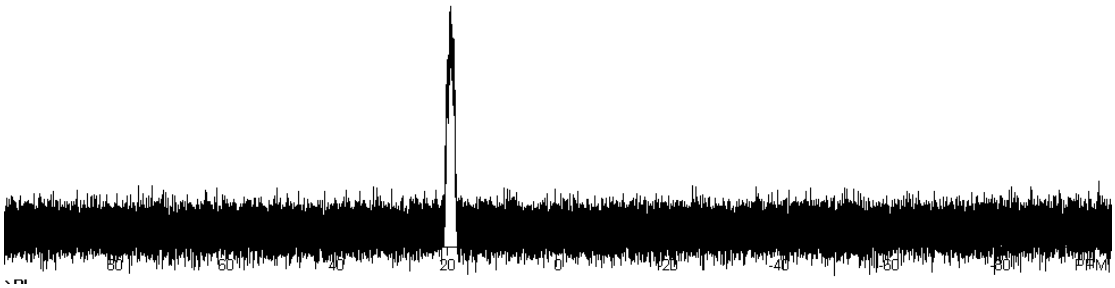
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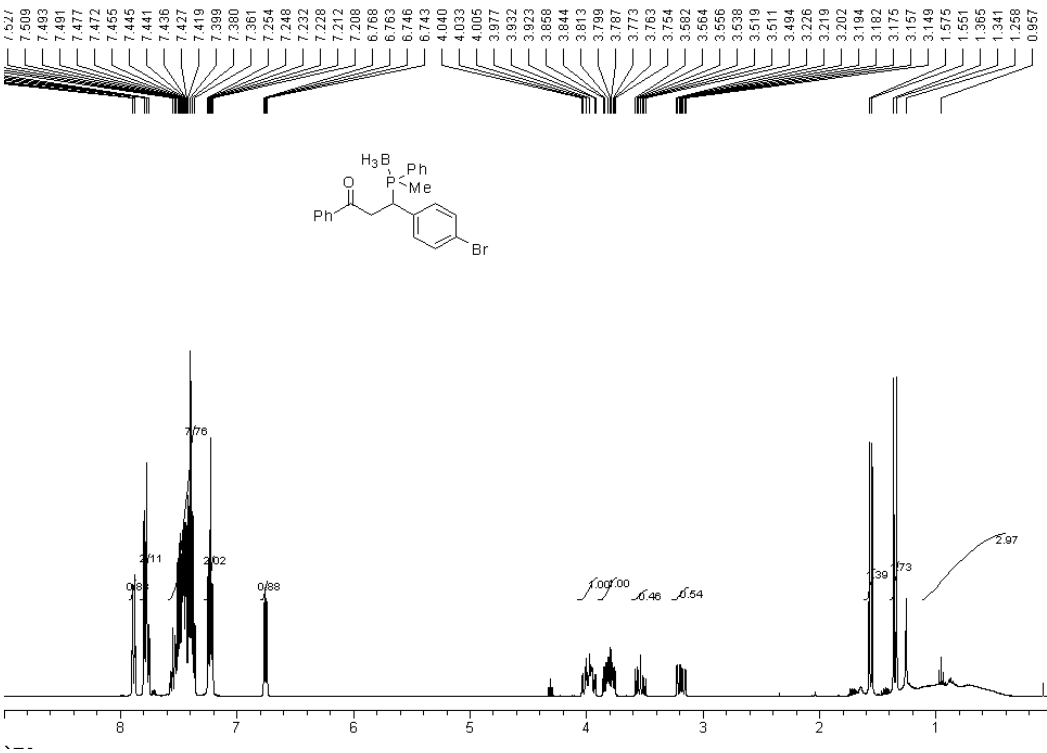
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7.232
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7.212
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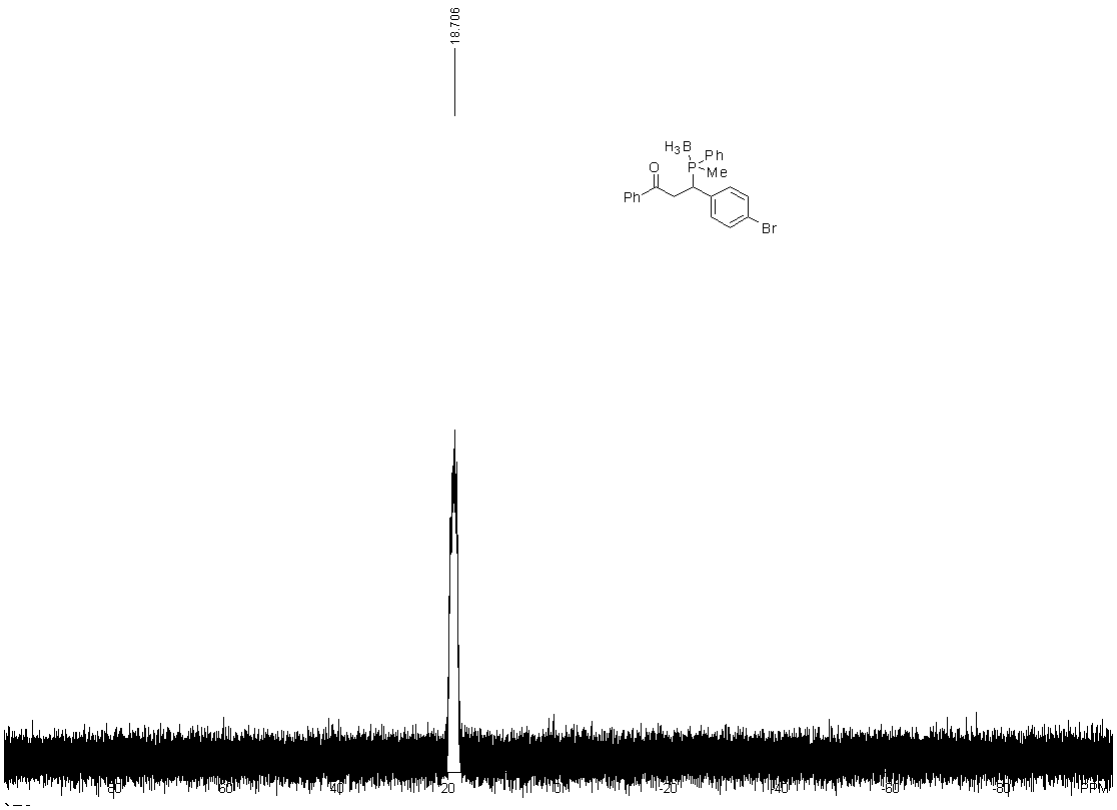
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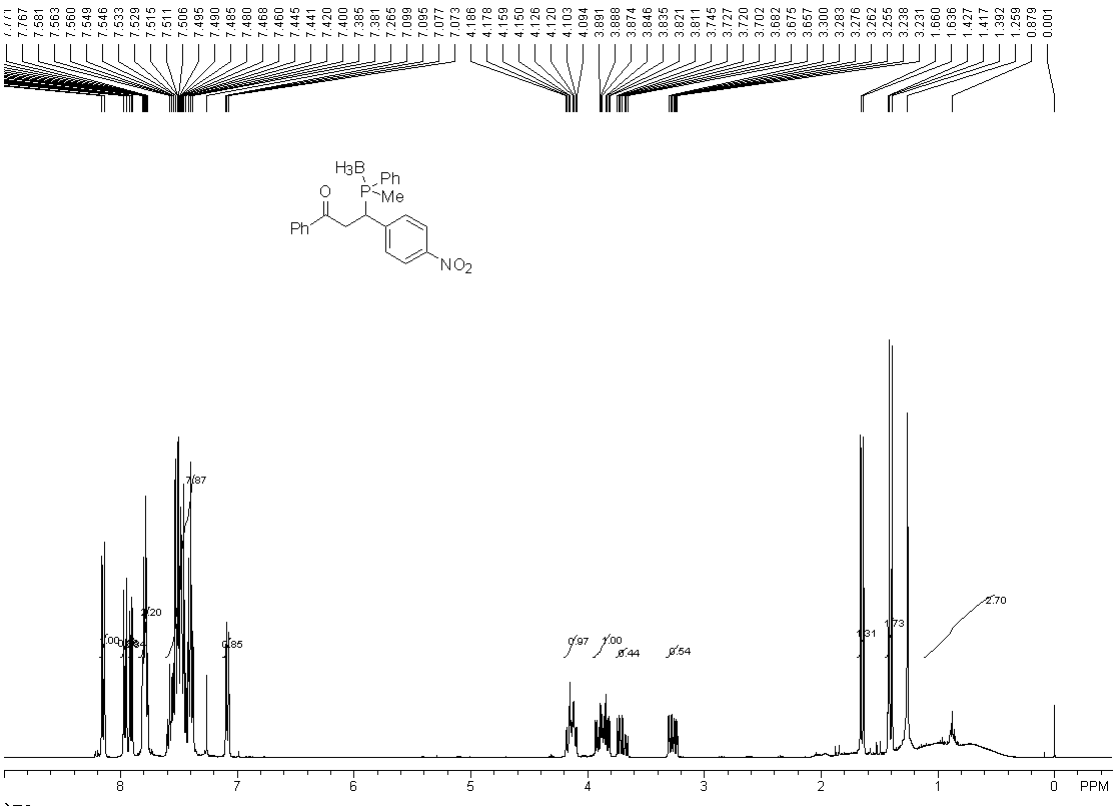
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7.441
7.420
7.400
7.385
7.381
7.265
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7.095
7.077
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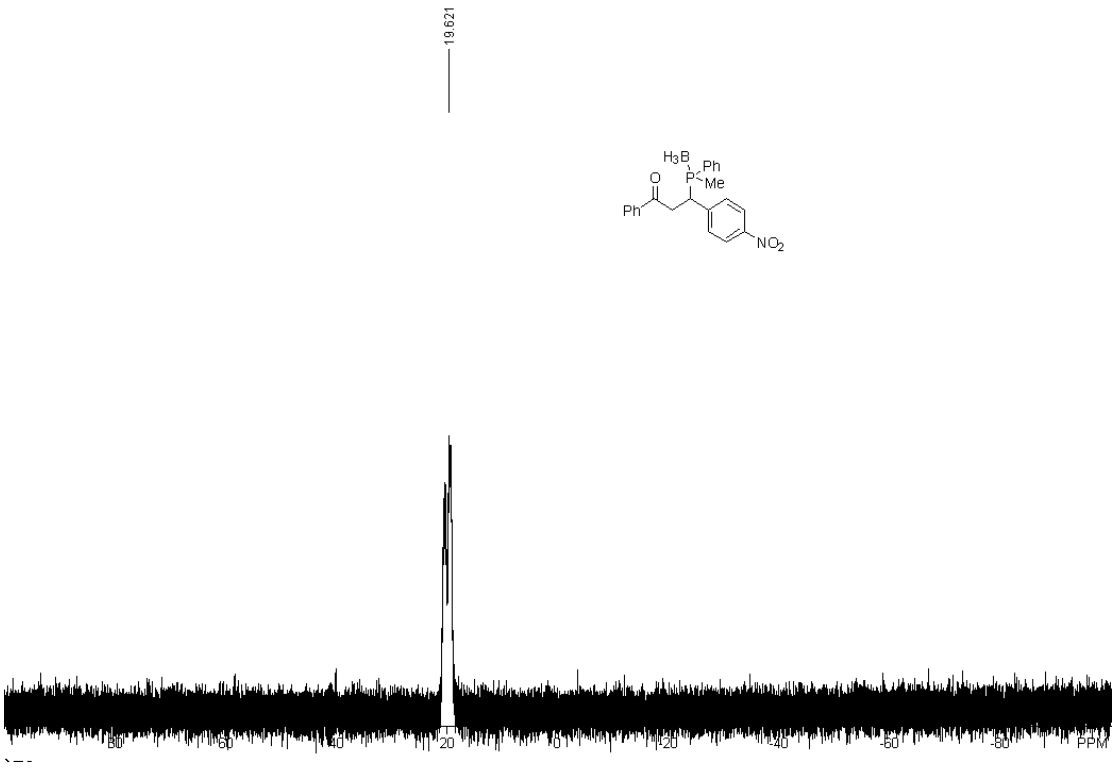
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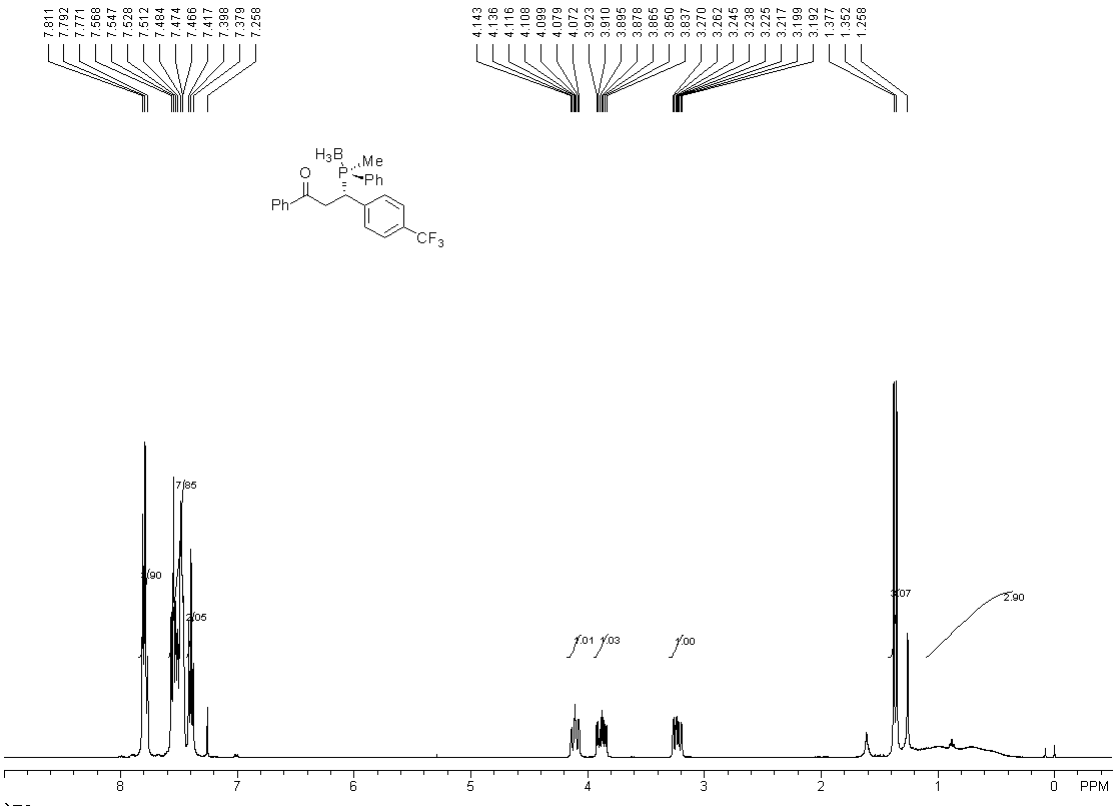
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4.108
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4.072
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3.238
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3.217
3.199
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1.377
1.362
1.258
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O
Ph
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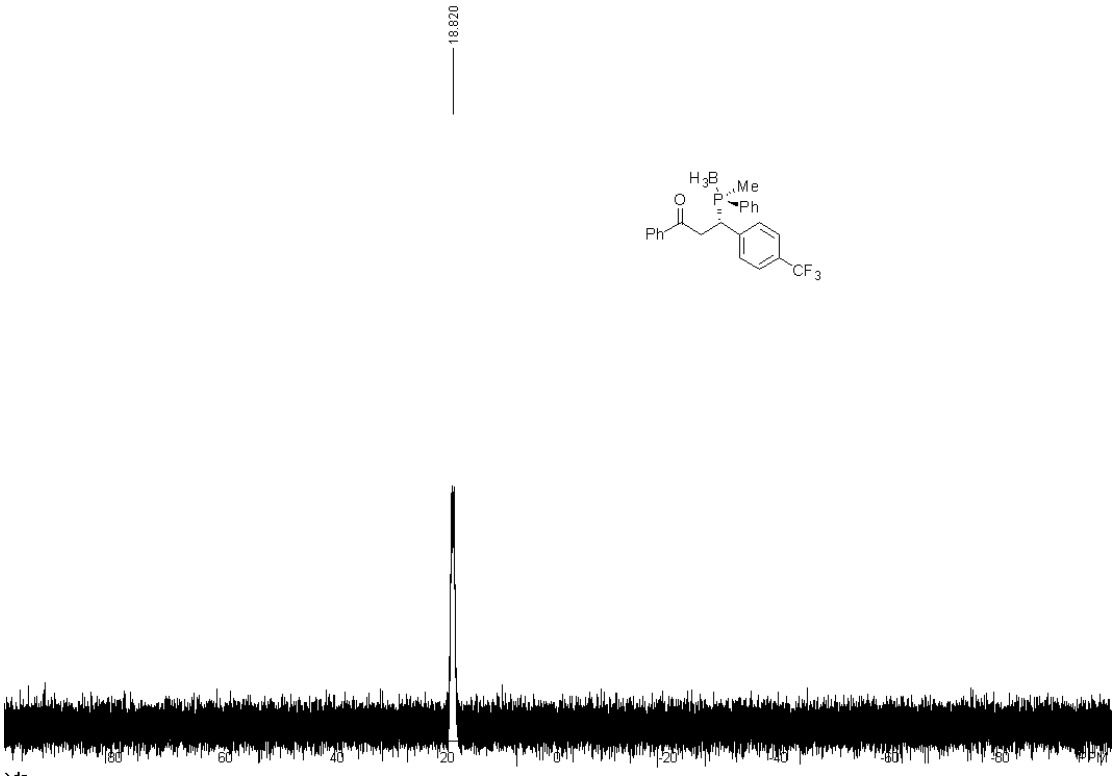
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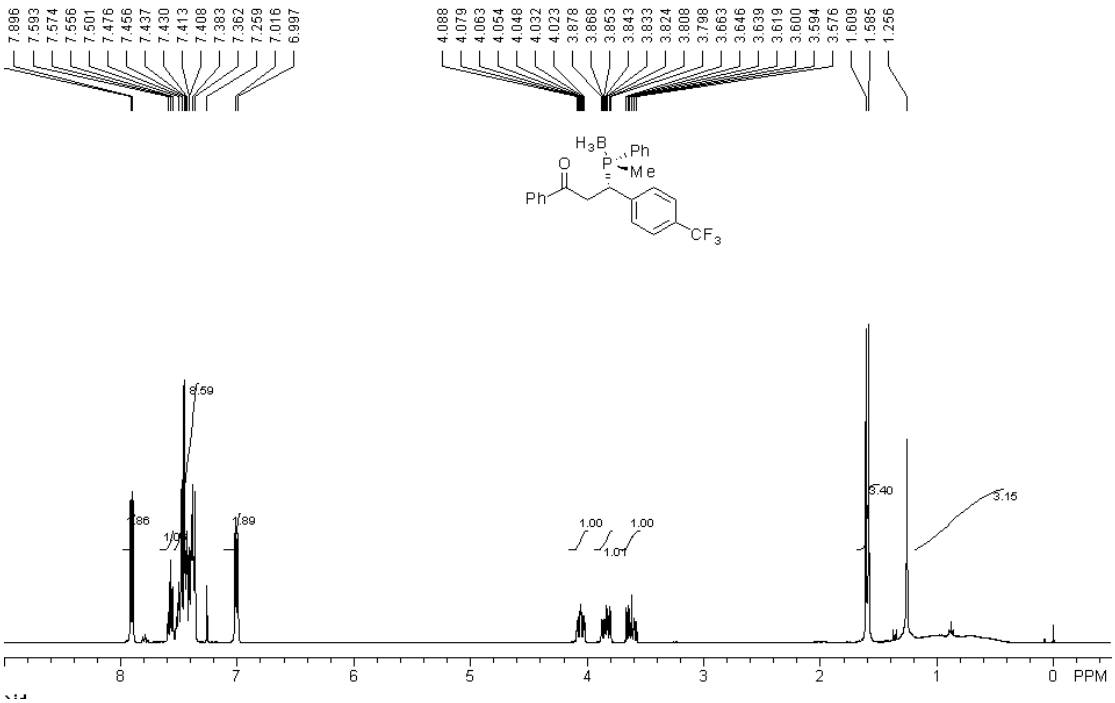
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4.063
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4.048
4.032
4.023
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3.843
3.833
3.824
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3.798
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3.646
3.639
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1.595
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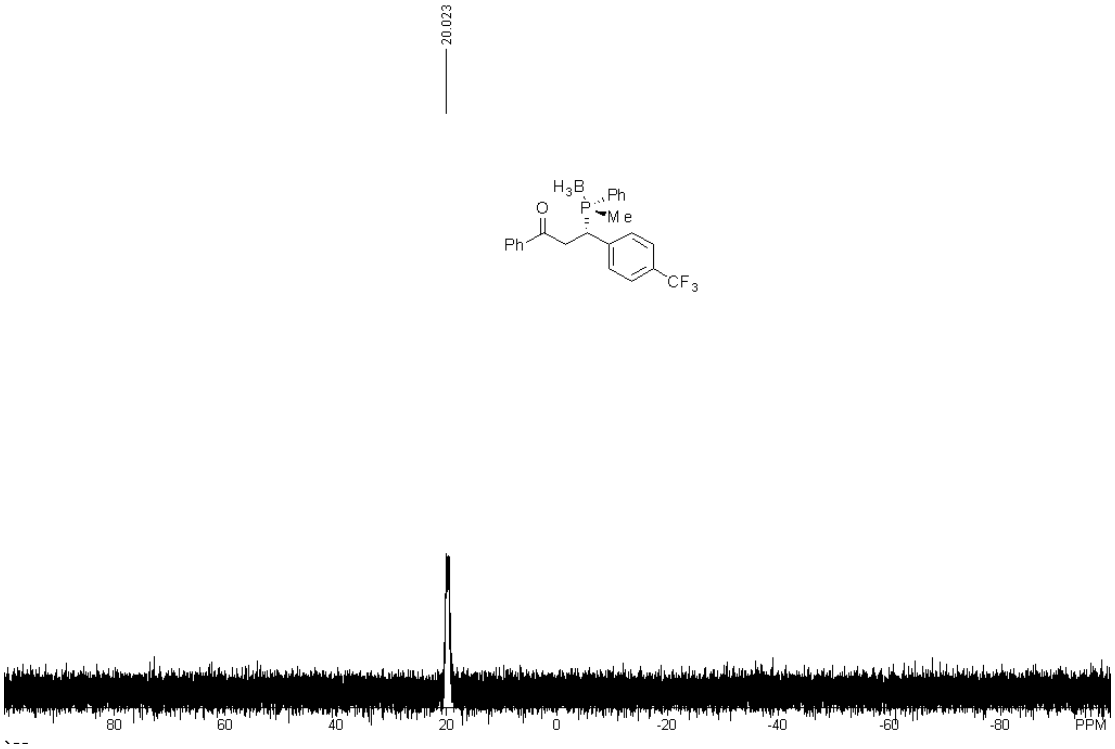
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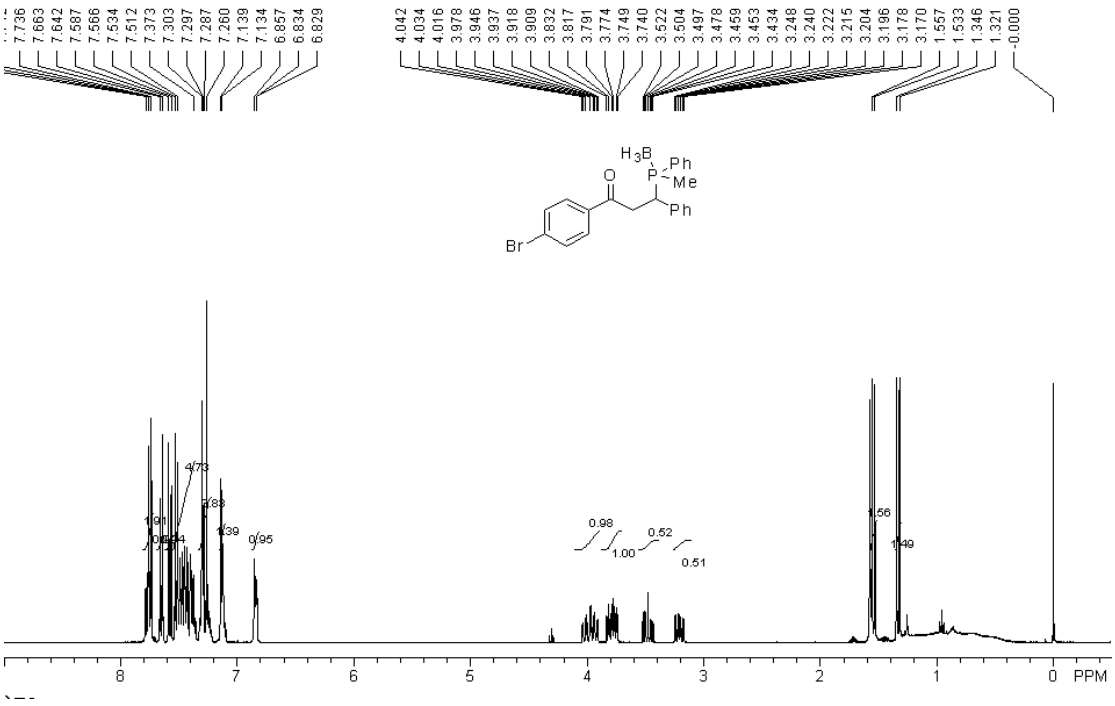
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Me
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Ph
Br
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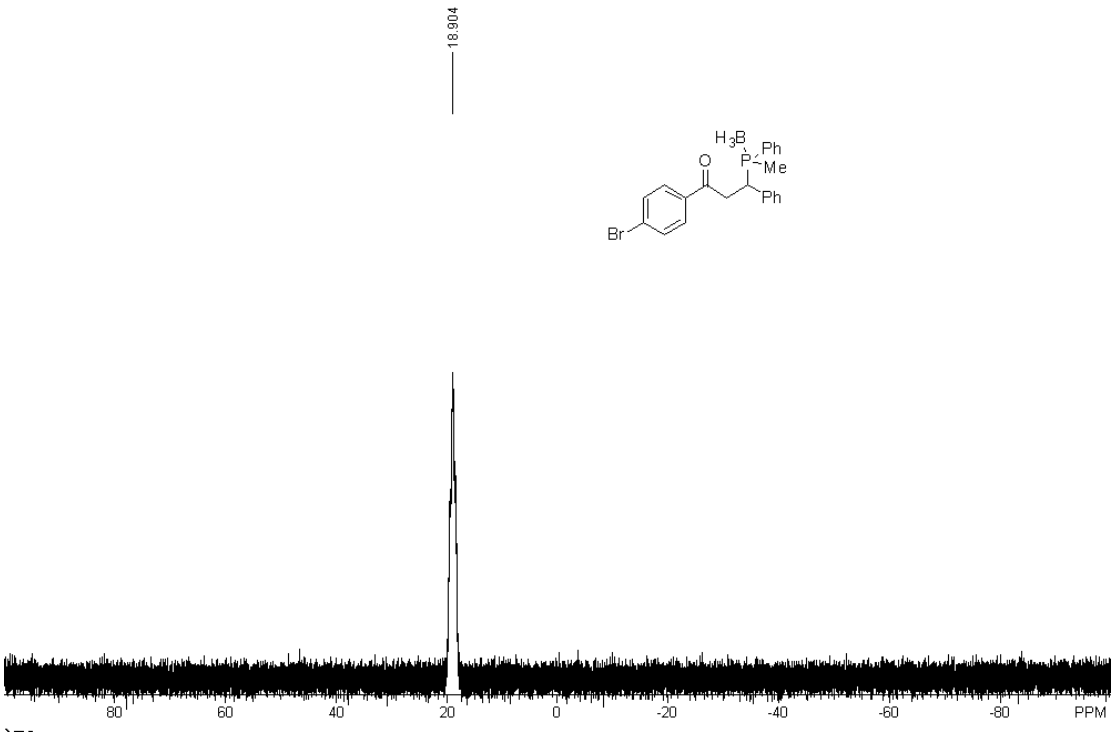
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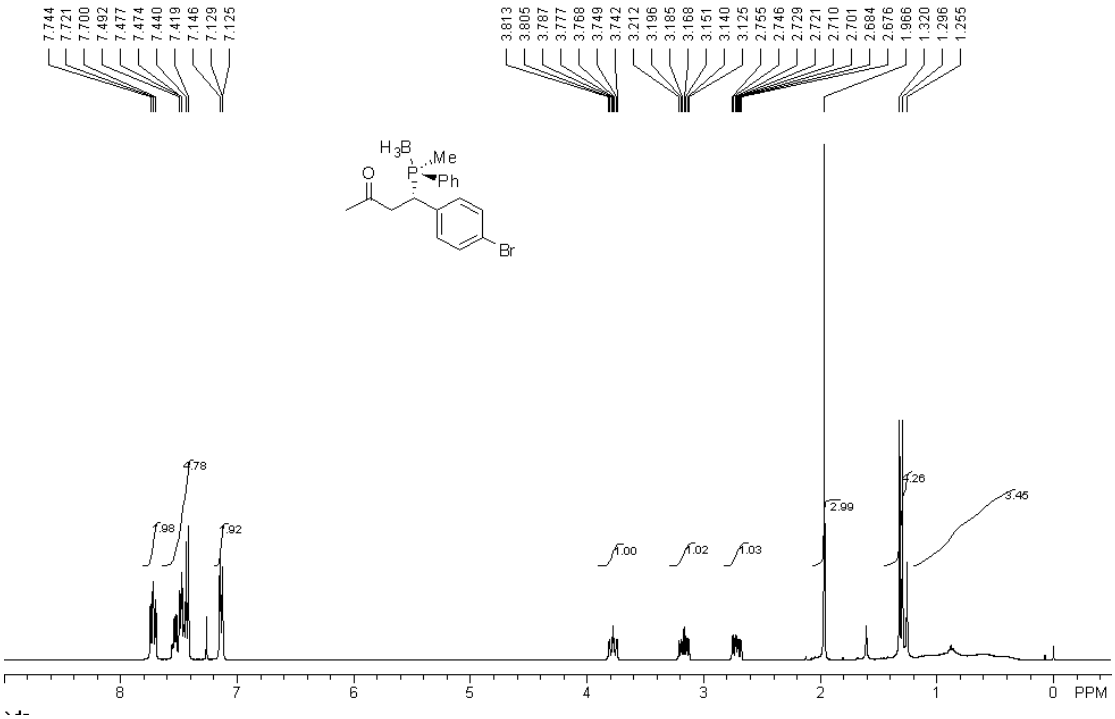
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3.185
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3.125
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Br
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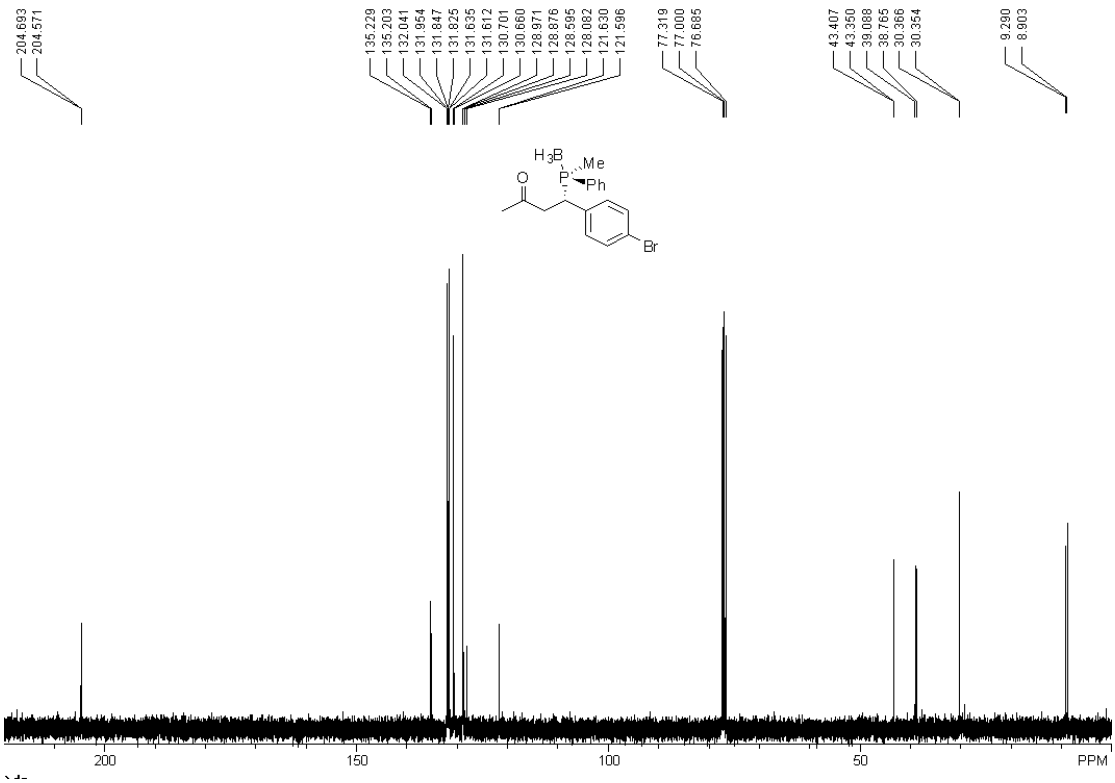
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77.000
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43.407
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O
Br
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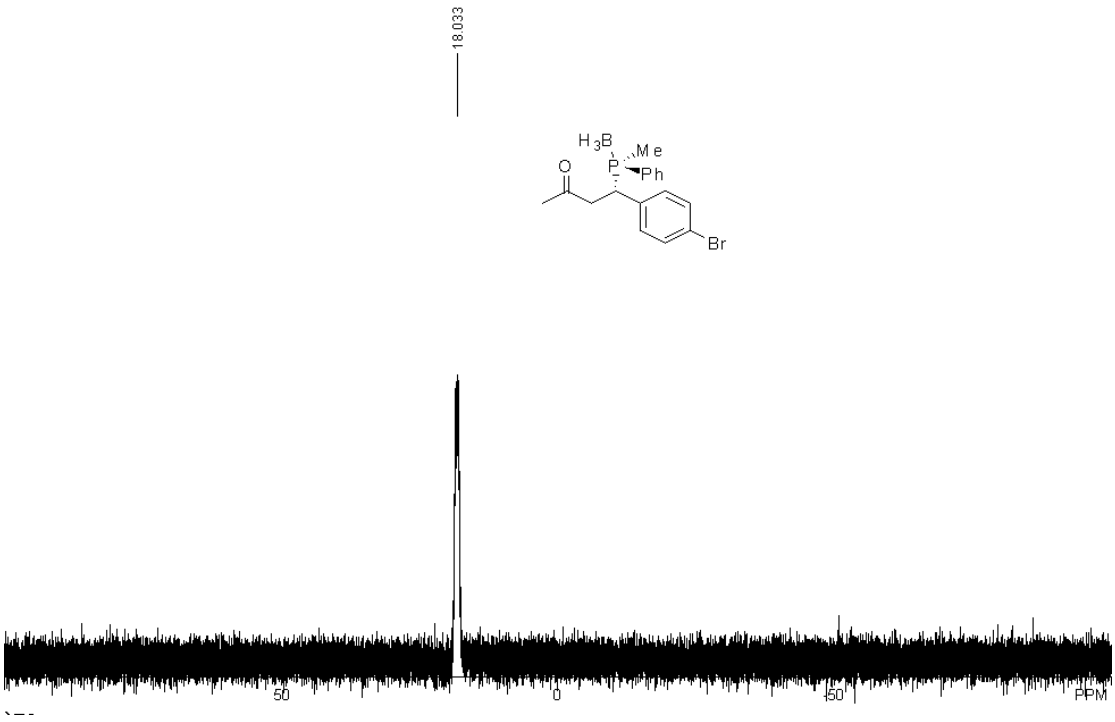
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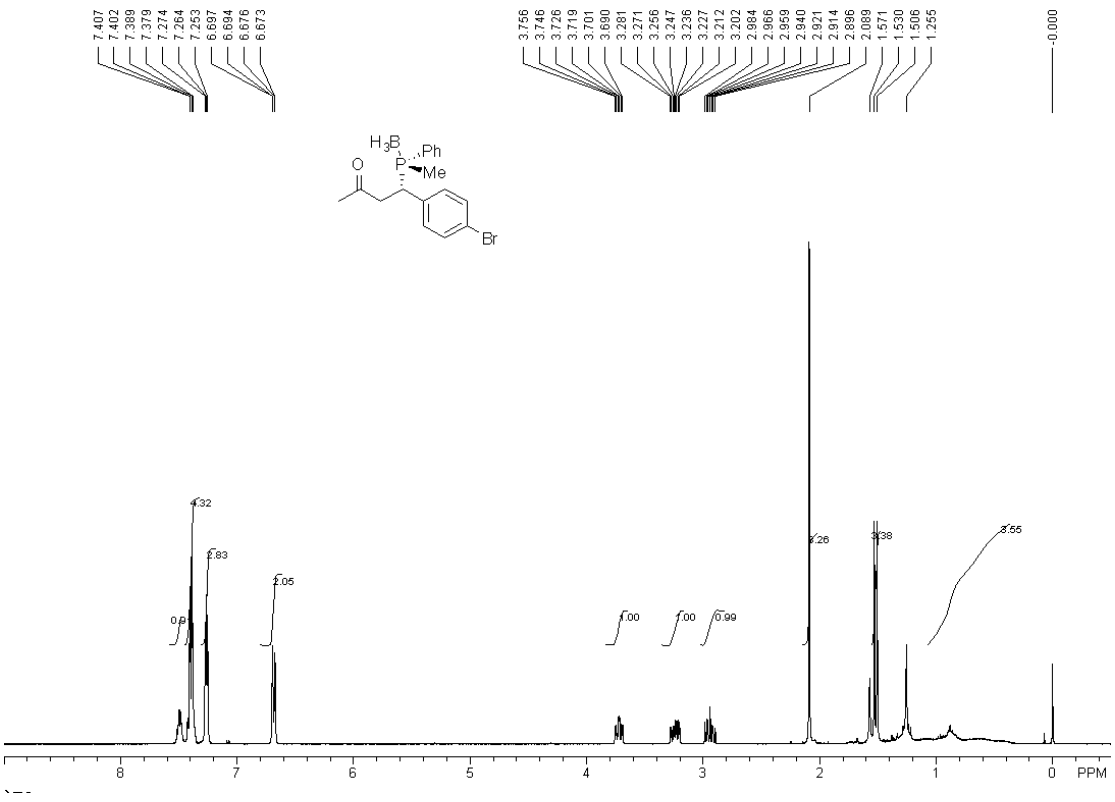
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O
Br
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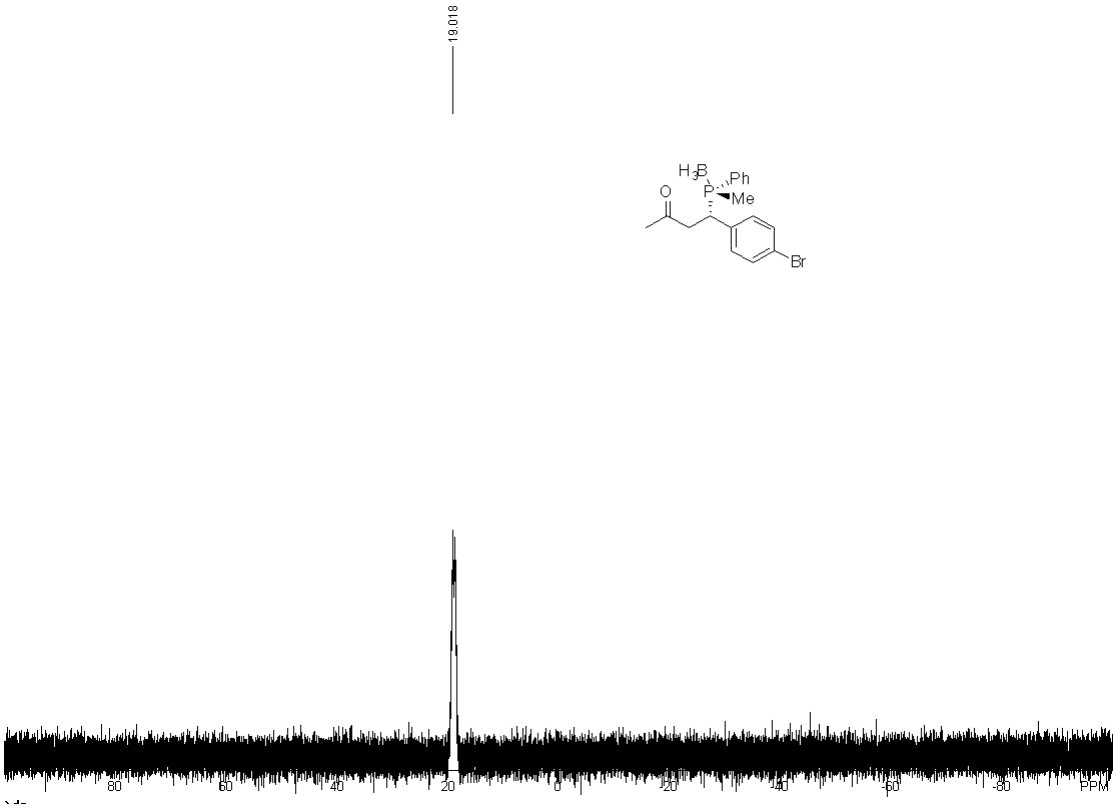
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-80
PPM


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7.497
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3.020
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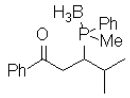
1.015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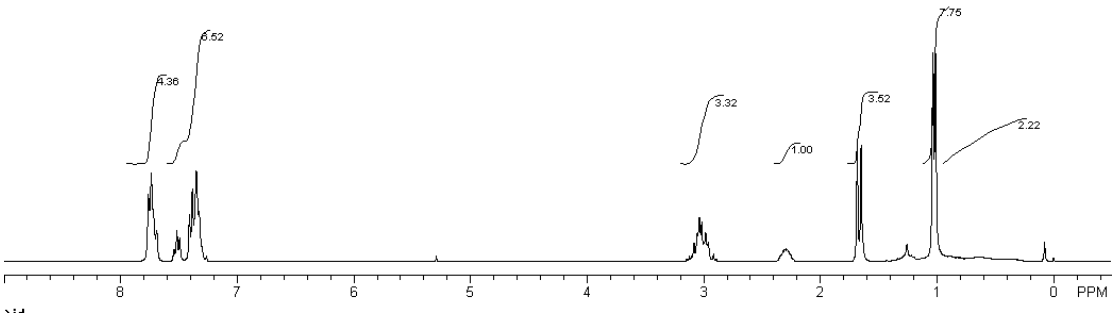
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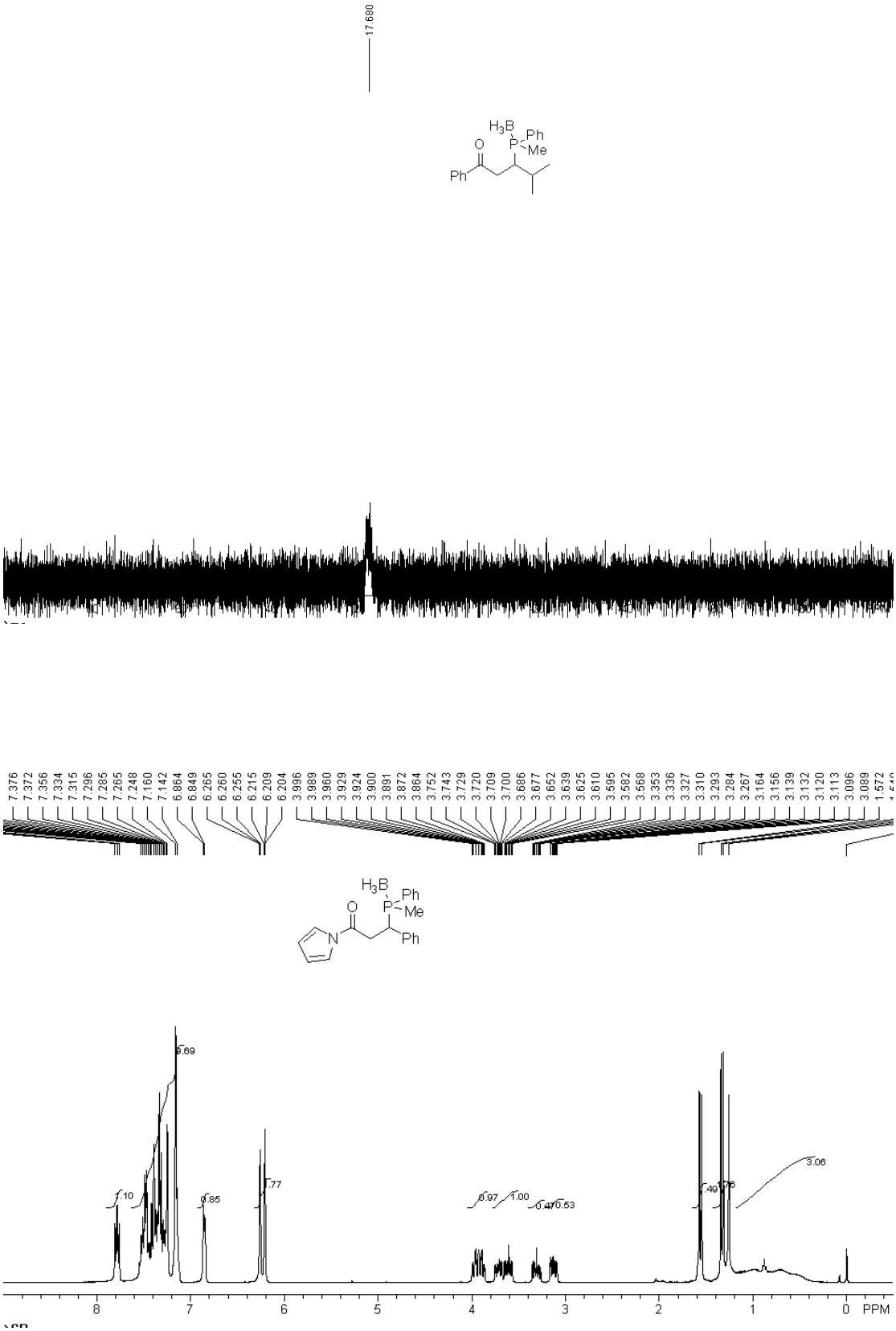
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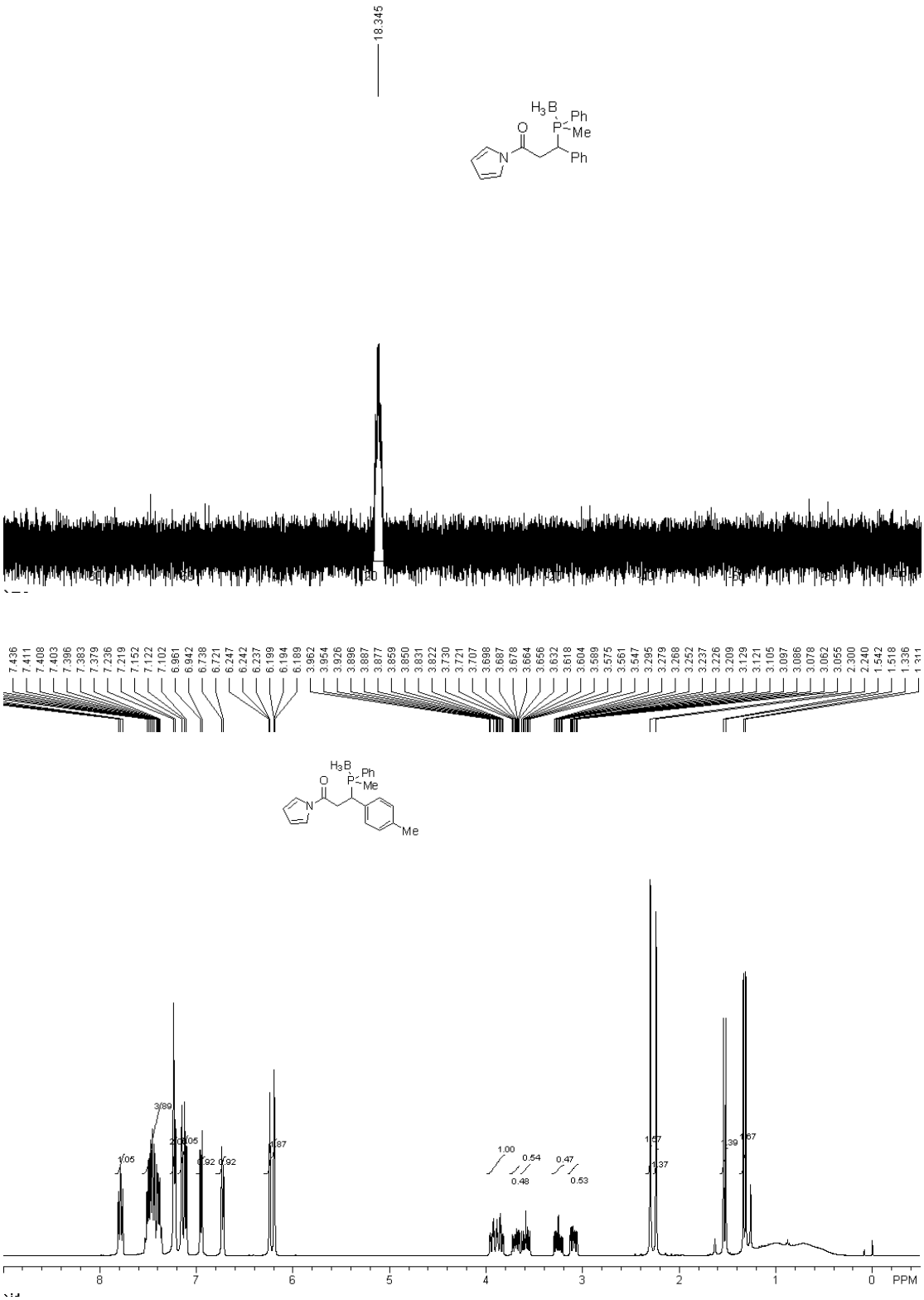
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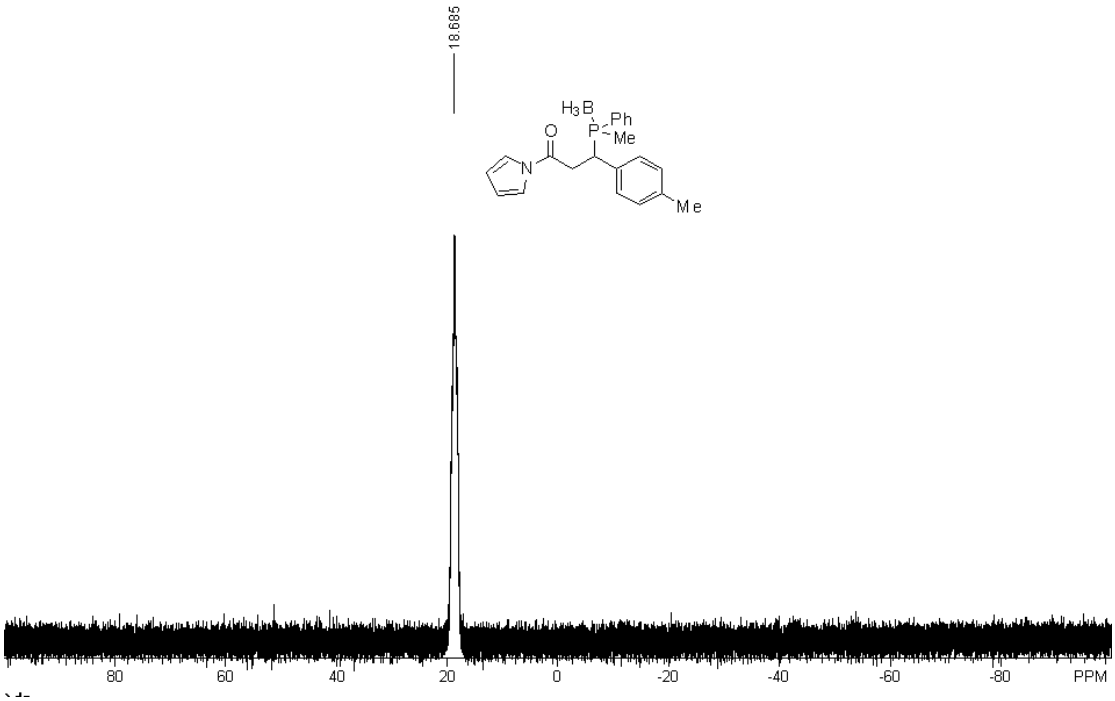
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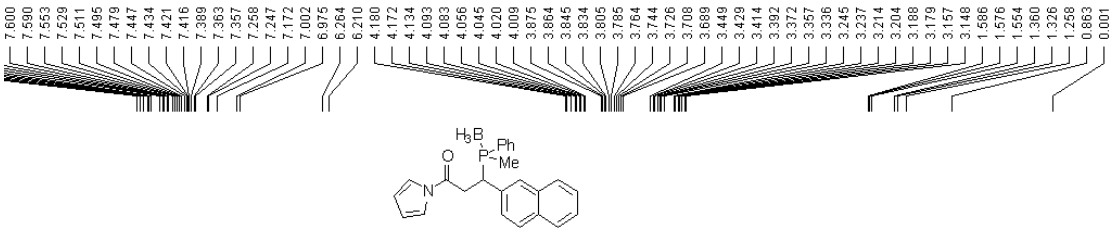
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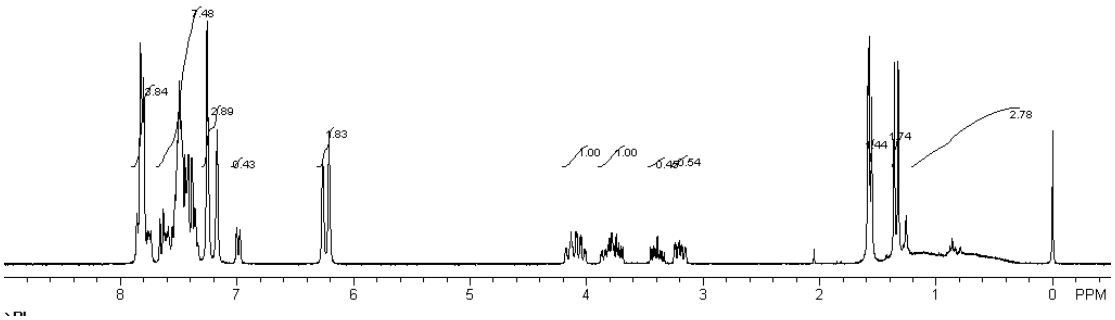
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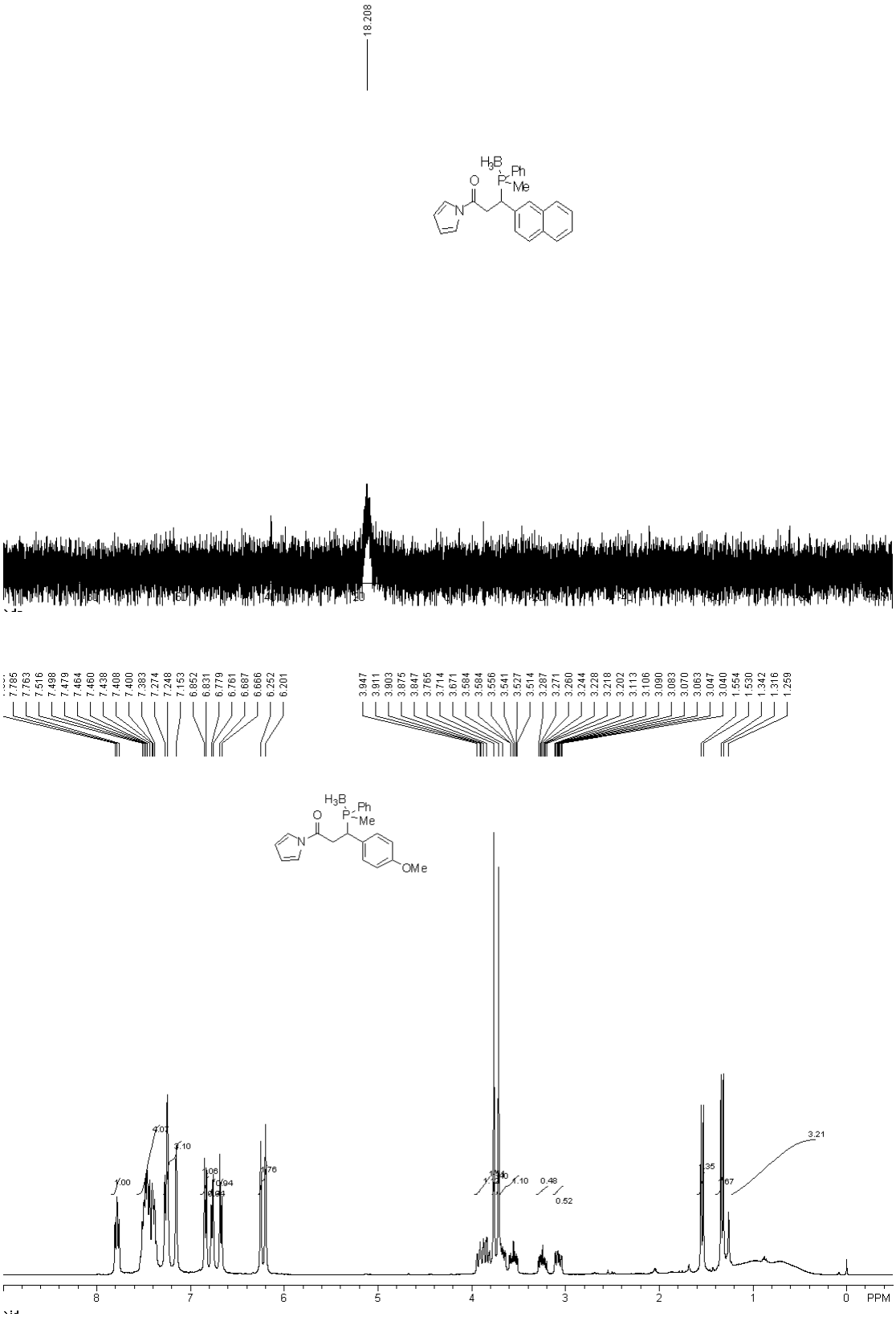
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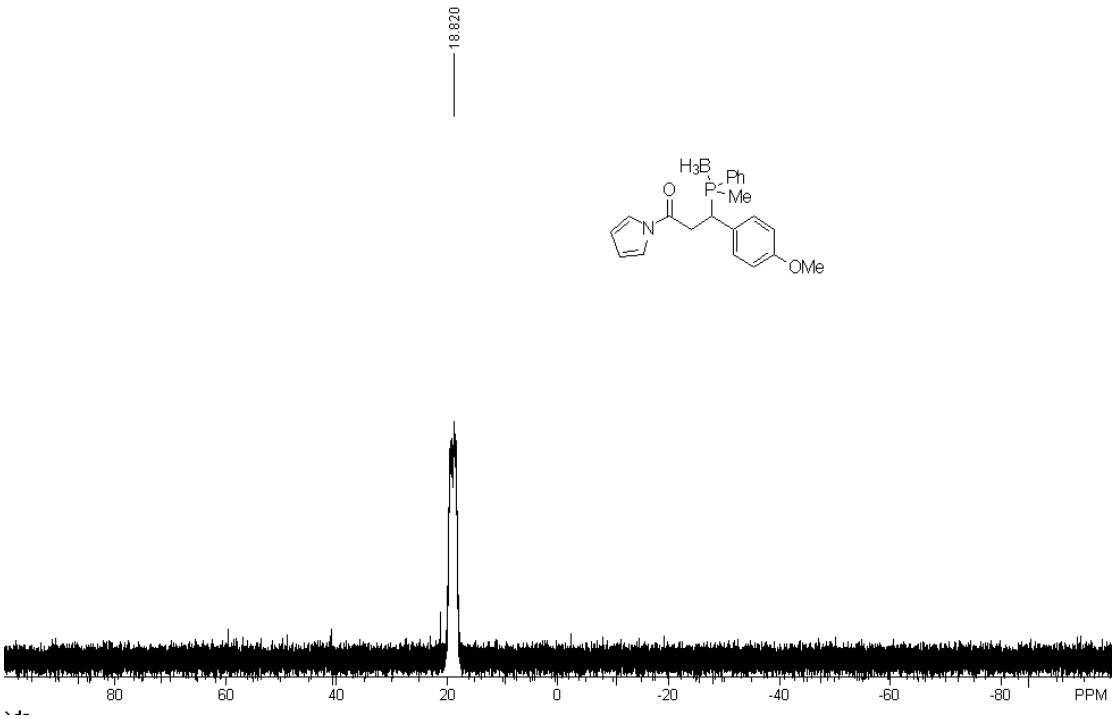
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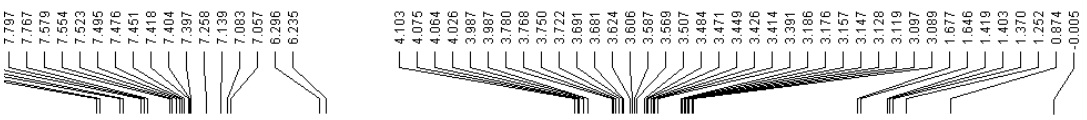
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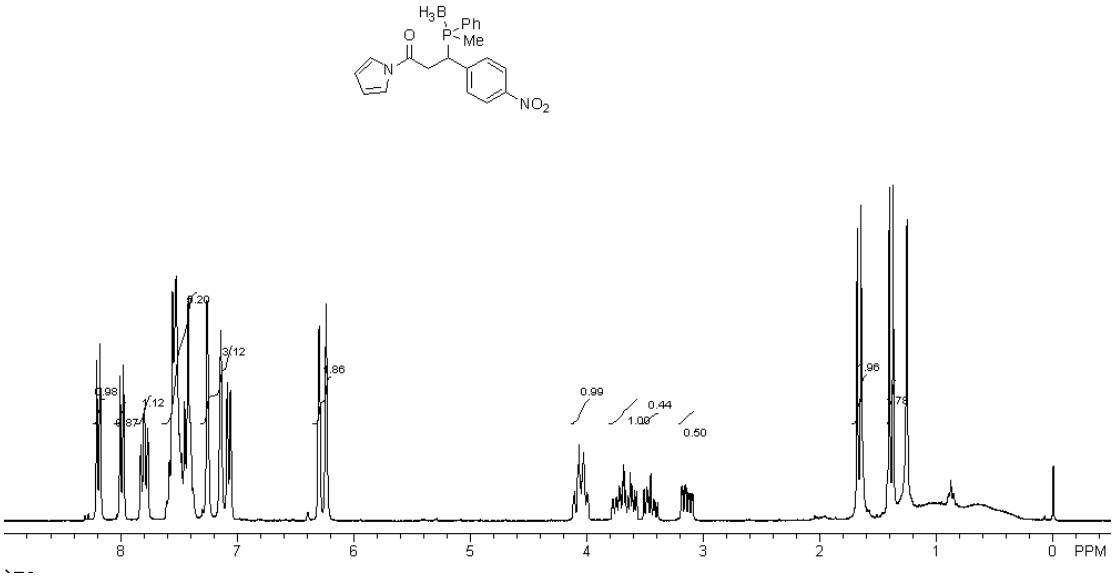
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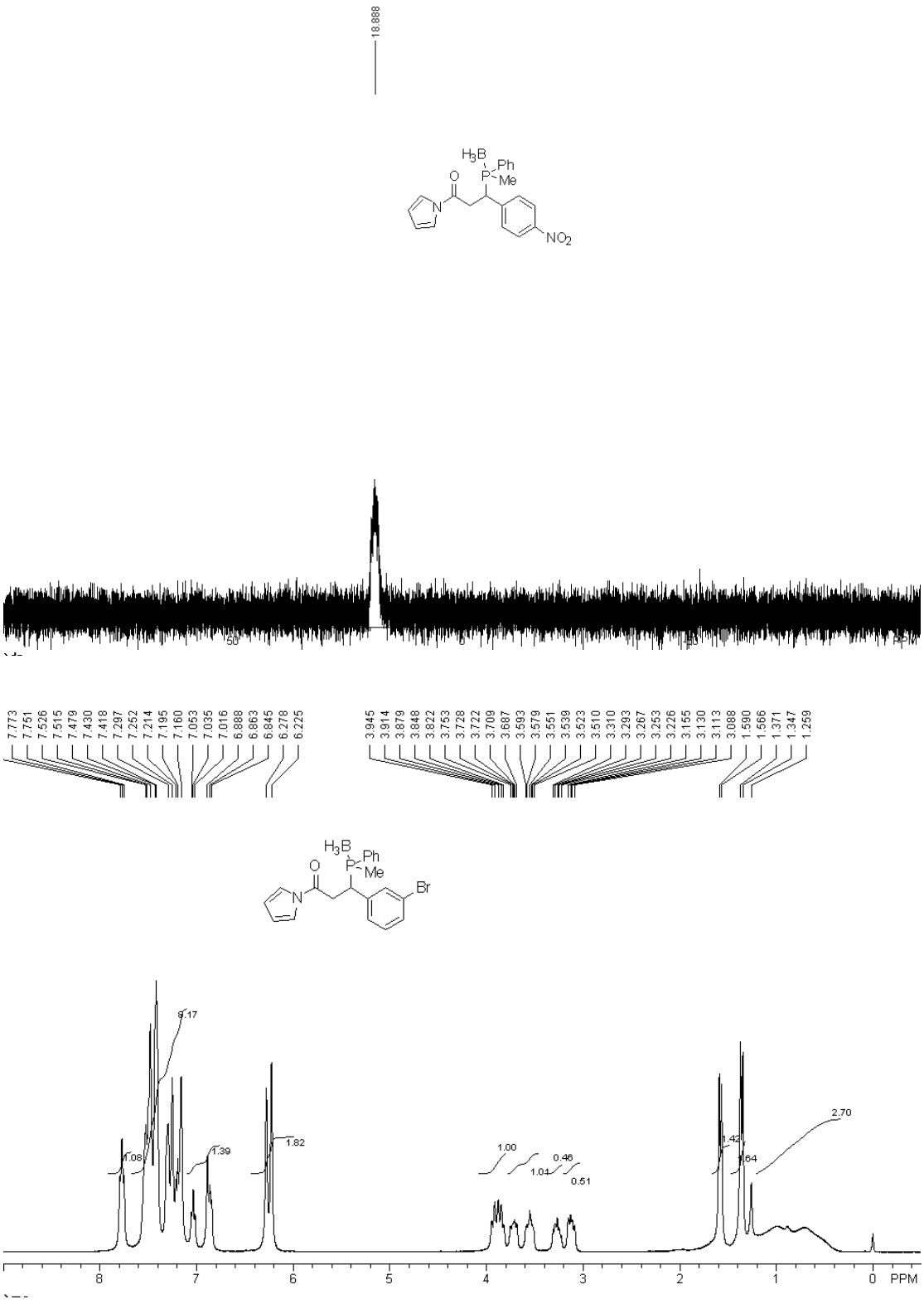
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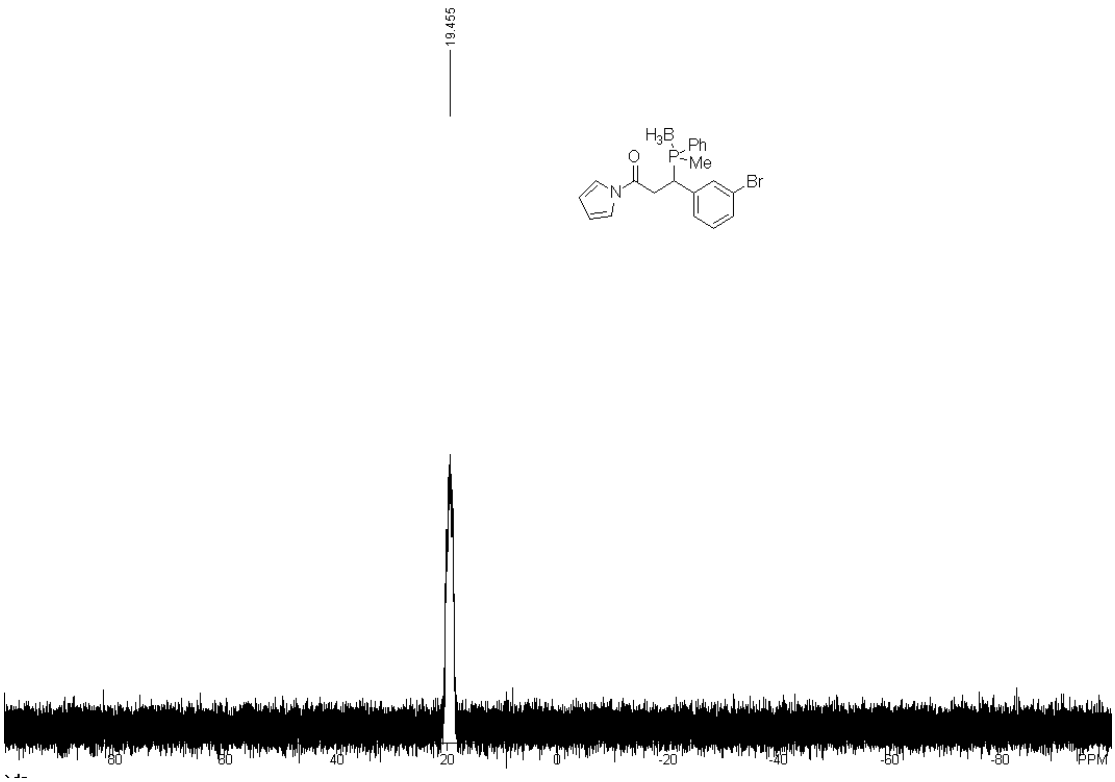
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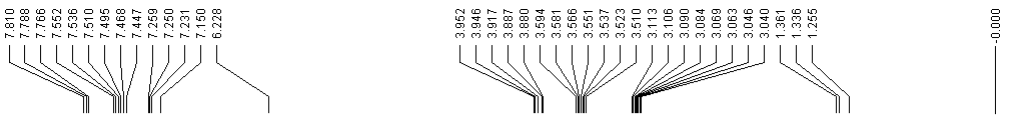
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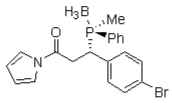
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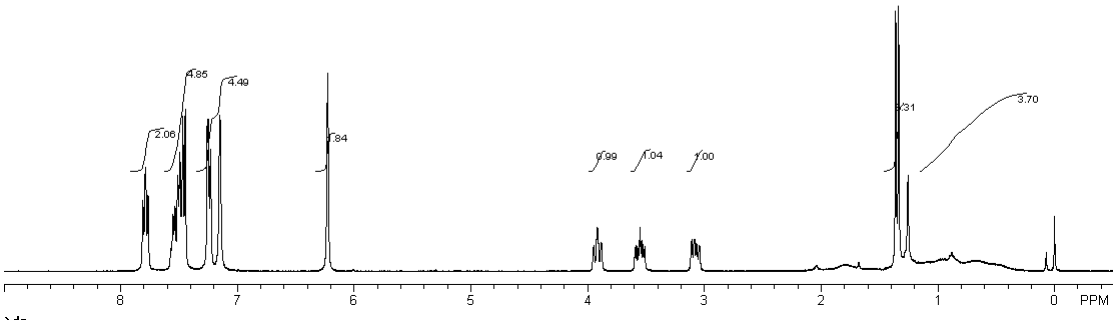
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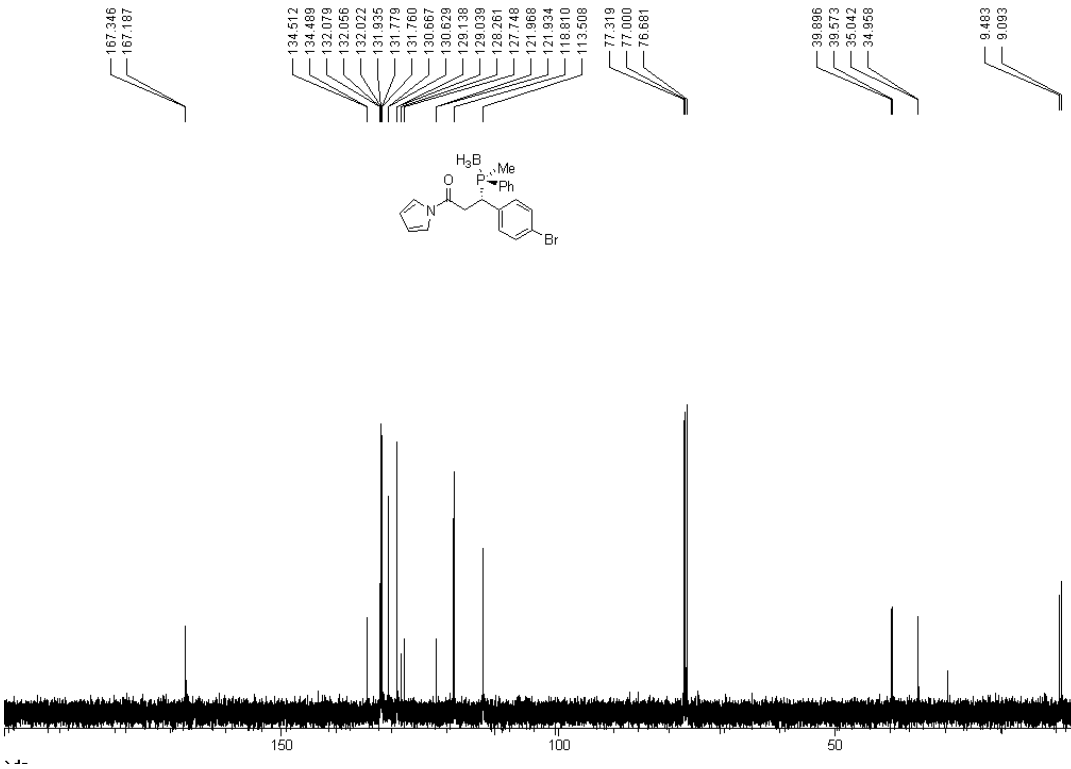
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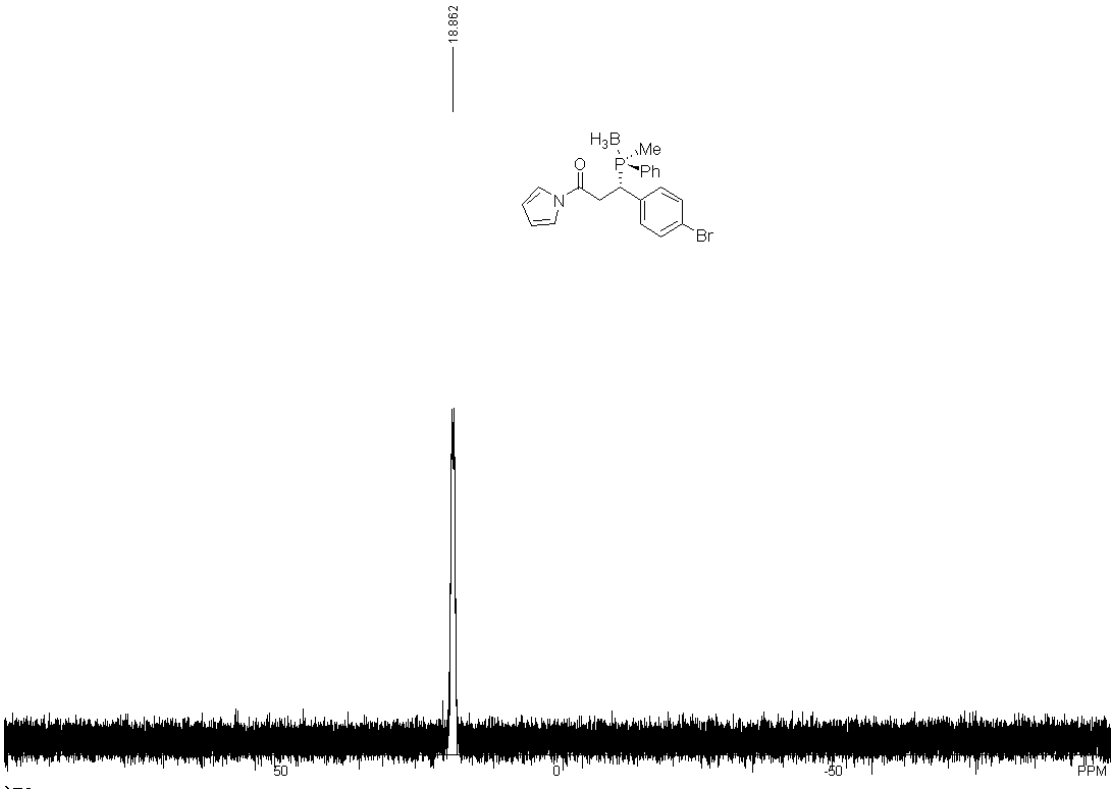
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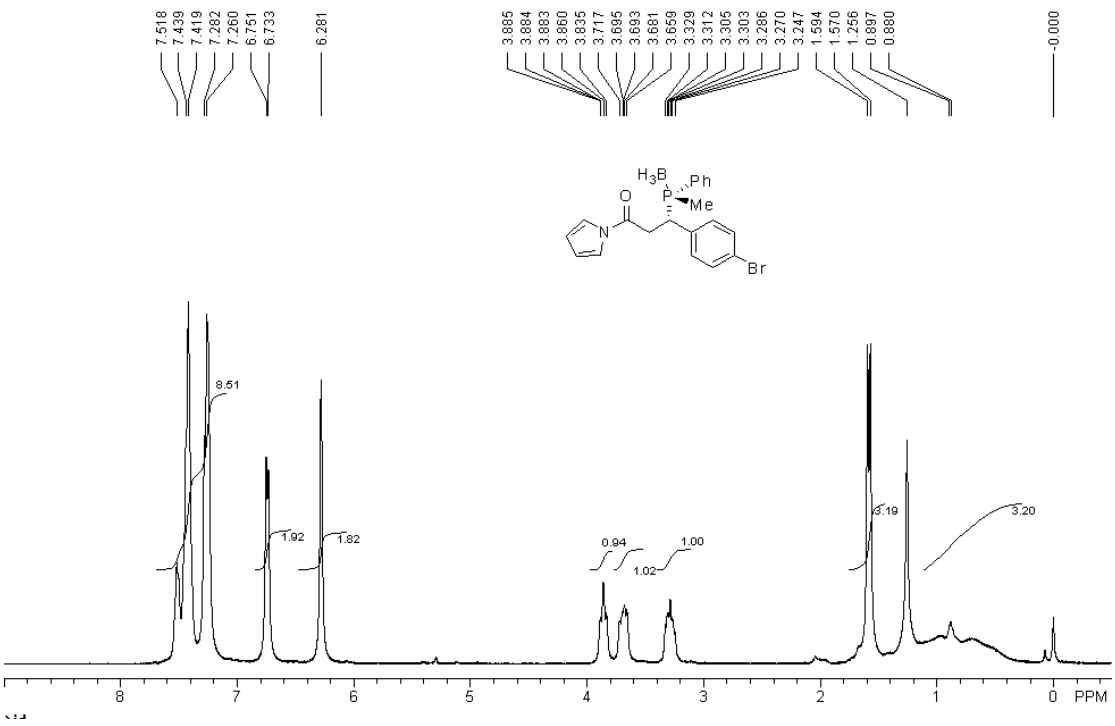
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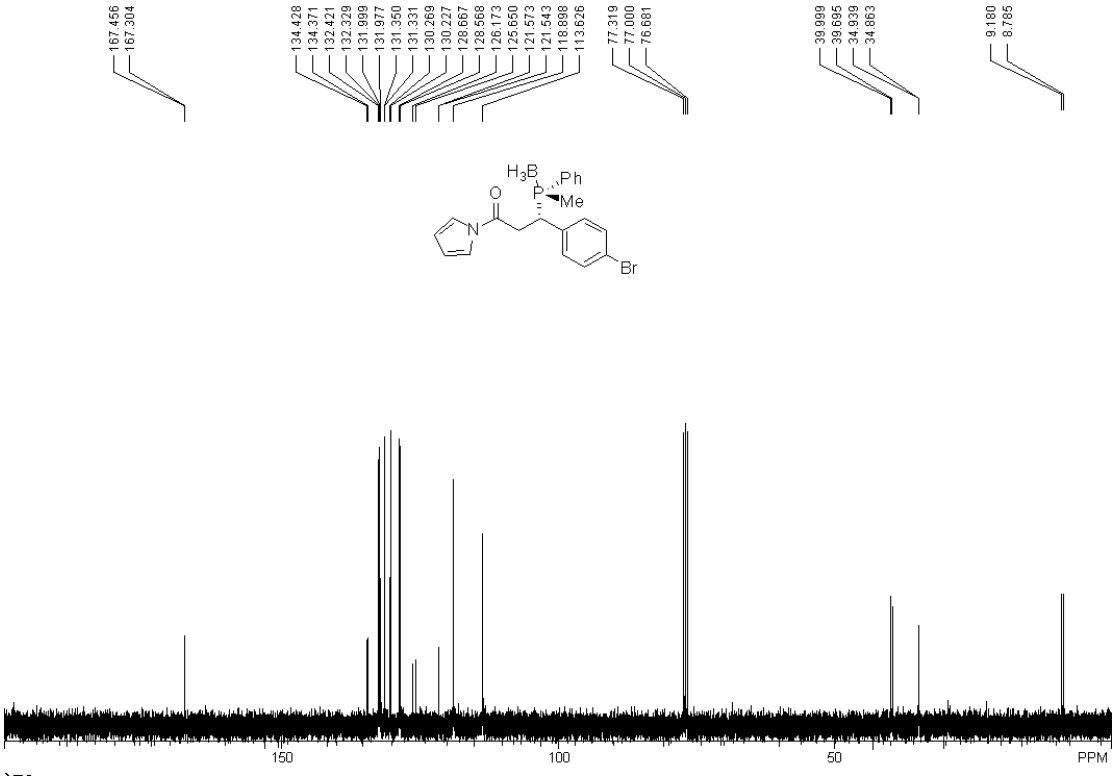
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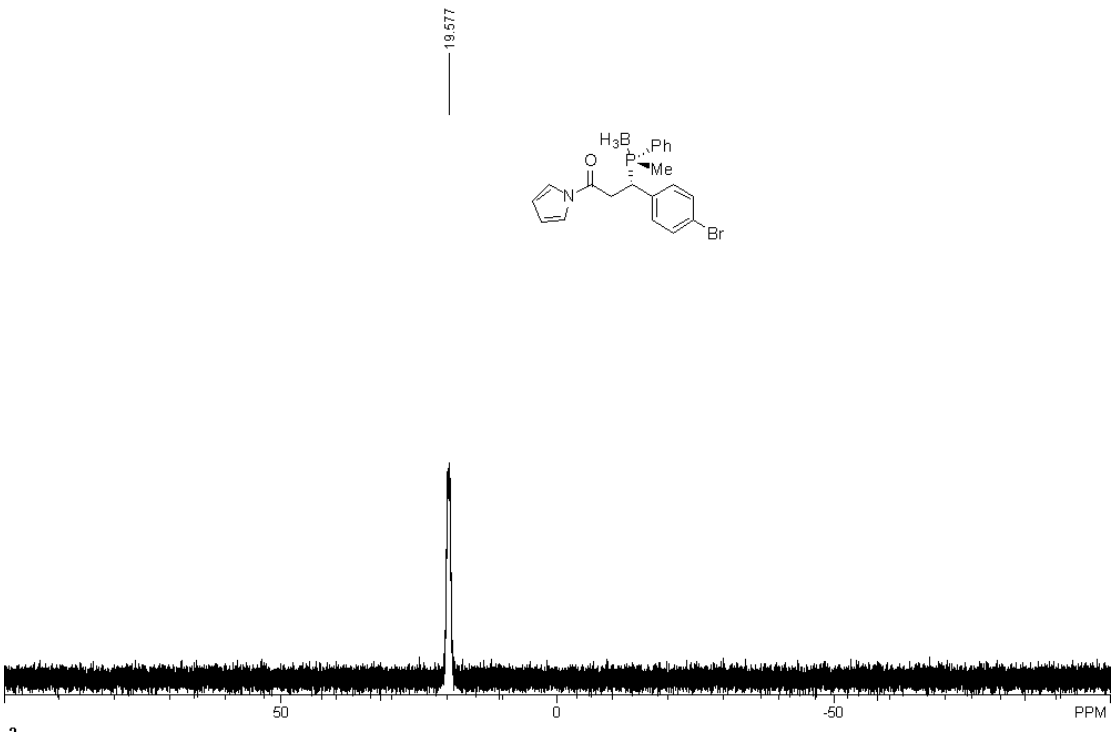
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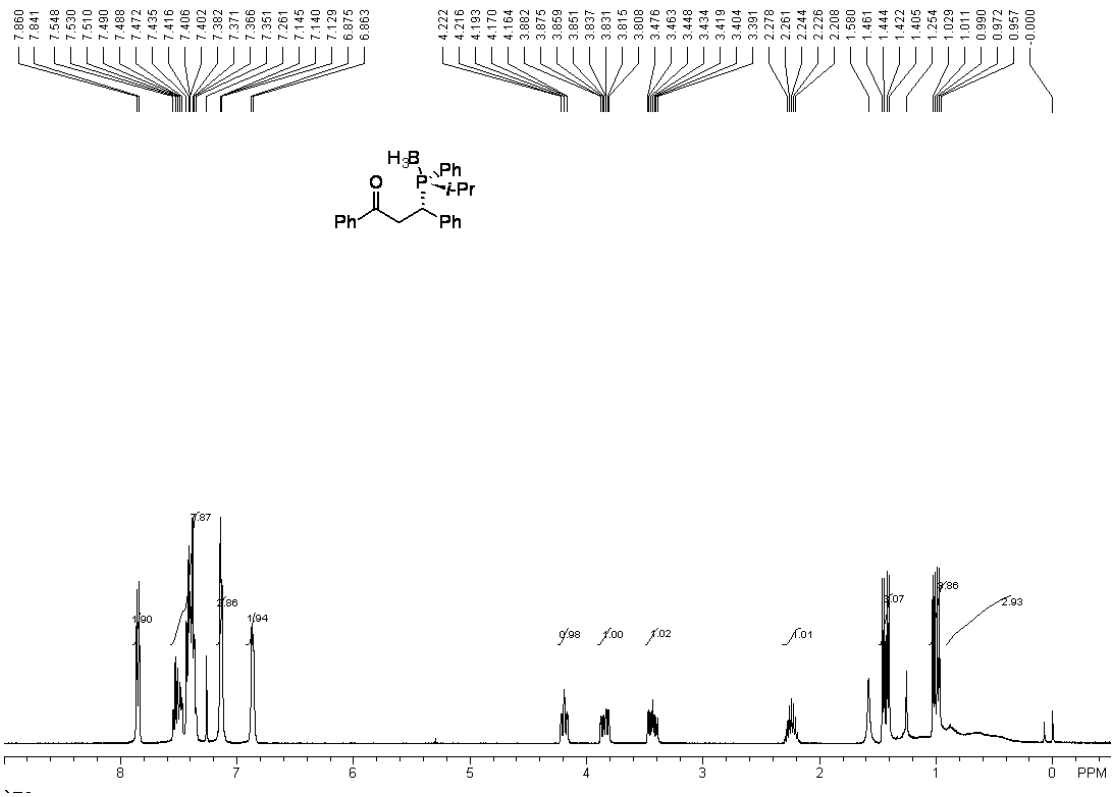
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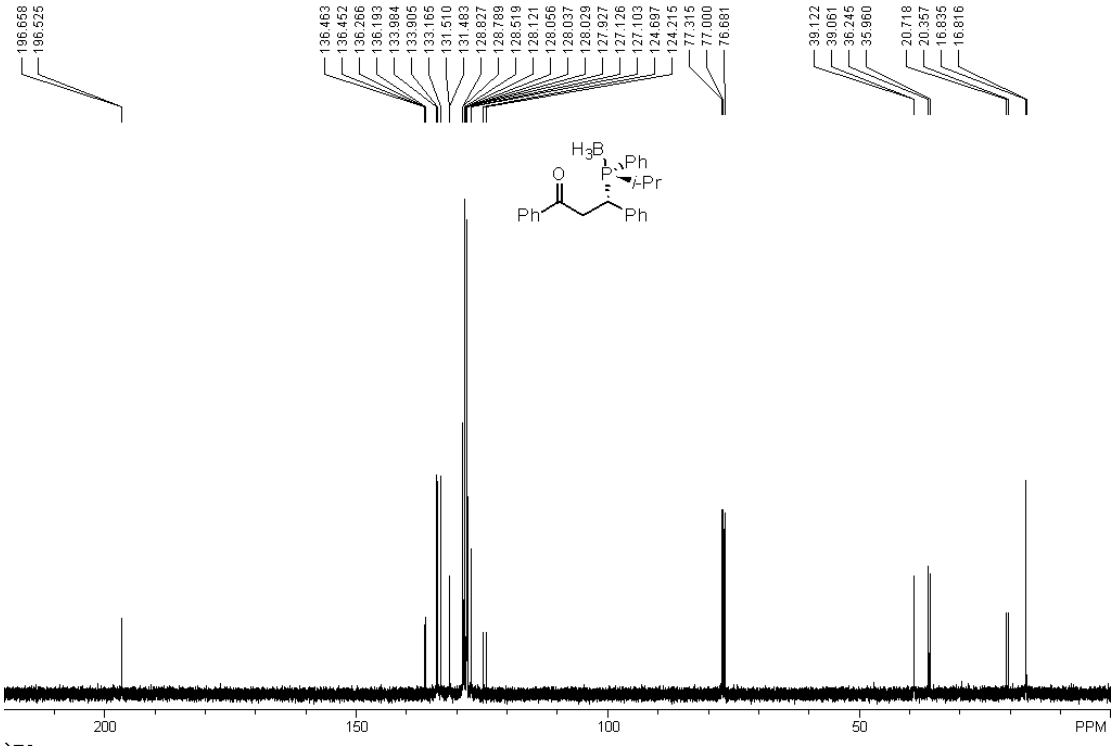
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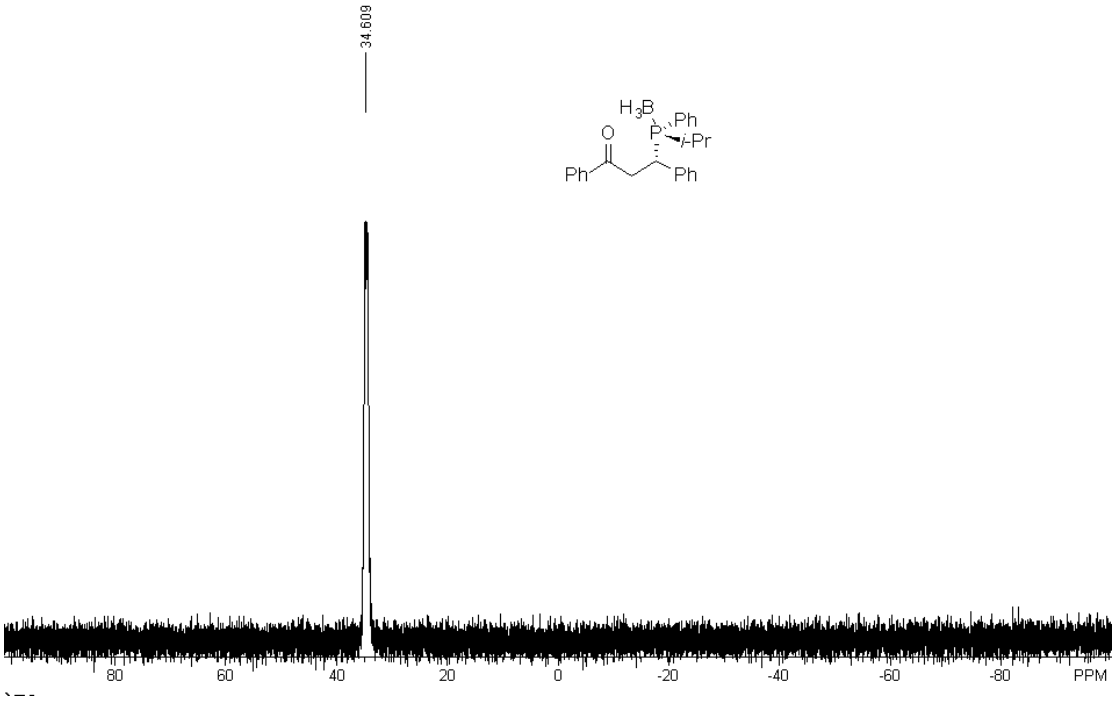
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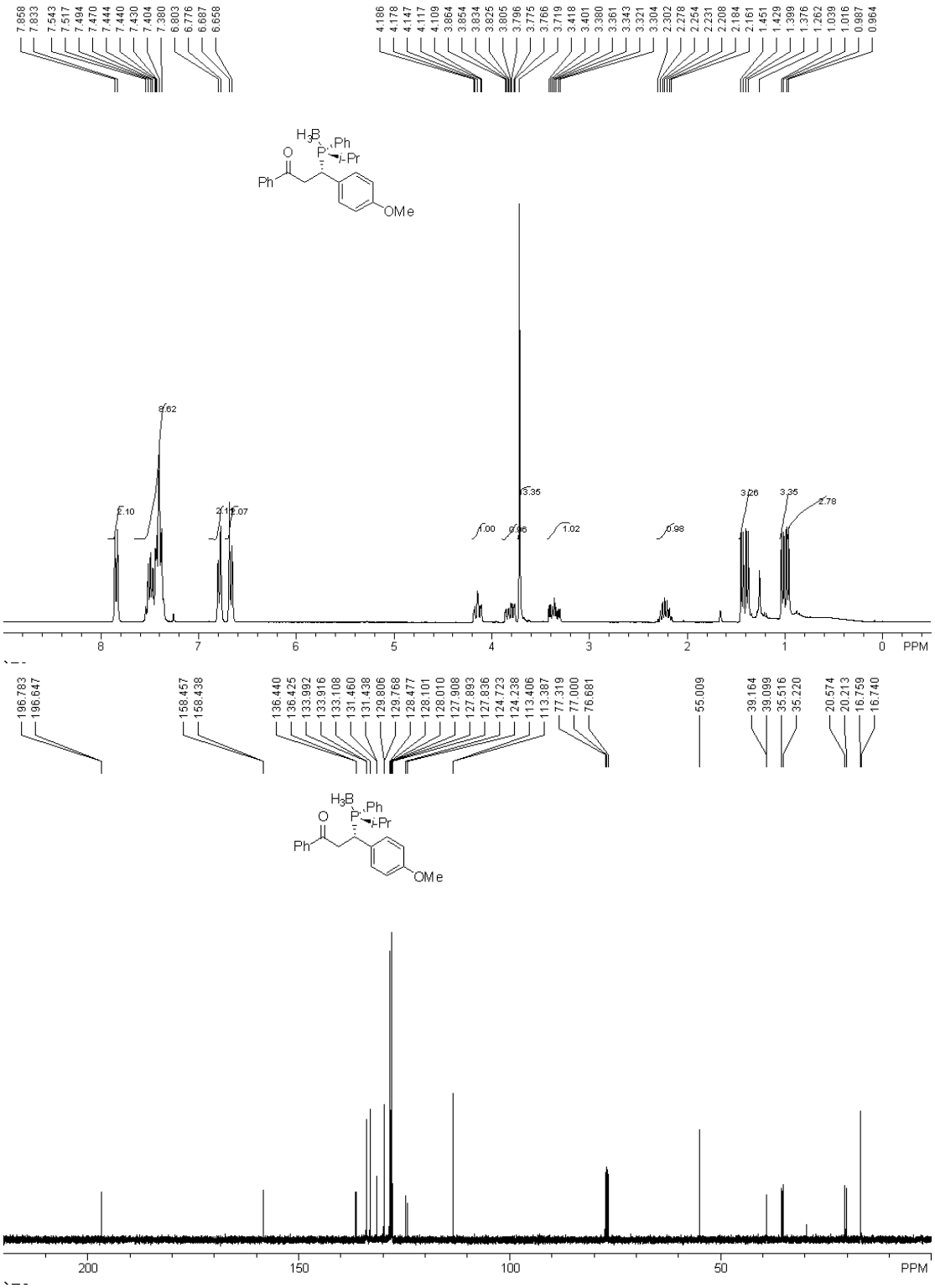
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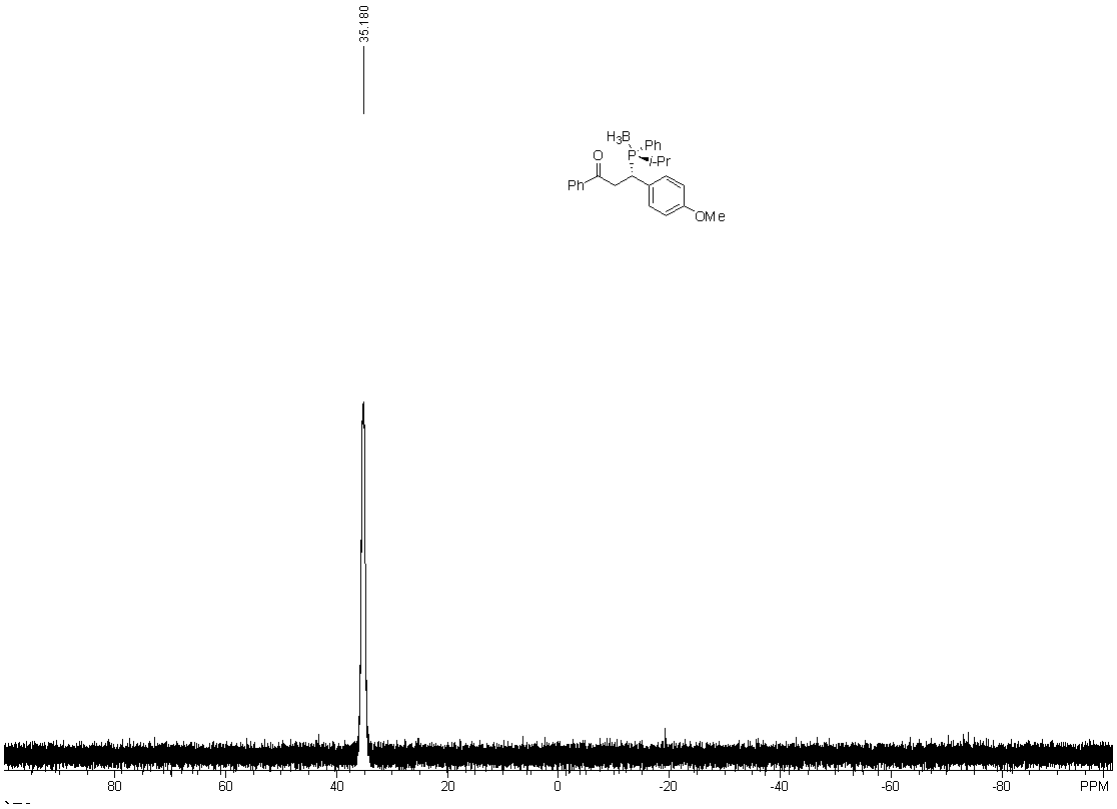
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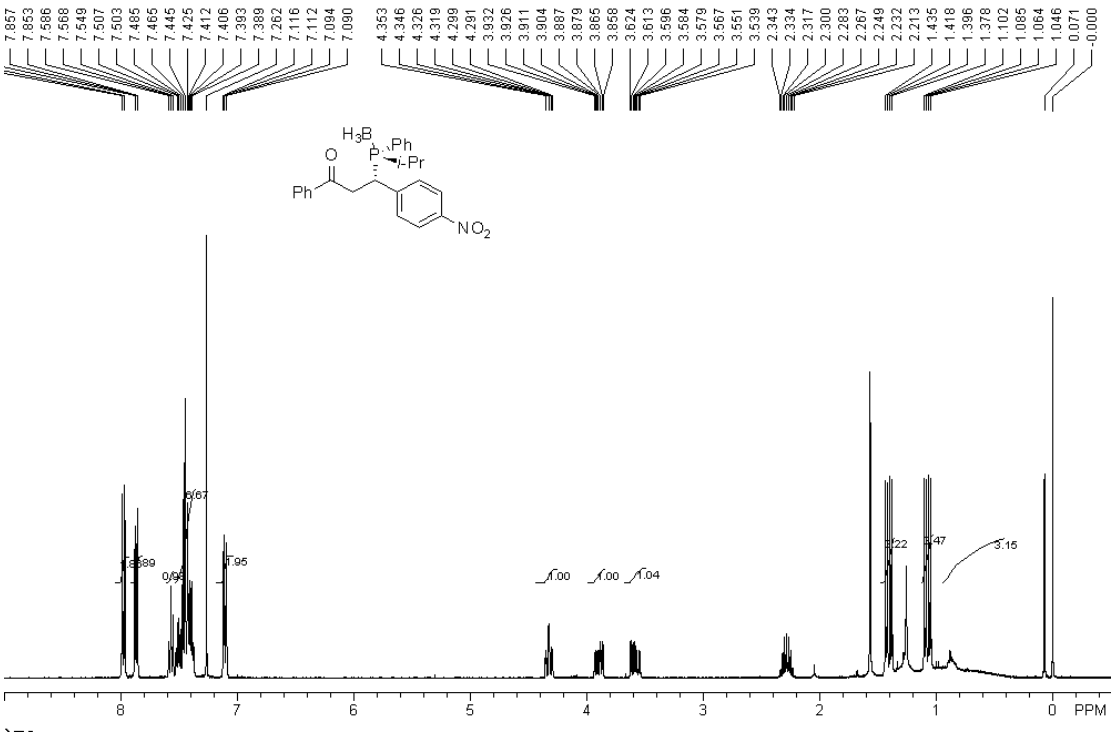
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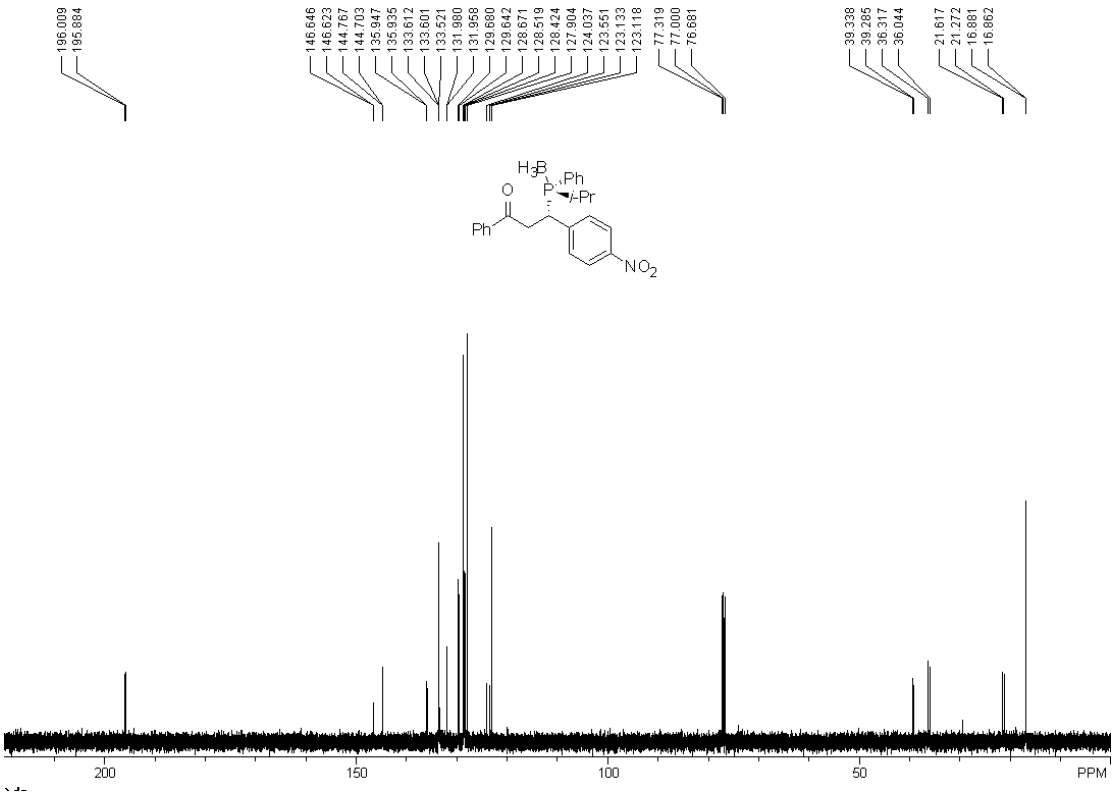
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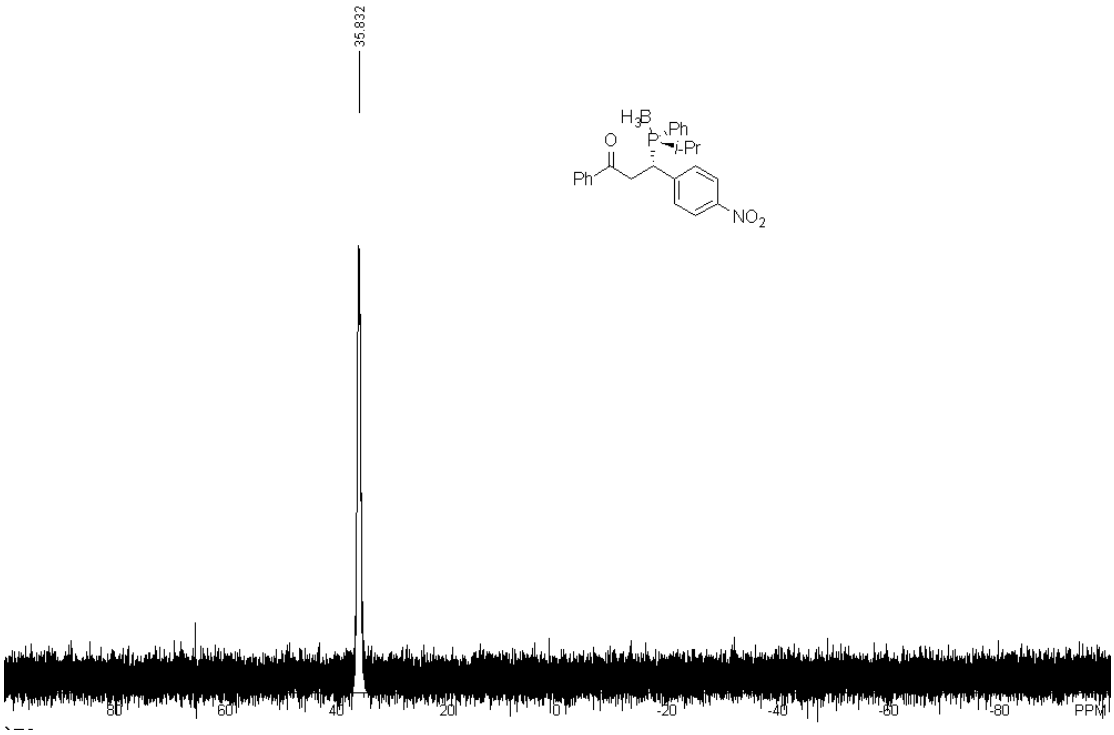
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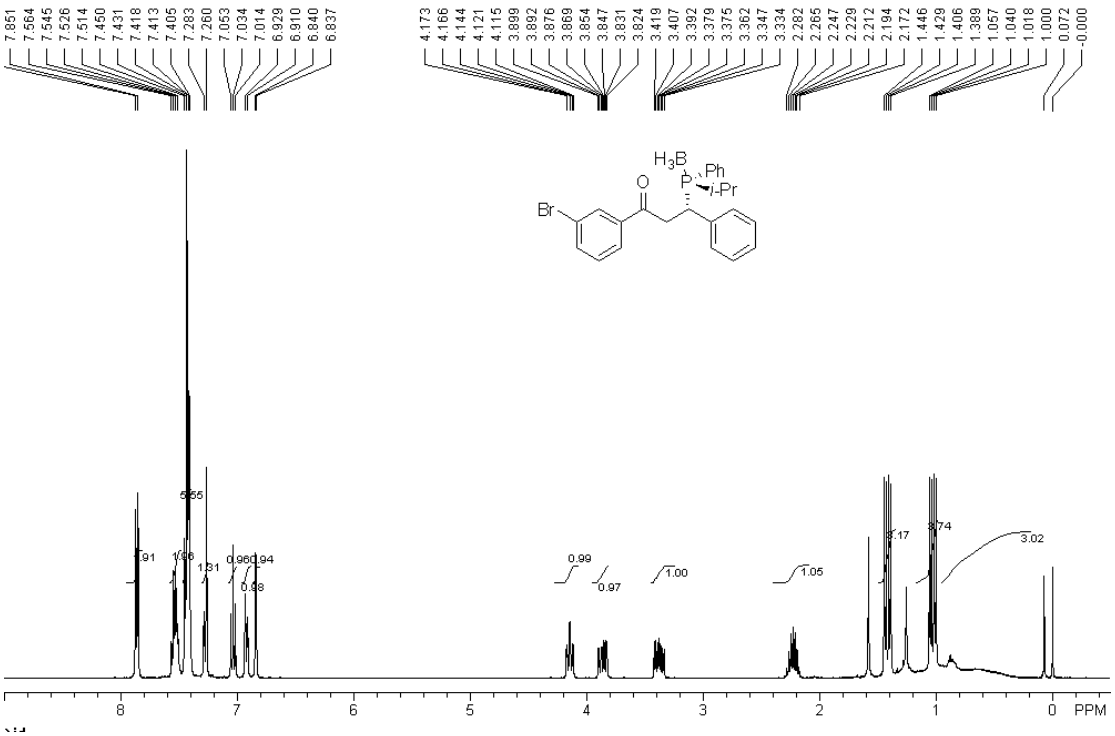
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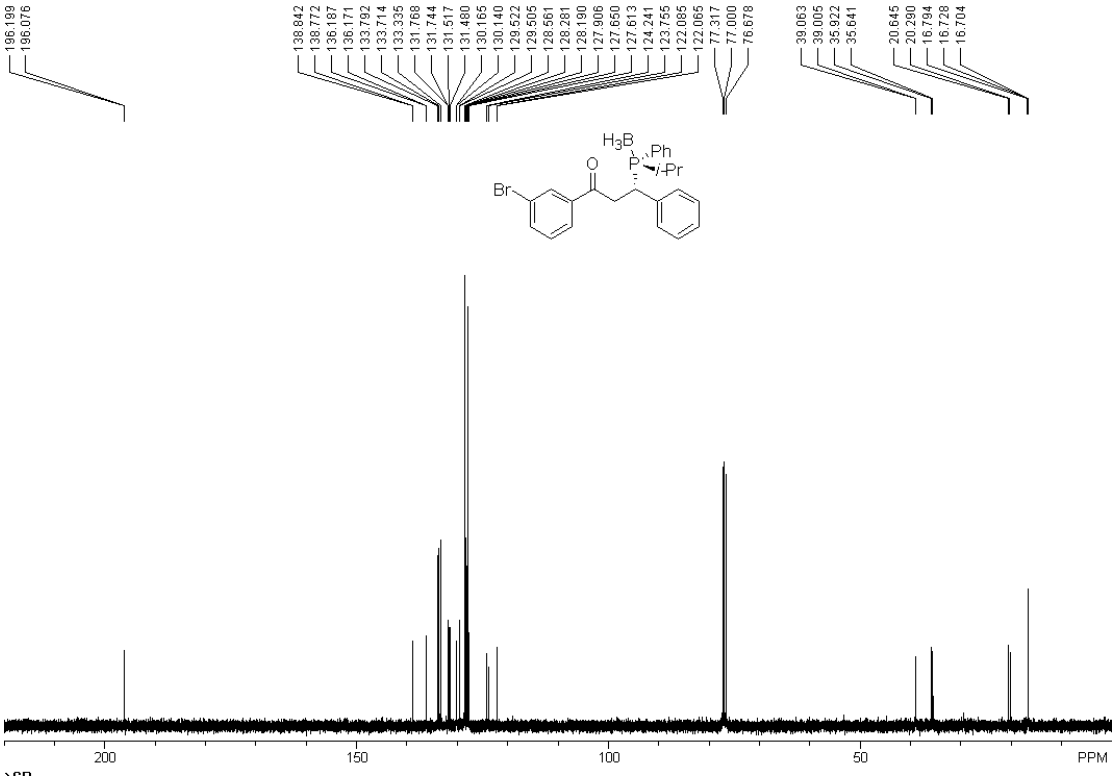
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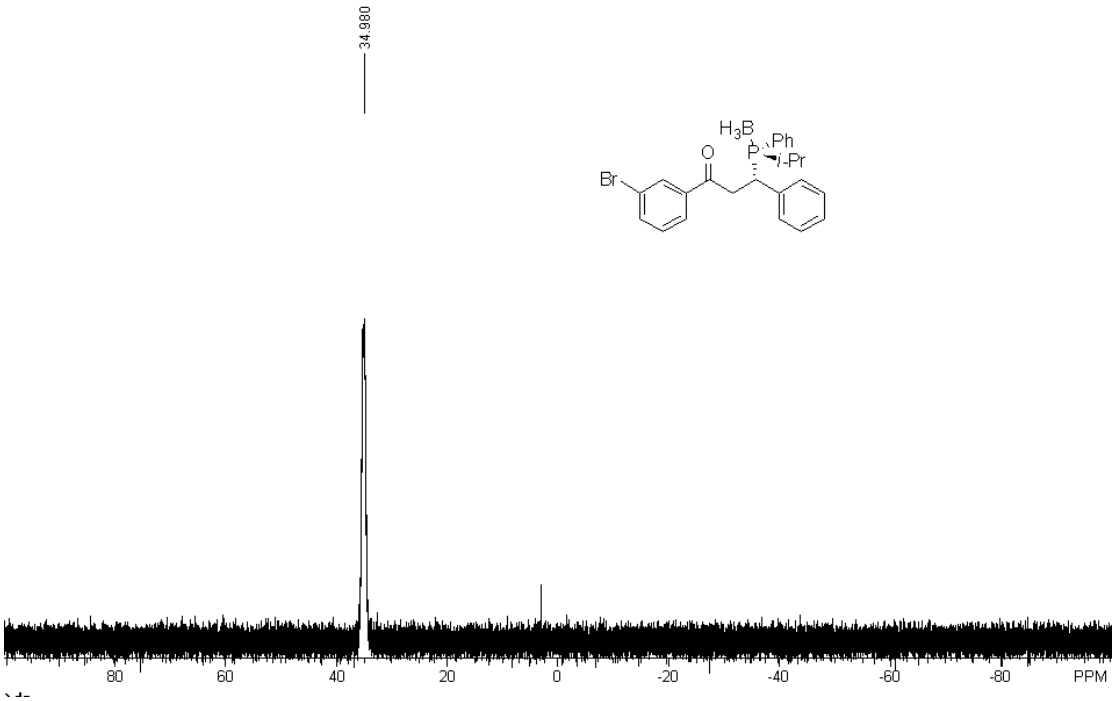
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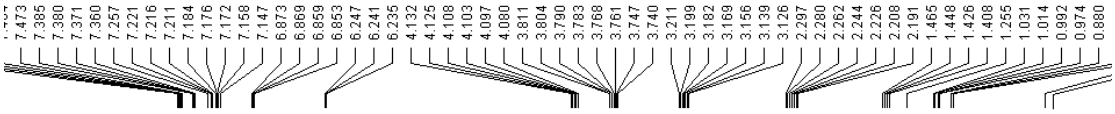
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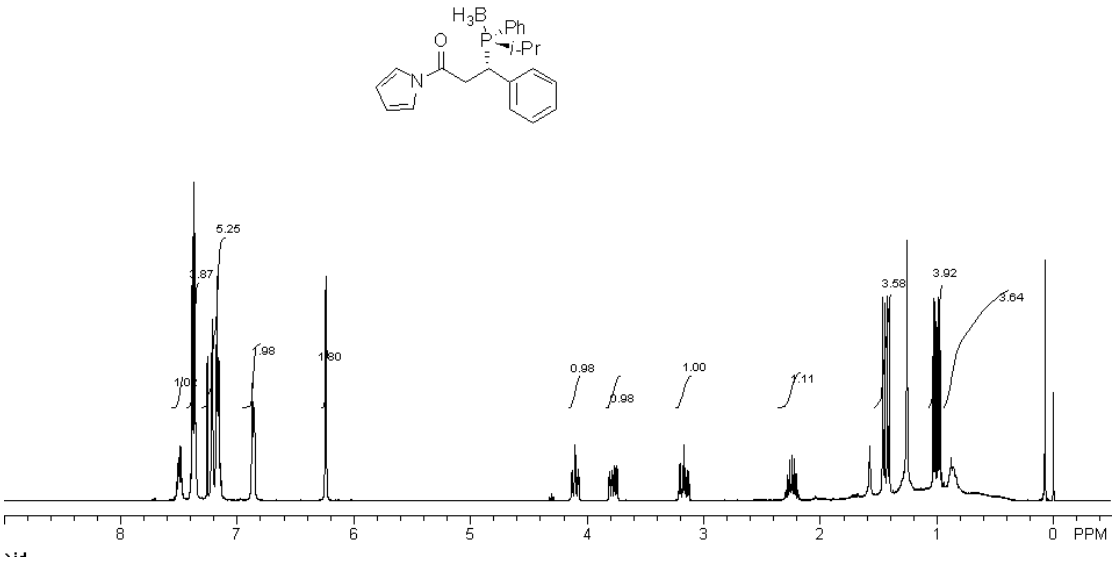
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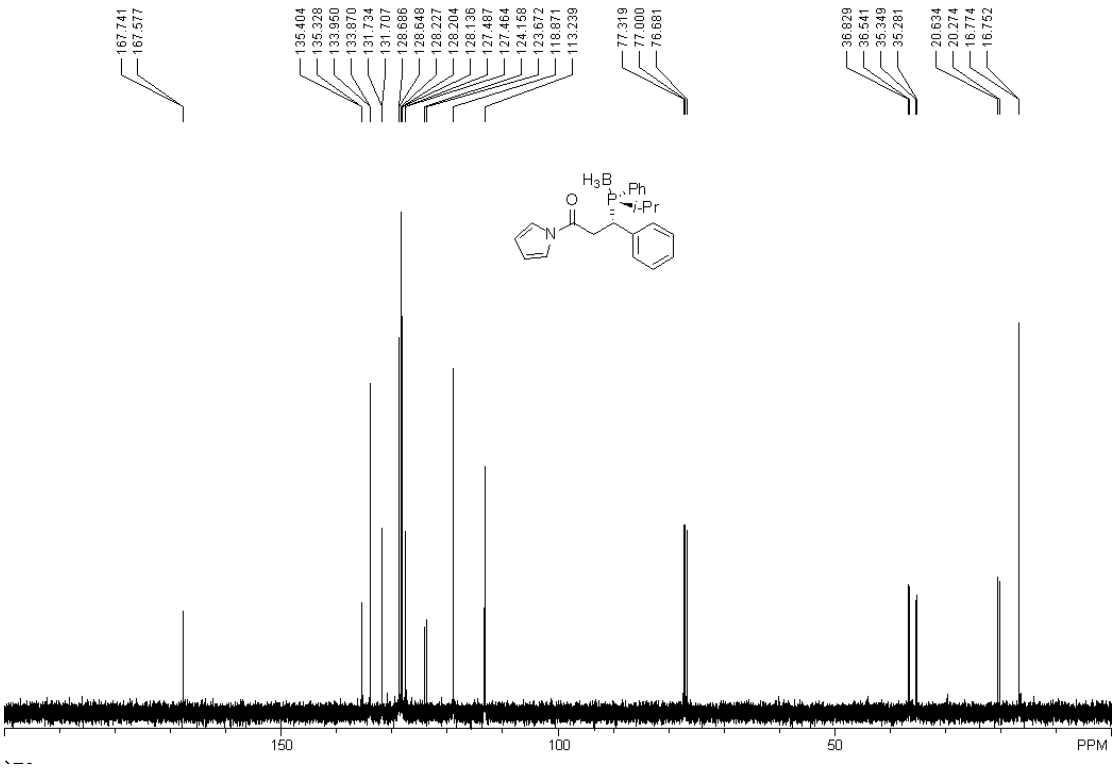
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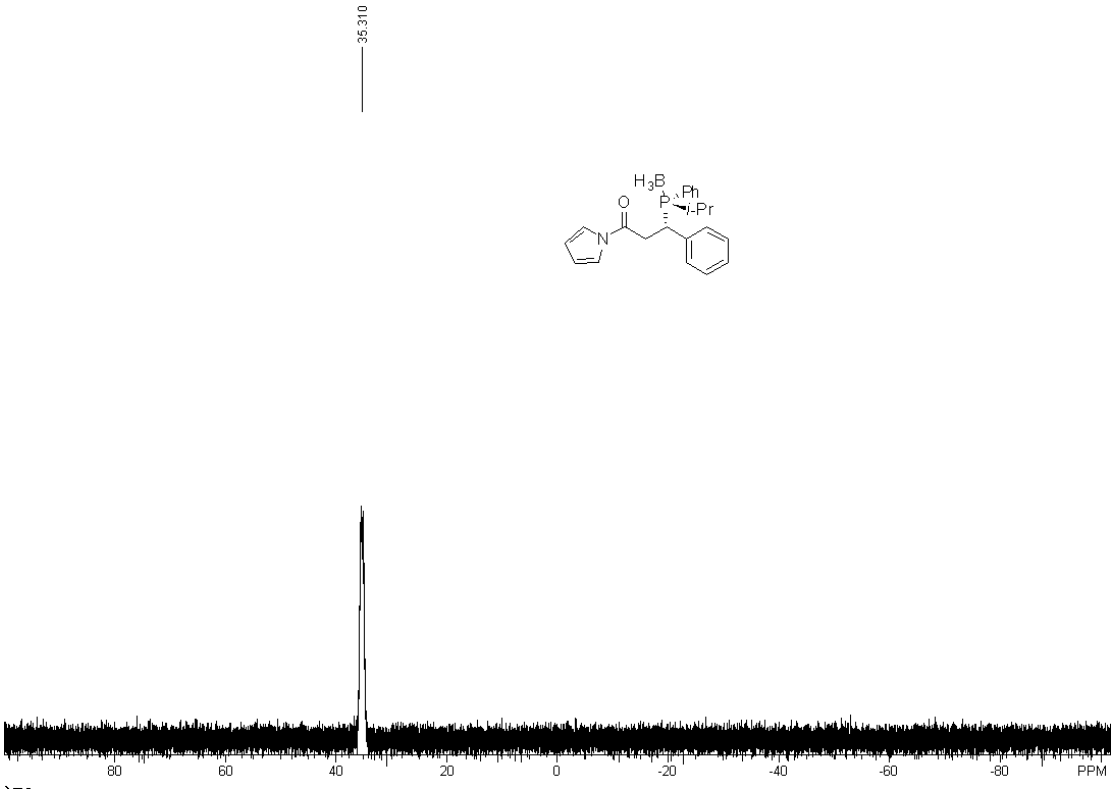
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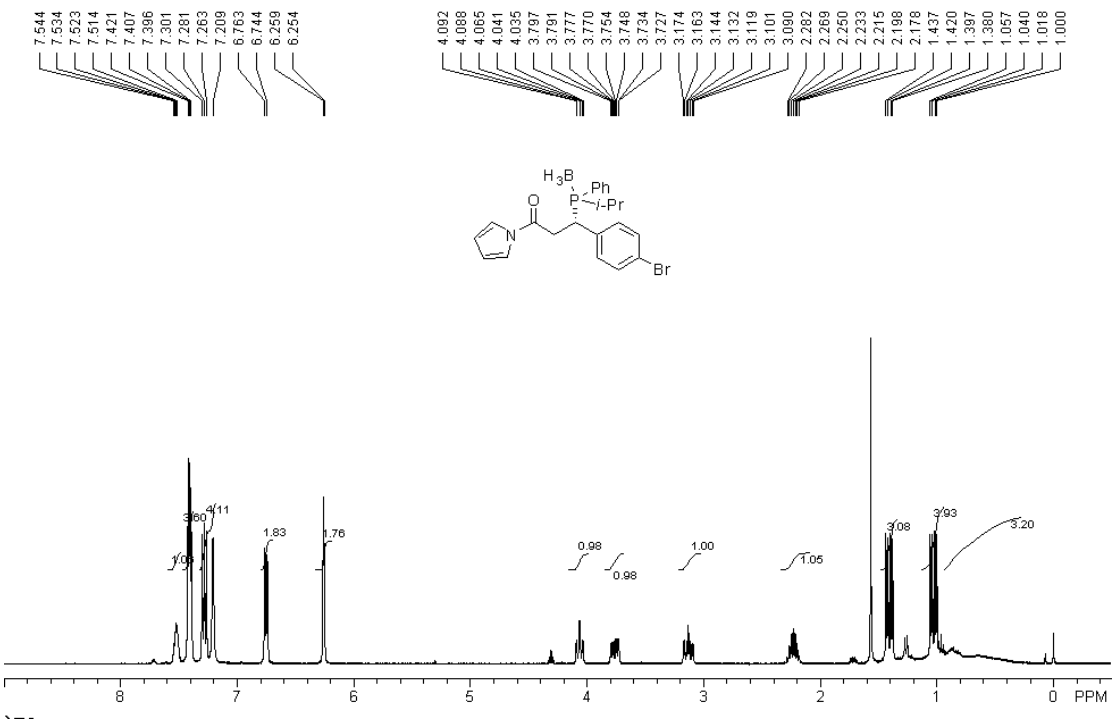
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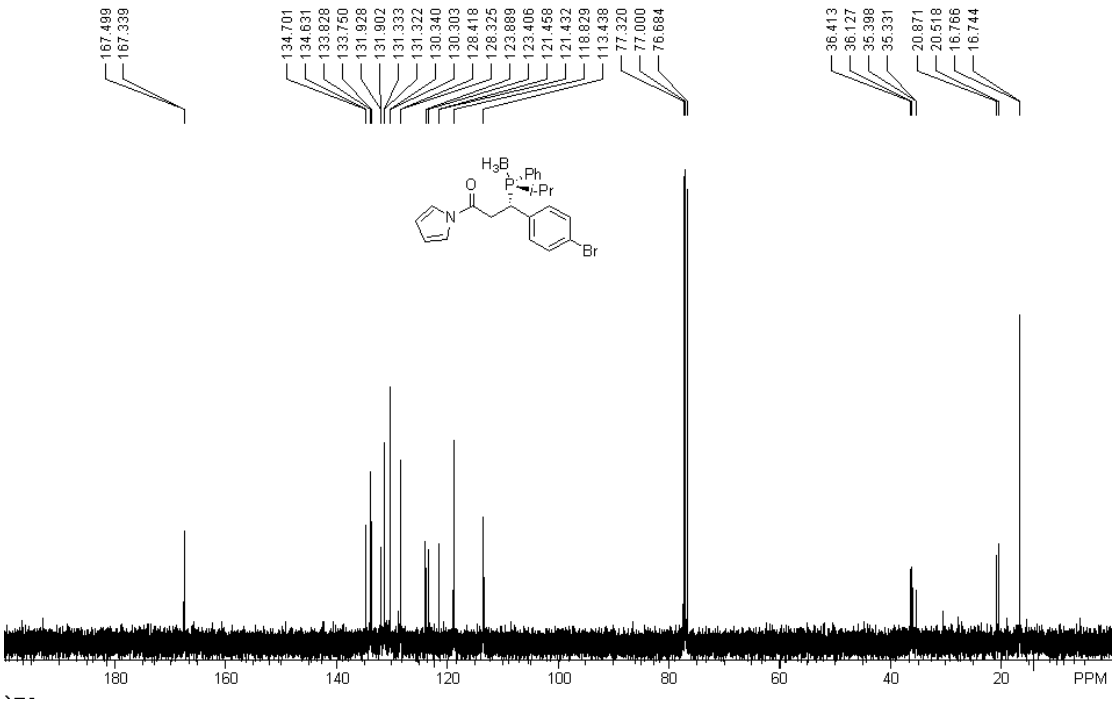
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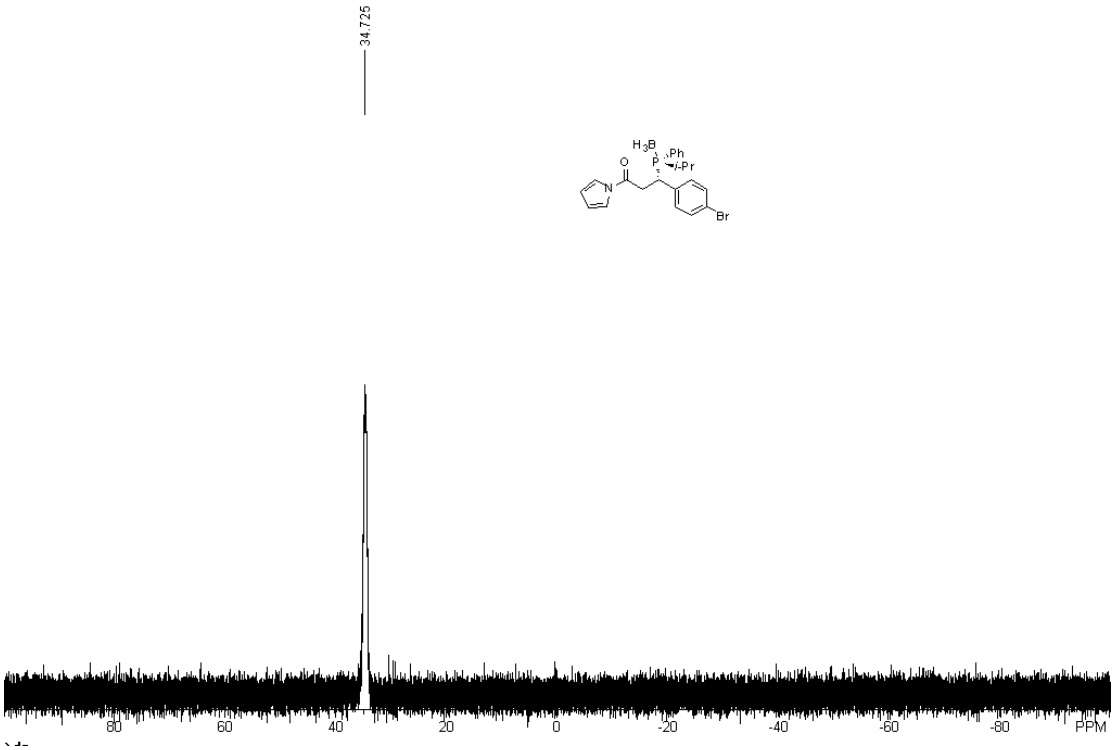
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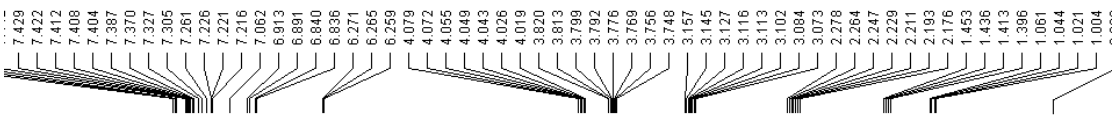
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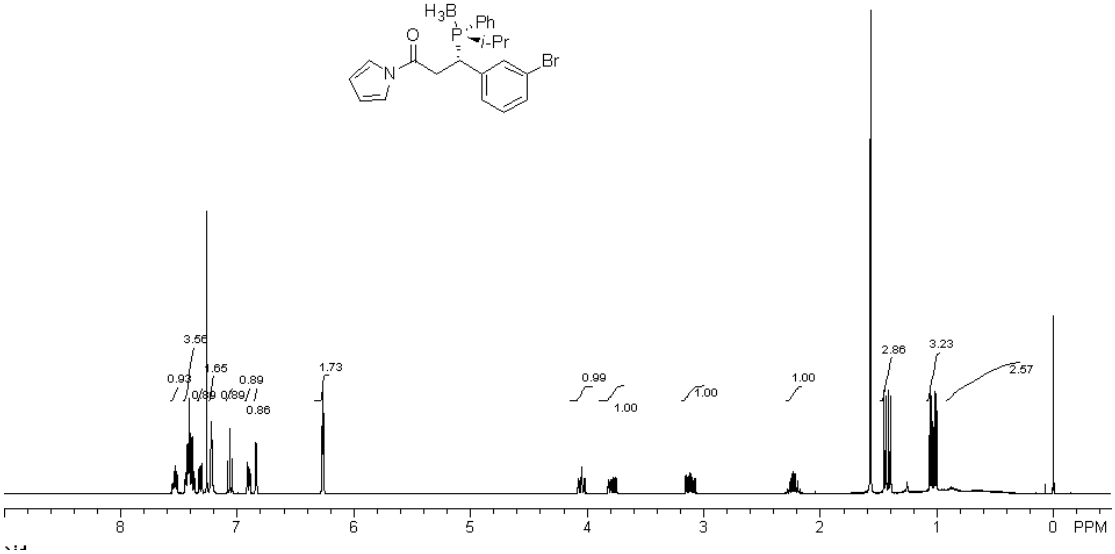
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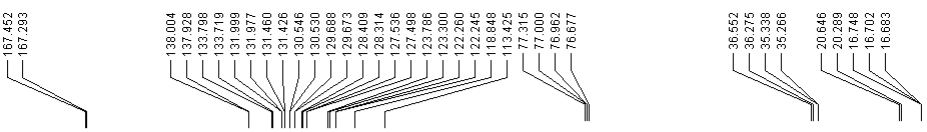
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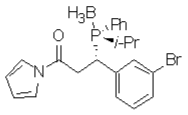
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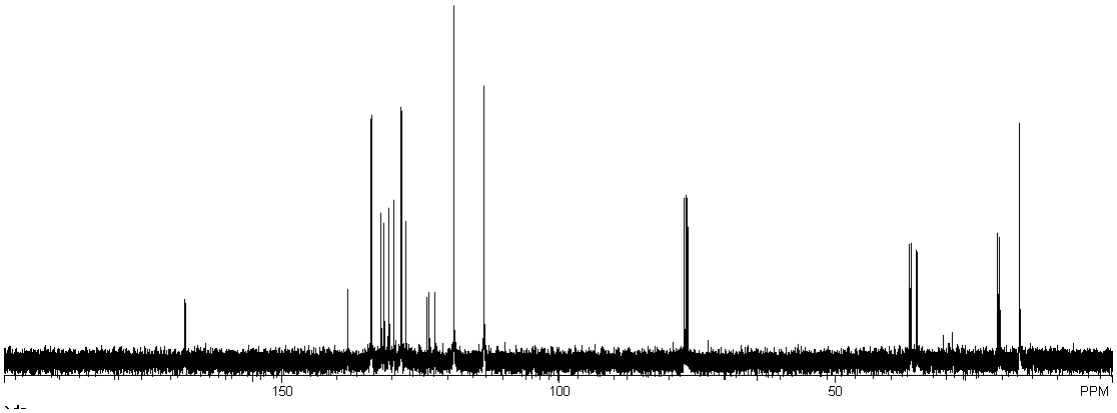
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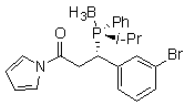
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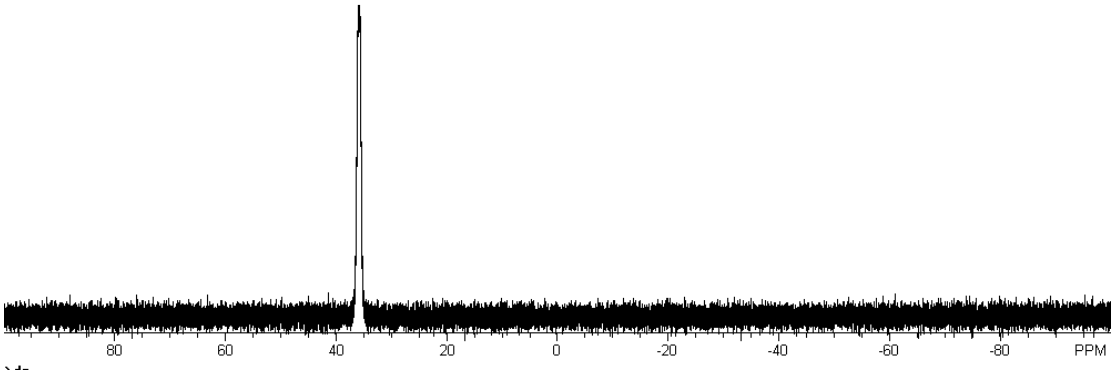
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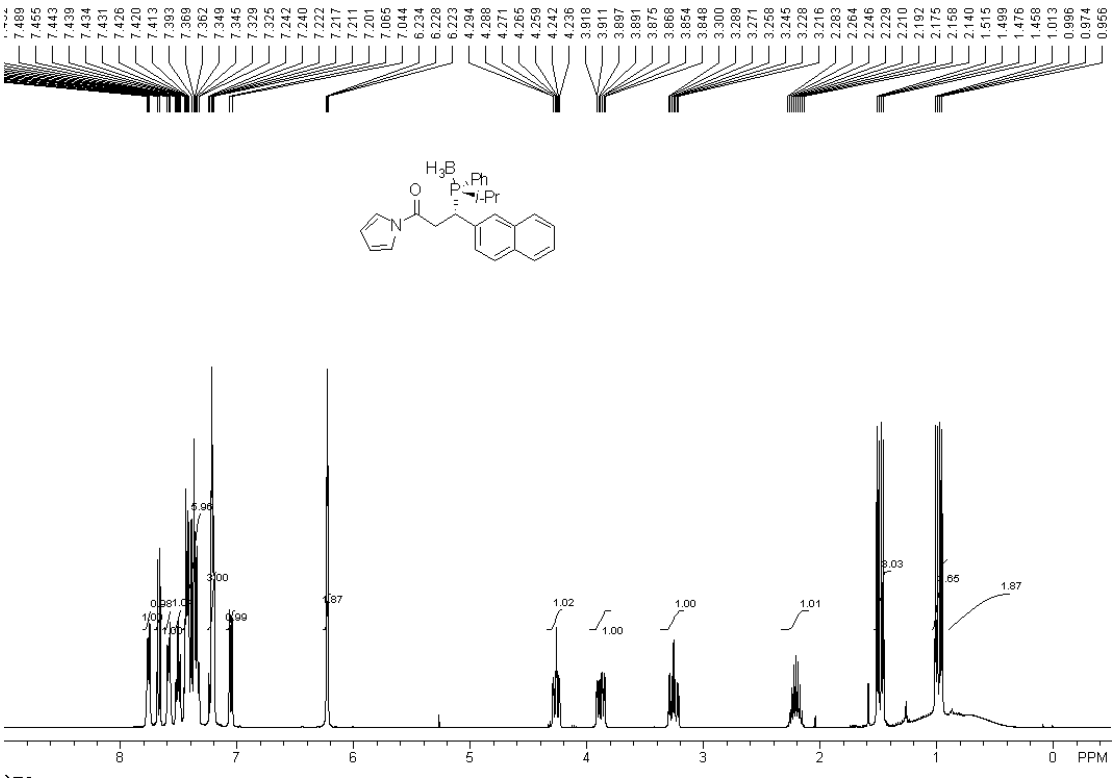
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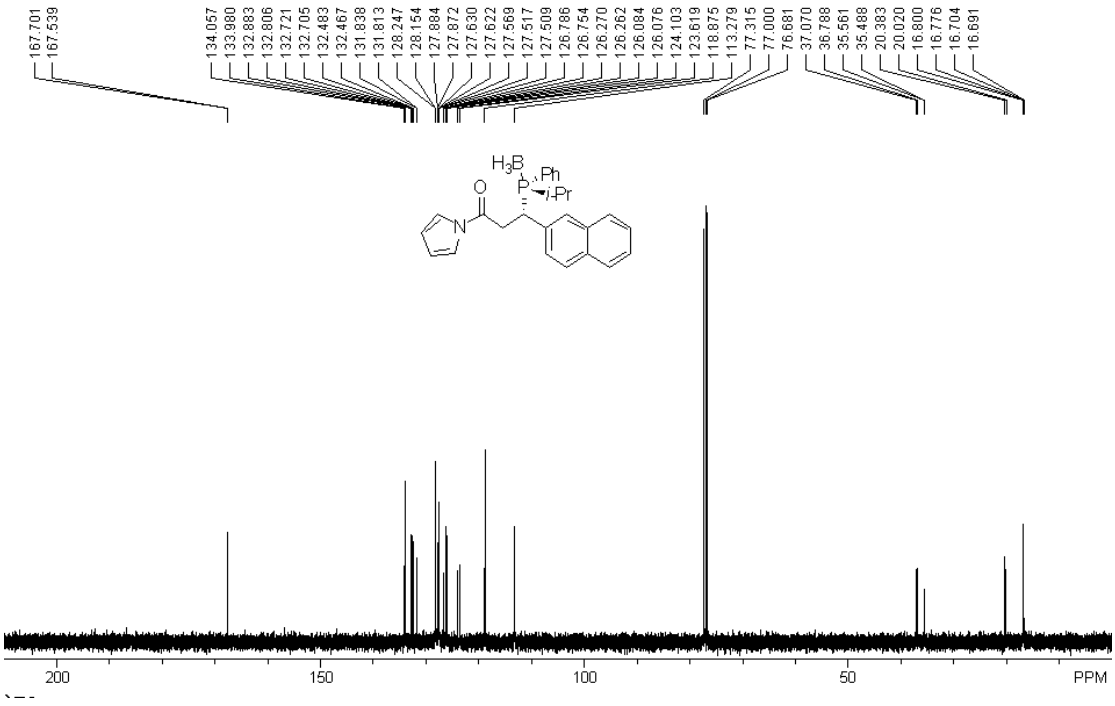
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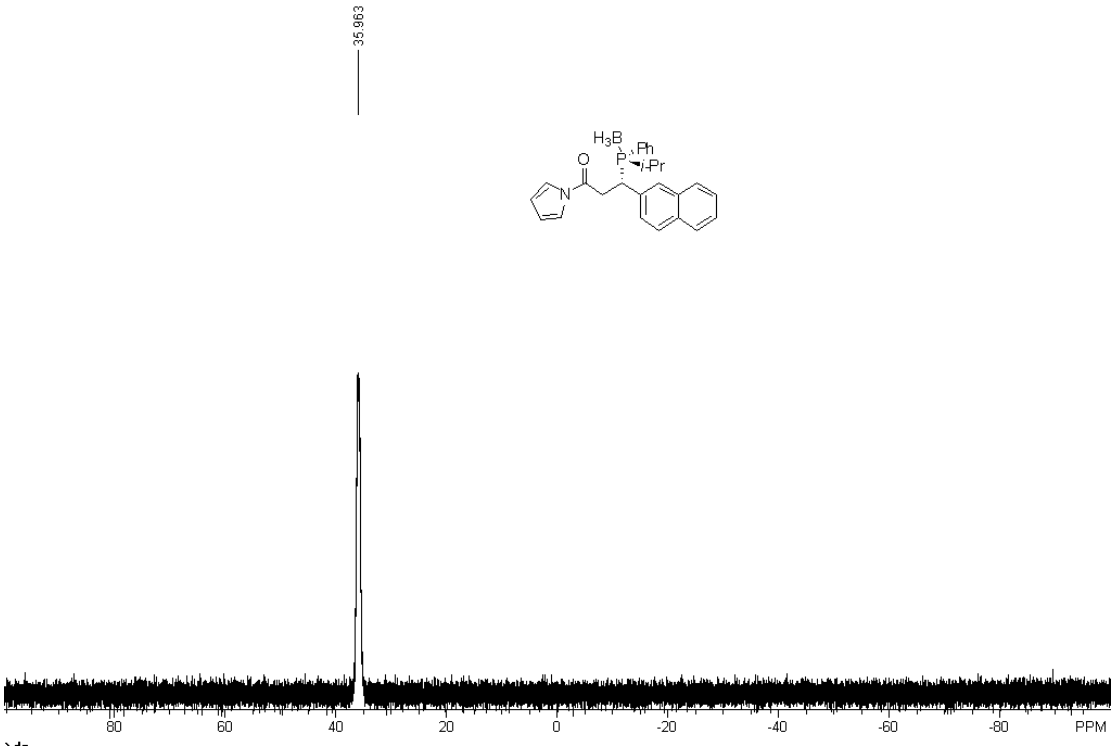
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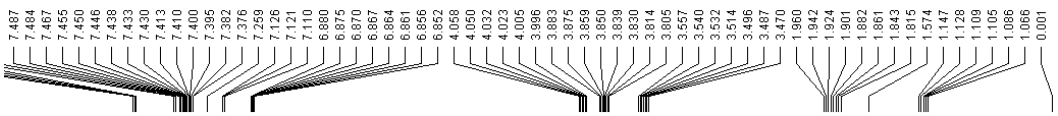
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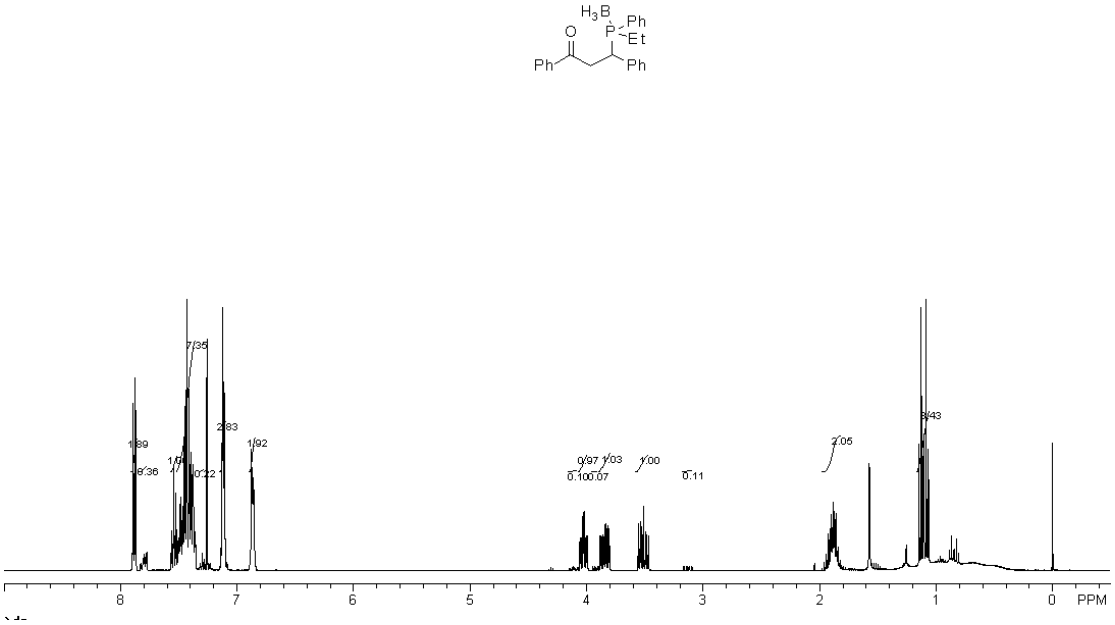
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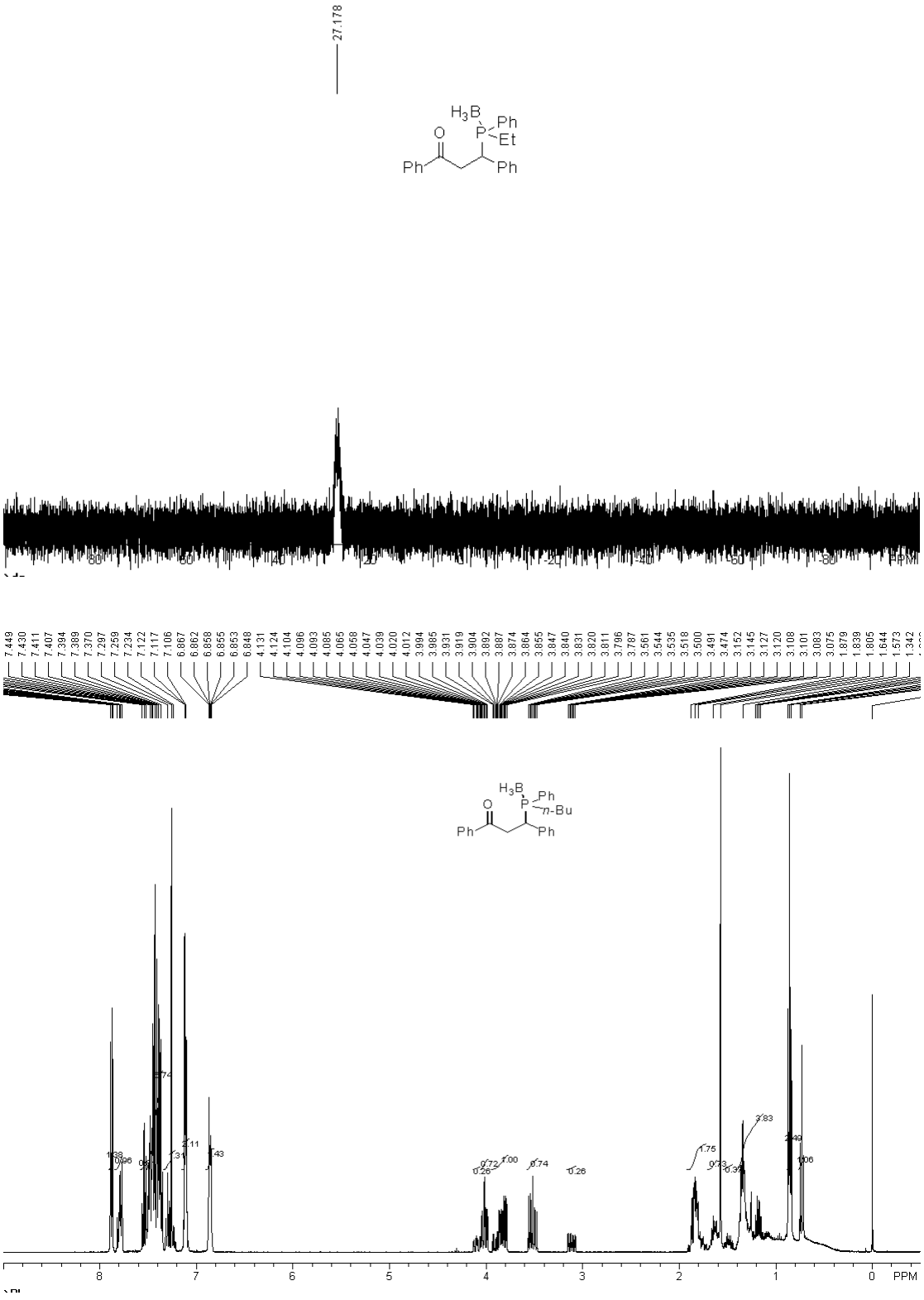
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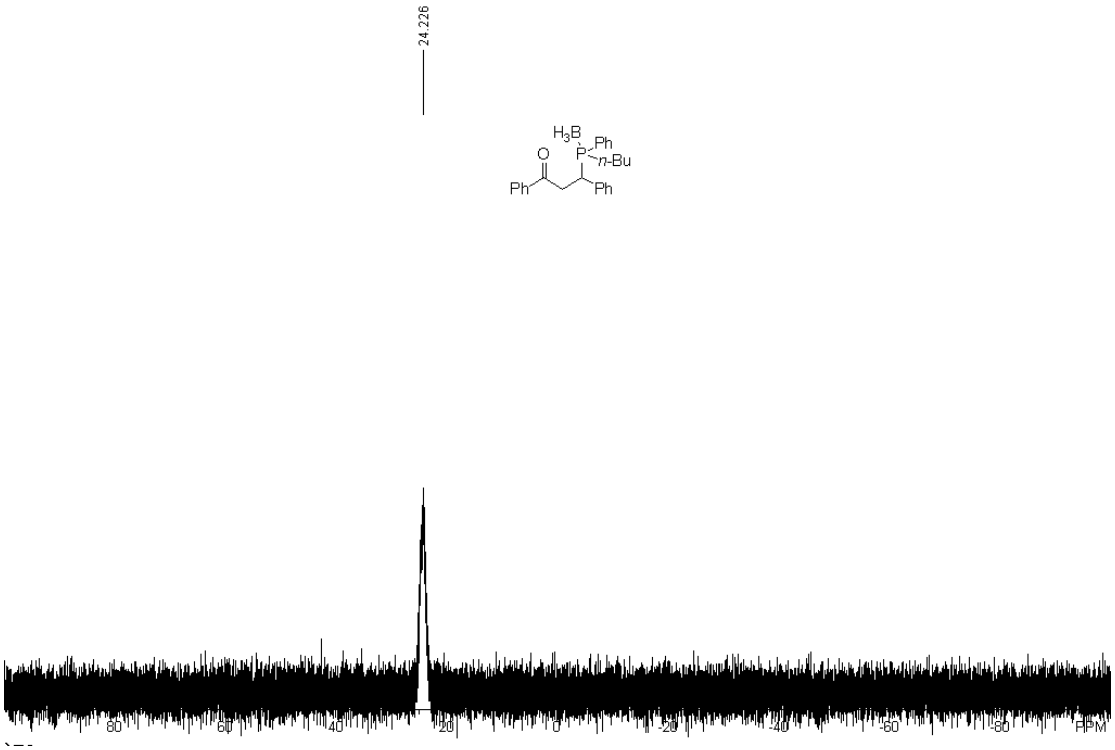
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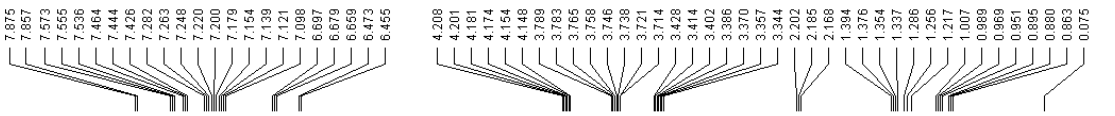
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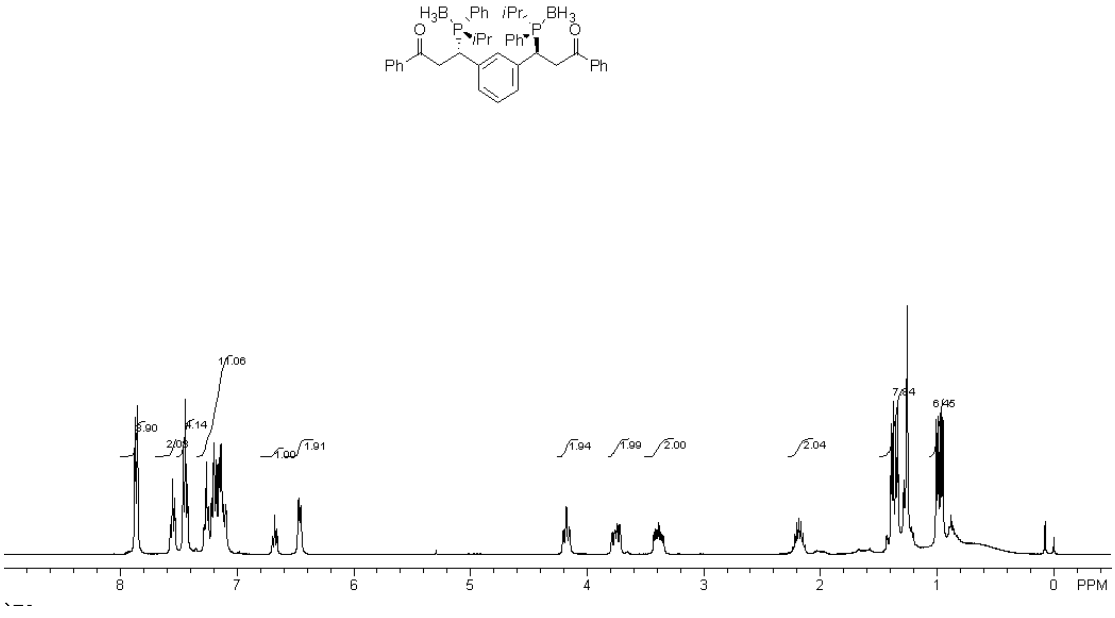
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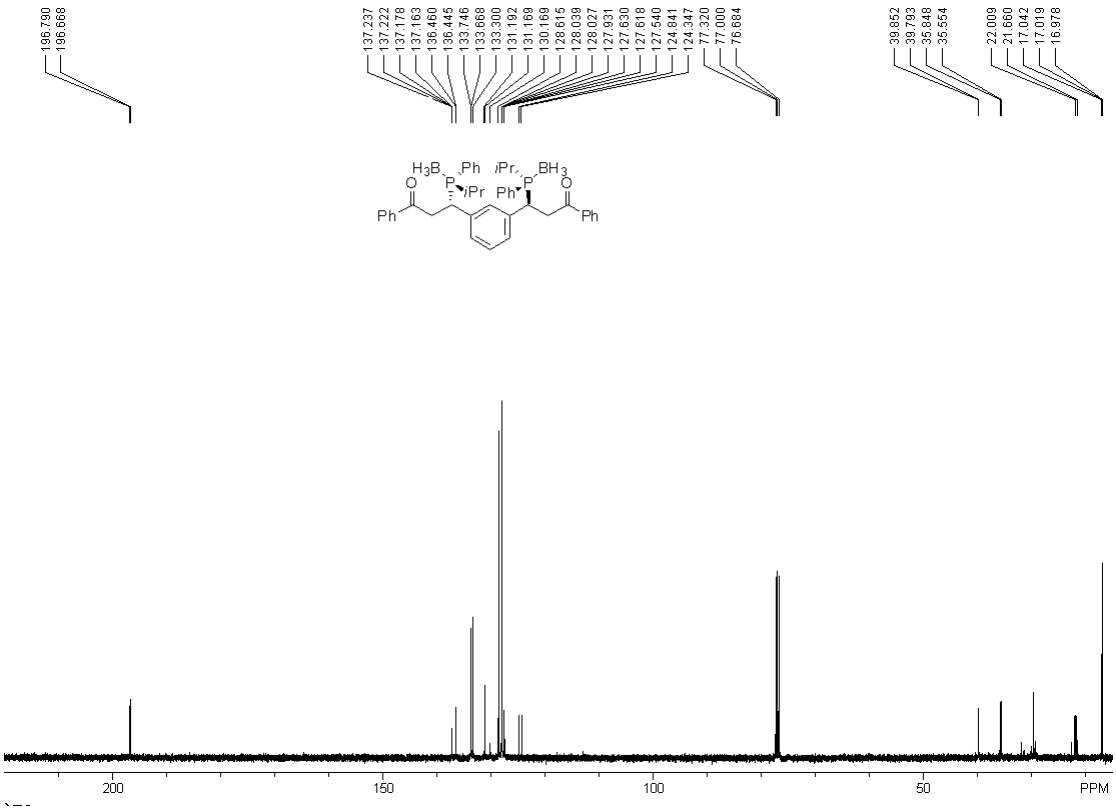
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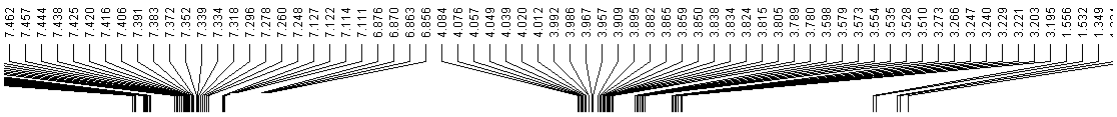

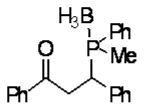
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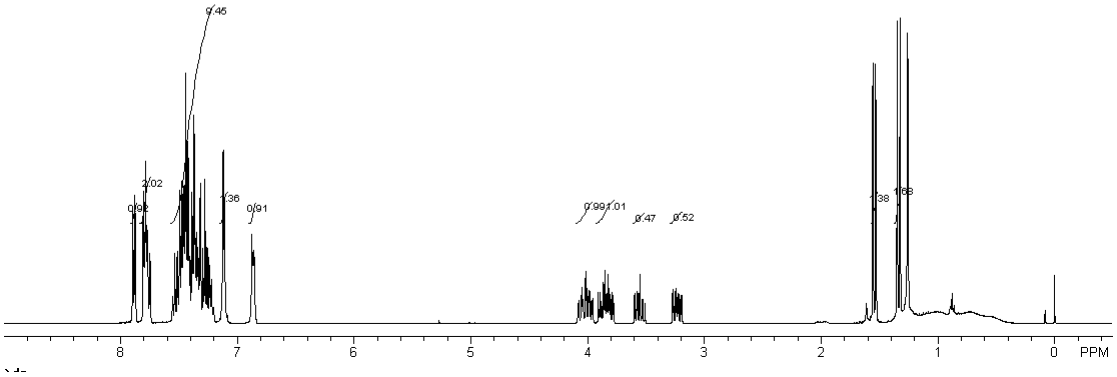
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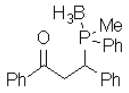
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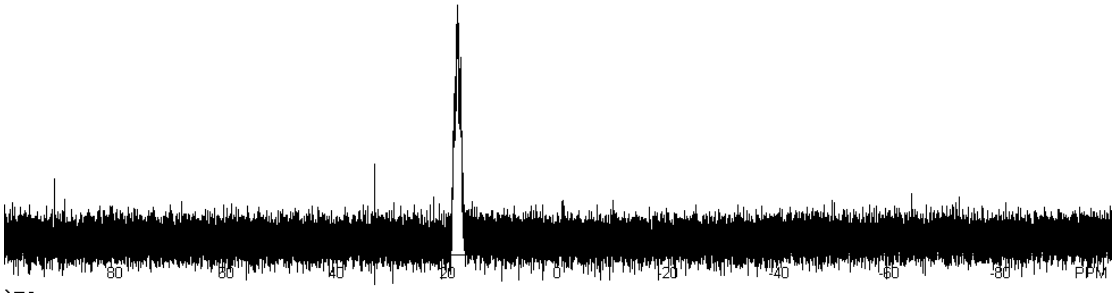
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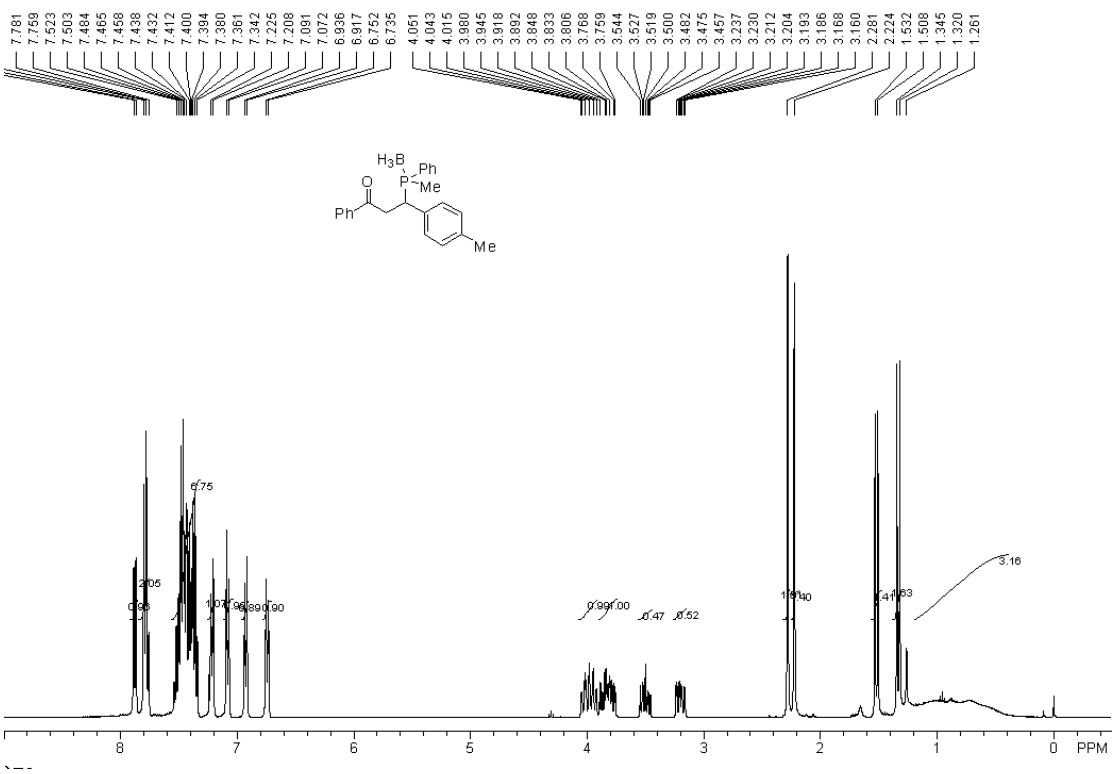
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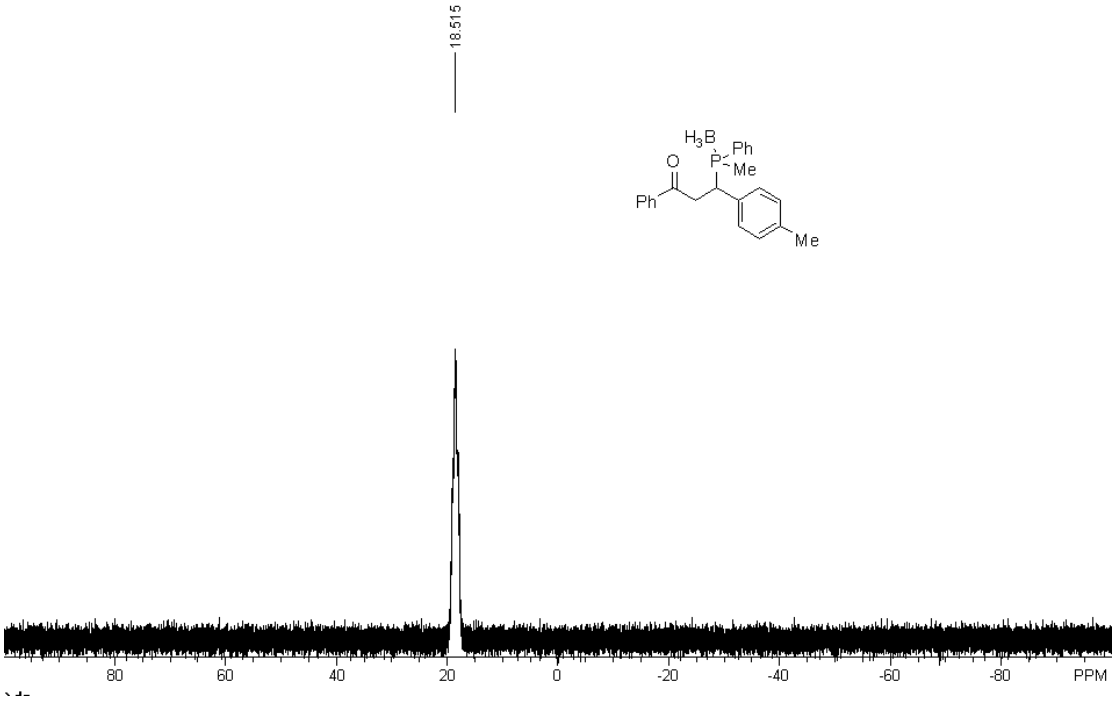
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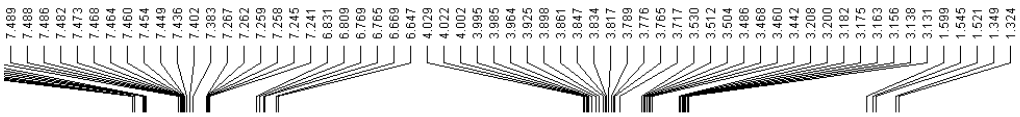
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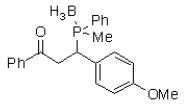
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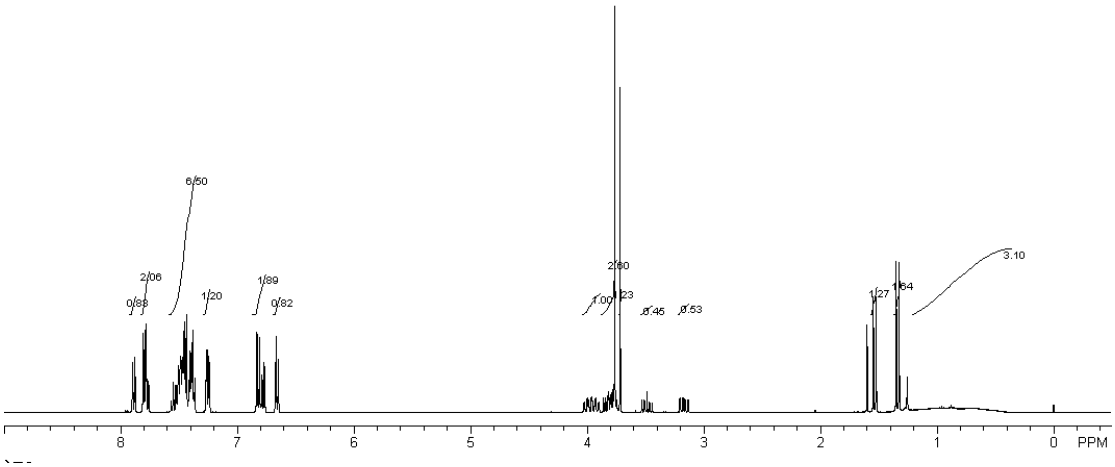
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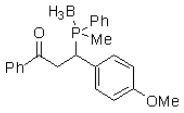
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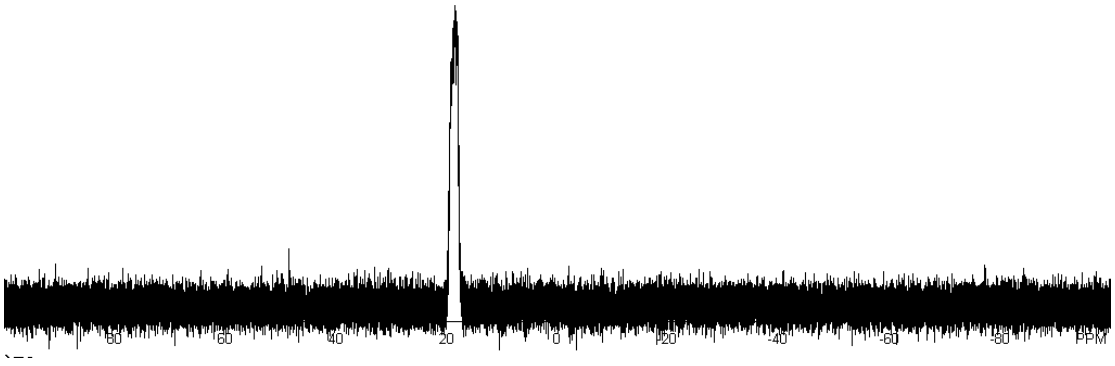
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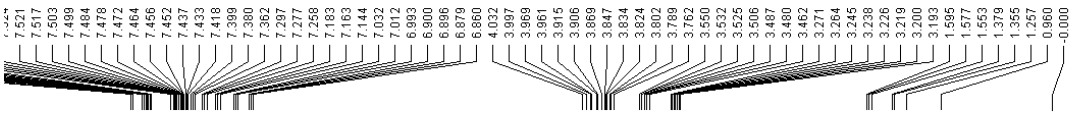

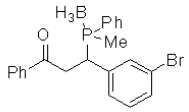
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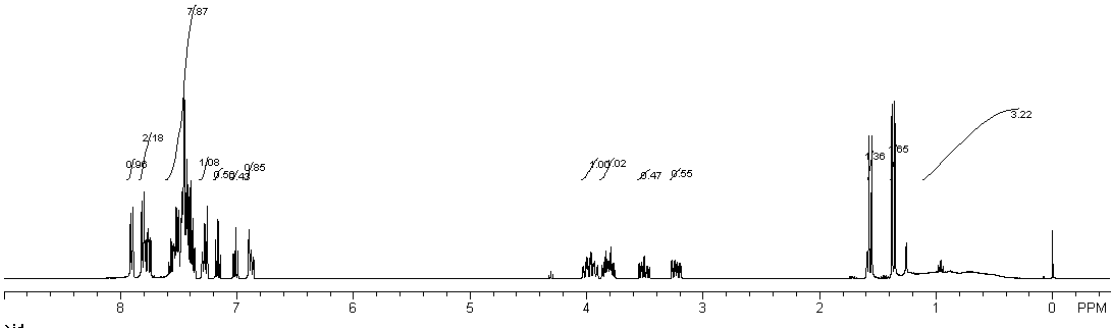
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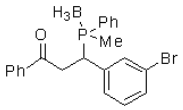
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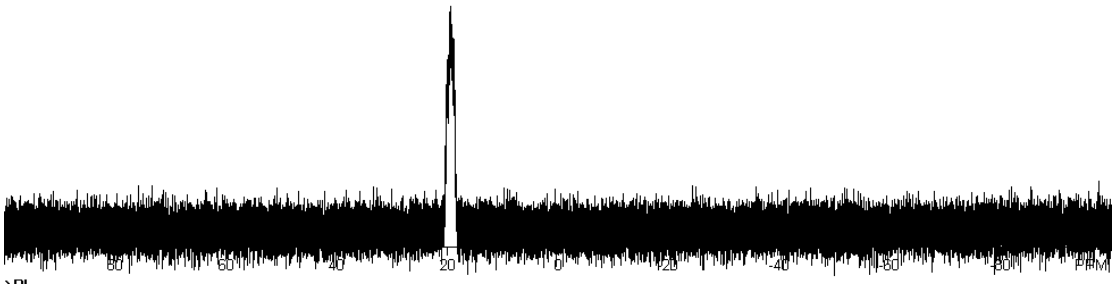
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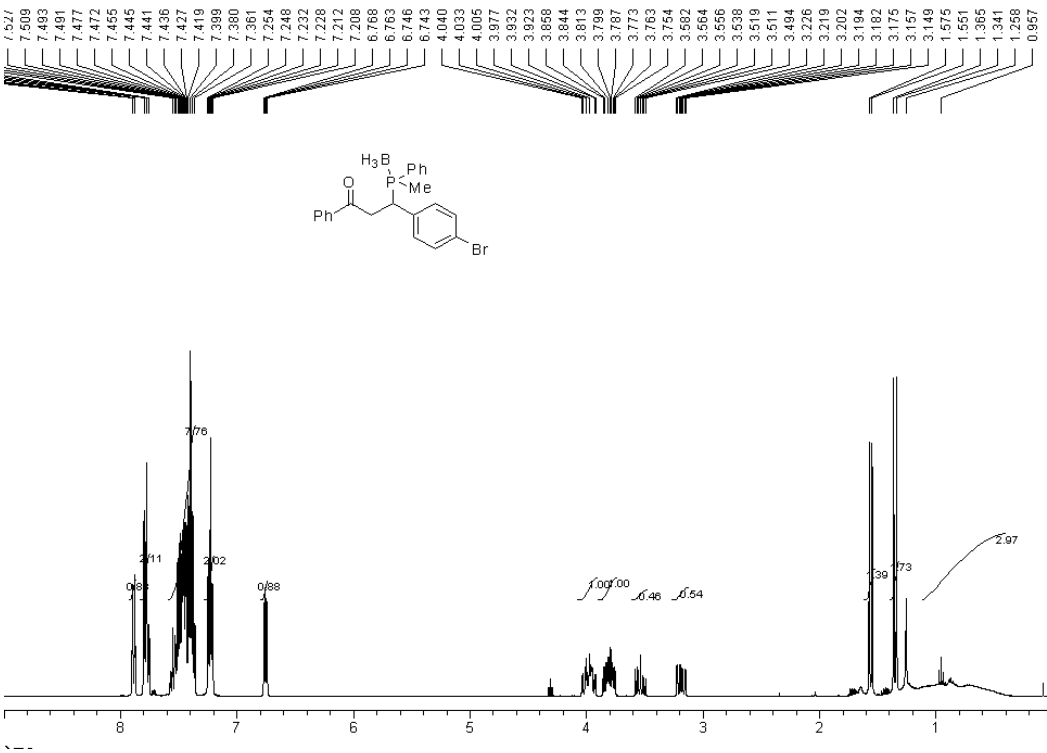
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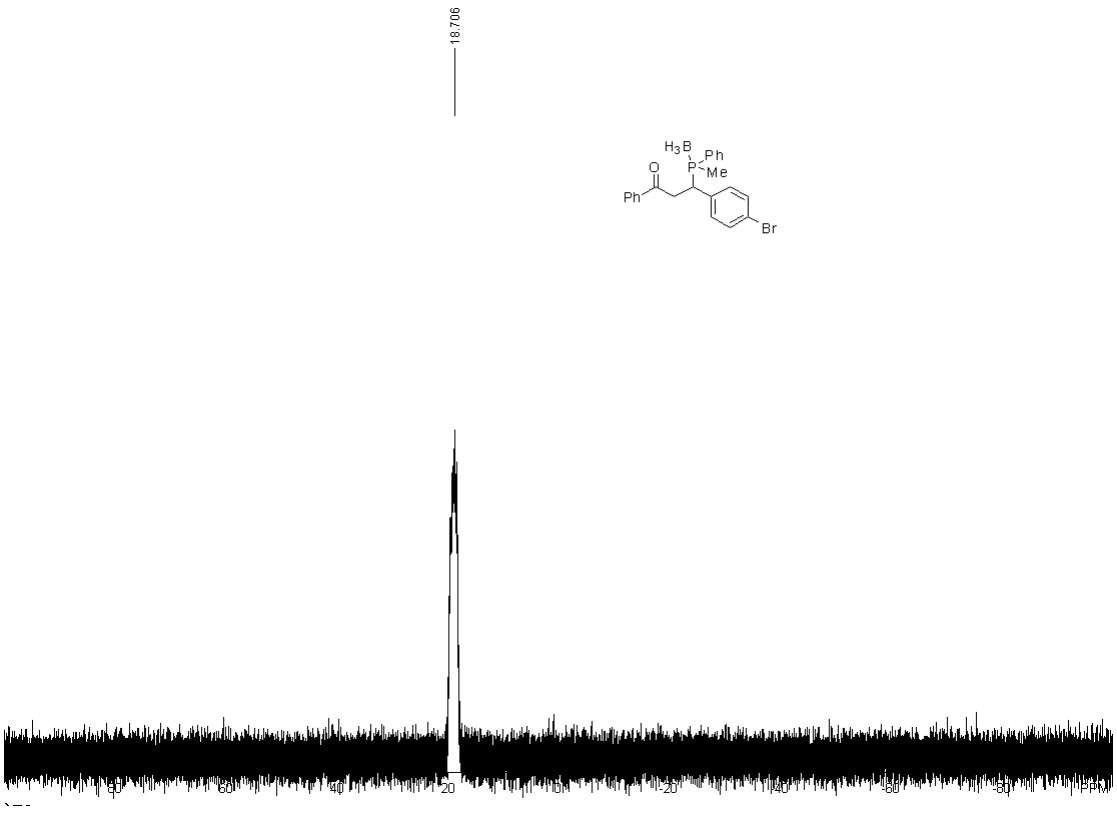
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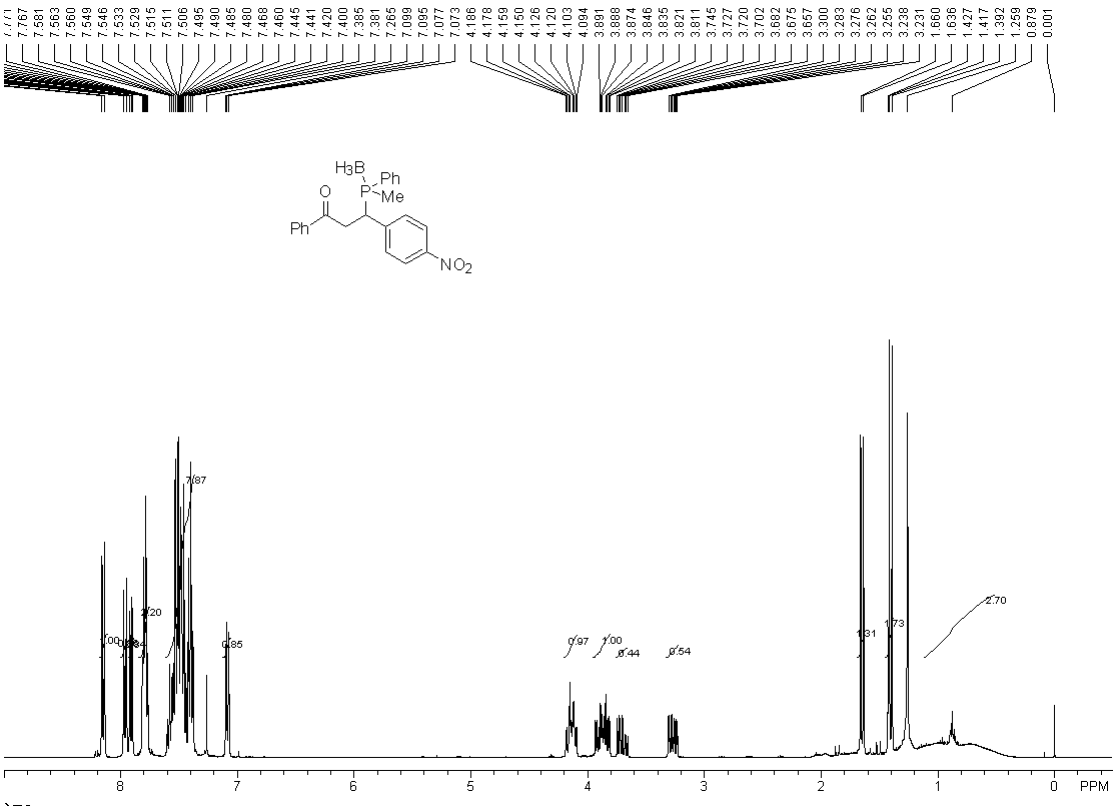
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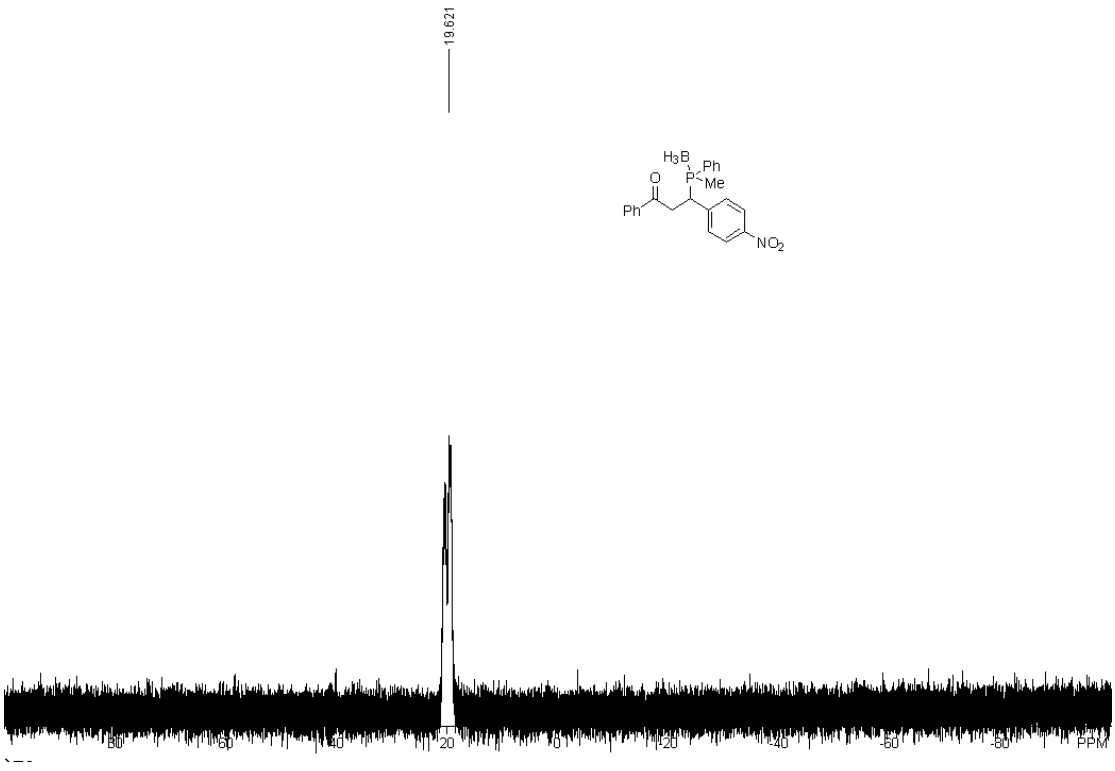
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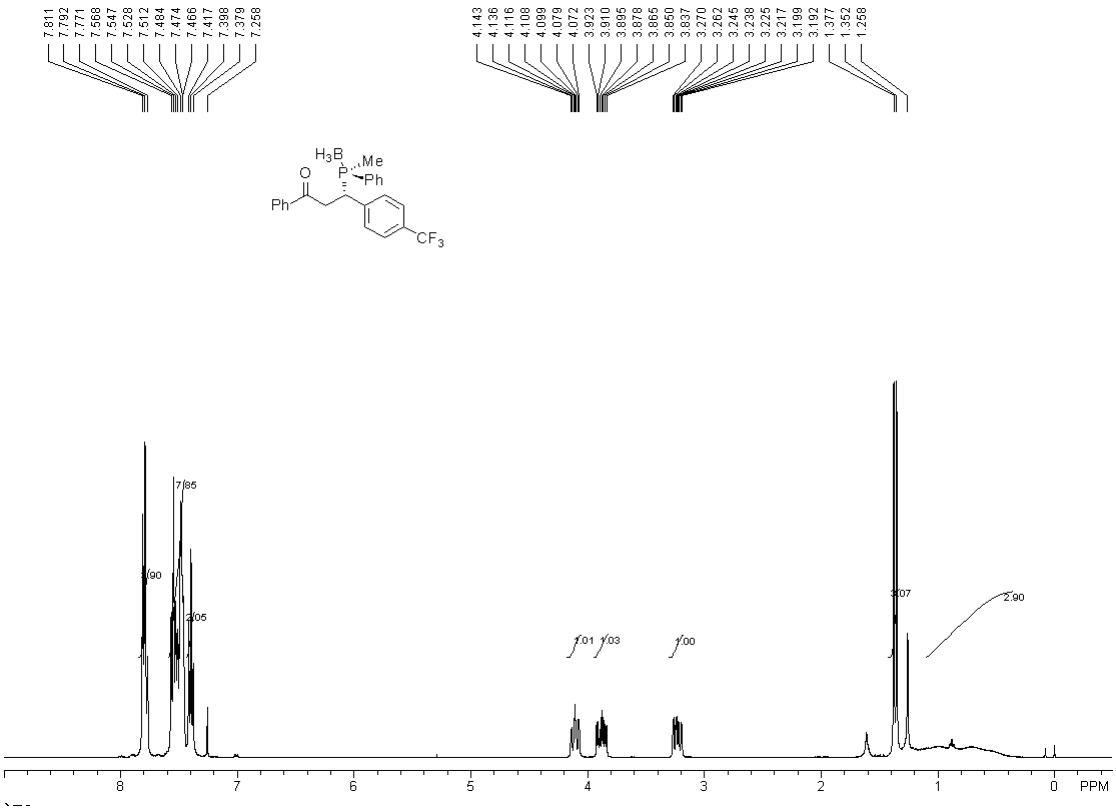
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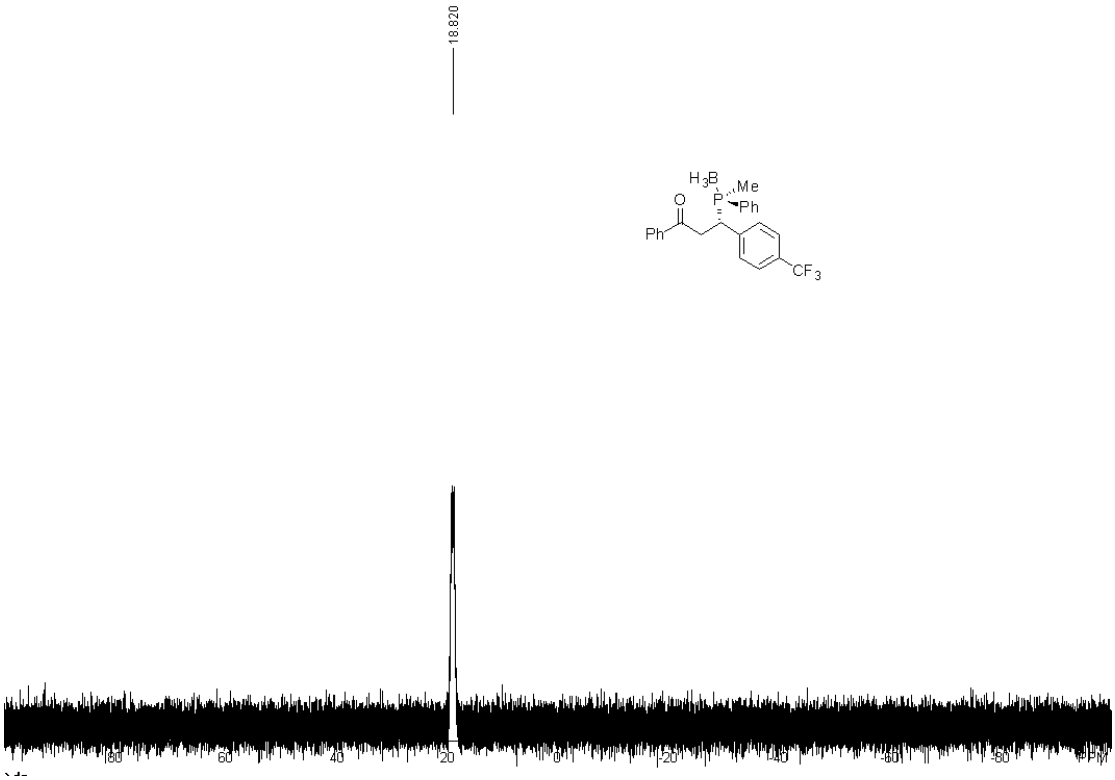
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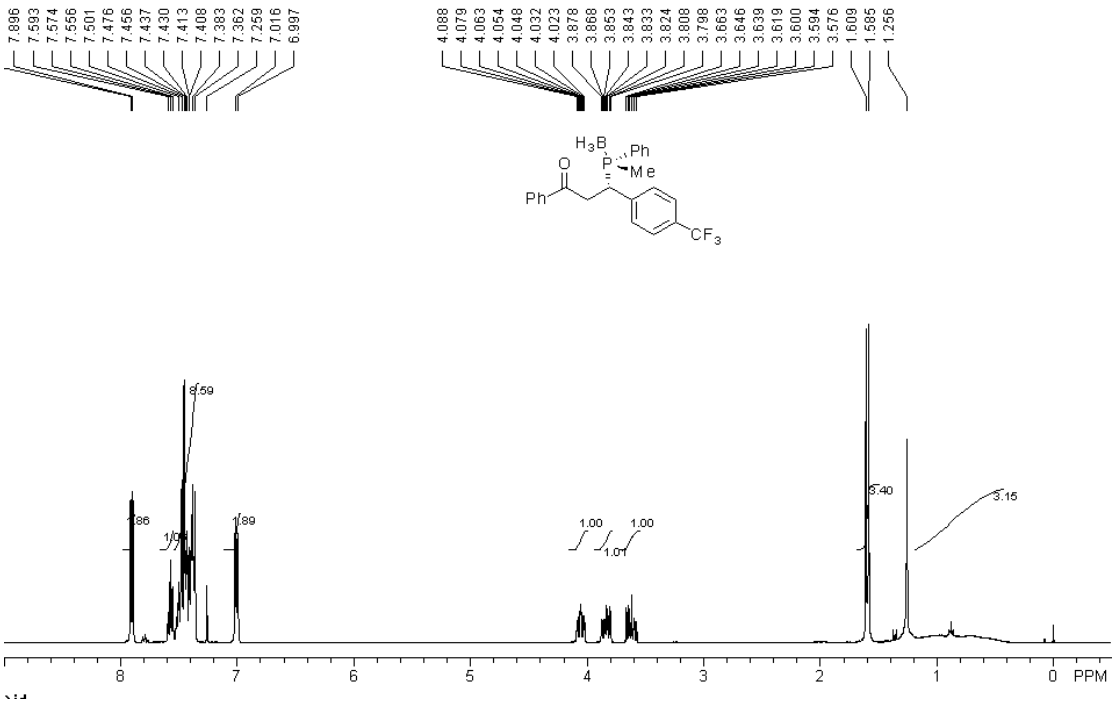
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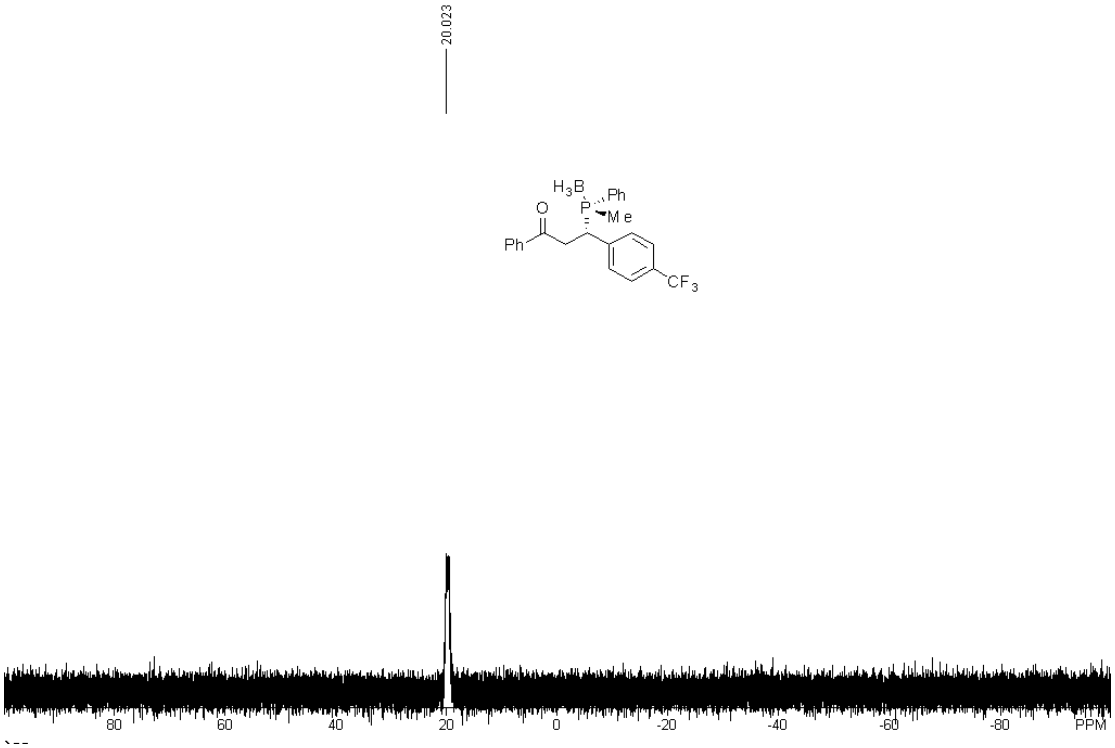
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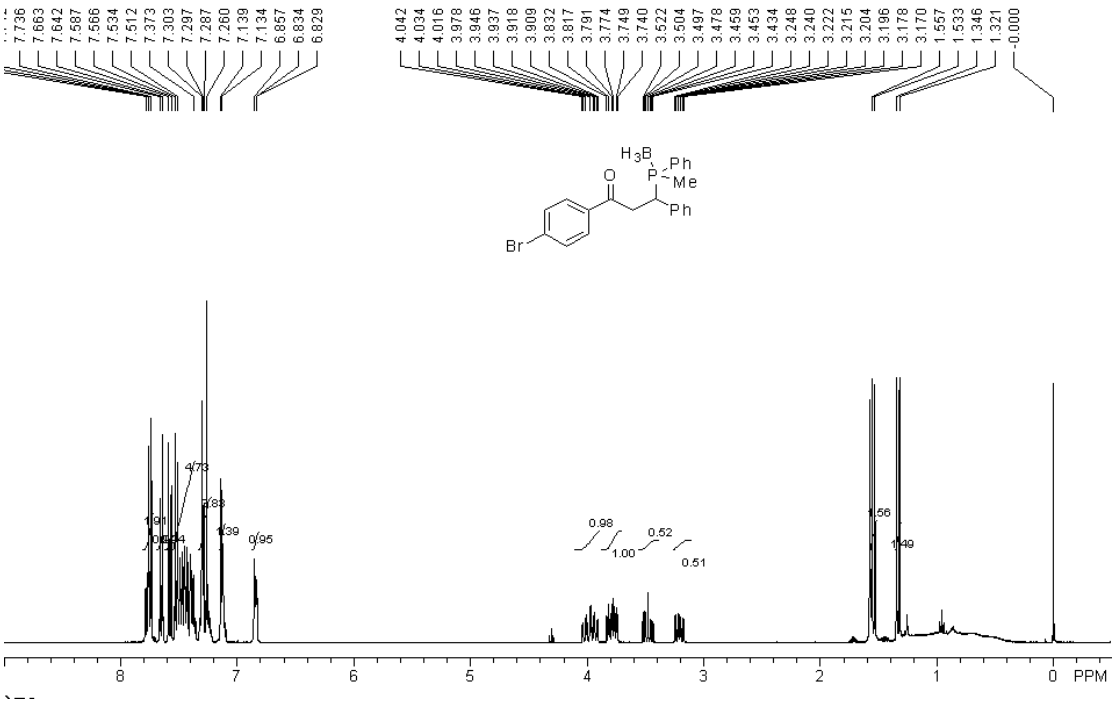
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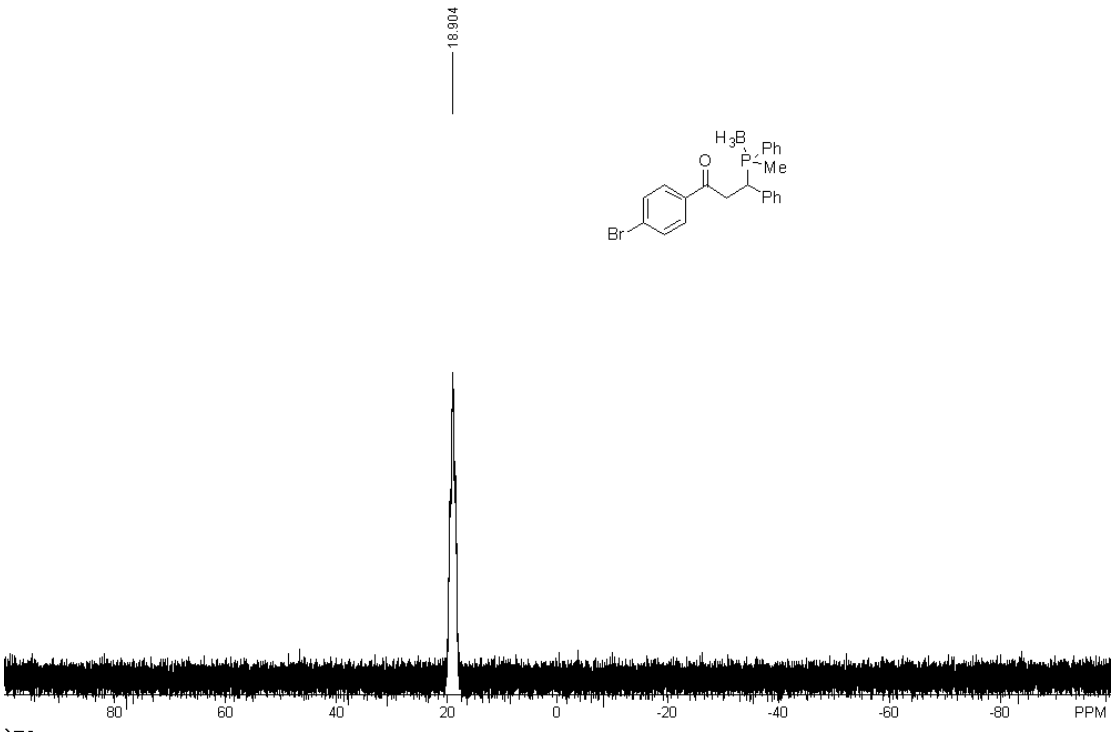
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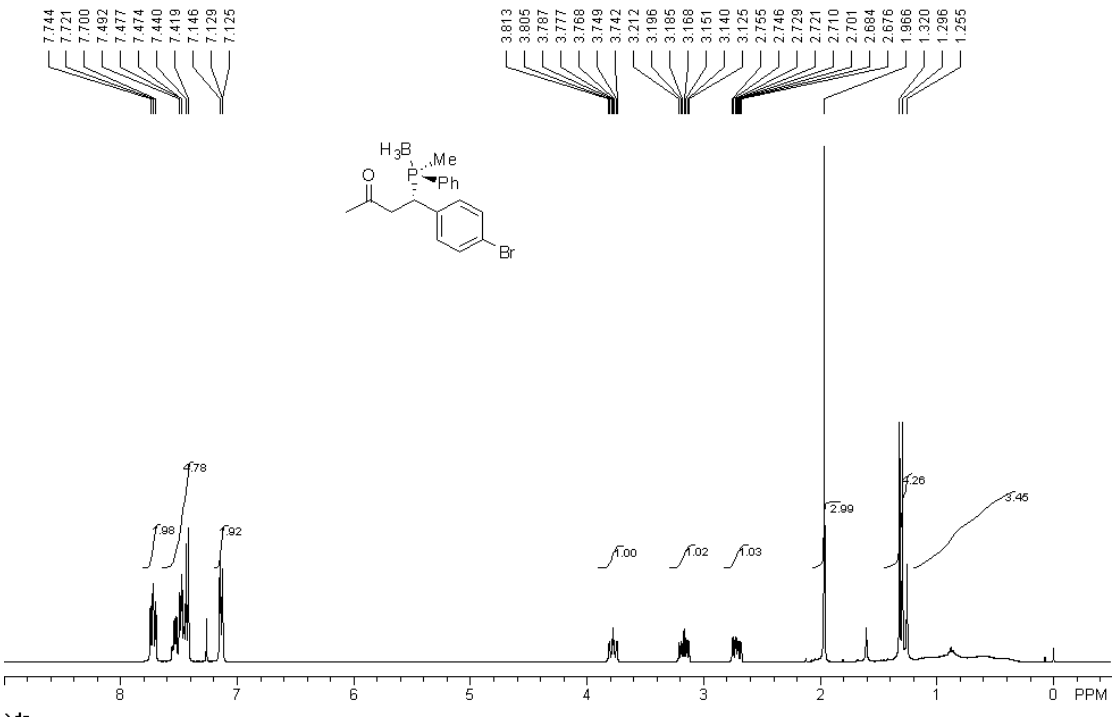
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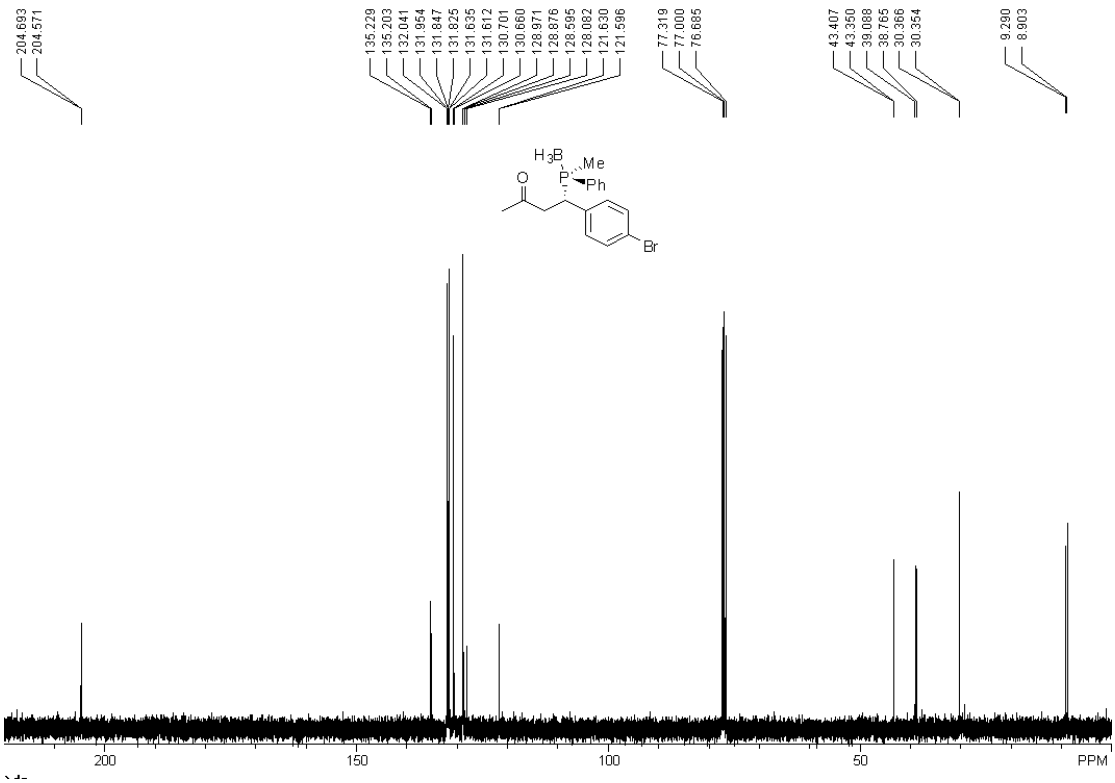
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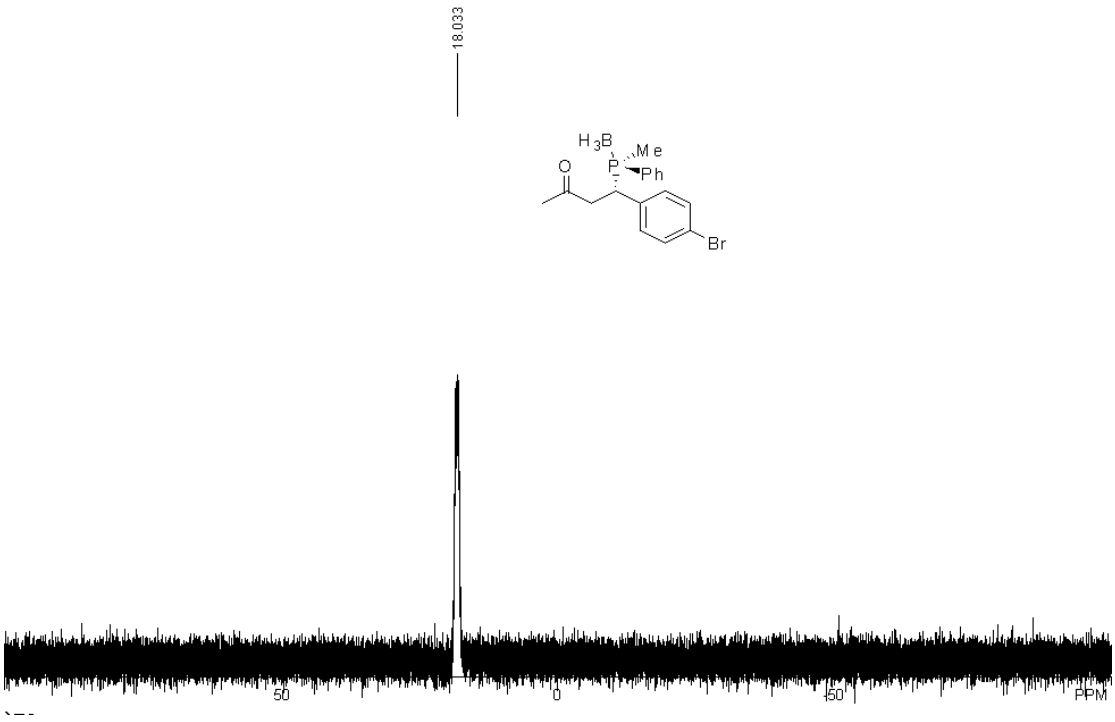
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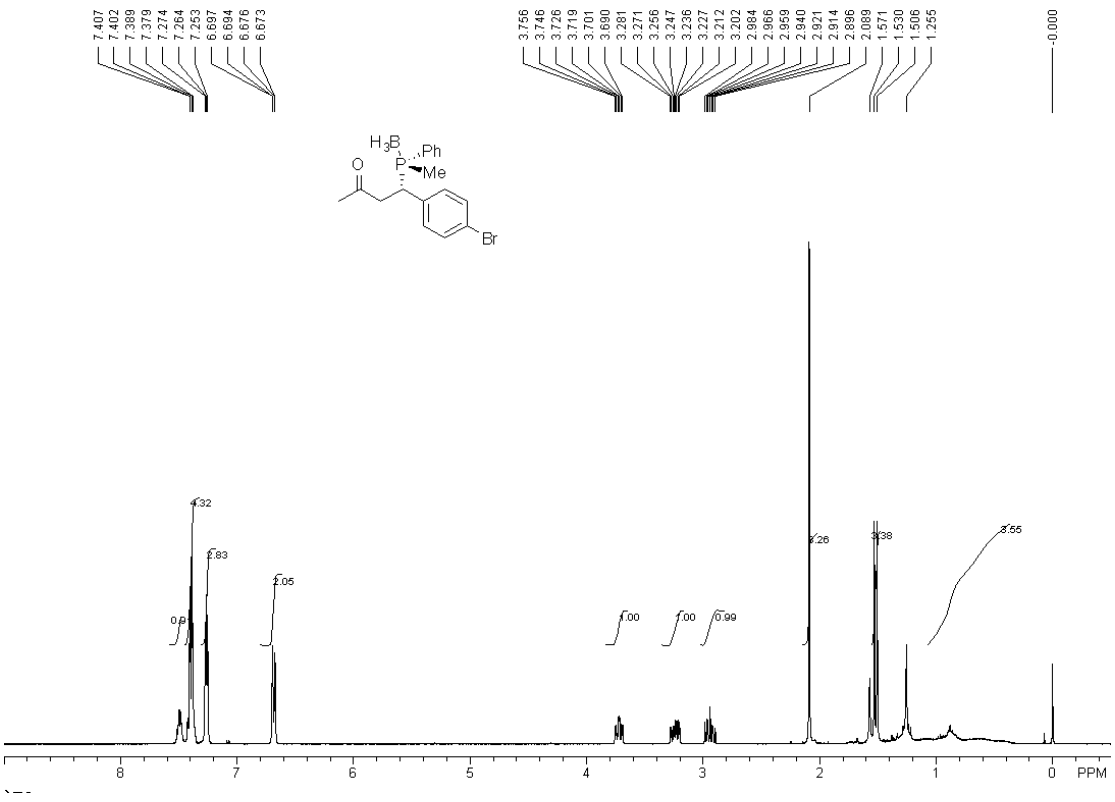
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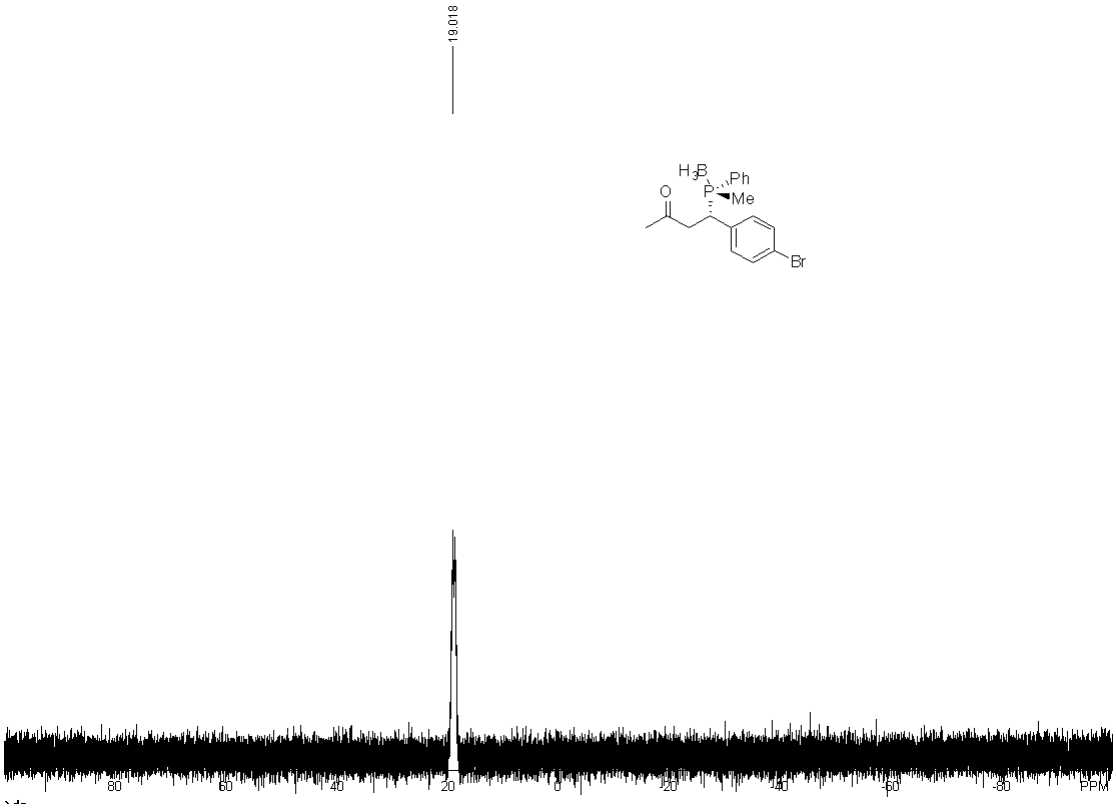
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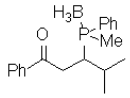
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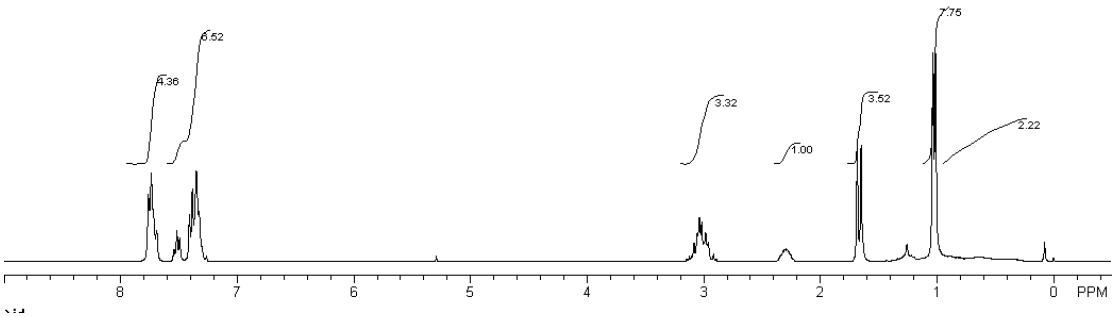
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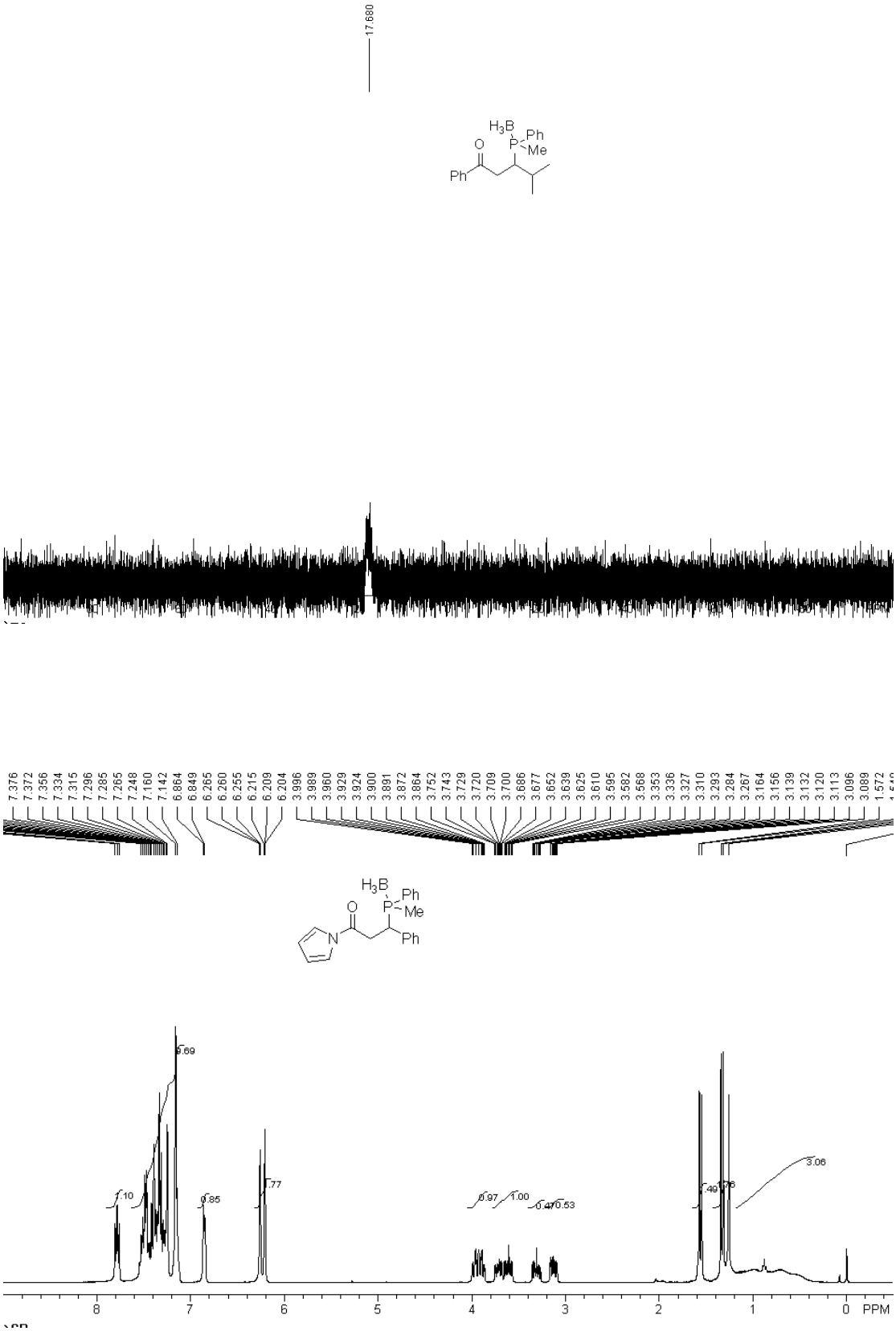
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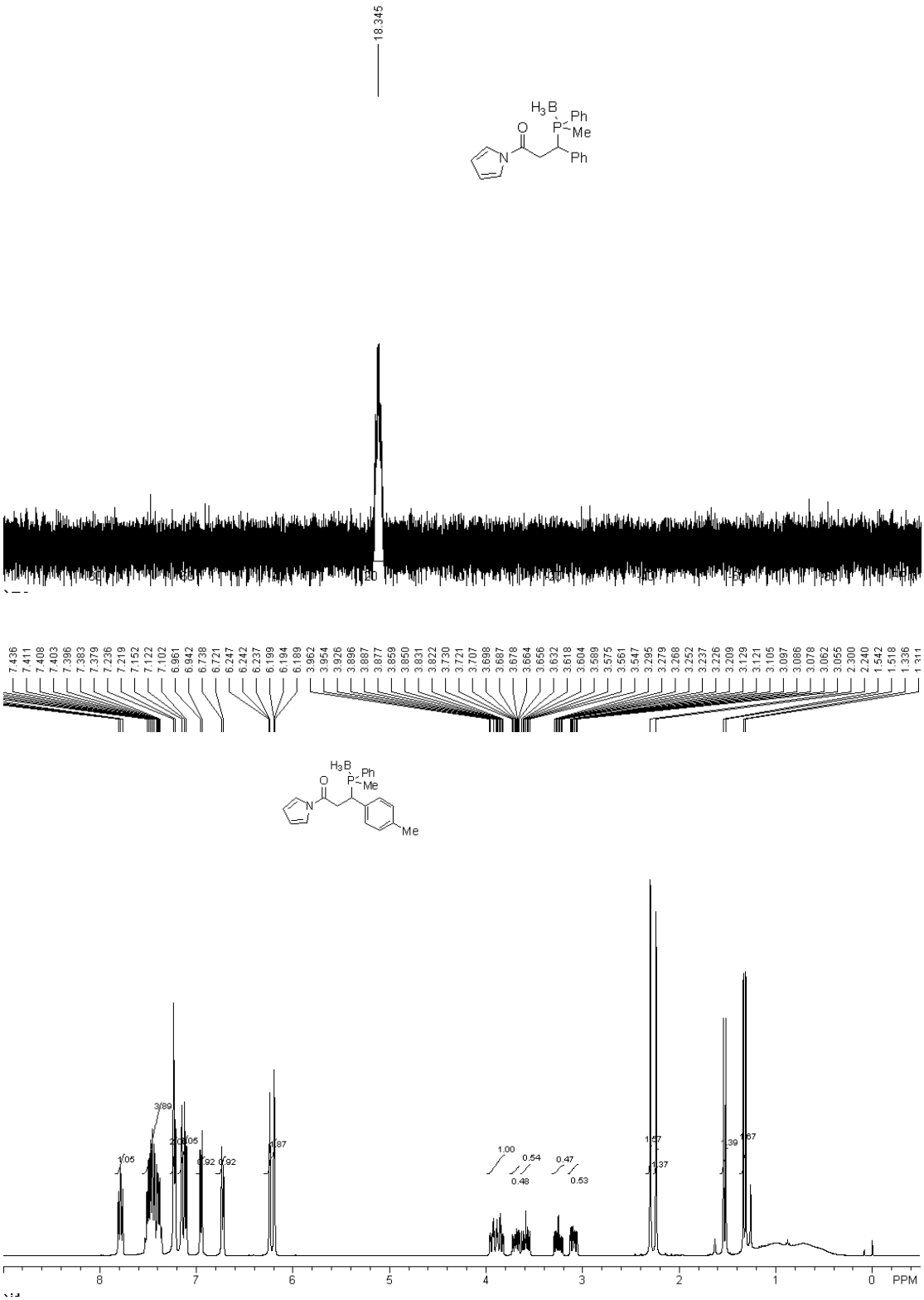
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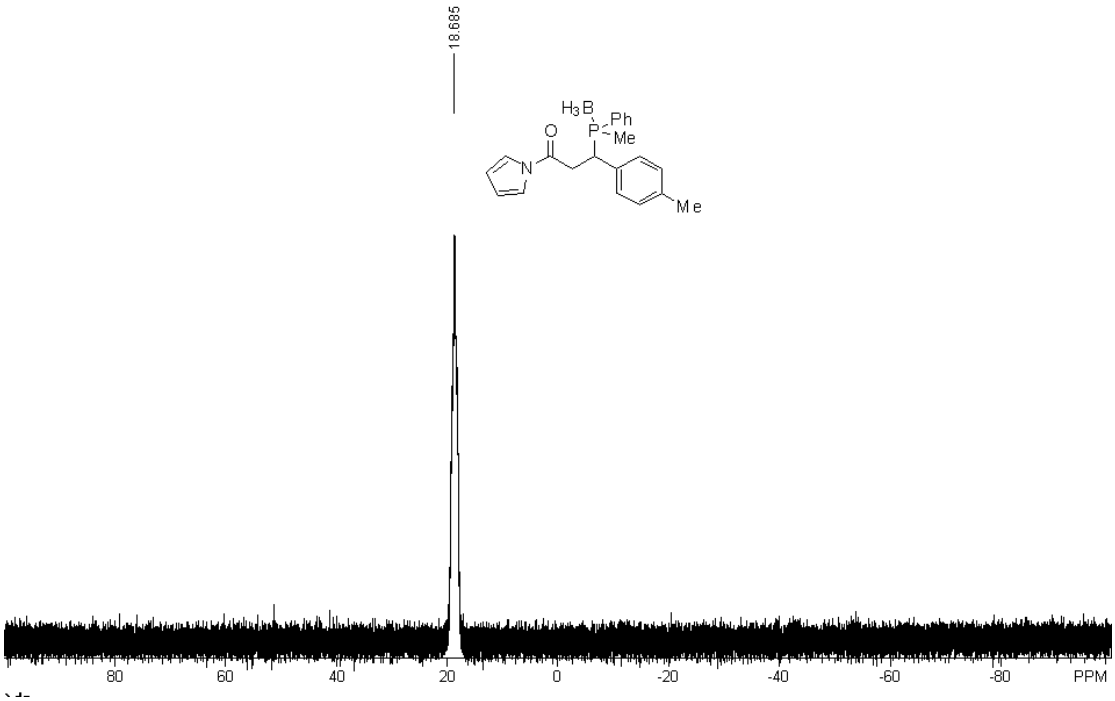
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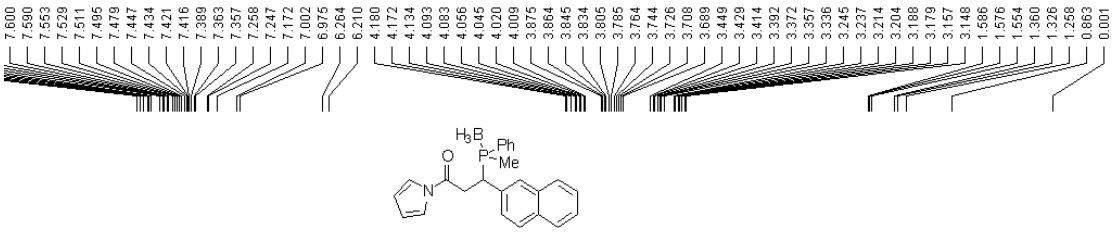
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Me
O
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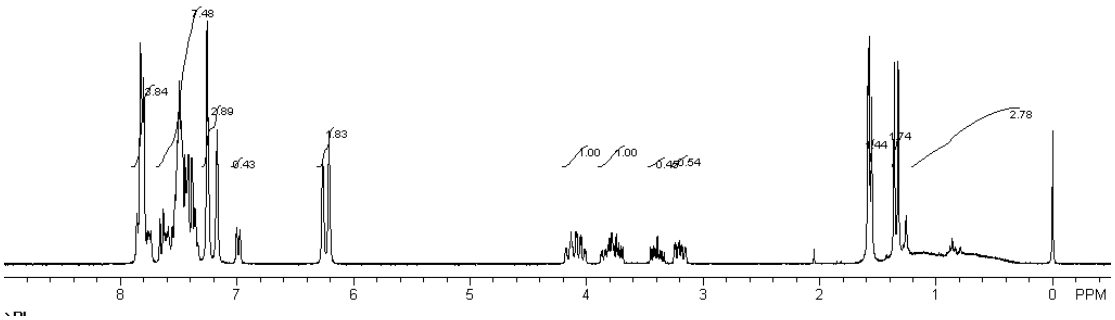
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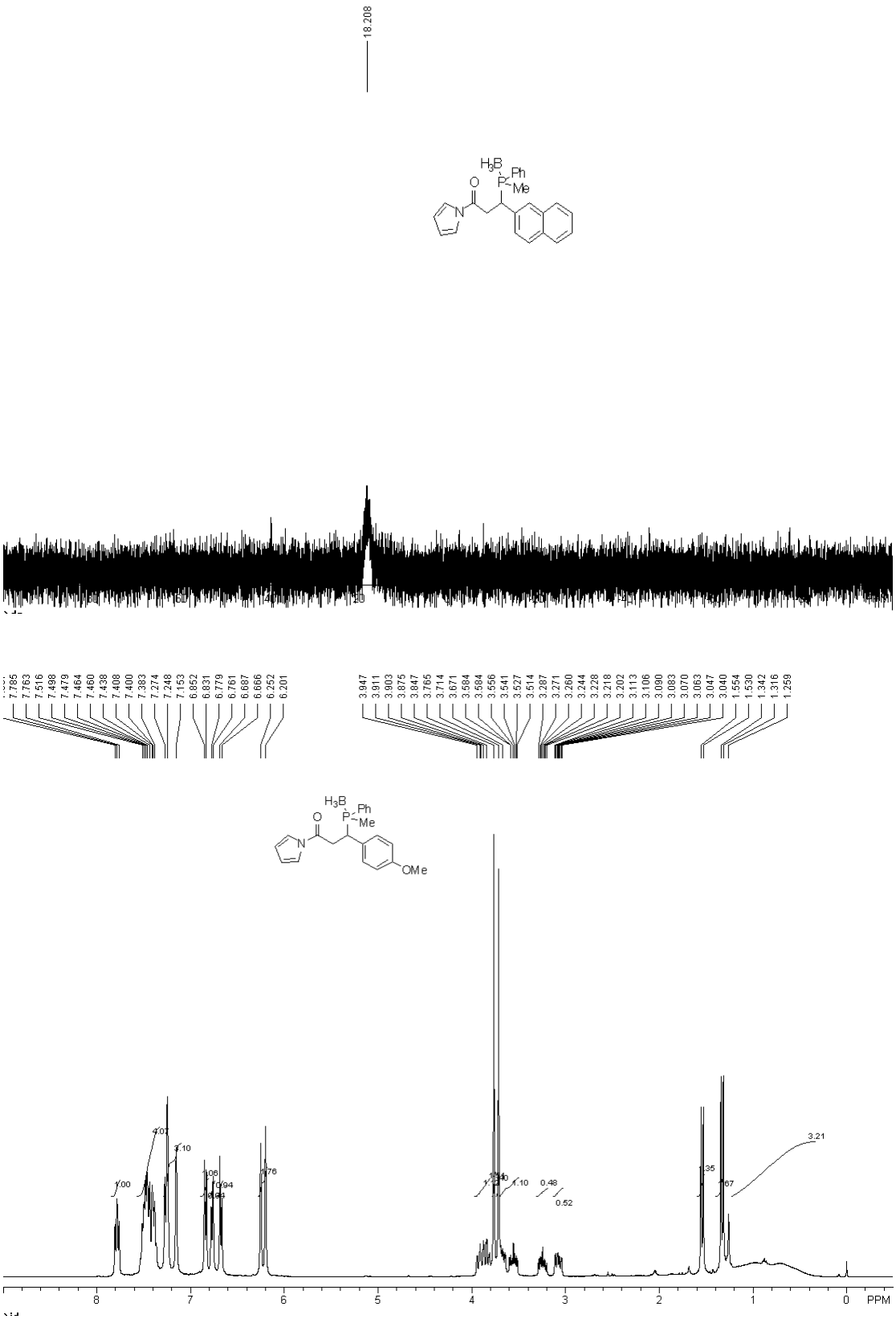
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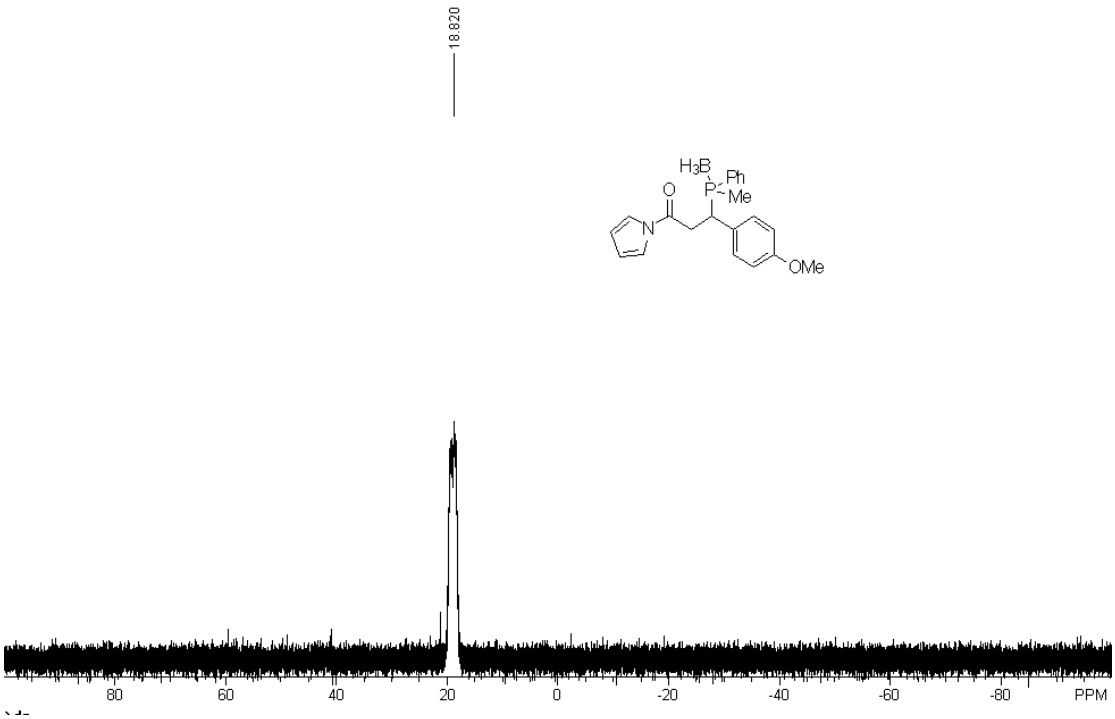
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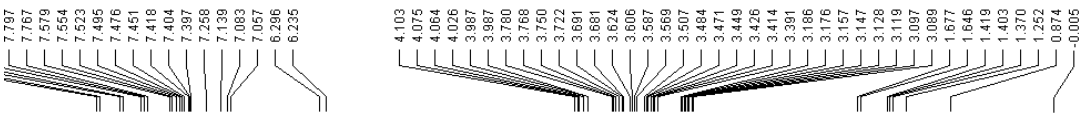
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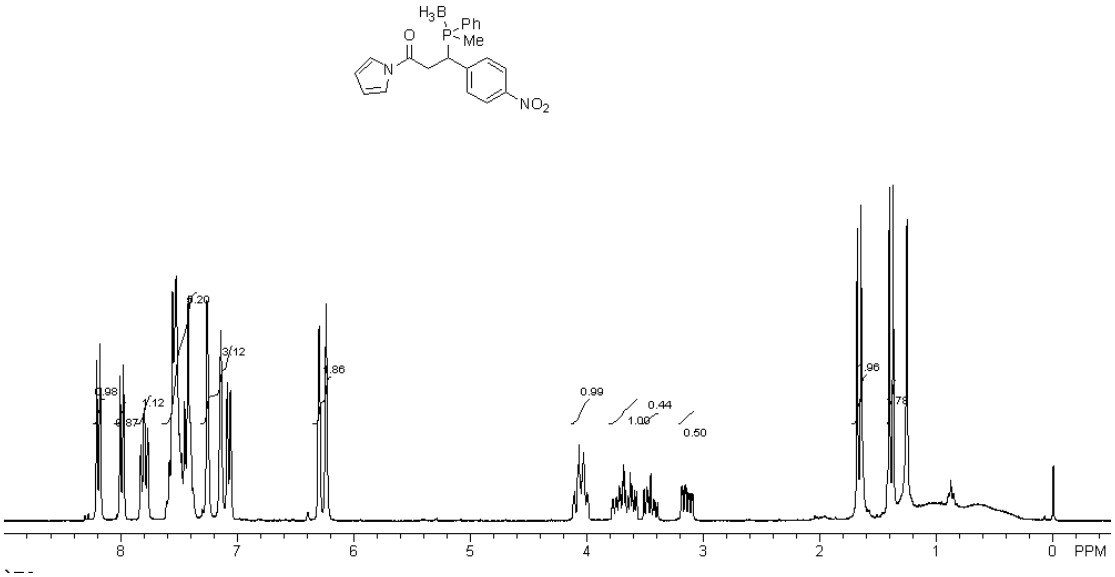
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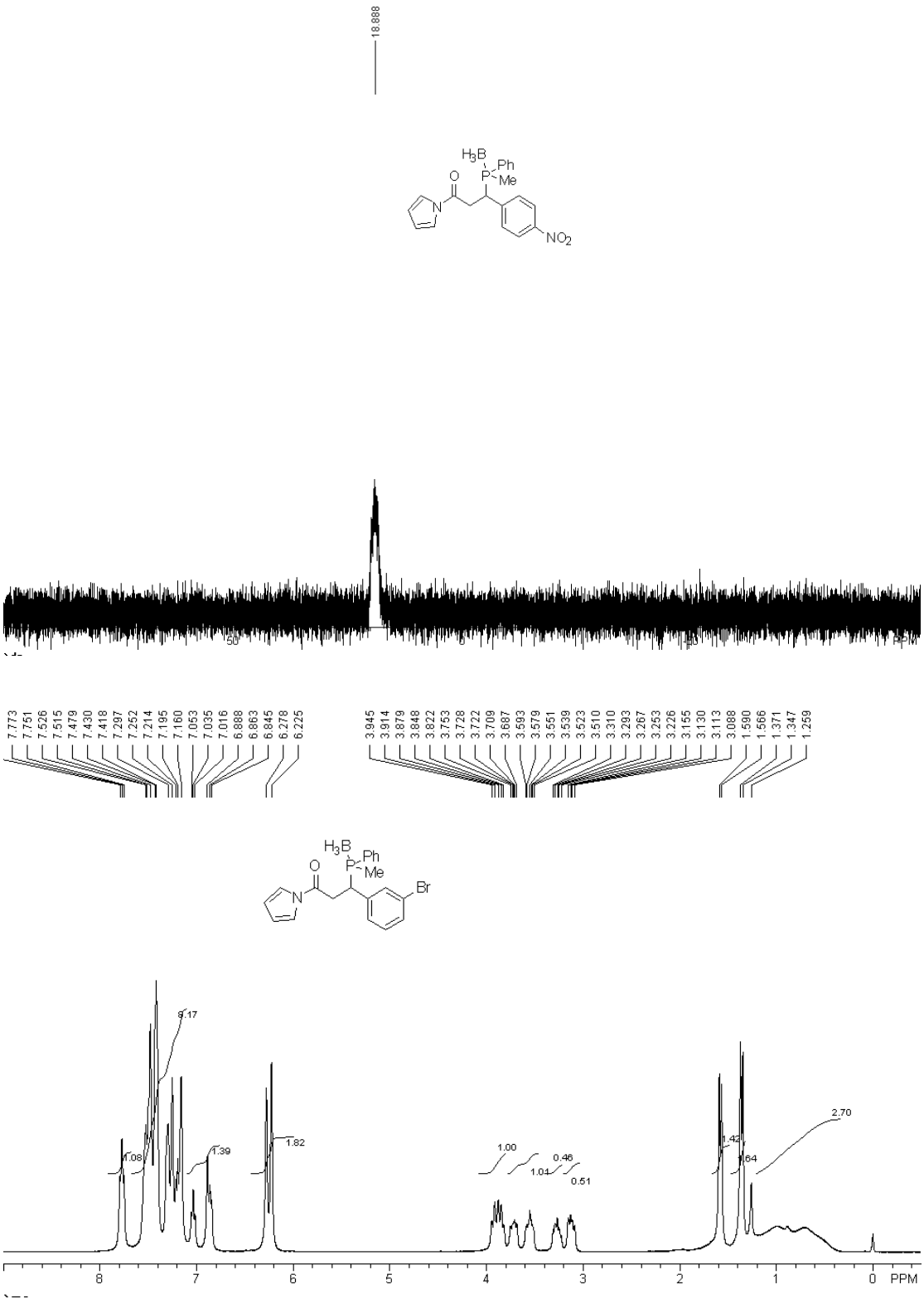
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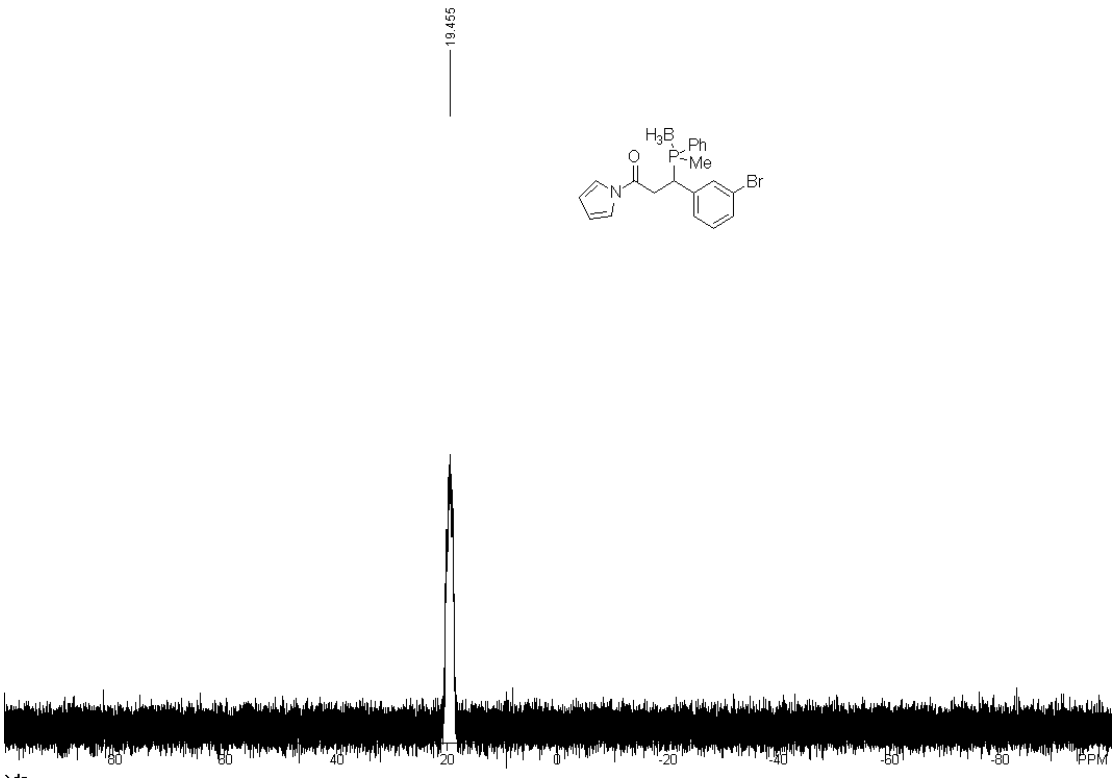
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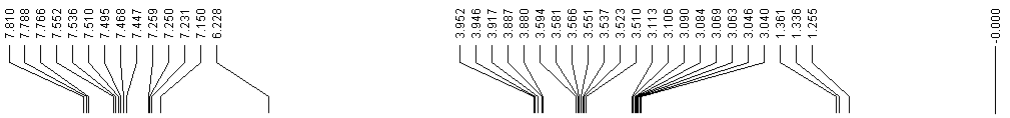
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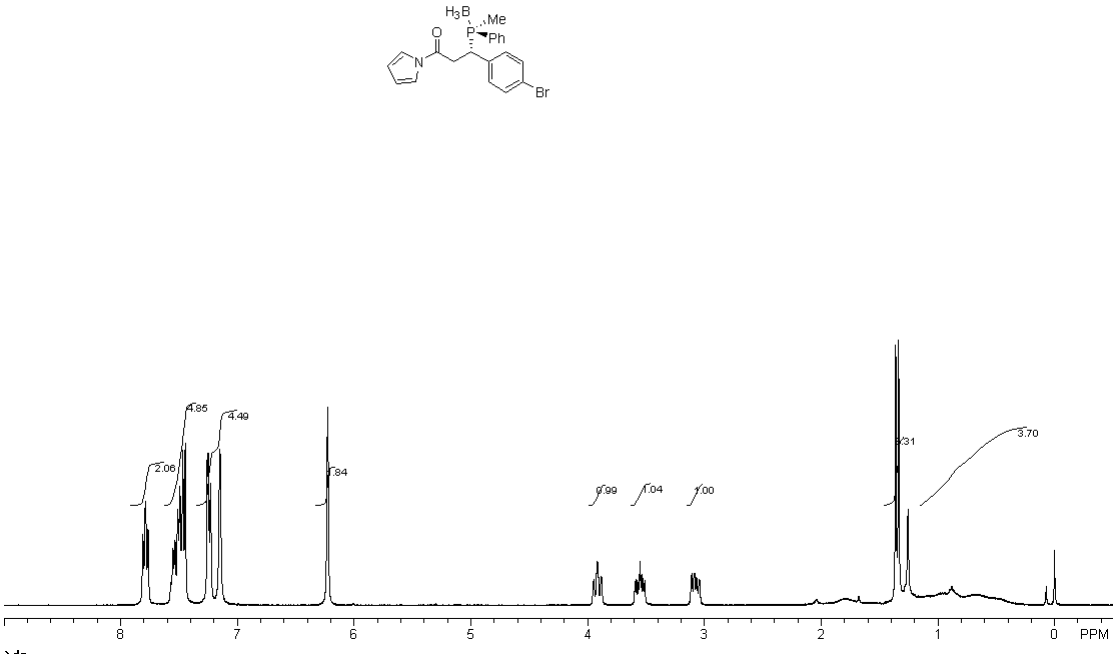
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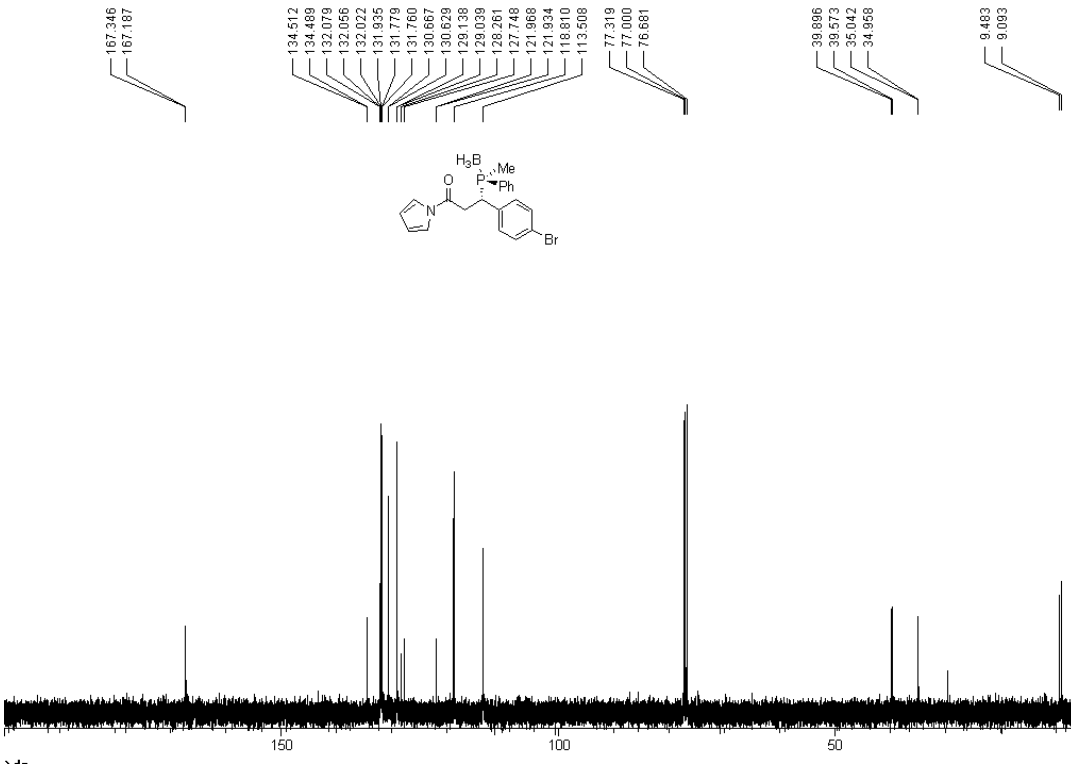
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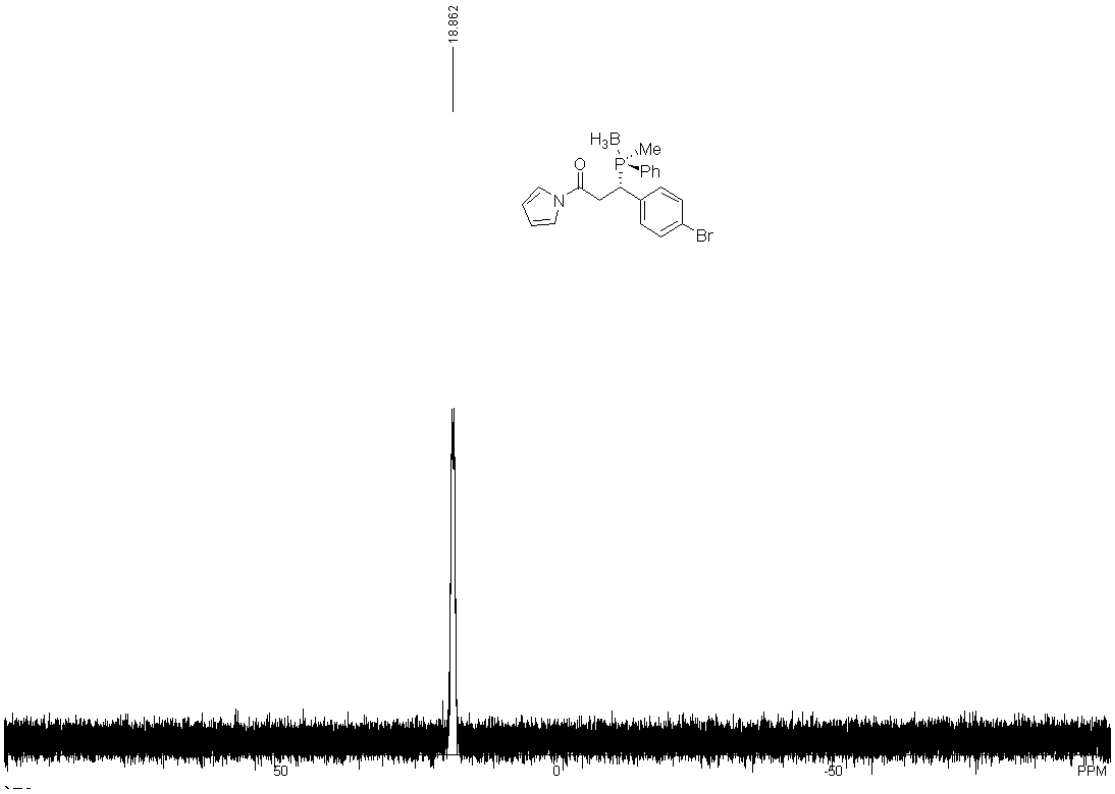
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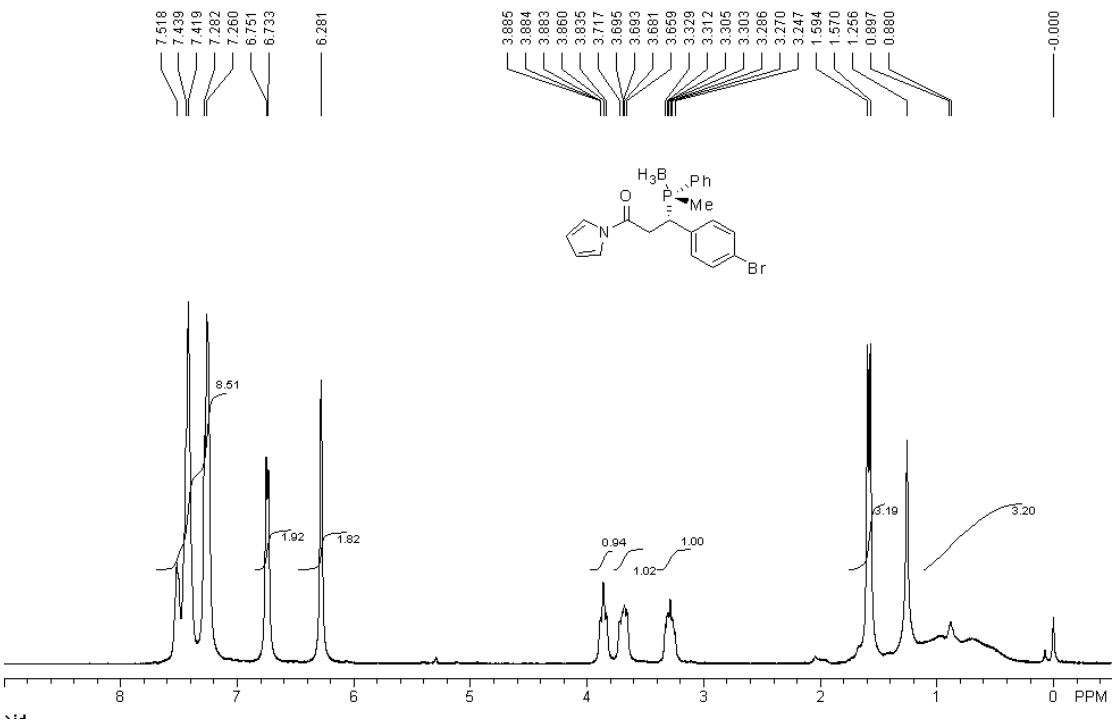
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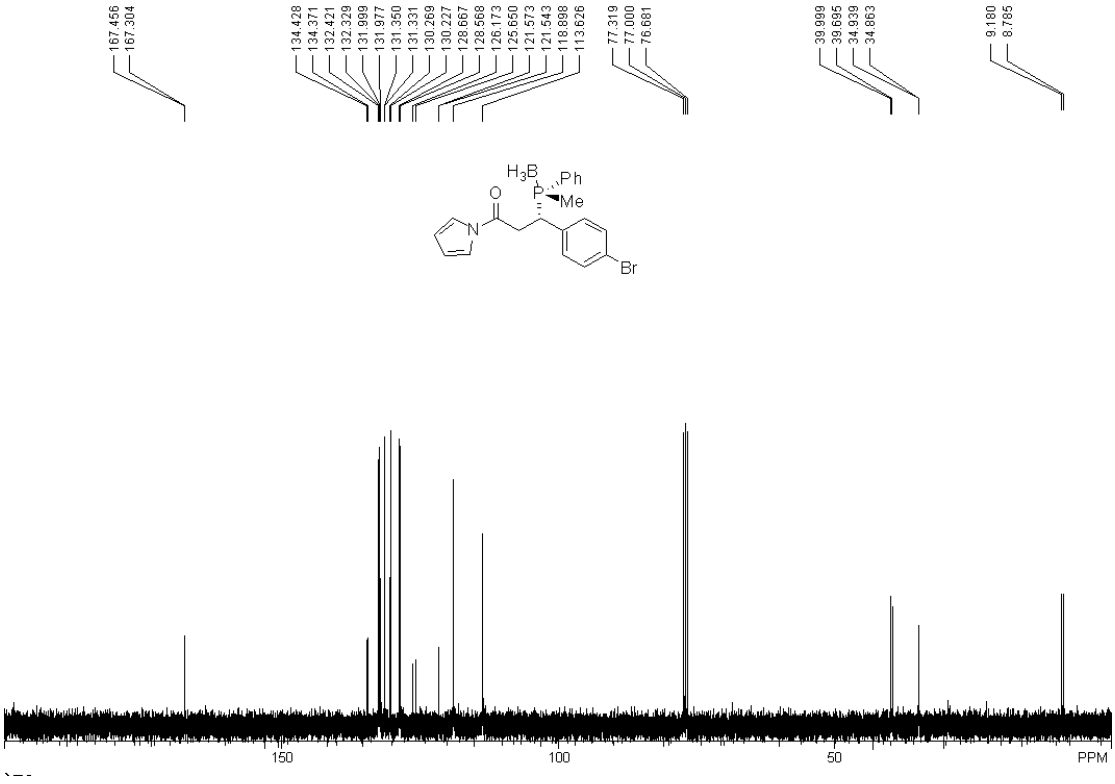
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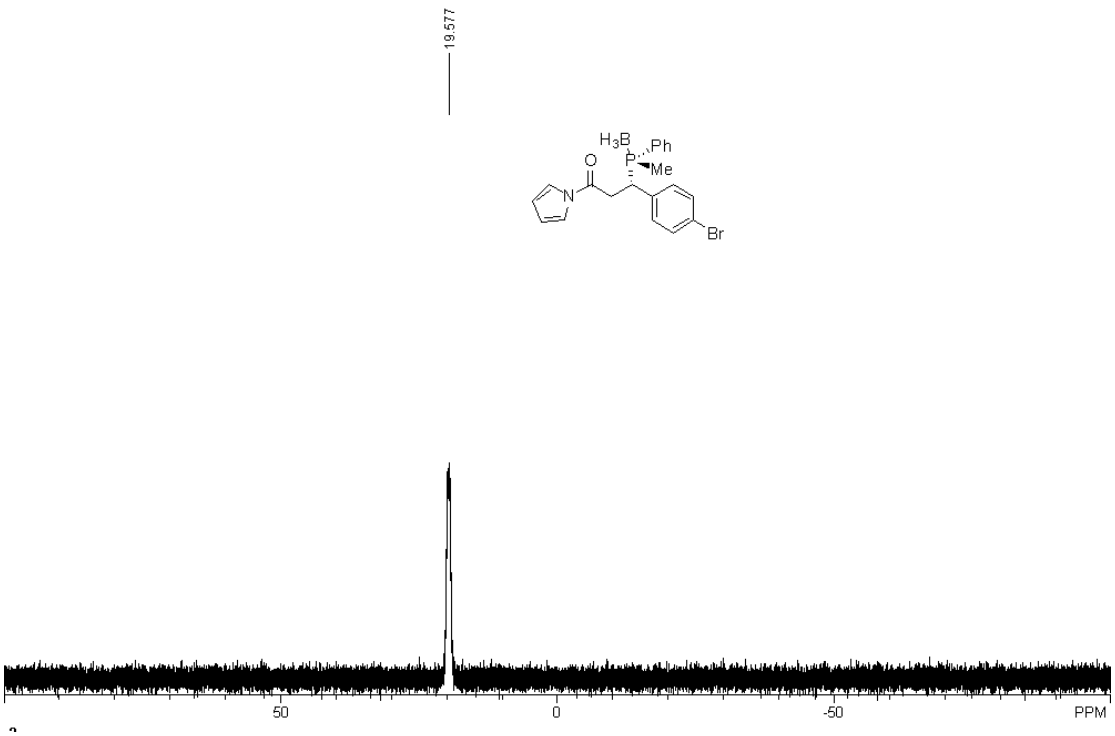
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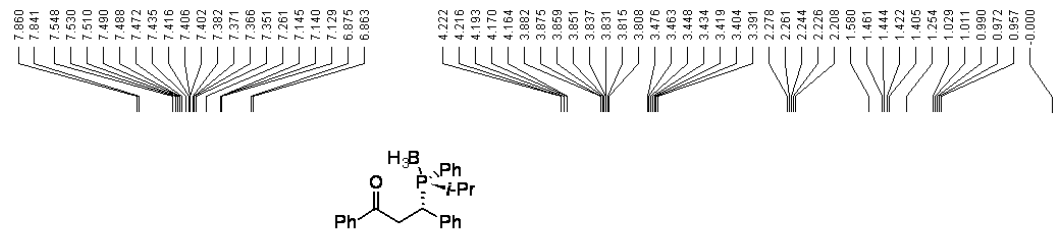
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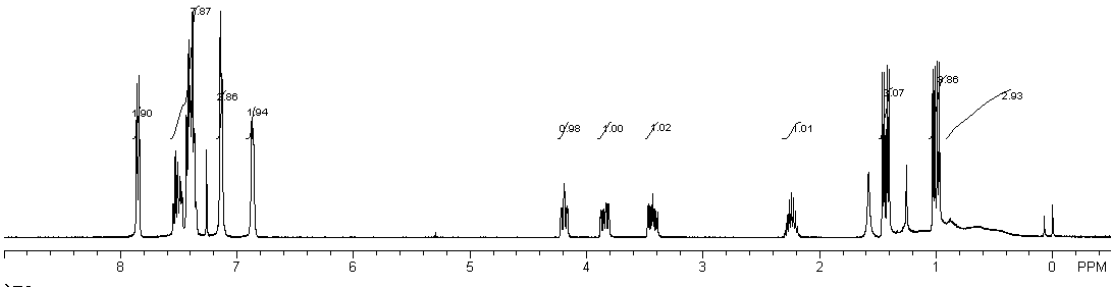
Ph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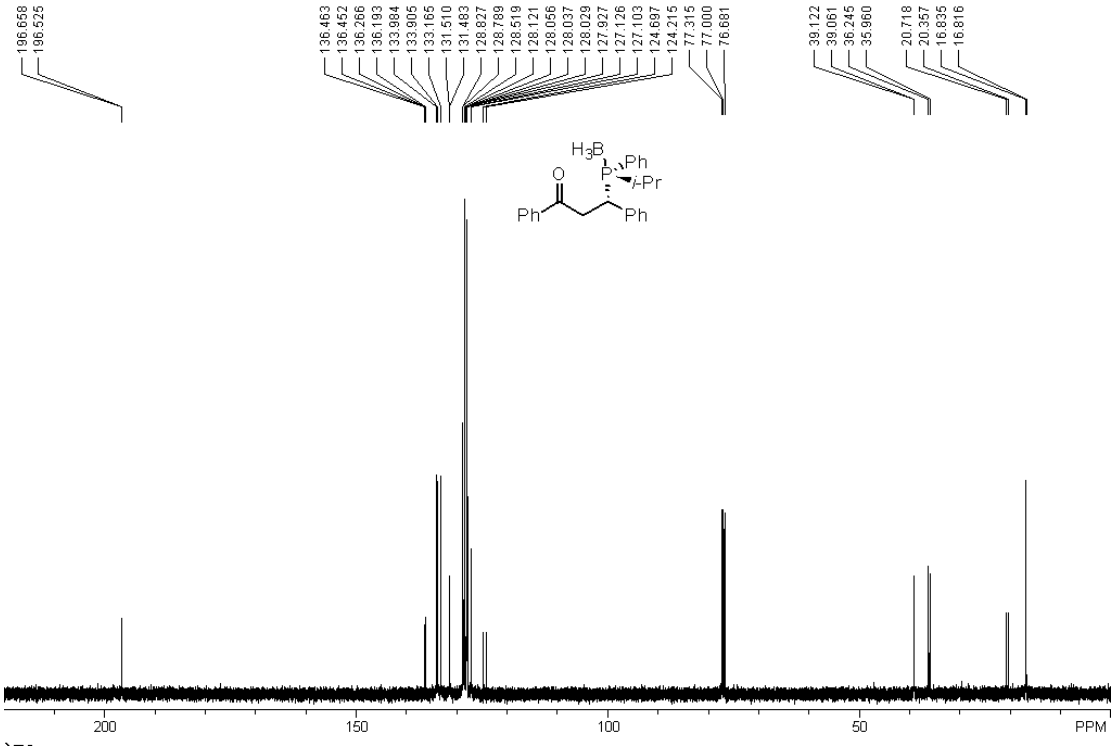
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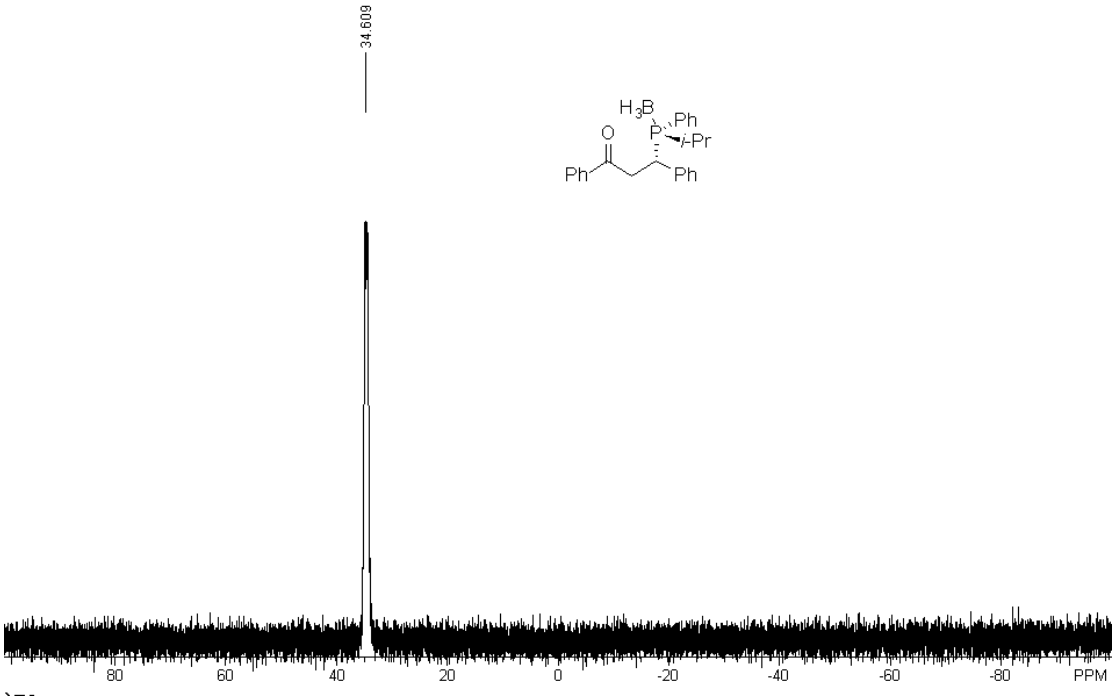
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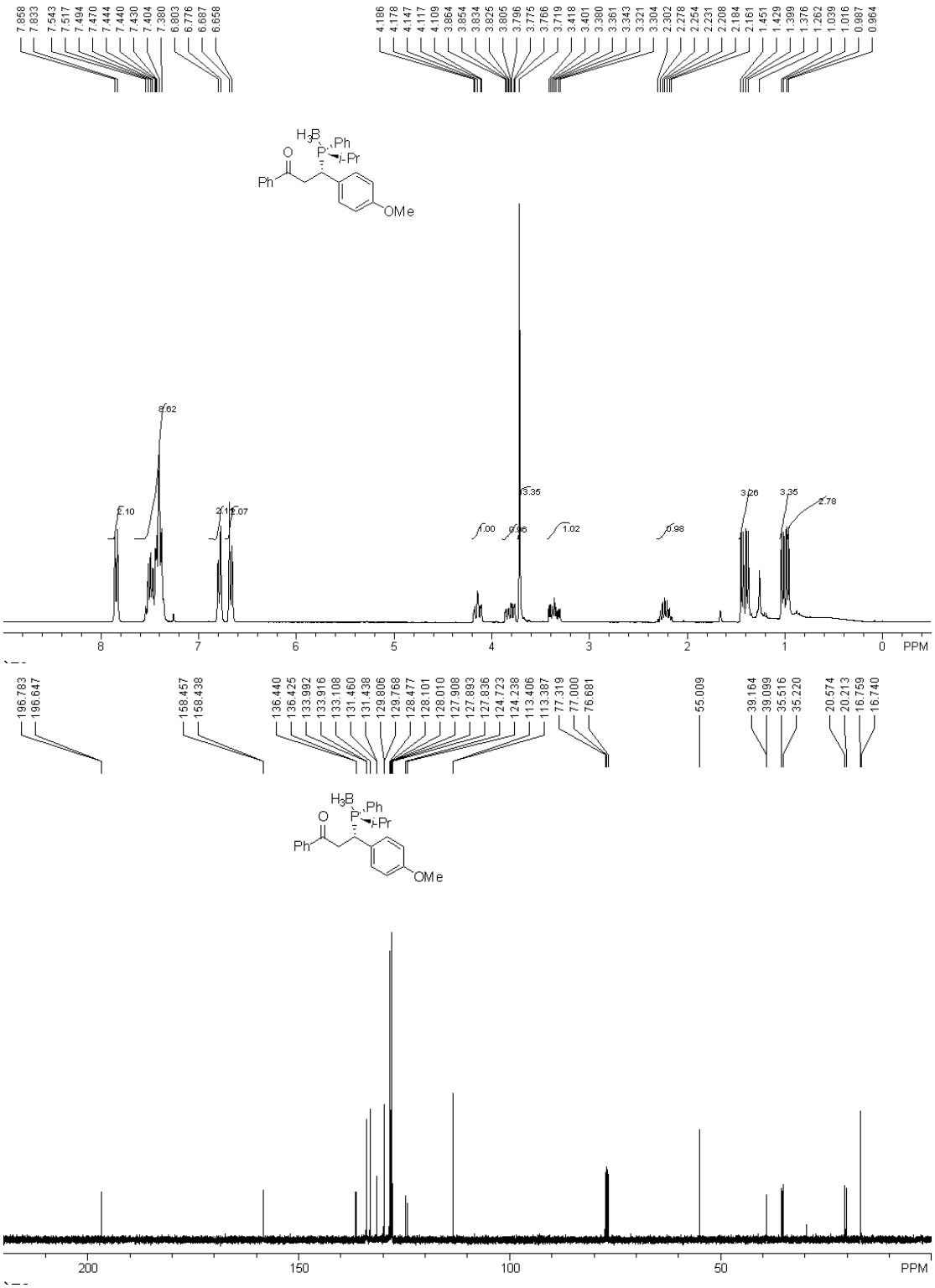
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Ph
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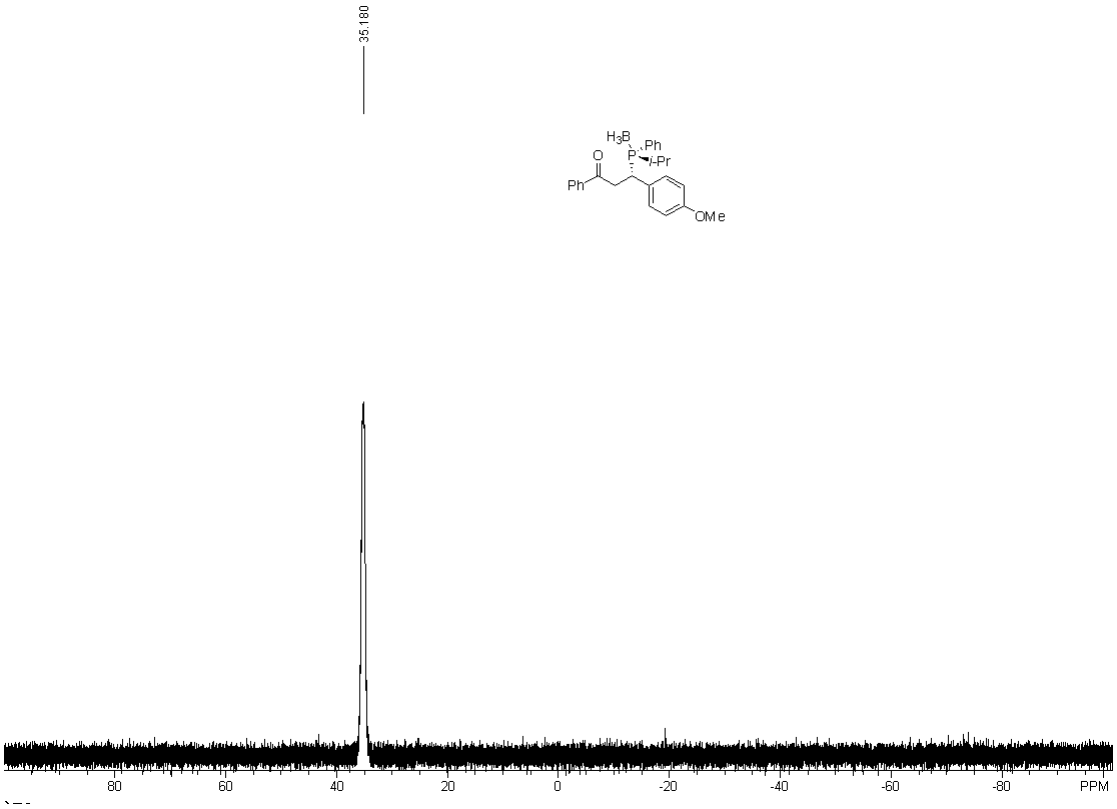
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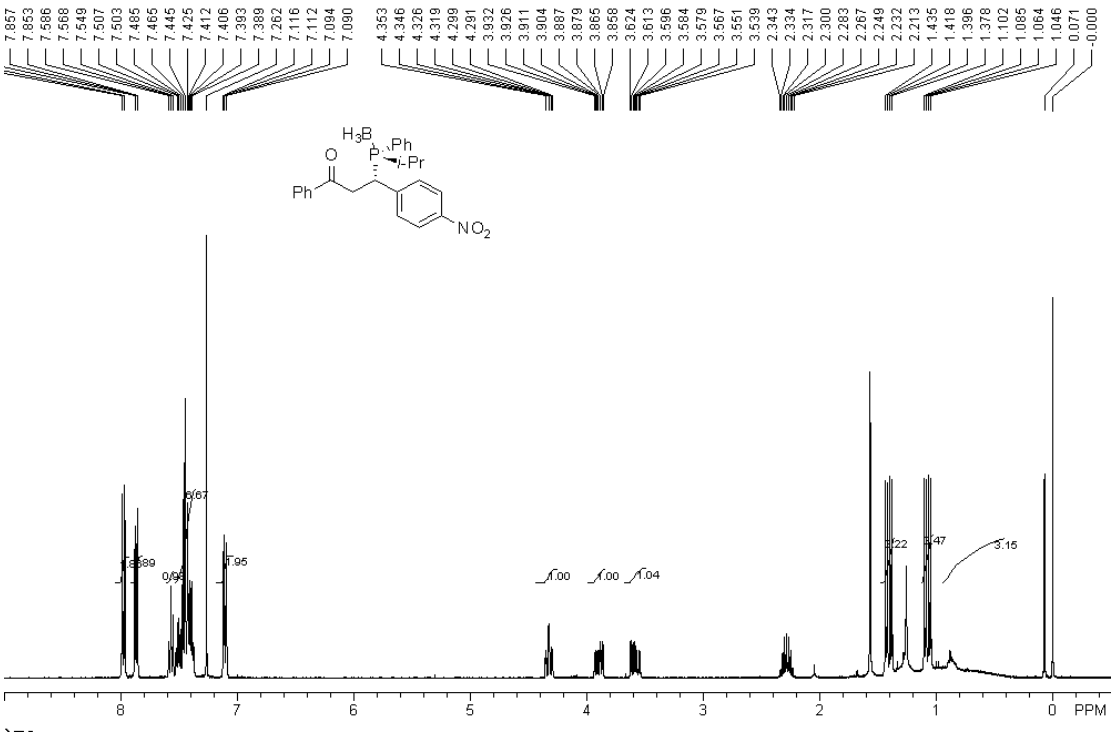
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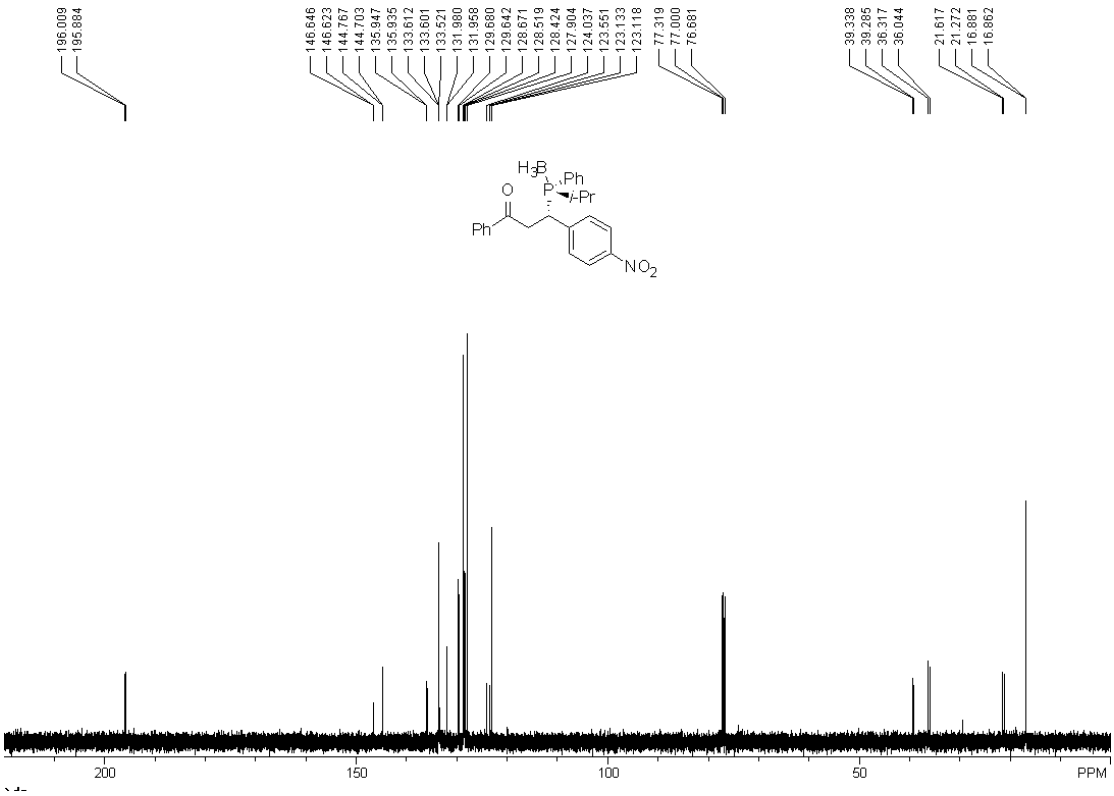
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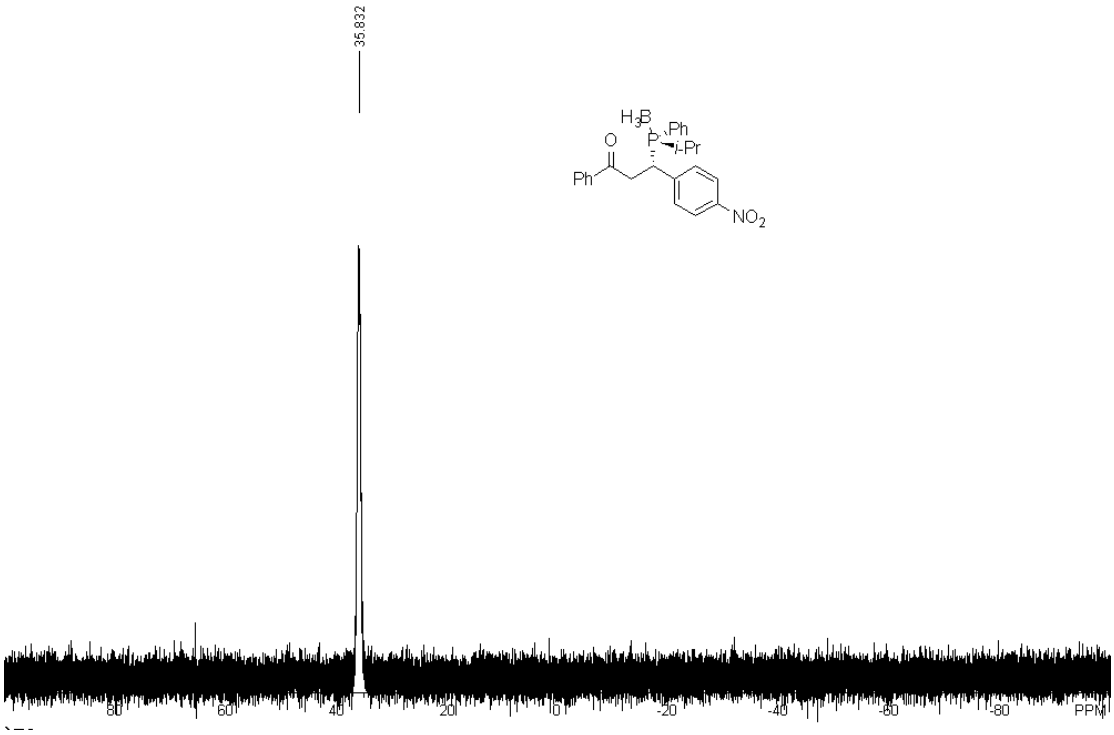
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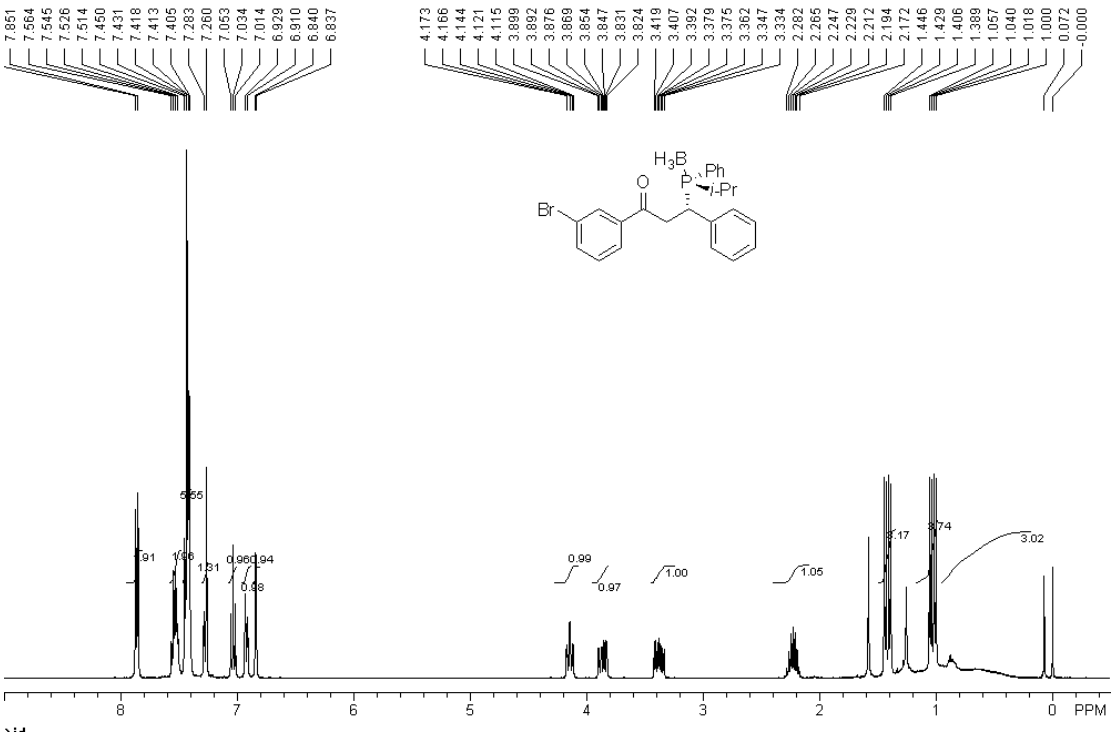
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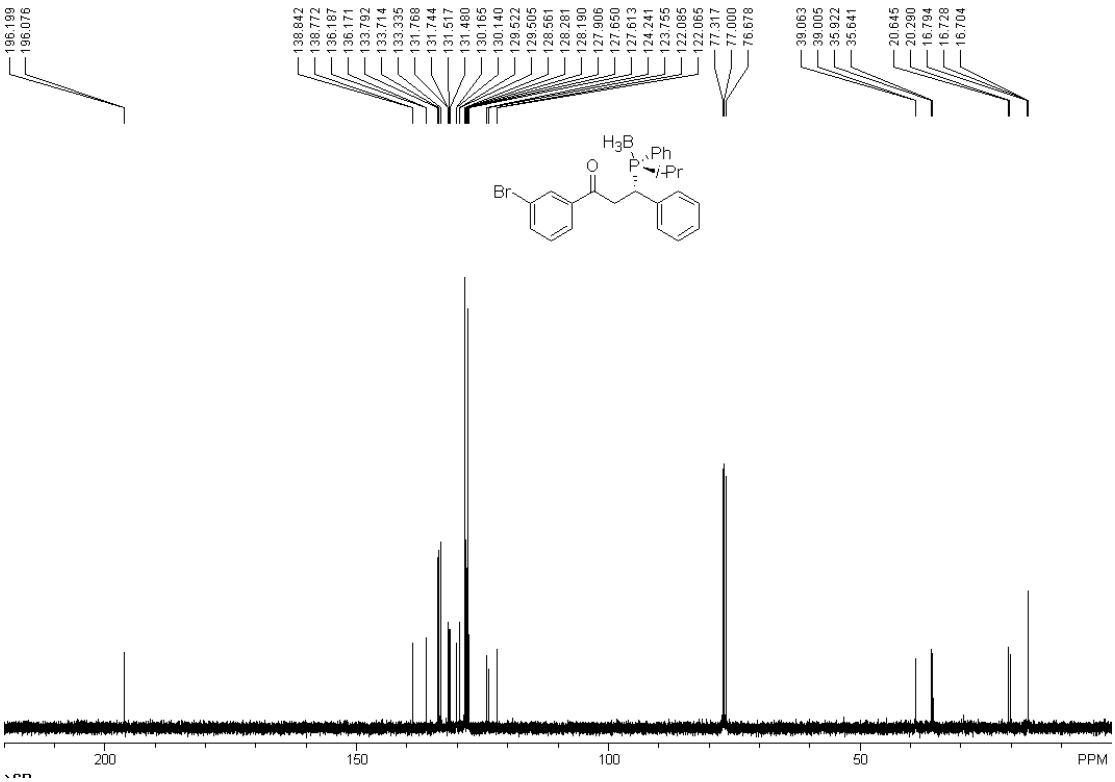
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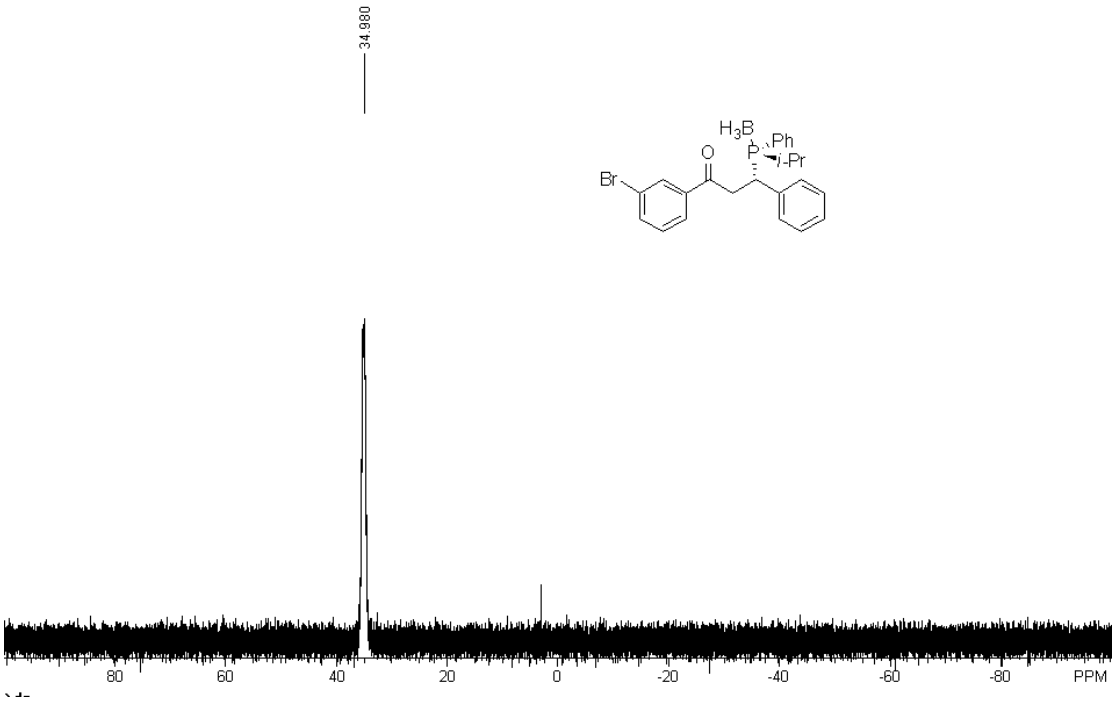
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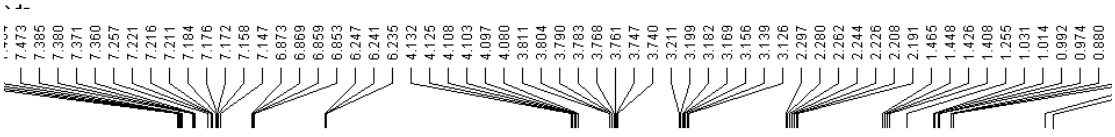
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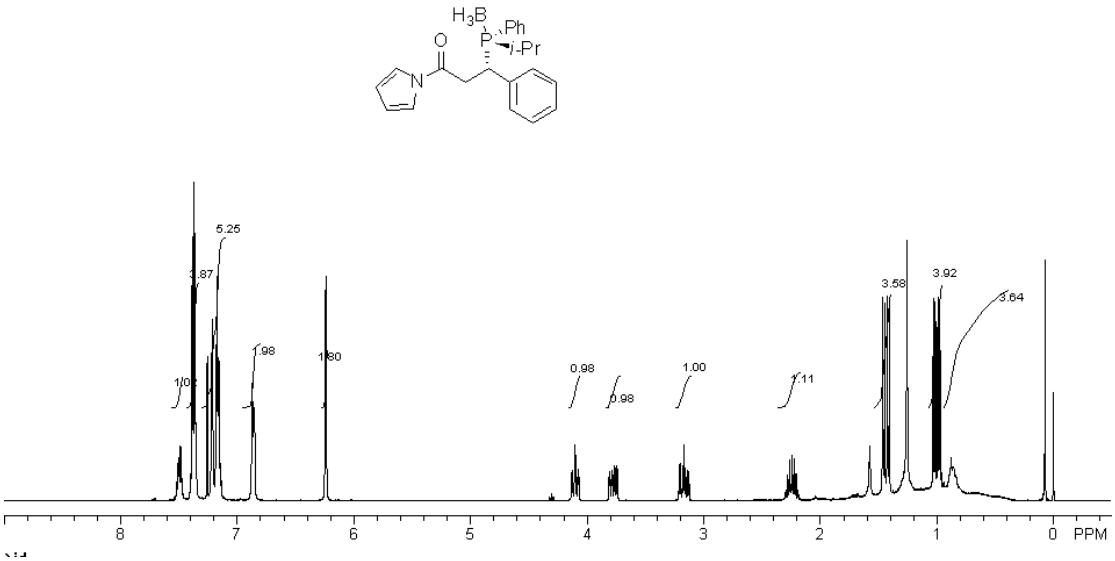
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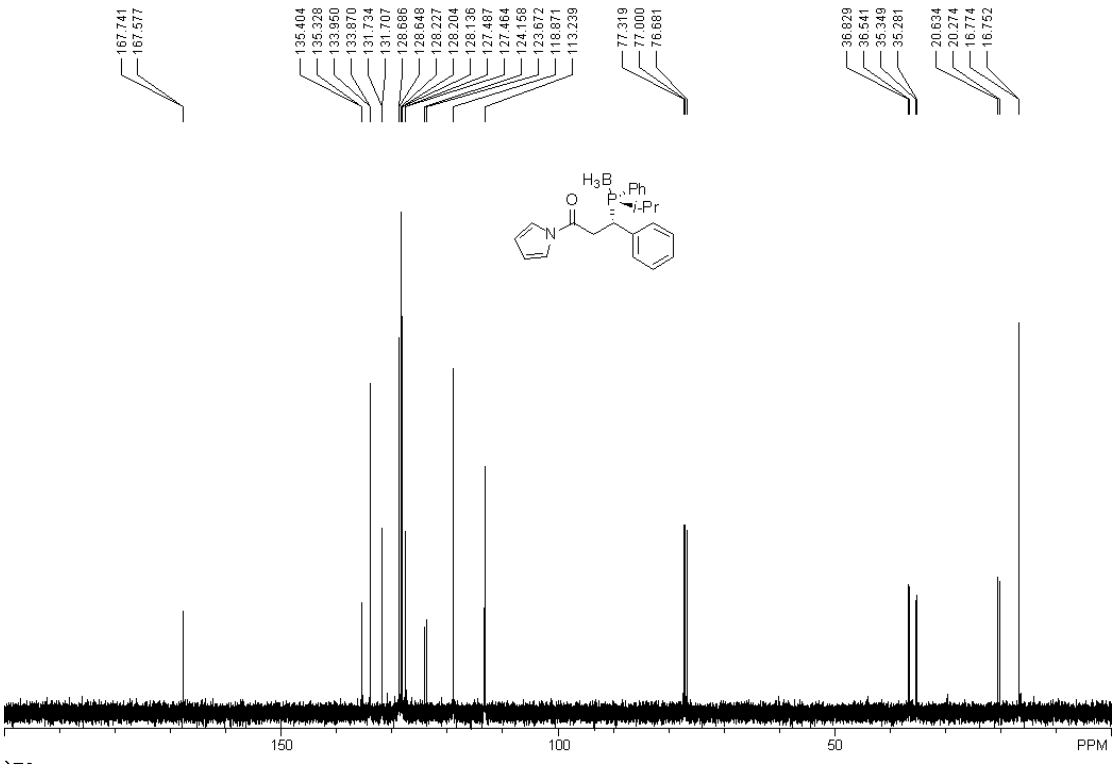
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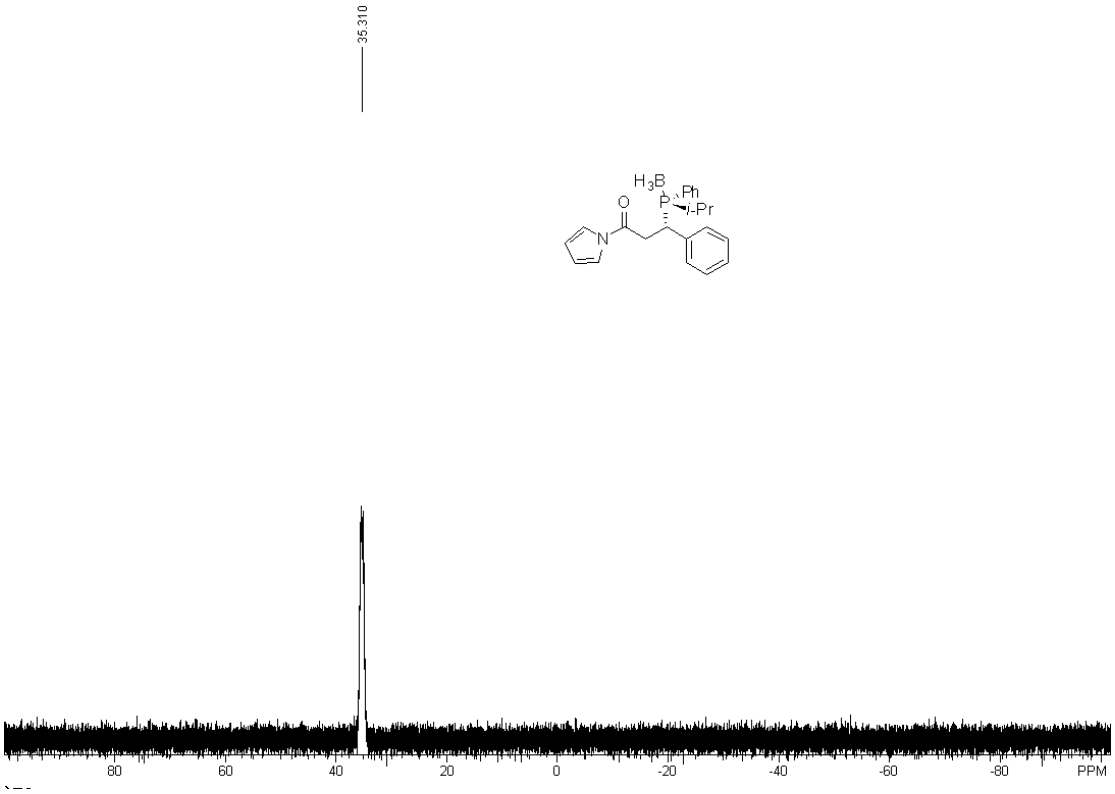
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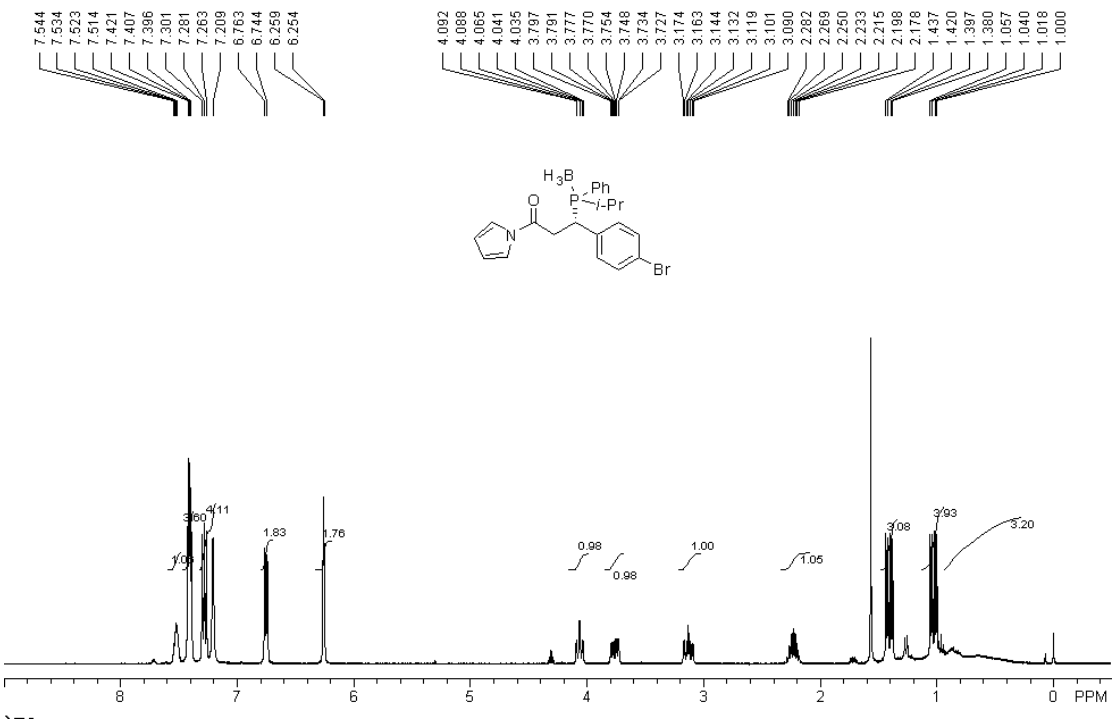
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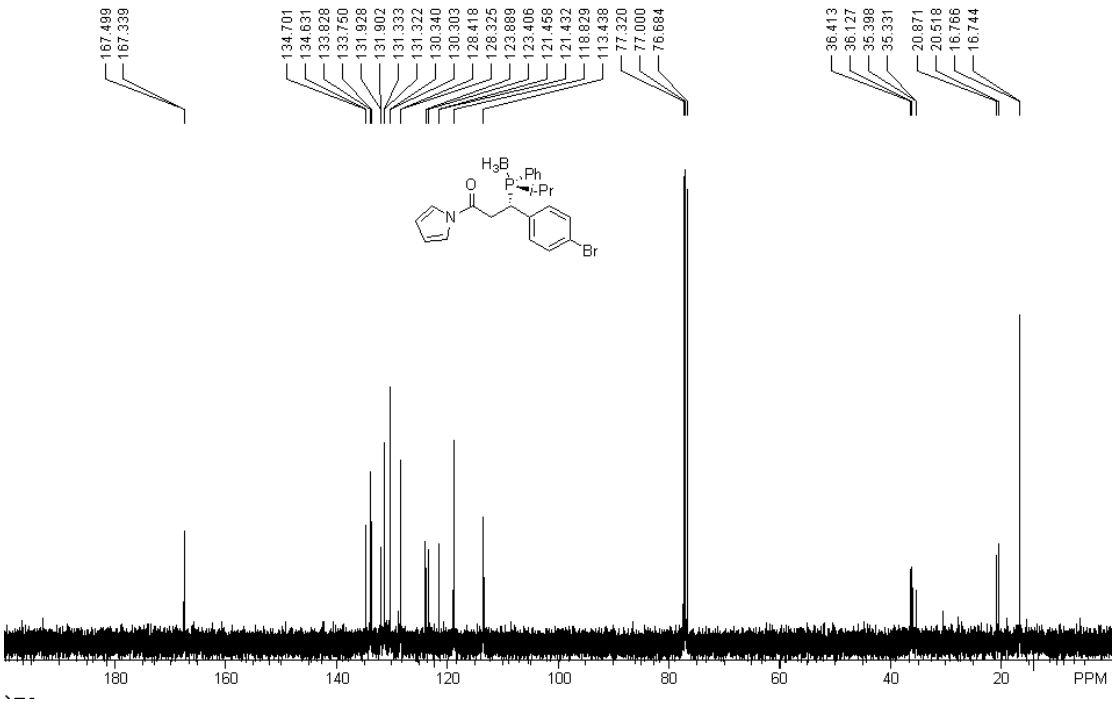
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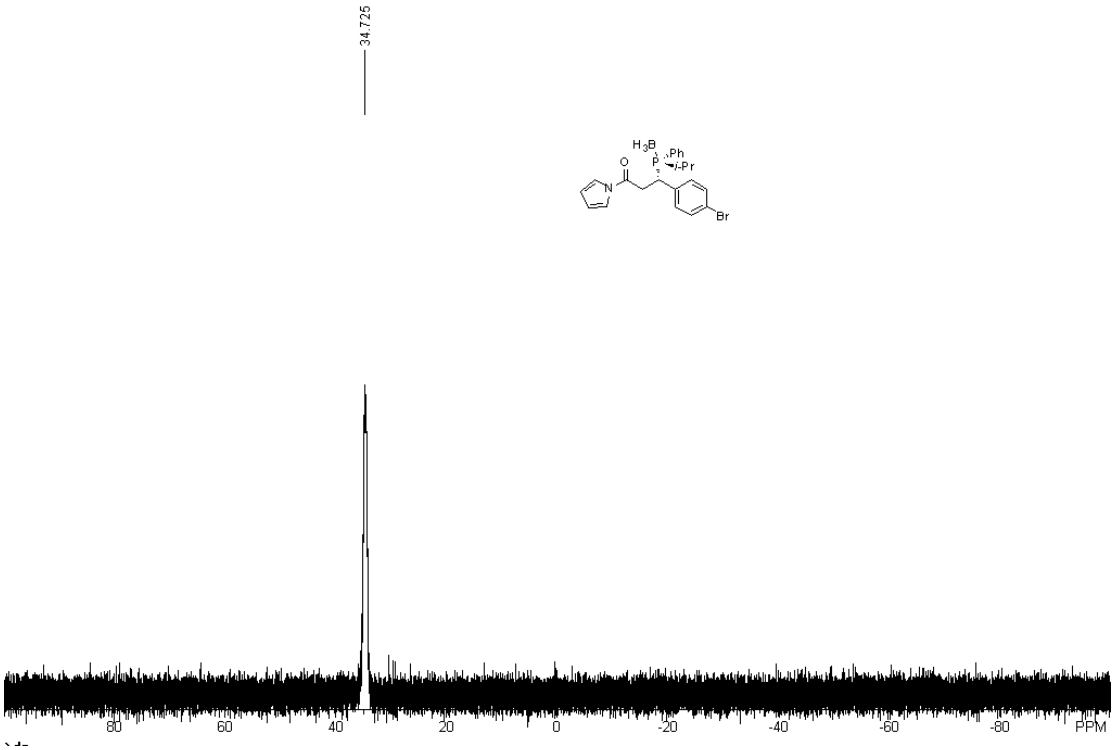
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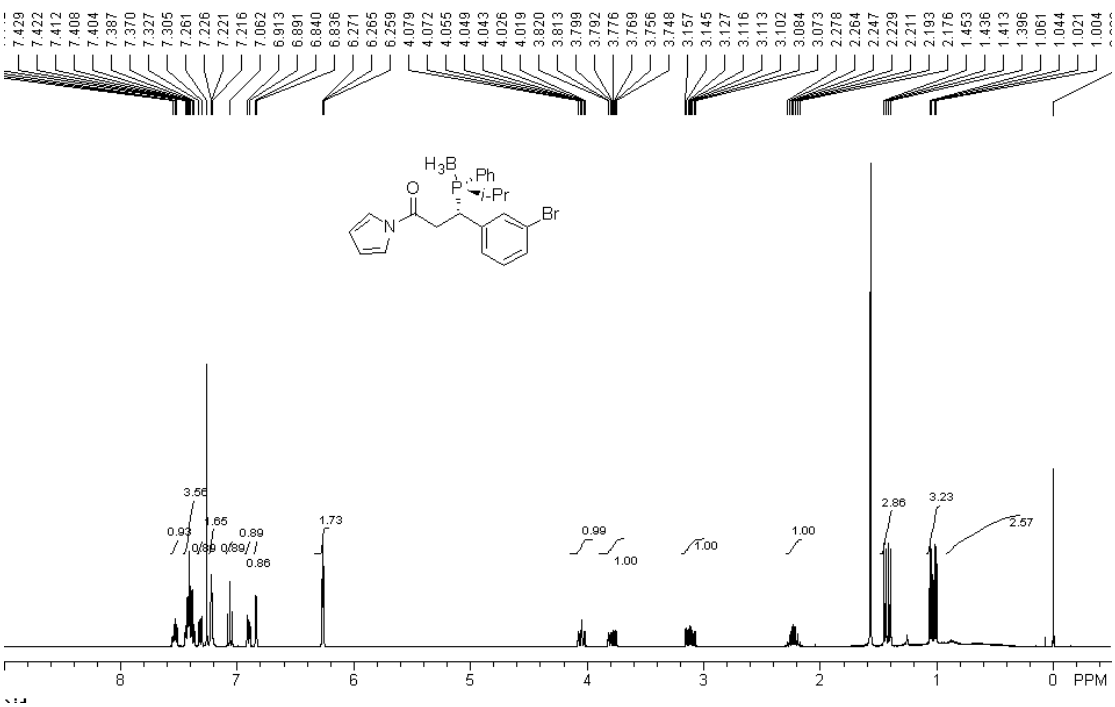
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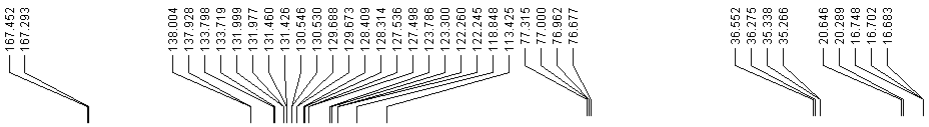
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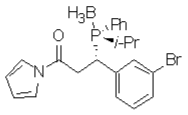
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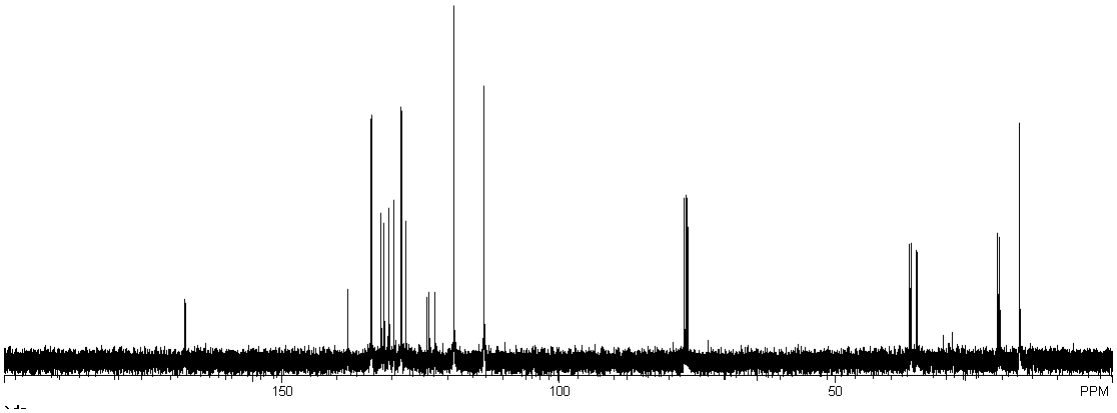
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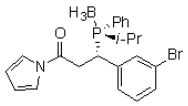
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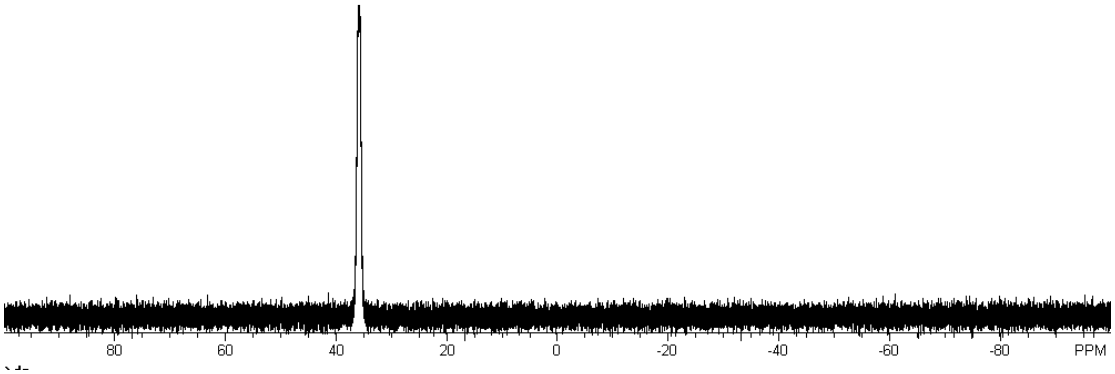
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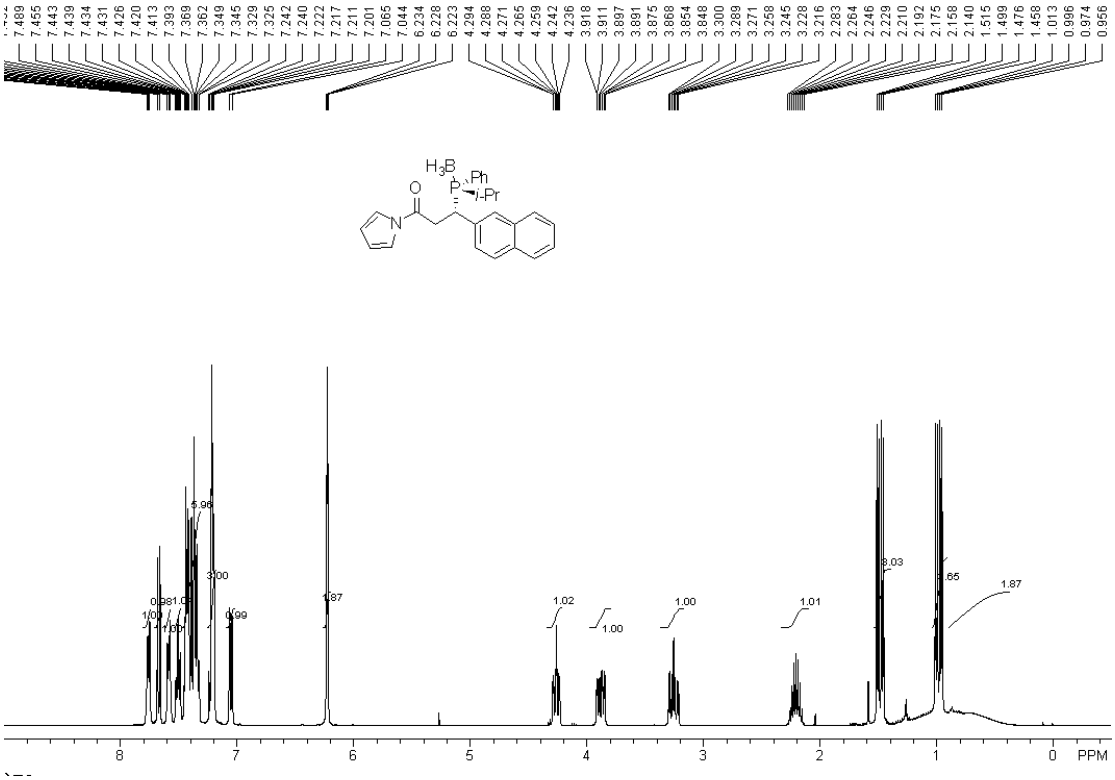
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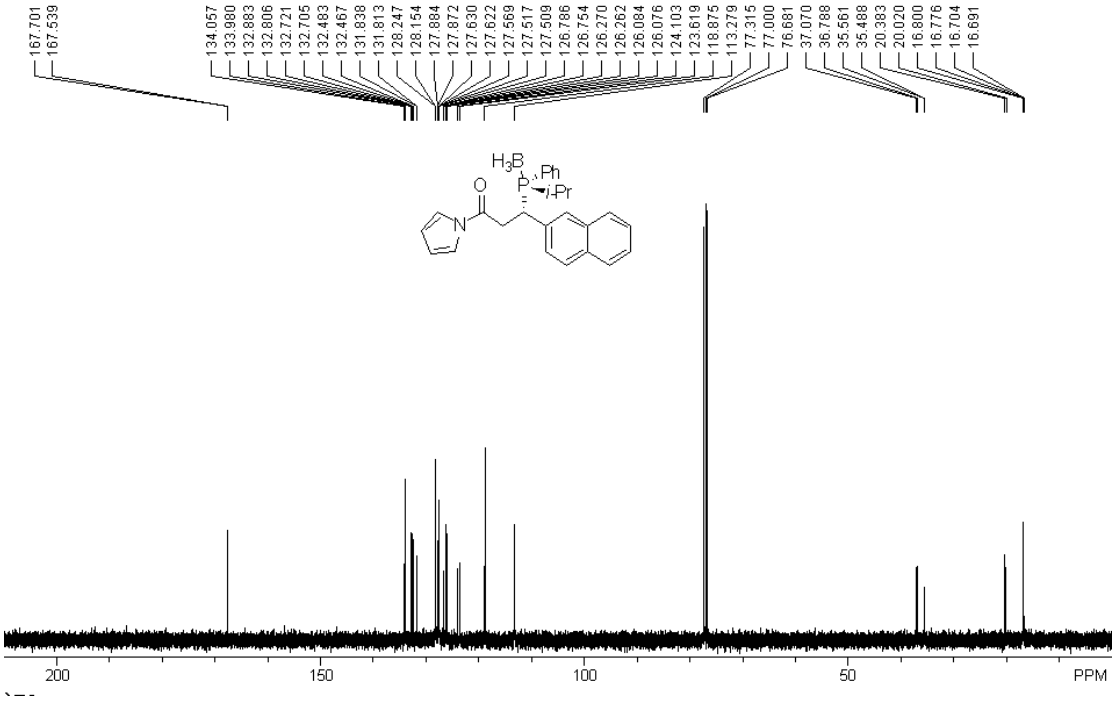
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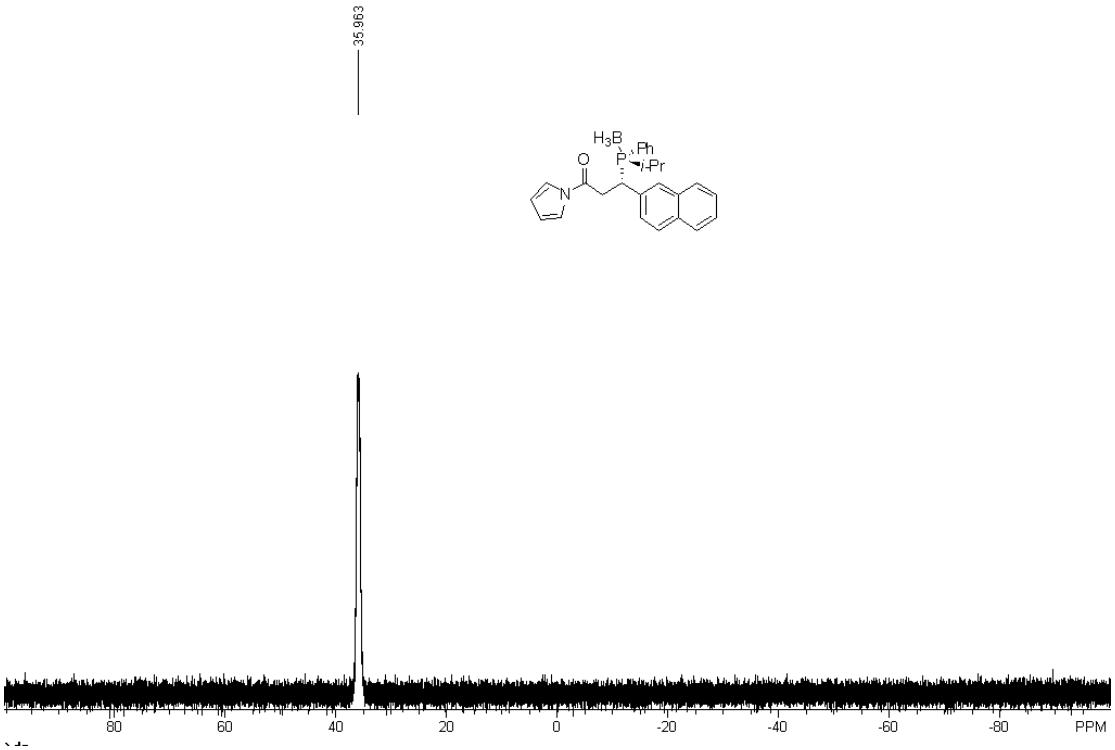
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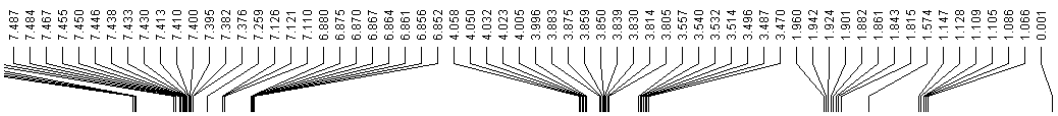
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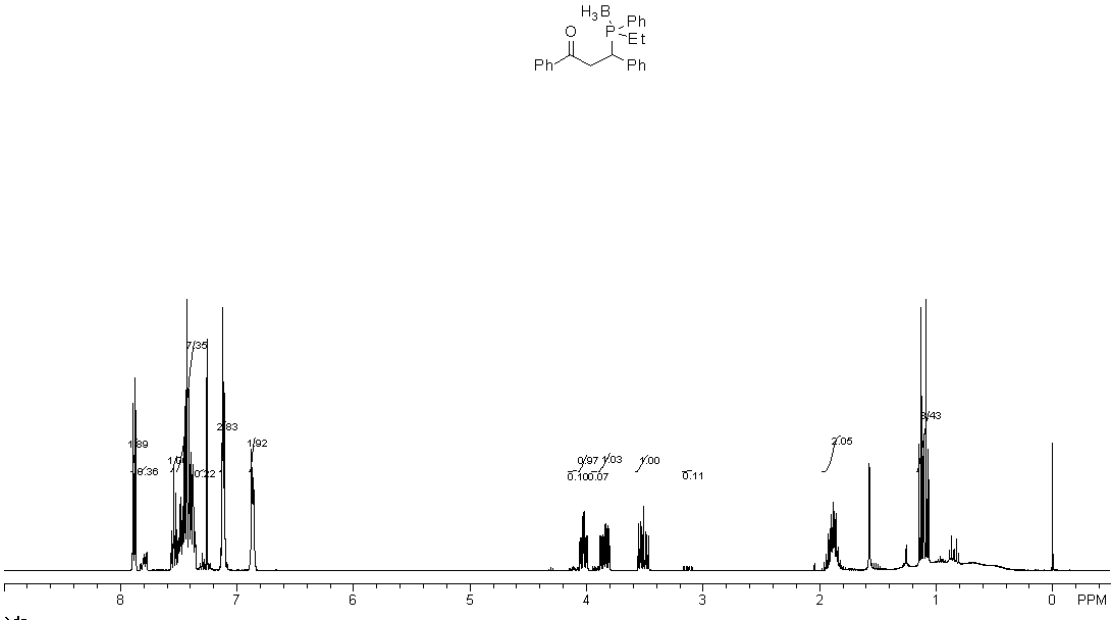
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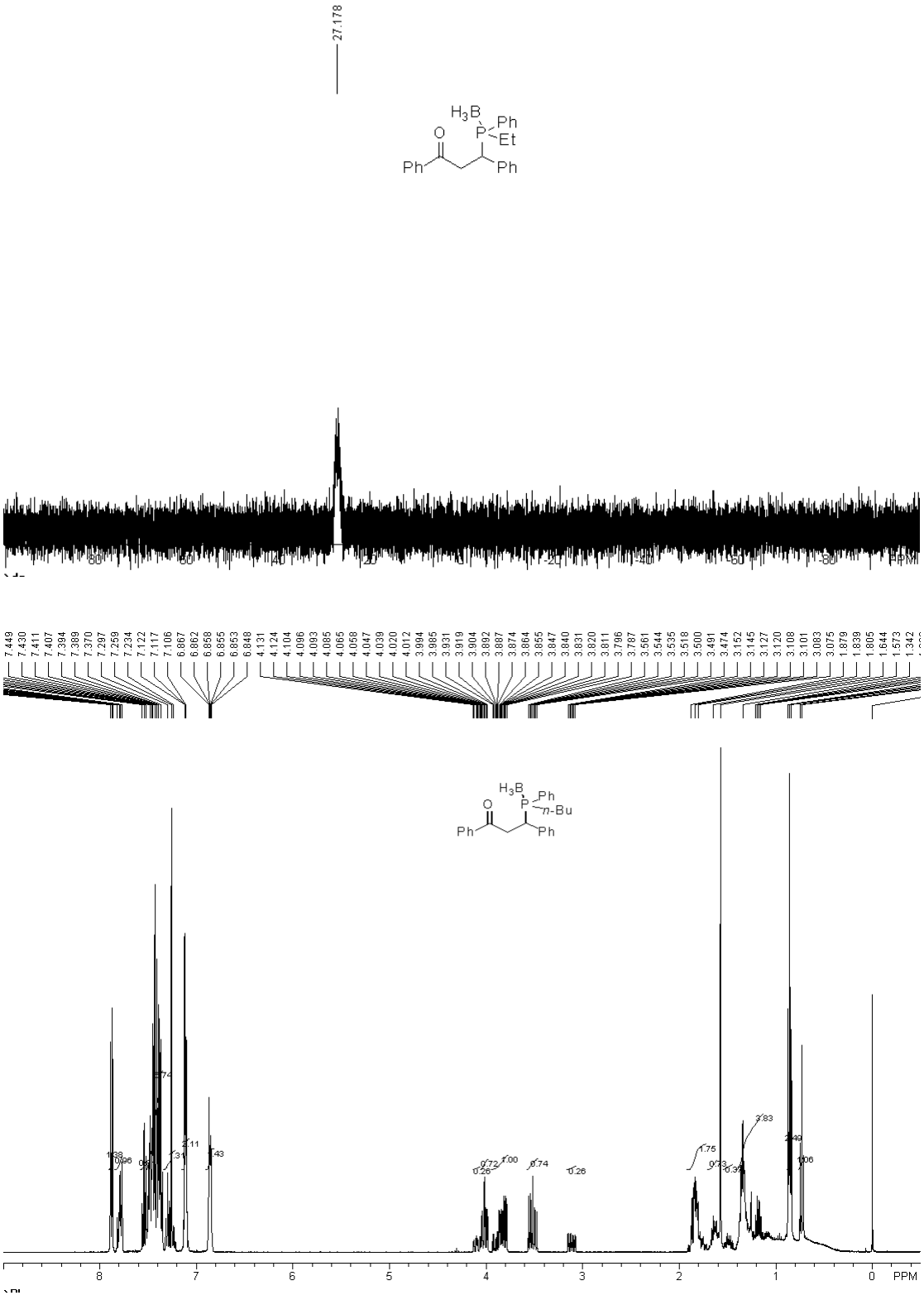
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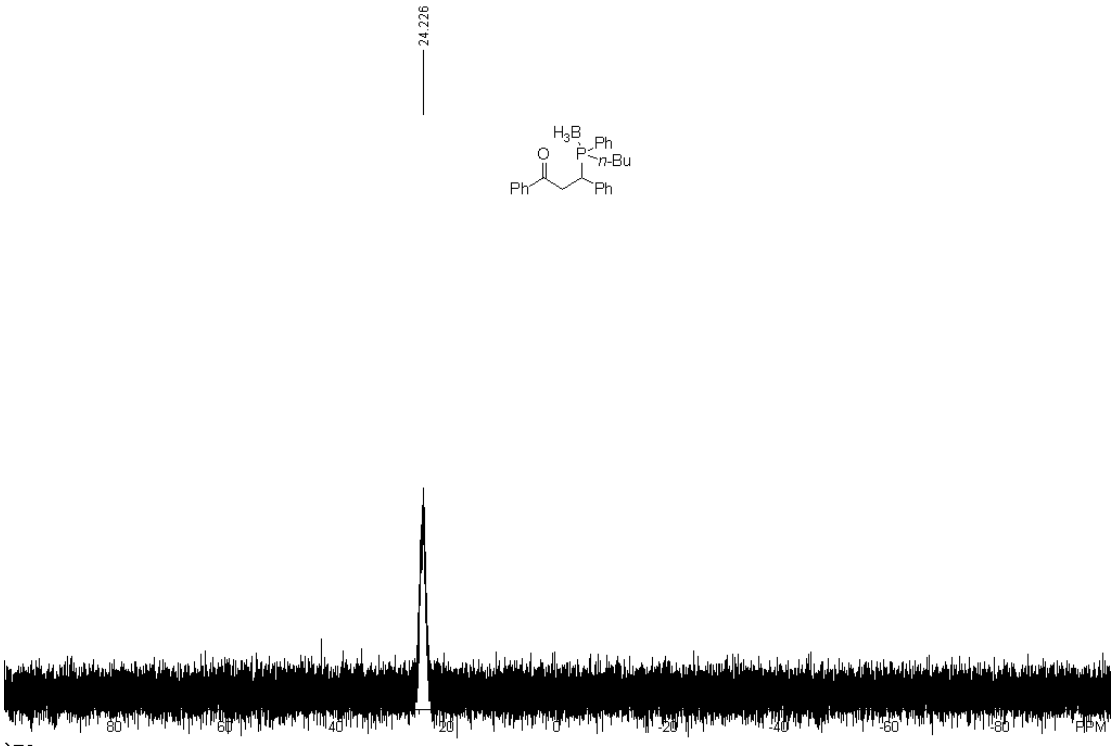
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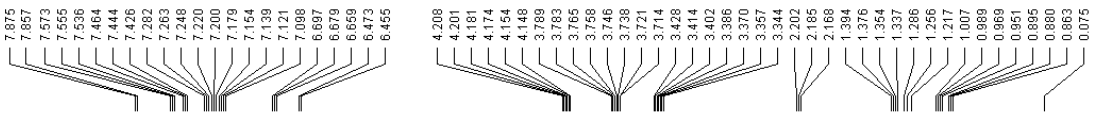
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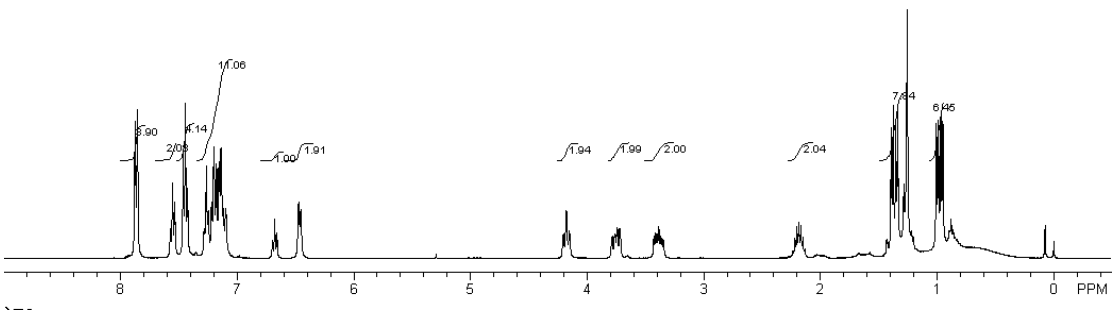
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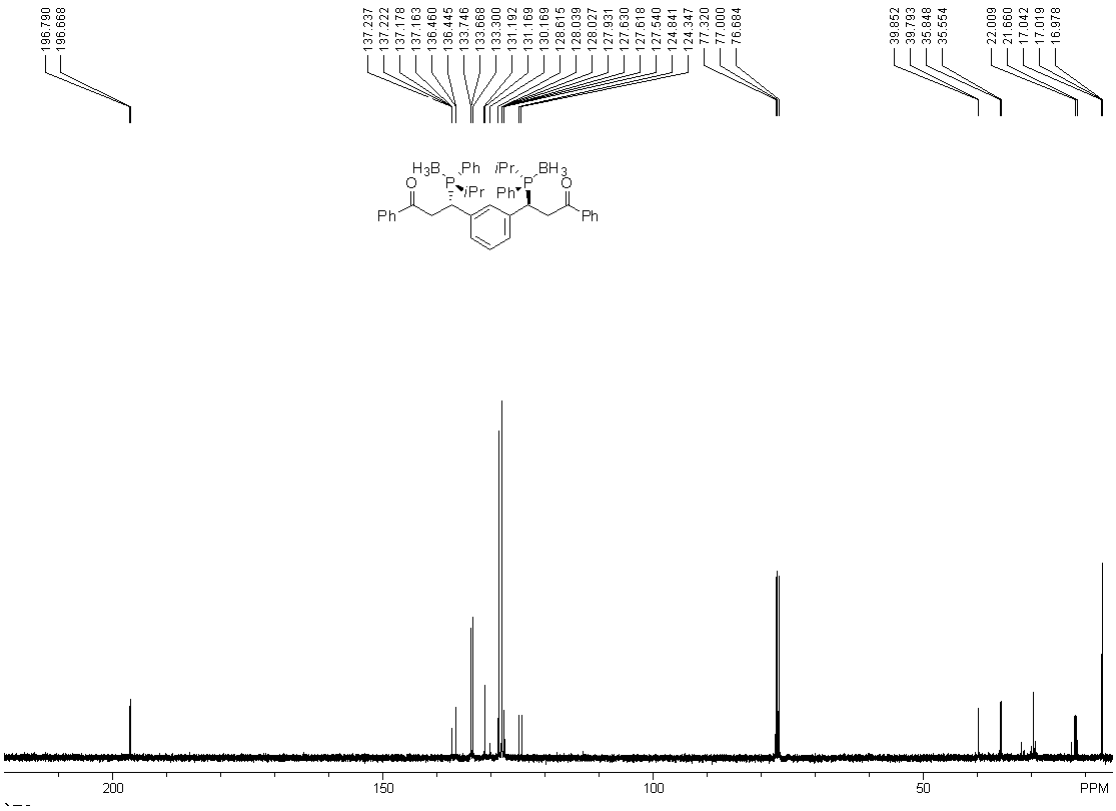
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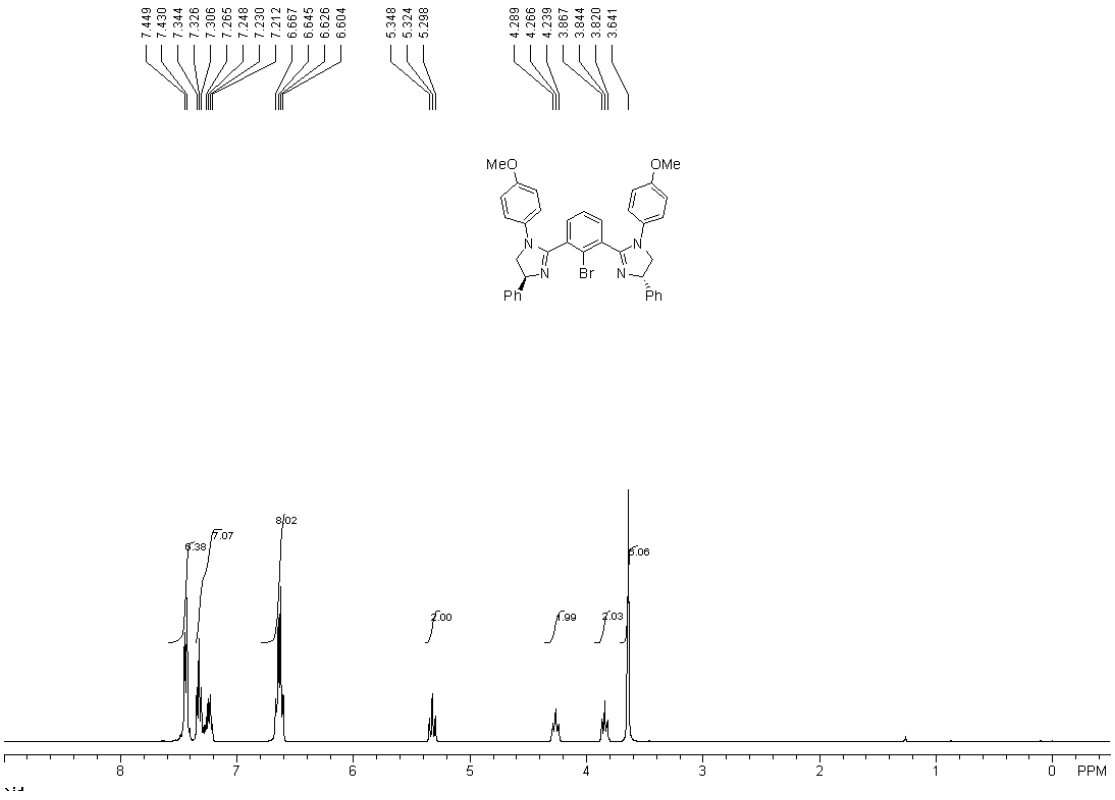
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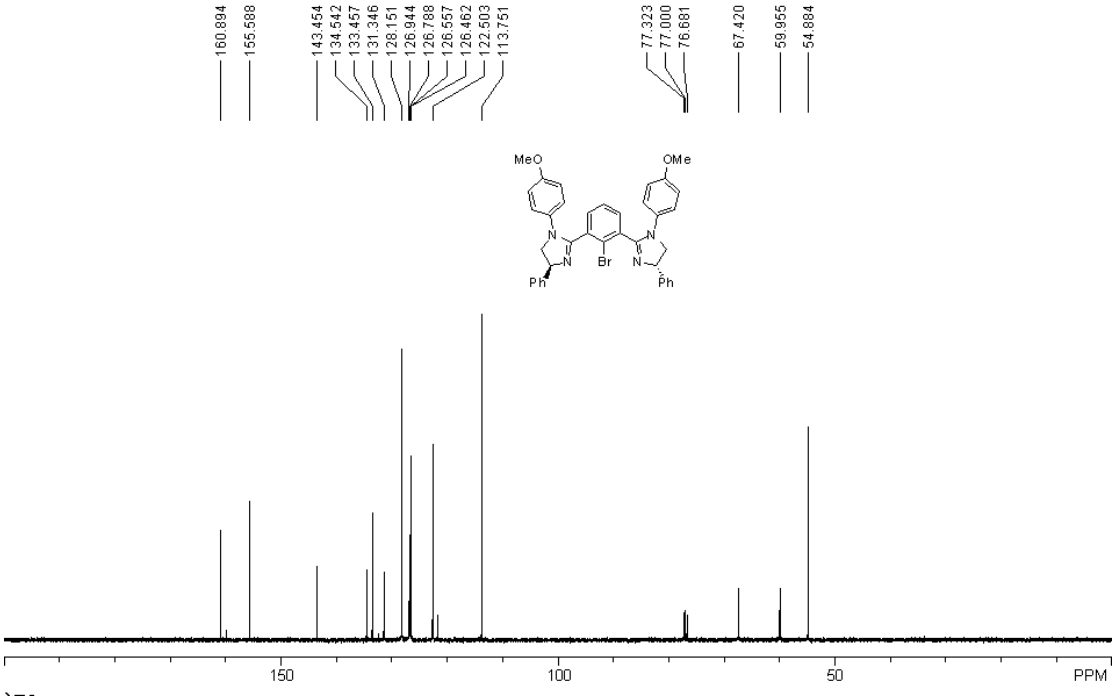
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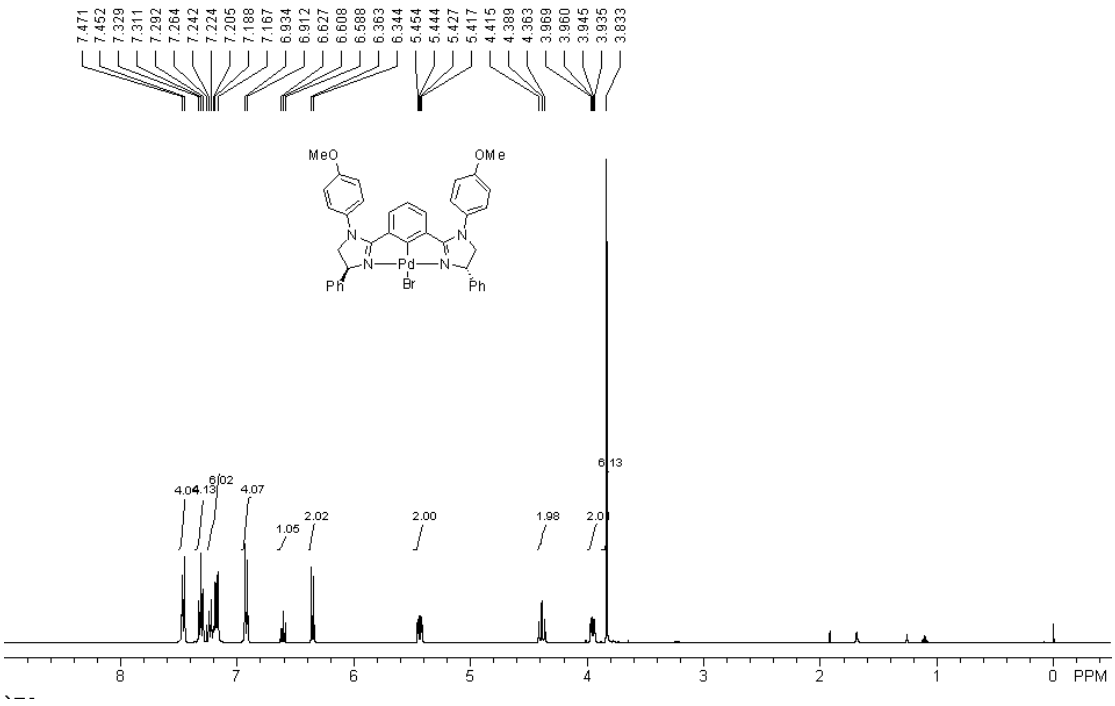
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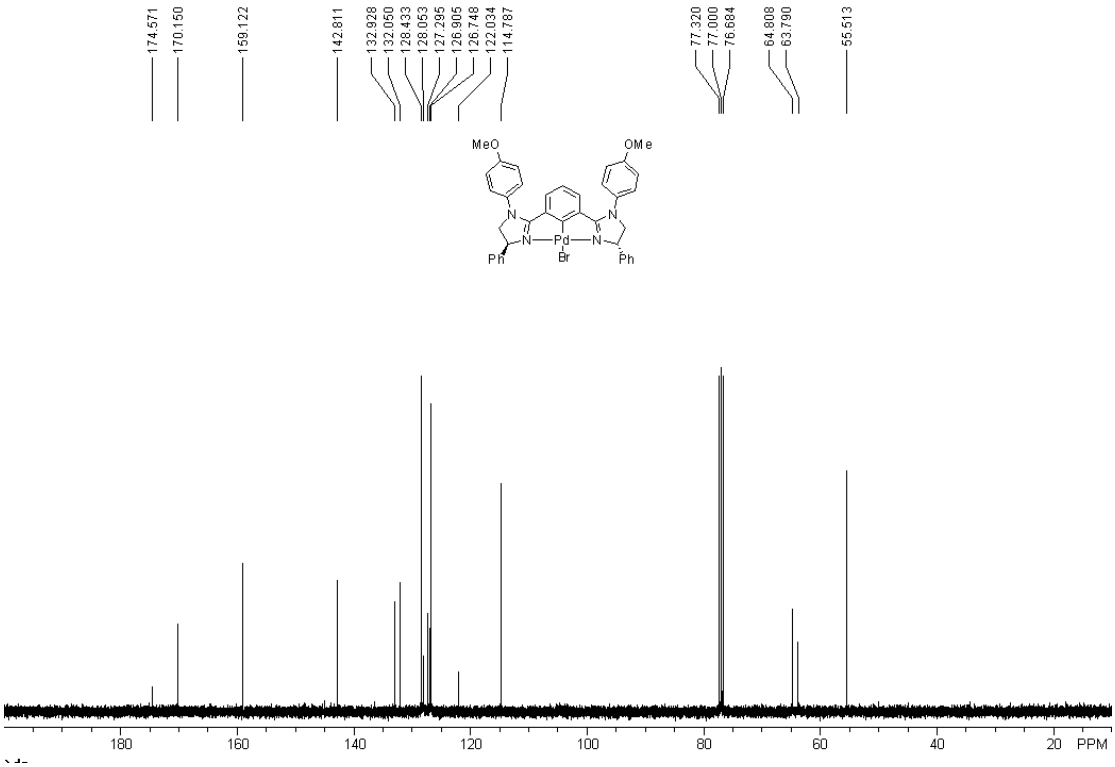
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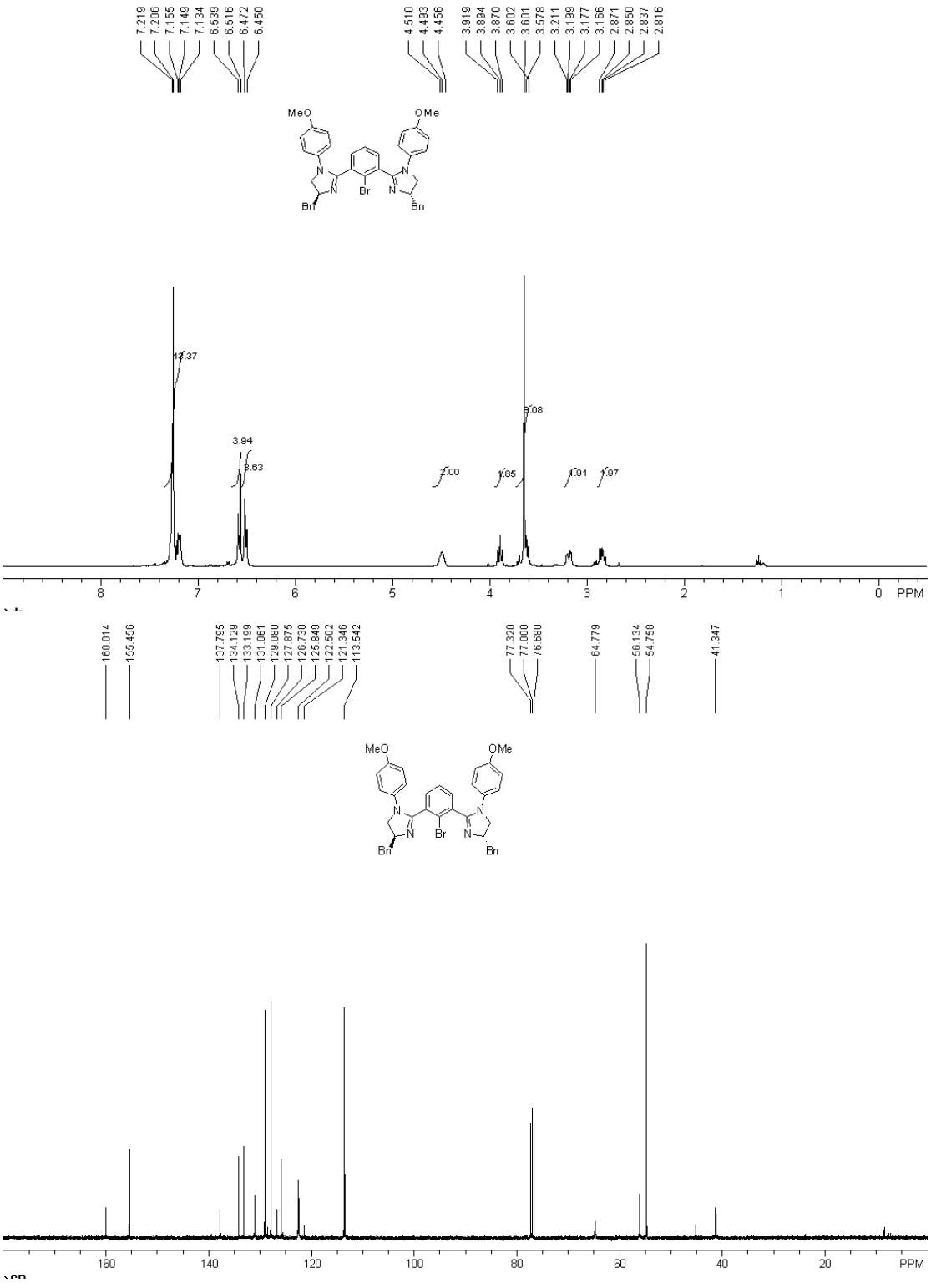
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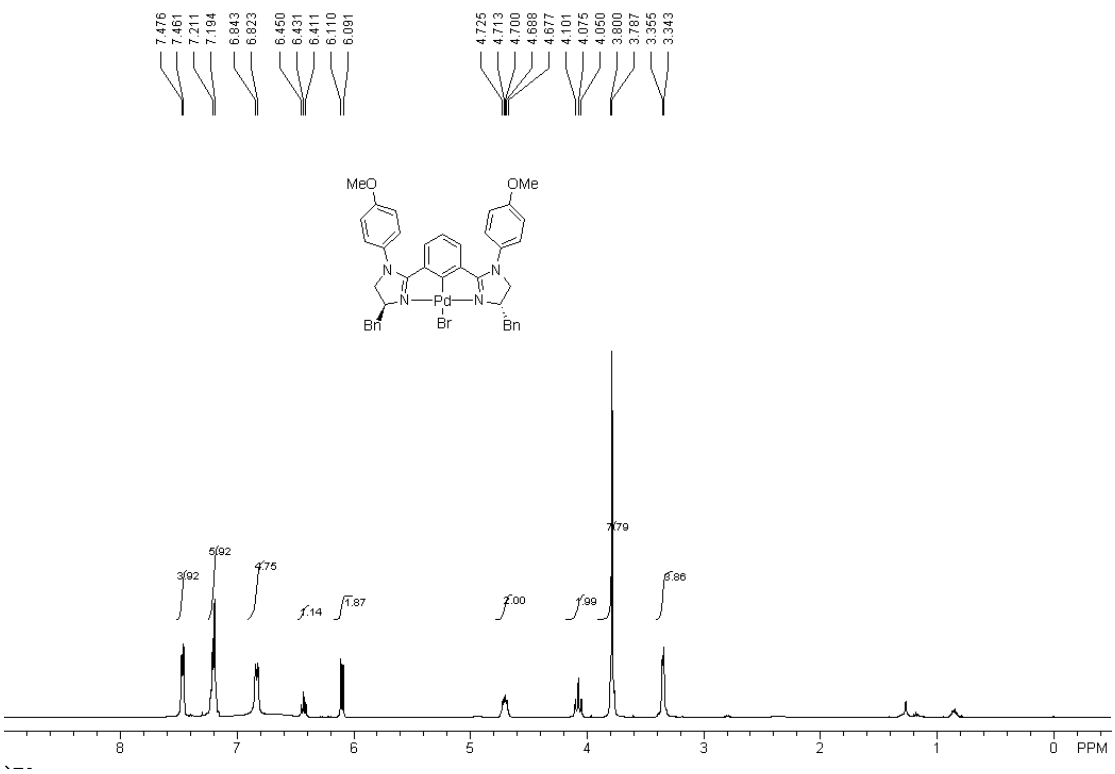
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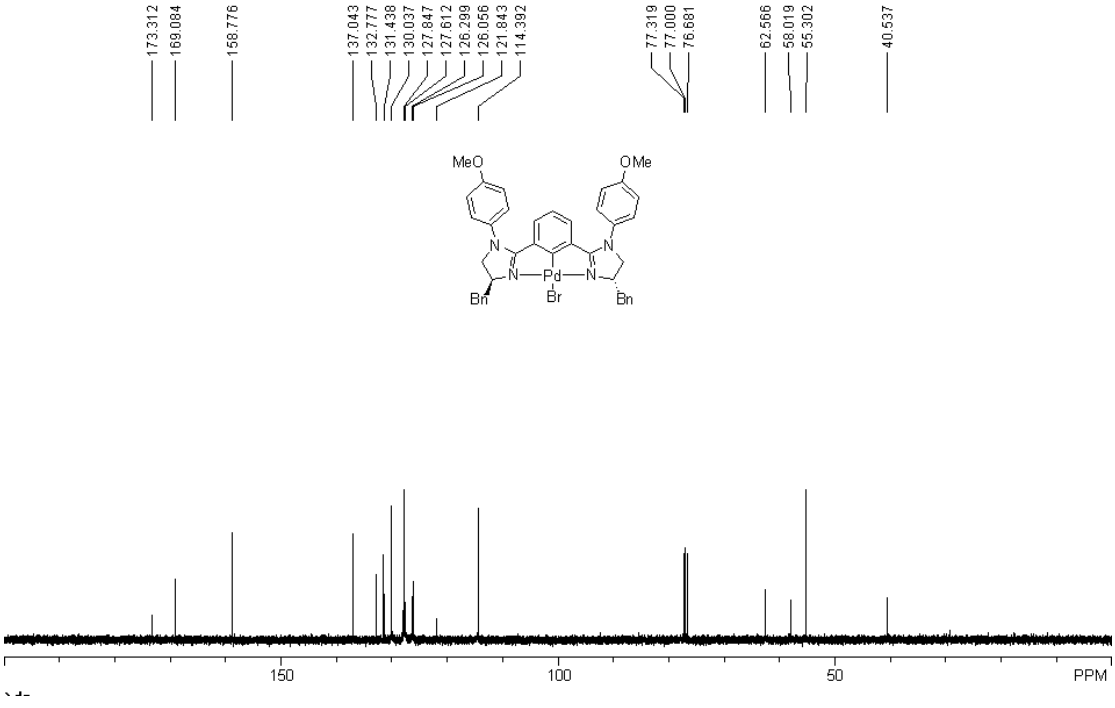
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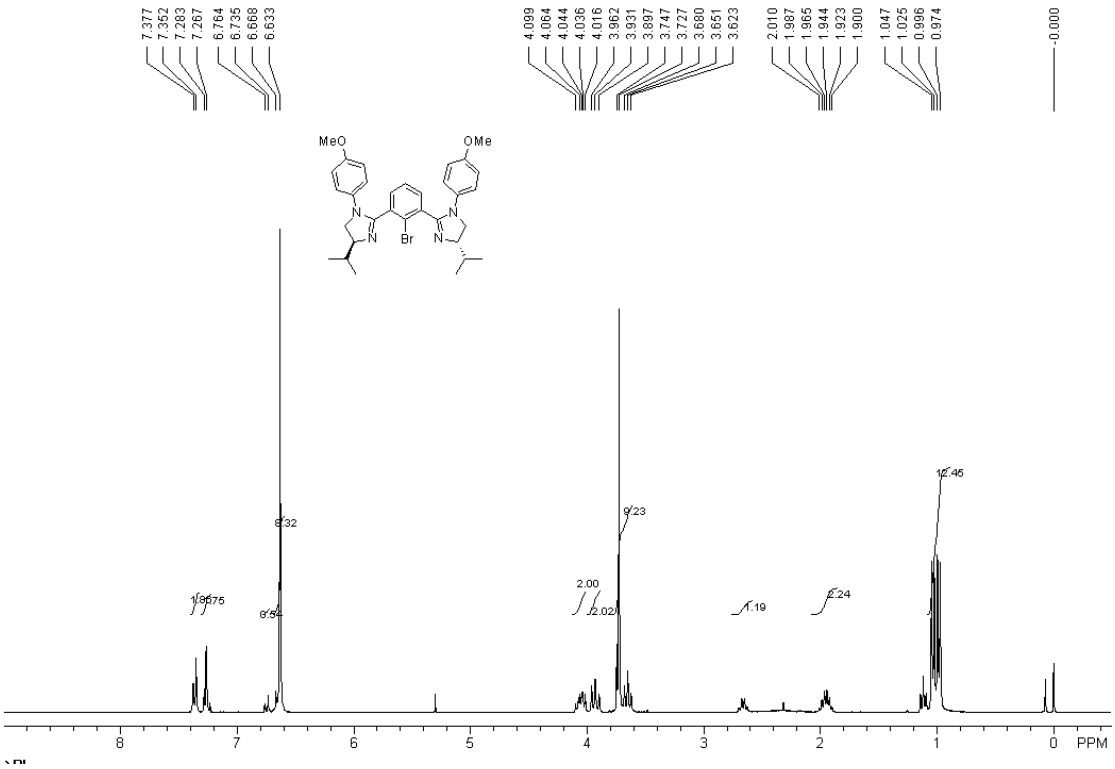
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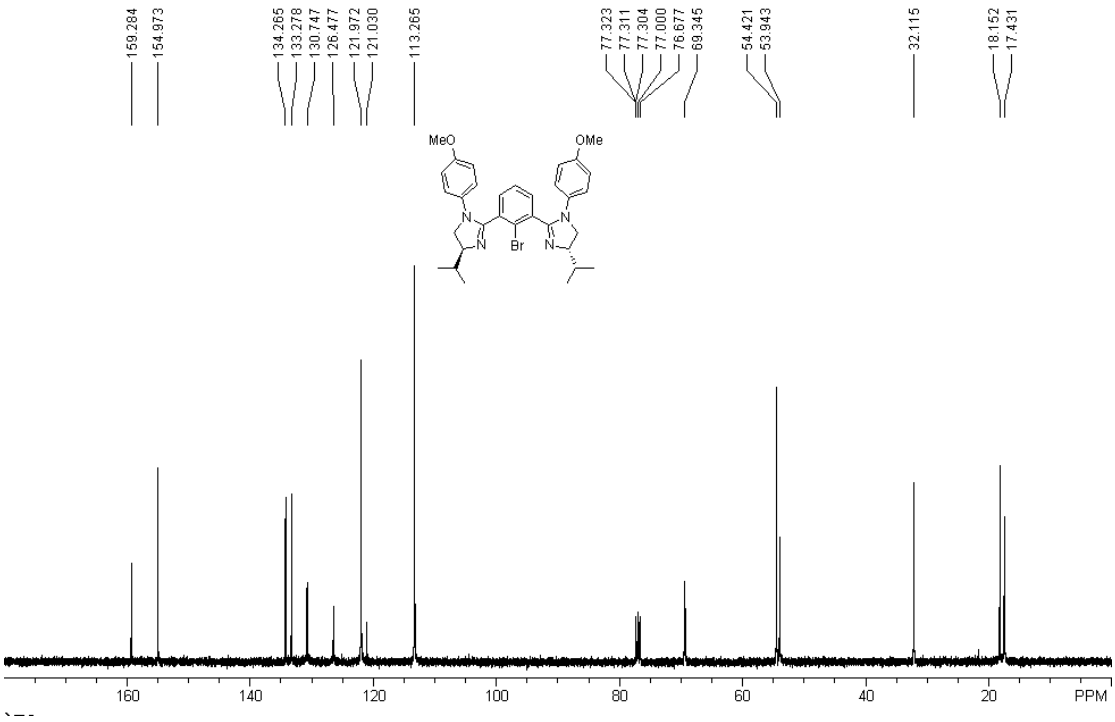
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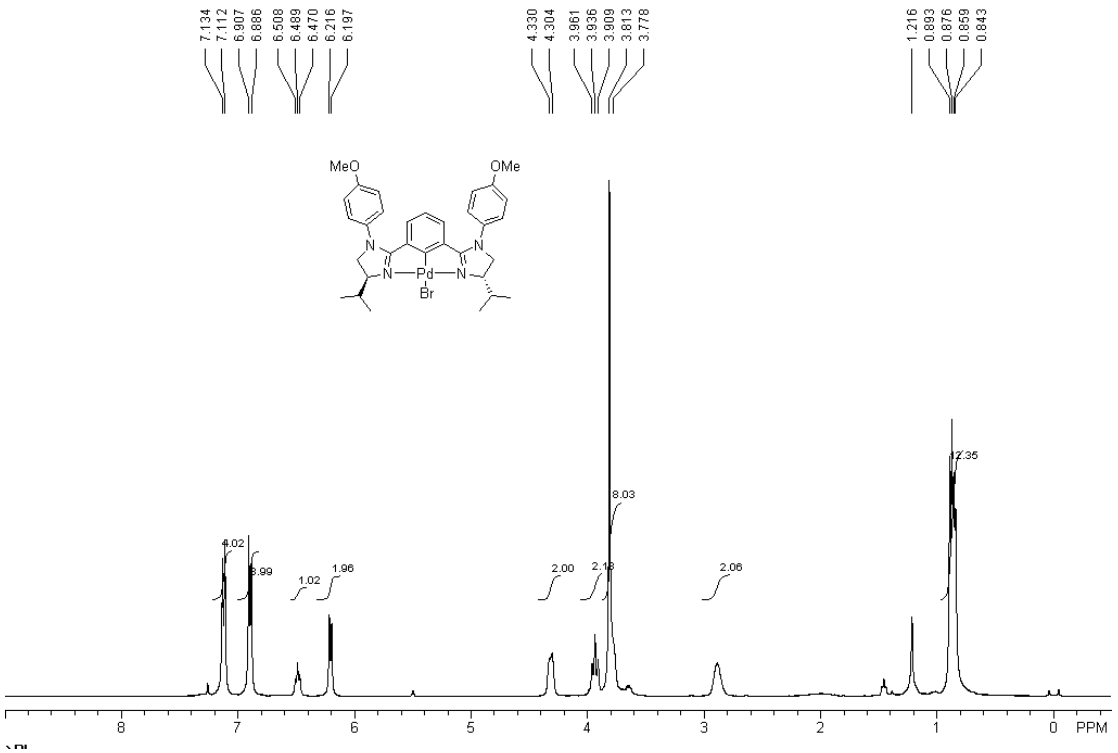
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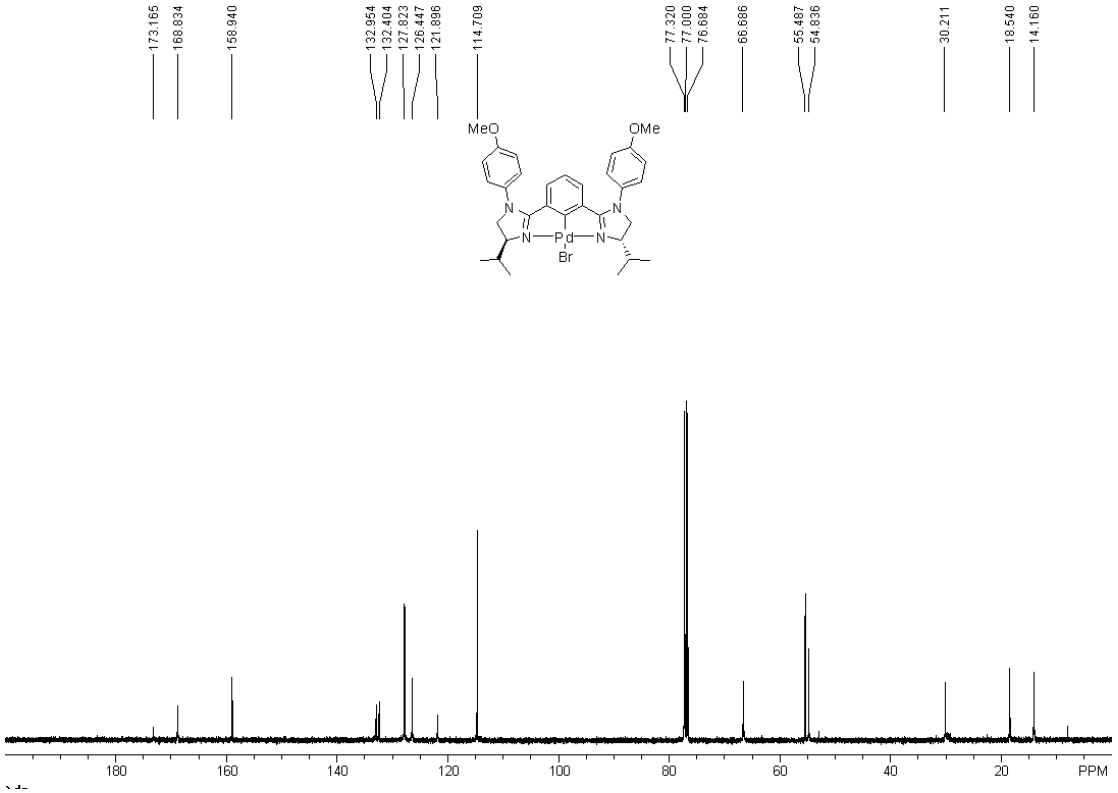
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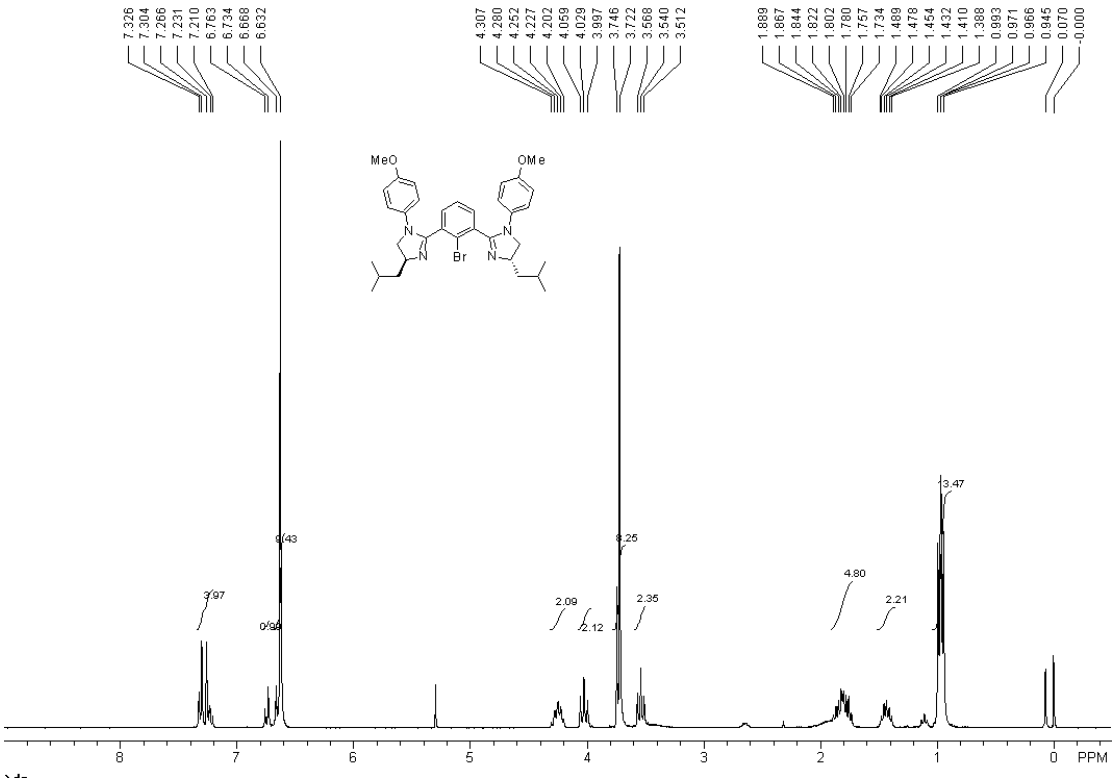
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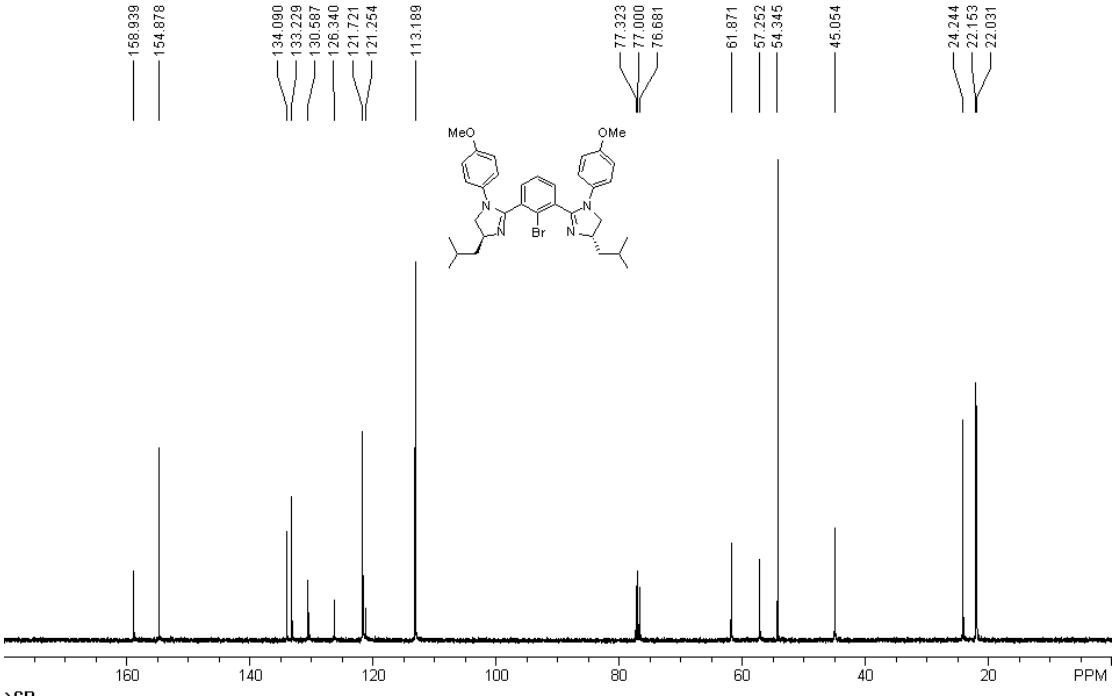
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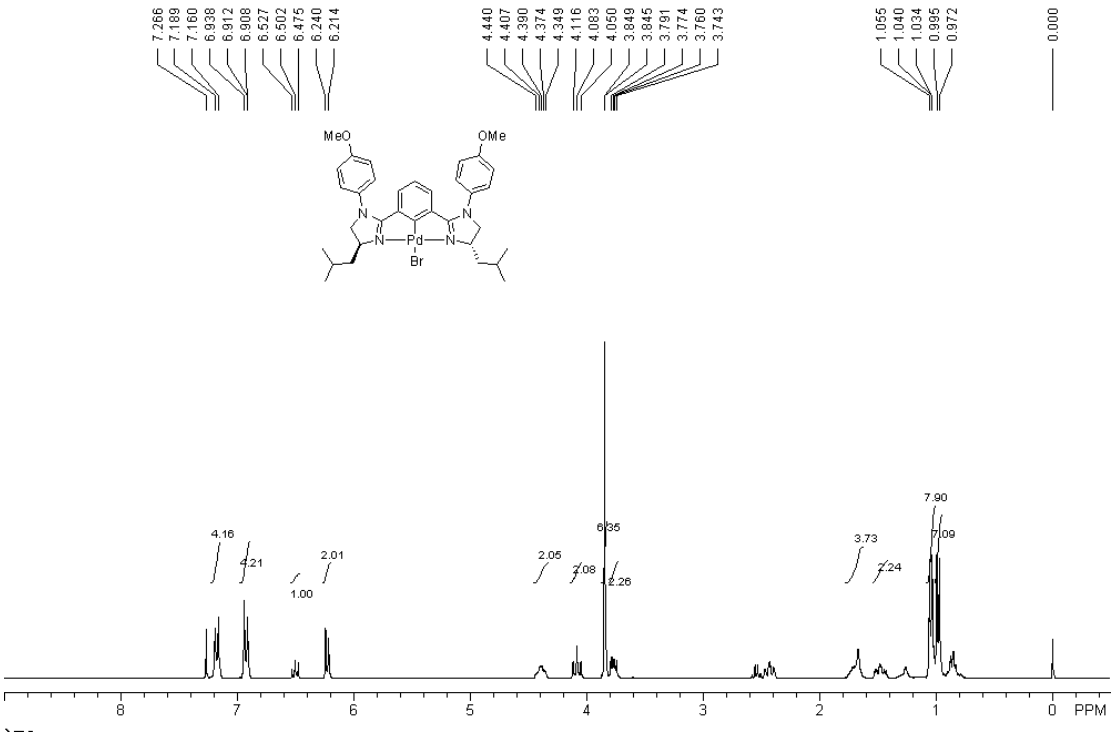
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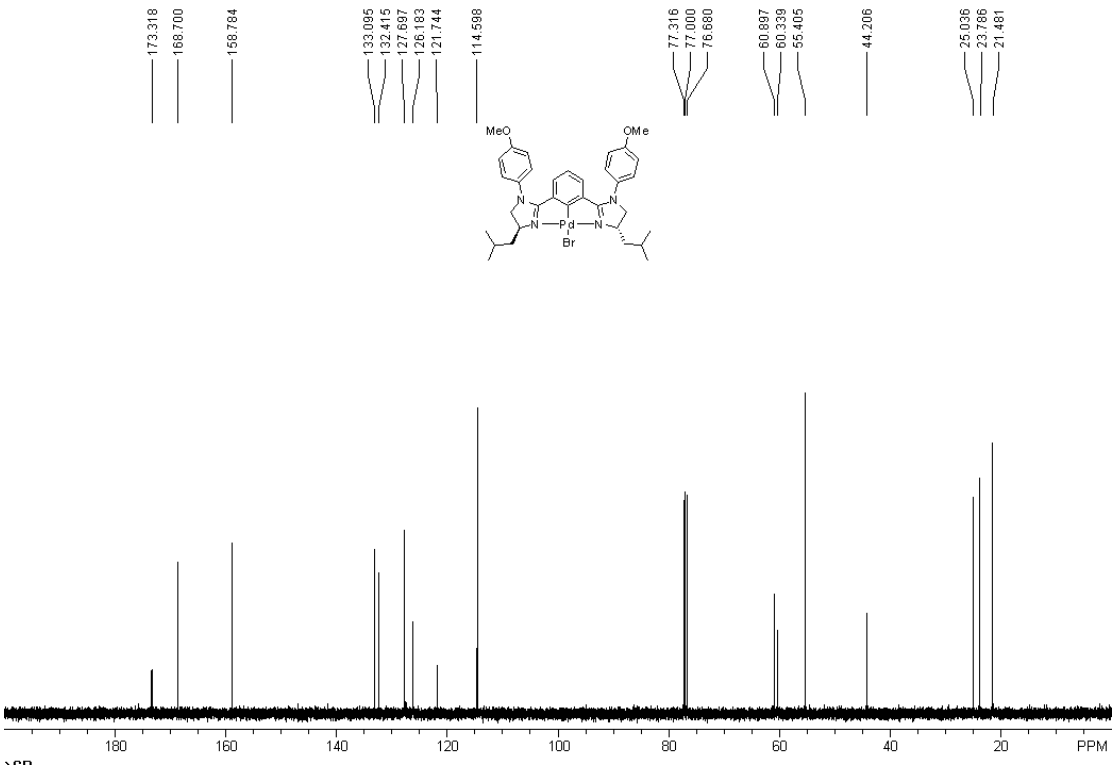
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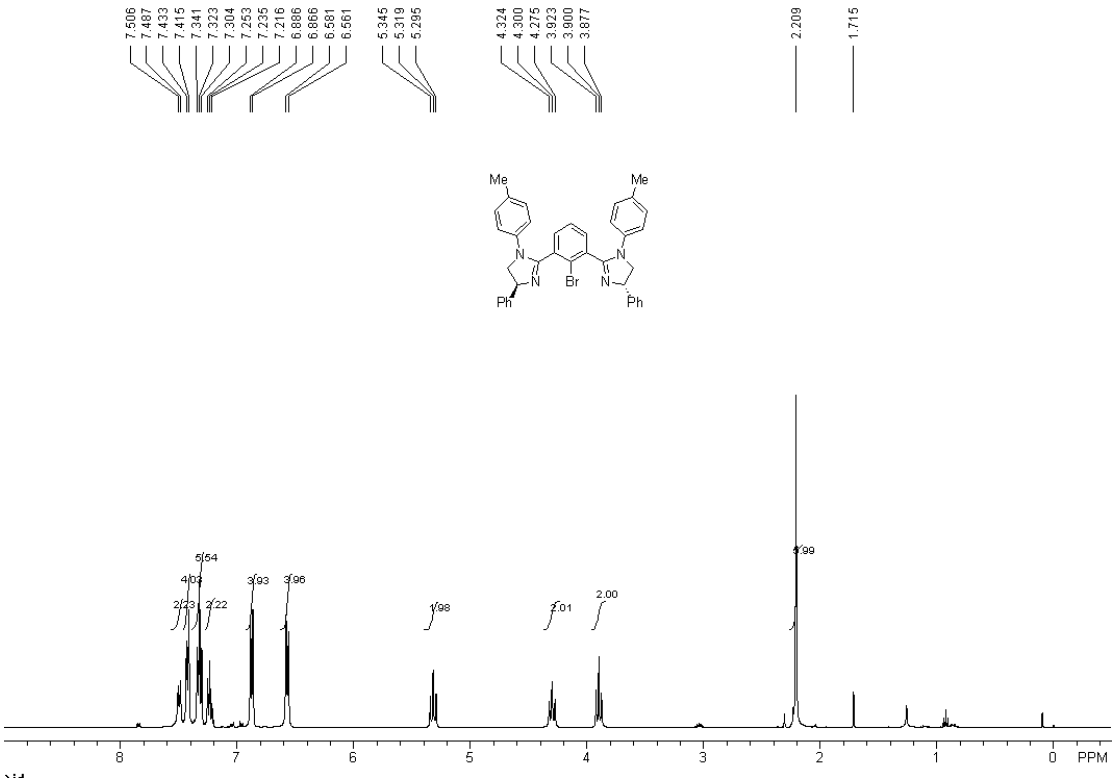
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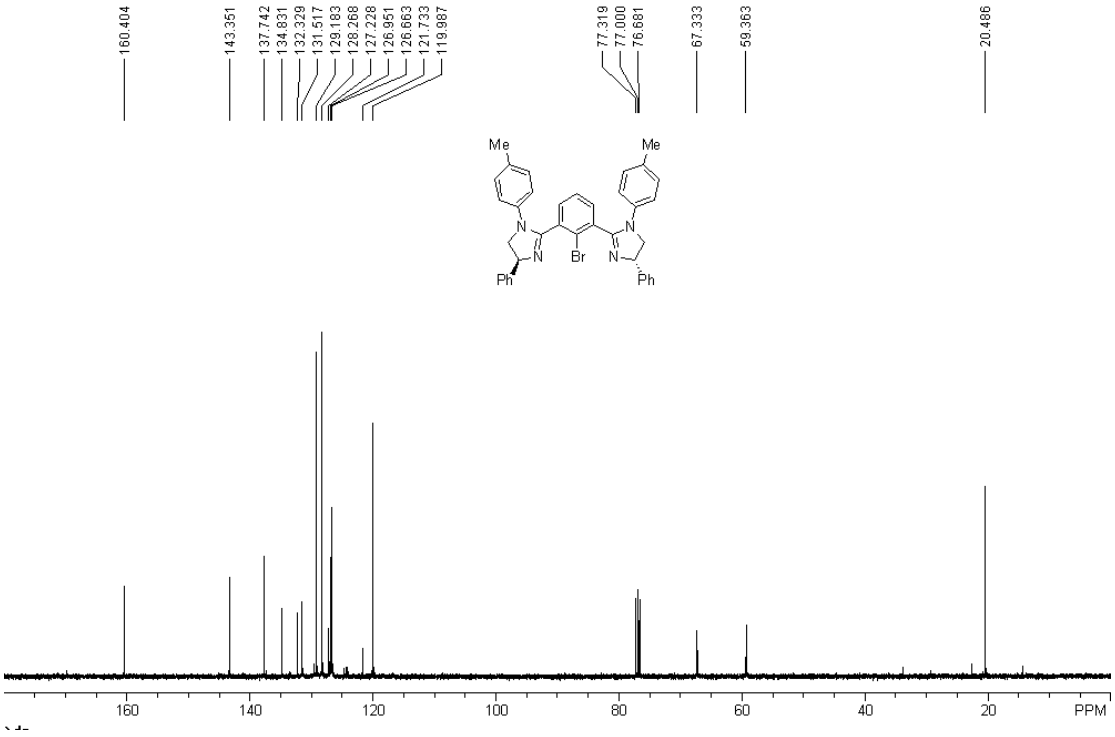
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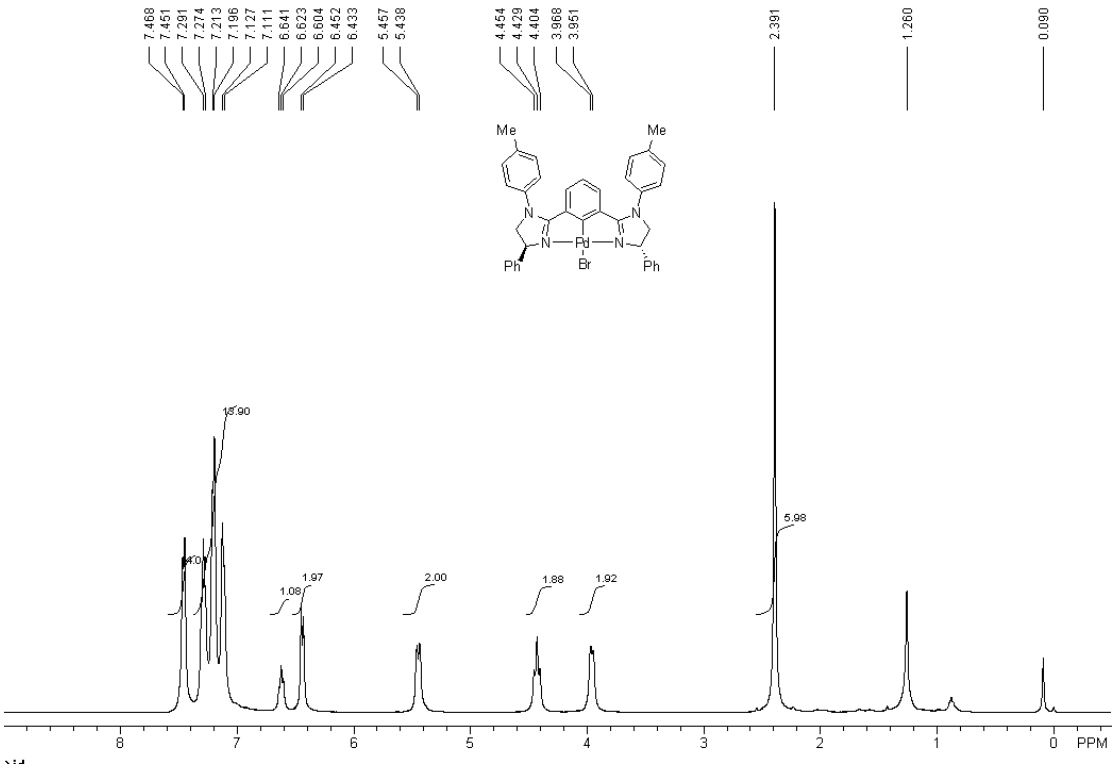
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4.454
4.429
4.404
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Me
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Pd
N
N
Br
Ph
Ph
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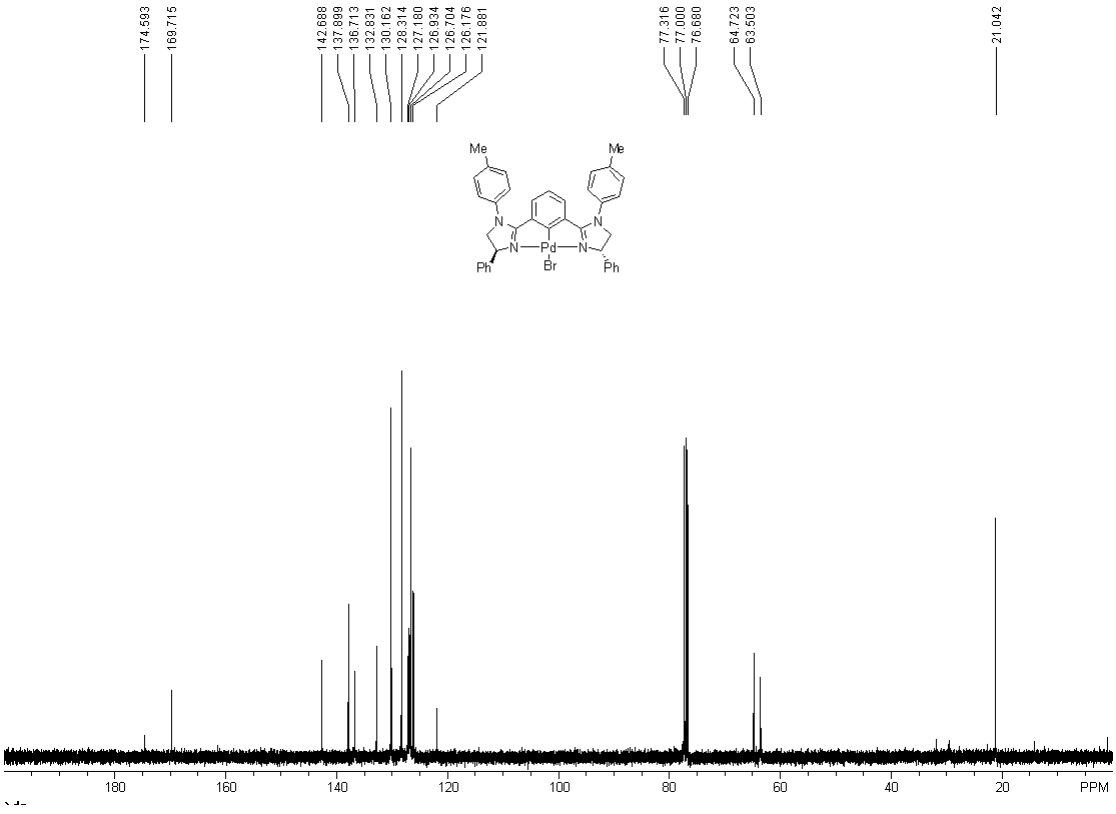
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77.000
76.680
64.723
63.503
21.042
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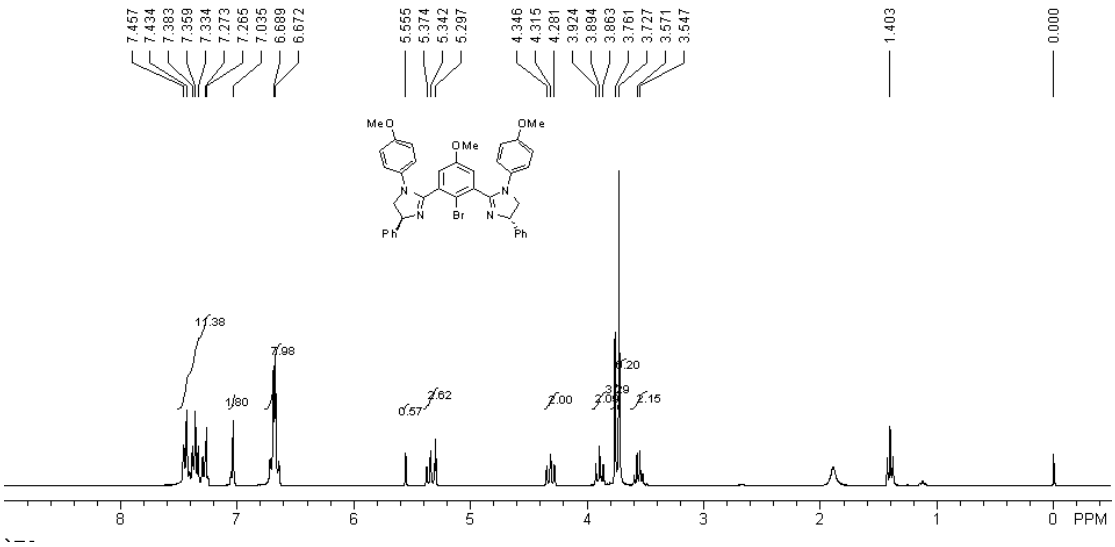
20
PPM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5.297
4.346
4.315
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3.924
3.894
3.863
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3.727
3.571
3.547
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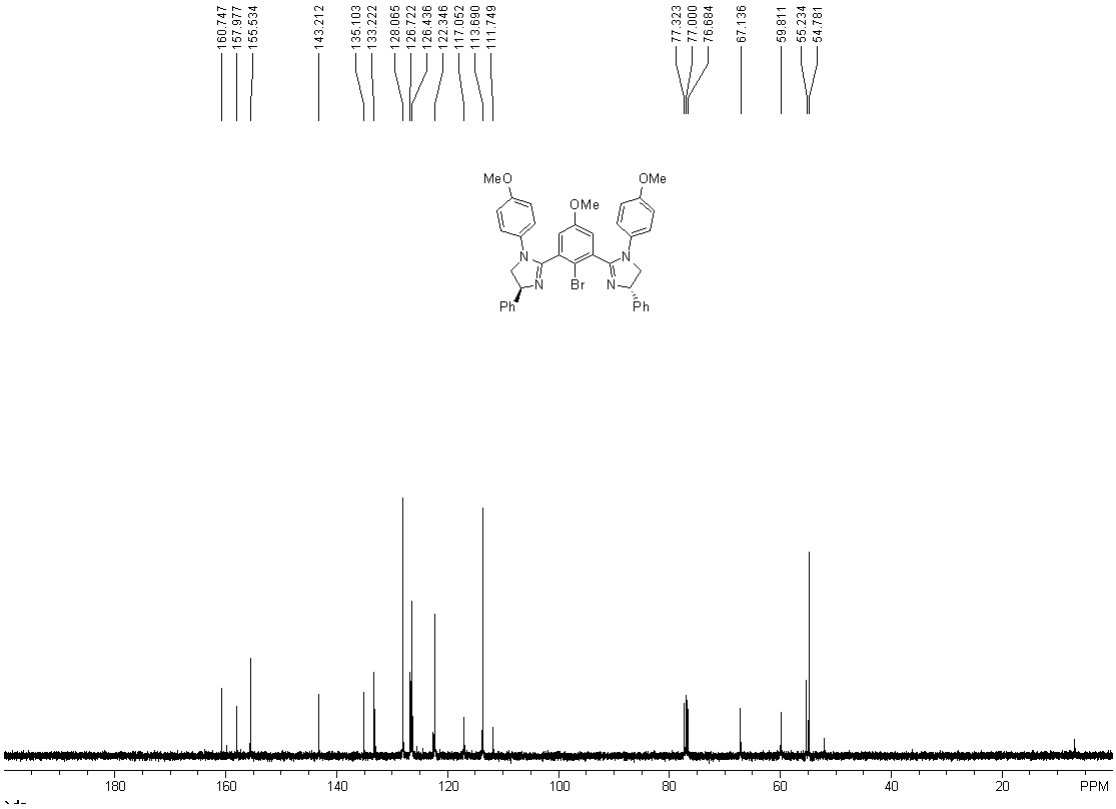
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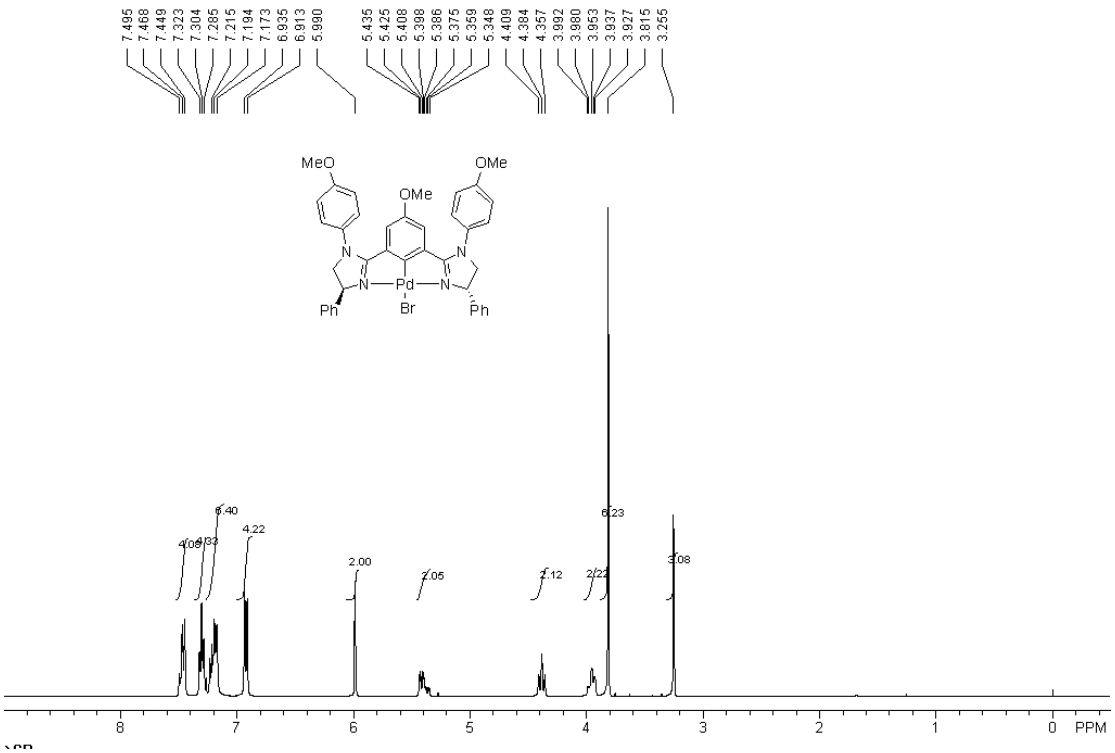
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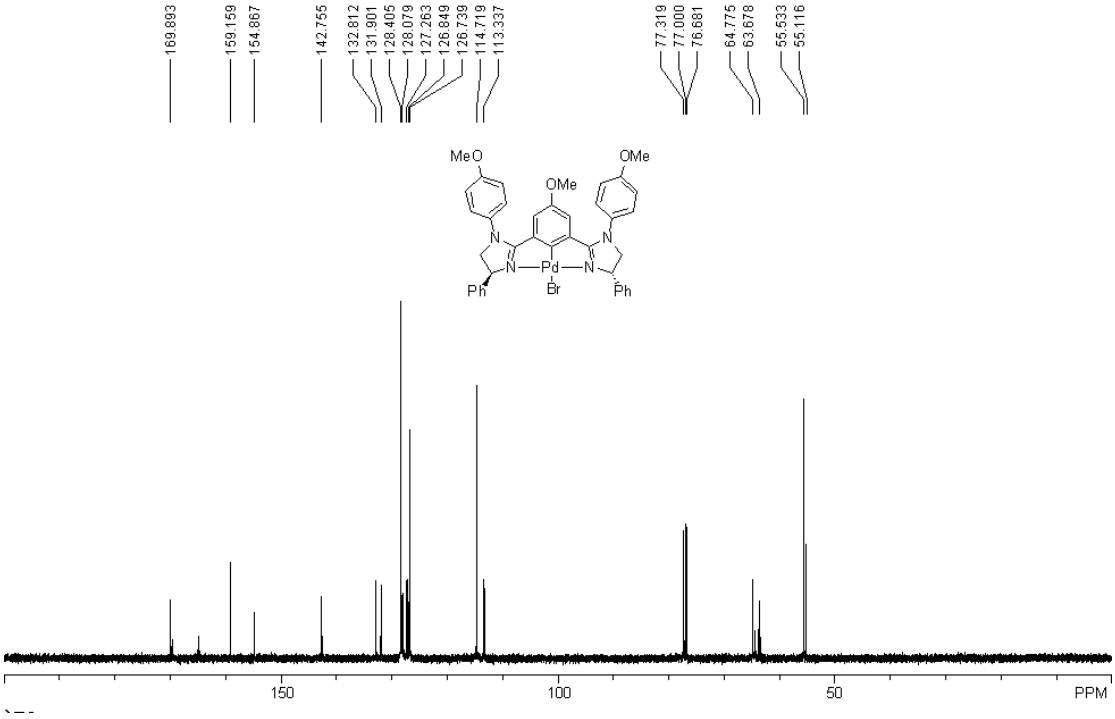
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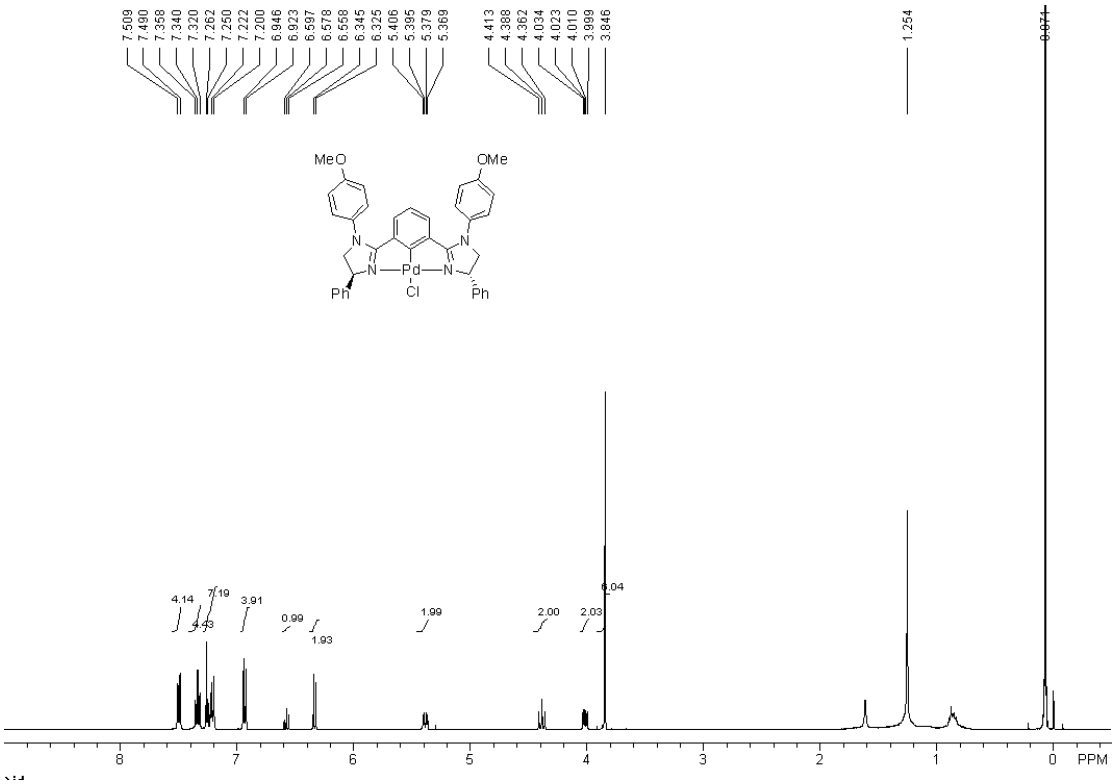
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4.388
4.362
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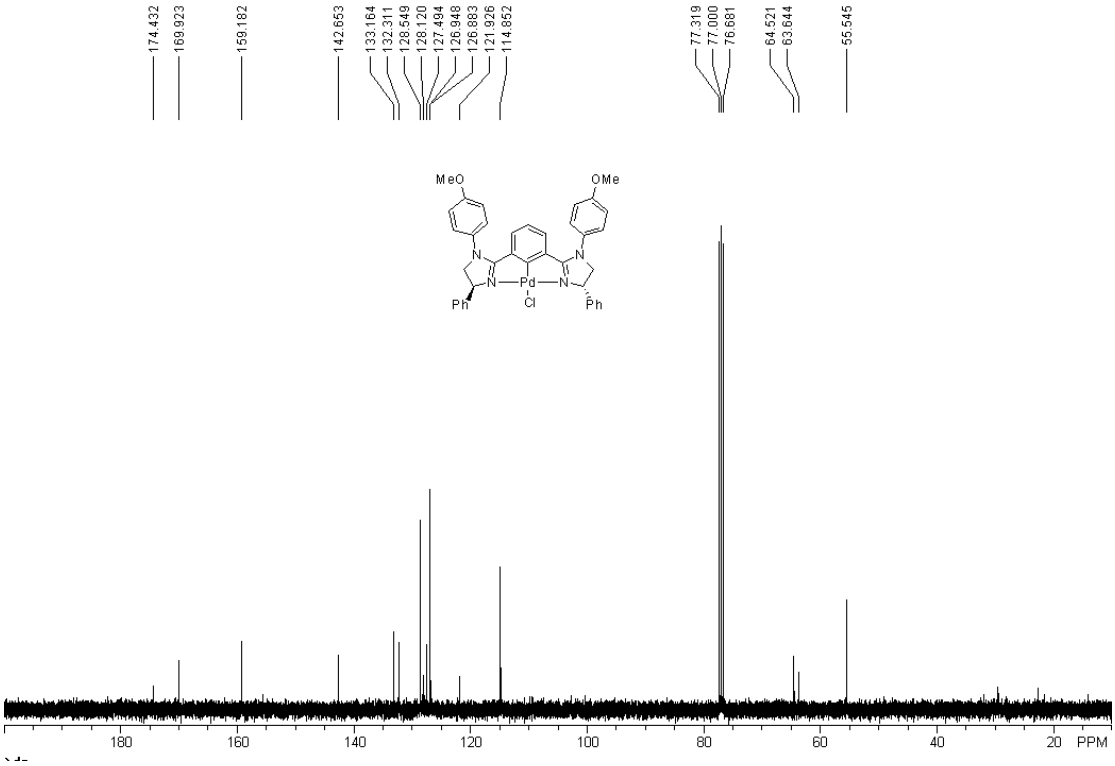
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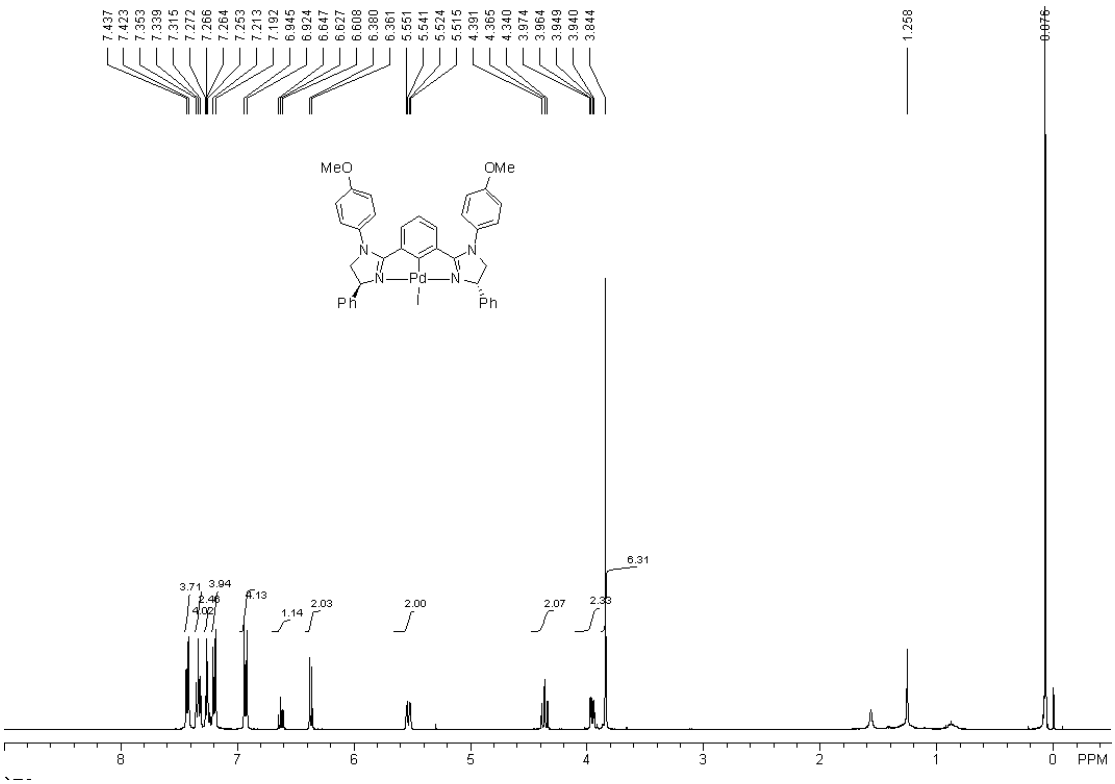
PPM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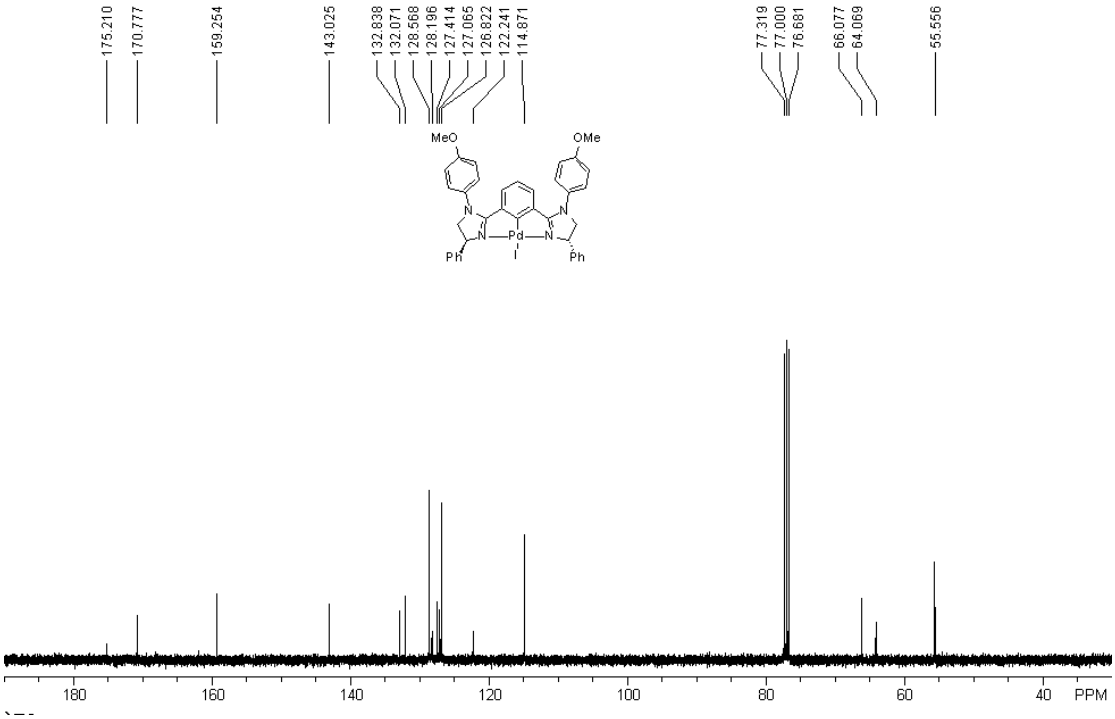
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76.681
66.077
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55.556
MeO
OMe
Pd
Ph
Ph
PPM

HPLC Charts

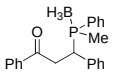
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-3-82-oz9505.lcd

Sample Name : lc-3-82-oz9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



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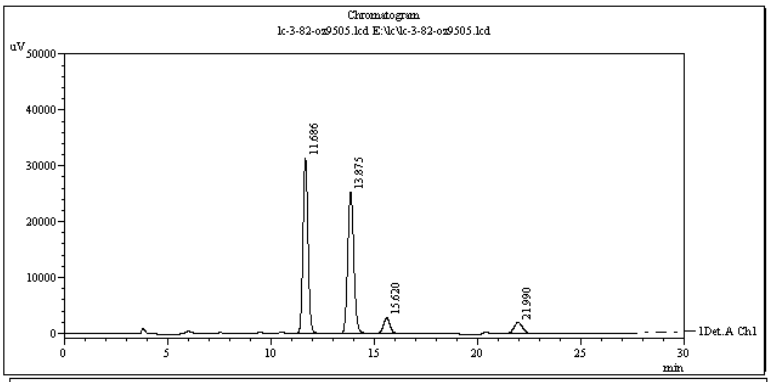


PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	11.686	527524	31461	44.893
2	13.875	524244	25322	44.614
3	15.620	62018	2815	5.278
4	21.990	61273	2060	5.214
Total		1175059	61657	100.000

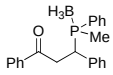
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-4-99-oz-0.8ml-9505.lcd

Sample Name : lc-4-99-oz-0.8ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



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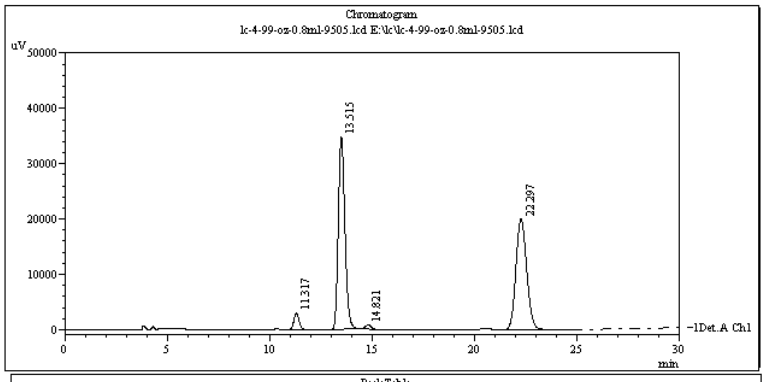


PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	11.317	52748	3017	3.341
2	13.515	777857	34841	49.266
3	14.821	16105	752	1.020
4	22.297	732170	20062	46.373
Total		1578880	58672	100.000

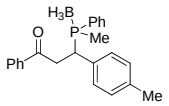
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-4-4-oz9505.lcd

Sample Name : lc-4-4-oz9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



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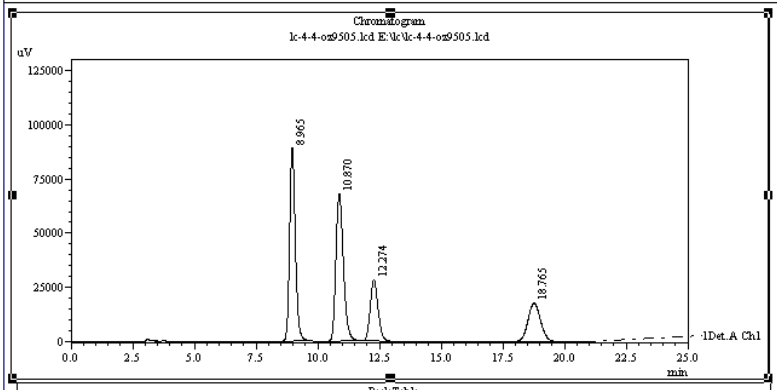


Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	8.965	1460246	89297	35.246
2	10.870	1437329	67965	34.693
3	12.274	621777	28372	15.008
4	18.765	623669	17580	15.053
Total		4143021	203213	100.000

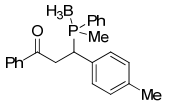
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-7-oz-1ml-9505.lcd

Sample Name : lc-5-7-oz-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



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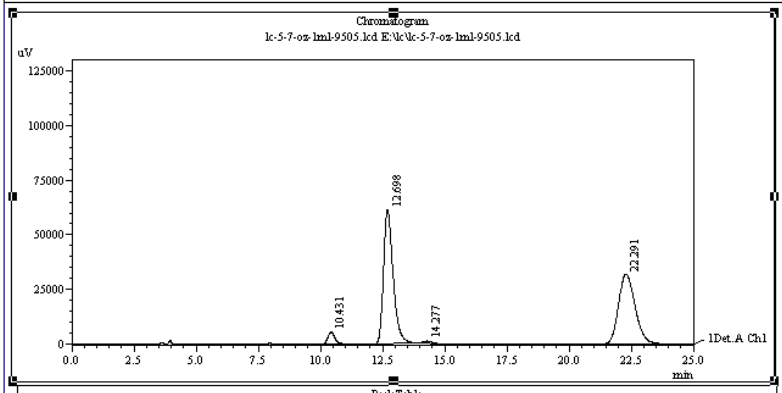


Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	10.431	102499	5283	3.134
2	12.698	1655738	61471	50.631
3	14.277	25661	1058	0.785
4	22.291	1486319	32118	45.450
Total		3270216	99930	100.000

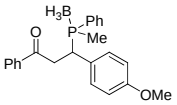
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lo-4-14-oz9505.lcd

Sample Name : lo-4-14-oz9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



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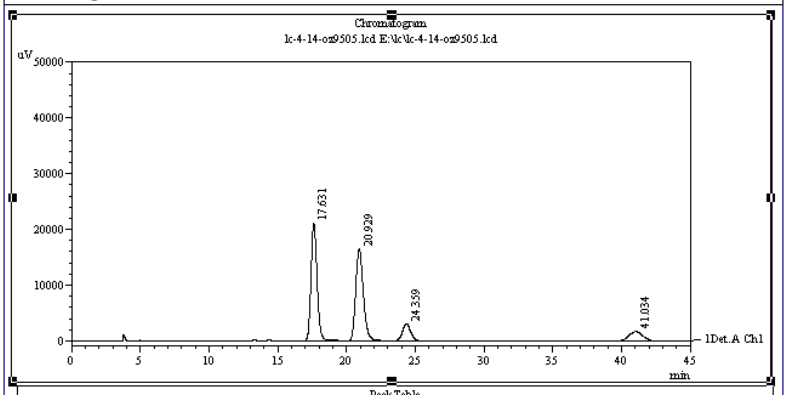


Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	17.631	647811	21031	42.039
2	20.929	643350	16518	41.750
3	24.359	125946	3065	8.173
4	41.034	123855	1720	8.038
Total		1540962	42334	100.000

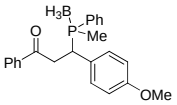
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lo-5-8-oz-1ml-9505.lcd

Sample Name : lo-5-8-oz-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



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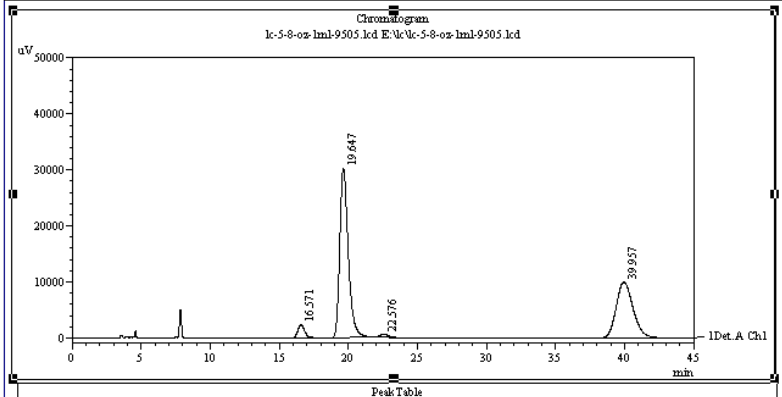


Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	16.571	79318	2309	3.520
2	19.647	1296529	30261	57.532
3	22.576	23692	561	1.051
4	39.957	854023	10015	37.897
Total		2253562	43146	100.000

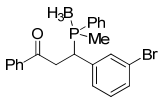
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-4-2-oz9802.lcd

Sample Name : lc-4-2-oz9802.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



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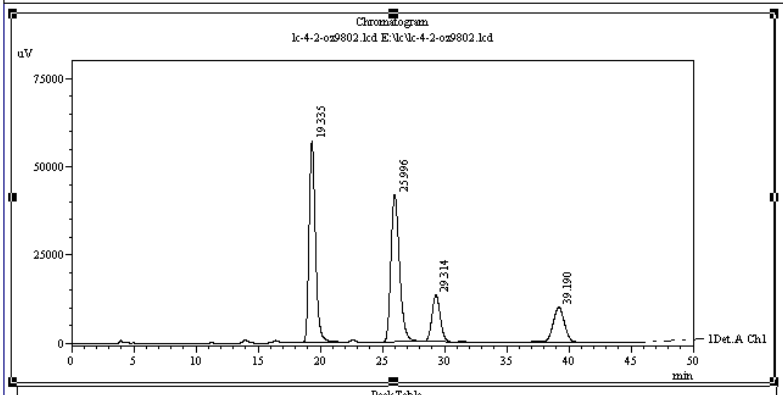


PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	19.335	2039128	57060	38.668
2	25.996	2003234	41837	37.987
3	29.314	603383	13202	11.442
4	39.190	627706	9877	11.903
Total		5273451	121977	100.000

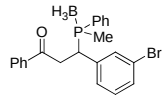
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-2-2ci-oz-0.8ml-9802.lcd

Sample Name : lc-5-2-2ci-oz-0.8ml-9802.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



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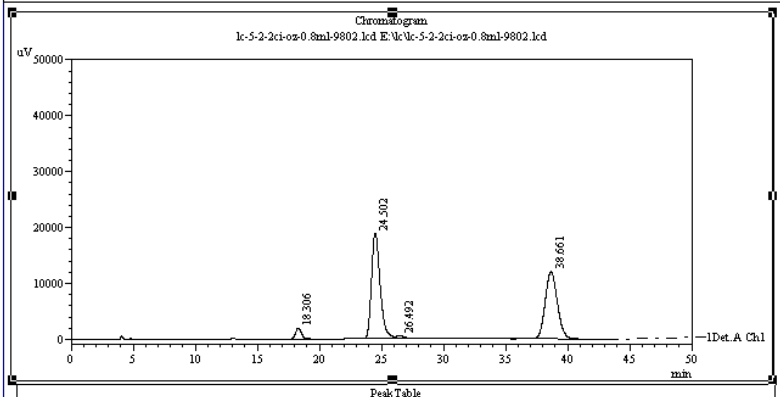


PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	18.306	63673	1902	3.508
2	24.502	916684	18916	50.499
3	26.492	17912	437	0.987
4	38.661	816998	11989	45.007
Total		1815267	33244	100.000

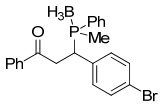
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-4-1-ad9505.lcd

Sample Name : lc-4-1-ad9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



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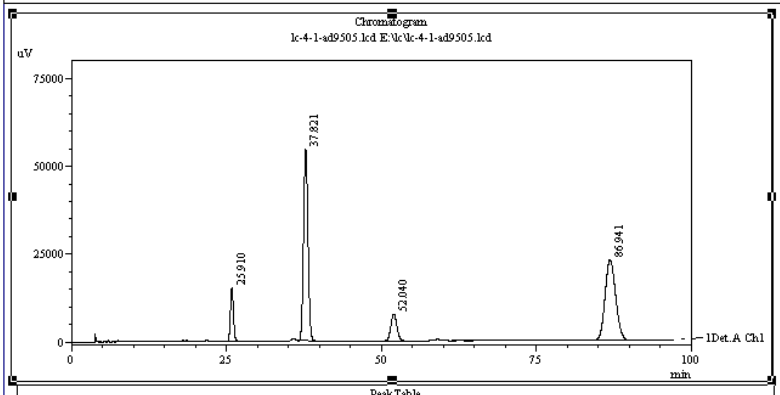


Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	25.910	514421	15248	7.933
2	37.821	2718976	54371	41.929
3	52.040	516804	7584	7.969
4	86.941	2734579	23027	42.169
Total		6484780	100230	100.000

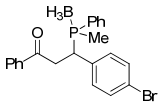
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-3-AD-0.8ml-9505.lcd

Sample Name : lc-5-3-AD-0.8ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



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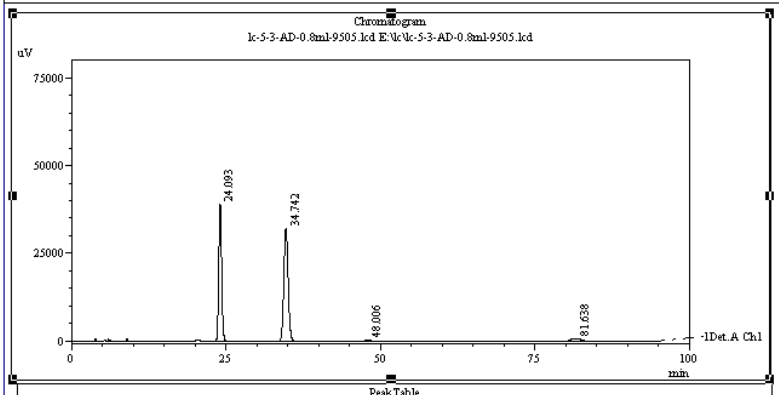


Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	24.093	1257770	38869	43.017
2	34.742	1539593	32043	52.656
3	48.006	23900	380	0.817
4	81.638	102625	904	3.510
Total		2923889	72196	100.000

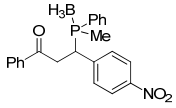
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-4-29-oz9505.lcd

Sample Name : lc-4-29-oz9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



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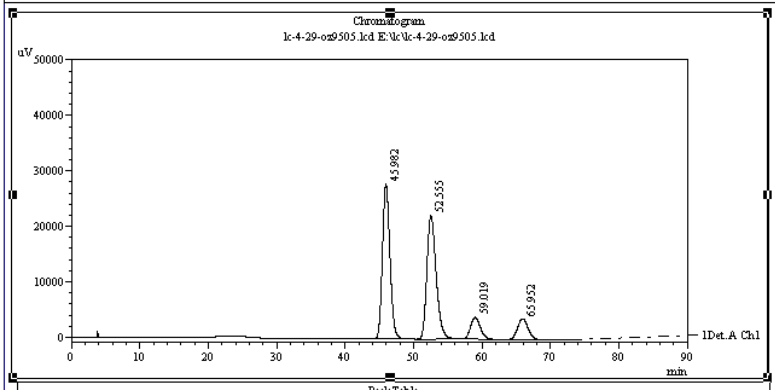


Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	45.982	2131450	27897	42.370
2	52.555	2103070	22213	41.806
3	59.019	392841	3941	7.809
4	65.952	403190	3784	8.015
Total		5030551	57835	100.000

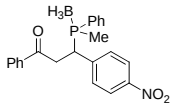
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-11-oz-1ml-9505.lcd

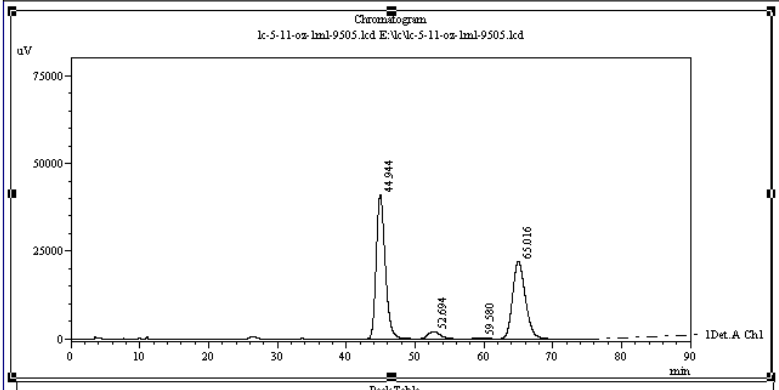
Sample Name : lc-5-11-oz-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



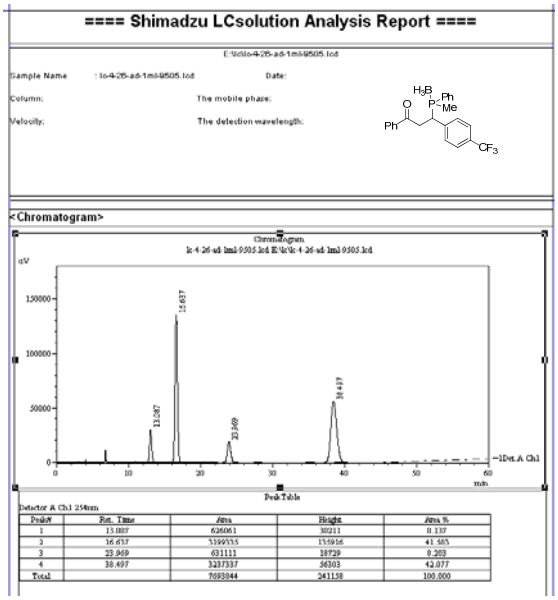
<Chromatogram>



Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	44.944	3761197	41177	54.380
2	52.694	252409	2098	3.649
3	59.580	39848	361	0.576
4	65.016	2863116	22082	41.395
Total		6916570	65719	100.000



==== Shimadzu LCsolution Analysis Report ====

E:\Mdlo-4-26-ad-1ml-9505.lcd

Sample Name : lo-4-26-ad-1ml-9505.lcd Date:

Column: The mobile phase:

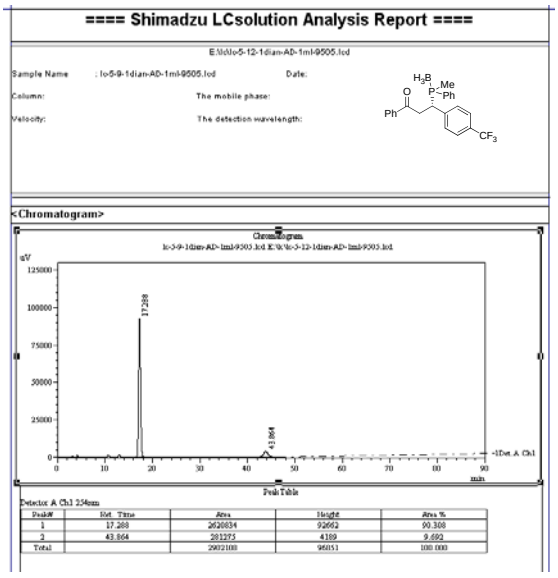
Velocity: The detection wavelength:

<Chromatogram>

Peak Table

Detector A Ch1 254nm

PeakN	Ret. Time	Area	Height	Area %
1	13.367	626061	30211	8.137
2	16.637	3199335	155916	41.585
3	23.969	631111	18729	8.203
4	38.437	3237337	56303	42.077
Total		7693844	261158	100.000



==== Shimadzu LCsolution Analysis Report ====

E:\Mdlo-5-12-1dian-AD-1ml-9505.lcd

Sample Name : lo-5-9-1dian-AD-1ml-9505.lcd Date:

Column: The mobile phase:

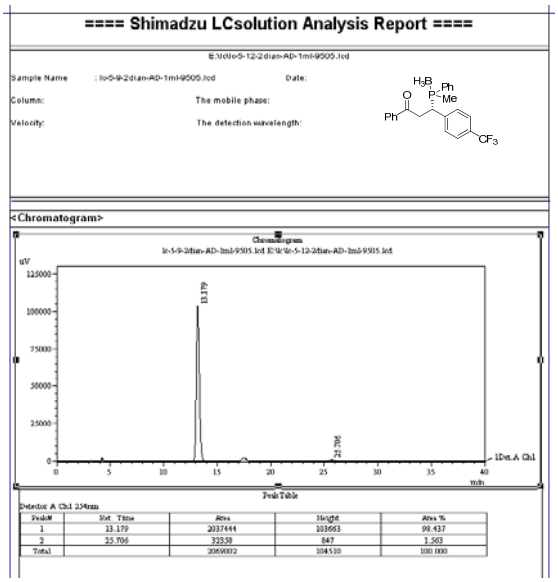
Velocity: The detection wavelength:

<Chromatogram>

Peak Table

Detector A Ch1 254nm

PeakN	Ret. Time	Area	Height	Area %
1	17.288	2620834	92662	90.308
2	43.864	281275	4189	9.692
Total		2902108	96851	100.000



==== Shimadzu LCsolution Analysis Report ====

E:\Mdlo-5-12-2dian-AD-1ml-9505.lcd

Sample Name : lo-5-9-2dian-AD-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:

<Chromatogram>

Peak Table

Detector A Ch1 254nm

PeakN	Ret. Time	Area	Height	Area %
1	13.179	2037444	103663	98.437
2	25.706	32238	847	1.563
Total		2069682	104510	100.000

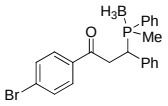
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-92-ic-1ml-9802.lcd

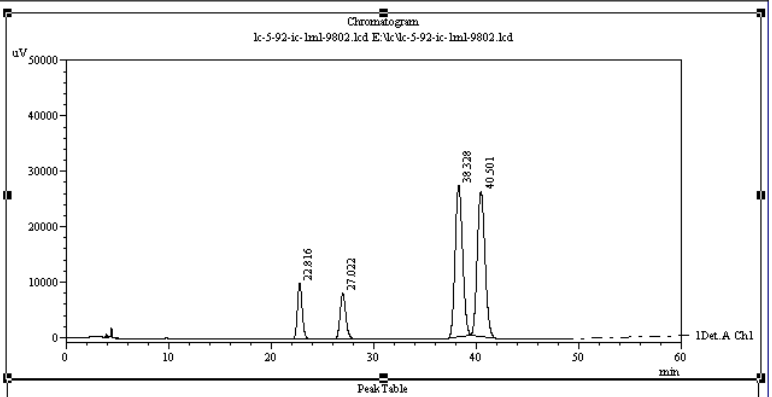
Sample Name : lc-5-92-ic-1ml-9802.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



<Chromatogram>



PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	22.816	327038	10103	9.619
2	27.022	319828	8250	9.407
3	38.328	1379202	27298	40.568
4	40.501	1373698	26137	40.406
Total		3399767	71788	100.000

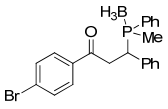
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-91-ic-1ml-9802.lcd

Sample Name : lc-5-91-ic-1ml-9802.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



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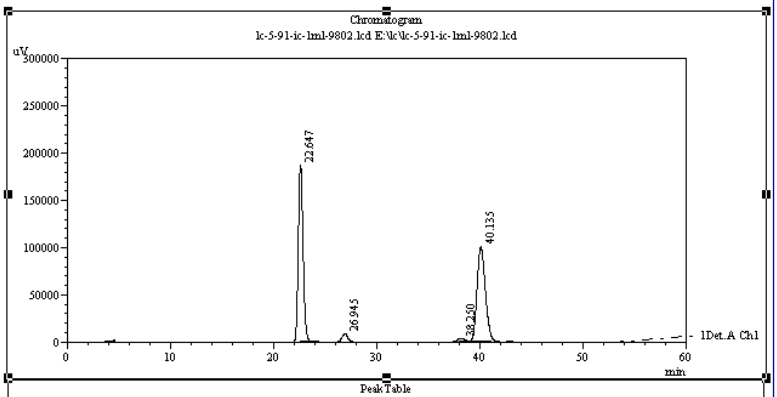
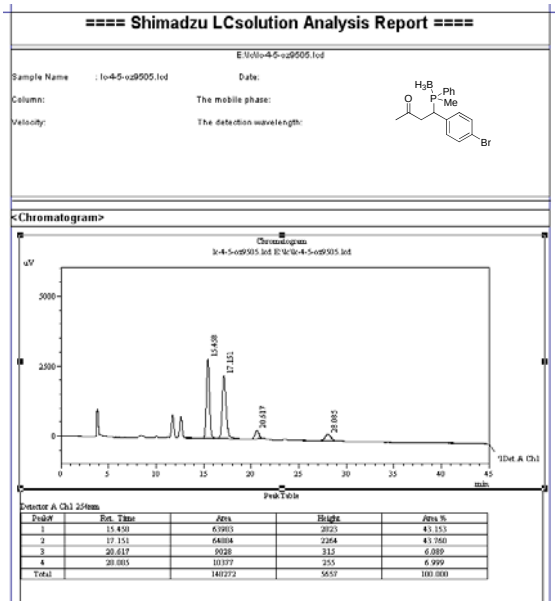


PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	22.647	5955929	186760	49.293
2	26.945	345628	8927	2.861
3	38.250	163734	3511	1.355
4	40.135	5617368	100149	46.491
Total		12082659	299346	100.000


==== Shimadzu LCsolution Analysis Report ====
E:\lolo-4-5-oz9505.lcd
Sample Name : lo-4-5-oz9505.lcd
Date:
Column:
The mobile phase:
Velocity:
The detection wavelength:
H3B
Ph
P
Me
O
Br
<Chromatogram>
Chromatogram
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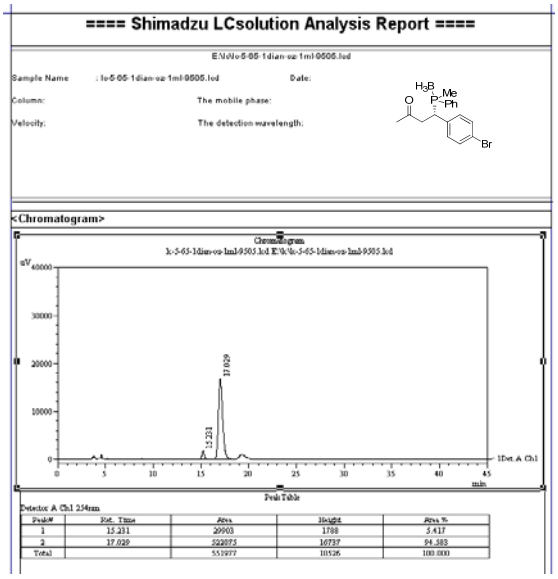
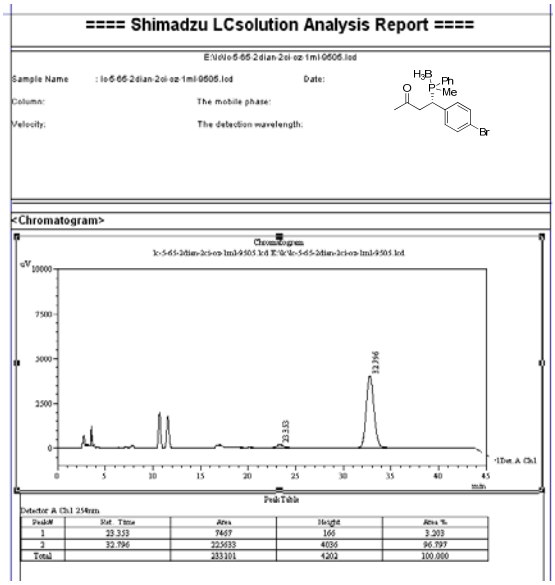
5000
2500
0
15.450
17.151
20.017
28.005
1Det.A Ch1
0
5
10
15
20
25
30
35
40
45
min
Peak Table
Detector A Ch1 254nm
PeakN Ret. Time Area Height Area %
1 15.450 63903 2023 43.153
2 17.151 64004 2264 43.760
3 20.017 9928 313 6.089
4 28.005 10337 255 6.999
Total 140272 5657 100.000


==== Shimadzu LCsolution Analysis Report ====
E:\lolo-5-65-1dian-oz-1ml-0505.lcd
Sample Name : lo-5-65-1dian-oz-1ml-0505.lcd
Date:
Column:
The mobile phase:
Velocity:
The detection wavelength:
H3B
Me
P
Ph
O
Br
<Chromatogram>
Chromatogram
lc-5-65-1dian-oz-1ml-0505.lcd E:\lolo-5-65-1dian-oz-1ml-0505.lcd
uV
40000
30000
20000
10000
0
15.231
17.029
1Det.A Ch1
0
5
10
15
20
25
30
35
40
45
min
Peak Table
Detector A Ch1 254nm
PeakN Ret. Time Area Height Area %
1 15.231 20903 1788 5.417
2 17.029 322073 10737 94.583
Total 551977 10526 100.000


==== Shimadzu LCsolution Analysis Report ====
E:\lolo-5-65-2dian-2ci-oz-1ml-0505.lcd
Sample Name : lo-5-65-2dian-2ci-oz-1ml-0505.lcd
Date:
Column:
The mobile phase:
Velocity:
The detection wavelength:
H3B
Ph
P
Me
O
Br
<Chromatogram>
Chromatogram
lc-5-65-2dian-2ci-oz-1ml-0505.lcd E:\lolo-5-65-2dian-2ci-oz-1ml-0505.lcd
uV
10000
7500
5000
2500
0
23.353
32.796
1Det.A Ch1
0
5
10
15
20
25
30
35
40
45
min
Peak Table
Detector A Ch1 254nm
PeakN Ret. Time Area Height Area %
1 23.353 7467 166 3.203
2 32.796 225633 4036 96.797
Total 233101 4202 100.000

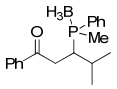
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-4-32-chong-ad-1ml-9505.lcd

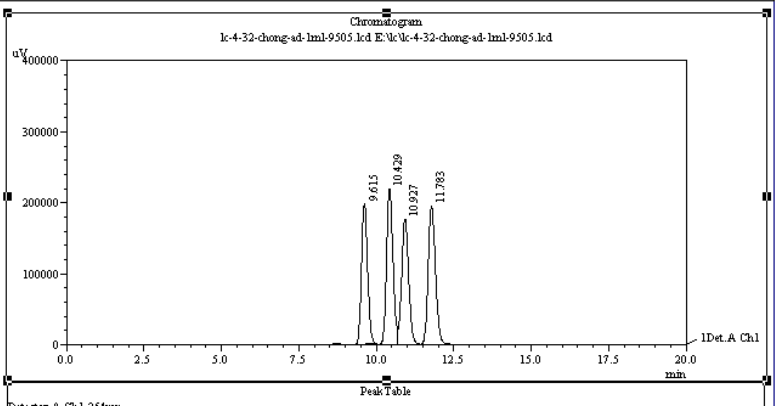
Sample Name : lc-4-32-chong-ad-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



<Chromatogram>



Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	9.615	2718161	198717	23.049
2	10.429	3154959	219035	26.752
3	10.927	2762432	176591	23.424
4	11.783	3157619	194175	26.775
Total		11793171	788519	100.000

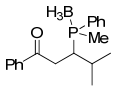
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-66-1-ad-1ml-9505.lcd

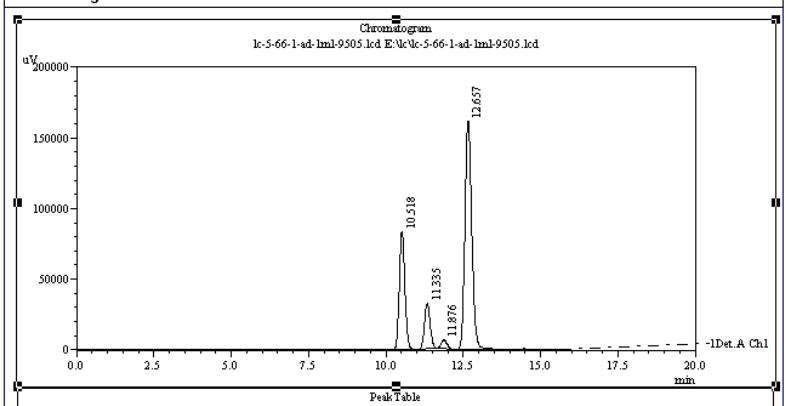
Sample Name : lc-5-66-1-ad-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



<Chromatogram>



Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	10.518	1032818	83051	25.736
2	11.335	410579	31942	10.231
3	11.876	80790	6114	2.013
4	12.657	2488962	161405	62.020
Total		4013150	282513	100.000

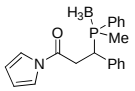
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-4-78-ic-1ml-9505.lcd

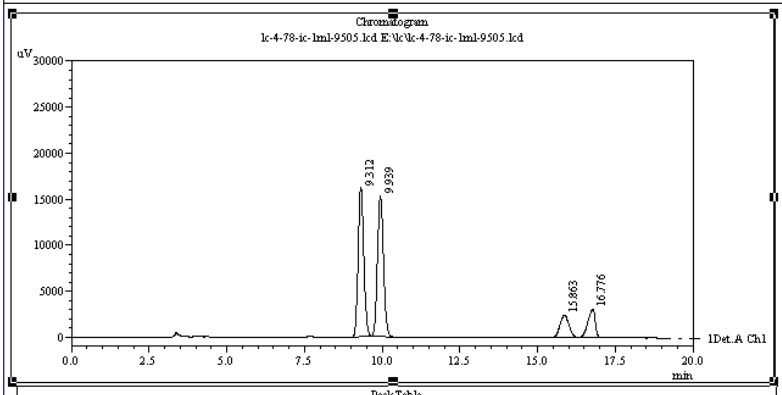
Sample Name : lc-4-78-ic-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



<Chromatogram>



Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	9.312	204642	16223	39.900
2	9.939	205420	15238	40.052
3	15.863	50538	2454	9.854
4	16.776	52287	3083	10.195
Total		512887	36998	100.000

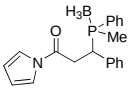
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-4-88-IC-1ml-9505.lcd

Sample Name : lc-4-88-IC-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



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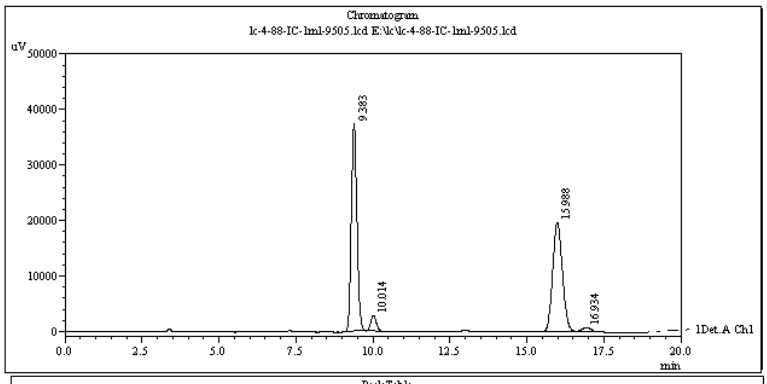


Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	9.383	479260	37520	49.739
2	10.014	37020	2812	3.842
3	15.988	432398	19662	44.875
4	16.934	14878	762	1.544
Total		963556	60756	100.000

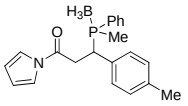
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-4-34-ic-1ml-9505.lcd

Sample Name : lc-4-34-ic-1.0ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



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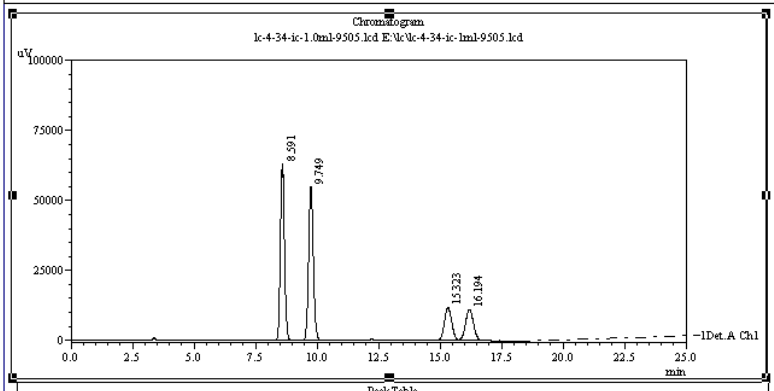


PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	8.591	741662	63005	37.816
2	9.749	738888	54891	37.675
3	15.323	240113	11702	12.243
4	16.194	240566	10945	12.266
Total		1961230	140543	100.000

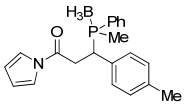
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-15-ic-1ml-9505.lcd

Sample Name : lc-5-15-ic-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



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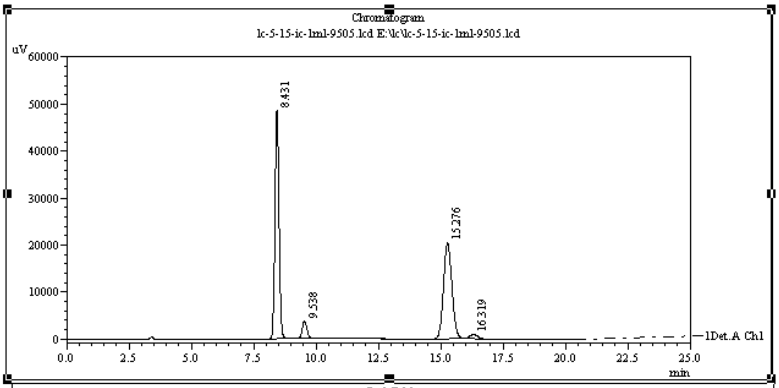


PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	8.431	552386	48644	50.281
2	9.538	48703	3735	4.433
3	15.276	479068	20430	43.607
4	16.319	18444	822	1.679
Total		1098601	73631	100.000

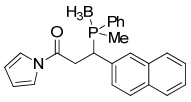
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-4-40-ad-1ml-9505.lcd

Sample Name : lc-4-40-ad-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



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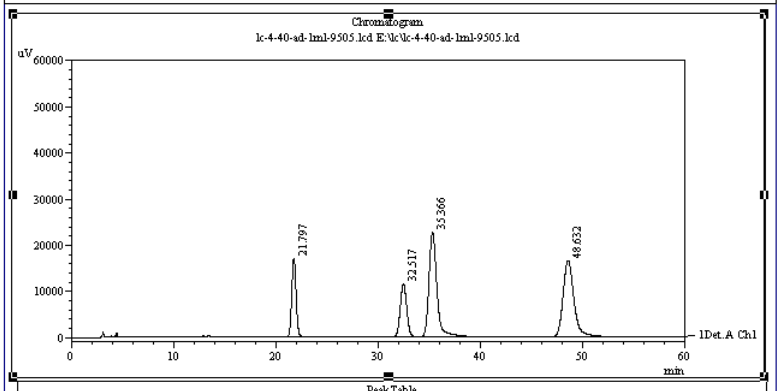


Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	21.797	505072	17077	14.484
2	32.517	504703	11476	14.474
3	35.366	1226113	22665	35.162
4	48.632	1251134	16603	35.880
Total		3487021	67821	100.000

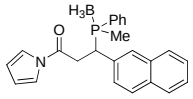
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-14-ad-1ml-9505.lcd

Sample Name : lc-5-14-ad-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



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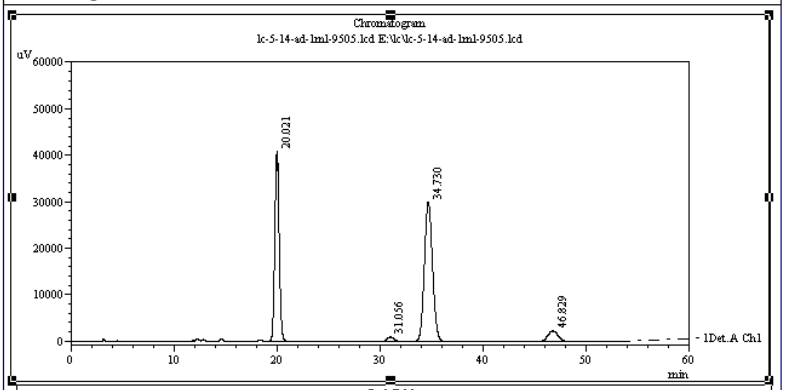


Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	20.021	1207864	40845	39.657
2	31.056	36129	867	1.186
3	34.730	1643463	29987	53.958
4	46.829	158342	2286	5.199
Total		3045797	73984	100.000

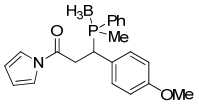
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-67-ic-1ml-9505.lcd

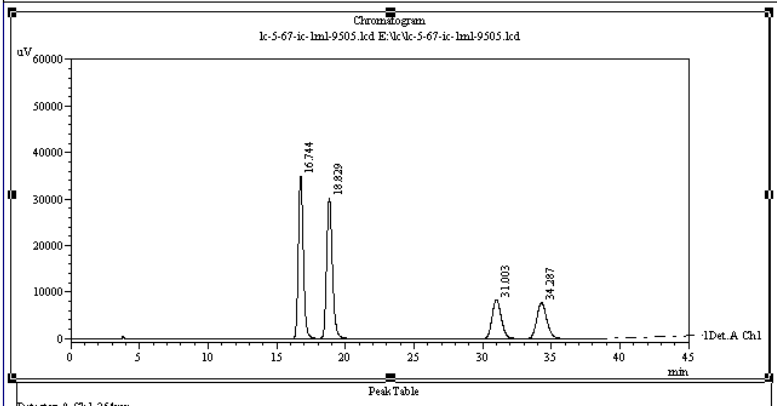
Sample Name : lc-5-67-ic-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



<Chromatogram>



Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	16.744	885464	34990	34.694
2	18.829	884323	30159	34.649
3	31.003	390708	8434	15.308
4	34.287	391740	7689	15.349
Total		2552234	81272	100.000

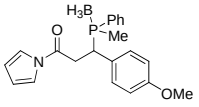
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-58-ic-1ml-9505.lcd

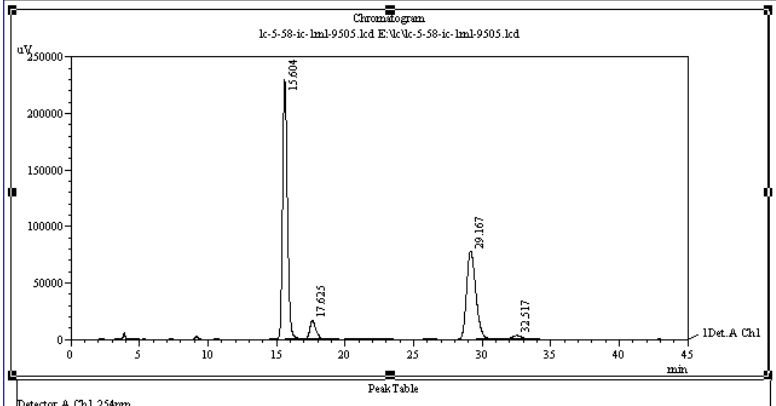
Sample Name : lc-5-58-ic-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



<Chromatogram>



Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	15.604	5624785	229576	56.468
2	17.625	506602	16790	5.086
3	29.167	3668716	78214	36.831
4	32.517	160962	3207	1.616
Total		9961065	327788	100.000

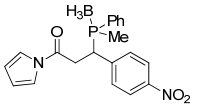
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-4-42-oz-0.8ml-9505.lcd

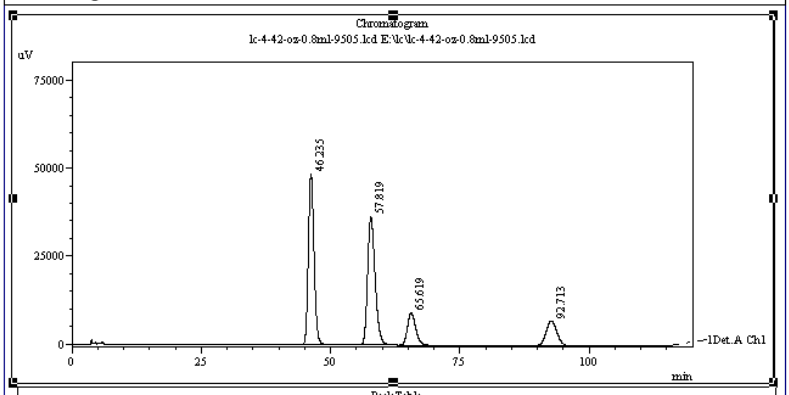
Sample Name : lc-4-42-oz-0.8ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



<Chromatogram>



PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	46.235	3694731	48536	39.231
2	57.819	3672759	36304	38.998
3	65.619	1020320	9178	10.834
4	92.713	1030033	7046	10.937
Total		9417843	101064	100.000

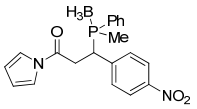
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-13-2ci-oz-0.8ml-9505.lcd

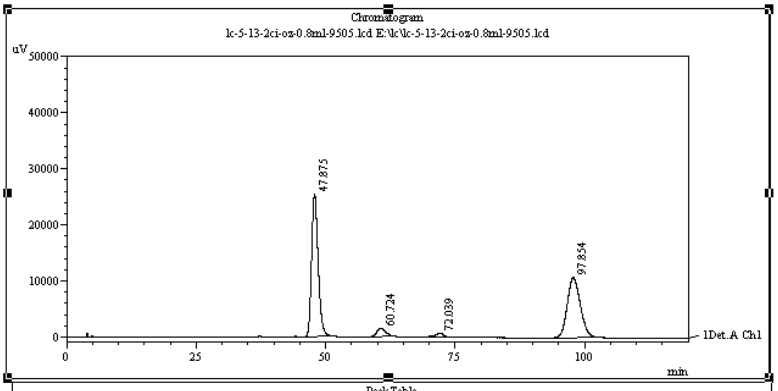
Sample Name : lc-5-13-2ci-oz-0.8ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



<Chromatogram>



PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	47.875	2242359	25352	51.141
2	60.724	177689	1510	4.052
3	72.039	72599	688	1.656
4	97.854	1892046	10721	43.151
Total		4384693	38271	100.000

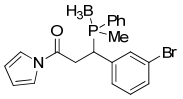
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-4-36-oz-0.8ml-9505.lcd

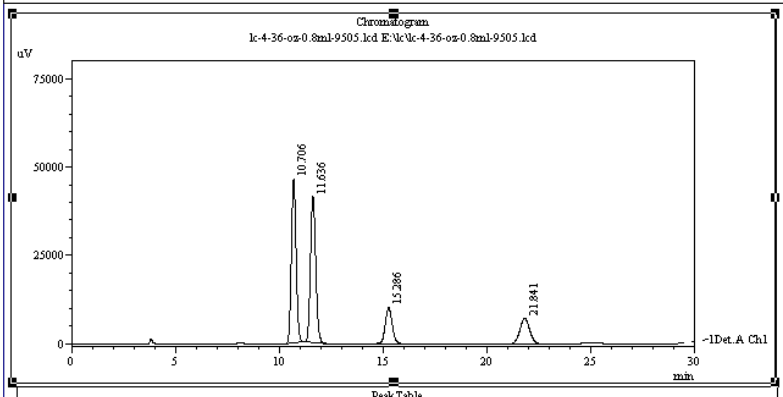
Sample Name : lc-4-36-oz-0.8ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



<Chromatogram>



Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	10.706	729964	46345	37.866
2	11.636	726155	41295	37.668
3	15.286	236019	10135	12.243
4	21.841	235625	7166	12.223
Total		1927763	104940	100.000

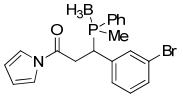
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-16-oz-0.8ml-9505.lcd

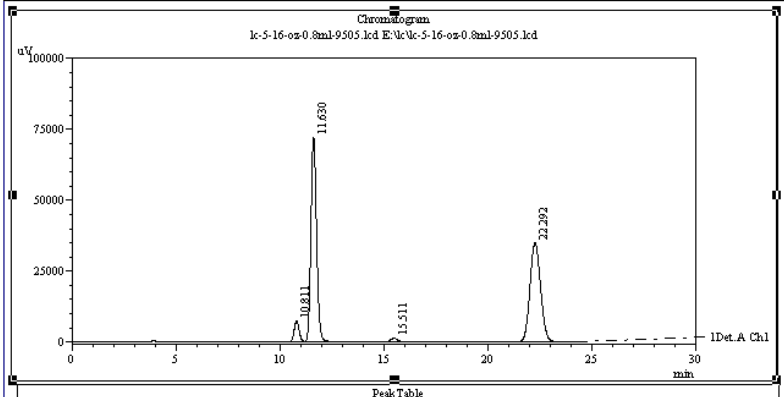
Sample Name : lc-5-16-oz-0.8ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



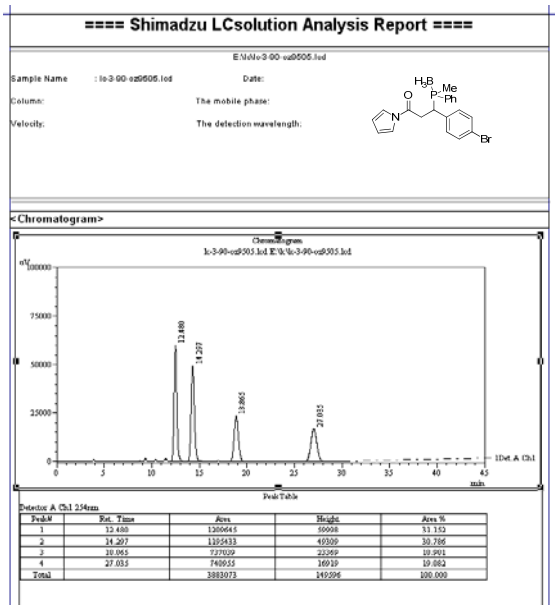
<Chromatogram>



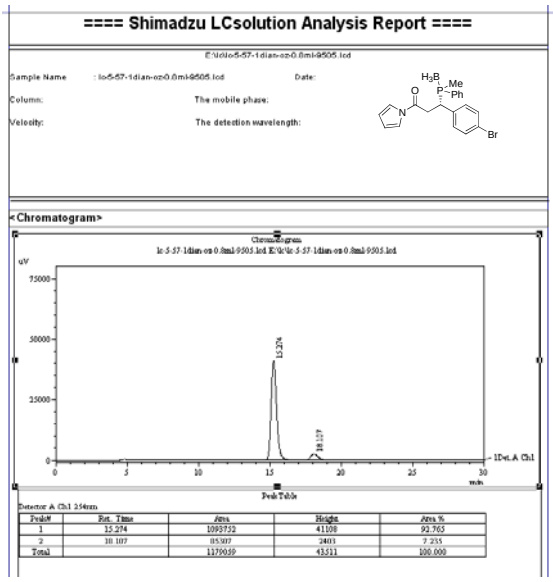
Peak Table

Detector A Ch1 254nm

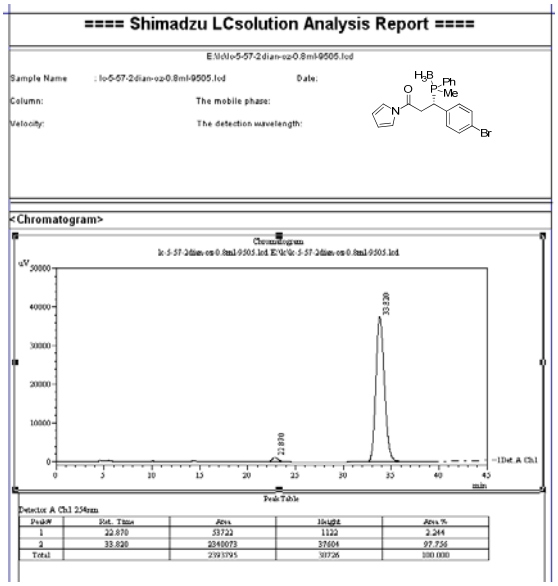
Peak#	Ret. Time	Area	Height	Area %
1	10.811	118434	7259	4.324
2	11.630	1345487	72152	49.124
3	15.511	30776	1267	1.124
4	22.292	1244268	34913	45.428
Total		2738965	115592	100.000



Peak#	Ret. Time	Area	Height	Area %
1	12.480	1206645	60008	31.153
2	14.297	1195433	46309	30.786
3	19.065	727029	22369	19.901
4	27.035	740955	16919	19.082
Total		3883073	145596	100.000



Peak#	Ret. Time	Area	Height	Area %
1	15.274	1093732	41108	92.765
2	18.107	85307	2003	7.235
Total		1179039	43111	100.000



Peak#	Ret. Time	Area	Height	Area %
1	22.870	53722	1122	2.244
2	33.820	2340073	37604	97.756
Total		2393795	38726	100.000

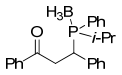
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-63-oz-1ml-9505.lcd

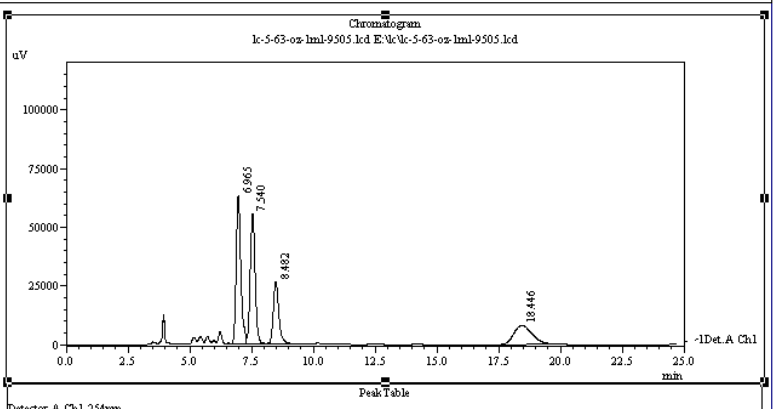
Sample Name : lc-5-63-oz-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



<Chromatogram>



Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	6.965	827544	62842	34.398
2	7.540	755977	55379	31.423
3	8.482	408985	26137	17.000
4	18.446	413304	8086	17.179
Total		2405809	152443	100.000

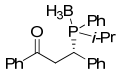
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-64-oz-1ml-9505.lcd

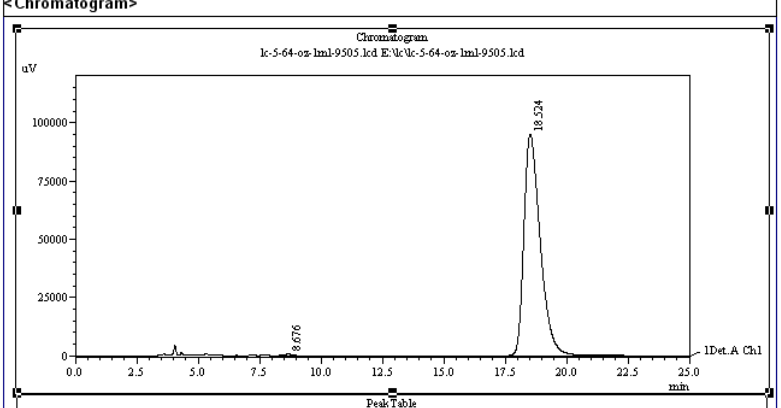
Sample Name : lc-5-64-oz-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



<Chromatogram>



Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	8.676	11708	665	0.266
2	18.524	4386722	94892	99.734
Total		4398430	95557	100.000

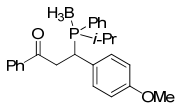
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lo-5-76-2ci-oz-1ml-9505.lcd

Sample Name : lo-5-76-2ci-oz-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



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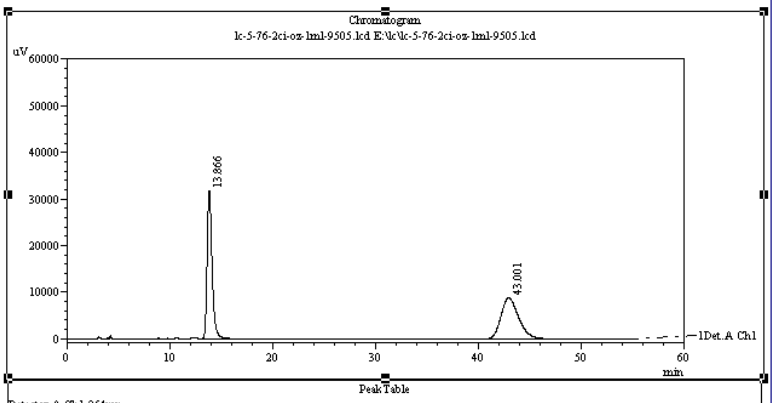


PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	13.866	1066282	31839	50.564
2	43.001	1042483	8745	49.436
Total		2108765	40584	100.000

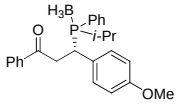
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lo-5-74-oz-1ml-9505.lcd

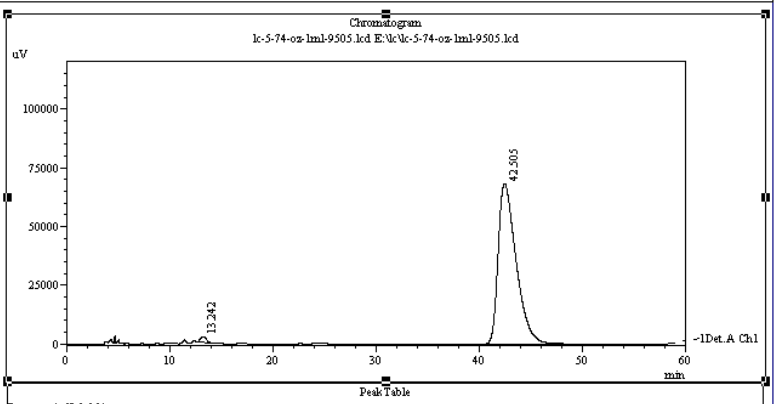
Sample Name : lo-5-74-oz-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



<Chromatogram>



PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	13.242	95357	2357	1.144
2	42.505	8238520	68353	98.856
Total		8333877	70710	100.000

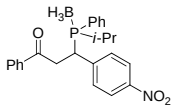
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lo-5-77-oz-1ml-9505.lcd

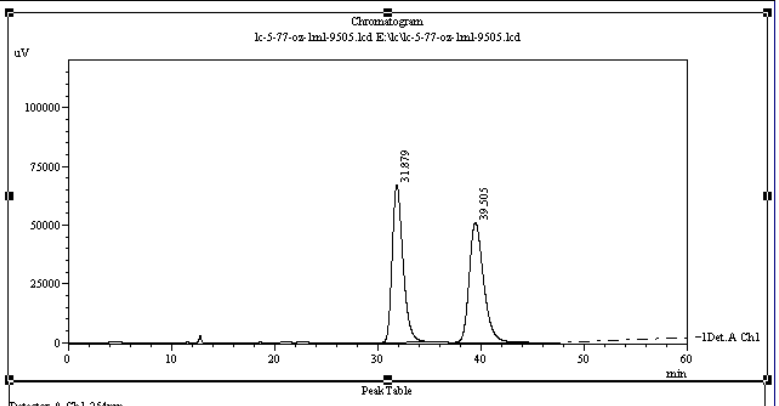
Sample Name : lo-5-77-oz-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



<Chromatogram>



Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	31.879	4901257	66941	49.790
2	39.505	4942555	50955	50.210
Total		9843812	117897	100.000

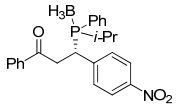
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lo-5-75-oz-1ml-9505.lcd

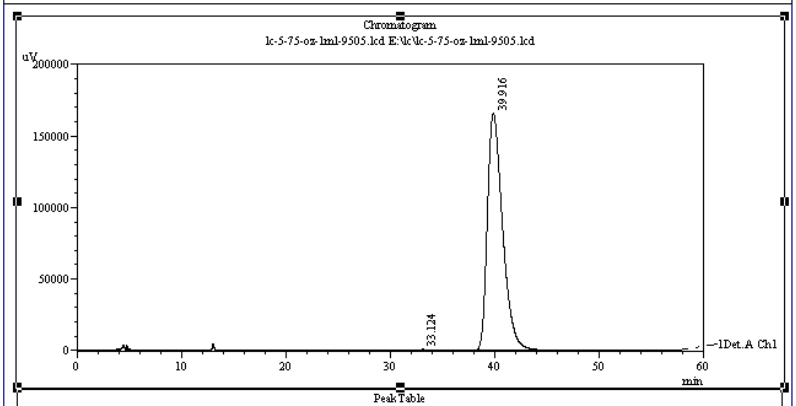
Sample Name : lo-5-75-oz-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



<Chromatogram>



Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	33.124	50567	634	0.300
2	39.916	16822109	165879	99.700
Total		16872677	166512	100.000

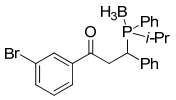
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lo-5-83-oz-1ml-9505.lcd

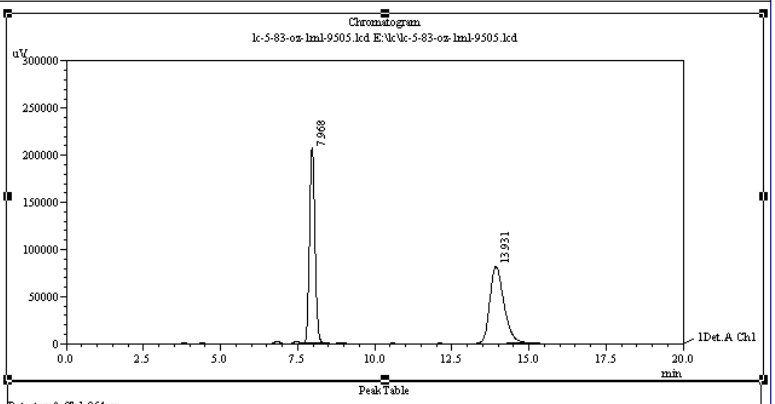
Sample Name : lo-5-83-oz-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



<Chromatogram>



Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	7.968	2572383	206996	49.687
2	13.931	2604792	81536	50.313
Total		5177176	288532	100.000

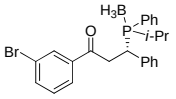
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lo-5-81-oz-1ml-9505.lcd

Sample Name : lo-5-81-oz-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



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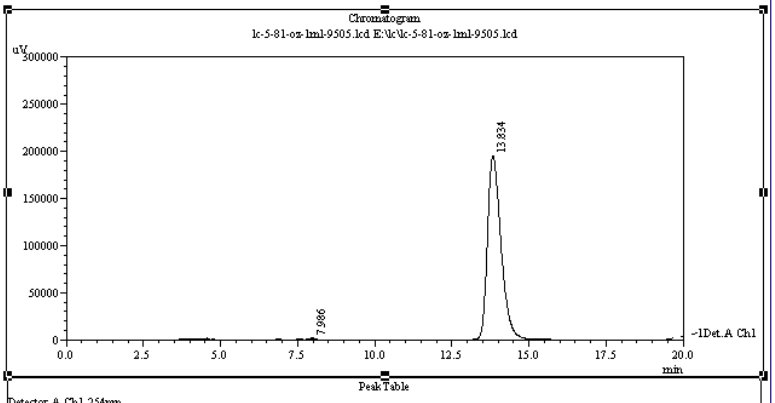


Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	7.986	17362	1594	0.289
2	13.834	5997816	195248	99.711
Total		6015178	196842	100.000

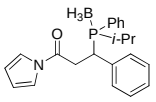
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-84-oz-1ml-9505.lcd

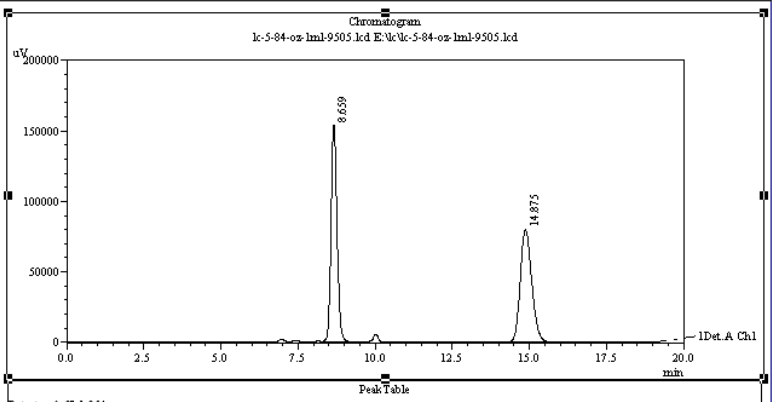
Sample Name : lc-5-84-oz-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



<Chromatogram>



PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	8.659	2079502	153538	50.338
2	14.875	2051577	79562	49.662
Total		4131078	233100	100.000

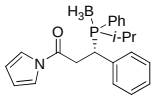
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-82-oz-1ml-9505.lcd

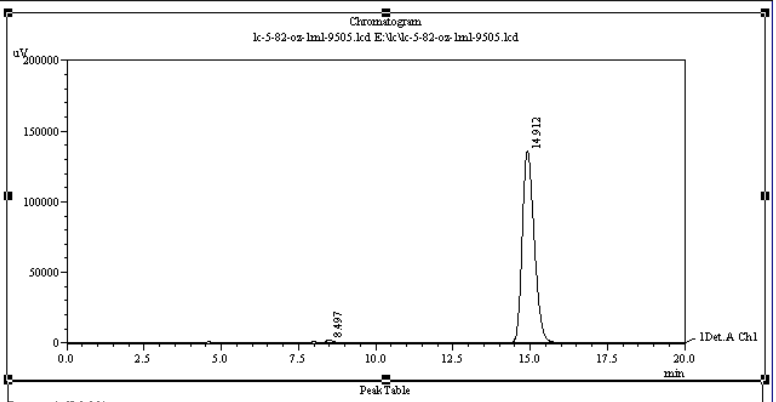
Sample Name : lc-5-82-oz-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



<Chromatogram>



PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	8.497	34901	2258	0.942
2	14.912	3668830	135608	99.058
Total		3703731	137867	100.000

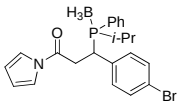
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-86-oz-1ml-9505.lcd

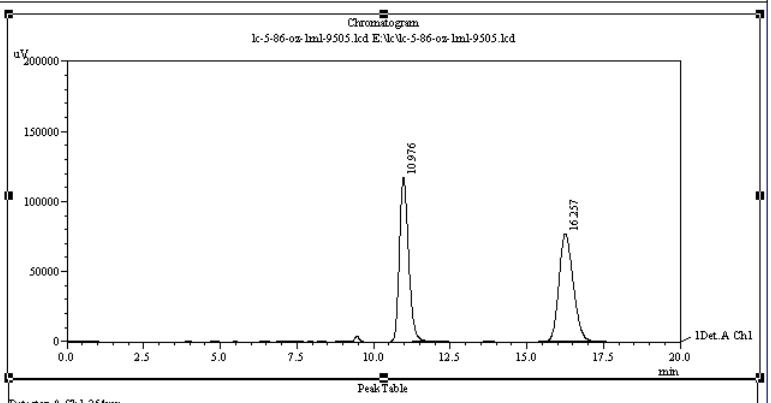
Sample Name : lc-5-86-oz-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



<Chromatogram>



Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	10.976	2452874	116996	49.456
2	16.257	2506798	77248	50.544
Total		4959672	194243	100.000

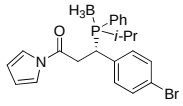
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-89-oz-1ml-9505.lcd

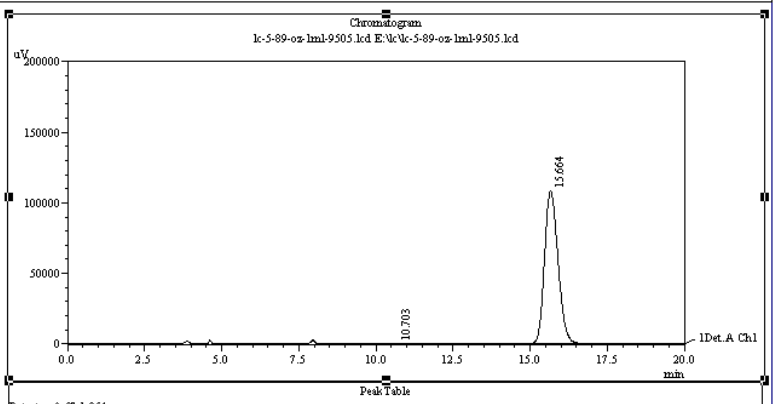
Sample Name : lc-5-89-oz-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



<Chromatogram>



Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	10.703	5996	306	0.181
2	15.664	3312213	108727	99.819
Total		3318209	109033	100.000

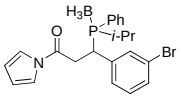
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-87-oz-1ml-9505.lcd

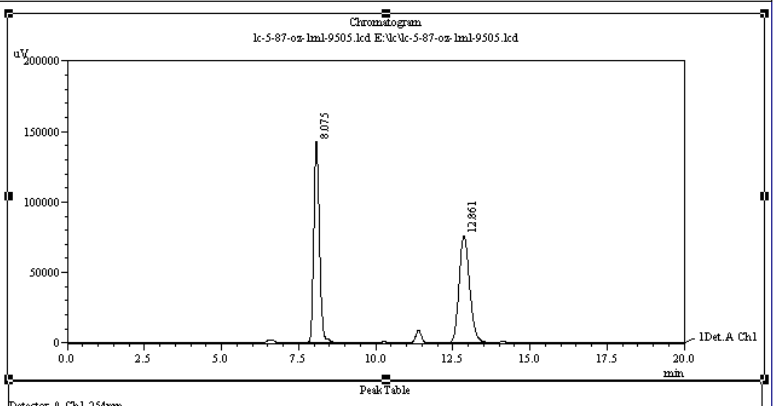
Sample Name : lc-5-87-oz-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



<Chromatogram>



PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	8.075	1825759	142207	50.154
2	12.861	1814566	75534	49.846
Total		3640326	217741	100.000

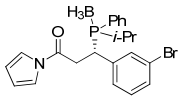
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-90-oz-1ml-9505.lcd

Sample Name : lc-5-90-oz-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



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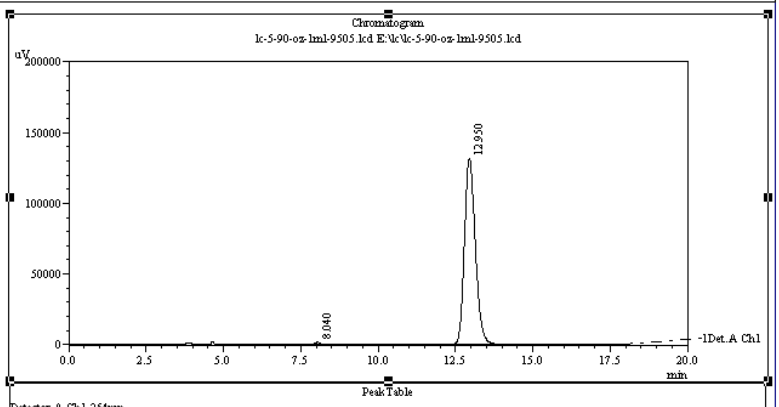


PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	8.040	18750	1702	0.576
2	12.950	3237986	131772	99.424
Total		3256736	133474	100.000

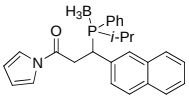
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-94-oz-1ml-9505.lcd

Sample Name : lc-5-94-oz-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



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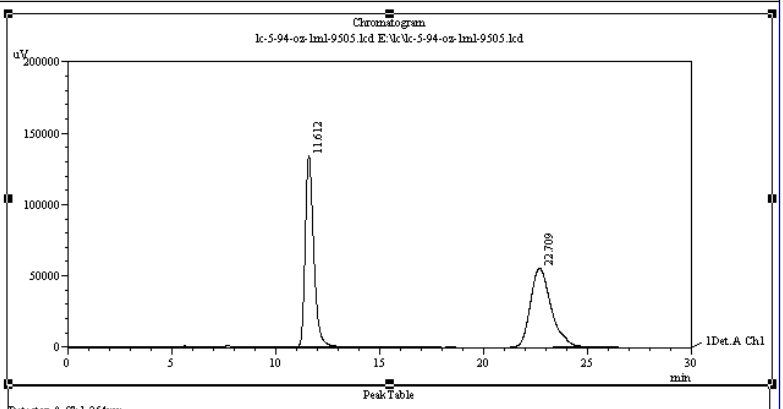


Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	11.612	3797333	133788	49.651
2	22.709	3850706	55347	50.349
Total		7648039	189135	100.000

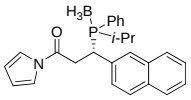
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-93-oz-1ml-9505.lcd

Sample Name : lc-5-93-oz-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



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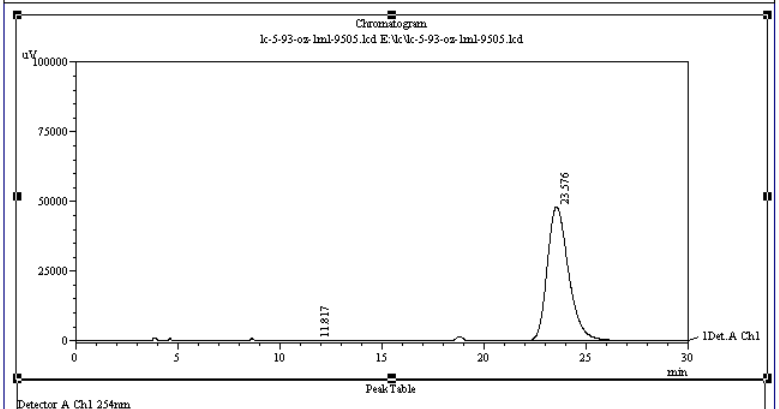


Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	11.817	1883	72	0.054
2	23.576	3506108	48208	99.946
Total		3507991	48279	100.000

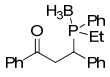
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-54-oz-0.8ml-9505.lcd

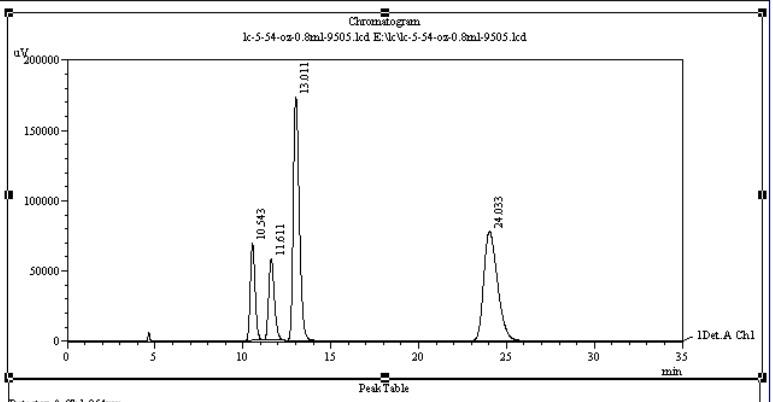
Sample Name : lc-5-54-oz-0.8ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



<Chromatogram>



Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	10.543	1320218	69642	11.943
2	11.611	1301268	57763	11.772
3	13.011	4159514	173516	37.629
4	24.033	4273123	78096	38.656
Total		11054122	379017	100.000

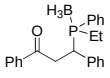
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-68-oz-0.8ml-9505.lcd

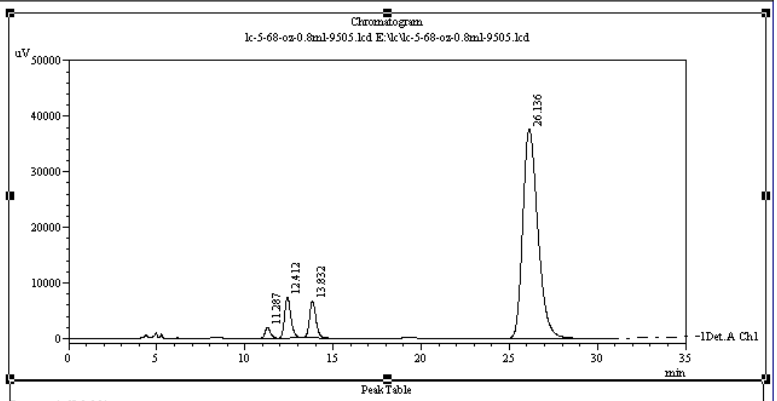
Sample Name : lc-5-68-oz-0.8ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



<Chromatogram>



Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	11.287	38997	1900	1.485
2	12.412	181459	7294	6.912
3	13.832	167356	6568	6.374
4	26.136	2237602	37624	85.229
Total		2625414	53387	100.000

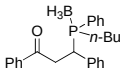
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-61-oz-1ml-9505.lcd

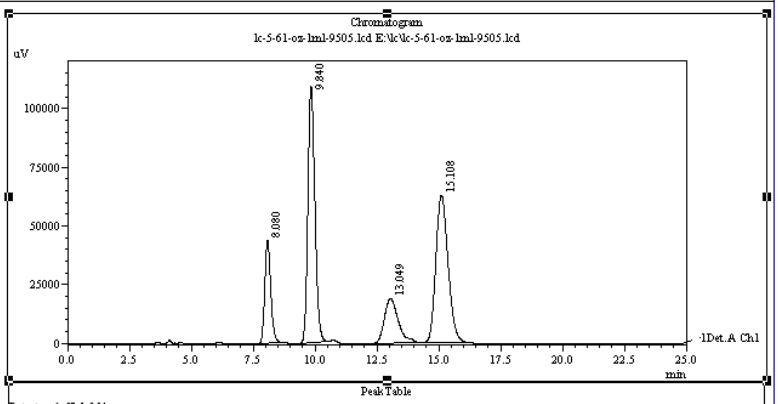
Sample Name : lc-5-61-oz-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



<Chromatogram>



Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	8.080	741587	43830	12.755
2	9.840	2152514	109139	37.021
3	13.049	740421	19053	12.735
4	15.108	2179717	63009	37.489
Total		5814238	235031	100.000

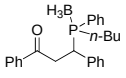
==== Shimadzu LCsolution Analysis Report ====

E:\lc\lc-5-69-oz-1ml-9505.lcd

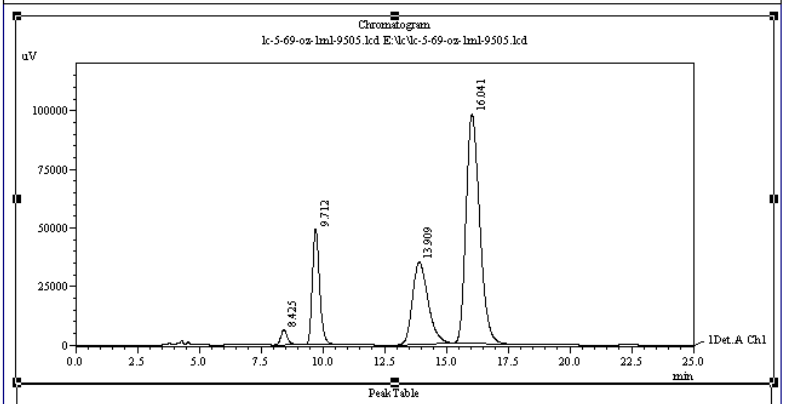
Sample Name : lc-5-69-oz-1ml-9505.lcd Date:

Column: The mobile phase:

Velocity: The detection wavelength:



<Chromatogram>



Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	8.425	116548	6352	1.812
2	9.712	1008711	49421	15.684
3	13.909	1527819	34931	23.755
4	16.041	3778427	97754	58.749
Total		6431505	188457	100.000

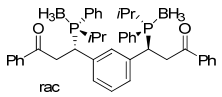
==== Shimadzu LCsolution Analysis Report ====

D:\bql\bql-2-2-oz-3-9010.lcd

Sample Name : bql-2-2-oz-3-9010 Date:

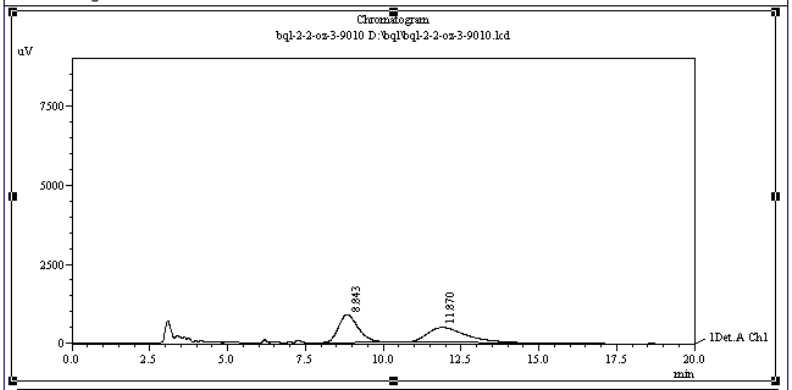
Column: The mobile phase:

Velocity: The detection wavelength:



rac

<Chromatogram>



Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	8.843	39648	885	47.812
2	11.870	43277	477	52.188
Total		82924	1362	100.000

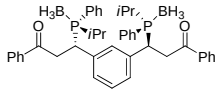
==== Shimadzu LCsolution Analysis Report ====

D:\bql\bql-2-4-oz-2-9010.lcd

Sample Name : bql-2-4-oz-2-9010 Date:

Column: The mobile phase:

Velocity: The detection wavelength:



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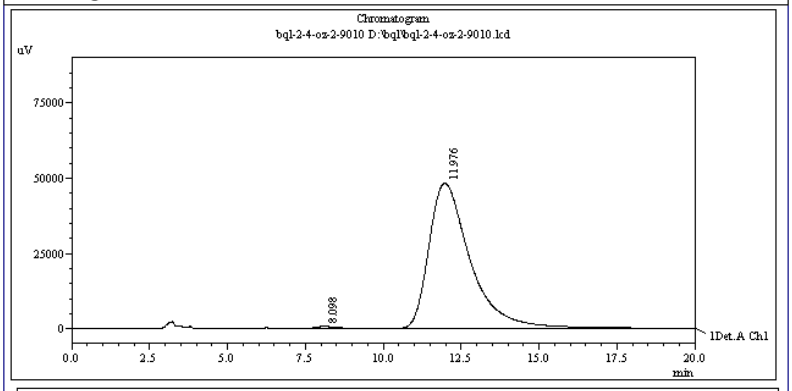
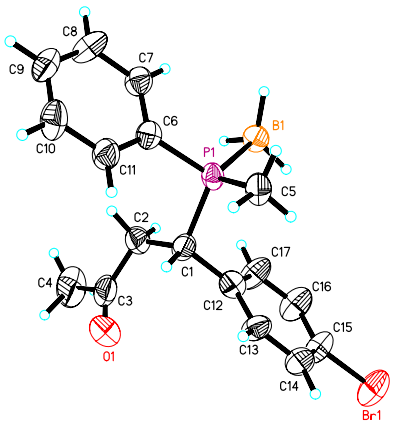


Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	8.098	28582	679	0.629
2	11.976	4516940	48374	99.371
Total		4545522	49054	100.000

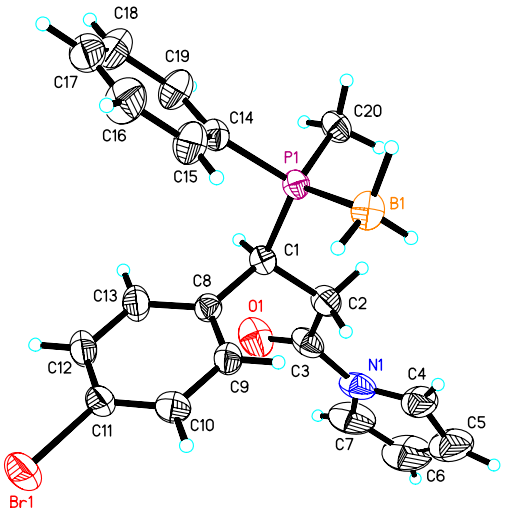
X-Ray Data



cd21370.tex

Table 1. Crystal data and structure refinement for cd21370.

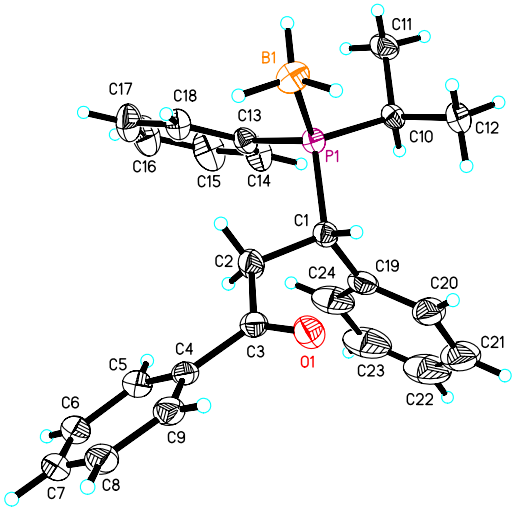
Identification code	cd21370
Empirical formula	C17 H21 B Br O P
Formula weight	363.03
Temperature	293(2) K
Wavelength	0.71073 A
Crystal system, space group	Triclinic, P1
Unit cell dimensions	a = 6.4951(15) A alpha = 81.333(5) deg b = 9.549(2) A beta = 86.707(5) deg. c = 15.501(4) A gamma = 74.351(5) deg.
Volume	915.0(4) A^3
Z, Calculated density	2, 1.318 Mg/m^3
Absorption coefficient	2.329 mm^-1
F(000)	372
Crystal size	0.213 x 0.121 x 0.045 mm
Theta range for data collection	2.24 to 25.50 deg.
Limiting indices	-7<=h<=7, -11<=k<=9, -18<=l<=18
Reflections collected / unique	5255 / 4178 [R(int) = 0.0223]
Completeness to theta = 25.50	99.6 %
Absorption correction	Empirical
Max. and min. transmission	1.00000 and 0.35197
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	4178 / 3 / 407
Goodness-of-fit on F^2	1.019
Final R indices [I>2sigma(I)]	R1 = 0.0552, wR2 = 0.1448
R indices (all data)	R1 = 0.0789, wR2 = 0.1598
Absolute structure parameter	-0.016(13)
Largest diff. peak and hole	0.701 and -0.299 e.A^-3



cd212400.tex

Table 1. Crystal data and structure refinement for cd212400.

Identification code	cd212400
Empirical formula	C20 H22 B Br N O P
Formula weight	414.08
Temperature	293(2) K
Wavelength	0.71073 A
Crystal system, space group	Orthorhombic, P2(1)2(1)2(1)
Unit cell dimensions	a = 6.2364(5) A alpha = 90 deg. b = 17.7803(18) A beta = 90 deg. c = 18.9588(17) A gamma = 90 deg.
Volume	2102.2(3) A^3
Z, Calculated density	4, 1.308 Mg/m^3
Absorption coefficient	2.038 mm^-1
F(000)	848
Crystal size	0.156 x 0.112 x 0.056 mm
Theta range for data collection	1.57 to 26.00 deg.
Limiting indices	-7<=h<=7, -20<=k<=21, -23<=l<=18
Reflections collected / unique	11836 / 4132 [R(int) = 0.0635]
Completeness to theta = 26.00	99.9 %
Absorption correction	Empirical
Max. and min. transmission	1.00000 and 0.08870
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	4132 / 0 / 239
Goodness-of-fit on F^2	0.975
Final R indices [I>2sigma(I)]	R1 = 0.0497, wR2 = 0.1008
R indices (all data)	R1 = 0.0995, wR2 = 0.1189
Absolute structure parameter	0.001(13)
Largest diff. peak and hole	0.477 and -0.331 e.A^-3



cd21374.tex

Table 1. Crystal data and structure refinement for cd21374.

Identification code	cd21374
Empirical formula	C24 H28 B O P
Formula weight	374.24
Temperature	293(2) K
Wavelength	0.71073 A
Crystal system, space group	Orthorhombic, P2(1)2(1)2(1)
Unit cell dimensions	a = 10.135(7) A alpha = 90 deg. b = 13.483(9) A beta = 90 deg. c = 15.598(10) A gamma = 90 deg.
Volume	2132(3) A^3
Z, Calculated density	4, 1.166 Mg/m^3
Absorption coefficient	0.139 mm^-1
F(000)	800
Crystal size	0.212 x 0.158 x 0.137 mm
Theta range for data collection	2.00 to 26.00 deg.
Limiting indices	-12<=h<=11, -16<=k<=16, -14<=l<=19
Reflections collected / unique	13040 / 4197 [R(int) = 0.0326]
Completeness to theta = 26.00	100.0 %
Absorption correction	Empirical
Max. and min. transmission	1.00000 and 0.66750
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	4197 / 24 / 259
Goodness-of-fit on F^2	1.056
Final R indices [I>2sigma(I)]	R1 = 0.0355, wR2 = 0.0902
R indices (all data)	R1 = 0.0383, wR2 = 0.0924
Absolute structure parameter	-0.01(8)
Extinction coefficient	0.0147(19)
Largest diff. peak and hole	0.220 and -0.191 e.A^-3