- Electronic Supplementary Information-

Asymmetric construction of quaternary stereocenters by magnesium catalyzed direct amination of β-ketoesters using in situ generated nitrosocarbonyl compounds as nitrogen sources

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1. General methods.

*Chemicals.*β-ketoesters **1a**[S1], **1b**[S2], **1c-g,**[S3]**1h-l**,[S4]**1m**,[S5]**1n-q**,[S6] and **1r-s**[S7]were prepared according to the literature procedure. Ligands **L3-6** were prepared according to the procedure described by Feng.[S8]Anhydrous THF, CH_2Cl_2, and Et_2O were dried with Glass Contour solvent purification system. All other chemicals were purchased from their commercial sources and used as it received.

Analytics.

NMR spectra were recorded on a JEOL JNM LA-400 (400 MHz for ^{1}H NMR and 100 MHz for ^{13}C NMR). Chemical shifts were reported in ppm on the δ scale relative to Me_4Si (δ = 0 for ^{1}H NMR), $CDCl_3$ (δ = 77.2 for ^{13}C NMR) as an internal reference. Multiplicities are indicated as: br (broad), s (singlet), d (doublet), t (triplet), dd (doublet of doublet), or m (multiplet). Coupling constants (*J*) are reported in Hertz (Hz). ESI mass spectra were measured on a Bruker Daltonics micrOTOF. High performance liquid chromatography (HPLC) was performed on Agilent Technologies 1220 Inifinity LC instruments using Daicel Chiralpak AD-H, OD-H, and AS-H 4.6 mm × 25 cm column. Optical rotations were measured on an ATAGO CO., LTD AP-300 polarimeter. Column chromatography was conducted with silica gel 60 N (KANTO CHEMICAL, spherical, neutral, 40-50 or 63-210 μm). For thin-layer chromatography (TLC) analysis Merck precoated TLC plates (silica gel 60 F254 0.25 mm) were used. Visualization was accomplished by UV light (254 nm), I_2, anisaldehyde, $KMnO_4$, and phosphomolybdic acid.

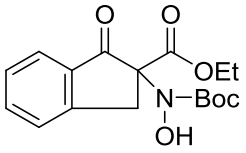
2.*N*-nitroso aldol reaction with in situ generated nitrosocarbonyl compounds.

General procedure:

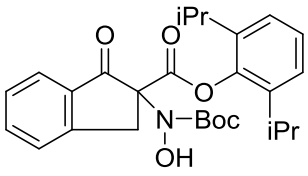
$Mg(OTf)_2$ (2.0 mg, 0.006 mmol) and **L3** (4.8 mg, 0.0075 mmol) were taken in a16 × 100 mm test tube equipped with a magnetic stirr bar and a rubber septum. The test tube was evacuted and carefully purged with nitrogen. CH_2Cl_2 (1 mL) was added to it and the suspension was stirred for 1.5 h. After that a CH_2Cl_2 (1 mL) solution of the ketoester (0.1 mmol) was added and the mixture was further stirred for another 30 min. Under a gentle pressure of nitrogen the septum was uncapped and solid MnO_2 (42 mg, 4.8 mmol) was added in one portion. Then a CH_2Cl_2 (1 mL) solution of the *N*-protected hydroxamic acid (0.12 mmol) was slowly added via a syringe pump over 15 h at room temperature (23 ^oC). The mixture was allowed to stir for an additional 1 h before it was directly loaded into a column packed with silica gel and purified using EtOAc/*n*-hexane (1:4 to 1:3) as eluent to afford the *N*-NA products **3**.

All the recimic sample were similarly prepared using 10 mol% of $Mg(OTf)_2$ in combination with 20 mol% 2-ethyl oxazoline.

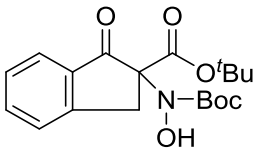
3a: Prepared according to general procedure. 30.5 mg, 91%. 68% ee. ^1H NMR (400 MHz, $CDCl_3$): δ= 1.25 (t, *J* = 7.1 Hz, 3 H), 1.41 (s, 9 H), 3.30 (d, *J* = 17.0 Hz, 1 H), 4.10 (d, *J* = 17.0 Hz, 1 H), 4.24 (q, *J* = 7.1 Hz, 2 H), 6.65 (s, 1 H), 7.40 (t, *J* = 7.5 Hz, 1 H), 7.50 (d, *J* = 7.7 Hz, 1 H), 7.71 – 7.59 (m, 1 H), 7.79 (d, *J* = 7.7 Hz, 1 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ =14.1, 28.1, 36.4, 63.0, 78.0, 84.0, 125.6, 126.4, 128.1, 133.8, 136.1, 152.4, 157.1, 166.4, 194.7 ppm. HRMS (ESI): Calculated for $C_{17}H_{21}N_1Na_1O_6$ ($[M + Na]^+$) is 358.1261, found 358.1256. HLPC analysis: Daicel Chiralpak AS-H, hexane/*i*-PrOH = 96/4, flow rate = 1.0 mL/min, λ = 245 nm, retention time; t_R(minor) = 17.3 min, t_R(major) = 19.8 min.



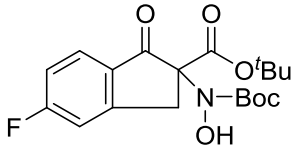
3b: Prepared according to general procedure. 31.8 mg, 68%. $[\alpha]_D^{25}$ +25.2 (*c* = 0.55, $CHCl_3$, 83% ee). ^1H NMR (400 MHz, $CDCl_3$): δ= 0.83 (s, 3 H), 1.14 (s, 9 H), 1.40 (s, 9 H), 2.68 (s, 1 H), 2.74 (s, 1 H), 3.49 (d, *J* = 17.2 Hz, 1 H), 4.25 (d, *J* = 17.2 Hz, 1 H), 6.66 (s, 1 H), 7.09(d, *J* = 7.4 Hz, 2 H), 7.17-7.19 (m, 1 H), 7.44 (t, *J* = 7.5 Hz, 1H), 7.54 (d, *J* = 7.7 Hz, 1H), 7.64-7.68 (m, 1 H), 7.90 (d, *J* = 7.7 Hz, 1H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 22.6, 22.9, 23.7, 23.9, 27.1, 27.3, 28.1, 37.4, 78.3, 84.1, 124.1, 125.6, 126.5, 127.1, 128.3, 134.3, 136.0, 140.3, 140.7, 145.4, 151.9, 156.9, 165.7, 193.5 ppm.HRMS (ESI): Calculated for $C_{27}H_{33}N_1Na_1O_6$ ($[M + Na]^+$) is 490.2200, found 490.2207. HLPC analysis: Daicel Chiralpak OD-H, hexane/*i*-PrOH = 98/2, flow rate = 1.0 mL/min, λ = 254 nm, retention time; t_R(major) = 8.7 min, t_R(minor) = 11.0 min.



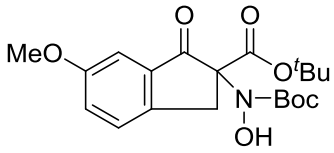
3c: Prepared according to general procedure. 33 mg, 91%. $[\alpha]_D^{25}$ +129.9 (*c* = 1.32, $CHCl_3$, 95% ee). ^1H NMR (400 MHz, $CDCl_3$): δ= 1.40 (2s, 9 + 9 H), 3.29 (d, *J* = 17.0 Hz, 1H), 4.01 (d, *J* = 17.0 Hz, 1H), 6.69 (s, 1 H), 7.39 (t, *J* = 7.5 Hz, 1H), 7.48 (d, *J* = 7.7 Hz, 1H), 7.63 (t, *J* = 6.9 Hz, 1H), 7.79 (d, *J* = 7.7 Hz, 1H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 27.9, 28.2, 37.1, 78.3, 83.6, 83.7, 125.4, 126.3, 128.0, 134.1, 135.8, 152.4, 156.9, 165.7, 194.9 ppm. HRMS (ESI): Calculated for $C_{19}H_{25}N_1Na_1O_6$ ($[M + Na]^+$) is 386.1574, found 386.1570. HLPC analysis: Daicel Chiralpak OD-H, hexane/*i*-PrOH = 96/4, flow rate = 1.0 mL/min, λ = 245 nm, retention time; t_R(minor) = 6.9 min, t_R(major) = 8.2 min.



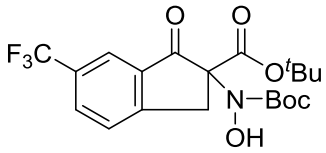
3d: Prepared according to general procedure. 36 mg, 94%. $[\alpha]_D^{23}$ +100.6 (*c* = 0.64, $CHCl_3$, 95% ee). ^1H NMR (400 MHz, $CDCl_3$): δ= 1.41 (s, 9 H), 1.42 (s, 9 H), 3.26 (d, *J* = 17.2 Hz, 1 H), 4.00 (d, *J* = 17.2 Hz, 1 H), 6.67 (s, 1 H), 7.07-7.16 (m, 2 H), 7.81 (dd, *J* = 8.5, 5.3 Hz, 1H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 27.9, 28.2, 36.9, 78.4, 83.8, 84.0, 113.2 (d, *J* = 22.7 Hz), 116.4 (d, *J* = 23.9 Hz), 127.8 (d, *J* = 10.6 Hz), 130.5, 155.4 (d, *J* = 10.5 Hz), 156.9, 165.4, 166.5, 169.0, 193.0 ppm. HRMS (ESI): Calculated for $C_{19}H_{24}F_1N_1Na_1O_6$ ([M + Na]$^+$) is 404.1480, found 404.1476. HLPC analysis: Daicel Chiralpak OD-H, hexane/*i*-PrOH = 97/3, flow rate = 1.0 mL/min, λ = 245 nm, retention time; t_R(minor) = 7.2 min, t_R(major) = 9.7 min.



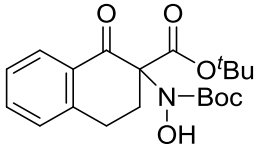
3e: Prepared according to general procedure. 35 mg, 89%. $[\alpha]_D^{22}$ +109.3 (*c* = 0.59, $CHCl_3$, 93% ee). ^1H NMR (400 MHz, $CDCl_3$): δ= 1.41 (s, 9 H), 1.42 (s, 9 H), 3.20 (d, *J* = 17.1 Hz, 1 H), 3.83 (s, 3 H), 4.92 (d, *J* = 16.7 Hz, 1 H), 6.61 (s, 1 H), 7.21-7.24 (m, 2 H), 7.36-7.38 (m, 1H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 27.9, 28.2, 36.4, 55.8, 79.0, 83.6, 83.7, 106.5, 125.2, 127.0, 135.2, 145.4, 156.9, 159.8, 165.8, 194.9 ppm. HRMS (ESI): Calculated for $C_{20}H_{27}N_1Na_1O_7$ ([M + Na]$^+$) is 416.1680, found 416.1680. HLPC analysis: Daicel Chiralpak OD-H, hexane/*i*-PrOH = 98/2, flow rate = 1.0 mL/min, λ = 254 nm, retention time; t_R(minor) = 15.4 min,t_R(major) = 21.0 min.



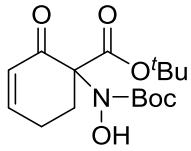
3f: Prepared according to general procedure. 38 mg, 88%. $[\alpha]_D^{22}$ +143.8 (*c* = 0.58, $CHCl_3$, 93% ee). ^1H NMR (400 MHz, $CDCl_3$): δ= 1.41 (s, 9 H), 142 (s, 9 H), 3.33 (d, *J* = 17.6 Hz, 1 H), 6.06 (d, *J* = 17.6 Hz, 1 H), 6.64 (s, 1 H), 7.63 (d, *J* = 8.4 Hz, 1 H), 7.88 (d, *J* = 8.1 Hz, 1 H), 8.07 (s, 1 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 27.9, 28.2, 37.1, 78.3, 84.0, 84.3, 122.4, 122.6, 122.7, 127.1, 130.7, 131.1, 132.1, 134.6, 155.4, 156.9, 165.2, 193.6 ppm. HRMS (ESI): Calculated for $C_{20}H_{24}F_3N_1Na_1O_6$ ([M + Na]$^+$) is 454.1448, found 454.1445. HLPC analysis: Daicel Chiralpak AD-H, hexane/*i*-PrOH = 97/3, flow rate = 1.0 mL/min, λ = 245 nm, retention time; t_R(minor) = 14.7 min, t_R(major) = 21.2 min.



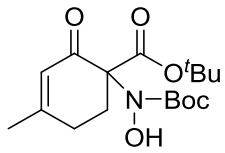
3g: Prepared according to general procedure. 36 mg, 95%. $[\alpha]_D^{23}$ +117.5 (*c* = 0.89, $CHCl_3$, 86% ee). ^1H NMR (400 MHz, $CDCl_3$): δ= 1.44 (s, 9 H), 1.51 (s, 9 H), 2.59-2.66 (m, 1 H), 2.85-2.94 (m 2 H), 3.21-3.29 (m, 1 H), 6.23 (s, 1 H), 7.22 (d, *J* = 7.7 Hz, 1H), 7.29 (t, *J* = 7.4 Hz, 1H), 7.44-7.48 (m, 1 H), 7.89 (dd, *J* = 7.8, 1.3 Hz, 1H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 25.8, 28.1, 28.2, 31.8, 76.9, 83.5, 84.2, 126.7, 128.3, 128.7, 132.4, 133.4, 143.3, 158.6, 168.0, 191.6 ppm. HRMS (ESI): Calculated for $C_{20}H_{27}N_1Na_1O_6$ ([M + Na]$^+$) is 400.1731, found 400.1735. HLPC analysis: Daicel Chiralpak AD-H, hexane/*i*-PrOH = 98/2, flow rate = 1.0 mL/min, λ = 254 nm, retention time; t_R(major) = 48.6 min, t_R(minor) = 54.4 min.



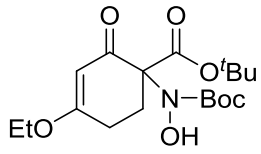
3h: Prepared according to general procedure. 31 mg, 95%. $[\alpha]_D^{23}$ +215.4 (*c* = 0.58, $CHCl_3$, 93% ee). ^1H NMR (400 MHz, $CDCl_3$): δ= 1.47 (s, 9 H), 1.51 (s, 9 H), 2.32-2.40 (m, 1 H), 2.45-2.52 (m, 1 H), 2.55-2.64 (m, 1 H), 2.72-2.78 (m, 1 H), 6.03-6.07 (m, 1 H), 6.09 (s, 1 H), 6.86-6.90 (m, 1 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 24.1, 28.1, 28.2, 31.2, 76.5, 83.5, 84.1, 128.1, 149.3, 158.4, 167.8, 191.7 ppm. HRMS (ESI): Calculated for $C_{16}H_{25}N_1Na_1O_6$ ([M + Na]$^+$) is 350.1574, found 350.1576. HLPC analysis: Daicel Chiralpak AD-H, hexane/*i*-PrOH = 97/3, flow rate = 1.0 mL/min, λ = 230 nm, retention time; t_R(minor) = 20.6 min, t_R(major) = 23.8 min.



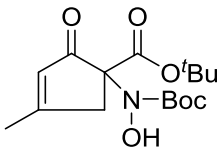
3i: Prepared according to general procedure. 33 mg, 97%. $[\alpha]_D^{23}$ +120.9 (*c* = 0.59, $CHCl_3$, 96% ee). ^1H NMR (400 MHz, $CDCl_3$): δ= 1.48 (s, 9 H), 1.49 (s, 9 H), 1.96 (s, 3 H), 2.24-230 (m, 1 H), 2.43-2.59 (m, 2 H), 2.71-2.76 (m, 1 H), 5.89 (s, 1 H), 6.13 (s, 1 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 24.1, 28.1, 28.2, 29.0, 30.9, 75.9, 83.3, 83.8, 124.7, 158.4, 161.7, 168.0, 191.4 ppm. HRMS (ESI): Calculated for $C_{17}H_{27}N_1Na_1O_6$ ([M + Na]$^+$) is 364.1731, found 364.1732. HLPC analysis: Daicel Chiralpak AD-H, hexane/*i*-PrOH = 97/3, flow rate = 1.0 mL/min, λ = 230 nm, retention time; t_R(minor) = 19.5 min, t_R(major) = 24.1 min.



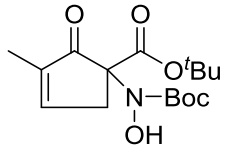
3j: Prepared according to general procedure. 36 mg, 97%. $[\alpha]_D^{24}$ +242.5 (*c* = 0.70, $CHCl_3$, 96% ee). ^1H NMR (400 MHz, $CDCl_3$): δ= 1.36 (t, *J* = 7.0 Hz, 3 H), 1.49 (s, 9 H), 1.50 (s, 9 H), 2.40-2.52 (m, 2 H), 2.60-2.68 (m, 1 H), 2.73-2.79 (m, 1 H), 3.89-3.95 (m, 2 H), 5.34 (s, 1 H), 6.16 (s, 1 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.3, 26.7, 28.1, 28.2, 29.1, 64.8, 76.1, 83.3, 83.5, 101.0, 158.3, 167.9, 177.1, 191.6 ppm. HRMS (ESI): Calculated for $C_{18}H_{29}N_1Na_1O_7$ ([M + Na]$^+$) is 394.1836, found 394.1841. HLPC analysis: Daicel Chiralpak AD-H, hexane/*i*-PrOH = 97/3, flow rate = 1.0 mL/min, λ = 230 nm, retention time; t_R(minor) = 32.2 min, t_R(major) = 41.5 min.



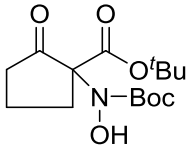
3k: Prepared according to general procedure. 27 mg, 83%. $[\alpha]_D^{23}$ +113.4 (*c* = 0.37, $CHCl_3$, 93% ee). ^1H NMR (400 MHz, $CDCl_3$): δ= 1.45 (s, 9 H), 1.48 (s, 9 H), 2.19 (s, 3 H), 2.75 (d, *J* = 17.5 Hz, 1 H), 3.44 (d, *J* = 17.5 Hz, 1 H), 5.91-5.92 (m, 1 H), 6.44 (s, 1 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 19.8, 27.9, 28.3, 43.2, 77.1, 83.3, 83.4, 127.2, 157.1, 165.7, 178.8, 197.4 ppm. HRMS (ESI): Calculated for $C_{16}H_{25}N_1Na_1O_6$ ([M + Na]$^+$) is 350.1574, found 350.1578. HLPC analysis: Daicel Chiralpak AD-H, hexane/*i*-PrOH = 97/3, flow rate = 1.0 mL/min, λ = 230 nm, retention time; t_R(minor) = 16.0 min, t_R(major) = 20.3 min.



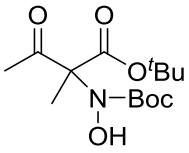
3l: Prepared according to general procedure. 30 mg, 92%. $[\alpha]_D^{25}$ –29.3 (*c* = 0.36, $CHCl_3$, 95% ee). ^1H NMR (400 MHz, $CDCl_3$): δ= 1.45 (s, 9 H), 1.47 (s, 9 H), 1.82 (q, *J* = 1.9 Hz, 3 H), 2.73 (dp, *J* = 18.5, 2.4 Hz, 1 H), 3.38 -3.45 (m, 1 H), 6.51 (s, 1 H), 7.39-7.41 (m, 1 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 10.9, 27.9, 28.3, 37.7, 75.5, 83.3, 83.5, 139.0, 157.0, 157.3, 165.8, 198.0 ppm. HRMS (ESI): Calculated for $C_{16}H_{25}N_1Na_1O_6$ ([M + Na]$^+$) is 350.1574, found 350.1573. HLPC analysis: Daicel Chiralpak AD-H, hexane/*i*-PrOH = 97/3, flow rate = 1.0 mL/min, λ = 230 nm, retention time; t_R(minor) = 22.2 min, t_R(major) = 25.0 min.



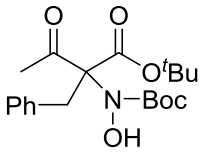
3m: Prepared according to general procedure. 29 mg, 92%. $[\alpha]_D^{22}$ + 108.0 (*c* = 0.27, $CHCl_3$, 85% ee). ^1H NMR (400 MHz, $CDCl_3$): δ= 1.48 (s, 9 H), 1.48 (s, 9 H), 1.96-2.15 (m, 2 H), 2.31-2.62 (m, 4 H), 6.34 (s, 1 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 18.5, 28.0, 28.3, 32.6, 36.2, 77.7, 83.6, 83.7, 157.2, 167.5, 206.5 ppm. HRMS (ESI): Calculated for $C_{15}H_{25}N_1Na_1O_6$ ([M + Na]$^+$) is 338.1574, found 338.1573. HLPC analysis: Daicel Chiralpak OD-H, hexane/*i*-PrOH = 99/1, flow rate = 1.0 mL/min, λ = 210 nm, retention time; t_R(minor) = 10.3 min, t_R(major) = 11.4 min.



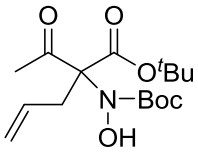
3n: Prepared according to general procedure. 27 mg, 89%. $[\alpha]_D^{23}$ + 99.8 (*c* = 0.42, $CHCl_3$, 94% ee). ^{1}HNMR (400 MHz, $CDCl_3$): δ= 1.48 (s, 9 H), 1.50 (s, 9 H), 1.68 (s, 3 H), 2.28 (s, 1 H), 6.30 (s, 1 H), ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 19.2, 25.5, 28.0, 28.2, 78.9, 83.5, 84.4, 158.0, 168.2, 200.0 ppm. HRMS (ESI): Calculated for $C_{14}H_{25}N_1Na_1O_6$ ([M + Na]$^+$) is 326.1574, found 326.1576. HLPC analysis: Daicel Chiralpak OD-H, hexane/*i*-PrOH = 99/1, flow rate = 1.0 mL/min, λ = 210 nm, retention time; t_R(minor) = 10.3 min, t_R(major) = 11.3 min.



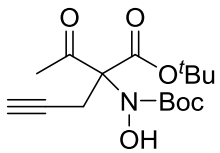
3o: Prepared according to general procedure. 36 mg, 95%. $[\alpha]_D^{23}$ + 82.0 (*c* = 0.70, $CHCl_3$, 93% ee). ^1H NMR (400 MHz, $CDCl_3$): δ= 1.34 (s, 9 H), 1.47 (s, 9 H), 2.10 (s, 3 H), 3.44 (d, *J* = 14.2 Hz, 1 H), 3.57 (d, *J* = 14.2 Hz, 1 H), 6.44 (s, 1 H), 7.18-7.27 (m, 3 H), 7.38-7.40 (m, 2 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 26.7, 27.9, 28.1, 36.8, 82.6, 83.6, 84.3, 127.1, 128.3, 131.3, 135.8, 156.4, 167.2, 197.4 ppm. HRMS (ESI): Calculated for $C_{20}H_{29}N_1Na_1O_6$ ([M + Na]$^+$) is 402.1887, found 402.1883. HLPC analysis: Daicel Chiralpak AD-H, hexane/*i*-PrOH = 99/1, flow rate = 1.0 mL/min, λ = 210 nm, retention time; t_R(minor) = 30.5 min, t_R(major) = 38.0 min.



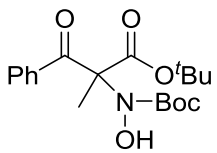
3p: Prepared according to general procedure. 29 mg, 88%. $[\alpha]_D^{22}$ – 47.0 (*c* = 0.43, $CHCl_3$, 94% ee). ^1H NMR (400 MHz, $CDCl_3$): δ= 1.48 (s, 9 H), 149 (s, 9 H), 2.24 (s, 3 H), 2.86-2.96 (m, 2 H), 5.08-5.18 (m, 2 H), 5.93-6.04 (m, 1 H), 6.36 (s, 1 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 26.9, 28.0, 28.2, 37.8, 81.5, 84.0, 84.1, 119.1, 133.5, 157.5, 167.5, 198.6 ppm. HRMS (ESI): Calculated for $C_{16}H_{27}N_1Na_1O_6$ ([M + Na]$^+$) is 352.1731, found 352.1732. HLPC analysis: Daicel Chiralpak AD-H, hexane/*i*-PrOH = 99/1, flow rate = 1.0 mL/min, λ = 210 nm, retention time; t_R(minor) = 25.0 min, t_R(major) = 27.8 min.



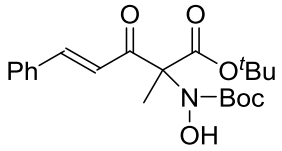
3q: Prepared according to general procedure. 27 mg, 82%. $[\alpha]_D^{25}$ + 22.7 (*c* = 0.44, $CHCl_3$, 94% ee). ^1H NMR (400 MHz, $CDCl_3$): δ= 1.50 (s, 9 H), 1.50 (s, 9 H), 2.10 (t, J = 2.7 Hz, 1 H), 2.37 (s, 3 H), 3.03-3.12 (m, 2 H), 6.35 (s, 1 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 23.4, 26.7, 28.0, 28.2, 71.8, 79.5, 80.0, 84.4, 157.2, 166.2, 198.3 ppm. HRMS (ESI): Calculated for $C_{16}H_{25}N_1Na_1O_6$ ([M + Na]$^+$) is 350.1574, found 350.1571. HLPC analysis: Daicel Chiralpak AS-H, hexane/*i*-PrOH = 99/1, flow rate = 1.0 mL/min, λ = 210 nm, retention time; t_R(major) = 11.9 min, t_R(minor) = 15.4 min.



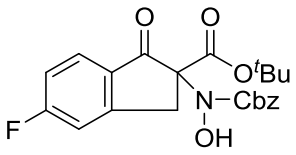
3r: Prepared according to general procedure. 30 mg, 82%. $[\alpha]_D^{23}$ + 34.7 (*c* = 0.40, $CHCl_3$, 86% ee). ^1H NMR (400 MHz, $CDCl_3$): δ= 1.27 (s, 9 H), 1.47 (s, 9 H), 1.85 (s, 3 H), 6.70 (s, 1 H), 7.42 (t, *J* = 7.7 Hz, 2 H), 7.53 (t, *J* = 7.4 Hz, 2 H), 8.20 (t, *J* = 7.3 Hz, 2 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 20.5, 27.9, 28.0, 78.6, 83.7, 84.8, 128.4, 129.8, 133.0, 135.1, 157.8, 168.8, 191.4 ppm. HRMS (ESI): Calculated for $C_{19}H_{27}N_1Na_1O_6$ ([M + Na]$^+$) is 388.1731, found 388.1734. HLPC analysis: Daicel Chiralpak AD-H, hexane/*i*-PrOH = 97/3, flow rate = 1.0 mL/min, λ = 230 nm, retention time; t_R(minor) = 14.9 min, t_R(major) = 18.8 min.



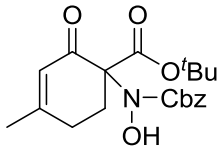
3s: Prepared according to general procedure. 35 mg, 89%. $[\alpha]_D^{24}$ – 51.7 (*c* = 0.42, $CHCl_3$, 87% ee). ^1H NMR (400 MHz, $CDCl_3$): δ= 1.14 (s, 9 H), 1.50 (s, 9 H), 1.75 (s, 3 H), 6.49 (s, 1 H), 7.17 (d, *J* = 16.0 Hz, 1 H), 7.38-7.41 (m, 3 H), 7.56-7.58 (m, 2 H), 7.71 (d, *J* = 16.0 Hz, 1 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 19.0, 28.1, 78.3, 83.6, 84.7, 121.5, 128.6, 129.1, 130.7, 134.8, 143.2, 158.0, 168.0, 191.2 ppm. HRMS (ESI): Calculated for $C_{21}H_{29}N_1Na_1O_6$ ($[M + Na]^+$) is 414.1887, found 414.1882. HLPC analysis: Daicel Chiralpak AS-H, hexane/*i*-PrOH = 97/3, flow rate = 1.0 mL/min, λ = 290 nm, retention time; t_R(major) = 12.5 min, t_R(minor) = 17.2 min.



3t: Prepared according to general procedure. 37 mg, 89%. $[\alpha]_D^{24}$ + 35.1 (*c* = 0.60, $CHCl_3$, 95% ee). ^1H NMR (400 MHz, $CDCl_3$): δ= 1.35 (s, 9 H), 3.28 (d, *J* = 17.3 Hz, 1 H), 3.97 (d, *J* = 17.3 Hz, 1 H), 5.13-5.19 (m, 2H), 6.92 (s, 1 H), 7.05-7.13 (m, 2 H), 7.31-7.37 (m, 5 H), 7.78 (dd, *J* = 8.4, 5.3 Hz, 1H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 27.8, 36.8, 68.8, 78.4, 84.3, 113.2 (d, *J* = 22.7 Hz)116.5 (d, *J* = 23.9 Hz), 127.9 (d, *J* = 10.6 Hz), 128.5, 128.6, 128.7, 155.3 (d, *J* = 10.6 Hz), 157.8, 165.2, 166.5, 169.1, 192.7 ppm. HRMS (ESI): Calculated for $C_{22}H_{22}F_1N_1Na_1O_6$ ($[M + Na]^+$) is 438.1323, found 438.1323. HLPC analysis: Daicel Chiralpak AD-H, hexane/*i*-PrOH = 96/4, flow rate = 1.0 mL/min, λ = 240 nm, retention time; t_R(minor) = 40.8 min, t_R(major) = 44.2 min.

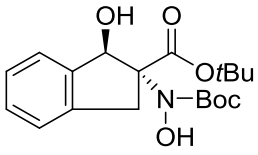


3u: Prepared according to general procedure. 35 mg, 93%. $[\alpha]_D^{25}$ + 59.2 (*c* = 0.45, $CHCl_3$, 93% ee). ^1H NMR (400 MHz, $CDCl_3$): δ= 1.43 (s, 9 H), 1.95 (s, 3 H), 2.29-2.36 (m, 1 H), 2.44-2.53 (m, 2 H), 2.76-2.83 (m, 1 H), 5.21 (s, 2 H), 5.92-5.93 (m, 1 H), 6.16 (s, 1 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 24.2, 28.0, 29.0, 30.5, 68.7, 76.0, 83.7, 124.9, 128.5, 128.7, 135.5, 159.1, 162.4, 167.6, 191.1 ppm. HRMS (ESI): Calculated for $C_{20}H_{25}N_1Na_1O_6$ ($[M + Na]^+$) is 398.1574, found 398.1573. HLPC analysis: Daicel Chiralpak AD-H, hexane/*i*-PrOH = 95/5, flow rate = 1.0 mL/min, λ = 230 nm, retention time; t_R(major) = 37.7 min, t_R(minor) = 43.0 min.



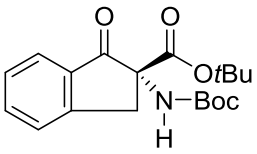
3. Synthesis of compound 4c.

To a 10 mL round bottom flask equipped with a magnetic stir bar and a rubber septum was added Pd-C (7.5 mg) and the flask was evacuated before purged with hydrogen using a balloon. Then a MeOH (2 mL) solution of **3c** (36.3 mg, 0.100 mmol) was added and the mixture was stirred and the progress of the reaction was monitored by TLC. After complete consumption of **3c** (4h) the mixture was filtered over celite. The residue was purified by silica gel column chromatography using *n*-hexane/ethyl acetate (3:1 to 2:1) as eluent. 34 mg, 93%. $[\alpha]_D^{25}$ +68.6 (*c* = 0.58, $CHCl_3$, 95% ee). ^1H NMR (400 MHz, $CDCl_3$): δ= 1.24 (s, 9 H), 1.57 (s, 9 H), 3.37 (d, *J* = 16.3 Hz, 1H), 3.51 (d, *J* = 16.4 Hz, 1H), 3.95 (brs, 1 H), 5.79 (d, *J* = 3.6 Hz, 1H), 6.31 (s, 1 H), 7.13-7.15 (m 1 H), 7.21-2.24 (m, 2 H), 7.35-7.37 (m, 1 H)ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ =27.9, 28.4, 42.4, 81.7, 81.8, 82.7, 83.7, 123.5, 123.8, 126.9, 128.1, 139.5, 141.5, 159.1, 169.9 ppm. HRMS (ESI): Calculated for $C_{19}H_{27}N_1Na_1O_6$ ($[M + Na]^+$) is 388.1731, found 388.1728. HLPC analysis: Daicel Chiralpak AD-H, hexane/*i*-PrOH = 94/6, flow rate = 1.0 mL/min, λ = 215 nm, retention time; t_R(minor) = 13.7 min, t_R(major) = 24.2 min.

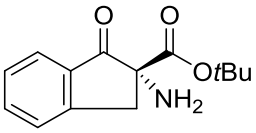


4. Synthesis of compound 5c.

A two necked Schlenk flask (10 mL) equipped with a reflux condenser and a magnetic stir bar was added **3c** (36.3 mg, 0.100 mmol) and $Mo(CO)_6$ (39.9 mg, 0.150 mmol). The whole system was purged with nitrogen. A mixture of CH_3CN-distilled H_2O (2 mL, 9: 1 v/v) was then added and the mixture was then heated at 80 °C. The reaction was monitored by TLC and after complete consumption of **3c** (12 h) the mixture was cooled to room temperature and diluted with CH_2Cl_2 (5 mL) and filtered after drying with anhydrous Na_2SO_4 and concentrated in vacuum. The crude product was then purified by silica gel flash chromatography using 2 : 3 EtOAc/*n*-hexane as eluent to obtain **5c-Boc** (25.4 mg, 73%). $[\alpha]_D^{23}$ +81.4 (*c* = 0.29, $CHCl_3$, 95% ee). ^{1}H NMR (400 MHz, $CDCl_3$): δ= 1.29 (s, 9 H), 1.43 (s, 9 H), 3.51 (d, *J* = 16.1 Hz, 1 H), 3.67 (d, *J* = 16.8 Hz, 1H), 5.98 (s, 1H), 7.38 (t, *J* = 7.5 Hz, 1H), 7.46 (d, *J* = 7.6 Hz, 1H), 7.62 (t, *J* = 7.3 Hz, 1H), 7.79 (d, *J* = 7.7 Hz, 1H)ppm. HRMS (ESI): Calculated for $C_{19}H_{25}N_1Na_1O_5$ ($[M + Na]^+$) is 370.1625, found 370.1621. HLPC analysis: Daicel Chiralpak AD-H, hexane/*i*-PrOH = 99/1, flow rate = 1.0 mL/min, λ = 215 nm, retention time; t_R(minor) = 21.6 min, t_R(major) = 26.2 min.

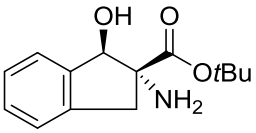


To an oven dried one necked round bottom flask (5 mL) equipped with a magnetic stir bar was added **3c-Boc** (35 mg, 0.10 mmol). The flask was then purged with nitrogen and dry CH_2Cl_2 (1 mL) was then added and the white suspension was the placed into an ice bath. Trifluroacetic acid (92 μL, 136 mg, 1.2 mmol) was added with gentle stirring. The mixture was allowed to stir at 0 °C. After complete consumption of **3c-Boc** (monitored by TLC, 3 h) the reaction was quenched with saturated NH_4Cl (0.2 mL) and the organics were extracted in CH_2Cl_2 (5 × 2 mL). Combined organic layer was dried over anhydrous Na_2SO_4, concentrated in vacuo, and the residue was purified by silica gel flash chromatography using 1:1 *n*-hexane/ethyl acetate as eluent to obtain **3c** (23.7 mg, 96%). ^{1}H and ^{13}C NMR data match with those reported in the literature.[S9] $[\alpha]_D^{24}$ +13.9 (*c* = 0.9, $CHCl_3$, 95% ee). ^{1}H NMR (400 MHz, $CDCl_3$): δ= 1.34 (s, 9 H), 1.94 (brs, 2 H), 3.06 (d, *J* = 16.9 Hz, 1H), 3.64 (d, *J* = 17.0 Hz, 1H), 7.41 (t, *J* = 7.5 Hz, 1H), 7.47 (d, *J* = 7.7 Hz, 1H), 7.61-7.65 (m, 1 H), 7.79 (d, *J* = 7.7 Hz, 1H)ppm. HLPC analysis: Daicel Chiralpak AD-H, hexane/*i*-PrOH = 94/6, flow rate = 1.0 mL/min, λ = 240 nm, retention time; t_R(major) = 14.7 min, t_R(major) = 17.3 min.



5. Synthesis of compound 6c.

To a 5 mL round bottom flask equipped with a magnetic stir bar and a rubber septum was added Pd-C (5 mg) and the flask was evacuated before purged with hydrogen using a balloon. Then a MeOH (1 mL) solution of **5c** (24.7 mg, 0.100 mmol) was added and the mixture was stirred overnight. After complete consumption of **5c** (monitored by TLC) the mixture was filtered over a short plug of silica gel and celite, wash with methanol. The residue was then concentrated to obtain **6c** (24.4 mg, 98%) as single diastereomer. ^{1}H and ^{13}C NMR data match with those reported in the literature.[S9] $[\alpha]_D^{25}$ +43.6 (*c* = 0.85, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$): δ= 1.45 (s, 9 H), 2.03 (brs, 2 H), 2.82 (d, *J* = 16.2 Hz, 1H), 3.60 (d, *J* = 16.2 Hz, 1H), 4.90 (s, 1 H), 7.20-7.29 (m, 3 H), 7.39-7.41 (m, 1 H)ppm.



6. References

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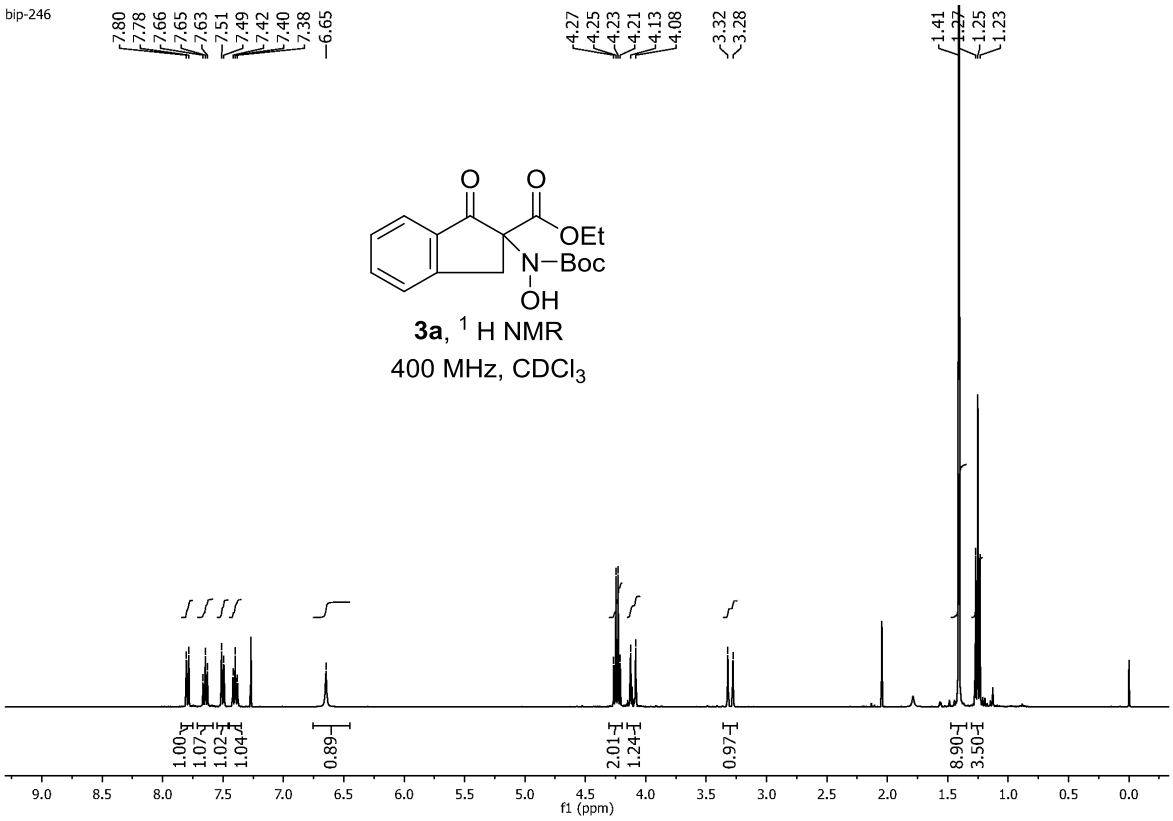
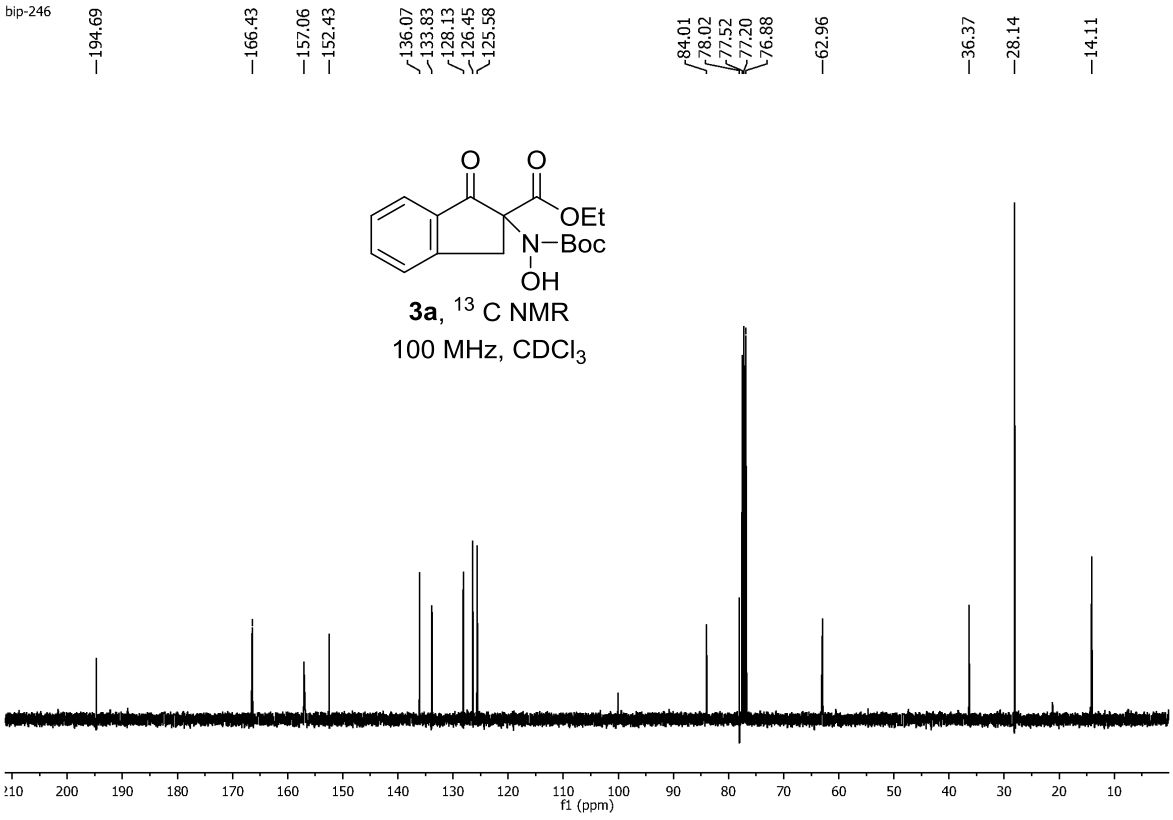
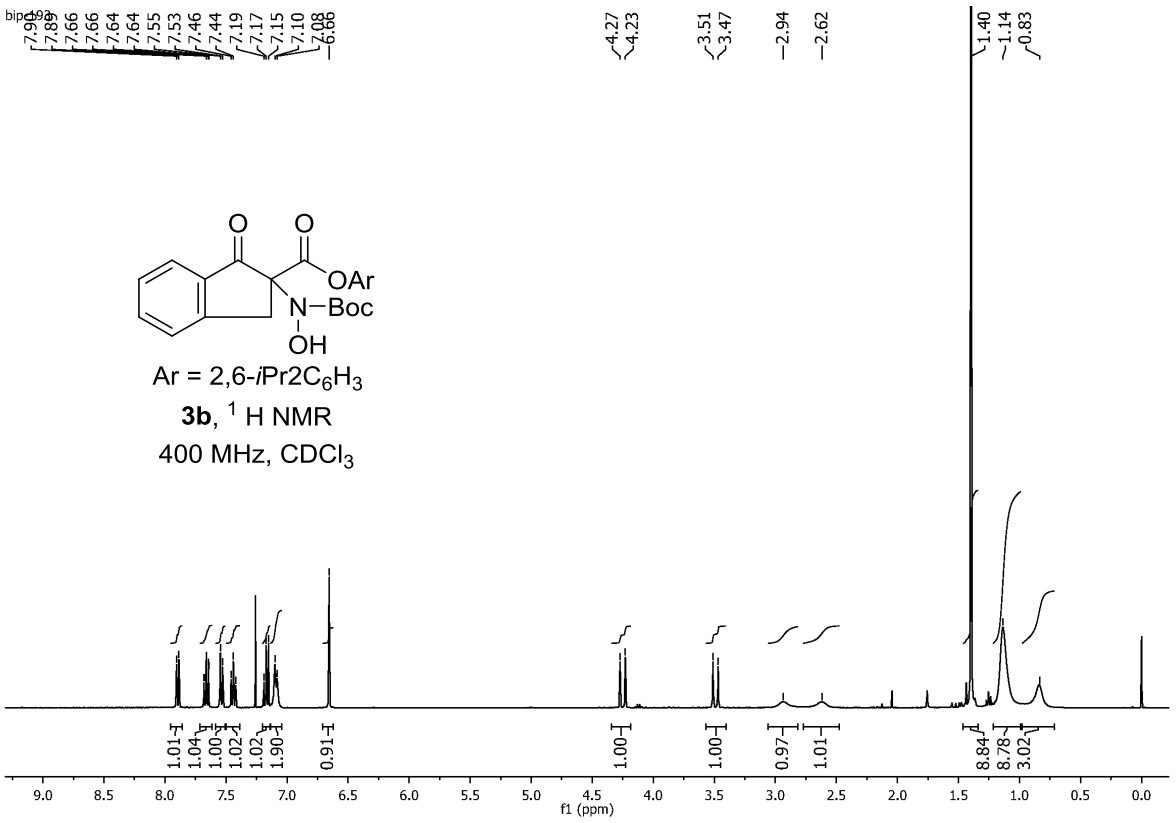
7. Copies of 1H and 13C NMR spectra



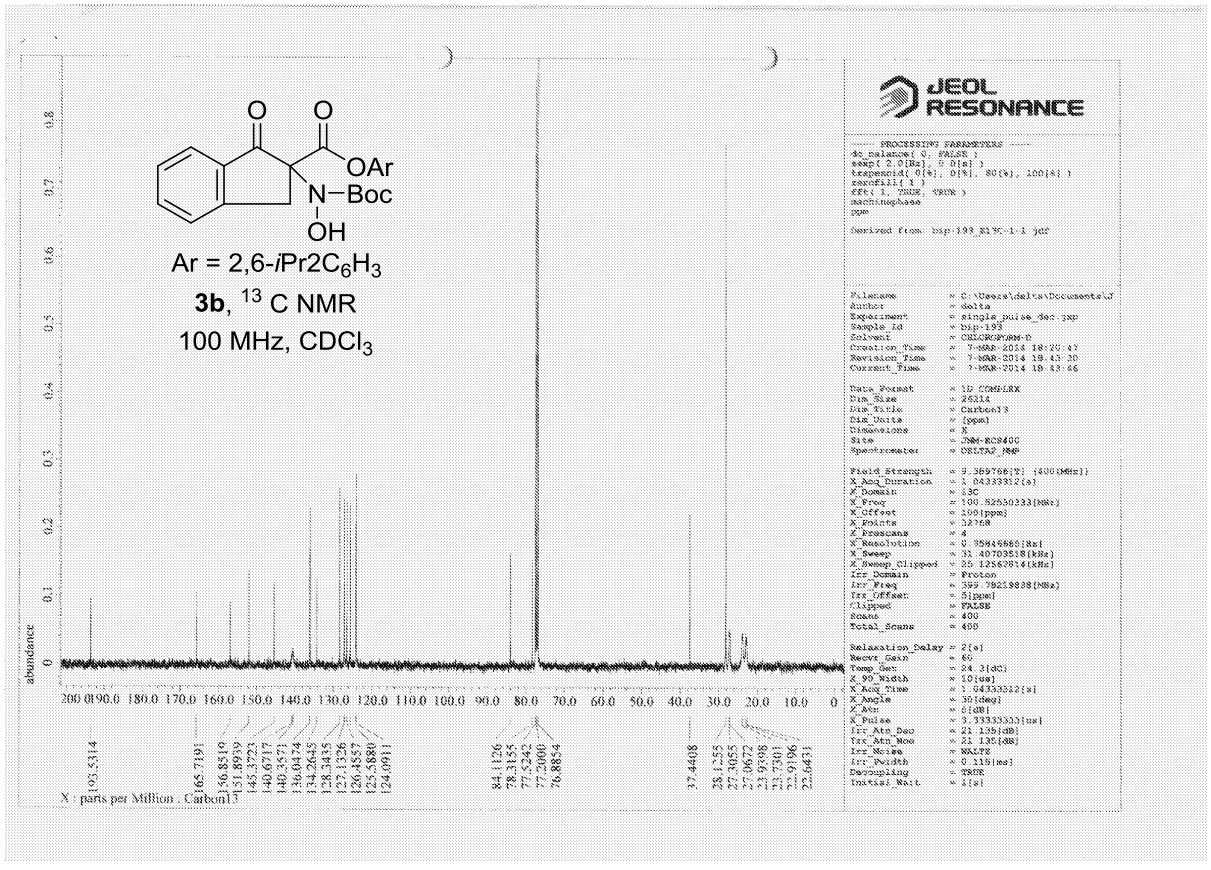




Ar = 2,6-*i*Pr2C_6H_3

3b, ^{1} H NMR

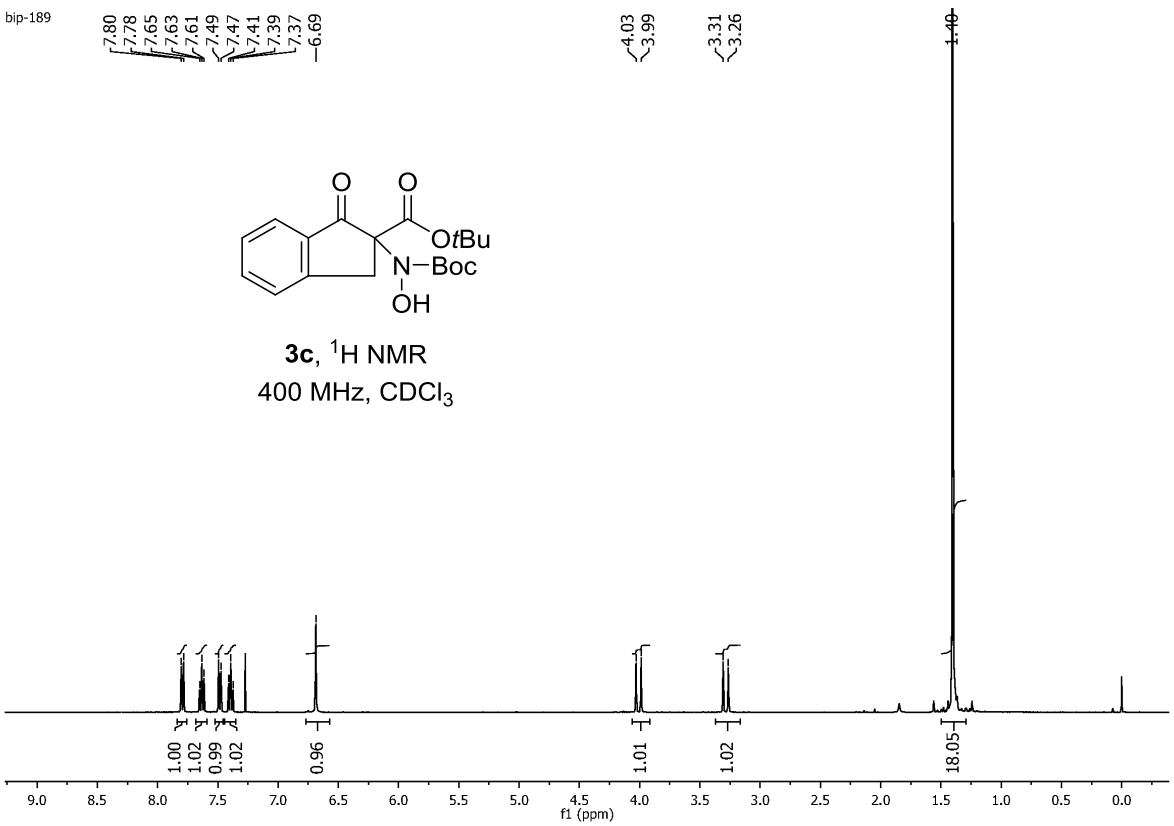
400 MHz, $CDCl_3$



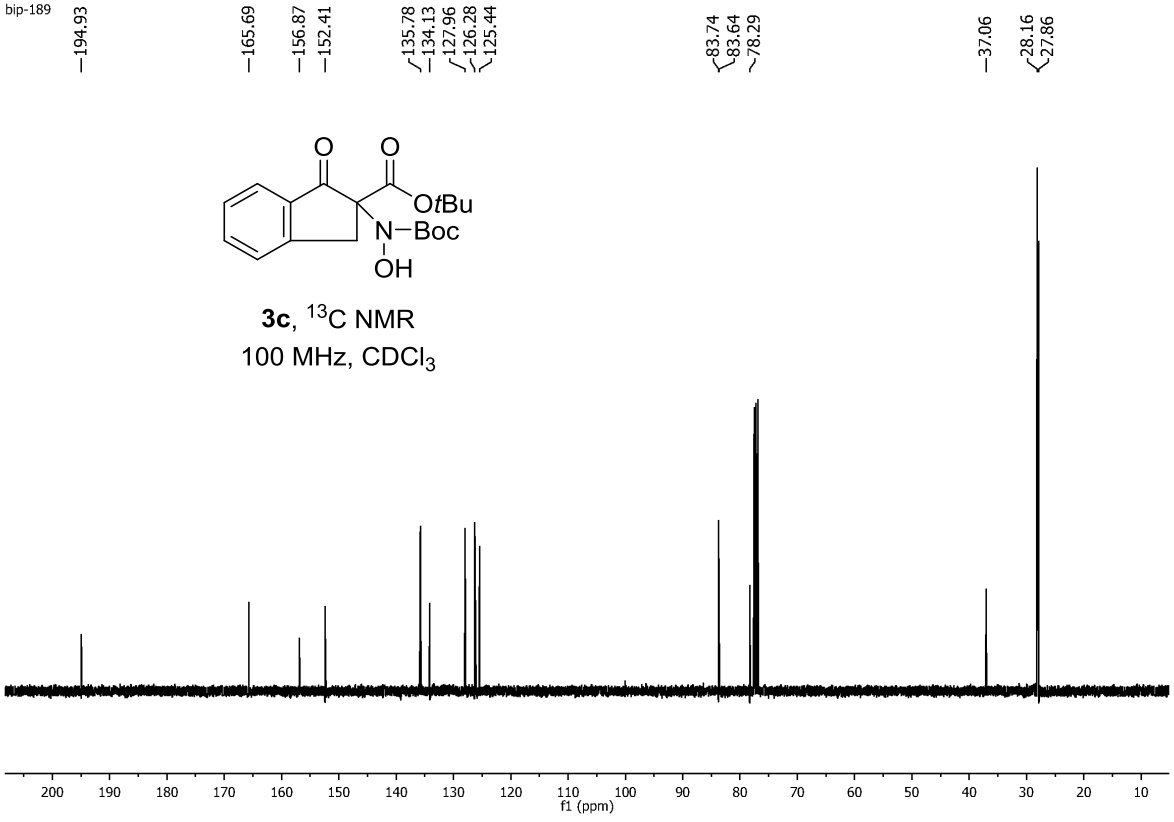
Ar = 2,6-*i*Pr2C_6H_3

3b, ^{13} C NMR

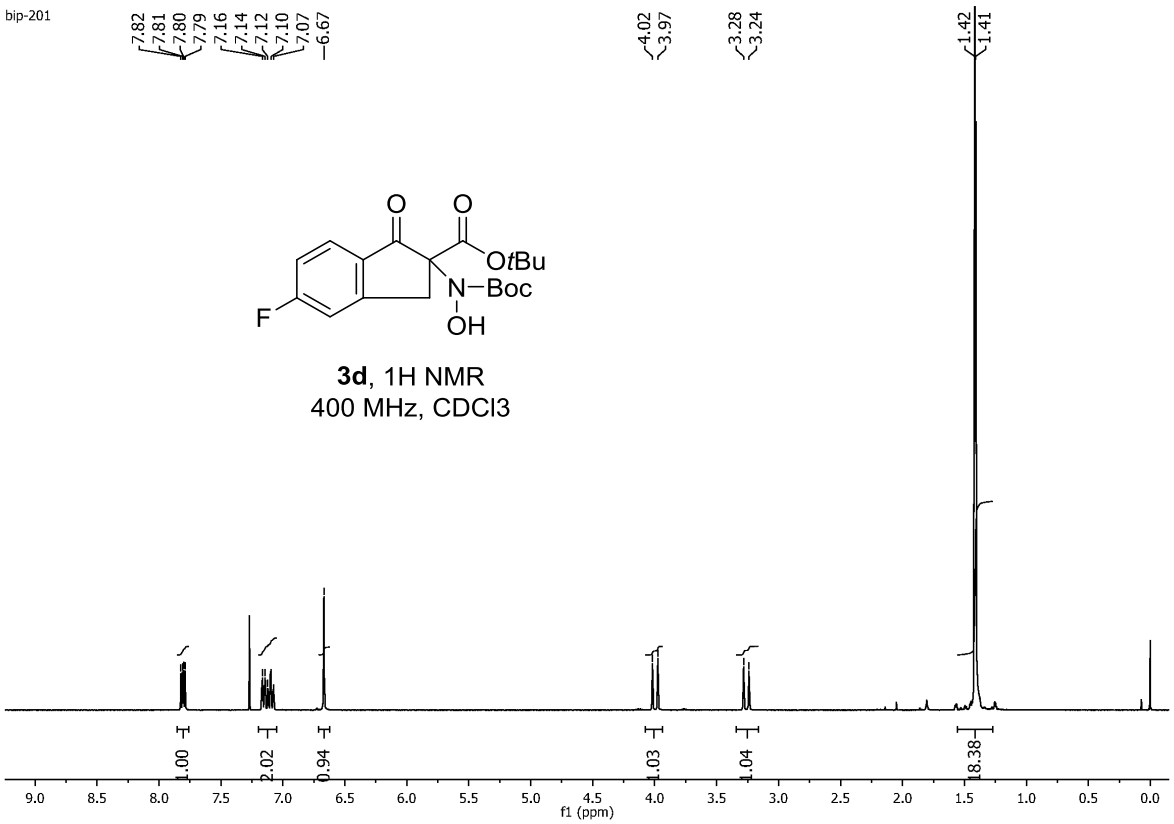
100 MHz, $CDCl_3$



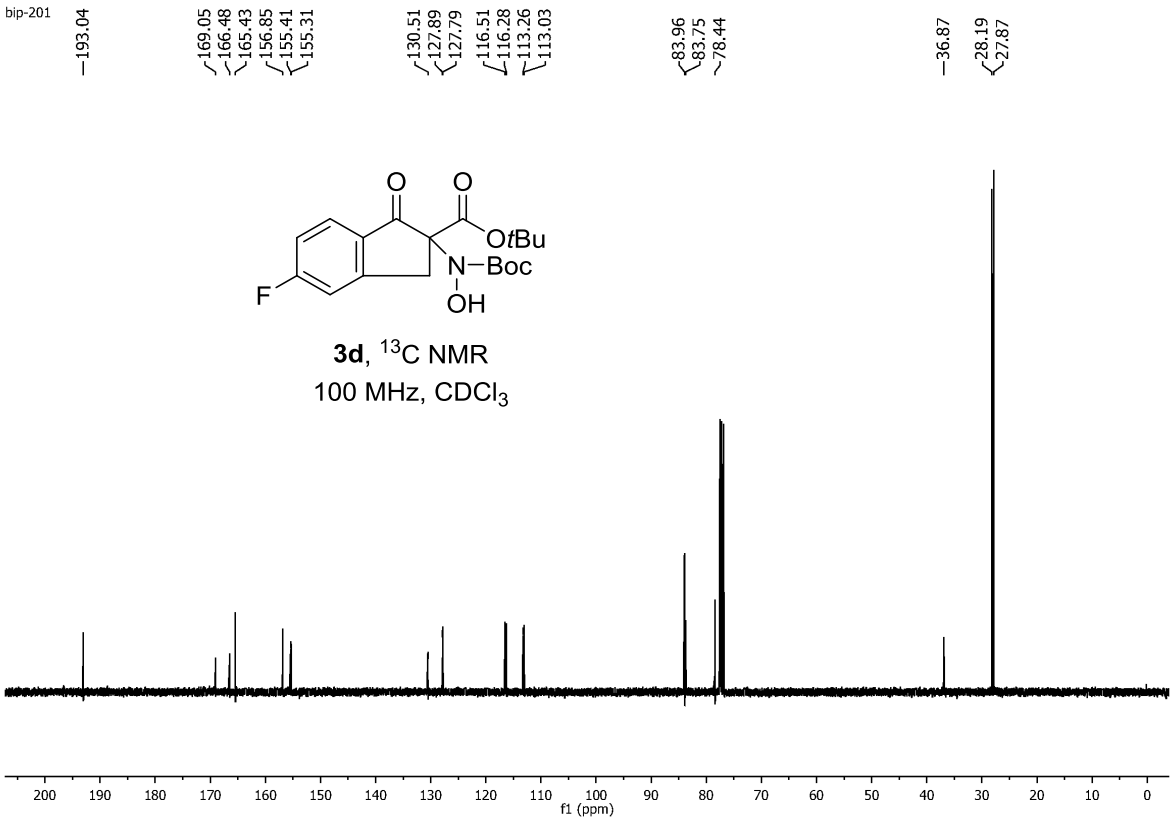
3c, ^{1}H NMR
400 MHz, $CDCl_3$



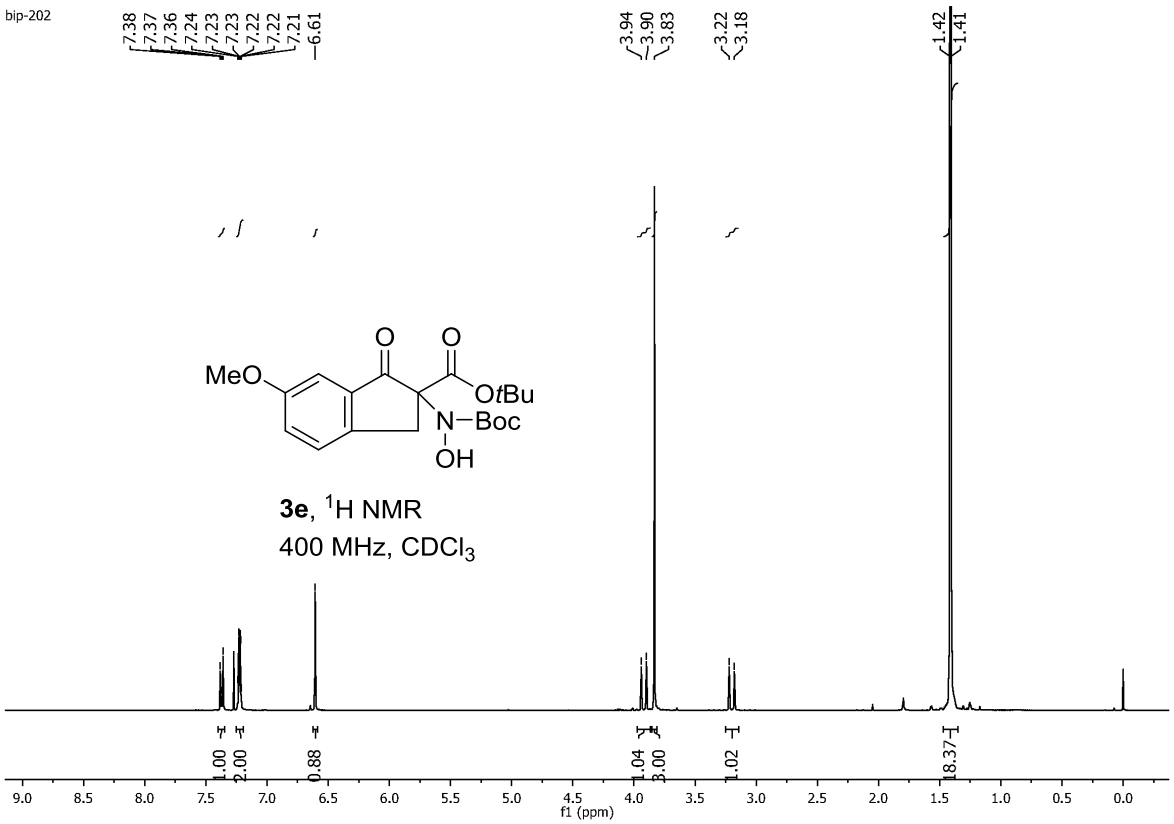
3c, ^{13}C NMR
100 MHz, $CDCl_3$



3d, 1H NMR
400 MHz, CDCl3



3d, ^{13}C NMR
100 MHz, $CDCl_3$



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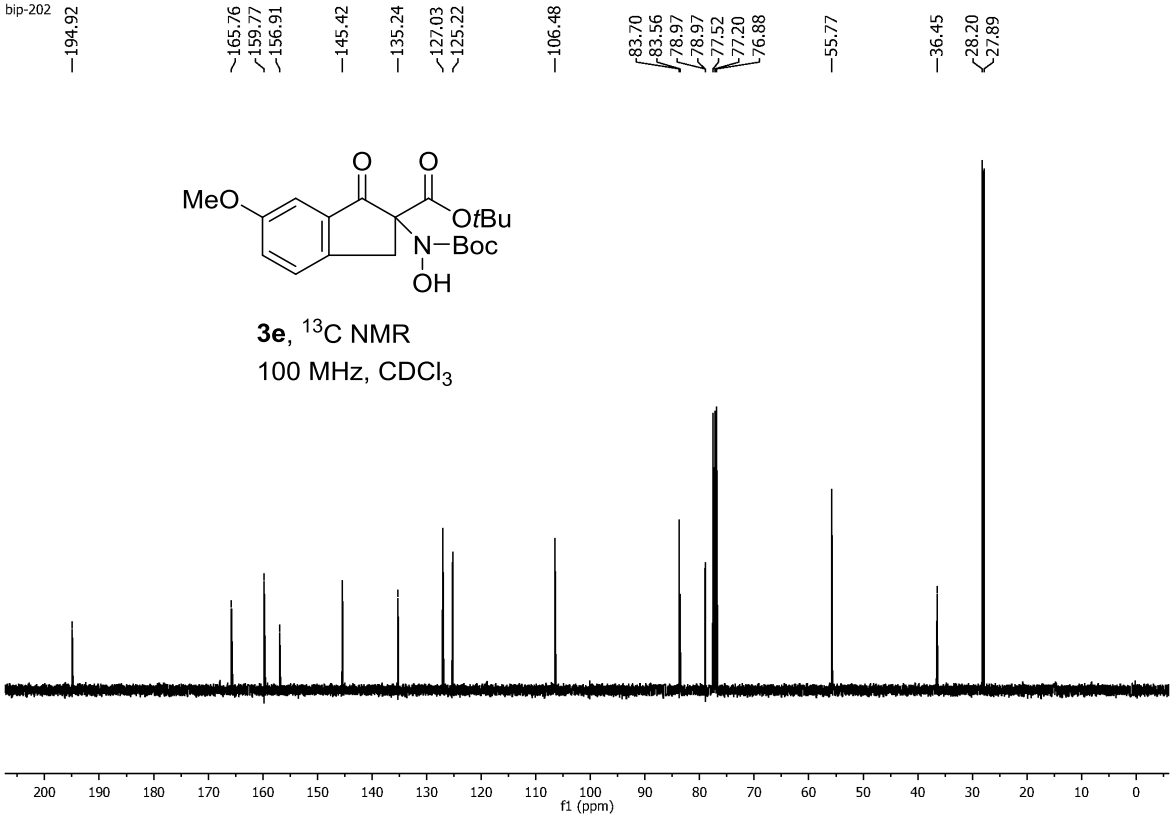
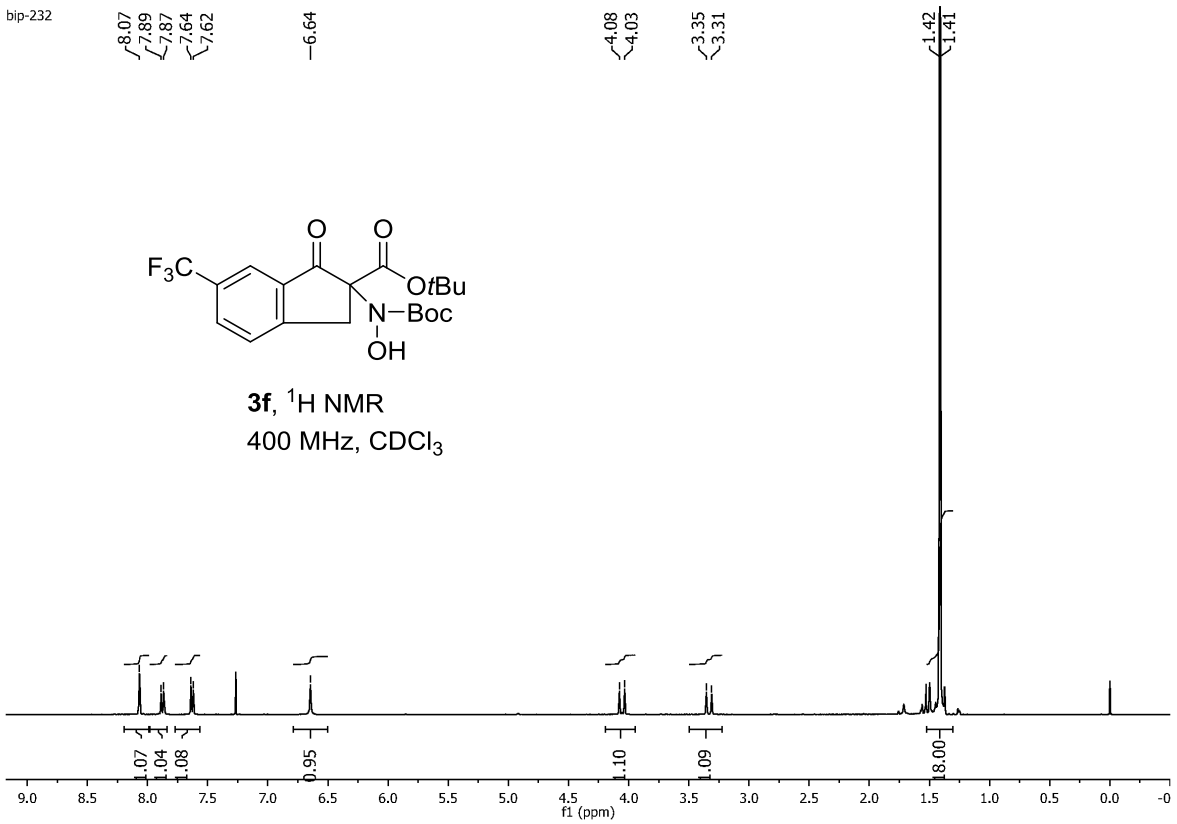
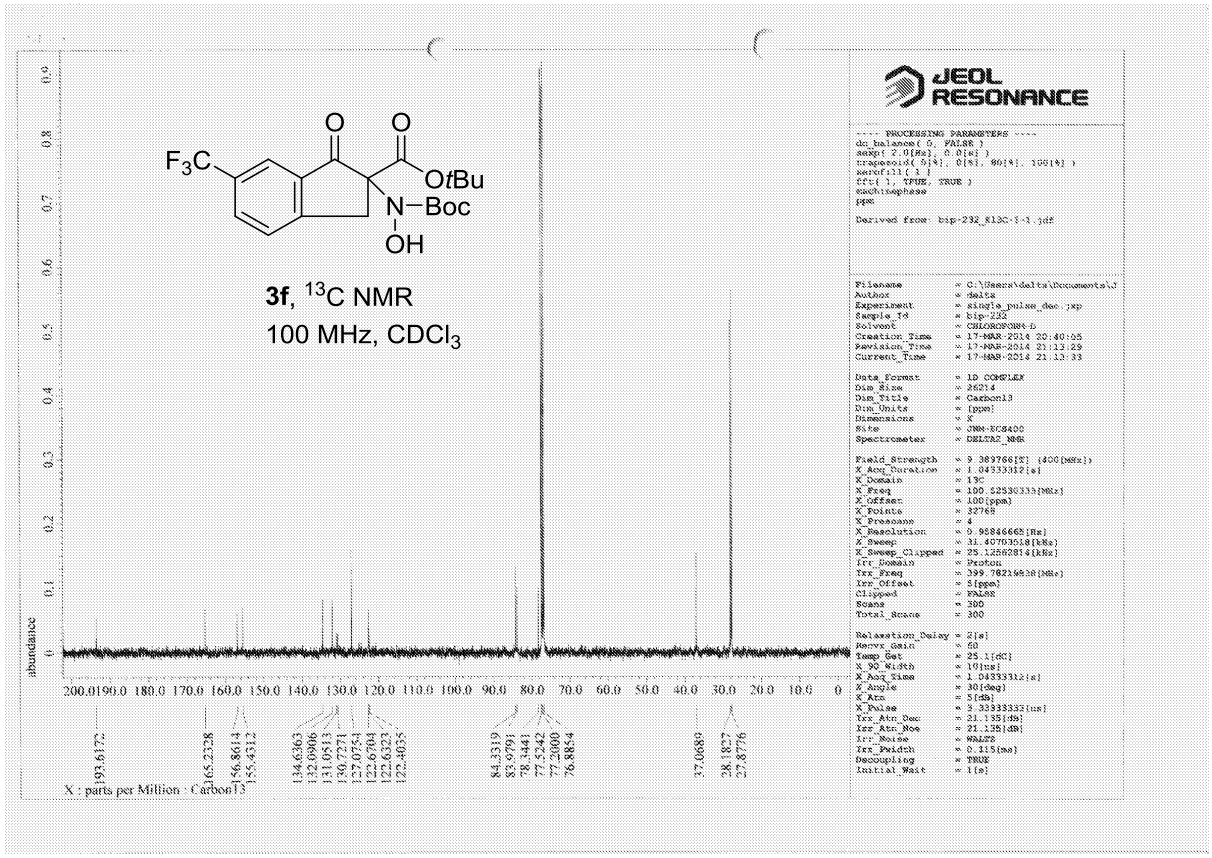


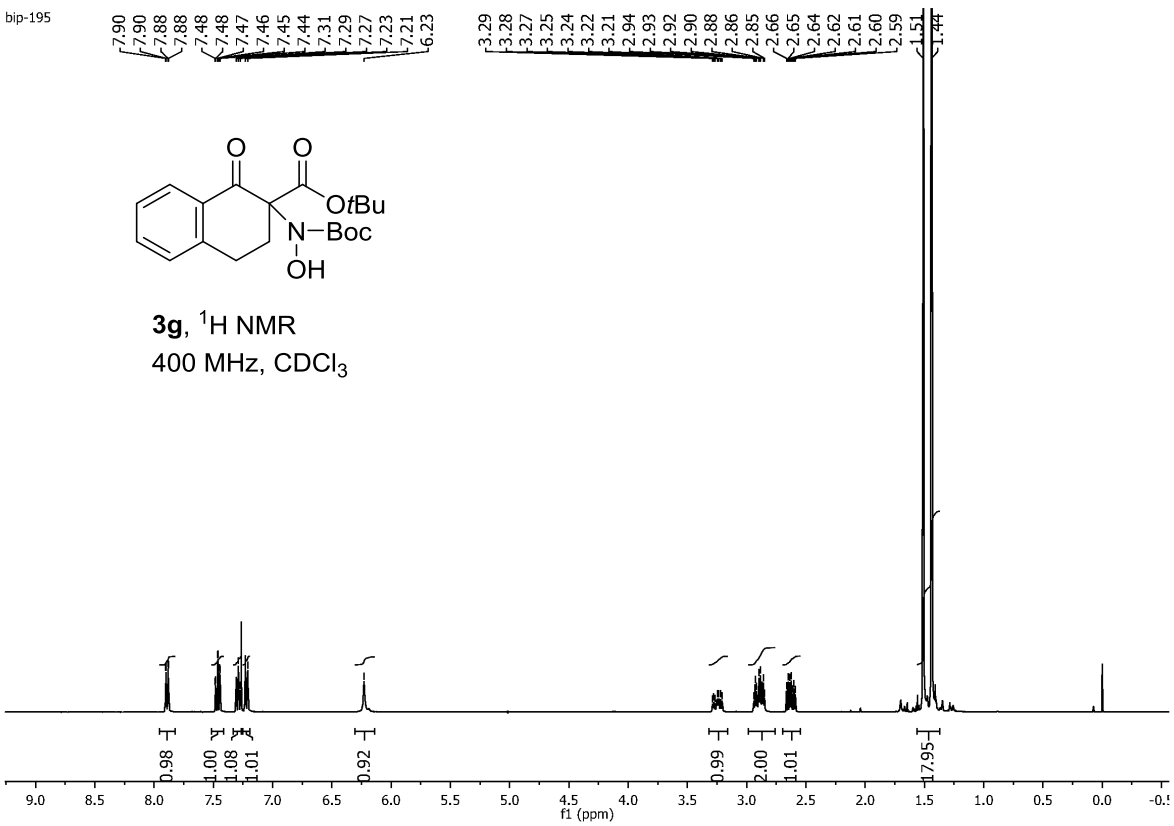
3e, ^{13}C NMR
100 MHz, $CDCl_3$



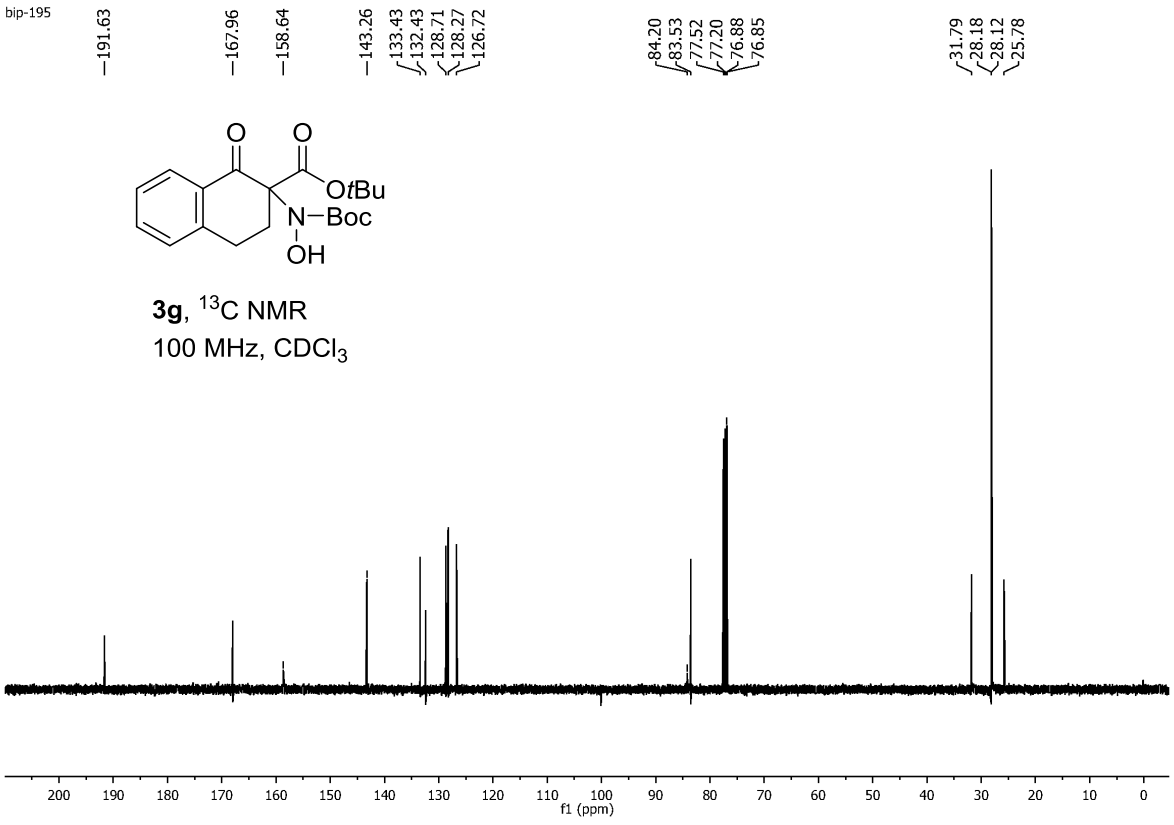
3f, ^{1}H NMR
400 MHz, $CDCl_3$



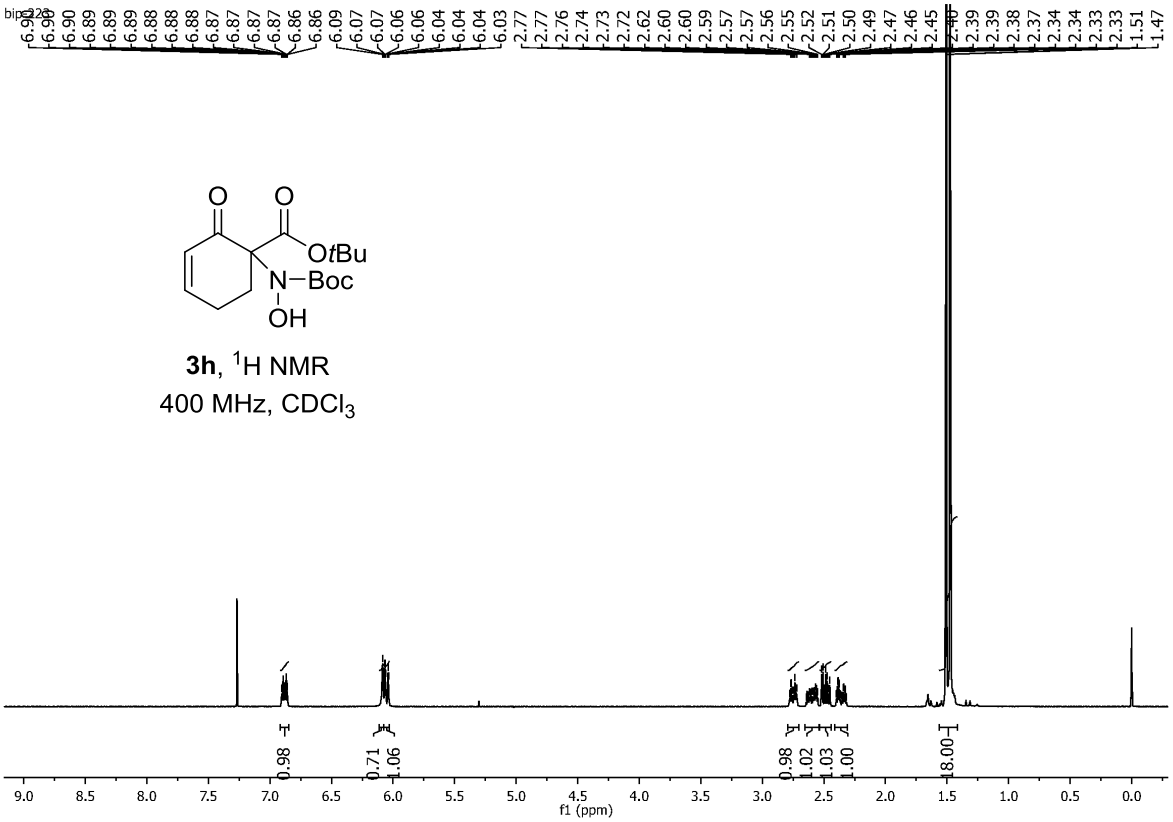
3f, ^{13}C NMR
100 MHz, $CDCl_3$



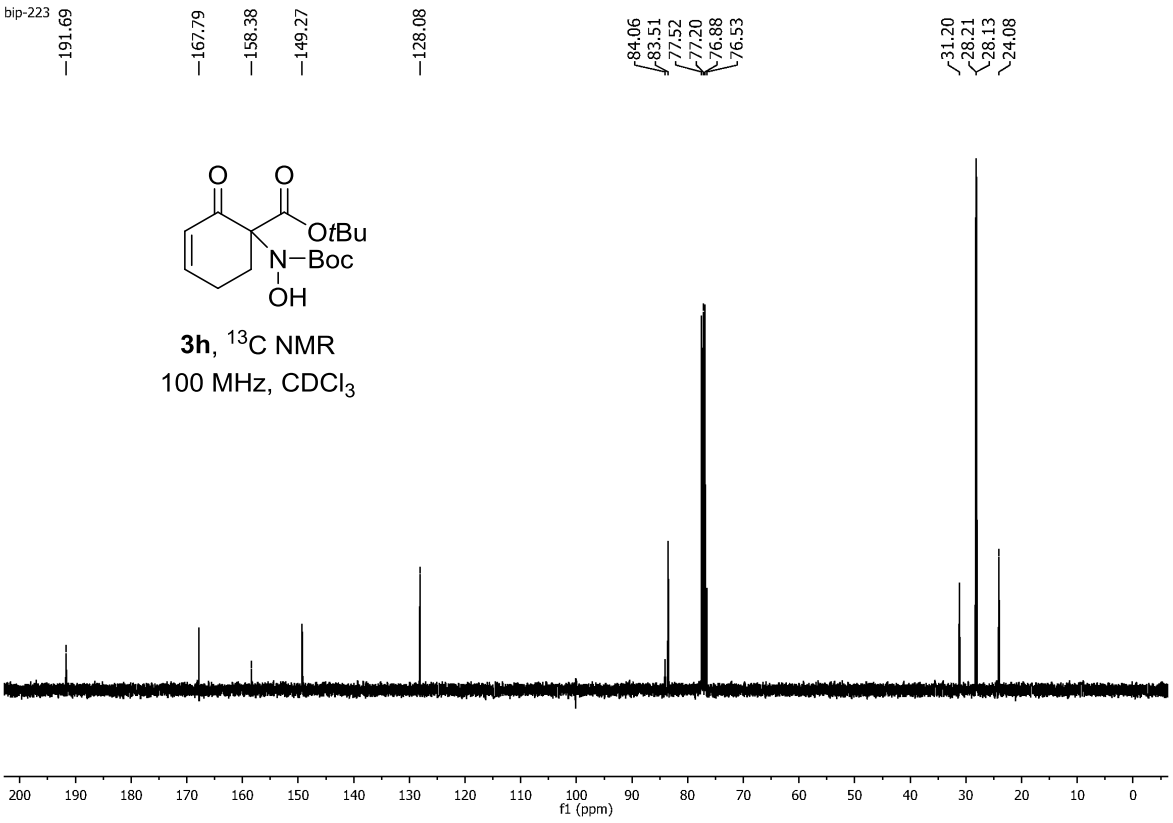
3g, ^{1}H NMR
400 MHz, $CDCl_3$



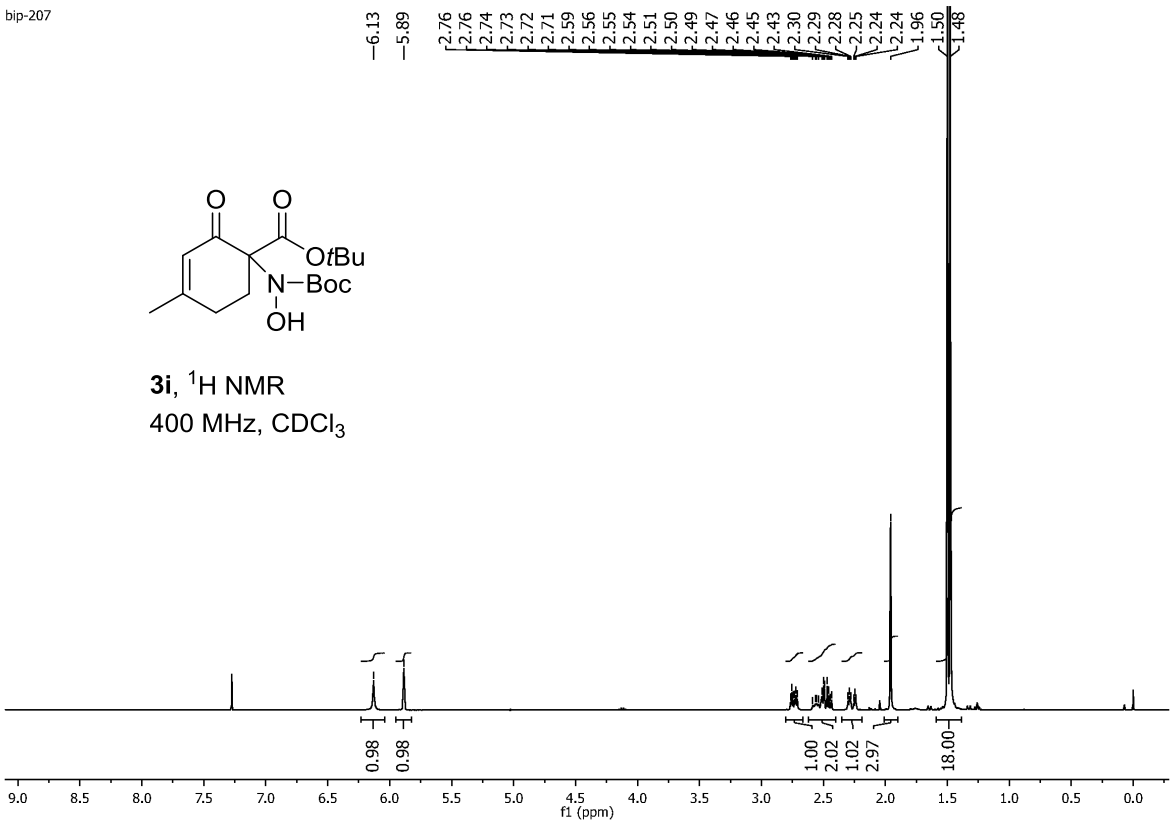
3g, ^{13}C NMR
100 MHz, $CDCl_3$



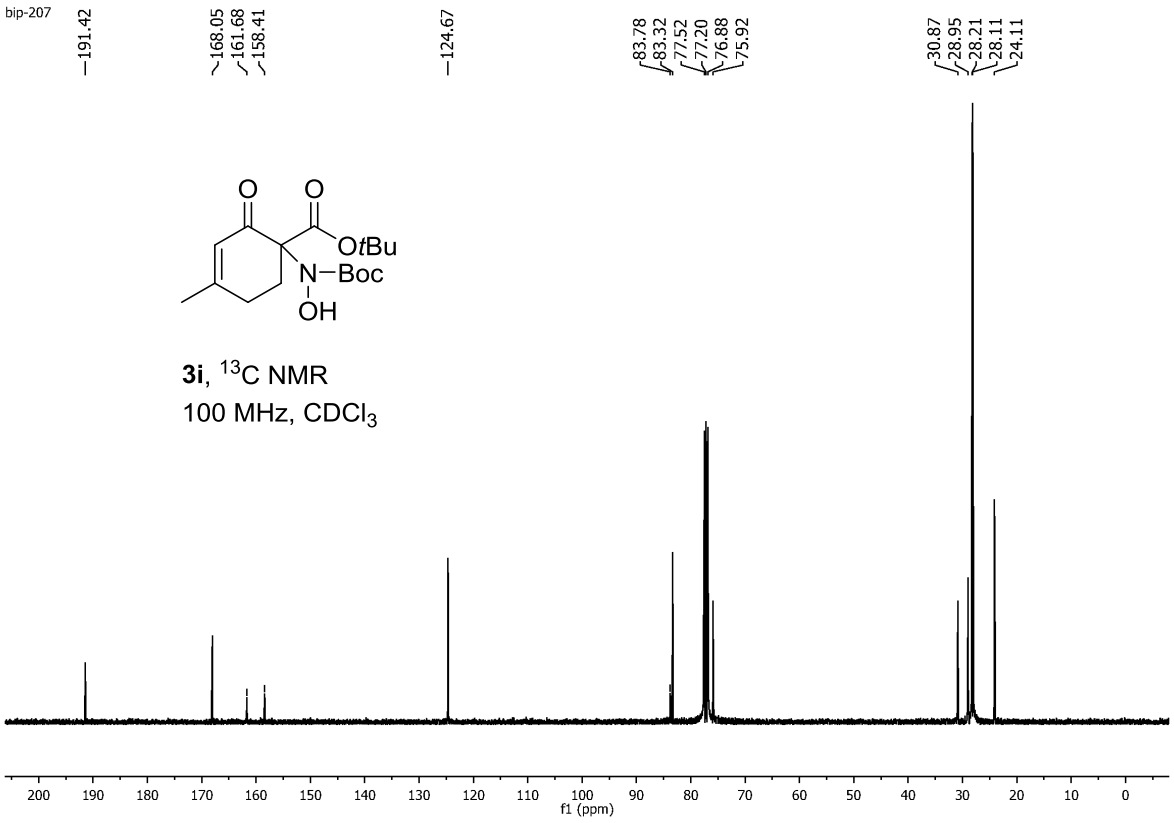
3h, ^{1}H NMR
400 MHz, $CDCl_3$



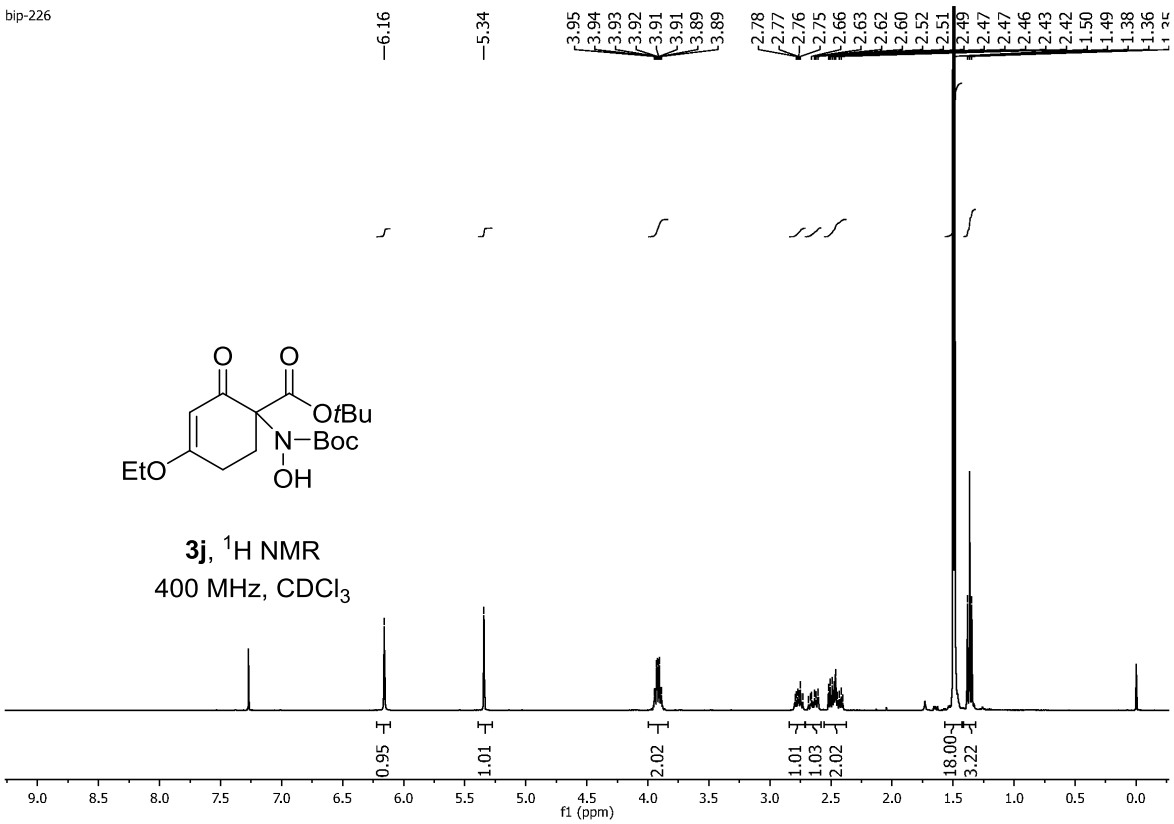
3h, ^{13}C NMR
100 MHz, $CDCl_3$



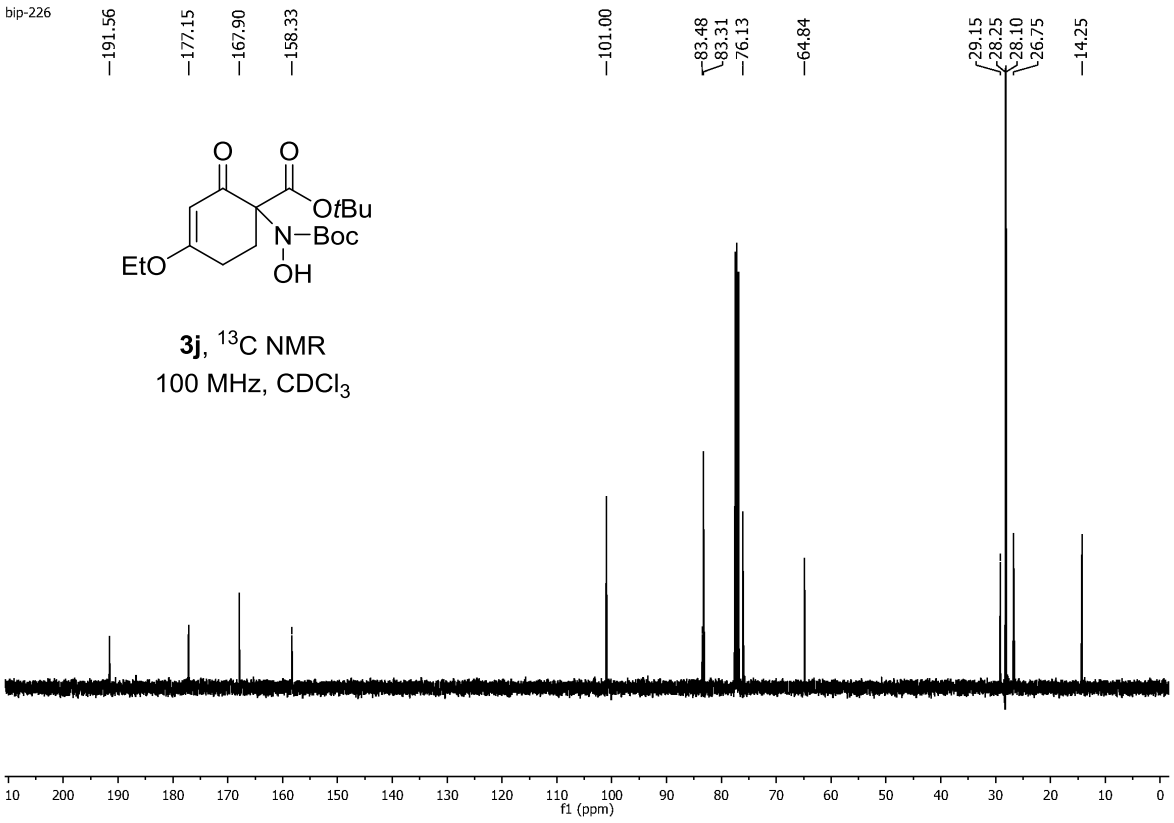
3i, ^{1}H NMR
400 MHz, $CDCl_3$



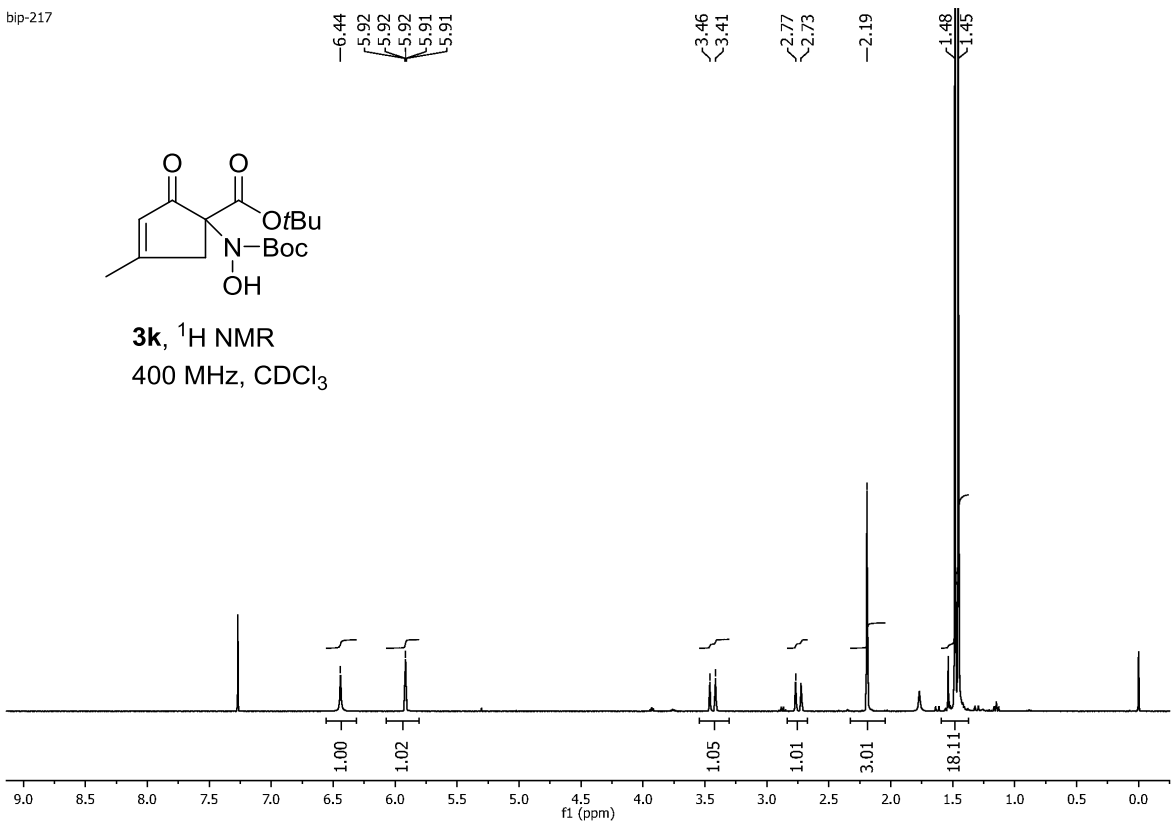
3i, ^{13}C NMR
100 MHz, $CDCl_3$



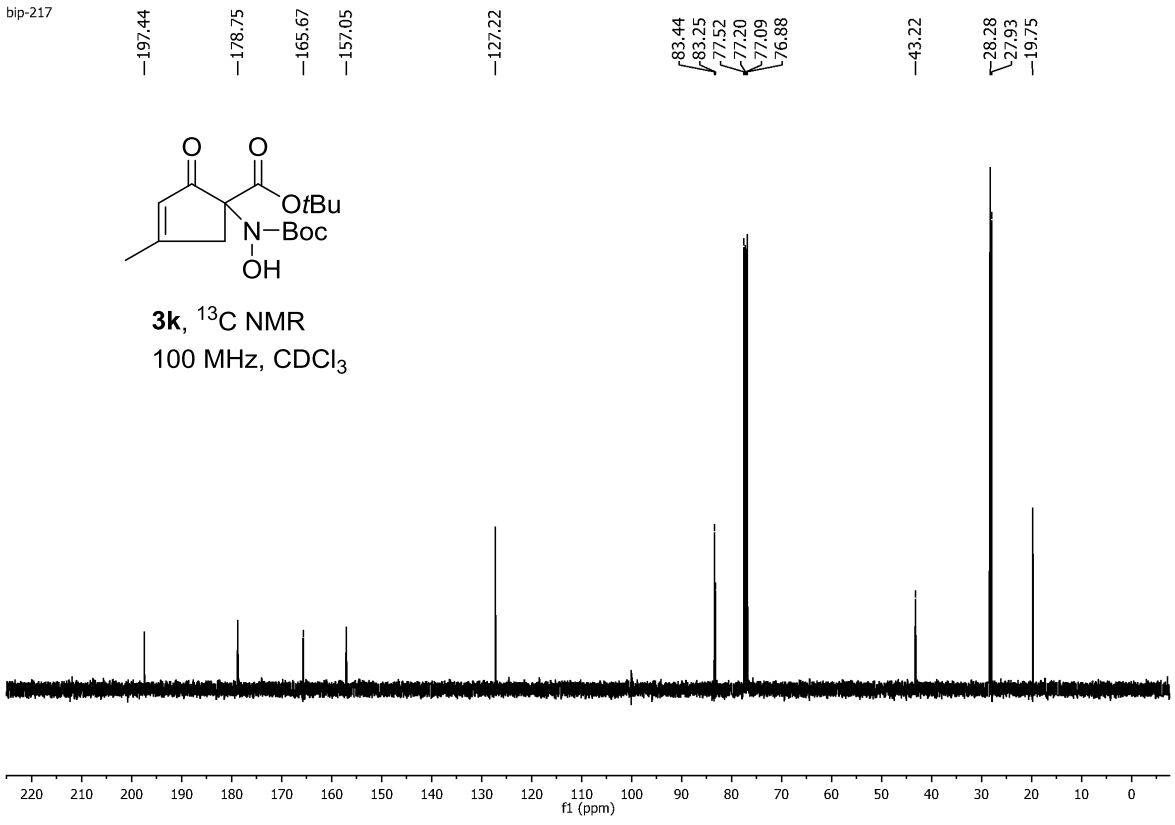
3j, ^{1}H NMR
400 MHz, $CDCl_3$



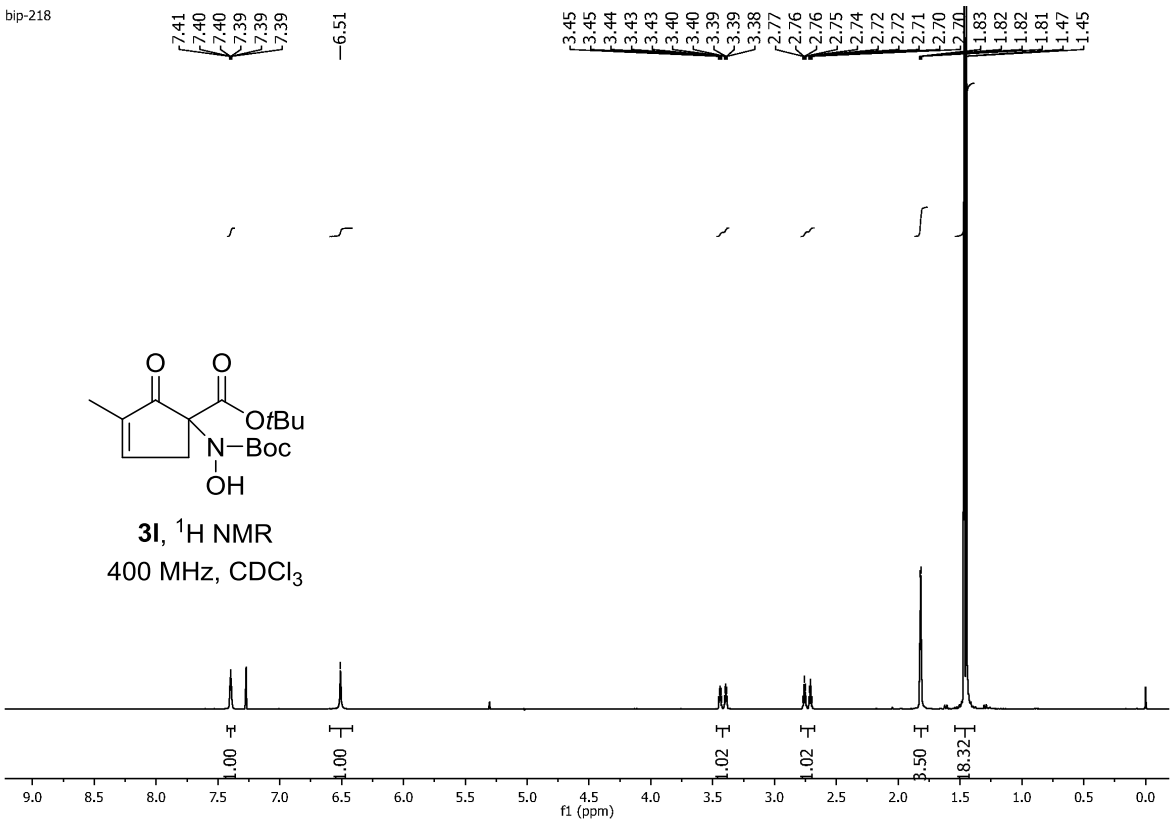
3j, ^{13}C NMR
100 MHz, $CDCl_3$



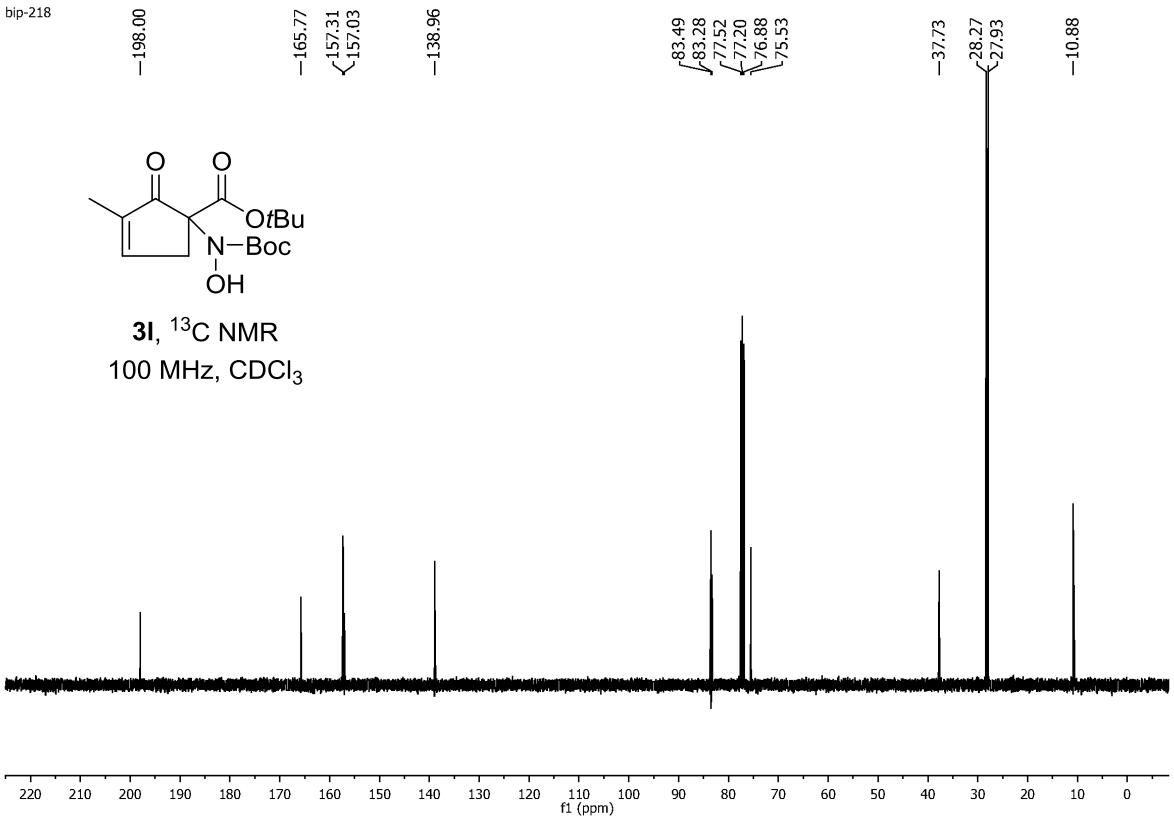
3k, ^{1}H NMR
400 MHz, $CDCl_3$



3k, ^{13}C NMR
100 MHz, $CDCl_3$

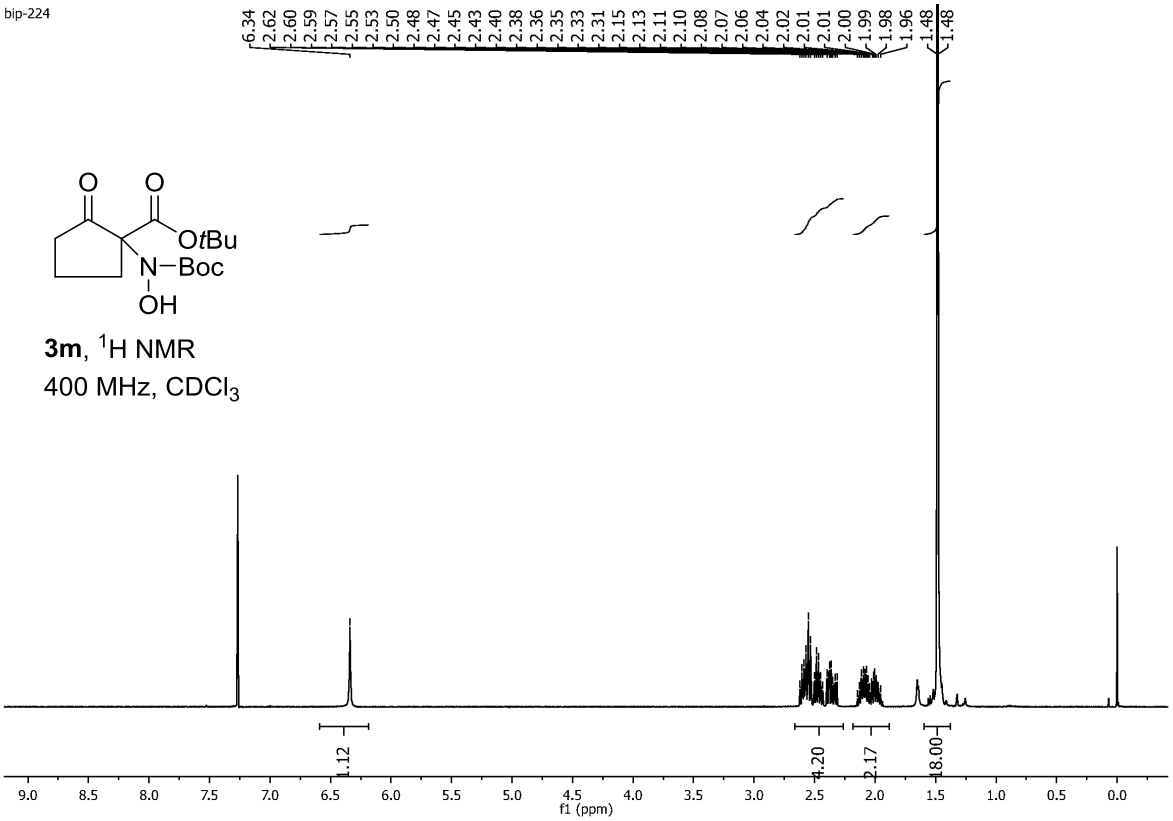


3l, ^{1}H NMR
400 MHz, $CDCl_3$



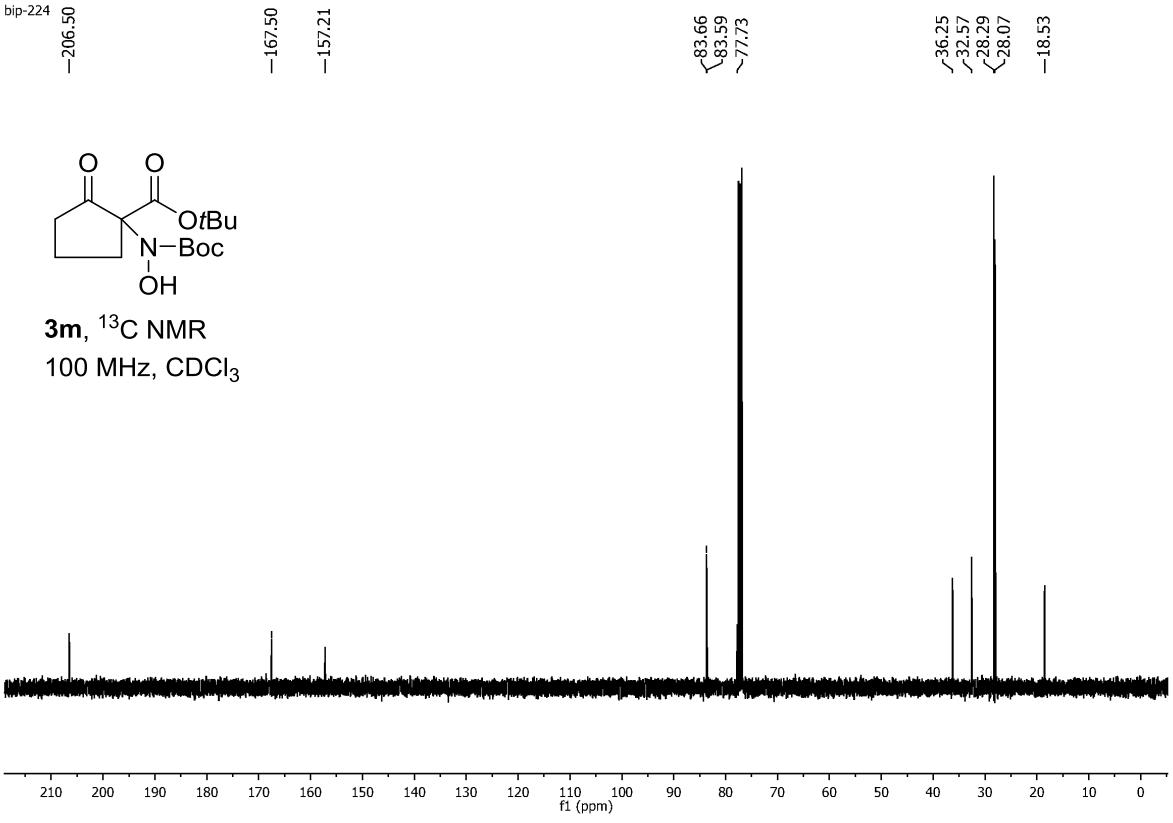
3l, ^{13}C NMR
100 MHz, $CDCl_3$

bip-224

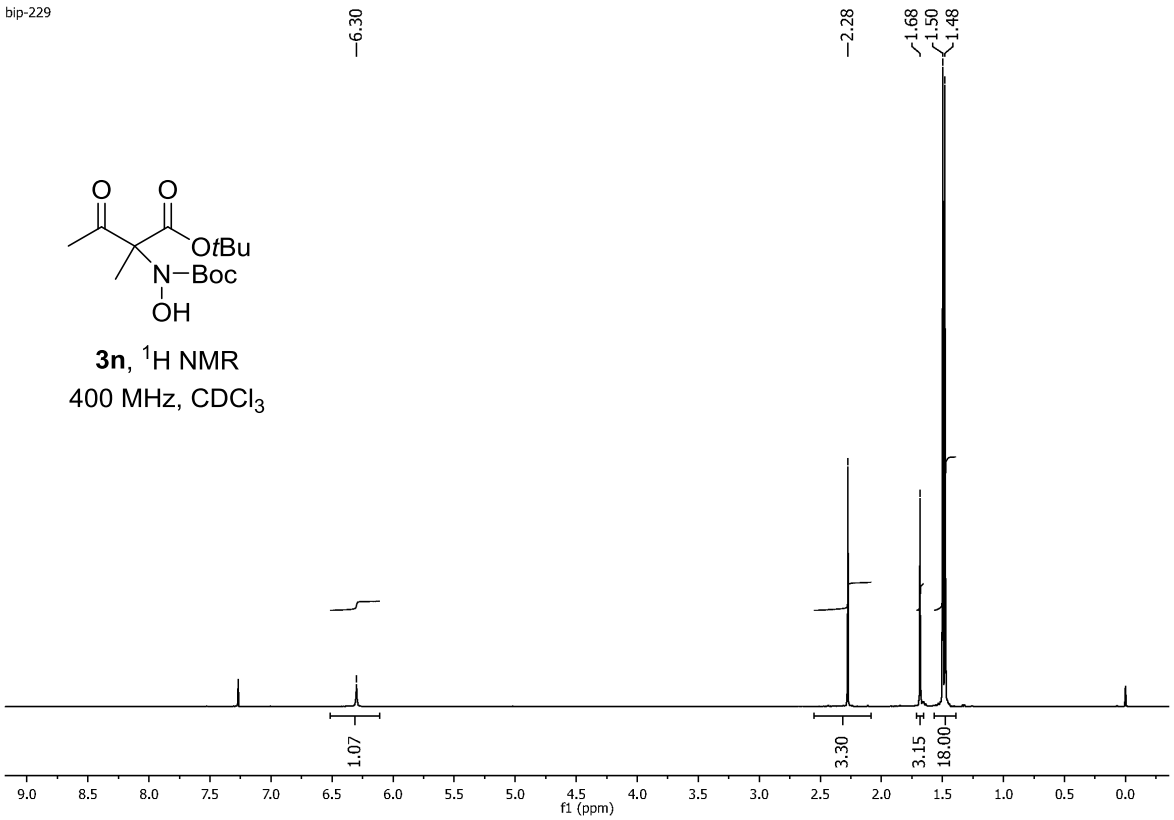


3m, ^{1}H NMR
400 MHz, $CDCl_3$

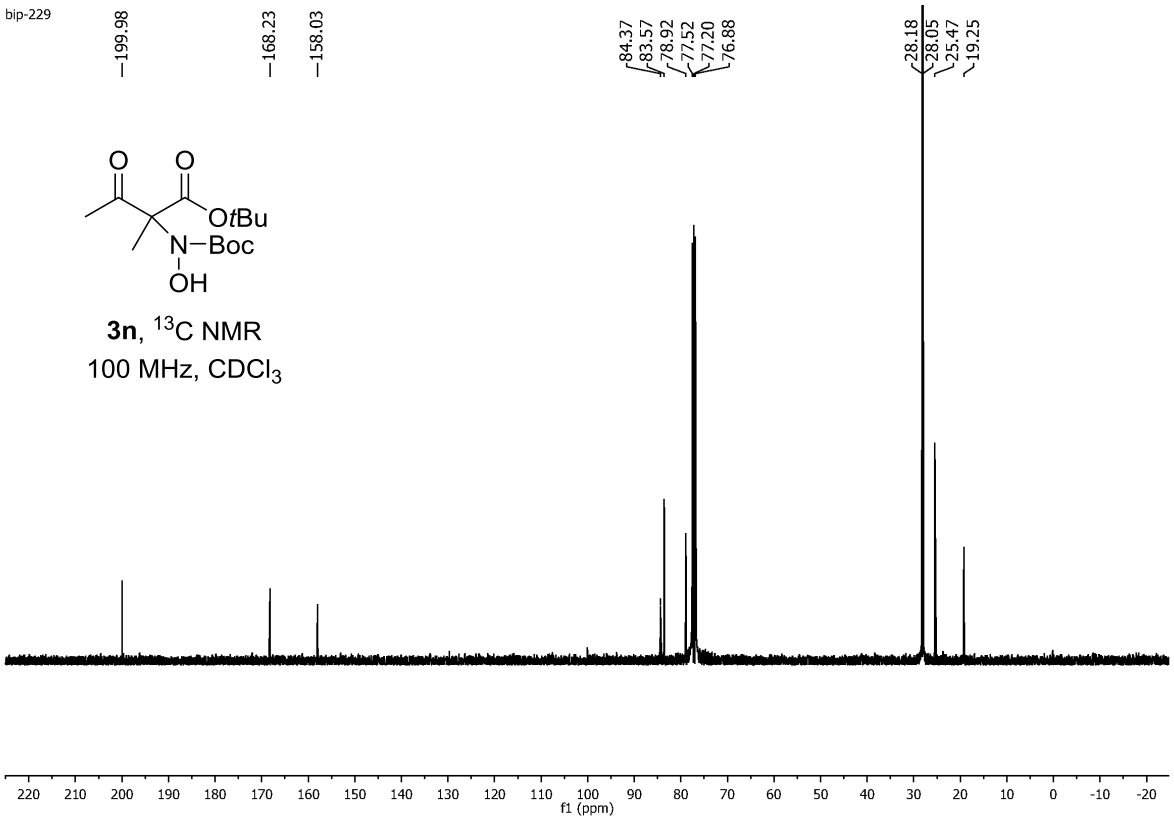
bip-224



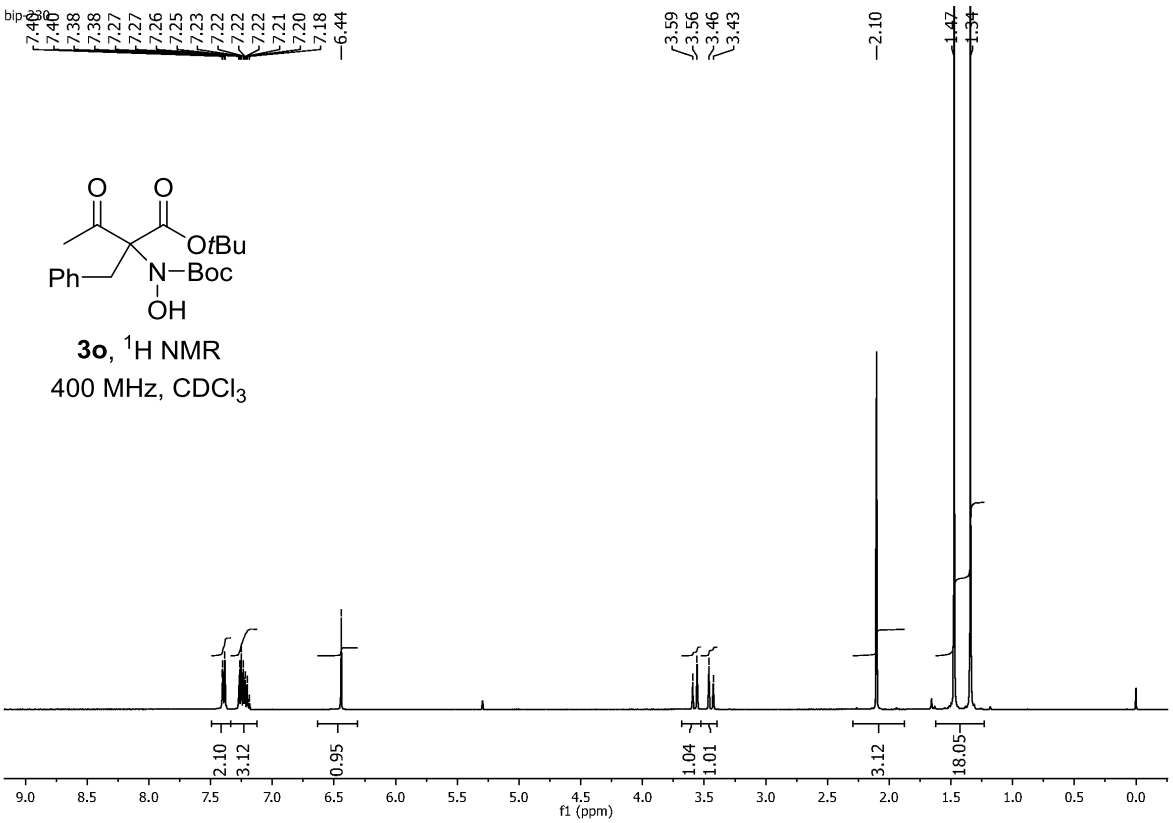
3m, ^{13}C NMR
100 MHz, $CDCl_3$



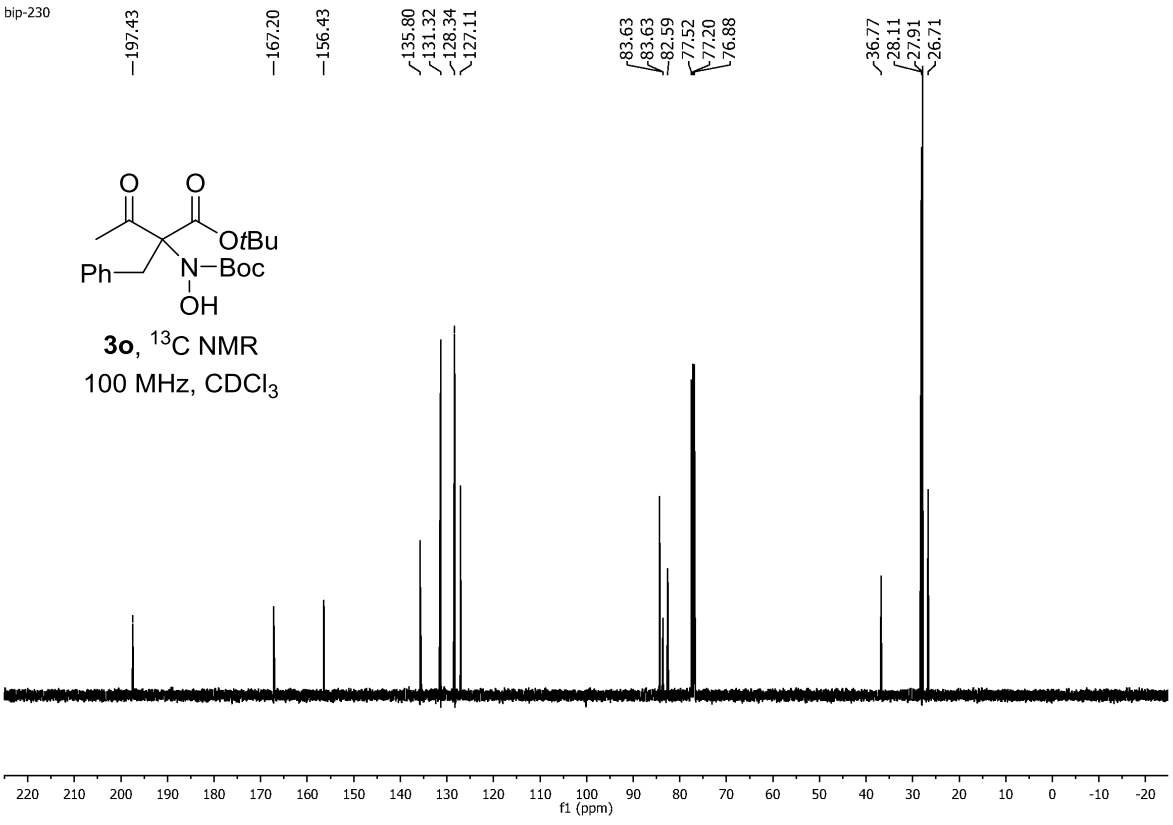
3n, ^{1}H NMR
400 MHz, $CDCl_3$



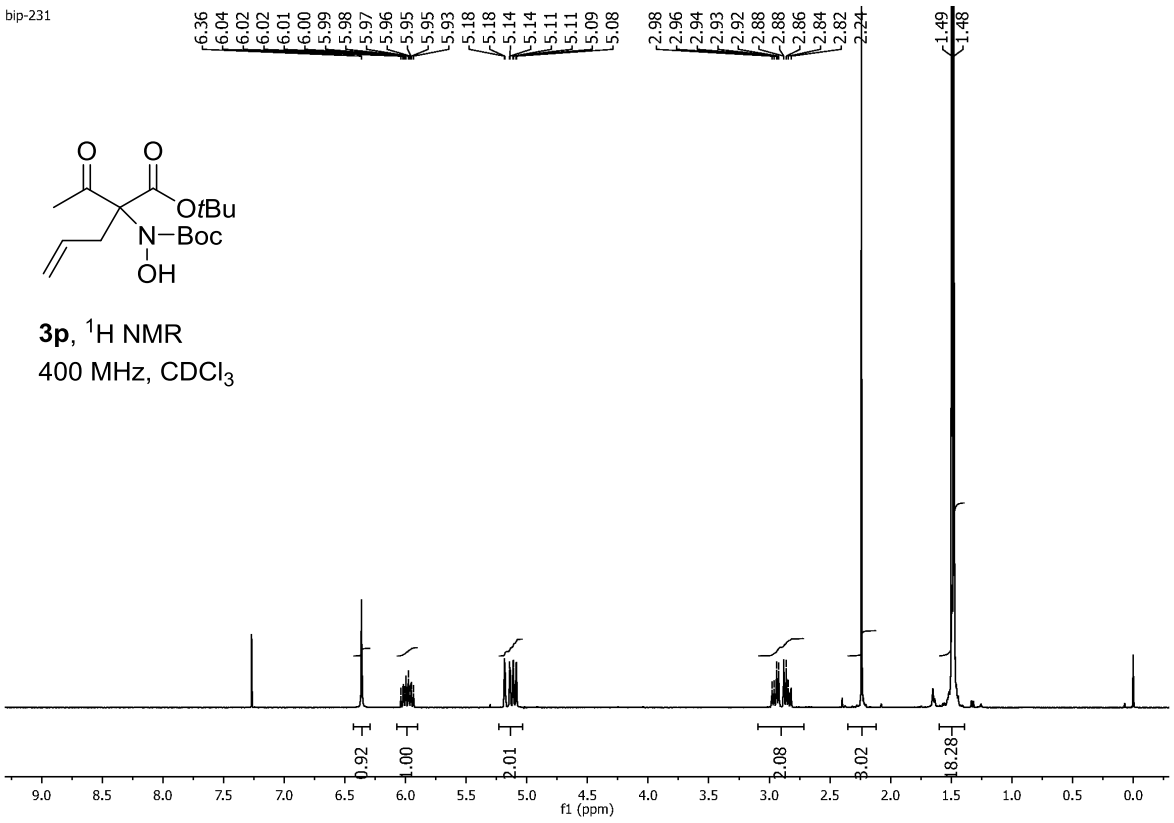
3n, ^{13}C NMR
100 MHz, $CDCl_3$



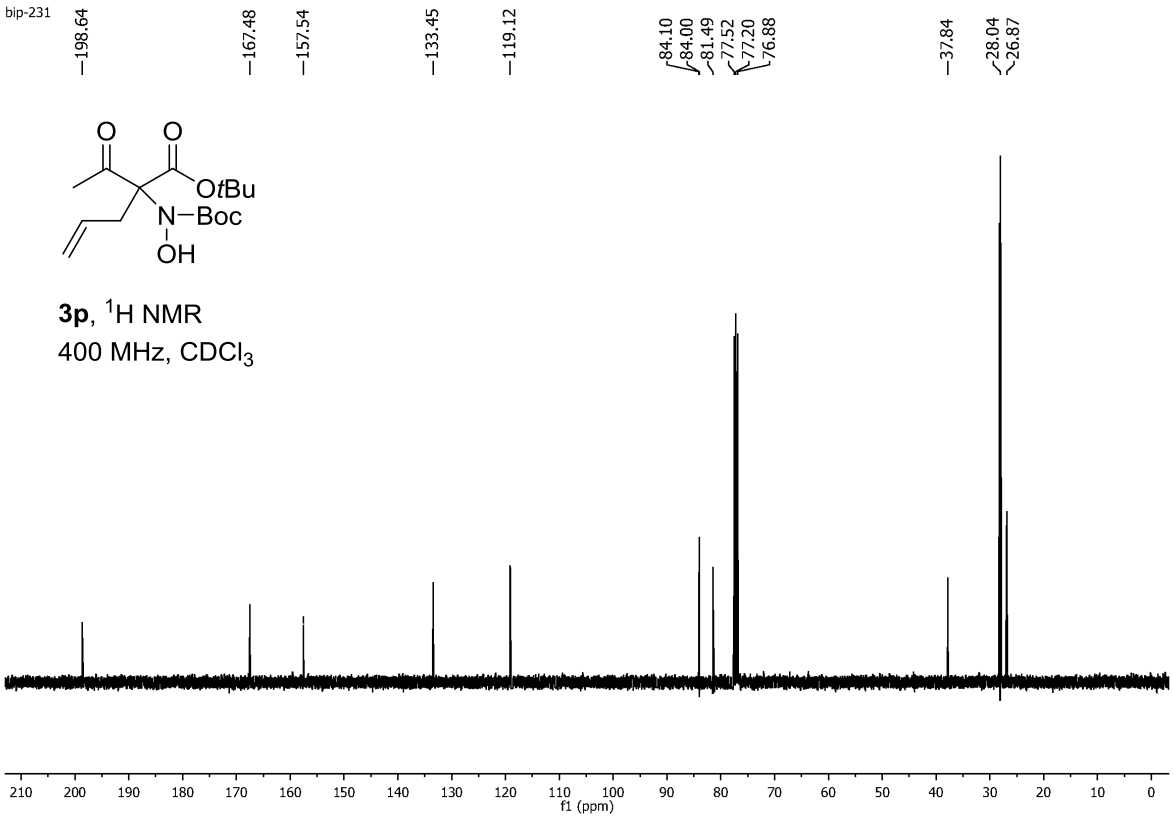
3o, ^{1}H NMR
400 MHz, $CDCl_3$



3o, ^{13}C NMR
100 MHz, $CDCl_3$



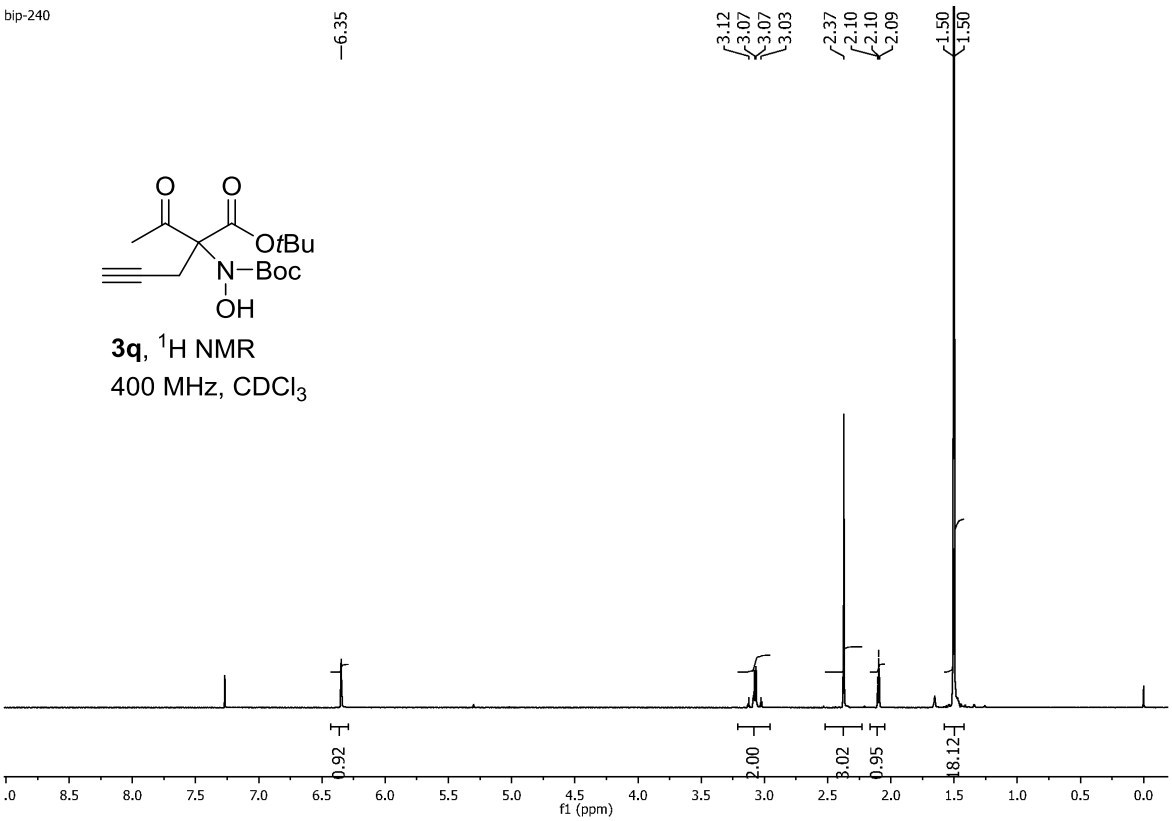
3p, ^{1}H NMR
400 MHz, $CDCl_3$



3p, ^{1}H NMR
400 MHz, $CDCl_3$

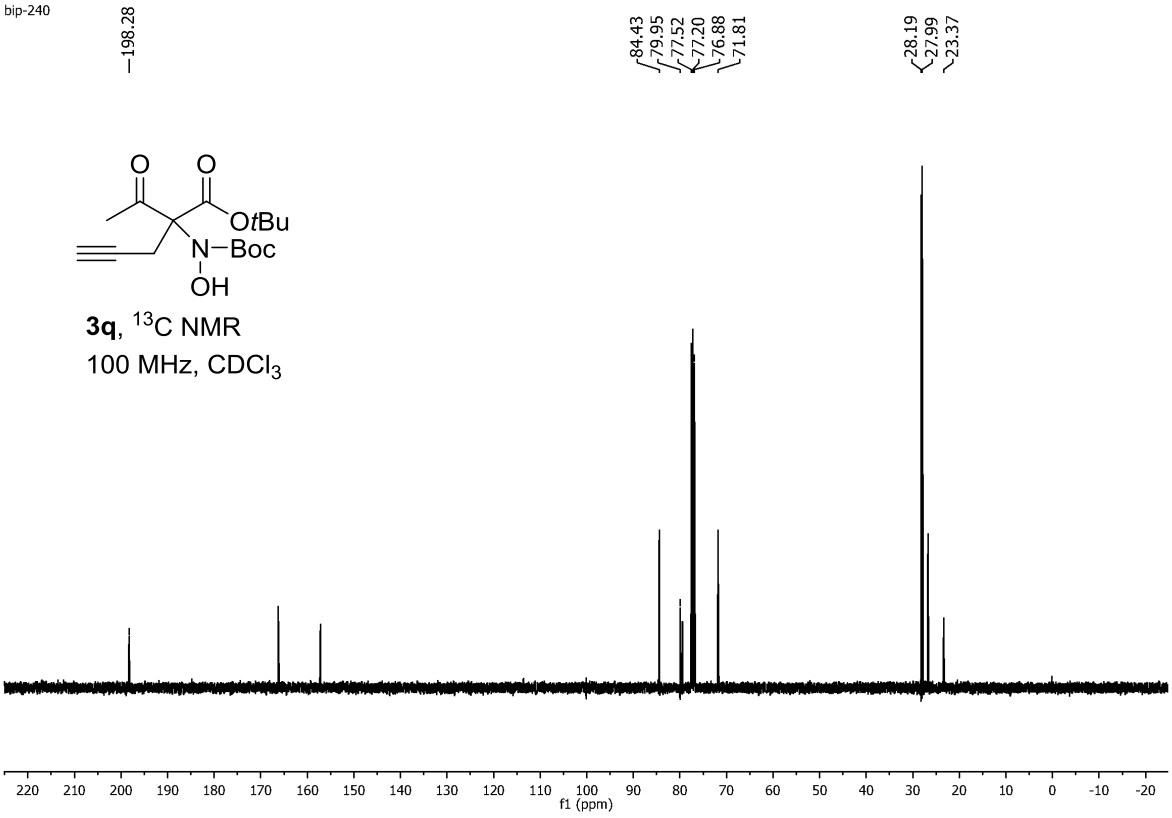
bip-240

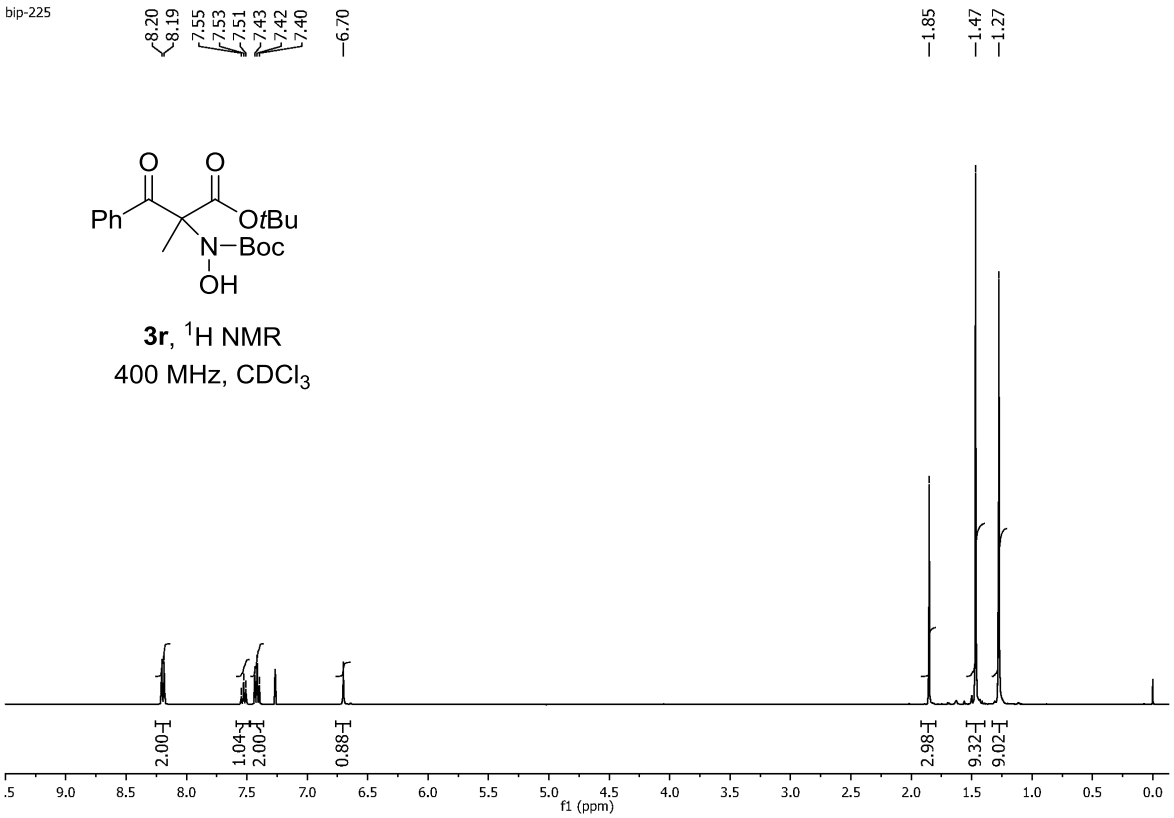
3q, ^{1}H NMR
400 MHz, $CDCl_3$



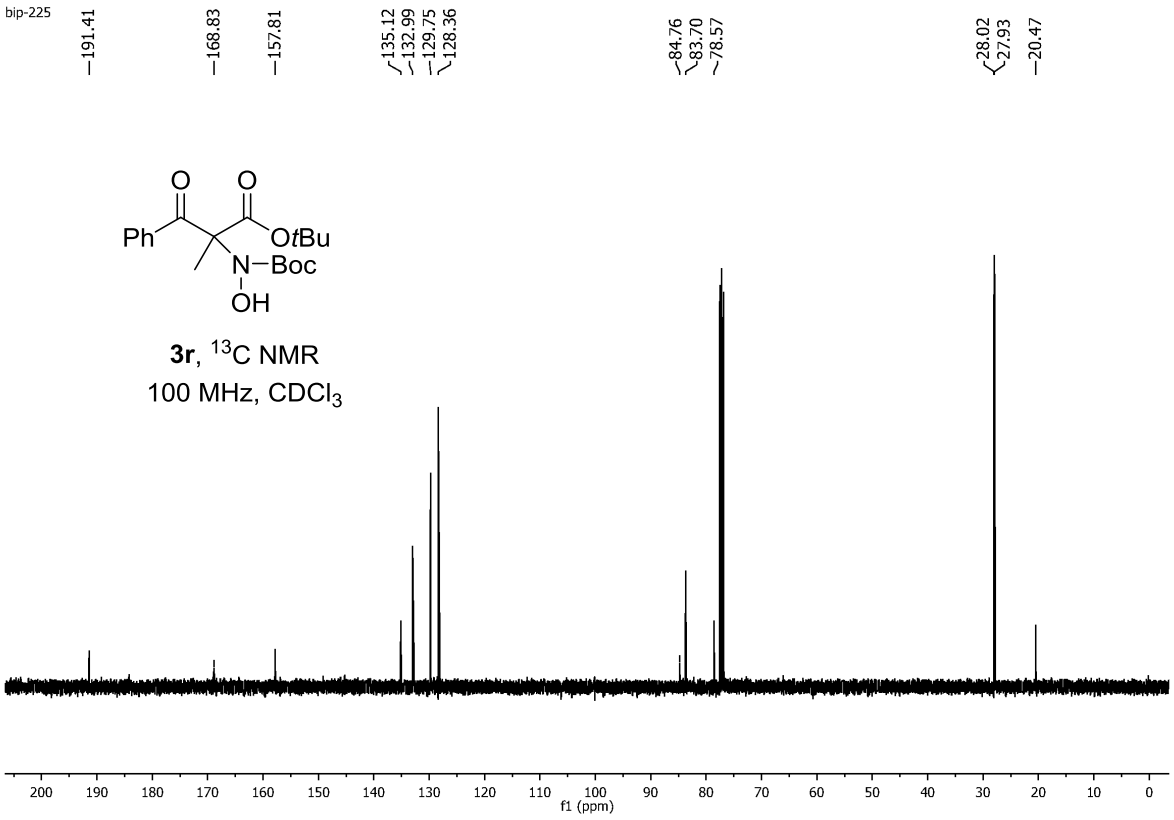
bip-240

3q, ^{13}C NMR
100 MHz, $CDCl_3$

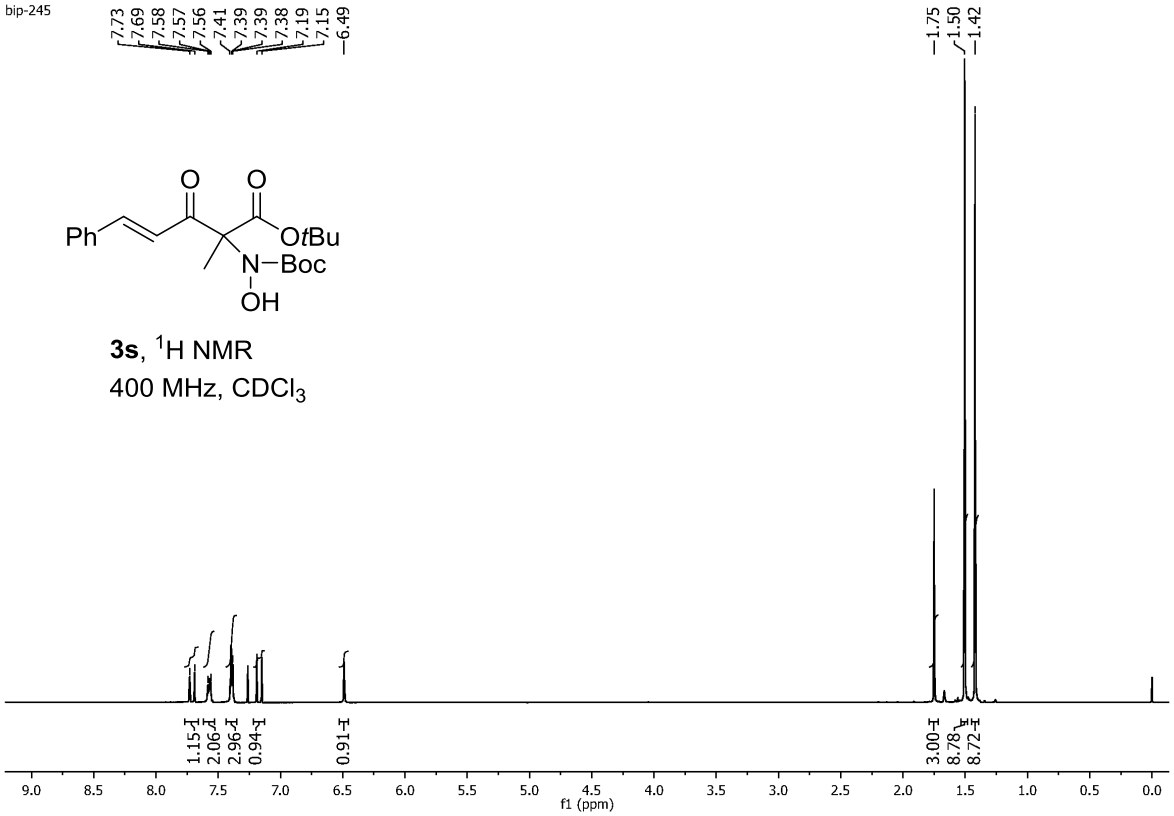




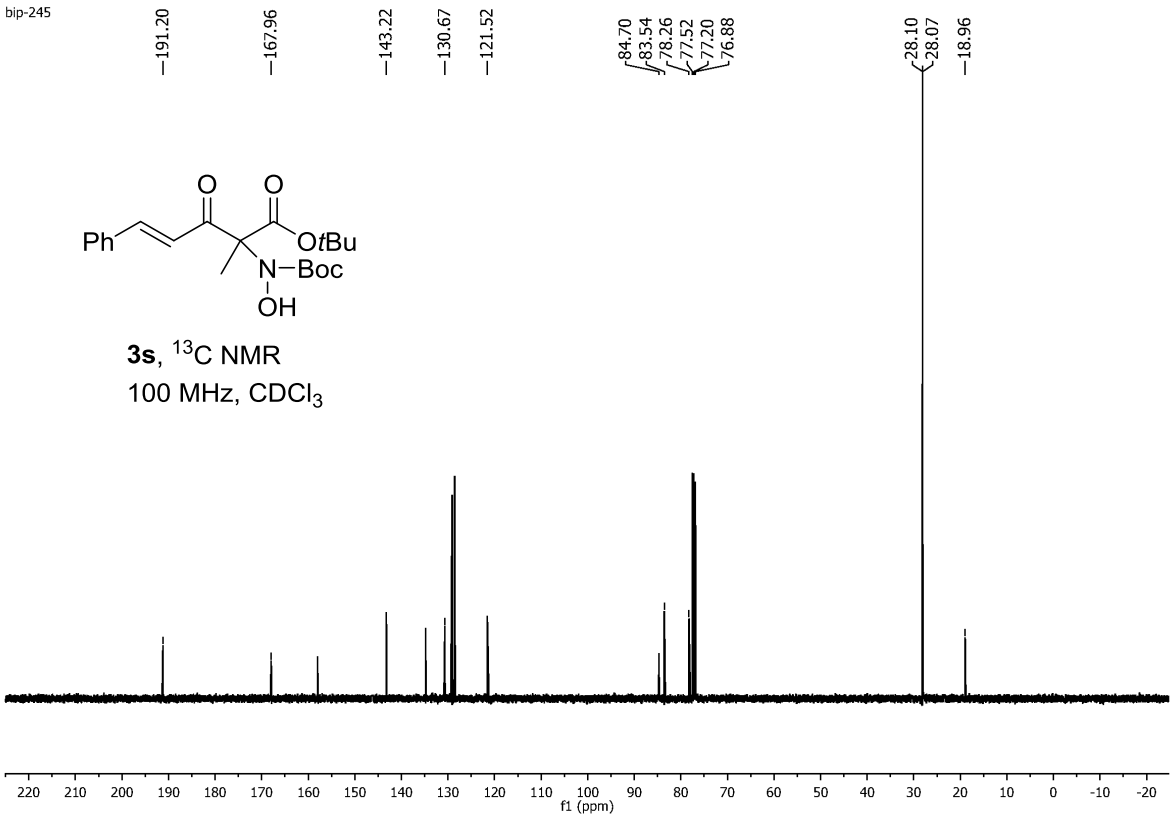
3r, ^{1}H NMR
400 MHz, $CDCl_3$



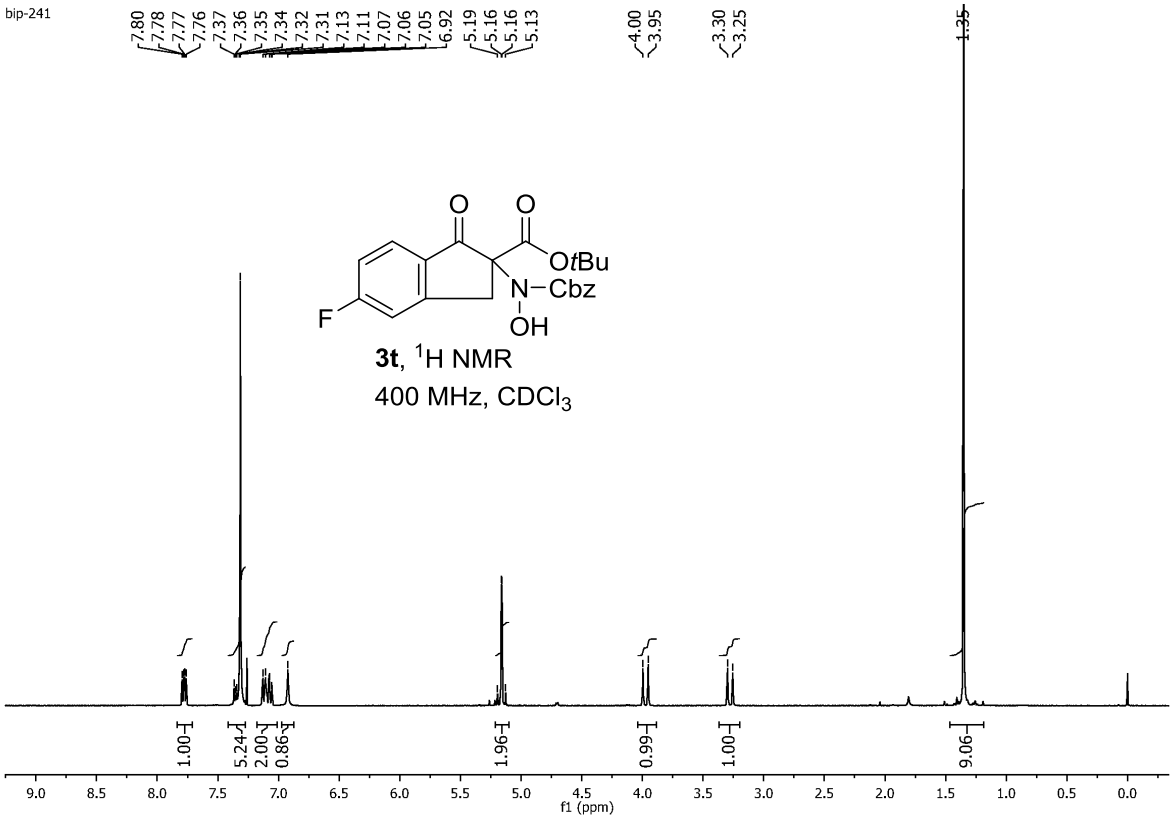
3r, ^{13}C NMR
100 MHz, $CDCl_3$



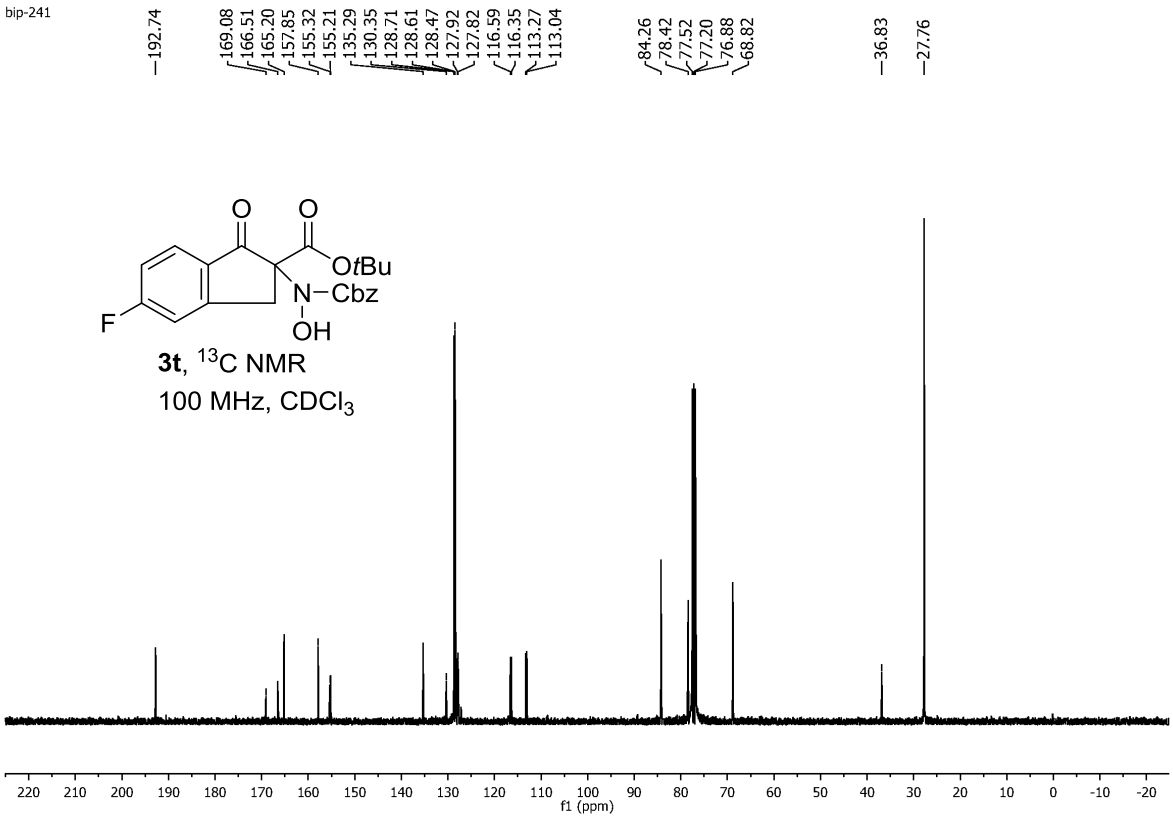
3s, ^{1}H NMR
400 MHz, $CDCl_3$



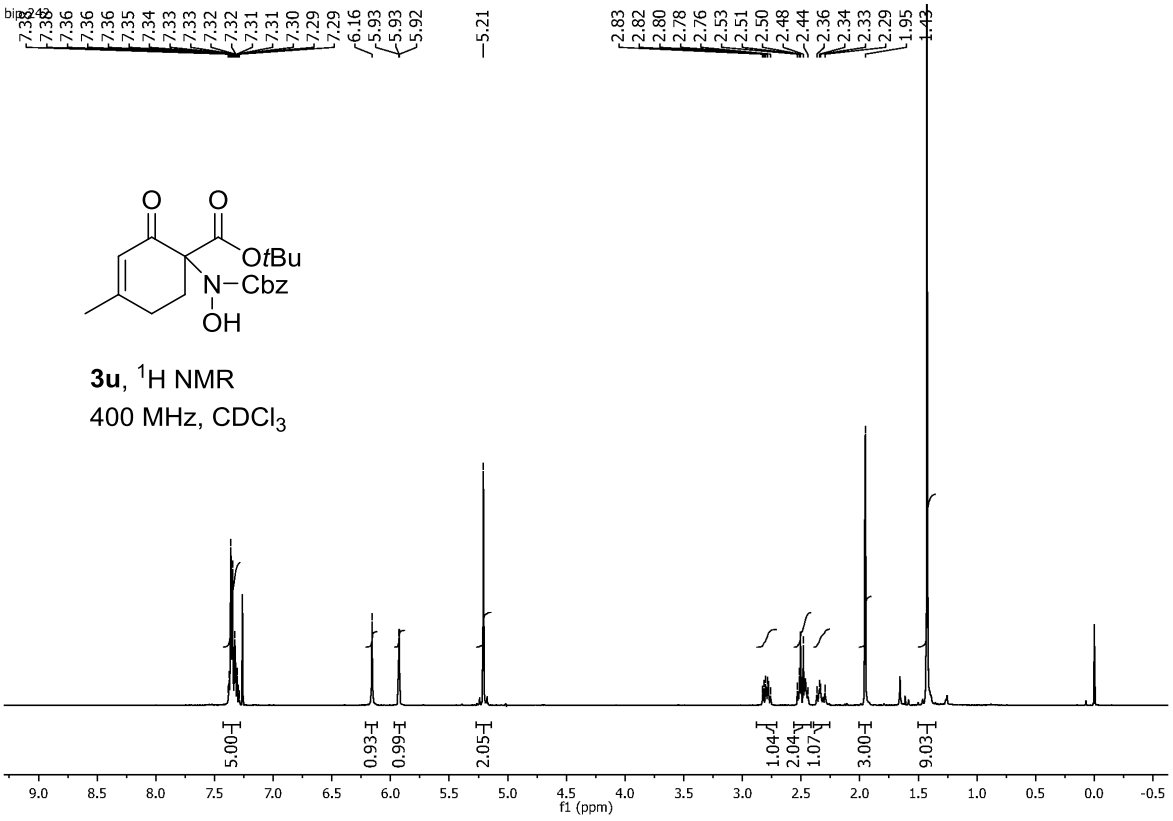
3s, ^{13}C NMR
100 MHz, $CDCl_3$



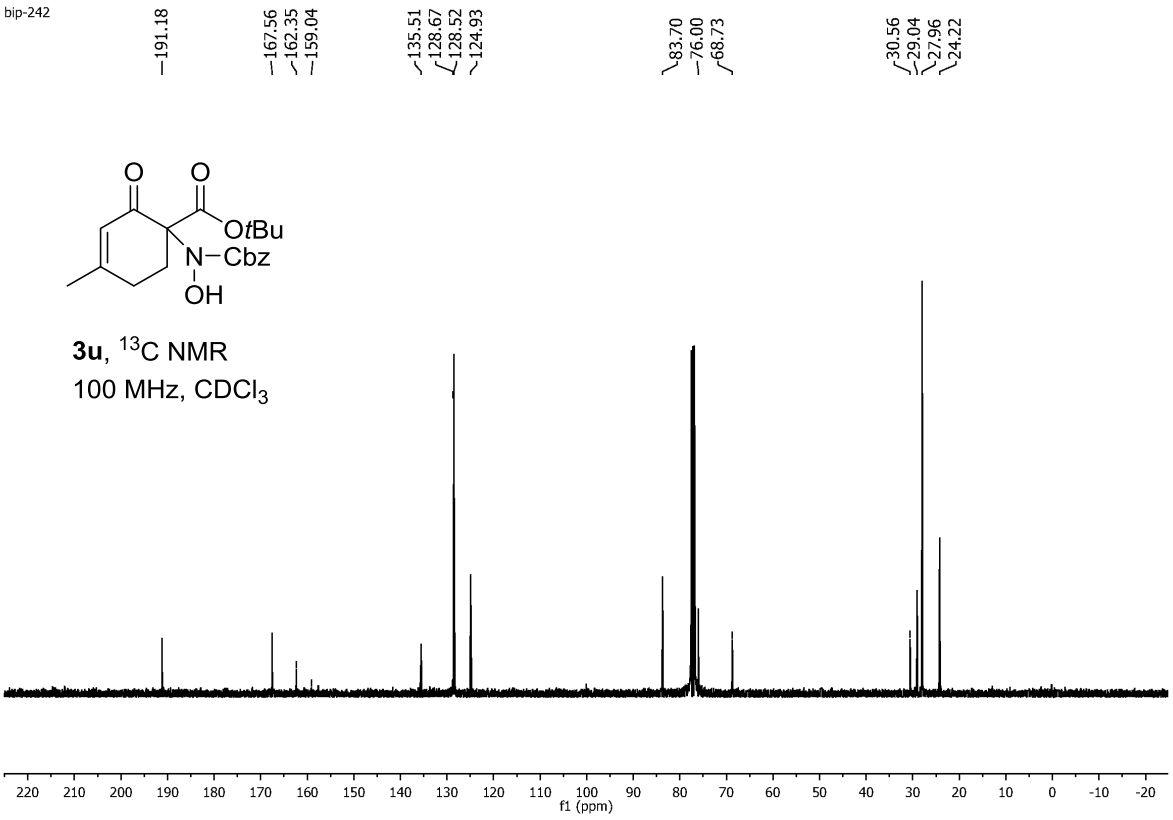
3t, ^{1}H NMR
400 MHz, $CDCl_3$



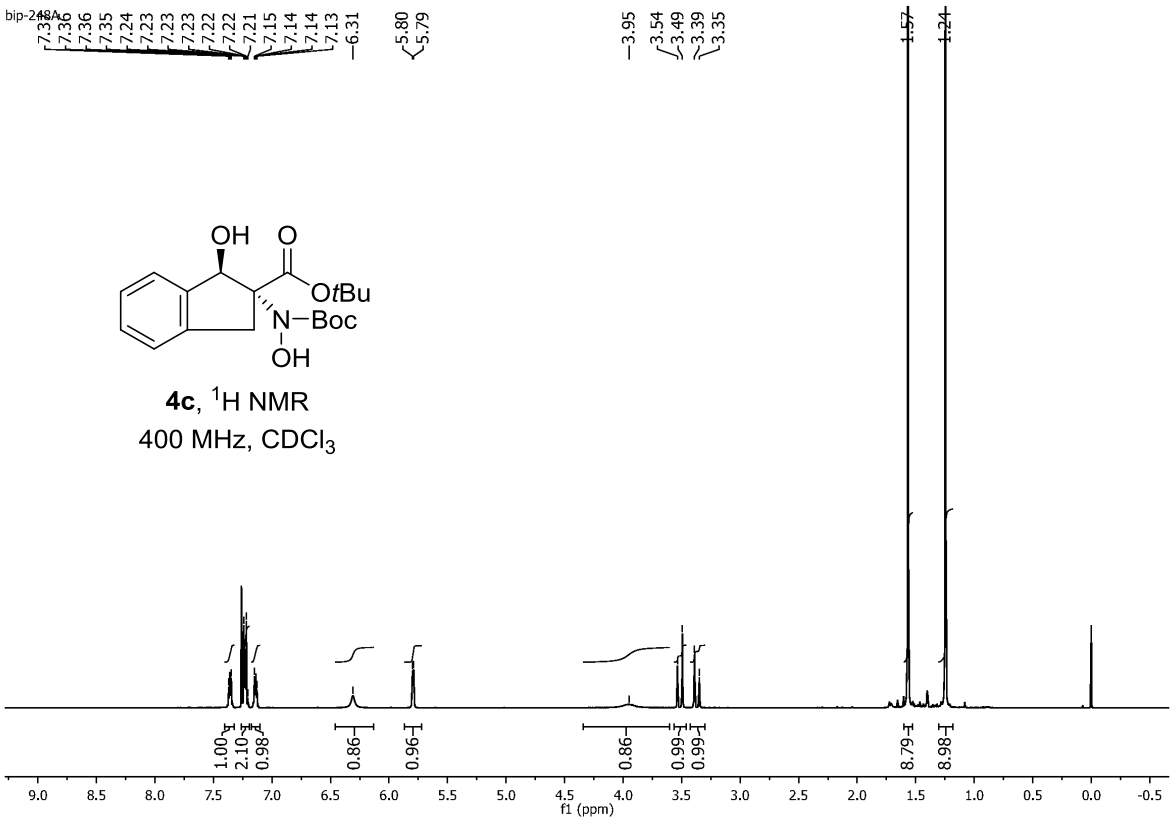
3t, ^{13}C NMR
100 MHz, $CDCl_3$



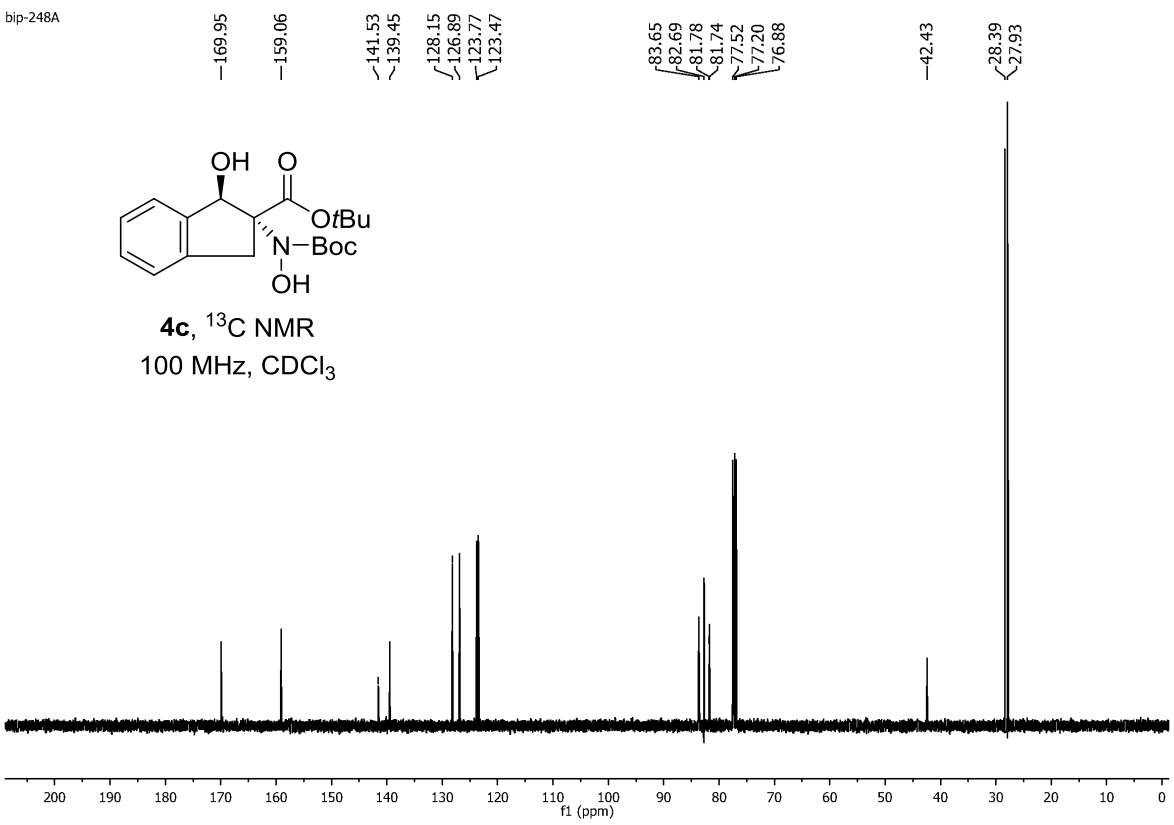
3u, ^{1}H NMR
400 MHz, $CDCl_3$



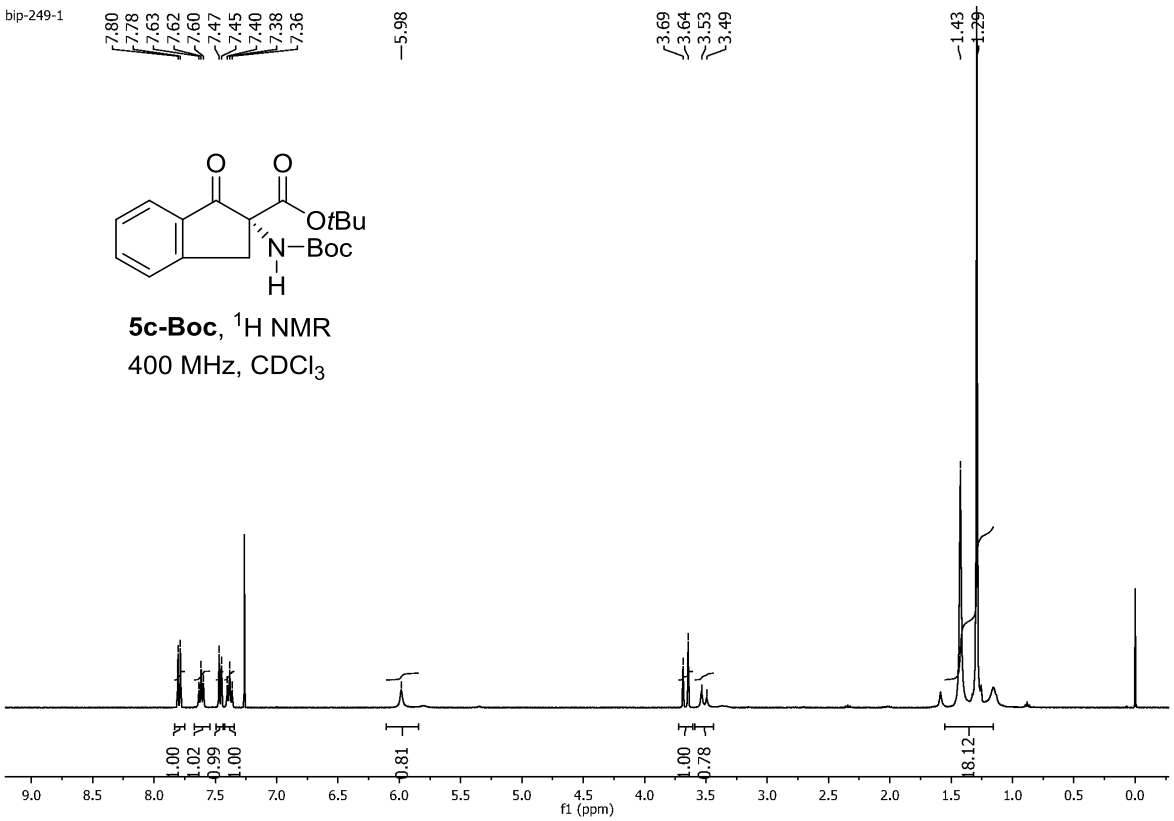
3u, ^{13}C NMR
100 MHz, $CDCl_3$



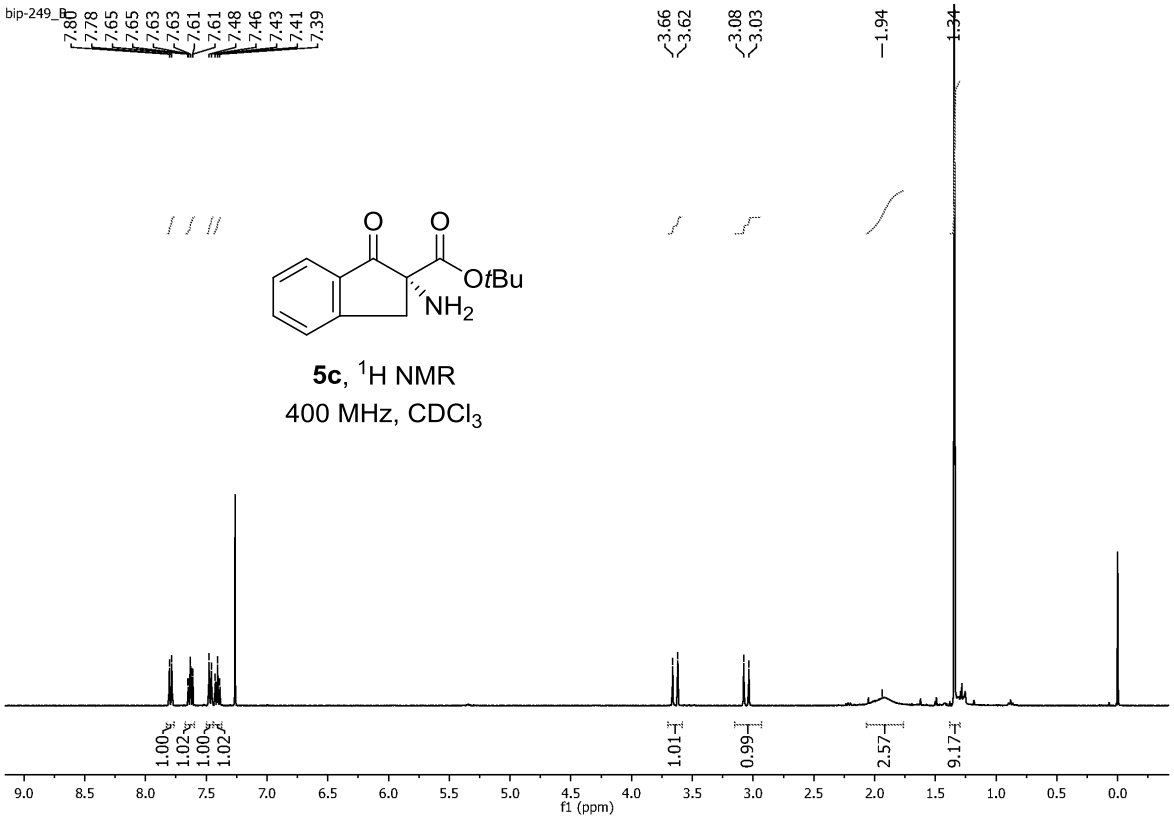
4c, ^{1}H NMR
400 MHz, $CDCl_3$



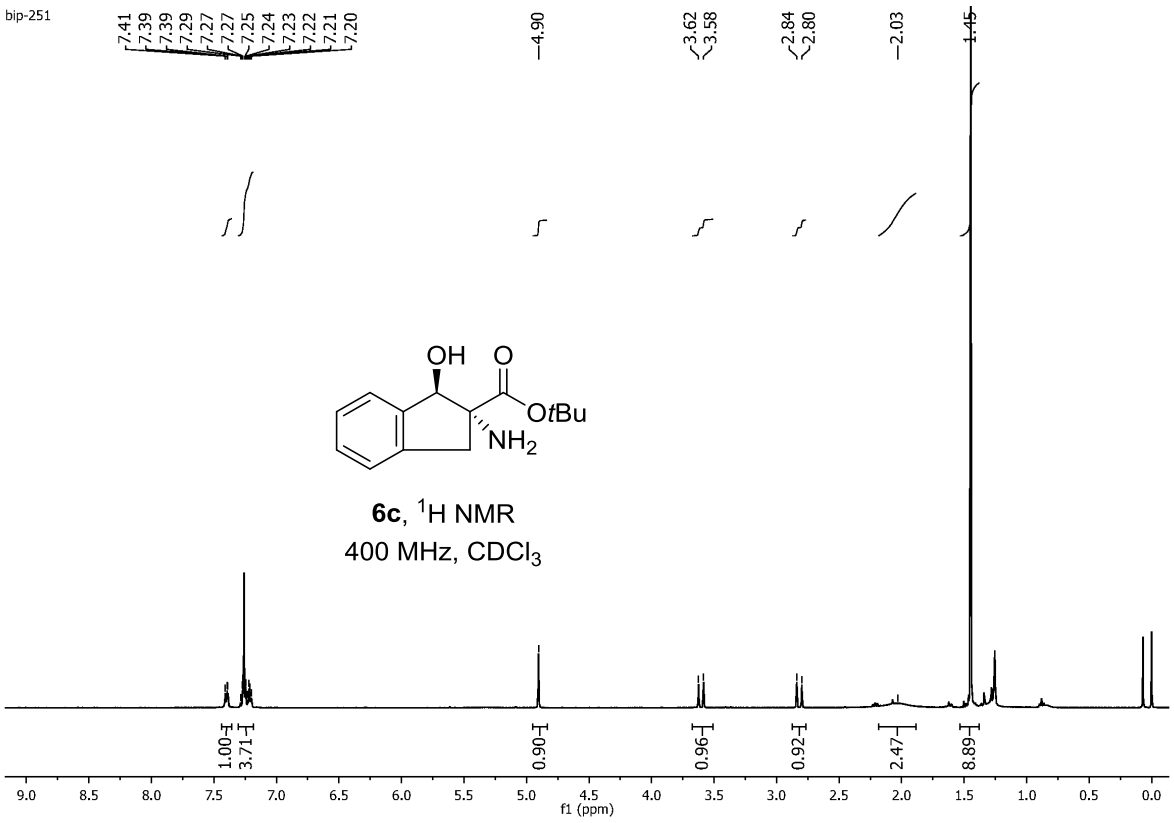
4c, ^{13}C NMR
100 MHz, $CDCl_3$



5c-Boc, ^{1}H NMR
400 MHz, $CDCl_3$



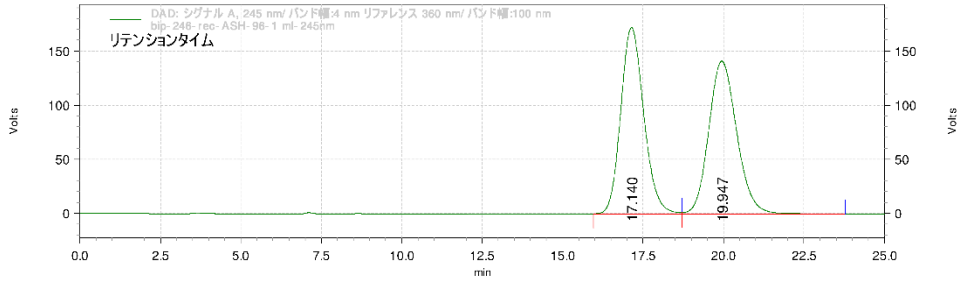
5c, ^{1}H NMR
400 MHz, $CDCl_3$


bip-251
7.41
7.39
7.39
7.29
7.27
7.27
7.25
7.24
7.23
7.22
7.21
7.20
4.90
3.62
3.58
2.84
2.80
2.03
1.45
OH
O
OtBu
NH2
6c, 1H NMR
400 MHz, CDCl3
1.00
3.71
0.90
0.96
0.92
2.47
8.89
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

8. Copies of HPLC chromatogram

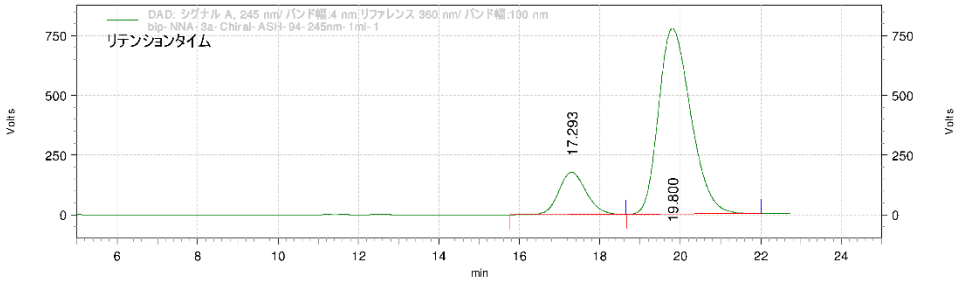
HPLC chromatogram of **3a**:

Daicel Chiralpak AS-H, hexane/*i*-PrOH = 96/4, flow rate = 1.0 mL/min, λ = 245 nm, retention time; t_R(minor) = 17.3 min, t_R(major) = 19.8 min.



DAD: シグナル A, 245 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

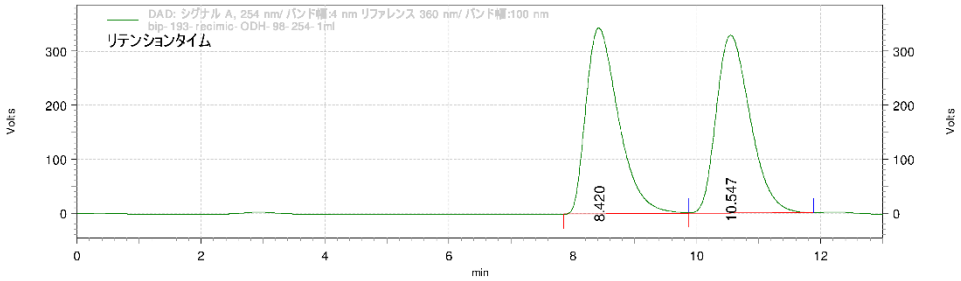
リテンションタイム	面積%
17.140	50.148
19.947	49.852
合計	100.000



DAD: シグナル A, 245 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

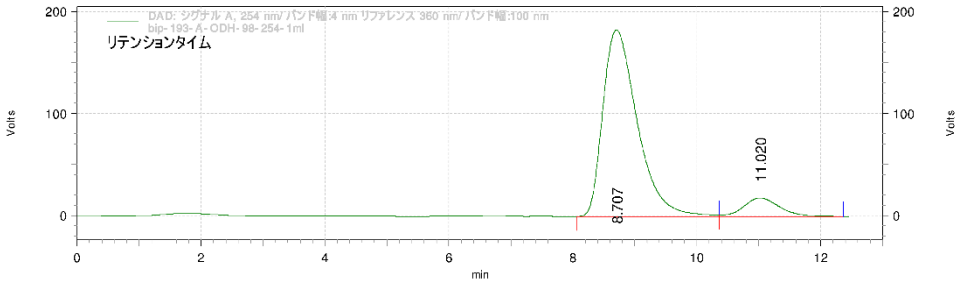
リテンションタイム	面積%
17.293	16.100
19.800	83.900
合計	100.000

HPLC chromatogram of **3b**:
Daicel Chiralpak OD-H, hexane/*i*-PrOH = 98/2, flow rate = 1.0 mL/min, λ = 254 nm, retention time; t_R(major) = 8.7 min, t_R(minor) = 11.0 min.



DAD: シグナル A, 254 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

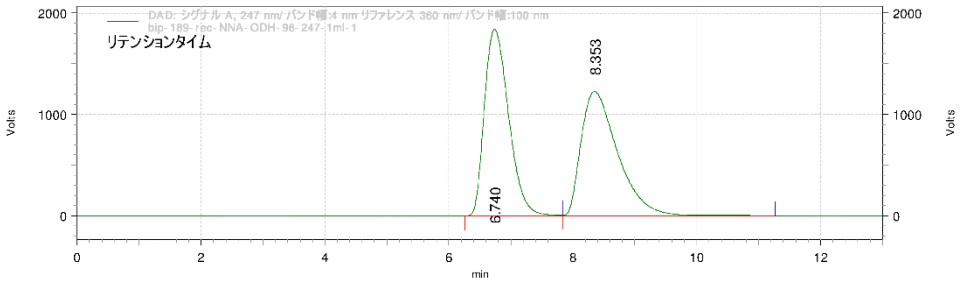
リテンションタイム	面積%
8.420	50.155
10.547	49.845
合計	100.000



DAD: シグナル A, 254 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

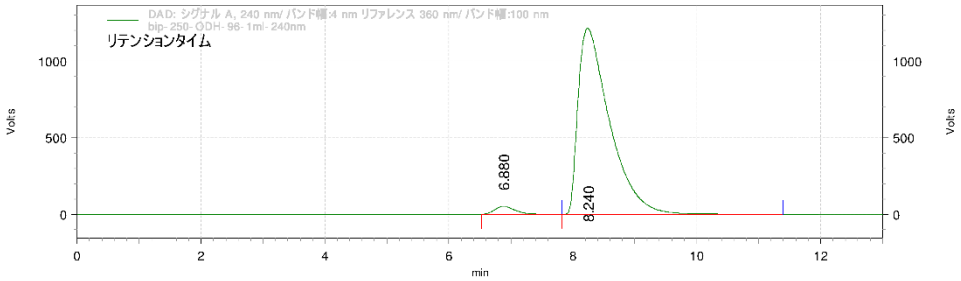
リテンションタイム	面積%
8.707	90.845
11.020	9.155
合計	100.000

HPLC chromatogram of **3c**:
Daicel Chiralpak OD-H, hexane/*i*-PrOH = 96/4, flow rate = 1.0 mL/min, λ = 245 nm, retention time; t_R(minor) = 6.9 min, t_R(major) = 8.2 min.



DAD: シグナル A, 247 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

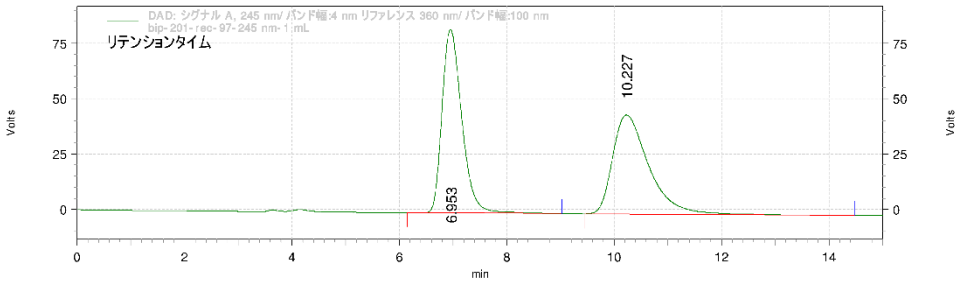
リテンションタイム	面積%
6.740	49.946
8.353	50.054
合計	100.000



DAD: シグナル A, 240 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

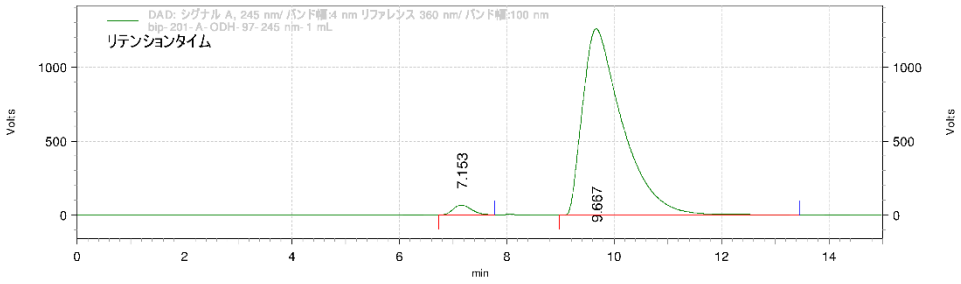
リテンションタイム	面積%
6.880	2.694
8.240	97.306
合計	100.000

HPLC chromatogram of **3d**:
Daicel Chiralpak OD-H, hexane/*i*-PrOH = 97/3, flow rate = 1.0 mL/min, λ = 245 nm, retention time; t_R(minor) = 7.2 min, t_R(major) = 9.7 min.



DAD: シグナル A, 245 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

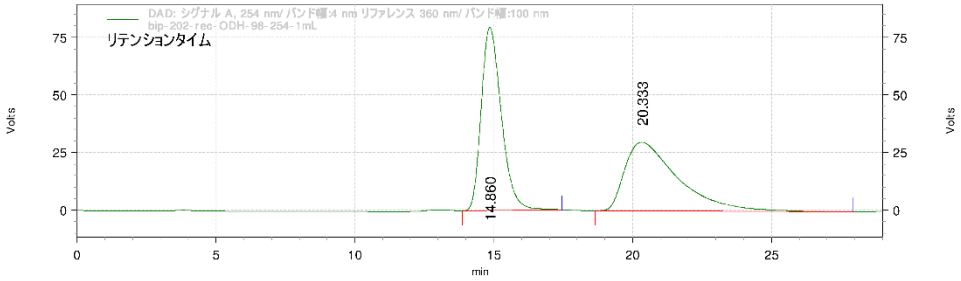
リテンションタイム	面積%
6.953	50.287
10.227	49.713
合計	100.000



DAD: シグナル A, 245 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

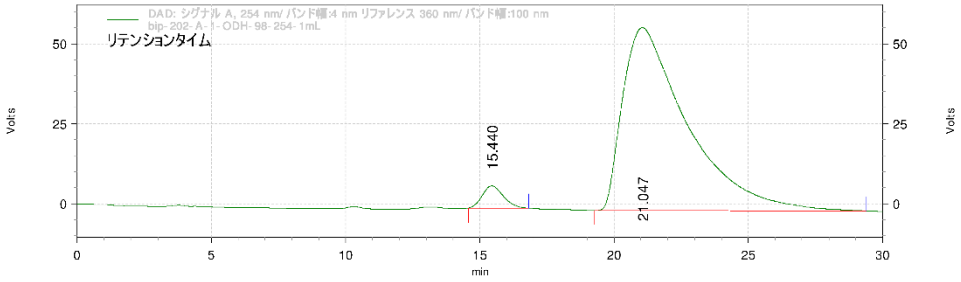
リテンションタイム	面積%
7.153	2.390
9.667	97.610
合計	100.000

HPLC chromatogram of **3e**:
Daicel Chiralpak OD-H, hexane/*i*-PrOH = 98/2, flow rate = 1.0 mL/min, λ = 254 nm, retention time; t_R(minor) = 15.4 min,t_R(major) = 21.0 min.



DAD: シグナル A, 254 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

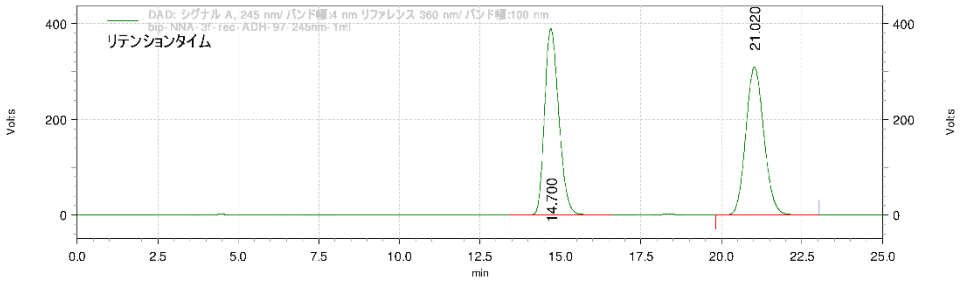
リテンションタイム	面積%
14.860	50.248
20.333	49.752
合計	100.000



DAD: シグナル A, 254 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

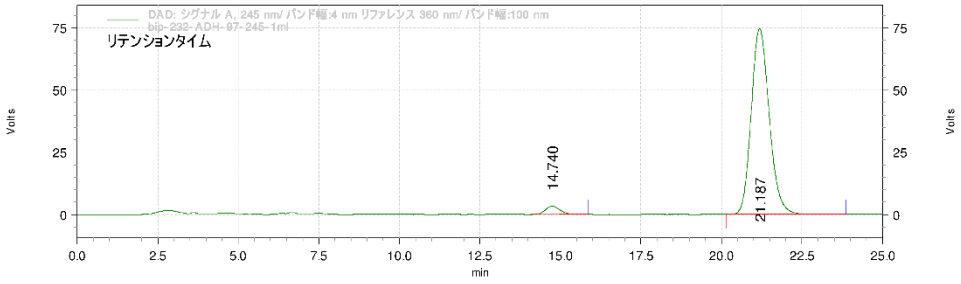
リテンションタイム	面積%
15.440	3.758
21.047	96.242
合計	100.000

HPLC chromatogram of **3f**:
Daicel Chiralpak AD-H, hexane/*i*-PrOH = 97/3, flow rate = 1.0 mL/min, λ = 245 nm, retention time; t_R(minor) = 14.7 min, t_R(major) = 21.2 min.



DAD: シグナル A, 245 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

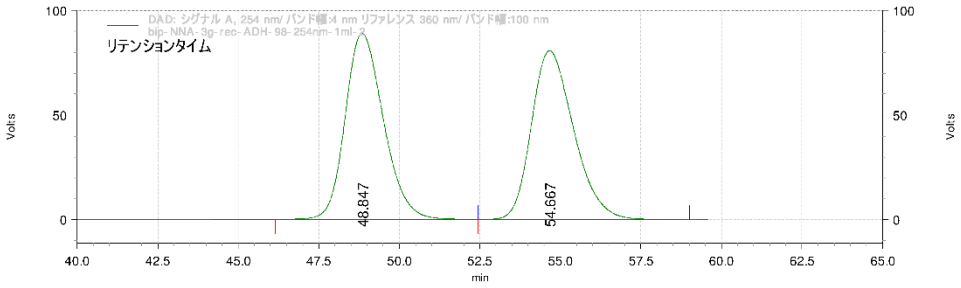
リテンションタイム	面積%
14.700	49.704
21.020	50.296
合計	100.000



DAD: シグナル A, 245 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

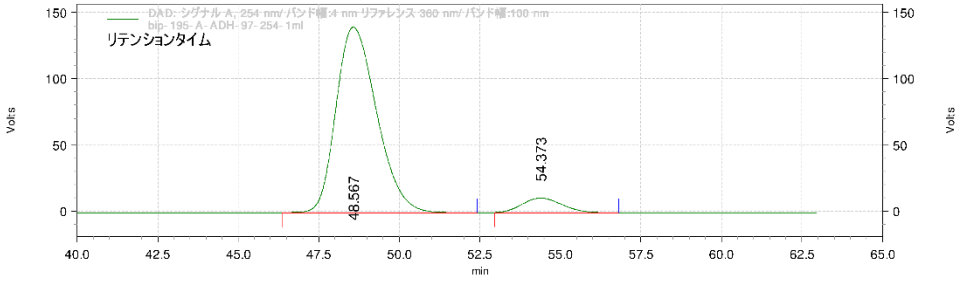
リテンションタイム	面積%
14.740	3.422
21.187	96.578
合計	100.000

HPLC chromatogram of **3g**:
Daicel Chiralpak AD-H, hexane/*i*-PrOH = 98/2, flow rate = 1.0 mL/min, λ = 254 nm, retention time; t_R(major) = 48.6 min, t_R(minor) = 54.4 min.



DAD: シグナル A, 254 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

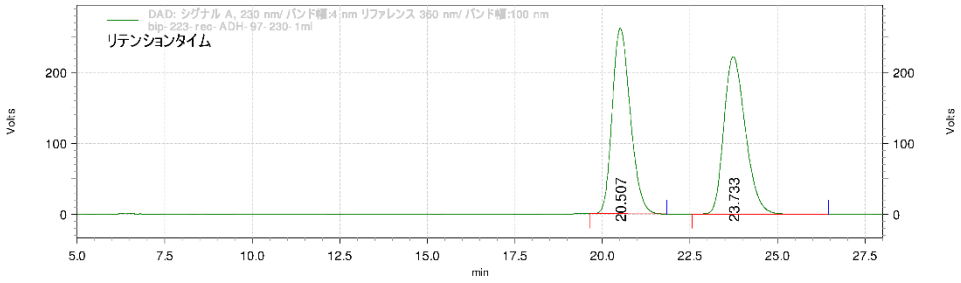
リテンションタイム	面積%
48.847	49.973
54.667	50.027
合計	100.000



DAD: シグナル A, 254 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

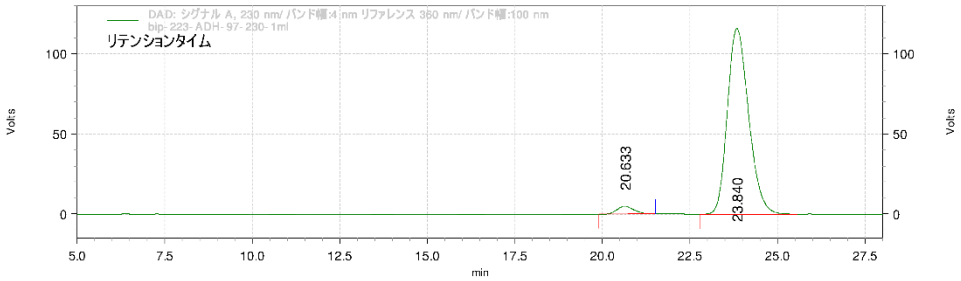
リテンションタイム	面積%
48.567	92.785
54.373	7.215
合計	100.000

HPLC chromatogram of **3h**:
Daicel Chiralpak AD-H, hexane/*i*-PrOH = 97/3, flow rate = 1.0 mL/min, λ = 230 nm, retention time; t_R(minor) = 20.6 min, t_R(major) = 23.8 min.



DAD: シグナル A, 230 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

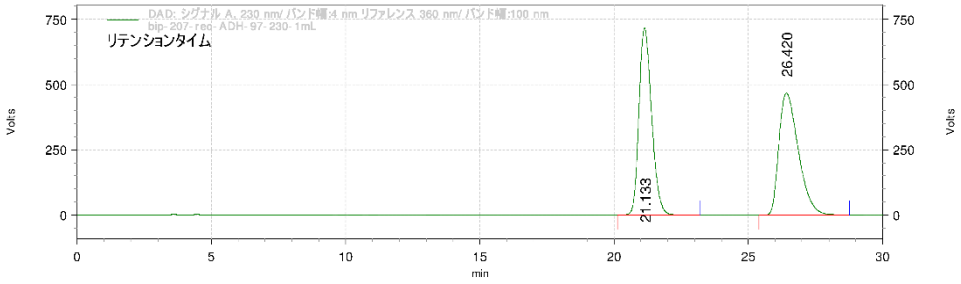
リテンションタイム	面積%
20.507	49.659
23.733	50.341
合計	100.000



DAD: シグナル A, 230 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

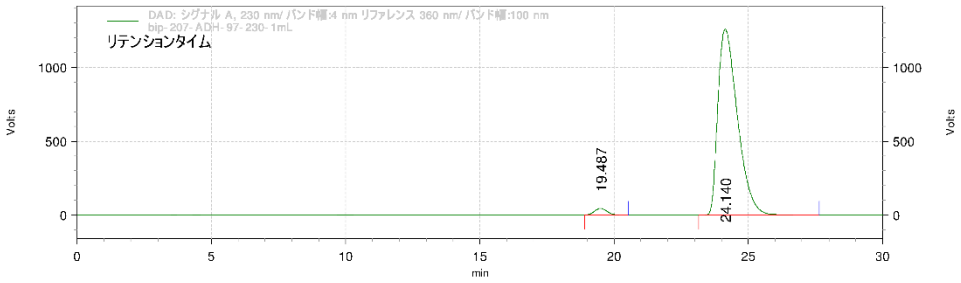
リテンションタイム	面積%
20.633	3.358
23.840	96.642
合計	100.000

HPLC chromatogram of **3i**:
Daicel Chiralpak AD-H, hexane/*i*-PrOH = 97/3, flow rate = 1.0 mL/min, λ = 230 nm, retention time; t_R(minor) = 19.5 min, t_R(major) = 24.1 min.



DAD: シグナル A, 230 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

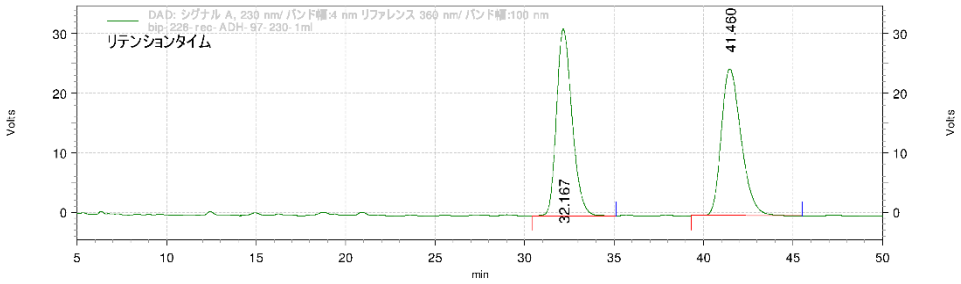
リテンションタイム	面積%
21.133	50.065
26.420	49.935
合計	100.000



DAD: シグナル A, 230 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

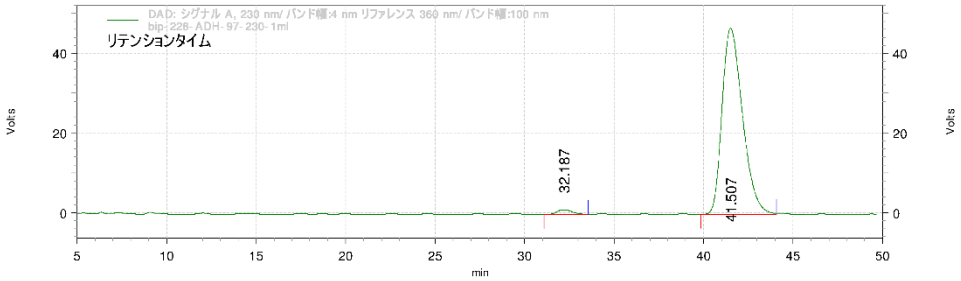
リテンションタイム	面積%
19.487	2.269
24.140	97.731
合計	100.000

HPLC chromatogram of **3j**:
Daicel Chiralpak AD-H, hexane/*i*-PrOH = 97/3, flow rate = 1.0 mL/min, λ = 230 nm, retention time; t_R(minor) = 32.2 min, t_R(major) = 41.5 min.



DAD: シグナル A, 230 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

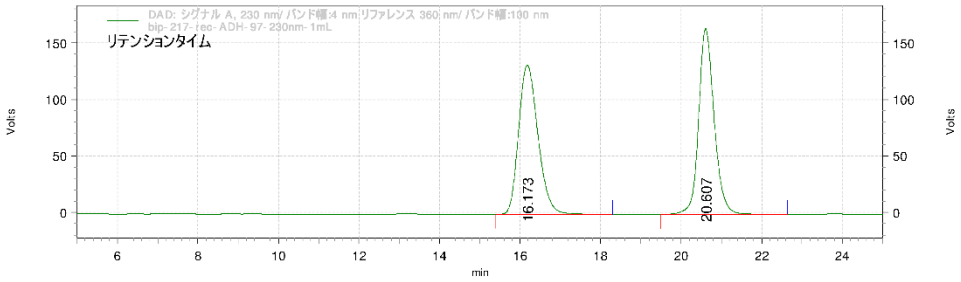
リテンションタイム	面積%
32.167	49.937
41.460	50.063
合計	100.000



DAD: シグナル A, 230 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

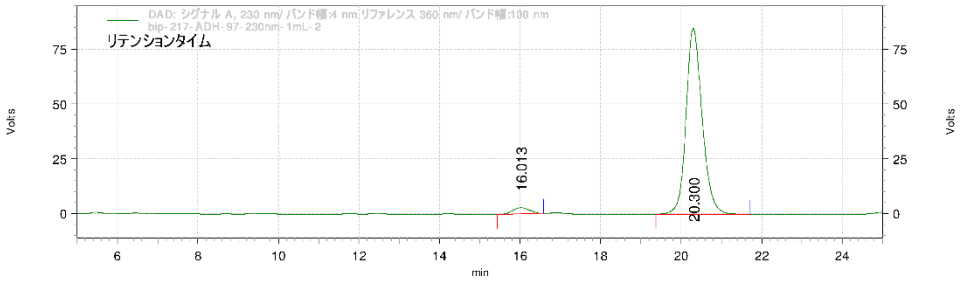
リテンションタイム	面積%
32.187	1.854
41.507	98.146
合計	100.000

HPLC chromatogram of **3k**:
Daicel Chiralpak AD-H, hexane/*i*-PrOH = 97/3, flow rate = 1.0 mL/min, λ = 230 nm, retention time; t_R(minor) = 16.0 min, t_R(major) = 20.3 min.



DAD: シグナル A, 230 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

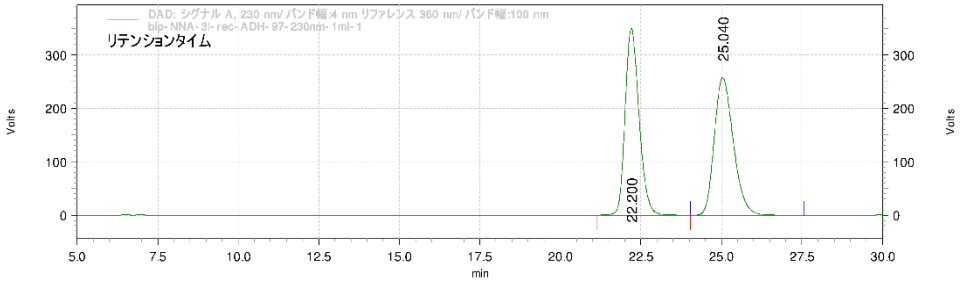
リテンションタイム	面積%
16.173	50.017
20.607	49.983
合計	100.000



DAD: シグナル A, 230 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

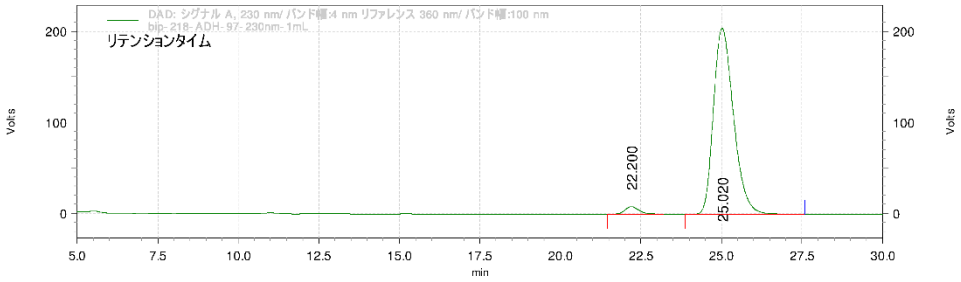
リテンションタイム	面積%
16.013	3.419
20.300	96.581
合計	100.000

HPLC chromatogram of **3l**:
Daicel Chiralpak AD-H, hexane/*i*-PrOH = 97/3, flow rate = 1.0 mL/min, λ = 230 nm, retention time; t_R(minor) = 22.2 min, t_R(major) = 25.0 min.



DAD: シグナル A, 230 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

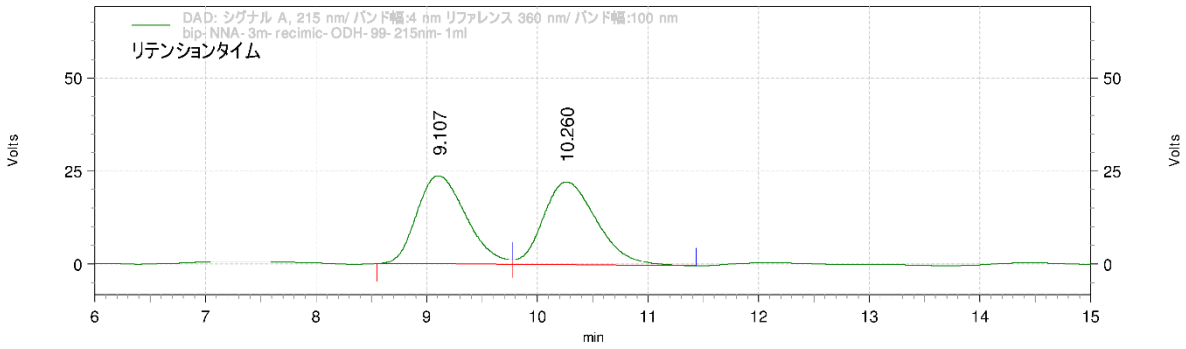
リテンションタイム	面積%
22.200	49.839
25.040	50.161
合計	100.000



DAD: シグナル A, 230 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

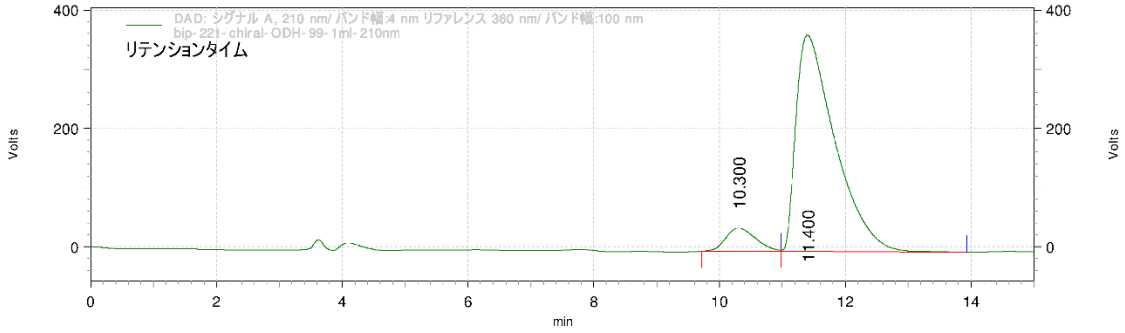
リテンションタイム	面積%
22.200	2.693
25.020	97.307
合計	100.000

HPLC chromatogram of **3m**:
Daicel Chiralpak OD-H, hexane/*i*-PrOH = 99/1, flow rate = 1.0 mL/min, λ = 210 nm, retention time; t_R(minor) = 10.3 min, t_R(major) = 11.4 min.



DAD: シグナル A, 215 nm/ バンド幅:4 nm リファレンス 360 nm/ バンド幅:100 nm 結果

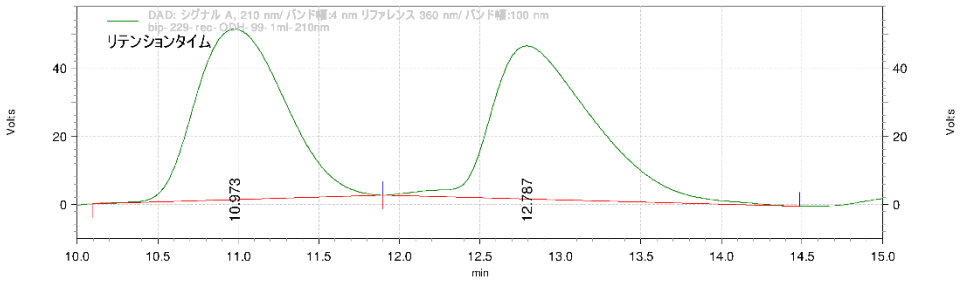
リテンションタイム	面積%
9.107	49.486
10.260	50.514
合計	100.000



DAD: シグナル A, 210 nm/ バンド幅:4 nm リファレンス 360 nm/ バンド幅:100 nm 結果

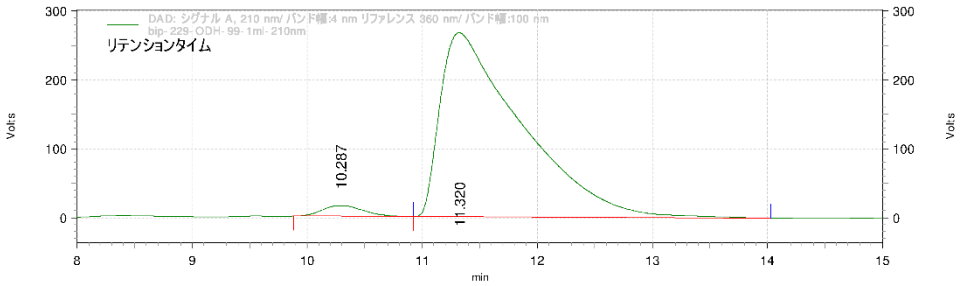
リテンションタイム	面積%
10.300	7.603
11.400	92.397
合計	100.000

HPLC chromatogram of **3n**:
Daicel Chiralpak OD-H, hexane/*i*-PrOH = 99/1, flow rate = 1.0 mL/min, λ = 210 nm, retention time; t_R(minor) = 10.3 min, t_R(major) = 11.3 min.



DAD: シグナル A, 210 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

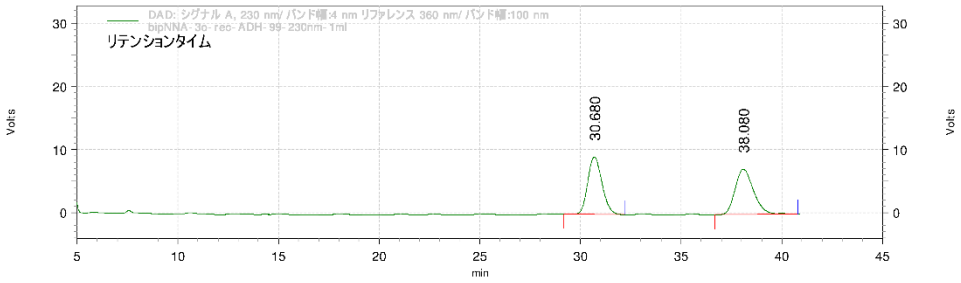
リテンションタイム	面積%
10.973	49.190
12.787	50.810
合計	100.000



DAD: シグナル A, 210 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

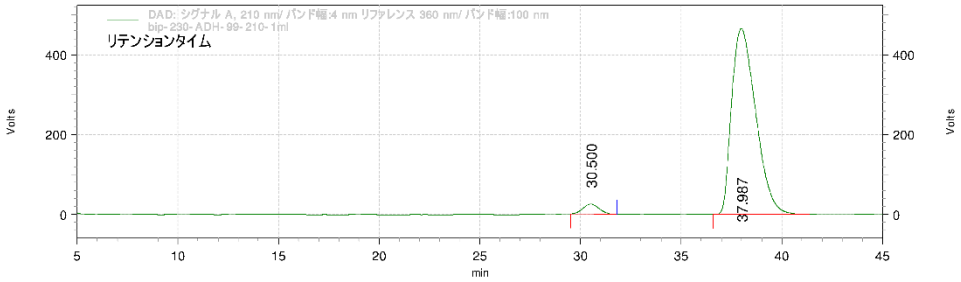
リテンションタイム	面積%
10.287	2.861
11.320	97.139
合計	100.000

HPLC chromatogram of **3o**:
Daicel Chiralpak AD-H, hexane/*i*-PrOH = 99/1, flow rate = 1.0 mL/min, λ = 210 nm, retention time; t_R(minor) = 30.5 min, t_R(major) = 38.0 min.



DAD: シグナル A, 230 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

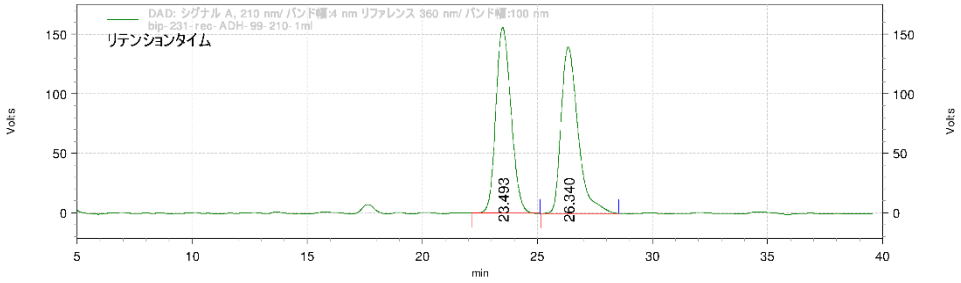
リテンションタイム	面積%
30.680	49.255
38.080	50.745
合計	100.000



DAD: シグナル A, 210 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

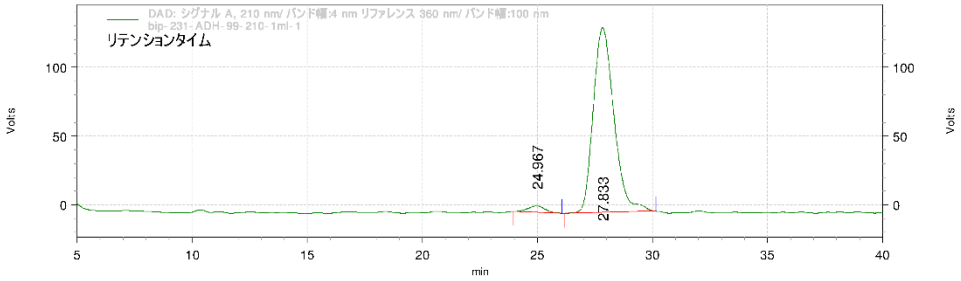
リテンションタイム	面積%
30.500	3.420
37.987	96.580
合計	100.000

HPLC chromatogram of **3p**:
Daicel Chiralpak AD-H, hexane/*i*-PrOH = 99/1, flow rate = 1.0 mL/min, λ = 210 nm, retention time; t_R(minor) = 25.0 min, t_R(major) = 27.8 min.



DAD: シグナル A, 210 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

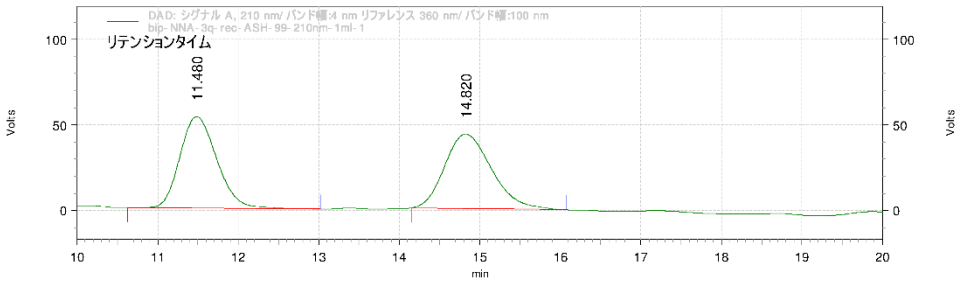
リテンションタイム	面積%
23.493	49.972
26.340	50.028
合計	100.000



DAD: シグナル A, 210 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

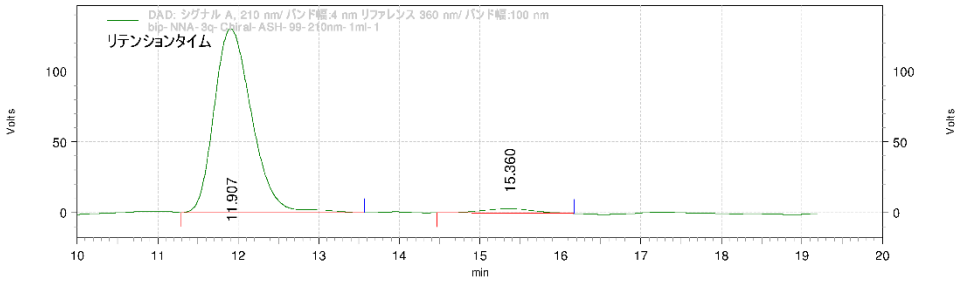
リテンションタイム	面積%
24.967	2.734
27.833	97.266
合計	100.000

HPLC chromatogram of **3q**:
Daicel Chiralpak AS-H, hexane/*i*-PrOH = 99/1, flow rate = 1.0 mL/min, λ = 210 nm, retention time; t_R(major) = 11.9 min, t_R(minor) = 15.4 min.



DAD: シグナル A, 210 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

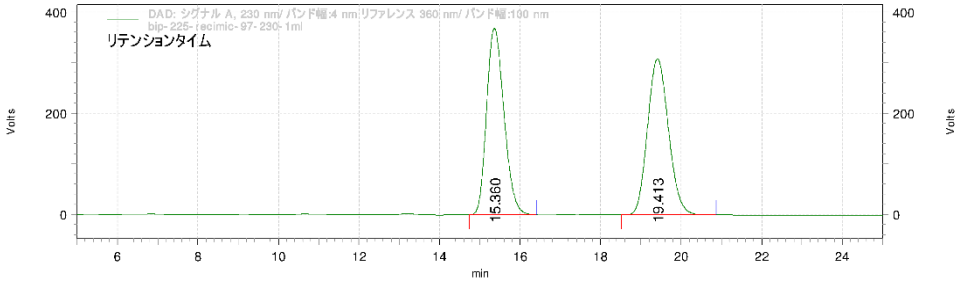
リテンションタイム	面積%
11.480	49.232
14.820	50.768
合計	100.000



DAD: シグナル A, 210 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

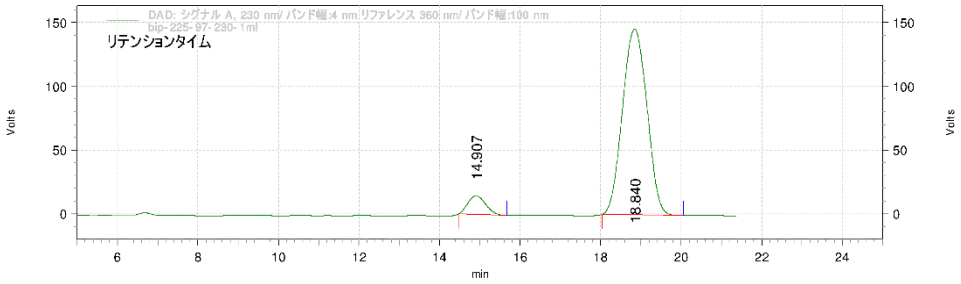
リテンションタイム	面積%
11.907	96.957
15.360	3.043
合計	100.000

HPLC chromatogram of **3r**:
Daicel Chiralpak AD-H, hexane/*i*-PrOH = 97/3, flow rate = 1.0 mL/min, λ = 230 nm, retention time; t_R(minor) = 14.9 min, t_R(major) = 18.8 min.



DAD: シグナル A, 230 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

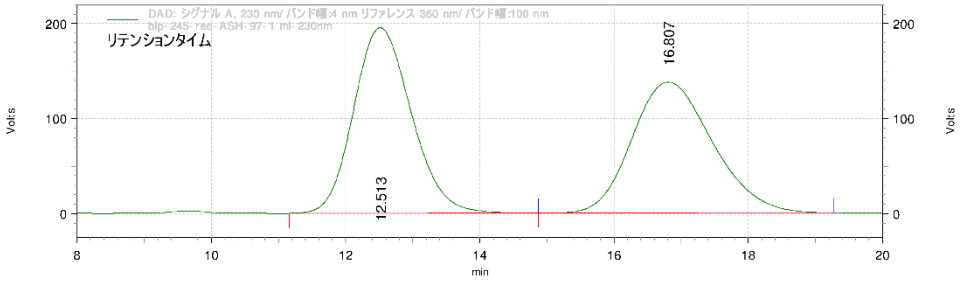
リテンションタイム	面積%
15.360	49.778
19.413	50.222
合計	100.000



DAD: シグナル A, 230 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

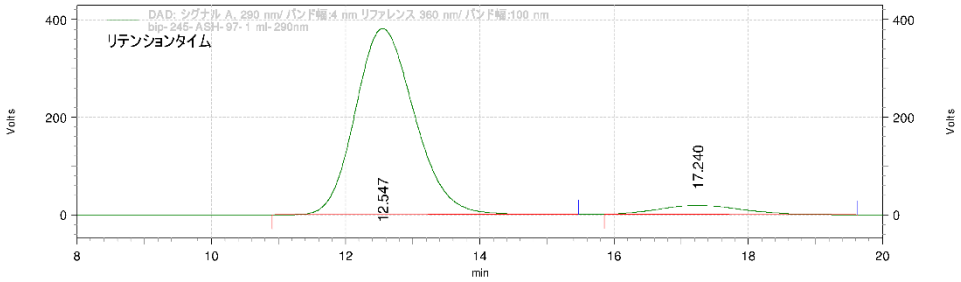
リテンションタイム	面積%
14.907	6.874
18.840	93.126
合計	100.000

HPLC chromatogram of **3s**:
Daicel Chiralpak AS-H, hexane/*i*-PrOH = 97/3, flow rate = 1.0 mL/min, λ = 290 nm, retention time; t_R(major) = 12.5 min, t_R(minor) = 17.2 min.



DAD: シグナル A, 230 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

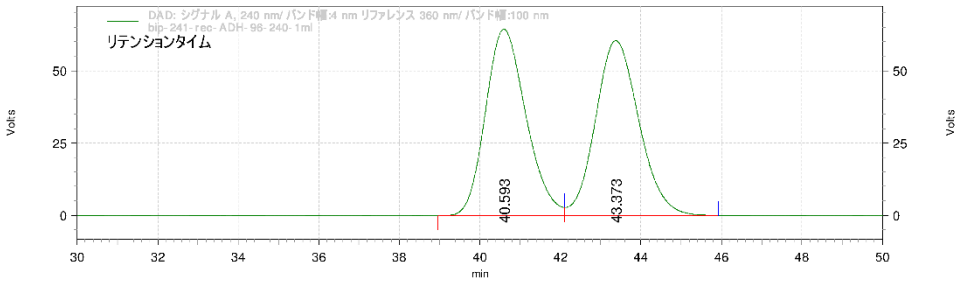
リテンションタイム	面積%
12.513	50.363
16.807	49.637
合計	100.000



DAD: シグナル A, 290 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

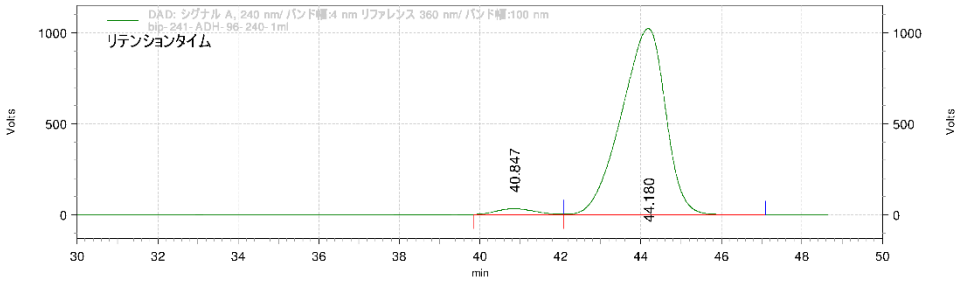
リテンションタイム	面積%
12.547	93.680
17.240	6.320
合計	100.000

HPLC chromatogram of **3t**:
Daicel Chiralpak AD-H, hexane/*i*-PrOH = 96/4, flow rate = 1.0 mL/min, λ = 240 nm, retention time; t_R(minor) = 40.8 min, t_R(major) = 44.2 min.



DAD: シグナル A, 240 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

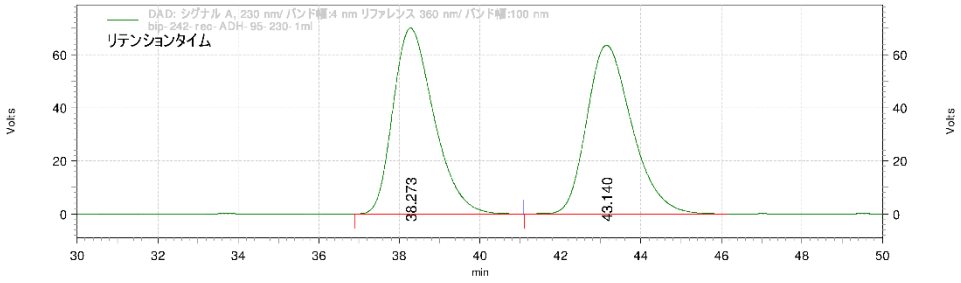
リテンションタイム	面積%
40.593	49.778
43.373	50.222
合計	100.000



DAD: シグナル A, 240 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

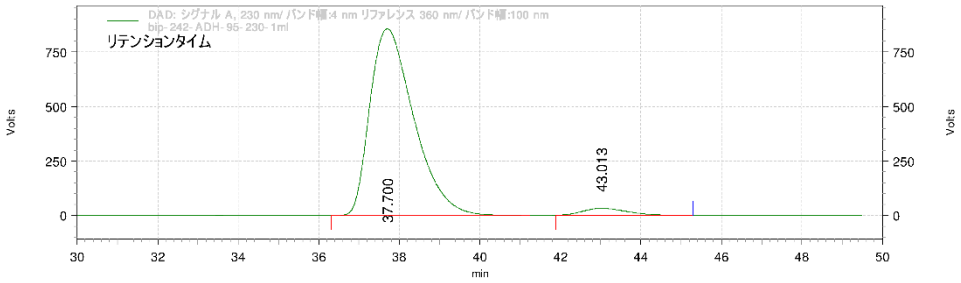
リテンションタイム	面積%
40.847	2.695
44.180	97.305
合計	100.000

HPLC chromatogram of **3u**:
Daicel Chiralpak AD-H, hexane/*i*-PrOH = 95/5, flow rate = 1.0 mL/min, λ = 230 nm, retention time; t_R(major) = 37.7 min, t_R(minor) = 43.0 min.



DAD: シグナル A, 230 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

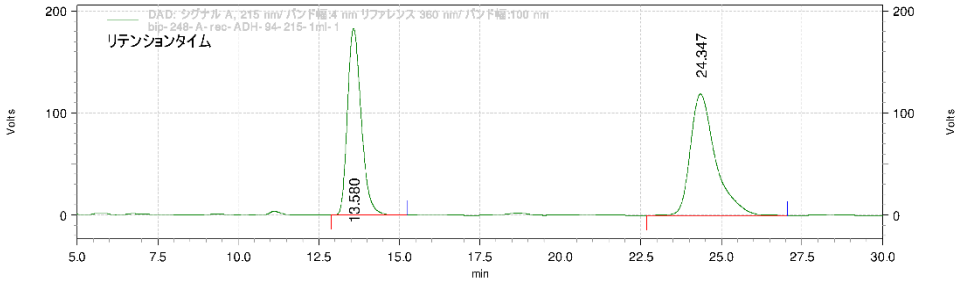
リテンションタイム	面積%
38.273	49.908
43.140	50.092
合計	100.000



DAD: シグナル A, 230 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

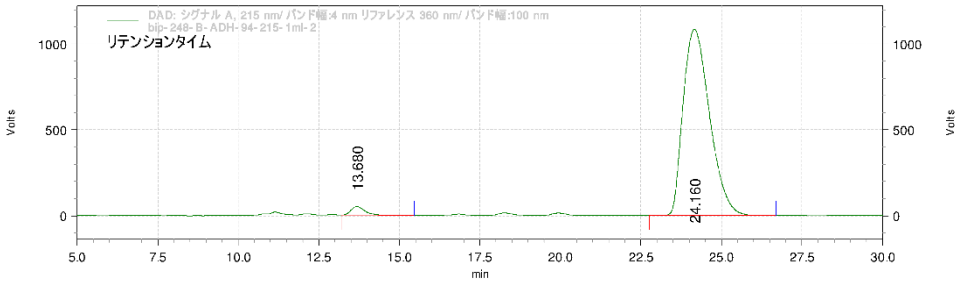
リテンションタイム	面積%
37.700	96.283
43.013	3.717
合計	100.000

HPLC chromatogram of **4c**:
Daicel Chiralpak AD-H, hexane/*i*-PrOH = 94/6, flow rate = 1.0 mL/min, λ = 215 nm, retention time; t_R(minor) = 13.7 min, t_R(major) = 24.2 min.



DAD: シグナル A, 215 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

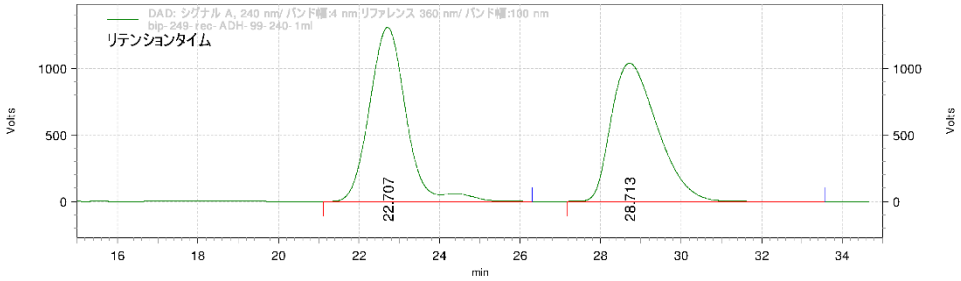
リテンションタイム	面積%
13.580	45.702
24.347	54.298
合計	100.000



DAD: シグナル A, 215 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

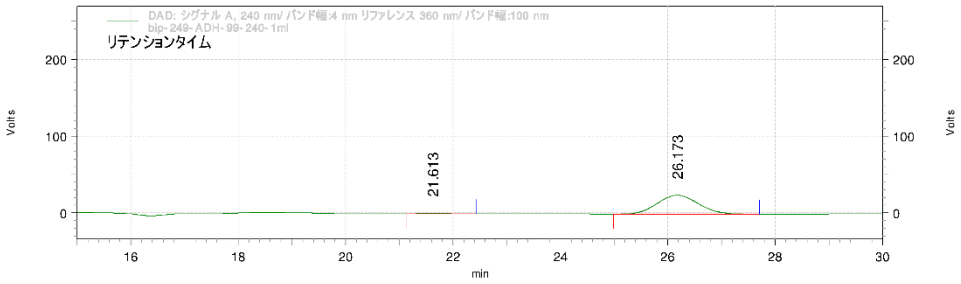
リテンションタイム	面積%
13.680	2.352
24.160	97.648
合計	100.000

HPLC chromatogram of **5c-Boc**:
Daicel Chiralpak AD-H, hexane/*i*-PrOH = 99/1, flow rate = 1.0 mL/min, λ = 215 nm, retention time; t_R(minor) = 21.6 min, t_R(major) = 26.2 min.



DAD: シグナル A, 240 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

リテンションタイム	面積%
22.707	50.037
28.713	49.963
合計	100.000



DAD: シグナル A, 240 nm/ バンド幅:4 nm リファレンス
360 nm/ バンド幅:100 nm 結果

リテンションタイム	面積%
21.613	2.649
26.173	97.351
合計	100.000