Electronic Supplementary Infomation

Asymmetric assembly of spirooxindole dihydropyra-nones through direct enantioselective organocatalytic vinylogous aldol−cyclization cascade reaction of 3-alkylidene oxindoles with isatins

Jeng-Liang Han* and Chia-Hao Chang

Department of Chemistry, Chung Yuan Christian University, Taoyuan City, Taiwan 320

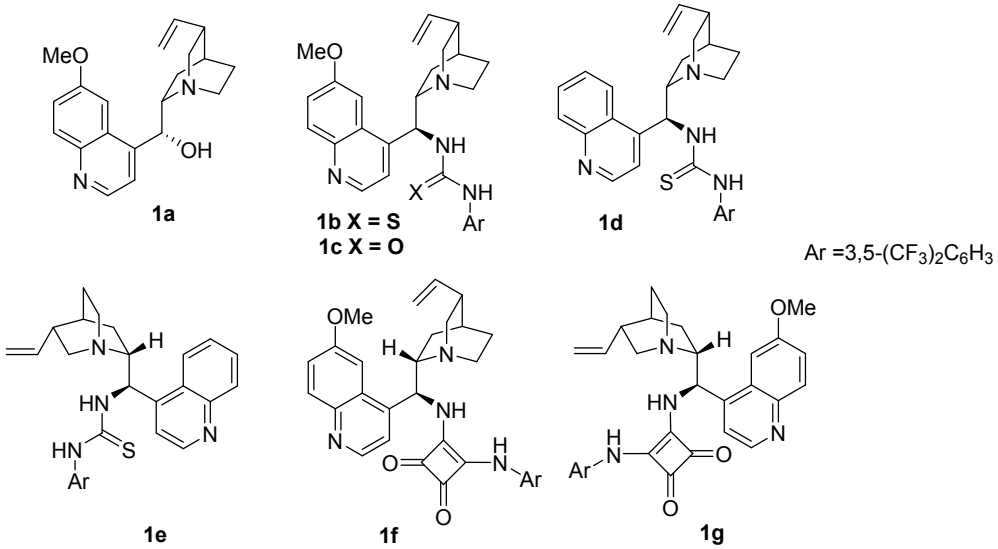
jlhan@cycu.edu.tw

Table of Contents:

1. General Experimental Details.

All commercially available reagents were used without further purification unless otherwise stated. All reaction solvents were purified before use. Proton nuclear magnetic resonance (^{1}H NMR) spectra were recorded on a commercial instrument at 400 MHz. Carbon-13 nuclear magnetic resonance (^{13}C NMR) spectra were recorded at 100 MHz. The proton signal for residual non-deuterated solvent (δ 7.26 for $CHCl_3$) was used as an internal reference for ^{1}H NMR spectra. For ^{13}C NMR spectra, chemical shifts are reported relative to the δ77.0 resonance of $CHCl_3$. Coupling constants are reported in Hz. Infrared (IR) spectra were recorded on a commercial FTIR instrument. Optical rotations were recorded on an ATAGO POLAX-2L polarimeter. Melting points were determined on a BUCHI B-545 melting point apparatus and are uncorrected. High resolution mass spectra were recorded on a commercial high resolution mass spectrometer Analytical thin layer chromatography (TLC) was performed on Kieselgel 60 F254 glass plates precoated with a 0.25 mm thickness of silica gel. The TLC plates were visualized with UV light and/or by staining with Hanessian solution (ceric sulfate and ammonium molybdate in aqueous sulfuric acid). Column chromatography was generally performed using Kieselgel 60 (230-400 mesh) silica gel, typically using a 50-100:1 weight ratio of silica gel to crude product. The ee values determination was carried out using chiral high-performance liquid chromatography (HPLC) with Daicel Chiracel OD-H, Chiracel AD-H, or Chiracel AS-H columns on JASCO with a UV-4075 detector. The HPLC spectra of racemic mixtures were determined by mixing compound **4** and ***ent*-4**.

Materials:



Catalysts **1b**[1]**, 1d**[1], **1e**[1], **1f**[2], **1g**[2] were prepared according to known procedures. 3-alkylidene oxindoles **2** were prepared according to literature procedures.[3]

2. Proposed Modes of Activation of Substrates

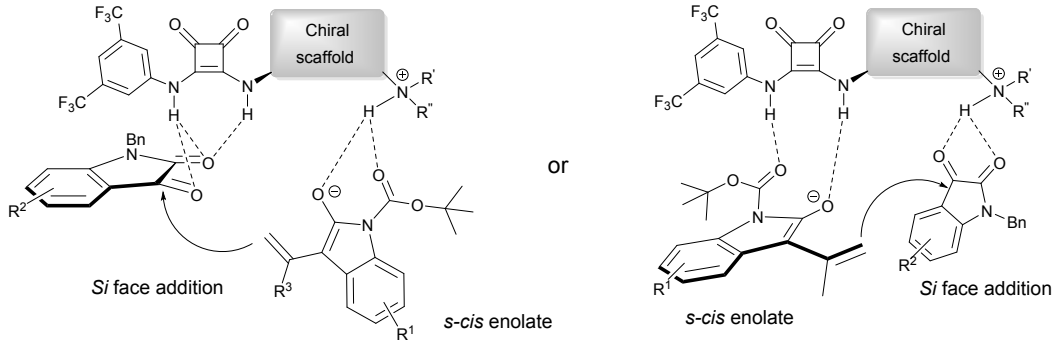


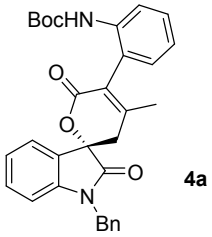
Figure S1. Proposed modes of activation of substrates for the vinylogous aldol reaction

3. General Procedure for the Synthesis of 4

To a solution of isatins **3** (0.1 mmol) and catalyst **1f** (0.01 mmol) in anhydrous CH_2Cl_2 was added 3-alkylidene oxindoles **2** (0.15 mmol) at room temperature. The reaction mixture was stirred at room temperature for 12-18 h. After completion of the reaction, the reaction solution was concentrated in vacuum and the crude was purified by silica gel flash chromatography (Hexanes/EA 5:1 to 3:1) to afford the pure products **4**. The enantiomeric ratio was determined by HPLC on a chiral stationary phase. The corresponding opposite enantiomers (***ent*-4**) were obtained by using catalyst **1g** under the same reaction conditions.

4. Characterization Data

***tert*-Butyl (*S*)-(2-(1-benzyl-4'-methyl-2,6'-dioxo-3',6'-dihydrospiro[indoline-3,2'-pyran]-5'-yl)phenyl)carbamate (4a).**

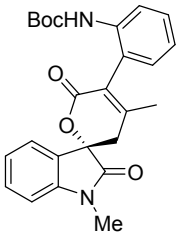


4a

White powder; Yield : 99%; $[\alpha]_D^{29}$: −34.6 (c = 1.04, CH_2Cl_2); mp: 78-80℃; IR (CH_2Cl_2): 3445, 1712, 1645, 1586, 1526 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 8.23 (m, 2H), 7.51 (dd, J = 7.5, 0.6 Hz, 1H), 7.37-7.26 (m, 8H), 7.15-7.12 (m, 2H), 7.07 (ddd, J = 8.3, 7.5, 1.0 Hz, 1H) 4.89 (s, 2H), 3.37 (dd, J = 18.4, 1.9 Hz, 1H), 2.64 (dd, J = 18.4, 1.9 Hz, 1H), 1.86 (s, 3H), 1.47 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 174.2, 163.1, 153.6, 150.5, 142.2, 137.8, 134.8, 131.1, 130.4, 129.1, 129.0, 128.0, 127.2, 126.8, 125.4, 124.5, 123.9, 122.6, 122.2, 119.5, 110.0, 79.6, 78.9, 43.9, 37.0,

28.3, 21.4; HRMS (ESI): cacld for $C_{31}H_{30}N_2O_5Na$ $[M+Na]^+$: 533.2052; found: 533.2046; HPLC analysis: *ee* = 96% on an AS-H column: hexane/*i*-PrOH = 70:30, flow rate = 0.8 mL/min, λ = 220 nm; t_{minor} = 22.49 min, t_{major} = 46.00 min.

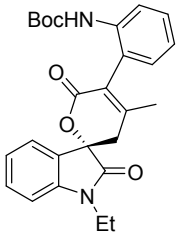
tert-Butyl (*S*)-(2-(1,4'-dimethyl-2,6'-dioxo-3',6'-dihydrospiro[indoline-3,2'-pyran]-5'-yl)phenyl)carbamate (4b).



4b

White powder; Yield : 92%; $[\alpha]_D^{29}$: −21.8 (*c* = 1.01, CH_2Cl_2); mp: 83-84℃; IR (CH_2Cl_2): 3445, 1713, 1617, 1586, 1528 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 8.25-8.22 (m, 2H), 7.48 (dd, *J* = 7.4, 0.7 Hz, 1H), 7.40 (ddd, *J* = 8.5, 7.8, 1.2 Hz, 1H), 7.33 (ddd, *J* = 8.5, 7.8, 1.7 Hz, 1H), 7.16 (ddd, *J* = 8.1, 7.6, 0.9 Hz, 1H), 7.11, (dd, *J* = 7.6, 1.7 Hz, 1H), 7.04 (ddd, *J* = 8.1, 7.4, 1.7 Hz, 1H), 6.88 (d, *J* = 7.8 Hz, 1H), 3.32 (dd, *J* = 18.4, 1.3 Hz, 1H), 3.19 (s, 3H), 2.57 (d, *J* = 18.4 Hz, 1H), 1.81 (d, *J* = 1.1 Hz 3H), 1.53 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 174.0, 163.1, 153.6, 150.5, 143.1, 137.8, 131.1, 130.3, 129.1, 126.8, 125.4, 124.5, 123.8, 122.6, 122.1, 119.4, 109.0, 79.6, 78.8, 36.8, 28.3, 26.3, 21.3 ; HRMS (ESI): cacld for $C_{25}H_{26}N_2O_5Na$ $[M+Na]^+$: 457.1739; found: 457.1733; HPLC analysis: *ee* = 95% on an OD-H column: hexane/*i*-PrOH = 70:30, flow rate = 1.0 mL/min, λ = 220 nm; t_{minor} = 11.10 min, t_{major} = 12.71 min.

tert-Butyl (*S*)-(2-(1-ethyl-4'-methyl-2,6'-dioxo-3',6'-dihydrospiro[indoline-3, 2'-pyran]-5'-yl)phenyl)carbamate (4c).

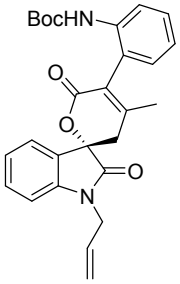


4c

White powder; Yield : 94%; $[\alpha]_D^{29}$: −19.1 (*c* = 1.05, CH_2Cl_2); mp: 68-69℃; IR (CH_2Cl_2): 3445, 3316, 1712, 1651, 1616, 1586, 1529 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 8.26 (bs, 1H), 8.22 (d, *J* = 8.3 Hz, 1H), 7.49 (dd, *J* = 7.6, 0.7 Hz, 1H), 7.39 (ddd, *J* = 8.5, 7.7, 1.2 Hz, 1H), 7.33 (ddd, *J* = 8.5, 7.7, 1.6 Hz, 1H), 7.15 (ddd, *J* = 8.5, 7.5, 0.8 Hz, 1H), 7.11, (dd, *J* = 7.6, 1.7 Hz, 1H), 7.04 (ddd, *J* = 8.2, 7.4, 1.0 Hz, 1H), 6.89 (d, *J* = 7.8 Hz, 1H), 3.72 (m, 2H), 3.31 (dd, *J* = 18.5, 1.3 Hz, 1H), 2.55 (d, *J* = 18.5 Hz, 1H), 1.81 (d, *J* = 0.8 Hz, 3H), 1.52 (s, 9H), 1.27 (t, *J* = 6.9 Hz, 3H); ^{13}C

NMR (100 MHz, $CDCl_3$): δ 173.7, 163.2, 153.6, 150.5, 142.1, 137.9, 131.1, 130.4, 129.1, 127.0, 125.4, 124.7, 123.6, 122.6, 122.1, 119.4, 109.1, 79.6, 78.8, 36.9, 35.0, 28.3, 21.3, 12.4 ; HRMS (ESI): cacld for $C_{26}H_{28}N_2O_5Na$ $[M+Na]^+$: 471.1896; found: 471.1895; HPLC analysis: *ee* = 94% on an AS-H column: hexane/*i*-PrOH = 85:15, flow rate = 1.0 mL/min, λ = 220 nm; t_{minor} = 21.90 min, t_{major} = 28.91 min.

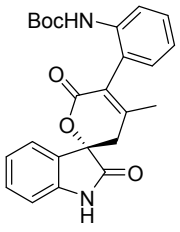
tert-Butyl (*S*)-(2-(1-allyl-4'-methyl-2,6'-dioxo-3',6'-dihydrospiro[indoline-3, 2'-pyran]-5'-yl)phenyl)carbamate (4d).



4d

White powder; Yield : 95%; $[\alpha]_D^{29}$: −28.6 (*c* = 1.05, CH_2Cl_2); mp: 65-66℃; IR (CH_2Cl_2): 3445, 3320, 1713, 1647, 1616, 1586, 1527 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 8.23-8.20 (m, 2H), 7.50 (d, *J* = 7.5 Hz, 1H), 7.39-7.30 (m, 2H), 7.15 (ddd, *J* = 8.4, 7.6, 0.8 Hz, 1H), 7.11, (dd, *J* = 7.7, 1.7 Hz, 1H), 7.04 (ddd, *J* = 8.2, 7.4, 1.0 Hz, 1H), 6.87 (d, *J* = 7.9 Hz, 1H), 5.86-5.78 (m, 1H), 5.28-5.24 (m, 2H), 4.31-4.29 (m, 2H), 3.33 (dd, *J* = 18.5, 1.1 Hz, 1H), 2.58 (d, *J* = 18.5 Hz, 1H), 1.82 (s, 3H), 1.51 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 173.8, 163.1, 153.6, 150.5, 142.2, 137.8, 131.1, 130.4, 129.1, 126.8, 125.4, 124.5, 123.8, 122.6, 122.1, 119.4, 118.4, 109.9, 79.6, 78.8, 42.5, 37.0, 28.3, 21.3; HRMS (ESI): cacld for $C_{27}H_{28}N_2O_5Na$ $[M+Na]^+$: 483.1896; found: 483.1887; HPLC analysis: *ee* = 95% on an OD-H column: hexane/*i*-PrOH = 70:30, flow rate = 1.0 mL/min, λ = 220 nm; t_{minor} = 7.40 min, t_{major} = 8.75 min.

tert-Butyl (*S*)-(2-(4'-methyl-2,6'-dioxo-3',6'-dihydrospiro[indoline-3,2' -pyran]-5'-yl)phenyl)carbamate (4e).

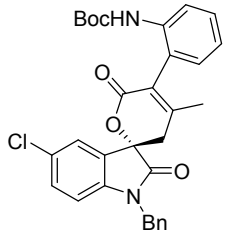


4e

Yellow powder; Yield : 90%; $[\alpha]_D^{29}$: −17.0 (*c* = 1.03, CH_2Cl_2); mp: 100-101℃; IR (CH_2Cl_2): 3445, 3323, 1720, 1624, 1586, 1526 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 8.92 (bs, 1H), 8.04 (bs, 2H), 7.44 (d, *J* = 7.4 Hz, 1H), 7.34 (ddd, *J* = 8.6, 7.7, 1.7 Hz, 1H), 7.28 (ddd, *J* = 8.4, 7.9, 1.0 Hz, 1H), 7.15 (dd, *J* = 7.7, 1.5 Hz, 1H), 7.12-7.06,

(m, 2H), 6.87 (d, *J* = 7.9 Hz, 1H), 3.29 (dd, *J* = 18.4, 1.0 Hz, 1H), 2.61 (d, *J* = 18.4 Hz, 1H), 1.81 (s, 3H), 1.46 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 176.3, 163.2, 153.8, 150.4, 140.3, 137.4, 131.2, 130.6, 129.1, 127.1, 125.2, 124.5, 123.7, 123.2, 122.7, 120.1, 111.3, 79.3, 36.9, 28.3, 21.3; HRMS (ESI): cacld for $C_{24}H_{24}N_2O_5Na$ $[M+Na]^+$: 443.1583; found: 443.1582; HPLC analysis: *ee* = 95% on an OD-H column: hexane/*i*-PrOH = 85:15, flow rate = 1.0 mL/min, λ = 220 nm; t_{minor} = 11.43 min, t_{major} = 13.75 min.

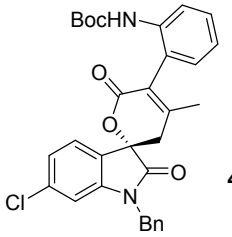
***tert*-Butyl (*S*)-(2-(1-benzyl-5-chloro-4'-methyl-2,6'-dioxo-3',6'-dihydrospiro[indoline-3,2'-pyran]-5'-yl)phenyl)carbamate (4f).**



4f

White powder; Yield : 92%; $[\alpha]_D^{29}$: −41.8 (*c* = 1.10, CH_2Cl_2); mp: 100-101℃; IR (CH_2Cl_2): 3449, 1716, 1648, 1617, 1586, 1526 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.23 (d, *J* = 8.2 Hz, 1H), 8.14 (bs, 1H), 7.50 (bs, 1H), 7.36-7.25 (m, 7H), 7.14 (d, *J* = 7.4, 1H), 7.07 (m, 1H), 6.68 (d, *J* = 8.3 Hz, 1H), 4.87 (dd, *J* = 23.5, 15.8 Hz, 2H), 3.34 (d, *J* = 18.8 Hz, 1H), 2.63 (d, *J* = 18.8 Hz, 1H), 1.86 (s, 3H), 1.46 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 173.4, 162.6, 153.5, 150.3, 140.6, 137.8, 134.3, 131.0, 130.4, 129.3, 129.2, 129.1, 128.3, 128.2, 127.2, 125.4, 125.2, 122.3, 122.2, 119.5, 111.1, 79.7, 78.6, 44.0, 36.8, 28.3, 21.4; HRMS (ESI): cacld for $C_{31}H_{29}N_2O_5Na^{35}Cl$ $[M+Na]^+$: 567.1663; found: 567.1656; HPLC analysis: *ee* = 90% on an OD-H column: hexane/*i*-PrOH = 80:20, flow rate = 0.8 mL/min, λ = 220 nm; t_{minor} = 18.90 min, t_{major} = 28.33 min.

***tert*-Butyl (*S*)-(2-(1-benzyl-6-chloro-4'-methyl-2,6'-dioxo-3',6'-dihydrospiro[indoline-3,2'-pyran]-5'-yl)phenyl)carbamate (4g).**

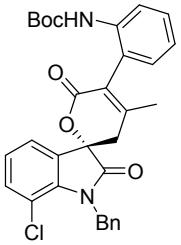


4g

White powder; Yield : 80%; $[\alpha]_D^{29}$: −23.3 (*c* = 0.86, CH_2Cl_2); mp: 85-86℃; IR (CH_2Cl_2): 3450, 1717, 1648, 1617, 1586, 1526 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.23 (d, *J* = 8.8 Hz, 1H), 8.12 (bs, 1H), 7.43 (d, *J* = 8.2 Hz, 1H), 7.38-7.26 (m, 6H), 7.14-7.10 (m, 2H), 7.06 (ddd, *J* = 8.2, 7.4, 1.0 Hz, 1H), 6.76 (d, *J* = 1.7 Hz, 1H), 4.86

(s, 2H), 3.34 (dd, *J* = 18.5, 1.5 Hz, 1H), 2.61 (d, *J* = 18.5 Hz, 1H), 1.85 (s, 3H), 1.46 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 174.2, 162.8, 153.5, 150.4, 143.4, 137.7, 137.0, 134.2, 130.4, 129.3, 129.2, 128.3, 127.2, 125.6, 125.4, 125.2, 123.9, 122.4, 122.2, 119.5, 110.7, 79.7, 78.4, 44.0, 36.9, 28.3, 21.4; HRMS (ESI): cacld for $C_{31}H_{29}N_2O_5Na^{35}Cl$ $[M+Na]^+$: 567.1663; found: 567.1658; HPLC analysis: *ee* = 98% on an OD-H column: hexane/*i*-PrOH = 80:20, flow rate = 0.8 mL/min, λ = 220 nm; t_{minor} = 17.39 min, t_{major} = 37.39 min.

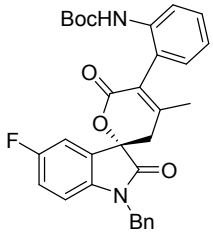
tert-Butyl (*S*)-(2-(1-benzyl-7-chloro-4'-methyl-2,6'-dioxo-3',6'-dihydrospiro[indoline-3,2'-pyran]-5'-yl)phenyl)carbamate (4h).



4h

White powder; Yield : 99%; $[\alpha]_D^{29}$: −8.62 (*c* = 1.16, CH_2Cl_2); mp: 78-79℃; IR (CH_2Cl_2): 3445, 3333, 1717, 1650, 1613, 1586, 1526 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.22 (d, *J* = 8.6 Hz, 1H), 8.13 (bs, 1H), 7.45 (dd, *J* = 7.4, 1.1 Hz, 1H), 7.36-7.20 (m, 7H), 7.14-7.03 (m, 3H), 5.33 (dd, *J* = 25.3, 16.3 Hz, 2H), 3.34 (dd, *J* = 18.4, 1.1 Hz, 1H), 2.61 (d, *J* = 18.4 Hz, 1H), 1.84 (s, 3H), 1.39 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 175.0, 162.8, 153.5, 150.2, 138.3, 137.8, 136.3, 133.6, 130.4, 129.7, 129.2, 128.8, 127.5, 126.2, 125.4, 124.9, 123.3, 122.3, 122.2, 119.5, 116.3, 79.6, 78.2, 45.0, 37.3, 28.3, 21.4; HRMS (ESI): cacld for $C_{31}H_{29}N_2O_5Na^{35}Cl$ $[M+Na]^+$: 567.1663; found: 567.1658; HPLC analysis: *ee* = 91% on an OD-H column: hexane/*i*-PrOH = 80:20, flow rate = 0.8 mL/min, λ = 220 nm; t_{minor} = 23.50 min, t_{major} = 36.90 min.

tert-Butyl (*S*)-(2-(1-benzyl-5-fluoro-4'-methyl-2,6'-dioxo-3',6'-dihydrospiro[indoline-3,2'-pyran]-5'-yl)phenyl)carbamate (4i).

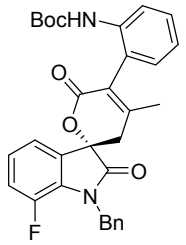


4i

White powder; Yield : 99%; $[\alpha]_D^{29}$: −18.2 (*c* = 1.10, CH_2Cl_2); mp: 101-102℃; IR (CH_2Cl_2): 3446, 1713, 1646, 1586, 1526 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.23 (d, *J* = 8.3 Hz, 1H), 8.19 (bs, 1H), 7.36-7.24 (m, 7H), 7.13 (dd, *J* = 7.6, 1.2 Hz, 1H), 7.06 (ddd, *J* = 7.6, 7.5, 1.2 Hz, 1H), 6.99 (dd, *J* = 9.5, 9.0, 2.6 Hz, 1H), 6.69 (dd, *J* = 8.7,

4.0 Hz, 1H), 4.87 (dd, *J* = 19.5, 15.8 Hz, 2H), 3.33 (dd, *J* = 18.5, 1.2 Hz, 1H), 2.64 (d, *J* = 18.5 Hz, 1H), 1.85 (s, 3H), 1.46 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 174.1, 162.7, 159.6 (d, *J* = 244 Hz), 153.6, 150.4, 138.0 (d, *J* = 2.2 Hz), 137.8, 134.4, 130.4, 129.2, 129.1, 128.3, 128.2, 128.1, 127.2, 125.4, 122.4, 122.2, 119.5, 117.5 (d, *J* = 23.7 Hz), 112.8 (d, *J* = 25.5 Hz), 110.9 (d, *J* = 7.8 Hz), 80.0, 78.8, 44.0, 36.9, 28.3, 21.4; HRMS (ESI): cacld for $C_{31}H_{29}N_2O_5NaF$ $[M+Na]^+$: 551.1958; found: 551.1954; HPLC analysis: *ee* = 99% on an OD-H column: hexane/*i*-PrOH = 80:20, flow rate = 0.8 mL/min, λ = 220 nm; t_{minor} = 17.71 min, t_{major} = 23.40 min.

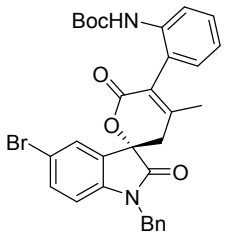
***tert*-Butyl (*S*)-(2-(1-benzyl-7-fluoro-4'-methyl-2,6'-dioxo-3',6'-dihydro-spiro[indoline-3,2'-pyran]-5'-yl)phenyl)carbamate (4j).**



4j

Yellow powder; Yield : 91%; $[\alpha]_D^{29}$: −20.8 (*c* = 0.96, CH_2Cl_2); mp: 80-81℃; IR (CH_2Cl_2): 3450, 1717, 1634, 1587, 1525 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.24 (d, *J* = 8.3 Hz, 1H), 8.14 (bs, 1H), 7.37-7.27 (m, 7H), 7.14-7.04 (m, 4H), 5.03 (dd, *J* = 26.4, 15.6 Hz, 2H), 3.33 (dd, *J* = 18.4, 1.3 Hz, 1H), 2.61 (d, *J* = 18.4 Hz, 1H), 1.84 (d, *J* = 0.8 Hz, 3H), 1.47 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 174.1, 162.7, 153.6, 150.2, 147.4 (d, *J* = 246.0 Hz), 137.7, 135.9, 130.4, 129.6 (d, *J* = 3.0 Hz), 129.2, 128.8 (d, *J* = 9.3 Hz), 128.8, 128.0, 127.4 (d, *J* = 1.5 Hz), 125.4, 124.8 (d, *J* = 6.4 Hz), 122.4, 122.2, 120.5 (d, *J* = 3.5 Hz), 119.5, 119.3 (d, *J* = 19.4 Hz), 80.0, 78.7, 45.5 (d, *J* = 4.5 Hz), 37.1, 28.3, 21.4; HRMS (ESI): cacld for $C_{31}H_{29}N_2O_5NaF$ $[M+Na]^+$: 551.1958; found: 551.1949; HPLC analysis: *ee* = 94% on an OD-H column: hexane/*i*-PrOH = 80:20, flow rate = 0.8 mL/min, λ = 220 nm; t_{minor} = 14.96 min, t_{major} = 17.78 min.

***tert*-Butyl (*S*)-(2-(1-benzyl-5-bromo-4'-methyl-2,6'-dioxo-3',6'-dihydro-spiro[indoline-3,2'-pyran]-5'-yl)phenyl)carbamate (4k).**

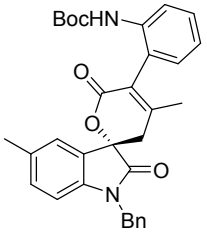


4k

White powder; Yield : 87%; $[\alpha]_D^{29}$: −49.0 (*c* = 1.02, CH_2Cl_2); mp: 145-146℃; IR (CH_2Cl_2): 3445, 1716, 1646, 1614, 1586, 1525 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): δ

8.23 (d, *J* = 8.2 Hz, 1H), 8.12 (bs, 1H), 7.64, (d, *J* = 1.8 Hz, 1H), 7.41 (dd, *J* = 8.4, 1.9 Hz, 1H), 7.36-7.26 (m, 6H), 7.14-7.05 (m, 2H), 6.64 (d, *J* = 8.4 Hz, 1H), 4.86 (dd, *J* = 24.6, 15.7 Hz, 2H), 3.35 (d, *J* = 18.4 Hz, 1H), 2.63 (d, *J* = 18.4 Hz, 1H), 1.86 (s, 3H), 1.46 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 173.8, 162.6, 153.5, 150.3, 141.1, 137.7, 134.3, 133.9, 130.4, 129.2, 129.1, 128.6, 128.2, 128.0, 127.2, 125.4, 122.3, 122.3, 119.5, 116.5, 111.6, 79.7, 78.6, 44.0, 36.9, 28.3, 21.4; HRMS (ESI): cacld for $C_{31}H_{29}N_2O_5Na^{79}Br$ $[M+Na]^+$: 611.1158; found: 611.1160; HPLC analysis: *ee* = 98% on an OD-H column: hexane/*i*-PrOH = 80:20, flow rate = 0.8 mL/min, λ = 220 nm; t_{minor} = 21.65 min, t_{major} = 33.83 min.

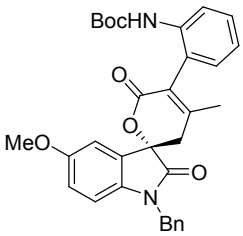
***tert*-Butyl (*S*)-(2-(1-benzyl-4',5-dimethyl-2,6'-dioxo-3',6'-dihydrospiro[indoline-3,2'-pyran]-5'-yl)phenyl)carbamate (4l).**



4l

White powder; Yield : 95%; $[\alpha]_D^{29}$: −26.8 (*c* = 1.12, CH_2Cl_2); mp: 88-89℃; IR (CH_2Cl_2): 3441, 3320, 1712, 1627, 1606, 1586, 1526 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.25-8.23 (m, 2H), 7.36-7.27 (m, 7H), 7.14 (dd, *J* = 7.6, 1.6 Hz, 1H), 7.09-7.04 (m, 2H), 6.65 (d, *J* = 8.0 Hz, 1H) ,4.86 (s, 2H), 3.36 (dd, *J* = 18.5, 1.2 Hz, 1H), 2.61 (d, *J* = 18.5 Hz, 1H), 2.32 (s, 3H), 1.85 (s, 3H), 1.47 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 174.2, 163.1, 153.6, 150.5, 139.7, 137.9, 134.9, 133.6, 131.3, 130.4, 129.1, 129.0, 127.9, 127.2, 126.8, 125.4, 125.3, 122.6, 122.2, 119.5, 109.8, 79.6, 79.0, 43.9, 37.1, 28.3, 21.3, 21.0; HRMS (ESI): cacld for $C_{32}H_{32}N_2O_5Na$ $[M+Na]^+$: 547.2209; found: 547.2205; HPLC analysis: *ee* = 97% on an AS-H column: hexane/*i*-PrOH = 70:30, flow rate = 0.8 mL/min, λ = 220 nm; t_{minor} = 16.84 min, t_{major} = 28.02 min.

***tert*-Butyl (*S*)-(2-(1-benzyl-5-methoxy-4'-methyl-2,6'-dioxo-3',6'-dihydro-spiro[indoline-3,2'-pyran]-5'-yl)phenyl)carbamate (4m).**

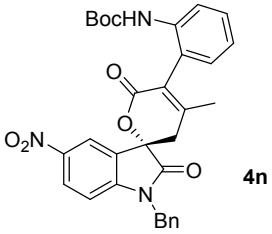


4m

Yellow solid; Yield : 85%; $[\alpha]_D^{29}$: −10.0 (*c* = 1.00, CH_2Cl_2); mp: 59-60℃; IR (CH_2Cl_2): 3445, 1708, 1636, 1587, 1527 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.26-

8.22 (m, 2H), 7.35-7.26 (m, 6H), 7.15-7.03 (m, 3H), 6.80 (dd, *J* = 8.5, 2.5 Hz, 1H), 6.65 (d, *J* = 8.5 Hz, 1H), 4.85 (s, 2H), 3.77 (s, 3H), 3.35 (d, *J* = 18.3 Hz, 1H), 2.63 (d, *J* = 18.3 Hz, 1H), 1.85 (s, 3H), 1.46 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 174.0, 163.1, 156.8, 153.6, 150.4, 137.9, 135.2, 134.9, 130.4, 129.1, 129.0, 128.0, 127.9, 127.2, 125.4, 125.3, 122.6, 122.2, 119.5, 115.7, 111.5, 110.7, 79.6, 79.2, 55.9, 44.0, 37.2, 28.3, 21.3; HRMS (ESI): cacld for $C_{32}H_{32}N_2O_6Na$ $[M+Na]^+$: 563.2158; found: 563.2162; HPLC analysis: *ee* = 94% on an OD-H column: hexane/*i*-PrOH = 70:30, flow rate = 1.0 mL/min, λ = 220 nm; t_{minor} = 8.66 min, t_{major} = 11.97 min.

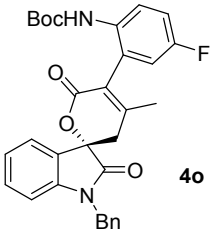
***tert*-Butyl (*S*)-(2-(1-benzyl-4'-methyl-5-nitro-2,6'-dioxo-3',6'-dihydrospiro-[indoline-3,2'-pyran]-5'-yl)phenyl)carbamate (4n).**



4n

Yellow solid; Yield : 62%; $[\alpha]_D^{29}$: −43.7 (*c* = 0.69, CH_2Cl_2); mp: 123-124℃; IR (CH_2Cl_2): 3445, 1721, 1622, 1586, 1524 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.42 (d, *J* = 2.2 Hz, 1H), 8.25-8.20 (m, 2H), 7.95 (bs, 1H), 7.38-7.26 (m, 6H), 7.16-7.06 (m, 2H), 6.87 (d, *J* = 8.7 Hz, 1H), 4.93 (dd, *J* = 28.4, 15.7 Hz, 1H), 3.44 (d, *J* = 18.5 Hz, 1H), 2.67 (d, *J* = 18.5 Hz, 1H), 1.87 (s, 3H), 1.46 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 174.5, 162.1, 153.4, 150.5, 147.6, 144.2, 137.6, 133.6, 130.4, 129.4, 129.3, 128.6, 128.0, 127.9, 127.3, 125.4, 122.4, 122.1, 120.7, 119.5, 110.0, 79.8, 78.1, 44.4, 36.5, 28.3, 21.4; HRMS (ESI): cacld for $C_{31}H_{29}N_3O_7Na$ $[M+Na]^+$: 578.1903; found: 578.1910; HPLC analysis: *ee* = 98% on an AD-H column: hexane/*i*-PrOH = 85:15, flow rate = 1.0 mL/min, λ = 220 nm; t_{major} = 36.34 min, t_{minor} = 42.87 min.

***tert*-Butyl (*S*)-(2-(1-benzyl-4'-methyl-2,6'-dioxo-3',6'-dihydrospiro[indoline-3,2'-pyran]-5'-yl)-4-fluorophenyl)carbamate (4o).**

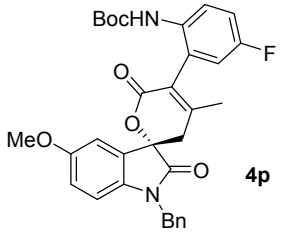


4o

Yellow powder; Yield : 98%; $[\alpha]_D^{29}$: −35.7 (*c* = 1.12, CH_2Cl_2); mp: 161-162℃; IR (CH_2Cl_2): 3450, 1711, 1618, 1528 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.21-8.18 (m, 2H), 7.50 (d, *J* = 7.5 Hz, 1H), 7.35-7.26 (m, 6H), 7.14 (t, *J* = 7.6, 1H), 7.04 (ddd, *J* = 9.0, 8.5, 3.0 Hz, 1H), 6.88 (dd, *J* = 9.0, 3.0 Hz, 1H), 6.77 (d, *J* = 7.7 Hz, 1H), 4.88 (s, 2H), 3.38 (dd, *J* = 18.5, 1.0 Hz, 1H), 2.63 (d, *J* = 18.5 Hz, 1H), 1.86 (s, 3H), 1.45 (s,

9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 174.2, 162.8, 157.7 (d, *J* = 242 Hz), 153.7, 151.2, 142.1, 134.7, 134.0 (d, *J* = 2.9 Hz), 131.2, 129.0, 128.1, 127.2, 126.6, 124.6, 124.5 (d, *J* = 1.4 Hz), 124.0, 117.0 (d, *J* = 22.6 Hz), 115.7 (d, *J* = 21.7 Hz), 110.1, 79.8, 78.9, 43.9, 37.0, 28.3, 21.3; HRMS (ESI): cacld for $C_{31}H_{29}N_2O_5NaF$ $[M+Na]^+$: 551.1958; found: 551.1954; HPLC analysis: *ee* = 98% on an OD-H column: hexane/*i*-PrOH = 85:15, flow rate = 0.6 mL/min, λ = 220 nm; t_{minor} = 31.07 min, t_{major} = 35.90 min.

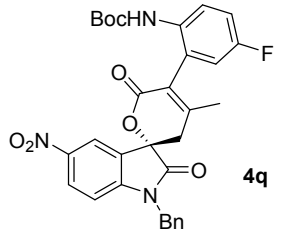
***tert*-Butyl (*S*)-(2-(1-benzyl-5-methoxy-4'-methyl-2,6'-dioxo-3',6'-dihydrospiro[indoline-3,2'-pyran]-5'-yl)-4-fluorophenyl)carbamate (4p).**



4p

Orangr powder; Yield : 96%; $[\alpha]_D^{29}$: −50.4 (*c* = 1.07, CH_2Cl_2); mp: 65-66℃; IR (CH_2Cl_2): 3310, 1709, 1655, 1607, 1528 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.24 (bs, 1H), 8.11 (bs, 1H), 7.34-7.26 (m, 5H), 7.10 (d, *J* = 2.5 Hz, 1H), 7.03 (ddd, *J* = 9.7, 8.8, 3.0 Hz, 1H), 6.87 (dd, *J* = 8.6, 3.0 Hz, 1H), 6.80 (dd, *J* = 8.6, 2.6 Hz, 1H), 6.65 (d, *J* = 8.6Hz, 1H), 4.84 (s, 2H), 3.76 (s, 3H), 3.35 (dd, *J* = 18.6, 1.2 Hz, 1H), 2.62 (d, *J* = 18.6 Hz, 1H), 1.82 (s, 3H), 1.44 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 173.9, 162.7, 157.7 (d, *J* = 242 Hz), 156.8, 153.7, 151.0, 135.2, 134.8, 134.1 (d, *J* = 2.4 Hz), 129.0, 128.0, 127.7, 127.2, 124.5 (d, *J* = 1.4 Hz), 117.0 (d, *J* = 22.6 Hz), 115.8, 115.7 (d, *J* = 21.7 Hz), 111.5, 110.7, 79.7, 79.2, 55.9, 44.0, 37.1, 28.3, 21.3; HRMS (ESI): cacld for $C_{32}H_{31}N_2O_6NaF$ $[M+Na]^+$: 581.2064; found: 581.2060; HPLC analysis: *ee* = 97% on an OD-H column: hexane/*i*-PrOH = 70:30, flow rate = 1.0 mL/min, λ = 220 nm; t_{minor} = 7.86 min, t_{major} = 10.44 min.

***tert*-Butyl (*S*)-(2-(1-benzyl-4'-methyl-5-nitro-2,6'-dioxo-3',6'-dihydrospiro-[indoline-3,2'-pyran]-5'-yl)-4-fluorophenyl)carbamate (4q).**

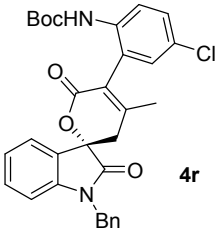


4q

Yellow powder; Yield : 84%; $[\alpha]_D^{29}$: −53.8 (*c* = 0.97, CH_2Cl_2); mp: 117-118℃; IR (CH_2Cl_2): 3334, 1721, 1655, 1622, 1526 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.41 (d, *J* = 2.2 Hz, 1H), 8.24 (dd, *J* = 8.7, 2.2 Hz, 1H), 8.16 (bs, 1H), 7.94 (bs, 1H), 7.38-7.26

(m, 4H), 7.05 (dd, *J* = 9.3, 8.7, 3.1 Hz, 1H), 7.03 (ddd, *J* = 9.7, 8.8, 3.0 Hz, 1H), 6.90-6.86 (m, 2H), 4.93 (dd, *J* = 25.4, 15.8 Hz, 2H), 3.46 (dd, *J* = 18.6, 1.1 Hz, 1H), 2.66 (d, *J* = 18.6 Hz, 1H), 1.88 (s, 3H), 1.45 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 174.4, 161.8, 157.8 (d, *J* = 244 Hz), 153.5, 151.1, 147.6, 144.2, 133.8 (d, *J* = 2.3 Hz), 133.6, 129.3, 128.6, 128.0, 127.5, 127.2, 120.8, 117.0 (d, *J* = 22.7 Hz), 116.0 (d, *J* = 21.9 Hz), 110.1, 79.9, 78.1, 44.4, 36.4, 28.3, 21.4; HRMS (ESI): cacld for $C_{31}H_{28}N_3O_7NaF$ $[M+Na]^+$: 596.1809; found: 596.1804; HPLC analysis: *ee* = 98% on an AD-H column: hexane/*i*-PrOH = 70:30, flow rate = 1.0 mL/min, λ = 220 nm; t_{major} = 10.50 min, t_{minor} = 14.06 min.

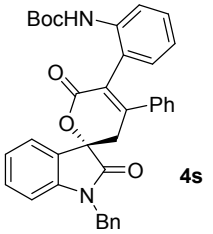
***tert*-Butyl (*S*)-(2-(1-benzyl-4'-methyl-2,6'-dioxo-3',6'-dihydrospiro[indoline-3,2'-pyran]-5'-yl)-4-chlorophenyl)carbamate (4r).**



4r

Yellow powder; Yield : 96%; $[\alpha]_D^{29}$: −17.5 (*c* = 1.15, CH_2Cl_2); mp: 86-87℃; IR (CH_2Cl_2): 3438, 3313, 1713, 1649, 1617, 1577, 1521 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.38 (bs, 1H), 8.36 (bs, 1H), 7.49 (d, *J* = 7.6 Hz, 1H), 7.35-7.26 (m, 6H), 7.14 (t, *J* = 7.6, 1H), 7.06-7.01 (m, 2H), 6.77 (d, *J* = 7.9 Hz, 1H), 4.88 (s, 2H), 3.39 (dd, *J* = 18.7, 1.0 Hz, 1H), 2.61 (d, *J* = 18.7 Hz, 1H), 1.85 (s, 3H), 1.46 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 174.3, 163.0, 153.3, 151.2, 142.1, 139.1, 135.0, 134.7, 131.4, 131.2, 129.0, 128.1, 127.2, 126.6, 124.6, 124.0, 122.2, 120.1, 119.1, 110.1, 80.1, 78.9, 43.9, 37.0, 28.3, 21.4; HRMS (ESI): cacld for $C_{31}H_{29}N_2O_5Na^{35}Cl$ $[M+Na]^+$: 567.1663; found: 567.1664; HPLC analysis: *ee* = 87% on an OD-H column: hexane/*i*-PrOH = 70:30, flow rate = 1.0 mL/min, λ = 220 nm; t_{minor} = 8.19 min, t_{major} = 9.68 min.

***tert*-Butyl (*S*)-(2-(1-benzyl-2,6'-dioxo-4'-phenyl-3',6'-dihydrospiro[indoline-3,2'-pyran]-5'-yl)phenyl)carbamate (4s).**

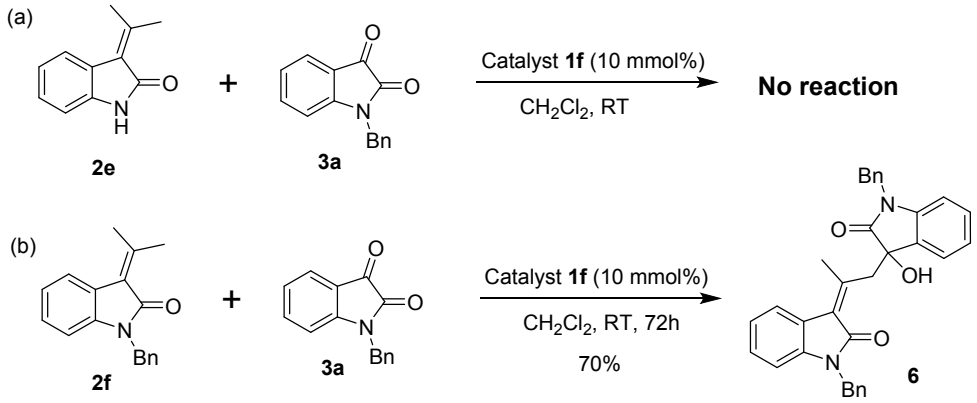


4s

Yellow powder; Yield : 98%; $[\alpha]_D^{27}$: +45.8 (*c* = 1.18, CH_2Cl_2); mp: 78-79℃; IR (CH_2Cl_2): 3445, 3326, 1713, 1616, 1586, 1530 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): δ

8.32 (bs, 1H), 8.04 (d, J = 8.0 Hz, 1H), 7.57 (dd, J = 7.4, 0.5 Hz, 1H), 7.36-7.07 (m, 15H), 6.94 (ddd, J = 7.9, 7.6, 1.0 Hz, 1H), 6.79 (d, J = 7.8 Hz, 1H), 4.93 (s, 2H), 3.74 (d, J = 18.5 Hz, 1H), 3.04 (d, J = 18.5 Hz, 1H), 1.45 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 174.2, 163.9, 153.3, 149.7, 142.1, 137.8, 137.3, 134.7, 131.2, 131.1, 129.2, 129.0, 128.3, 128.0, 127.5, 127.2, 126.8, 125.7, 124.6, 124.0, 122.1, 110.1, 79.5, 79.1, 43.9, 37.3, 28.4; HRMS (ESI): cacld for $C_{36}H_{32}N_2O_5Na[M+Na]^+$: 595.2209; found: 595.2211; HPLC analysis: *ee* = 87% on an OD-H column: hexane/*i*-PrOH = 70:30, flow rate = 1.0 mL/min, λ = 220 nm; t_{major} = 8.55 min, t_{minor} = 10.22 min.

5. The Reaction of Unprotected and *N*-Benzyl Protected 3-Alkylidene Oxindoles with isatin 3a

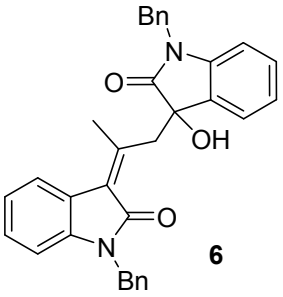


Schem S1.

We had examined the reactivity of unprotected and *N*-benzyl protected 3-alkylidene oxindoles **2e** and **2f** with isatin **3a**. As shown in scheme S1, the unprotected oxindole delivered no product in our optimal conditions. This is probably due to slightly solubility of oxindole **2e** in CH_2Cl_2. The *N*-benzyl protected oxindole **2f**, in contrast, gave the vinylogous aldol adduct **6** in 70% yield after 72h in our optimal conditions. We didn't prove the absolute configuration of **6**, but it is probably the addition may be still through the *Si* face by the catalyst **1f.** From these results, we presumed the occurrence of intramolecular lactonization was probably due to an increasing reactivity of the oxindole ring by placing the Boc protecting group on nitrogen atom.

6. Characterization Data of 6

(*Z*)-1-benzyl-3-(2-(1-benzyl-2-oxoindolin-3-ylidene)propyl)-3-hydroxyindolin-2-one



6

Yellow oil; Yield : 70%; IR (CH_2Cl_2): 3395, 1715, 1697, 1606 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 7.60 (d, *J* = 7.6 Hz, 1H), 7.42 (d, *J* = 7.4 Hz, 1H), 7.38-7.25 (m, 10H), 7.22-7.18 (m, 2H), 7.07 (t, *J* = 7.6 Hz, 1H), 7.02 (t, *J* = 7.4 Hz, 1H), 6.80 (d, *J* = 7.6, 1H), 6.75 (d, *J* = 7.9 Hz, 1H), 6.07 (bs, 1H), 5.04 (d, *J* = 15.8 Hz, 1H), 5.00 (d, *J* = 5.3 Hz, 2H), 4.81 (d, *J* = 15.8 Hz, 1H), 3.79 (d, *J* = 13.0 Hz, 1H), 3.55 (d, *J* = 13.0 Hz, 1H), 2.39 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 177.7, 169.4, 152.4, 142.0, 141.3, 135.9, 135.8, 131.0, 129.5, 128.9, 128.8, 128.3, 127.7, 127.6, 127.4, 127.2, 124.5, 124.2, 123.6, 122.8, 122.5, 109.4, 109.1, 78.2, 44.8, 43.9, 43.6, 27.0; HRMS (ESI): cacld for $C_{33}H_{28}N_2O_3Na[M+Na]^+$: 523.1998; found: 523.1992;

7. References

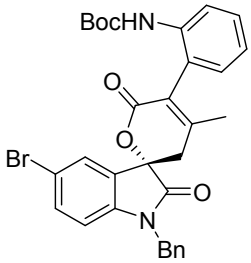
1. a) B. Vakulya, S. Varga, A. Csámpai, T. Soós, *Org. Lett.* **2005**, *7*, 1967-1969; b) K. Asano, S. Matsubara, *J. Am. Chem. Soc.* **2011**, *133*, 16711–16713.
2. W. Yang, D.-M. Du, *Org. Lett.* **2010**, *12*, 5450-5453.
3. a) B. M. Trost, N. Cramer, S. M. Silverman, *J. Am. Chem. Soc.* **2007**, *129*, 12396-12397; b) G. Rassu, V. Zambrano, R. Tanca, A. Sartori, L. Battistini, F. Zanardi, C. Curti, G. Casiraghi, *Eur. J. Org. Chem.* **2012**, 466-470.

8. Absolute Configuration and X-Ray Analysis Data

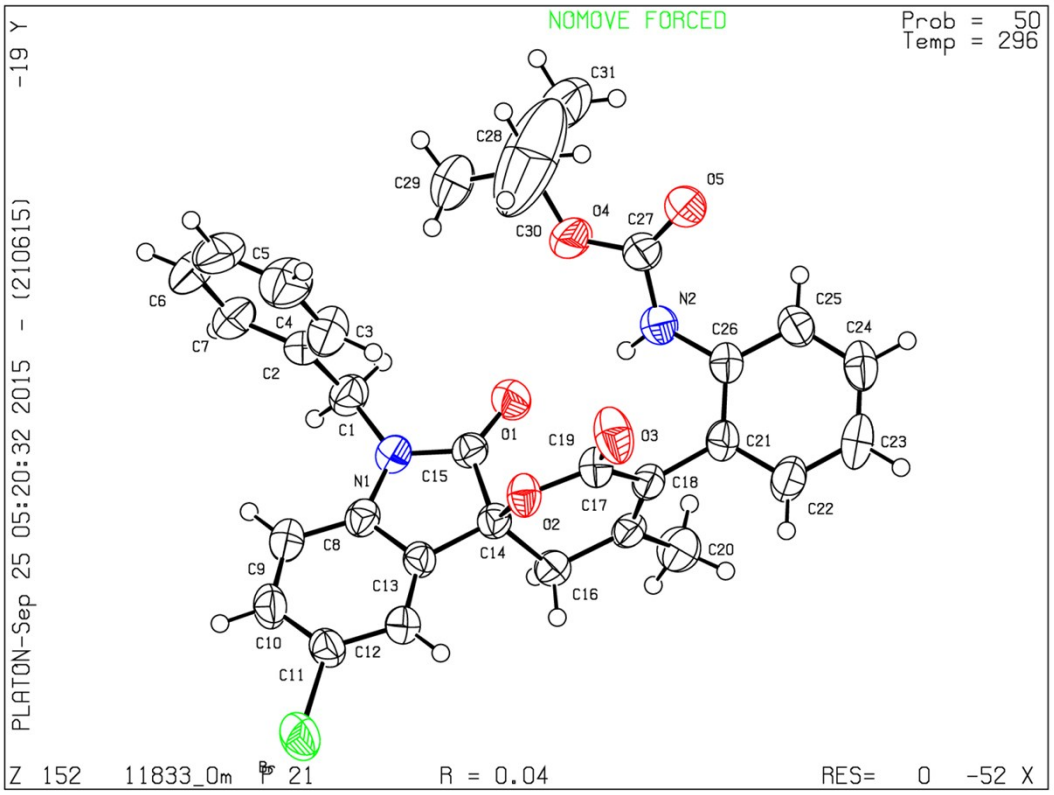
Table 1. Crystal data and structure refinement for **4K**

Identification code	11833_0m	
Empirical formula	C31 H29 Br N2 O5	
Formula weight	589.47	
Temperature	296(2) K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	$P2_1$	
Unit cell dimensions	a = 10.6073(4) Å	a= 90°.
	b = 9.8229(4) Å	b= 107.283(2)°.
	c = 14.4413(6) Å	g = 90°.
Volume	1436.76(10) $Å^3$	
Z	2	
Density (calculated)	1.363 Mg/m^3	
Absorption coefficient	1.472 mm^{-1}	
F(000)	608	
Crystal size	0.400 x 0.200 x 0.100 mm^3	
Theta range for data collection	2.011 to 28.345°.	
Index ranges	-14<=h<=14, -13<=k<=13, -18<=l<=19	
Reflections collected	26335	
Independent reflections	7077 [R(int) = 0.0320]	
Completeness to theta = 25.242°	99.9 %	
Absorption correction	None	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	7077 / 1 / 353	
Goodness-of-fit on F^2	1.049	
Final R indices [I>2sigma(I)]	R1 = 0.0358, wR2 = 0.0903	
R indices (all data)	R1 = 0.0490, wR2 = 0.0956	
Absolute structure parameter	0.015(9)	
Extinction coefficient	n/a	
Largest diff. peak and hole	0.436 and -0.365 $e.Å^{-3}$	

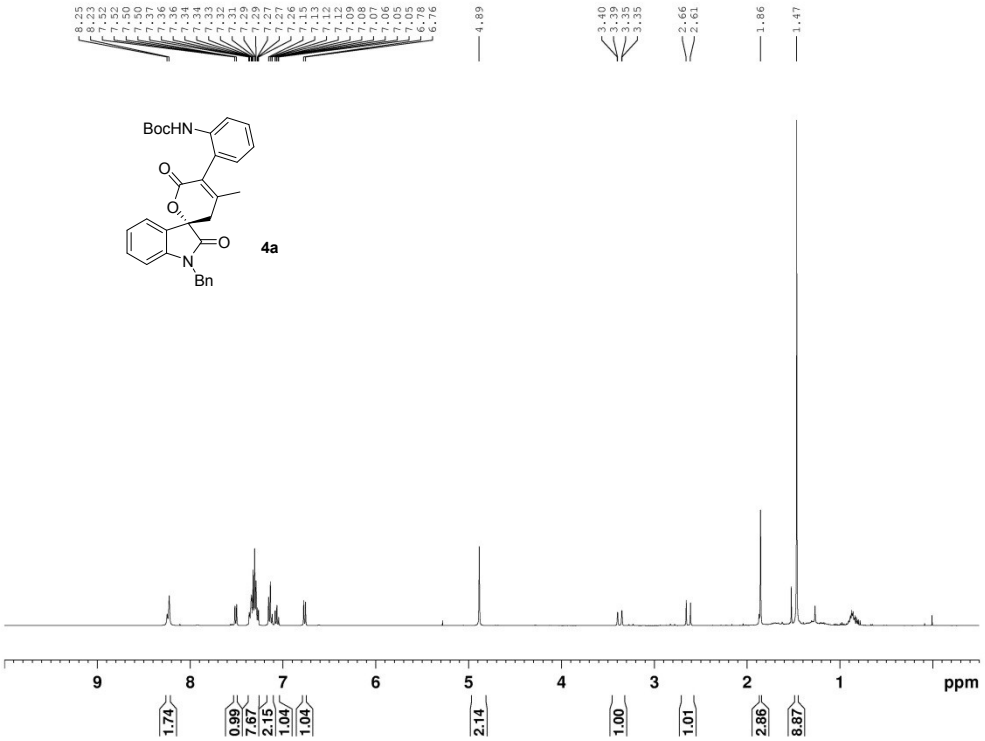
CCDC 1429592 (**4K**)

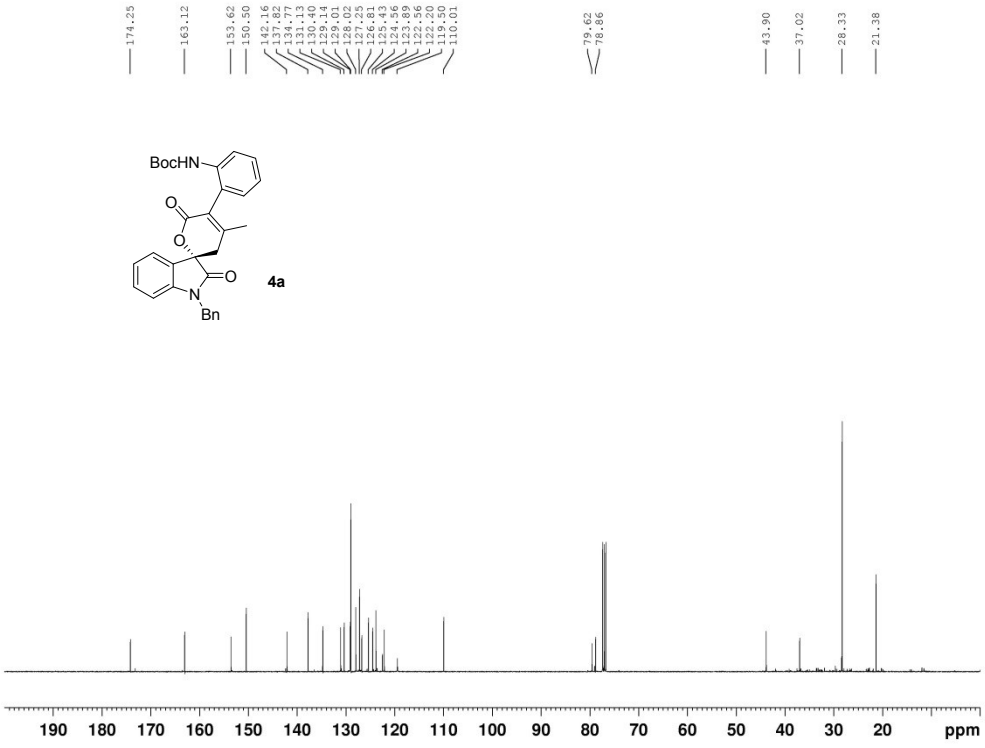


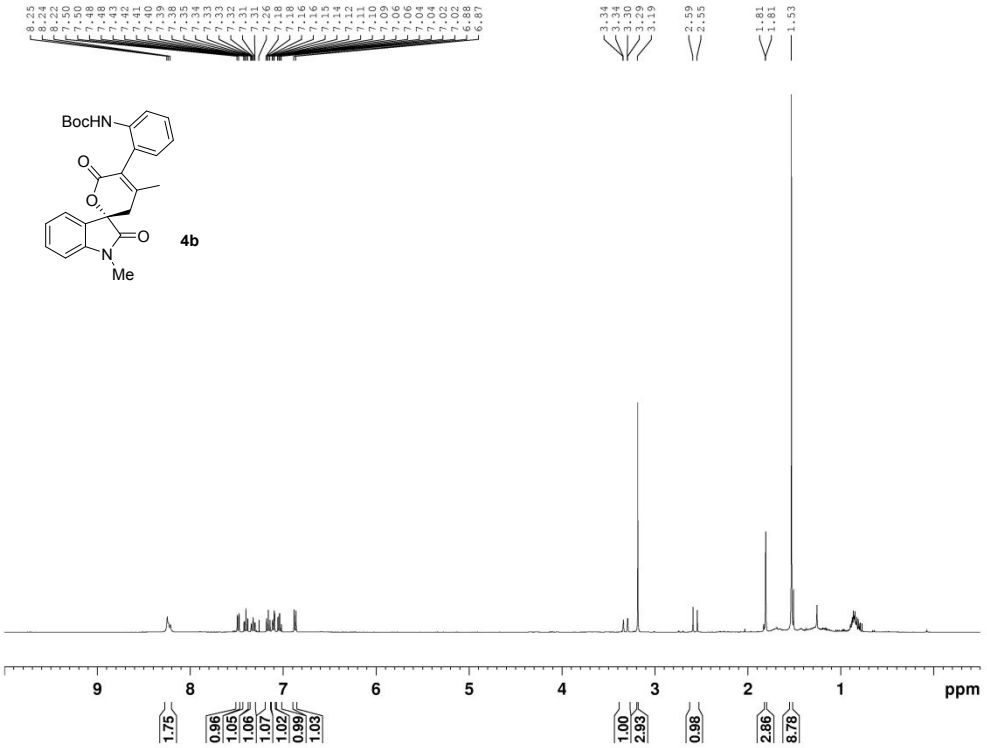
Datablock 11833_0m - ellipsoid plot

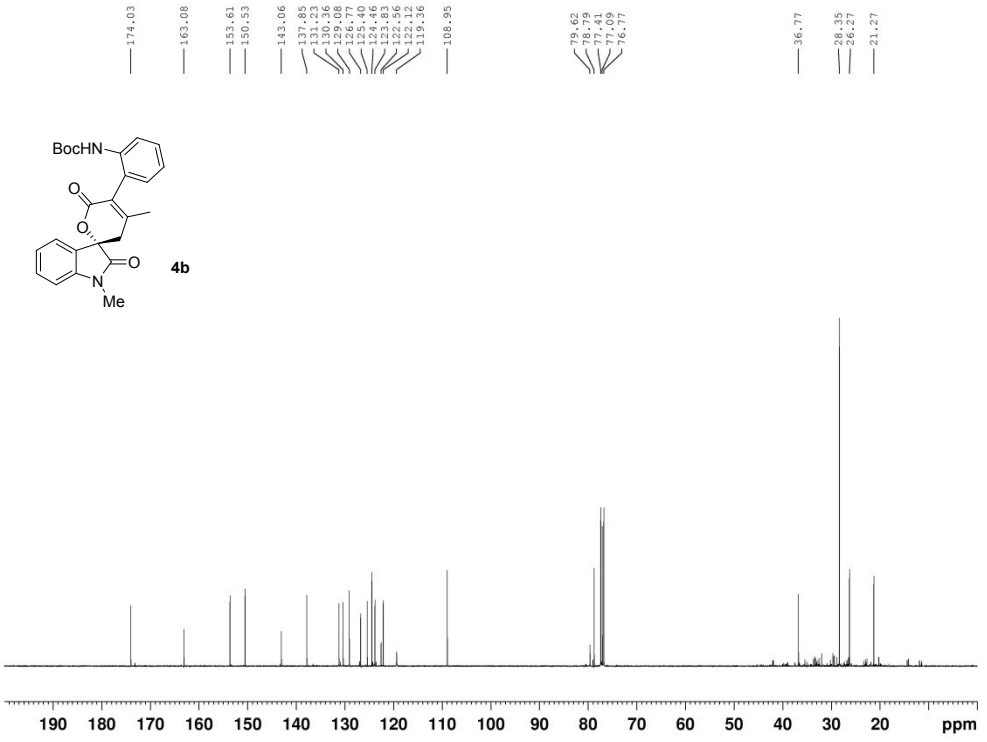


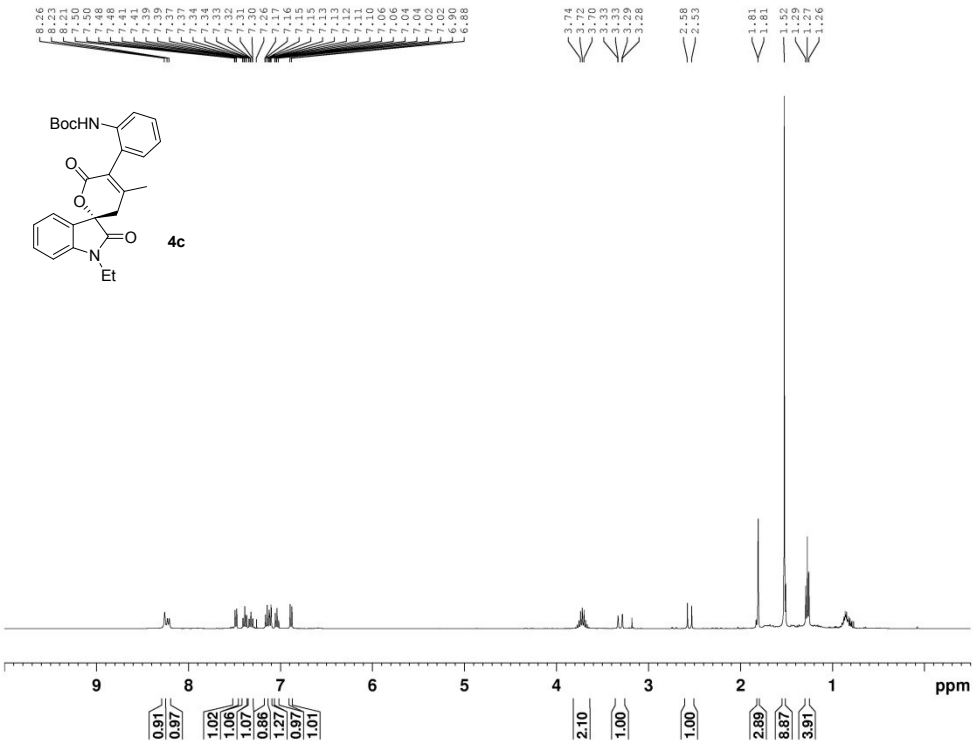
9. Copies of NMR Spectra of Products

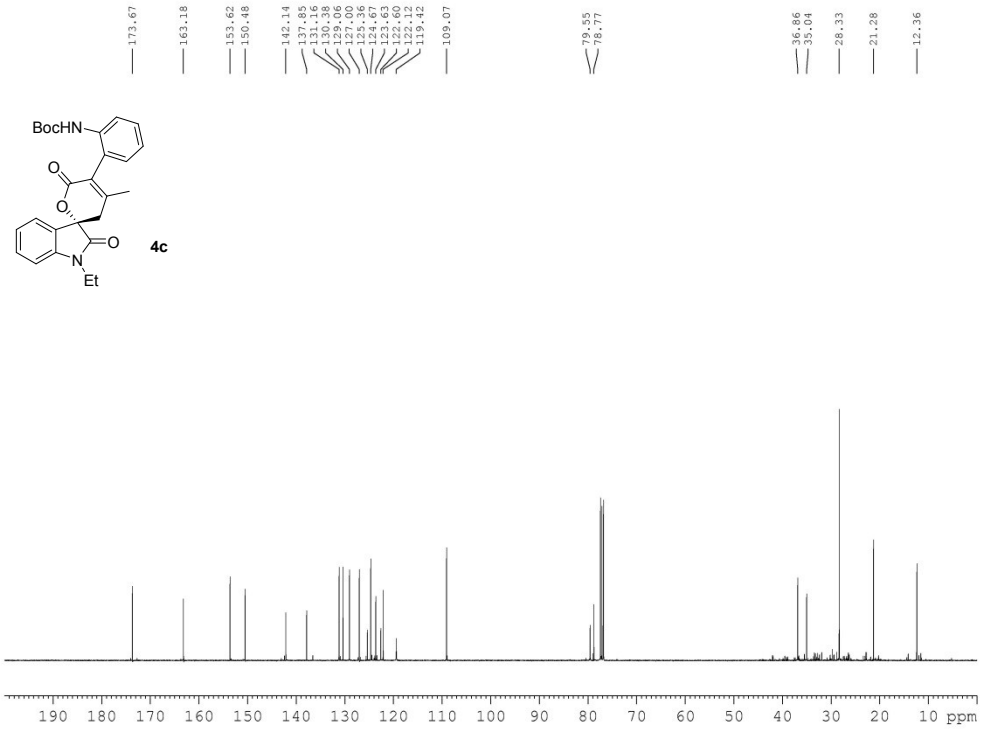


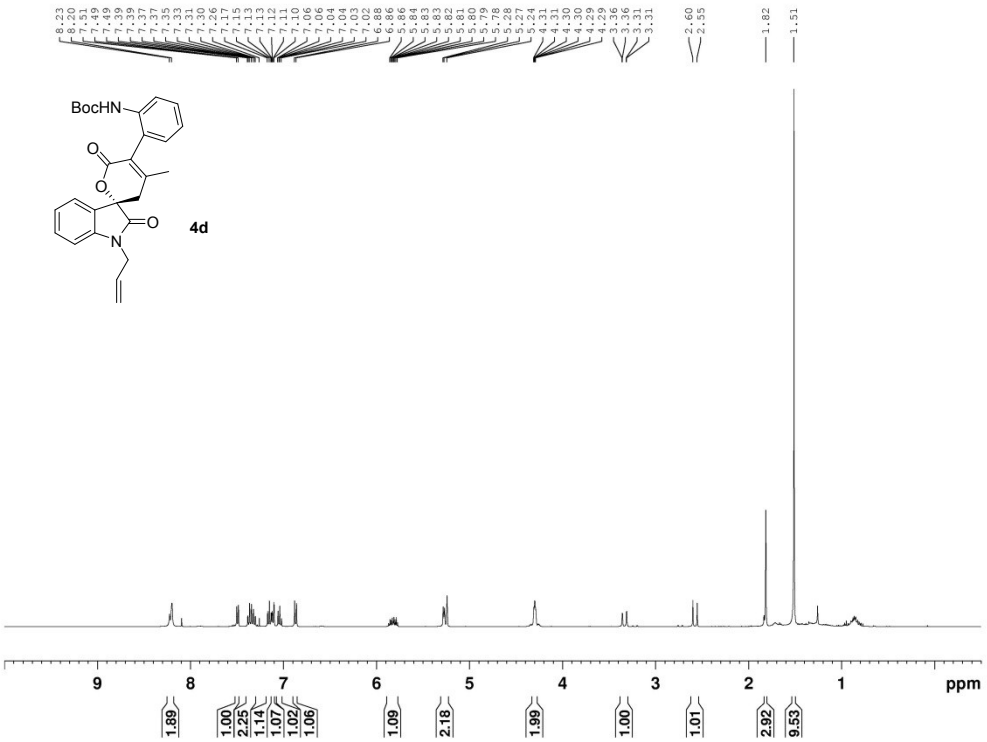


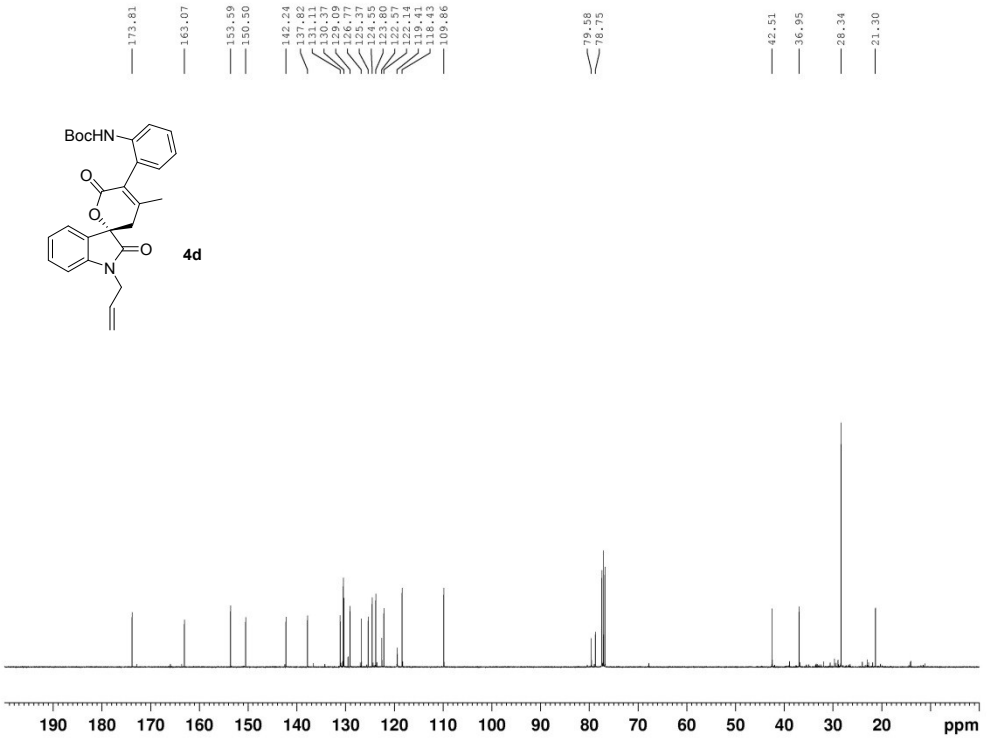

BocHN
O
O
O
N
Me
4b
9
8
7
6
5
4
3
2
1
ppm
1.75
0.96
1.05
1.06
1.07
1.02
0.99
1.03
1.00
2.93
0.98
2.86
8.78

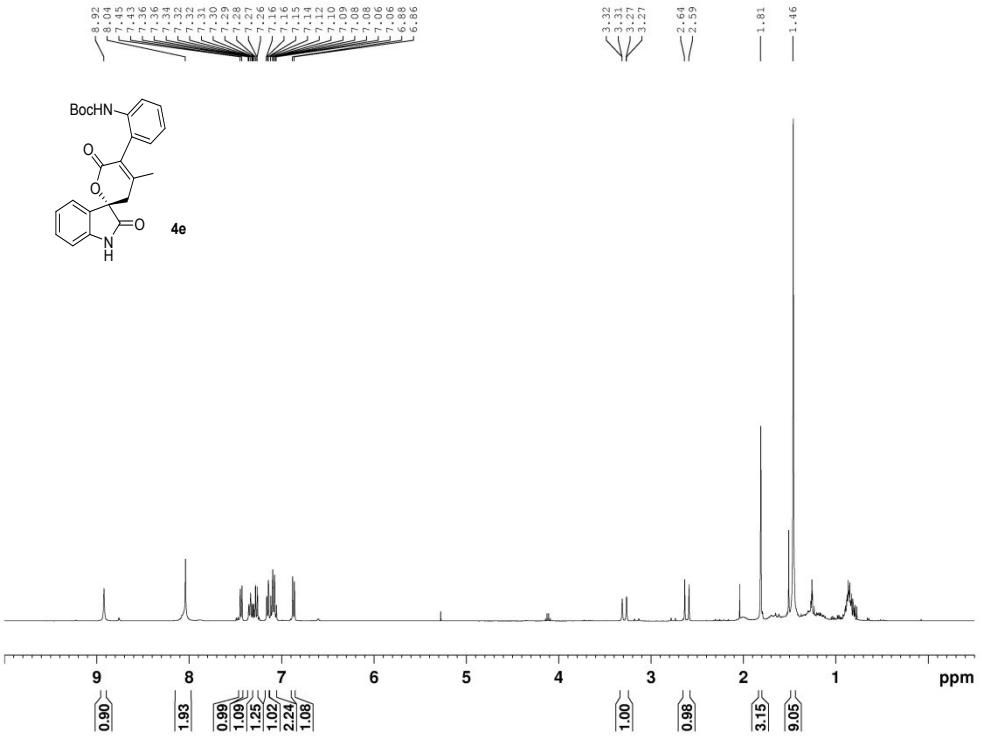

BocHN
O
O
O
N
Me
4b
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

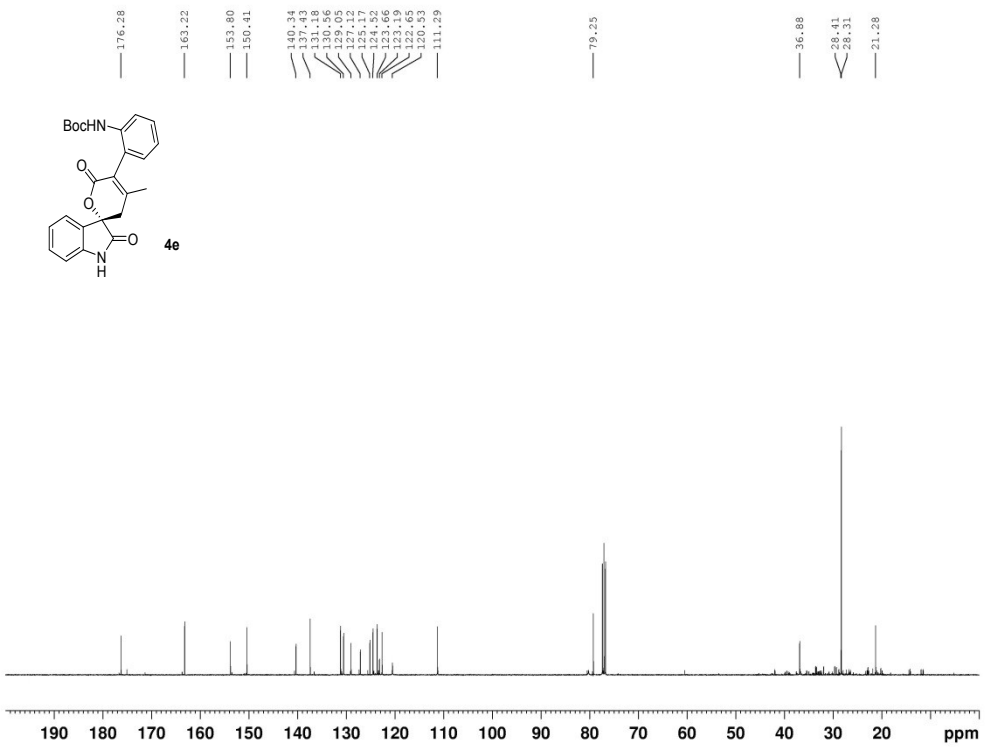

8.26
8.23
8.21
7.50
7.50
7.48
7.48
7.41
7.41
7.39
7.39
7.37
7.37
7.34
7.34
7.33
7.32
7.31
7.30
7.26
7.17
7.16
7.15
7.15
7.13
7.13
7.12
7.11
7.10
7.06
7.06
7.04
7.04
7.02
7.02
6.90
6.88
3.74
3.72
3.70
3.33
3.33
3.29
3.28
2.58
2.53
1.81
1.81
1.52
1.29
1.27
1.26
BocHN
O
O
O
N
Et
4c
9
8
7
6
5
4
3
2
1
ppm
0.91
0.97
1.02
1.06
1.07
0.86
1.27
0.97
1.01
2.10
1.00
1.00
2.89
8.87
3.91

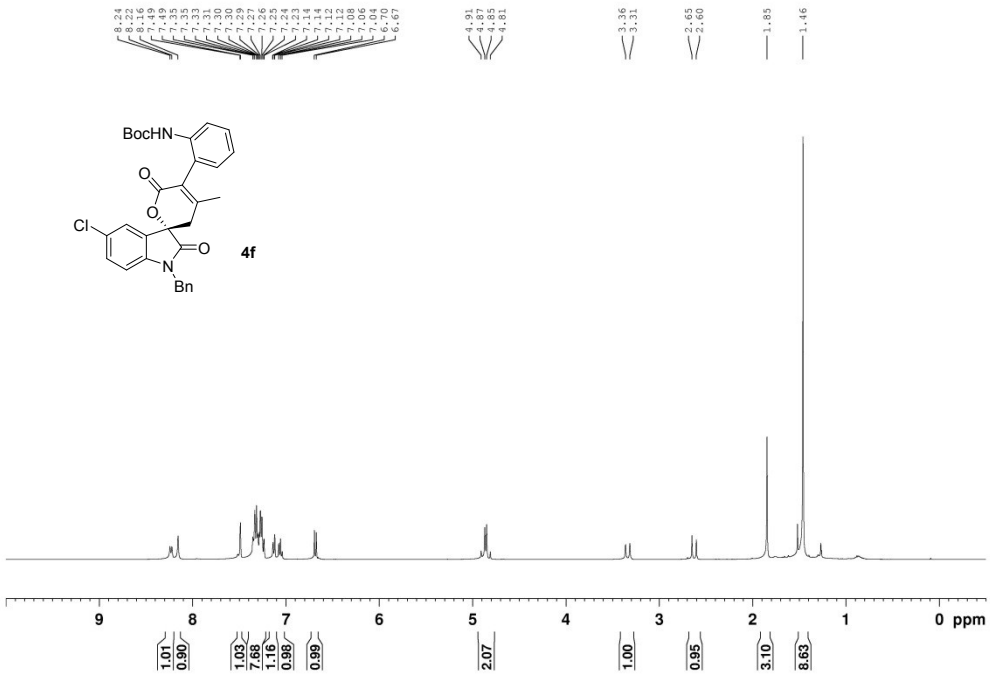

173.67
163.18
153.62
150.48
142.14
137.85
131.16
130.38
129.06
127.30
125.36
124.67
123.63
122.60
122.12
119.42
109.07
79.55
78.77
36.86
35.04
28.33
21.28
12.36
BocHN
O
O
O
N
Et
4c
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10 ppm

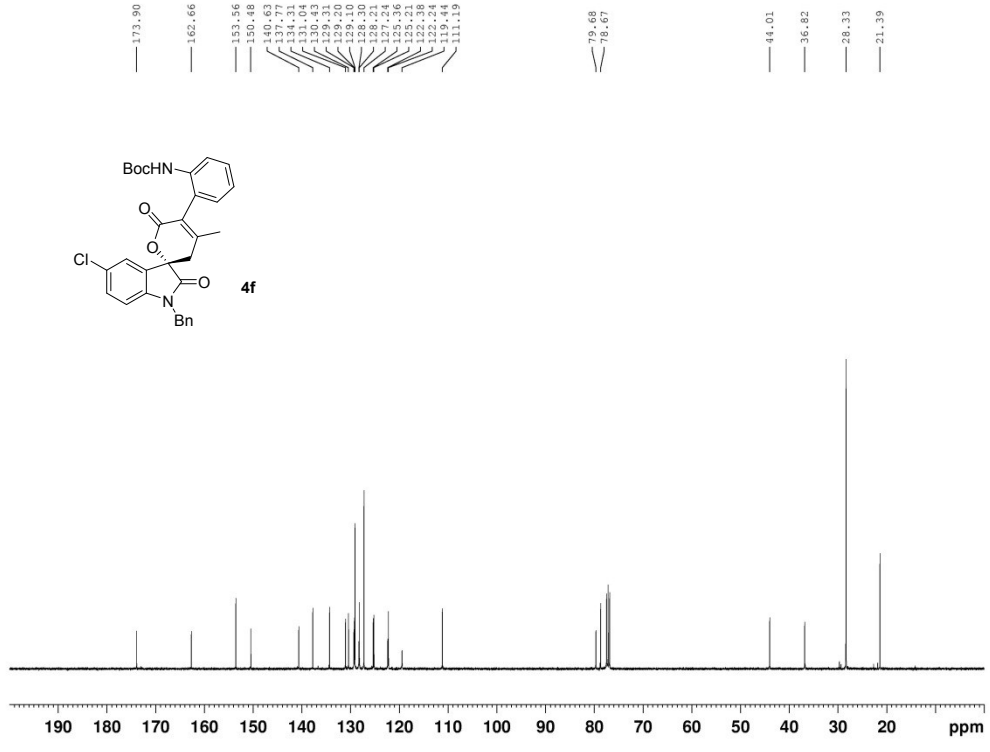

8.23
8.20
7.51
7.49
7.49
7.39
7.39
7.37
7.37
7.35
7.33
7.31
7.30
7.26
7.17
7.15
7.13
7.13
7.12
7.11
7.10
7.06
7.06
7.04
7.04
7.03
7.02
6.88
6.86
5.86
5.84
5.83
5.82
5.81
5.80
5.79
5.78
5.28
5.27
4.34
4.31
4.31
4.30
4.30
4.29
4.29
3.36
3.31
3.31
2.60
2.55
1.82
1.51
BocHN
O
O
O
N
4d
9
8
7
6
5
4
3
2
1
ppm
1.89
1.00
2.25
1.14
1.07
1.02
1.06
1.09
2.18
1.99
1.00
1.01
2.92
9.53

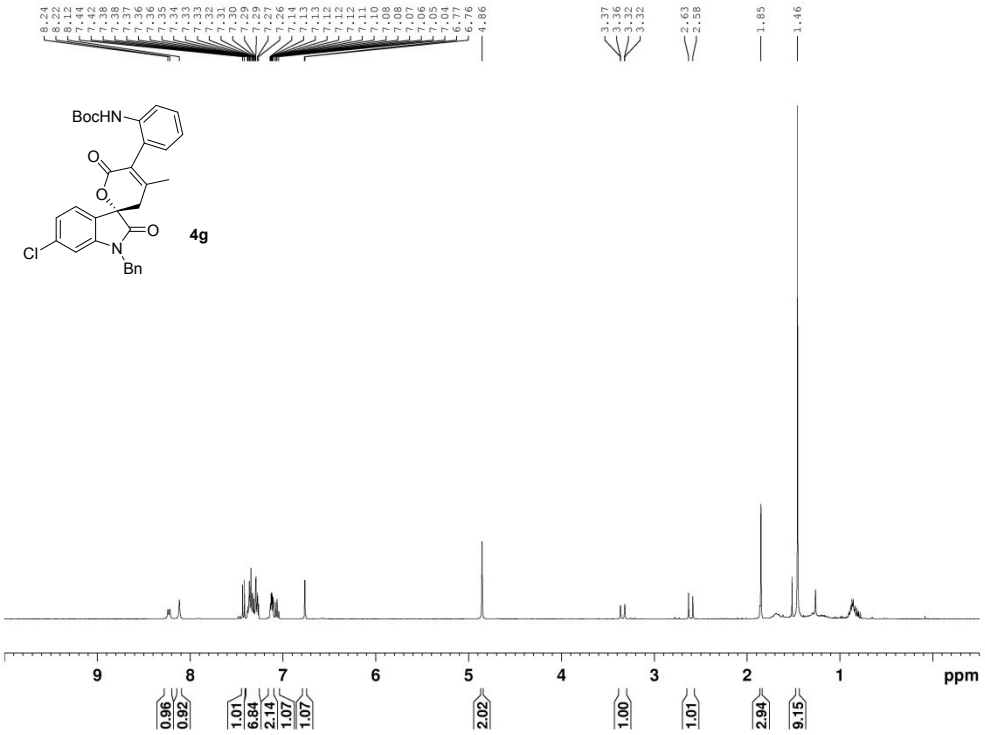

173.81
163.07
153.59
150.50
142.24
137.82
131.11
130.37
129.09
126.77
125.37
124.55
123.80
122.57
122.14
119.41
118.43
109.86
79.58
78.75
42.51
36.95
28.34
21.30
BocHN
O
O
O
N
4d
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

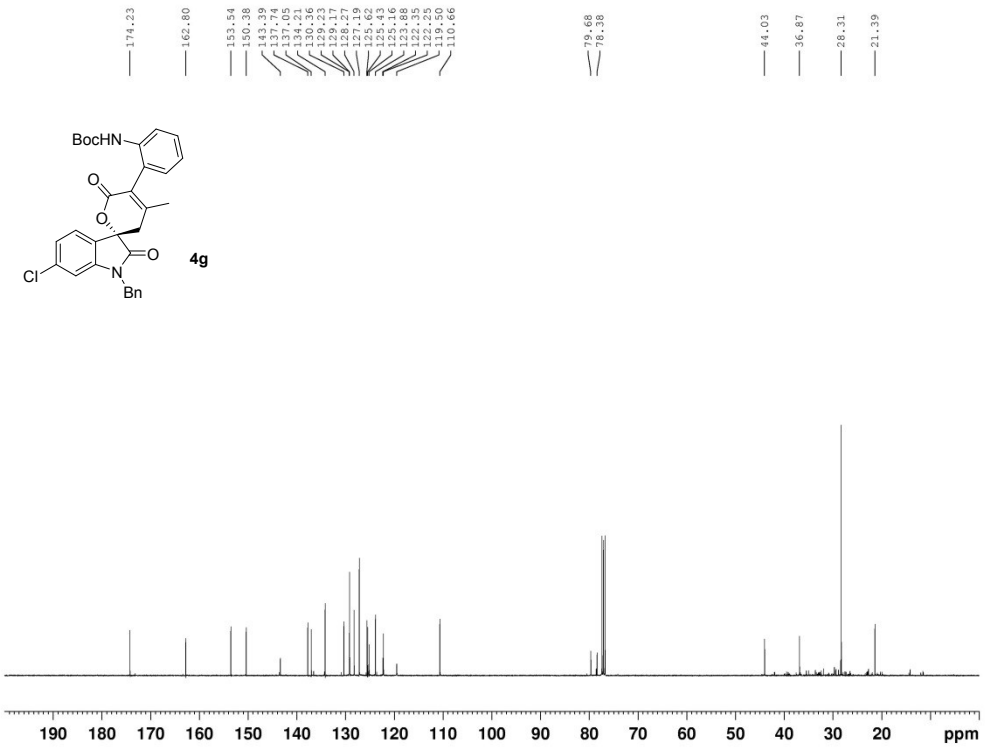

8.92
8.04
7.45
7.43
7.36
7.36
7.34
7.32
7.31
7.30
7.29
7.28
7.27
7.26
7.16
7.15
7.14
7.12
7.10
7.09
7.08
7.08
7.06
7.06
6.88
6.86
3.32
3.31
3.27
3.27
2.64
2.59
1.81
1.46
BocHN
O
O
O
O
N
H
4e
9
8
7
6
5
4
3
2
1
ppm
0.90
1.93
0.99
1.09
1.25
1.02
2.24
1.08
1.00
0.98
3.15
9.05

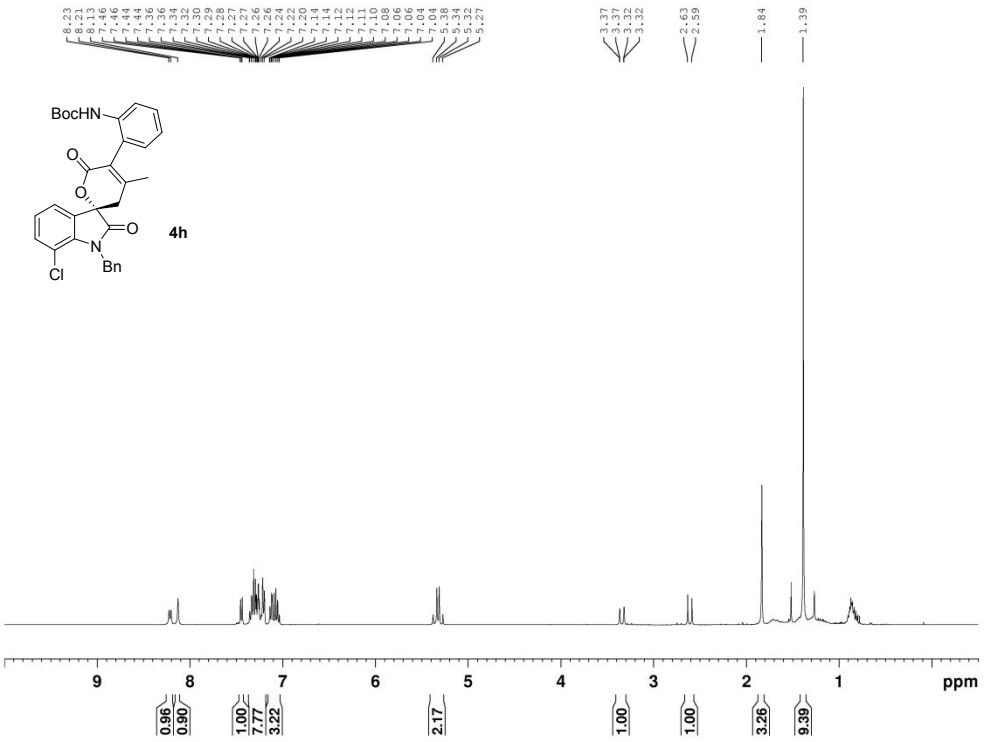

176.28
163.22
153.80
150.41
140.34
137.43
131.18
130.56
129.05
127.12
125.17
124.52
123.66
123.19
122.65
120.53
111.29
79.25
36.88
28.41
28.31
21.28
BocHN
O
O
O
O
N
H
4e
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

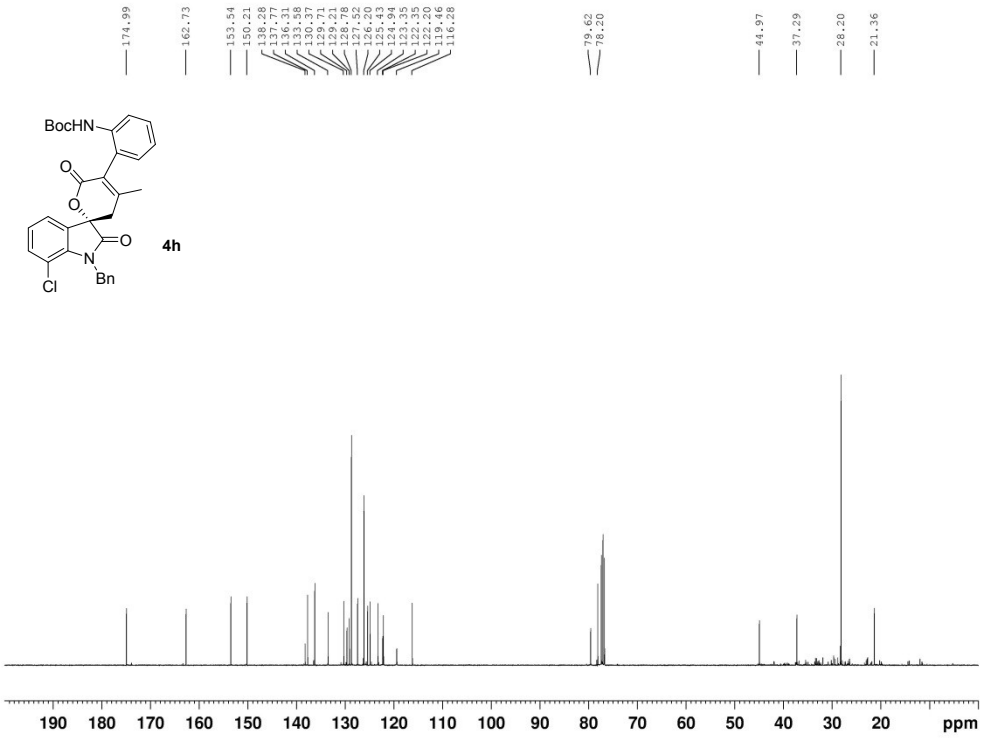

8.24
8.22
8.16
7.49
7.49
7.35
7.33
7.31
7.30
7.30
7.29
7.27
7.26
7.25
7.24
7.23
7.14
7.12
7.11
7.08
7.04
6.70
6.67
4.91
4.87
4.85
4.81
3.36
3.31
2.65
2.60
1.85
1.46
BocHN
O
O
Cl
O
N
Bn
4f
9
8
7
6
5
4
3
2
1
0 ppm
1.01
0.90
1.03
7.68
1.16
0.98
0.99
2.07
1.00
0.95
3.10
8.63

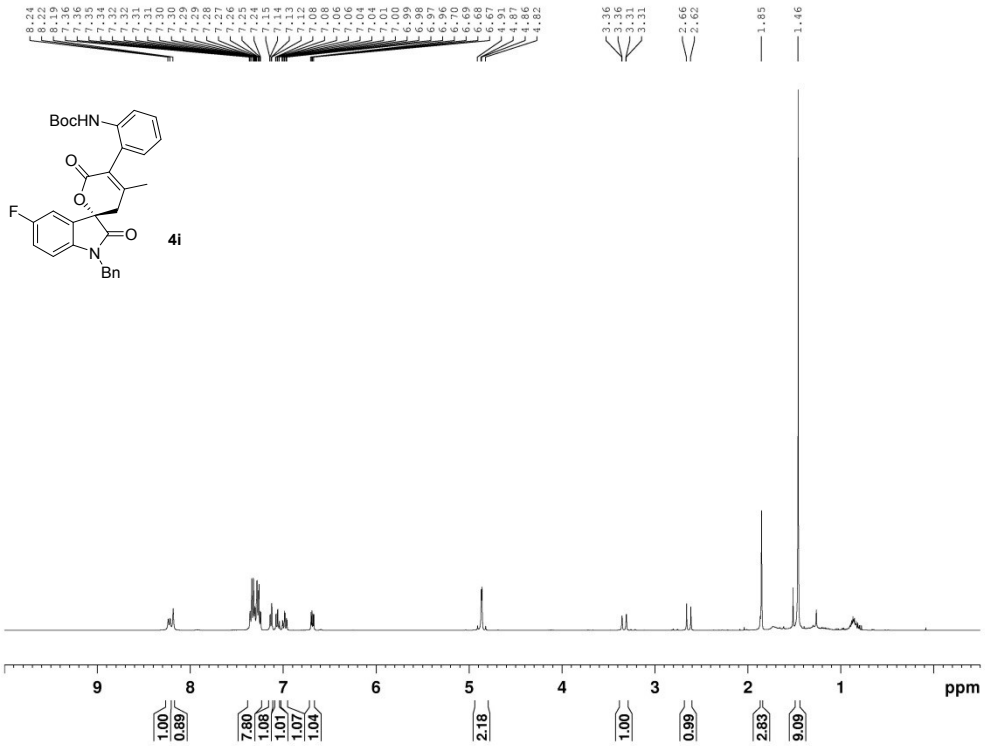

173.90
162.66
153.56
150.48
140.63
137.77
134.31
131.04
130.43
129.31
129.20
129.10
128.30
128.21
127.24
125.36
123.31
122.38
122.24
119.44
111.19
79.68
78.67
44.01
36.82
28.33
21.39
BocHN
O
O
Cl
O
N
Bn
4f
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

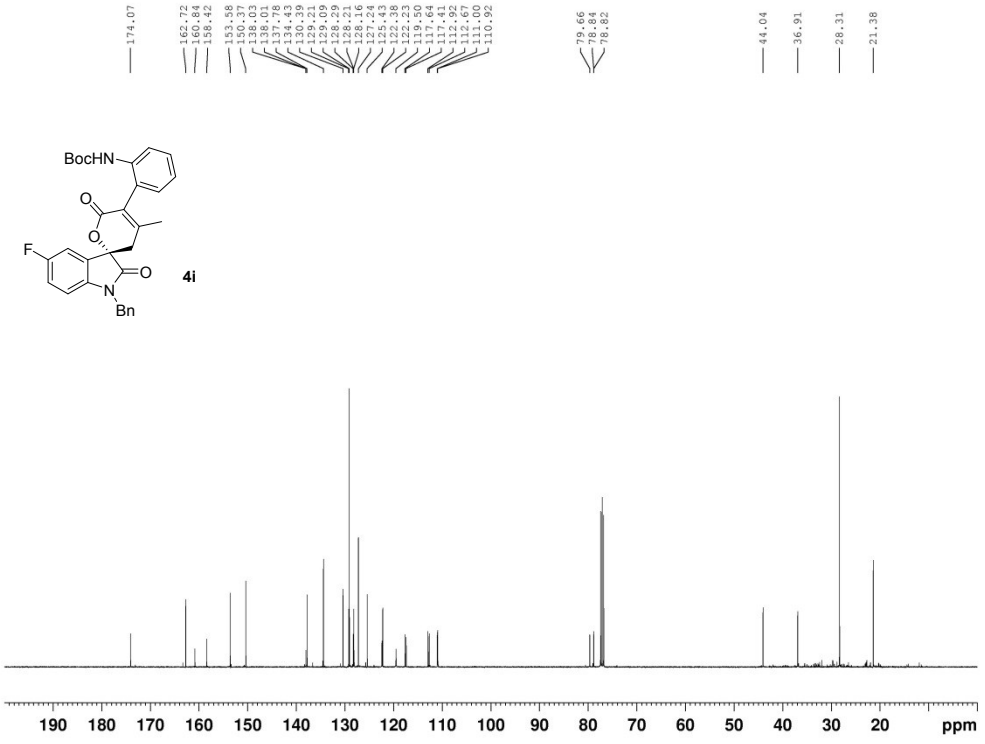

8.24
8.22
8.12
8.11
7.44
7.42
7.38
7.37
7.36
7.36
7.35
7.34
7.33
7.32
7.31
7.30
7.29
7.29
7.27
7.26
7.14
7.13
7.13
7.12
7.12
7.11
7.10
7.08
7.08
7.07
7.06
7.05
7.04
6.77
6.76
4.86
3.37
3.36
3.32
3.32
2.63
2.58
1.85
1.46
BocHN
O
O
O
Cl
N
Bn
4g
9
8
7
6
5
4
3
2
1
ppm
0.96
0.92
1.01
6.84
2.14
1.07
1.07
2.02
1.00
1.01
2.94
9.15

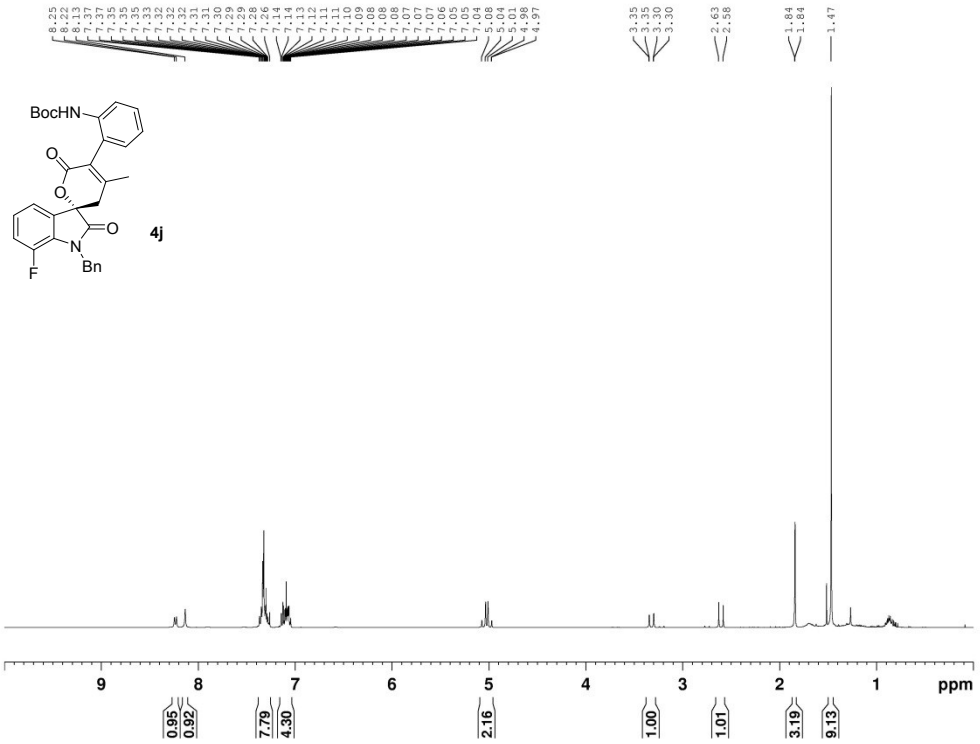

174.23
162.80
153.54
150.38
143.39
137.74
137.05
134.21
130.36
130.23
129.17
128.27
127.19
125.62
125.43
125.16
123.88
122.35
122.25
119.50
110.66
79.68
78.38
44.03
36.87
28.31
21.39
BocHN
O
O
O
Cl
N
Bn
4g
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

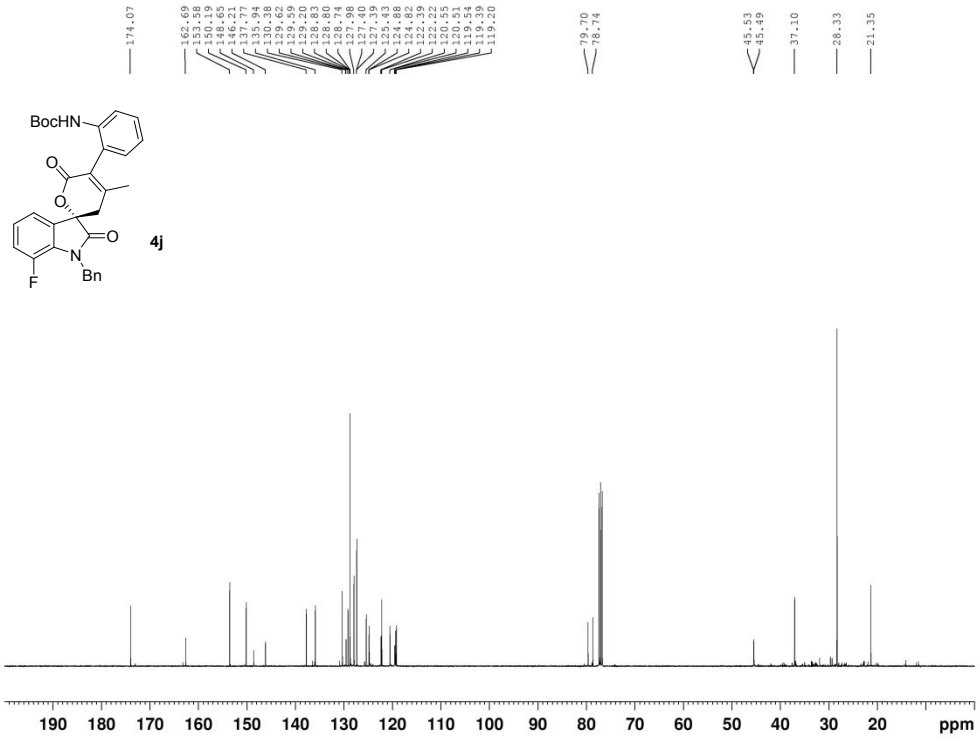

8.23
8.21
8.13
7.46
7.46
7.44
7.44
7.36
7.34
7.32
7.30
7.29
7.28
7.27
7.27
7.26
7.26
7.24
7.22
7.20
7.14
7.14
7.12
7.12
7.11
7.10
7.08
7.06
7.06
7.04
7.04
5.38
5.34
5.32
5.27
3.37
3.37
3.32
3.32
2.63
2.59
1.84
1.39
BocHN
O
O
O
O
N
Bn
Cl
4h
9
8
7
6
5
4
3
2
1
ppm
0.96
0.90
1.00
7.77
3.22
2.17
1.00
1.00
3.26
9.39

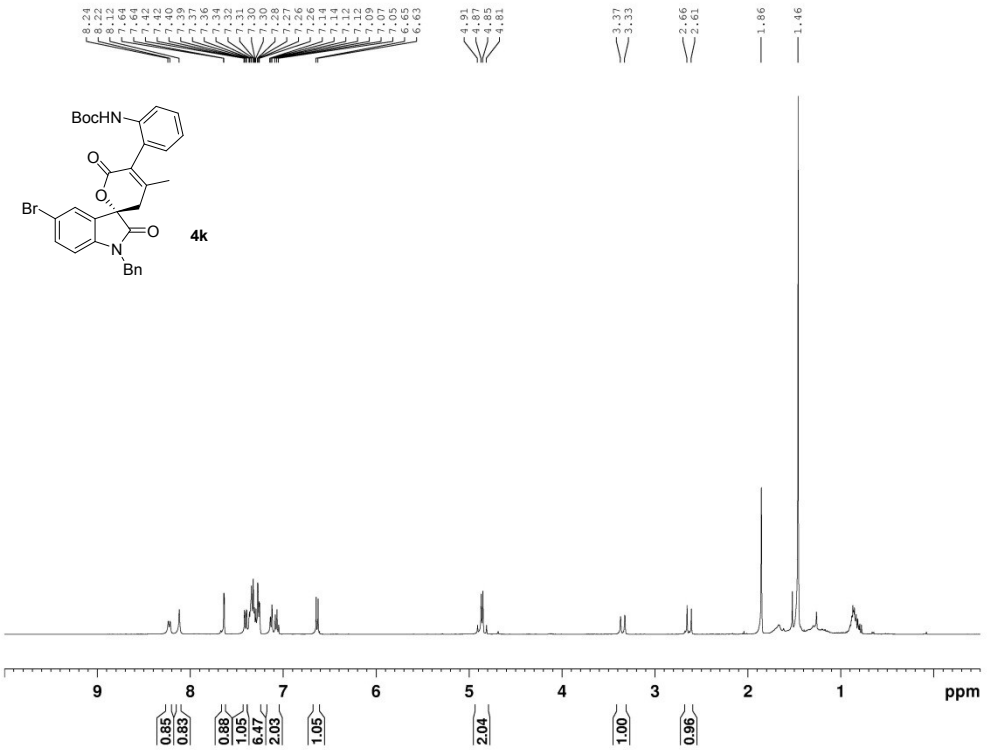

174.99
162.73
153.54
150.21
138.28
137.77
136.31
133.58
130.37
129.71
129.21
128.78
127.52
126.20
125.43
124.94
124.35
122.35
122.20
119.46
116.28
79.62
78.20
44.97
37.29
28.20
21.36
BocHN
O
O
O
O
N
Bn
Cl
4h
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

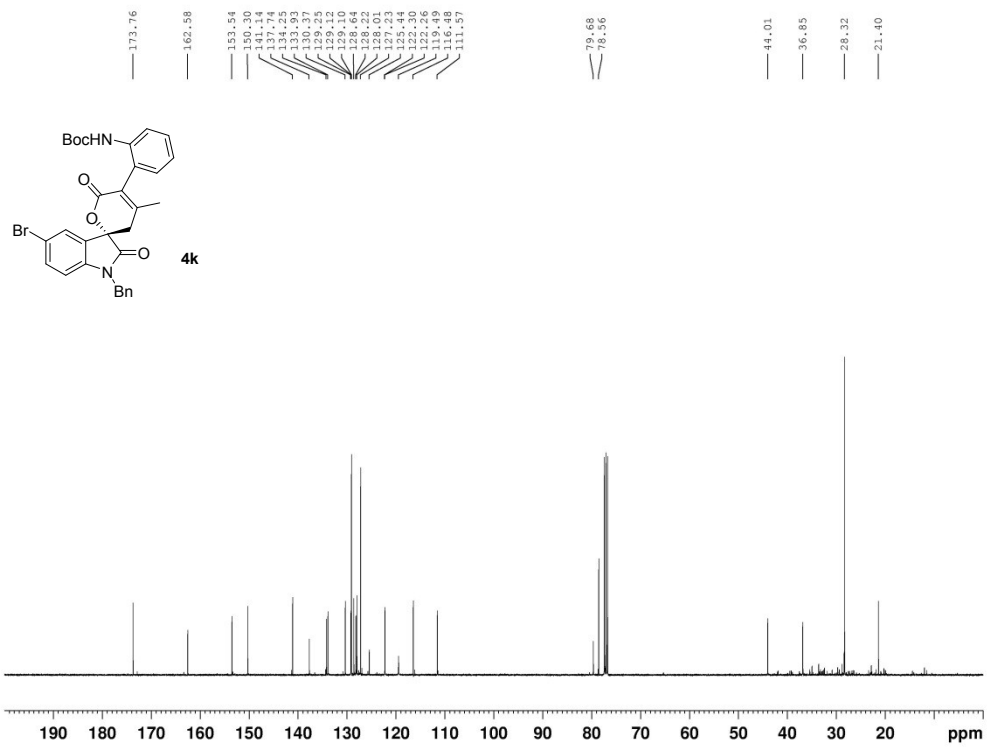

8.24
8.22
8.19
7.36
7.35
7.34
7.32
7.32
7.31
7.31
7.30
7.30
7.29
7.28
7.28
7.27
7.26
7.25
7.24
7.15
7.14
7.13
7.12
7.08
7.08
7.06
7.06
7.04
7.04
7.01
7.00
6.99
6.98
6.97
6.96
6.70
6.69
6.68
6.67
4.91
4.87
4.86
4.82
3.36
3.36
3.31
3.31
2.66
2.62
1.85
1.46
BocHN
O
O
F
O
N
Bn
4i
9
8
7
6
5
4
3
2
1
ppm
1.00
0.89
7.80
1.08
1.01
1.07
1.04
2.18
1.00
0.99
2.83
9.09

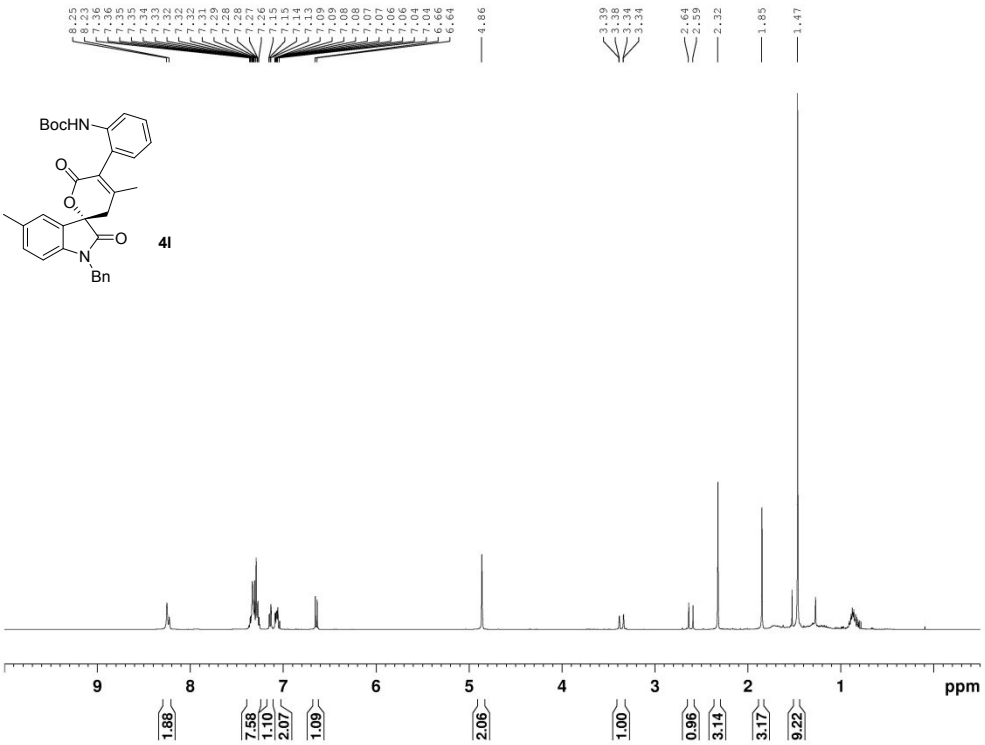

174.07
162.72
160.84
158.42
153.58
150.37
138.03
138.01
137.78
134.43
130.39
129.21
129.09
128.29
128.21
128.16
127.24
125.43
122.38
122.23
119.60
117.64
117.41
112.92
112.67
111.00
110.92
79.66
78.84
78.82
44.04
36.91
28.31
21.38
BocHN
O
O
F
O
N
Bn
4i
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

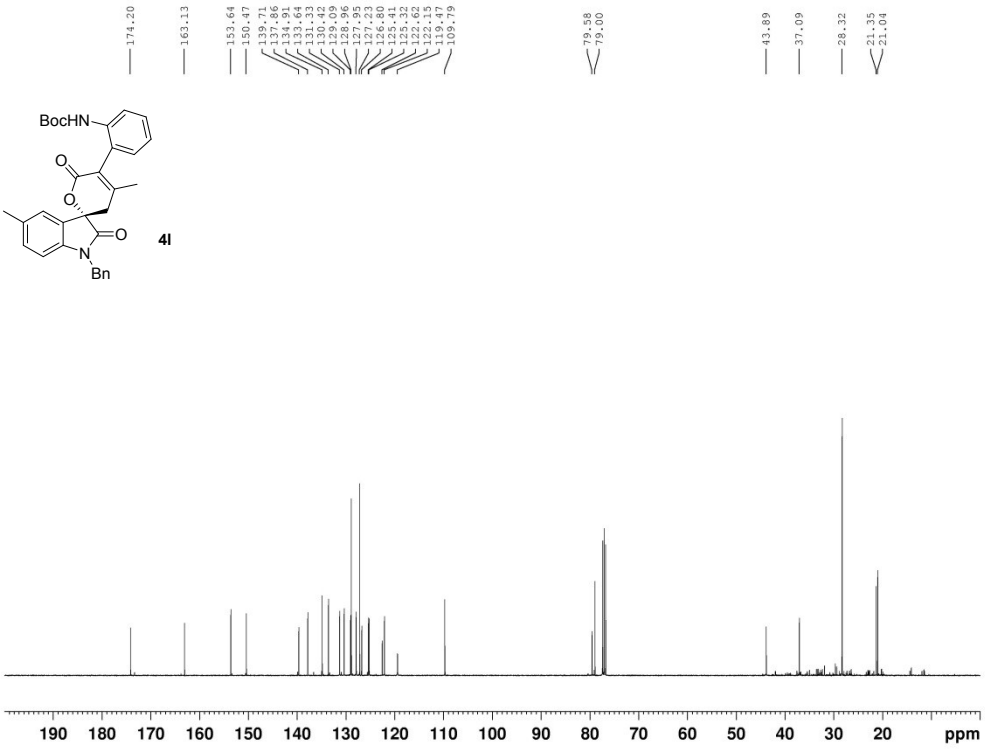

BocHN
O
O
O
N
Bn
F
4j
8.25
8.22
8.13
7.37
7.35
7.33
7.32
7.31
7.30
7.29
7.28
7.14
7.13
7.12
7.11
7.10
7.09
7.08
7.07
7.06
7.05
7.04
5.04
5.01
4.98
4.97
3.35
3.30
2.63
2.58
1.84
1.47
9
8
7
6
5
4
3
2
1
ppm
0.95
0.92
7.79
4.30
2.16
1.00
1.01
3.19
9.13

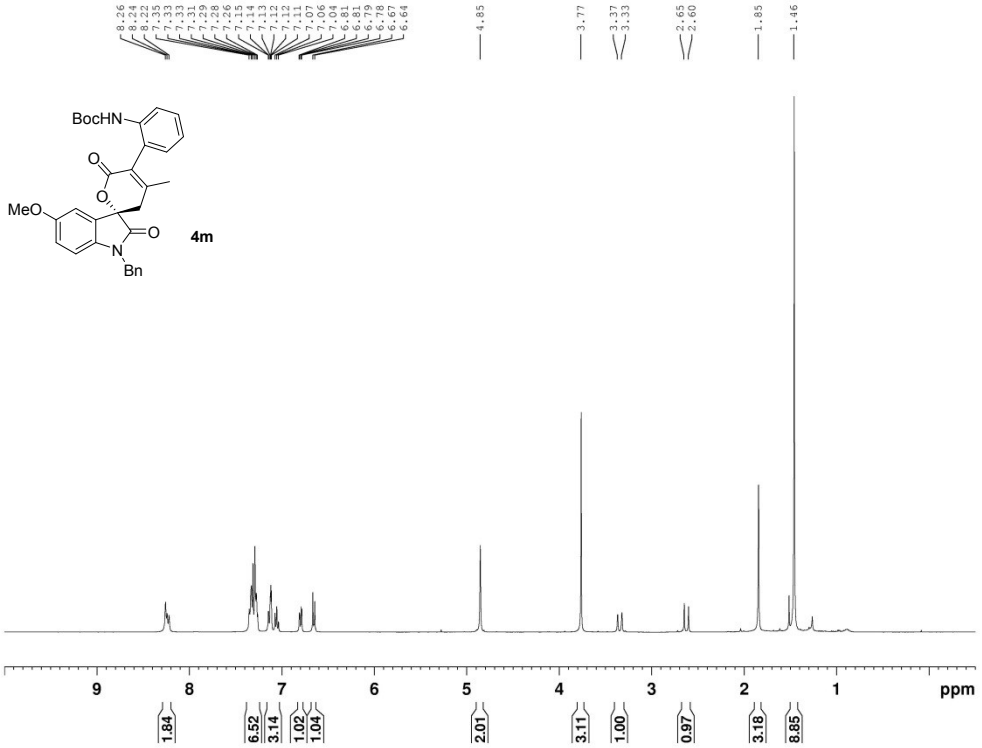

BocHN
O
O
O
N
Bn
F
4j
174.07
162.69
153.58
151.19
148.65
146.21
137.77
135.94
130.38
129.62
129.45
129.20
128.83
128.80
128.74
127.98
127.40
127.39
125.43
124.88
124.82
122.39
122.22
120.50
120.51
119.54
119.39
119.20
79.70
78.74
45.53
45.49
37.10
28.33
21.35
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

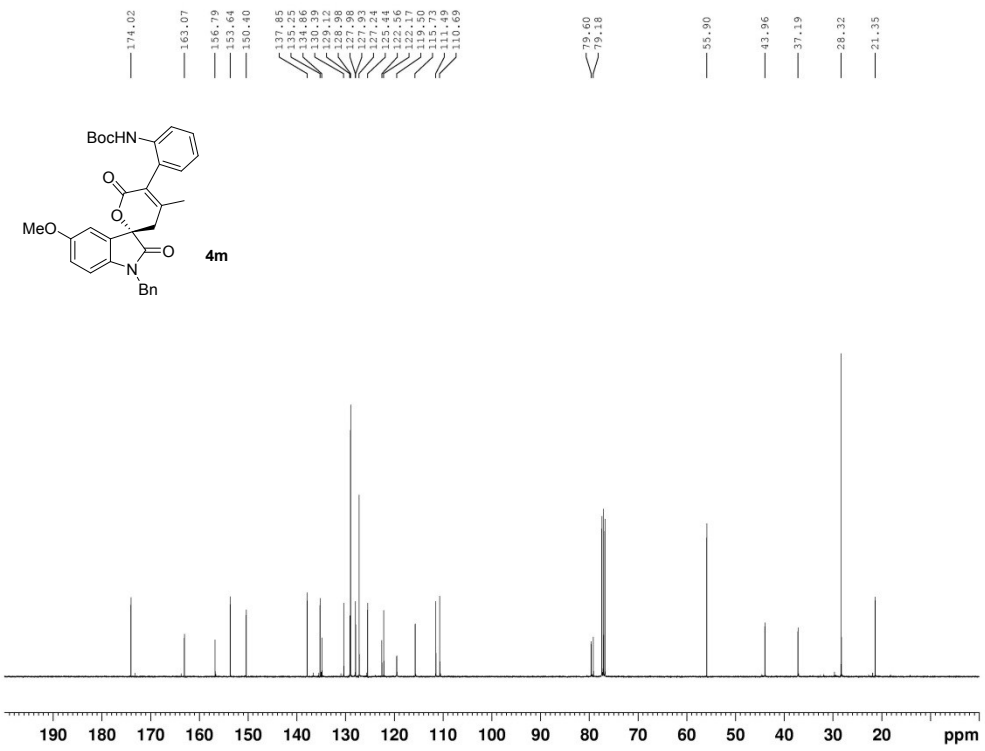

8.24
8.22
8.12
7.64
7.64
7.42
7.40
7.39
7.37
7.36
7.34
7.32
7.31
7.30
7.30
7.28
7.27
7.26
7.26
7.14
7.14
7.12
7.09
7.07
7.05
6.65
6.63
4.91
4.87
4.85
4.81
3.37
3.33
2.66
2.61
1.86
1.46
BocHN
O
O
O
Br
O
N
Bn
4k
9
8
7
6
5
4
3
2
1
ppm
0.85
0.83
0.88
1.05
6.47
2.03
1.05
2.04
1.00
0.96

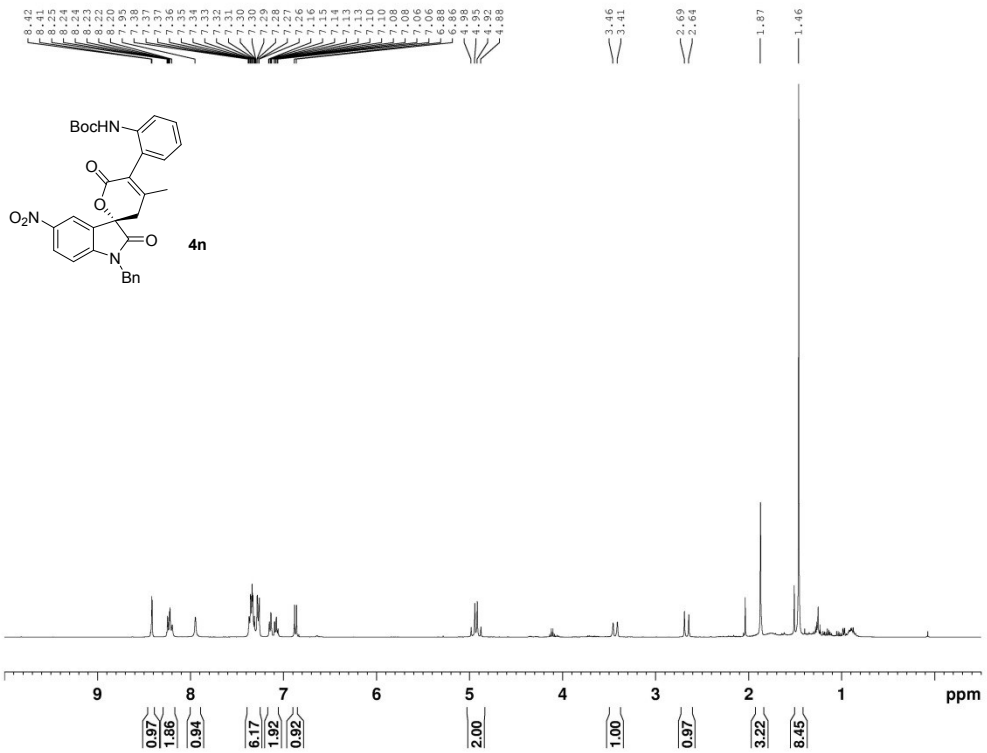

173.76
162.58
153.54
150.30
141.14
137.74
134.25
133.93
130.37
129.25
129.12
129.10
128.64
128.22
128.01
127.23
125.44
122.30
122.26
119.49
116.48
111.57
79.68
78.56
44.01
36.85
28.32
21.40
BocHN
O
O
O
Br
O
N
Bn
4k
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

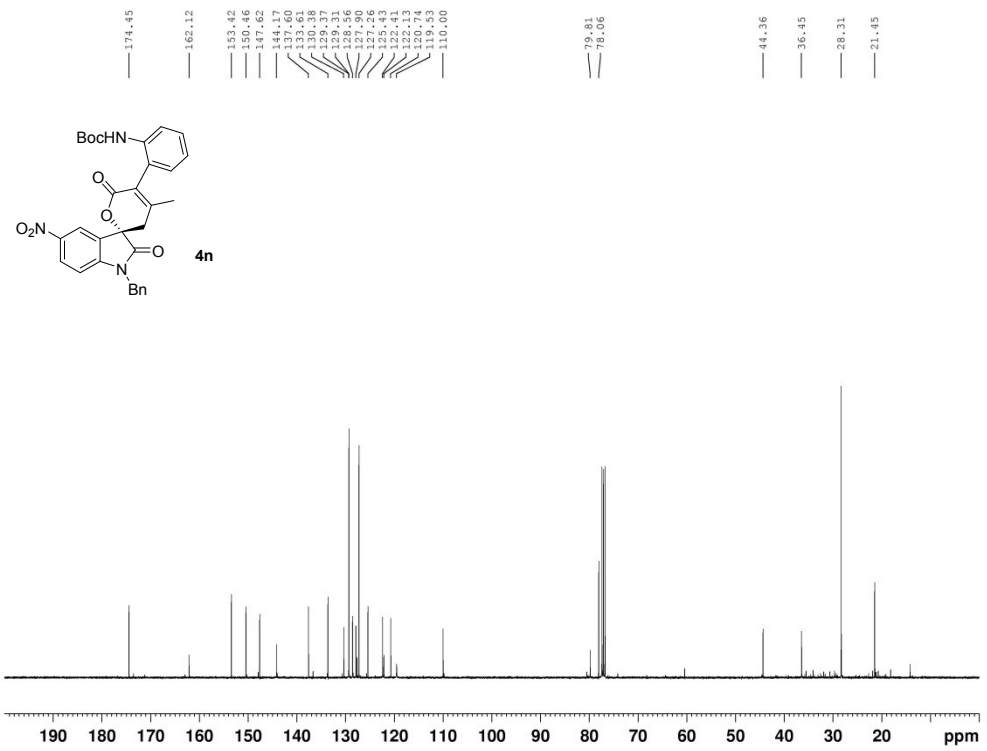

8.25
8.23
7.36
7.35
7.34
7.33
7.32
7.31
7.29
7.28
7.27
7.26
7.15
7.14
7.13
7.10
7.09
7.08
7.08
7.07
7.07
7.06
7.06
7.04
7.04
6.66
6.64
4.86
3.39
3.38
3.34
3.34
2.64
2.59
2.32
1.85
1.47
BocHN
O
O
O
O
N
Bn
4l
9
8
7
6
5
4
3
2
1
ppm
1.88
7.58
1.10
2.07
1.09
2.06
1.00
0.96
3.14
3.17
9.22

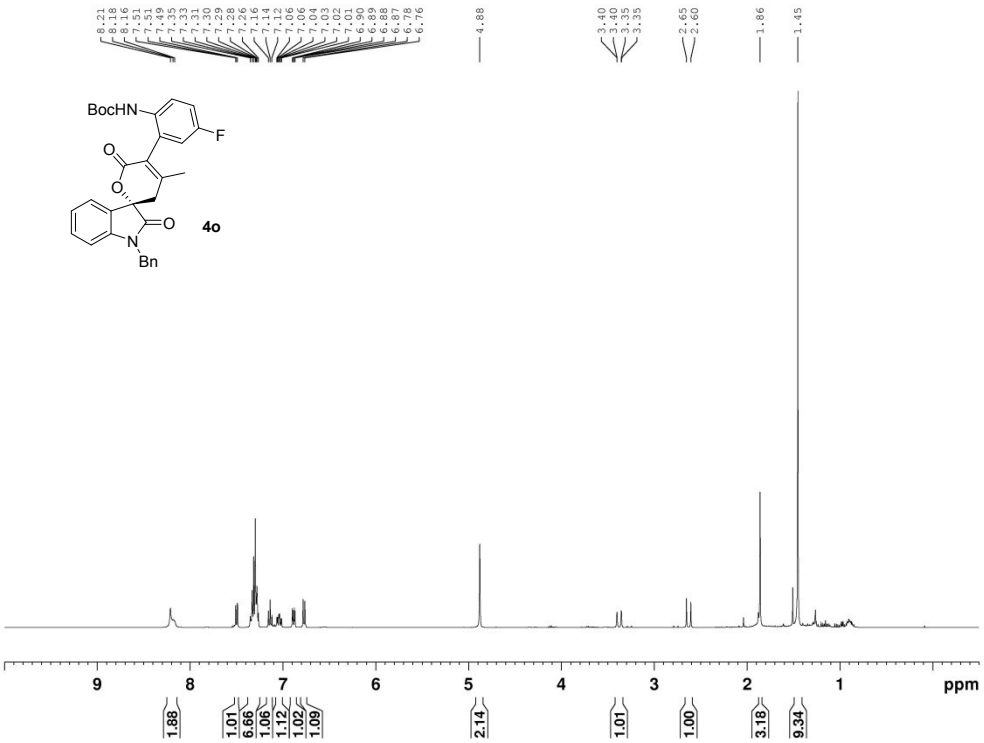

174.20
163.13
153.64
150.47
139.71
137.86
134.91
133.64
131.33
130.43
129.09
128.96
127.95
127.23
126.80
125.41
125.22
122.62
122.15
119.47
109.79
79.58
79.00
43.89
37.09
28.32
21.35
21.04
BocHN
O
O
O
O
N
Bn
4l
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

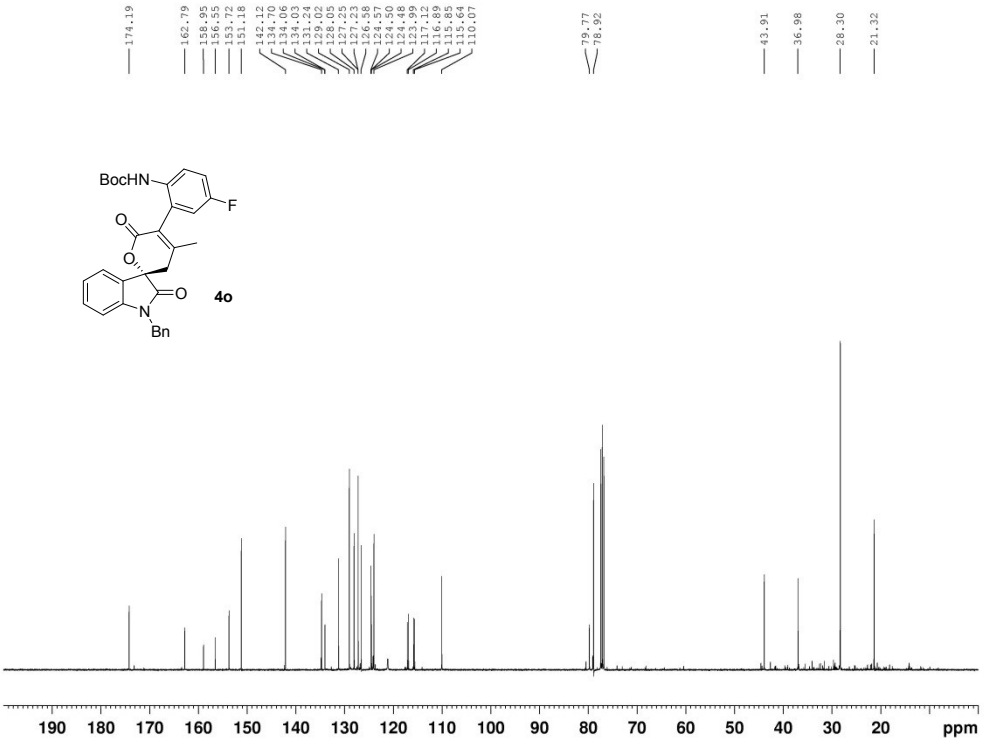

8.26
8.24
8.22
7.35
7.33
7.33
7.31
7.29
7.28
7.26
7.15
7.14
7.13
7.12
7.12
7.11
7.07
7.06
7.04
6.81
6.81
6.79
6.78
6.67
6.64
4.85
3.77
3.37
3.33
2.65
2.60
1.85
1.46
BocHN
O
O
MeO
O
N
Bn
4m
9
8
7
6
5
4
3
2
1
ppm
1.84
6.52
3.14
1.02
1.04
2.01
3.11
1.00
0.97
3.18
8.85

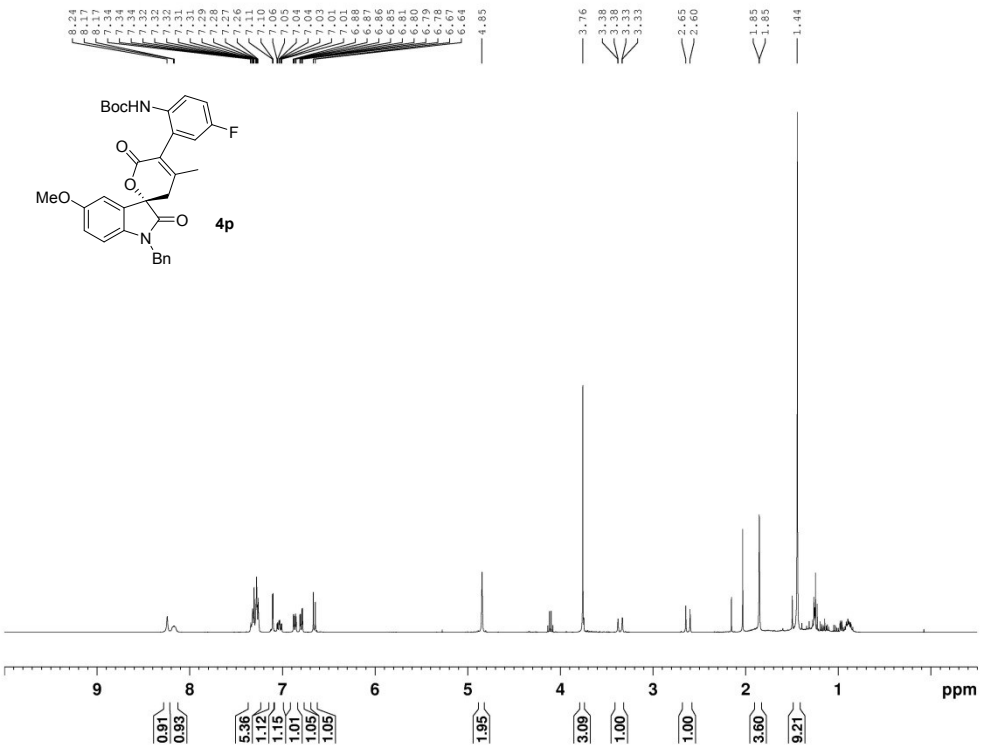

174.02
163.07
156.79
153.64
150.40
137.85
135.25
134.86
130.39
129.12
128.98
127.98
127.83
127.24
125.44
122.56
122.17
119.50
115.73
111.49
110.69
79.60
79.18
55.90
43.96
37.19
28.32
21.35
BocHN
O
O
MeO
O
N
Bn
4m
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

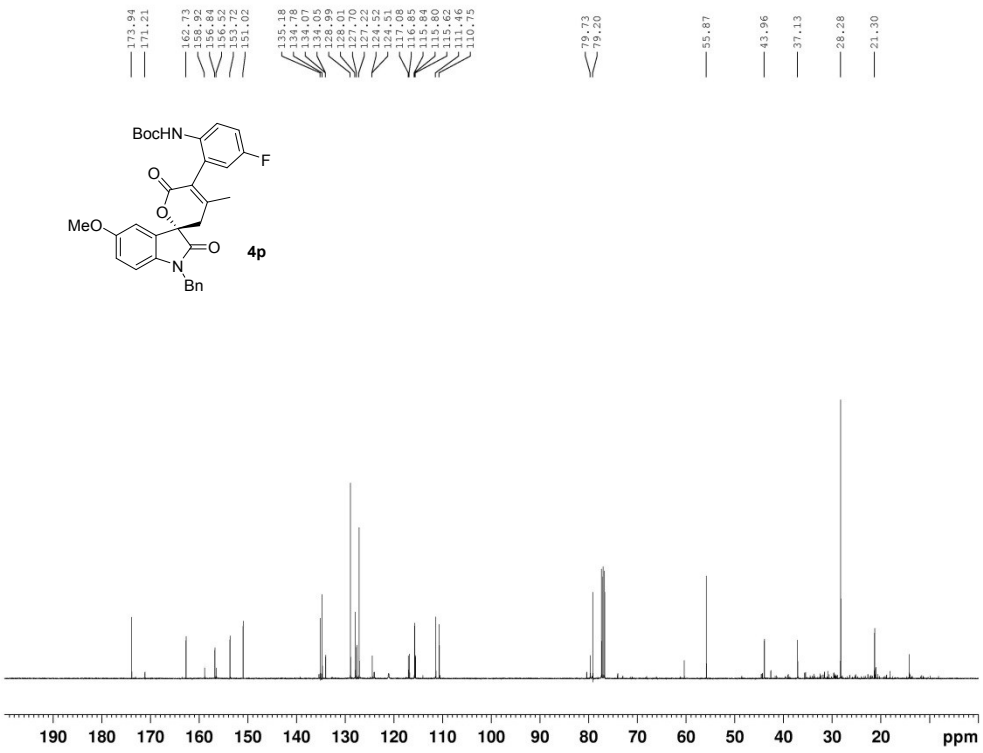

8.42
8.41
8.25
8.24
8.24
8.23
8.22
8.20
8.00
7.95
7.38
7.37
7.36
7.35
7.34
7.33
7.32
7.31
7.30
7.30
7.29
7.28
7.27
7.26
7.16
7.15
7.14
7.13
7.10
7.10
7.08
7.08
7.06
7.06
6.88
6.86
4.98
4.95
4.92
4.88
3.46
3.41
2.69
2.64
1.87
1.46
BocHN
O
O
O2N
O
N
Bn
4n
9
8
7
6
5
4
3
2
1
ppm
0.97
1.86
0.94
6.17
1.92
0.92
2.00
1.00
0.97
3.22
8.45

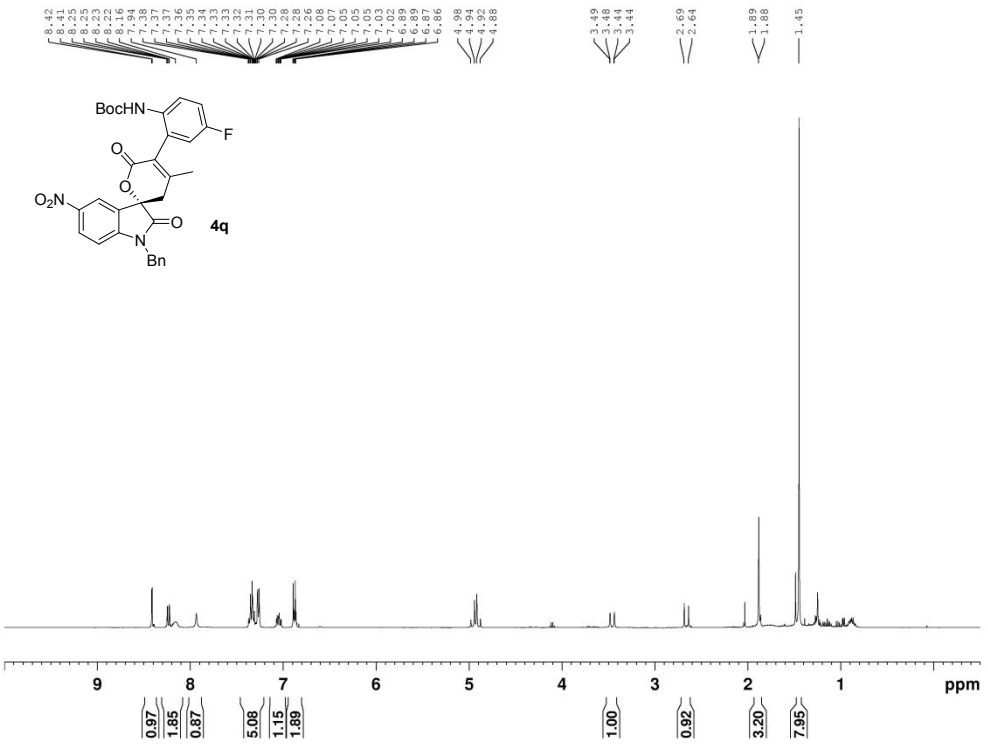

174.45
162.12
153.42
150.46
147.62
144.17
137.60
133.61
130.38
129.37
128.91
128.56
127.90
127.26
125.43
122.41
122.13
120.74
119.53
110.00
79.81
78.06
44.36
36.45
28.31
21.45
BocHN
O
O
O2N
O
N
Bn
4n
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

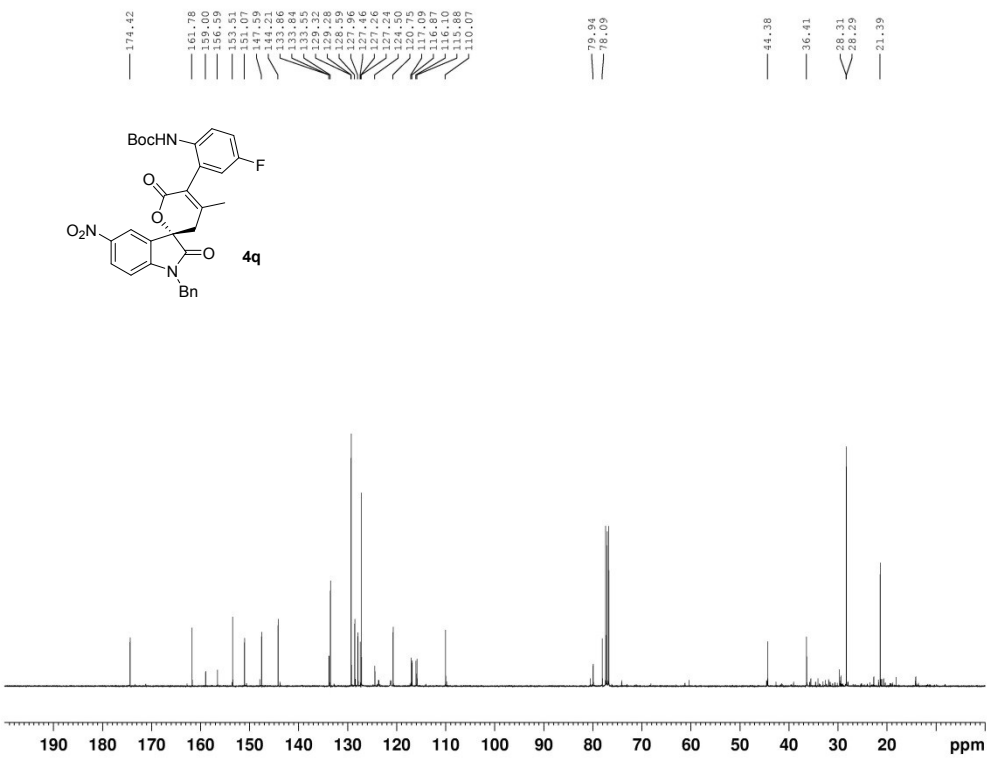

8.21
8.18
8.16
8.11
7.51
7.49
7.35
7.33
7.31
7.30
7.29
7.28
7.26
7.16
7.14
7.12
7.06
7.06
7.04
7.03
7.02
7.01
6.90
6.89
6.88
6.87
6.78
6.76
4.88
3.40
3.40
3.35
3.35
2.65
2.60
1.86
1.45
BocHN
F
O
O
O
O
N
Bn
4o
9
8
7
6
5
4
3
2
1
ppm
1.88
1.01
6.66
1.06
1.12
1.02
1.09
2.14
1.01
1.00
3.18
9.34

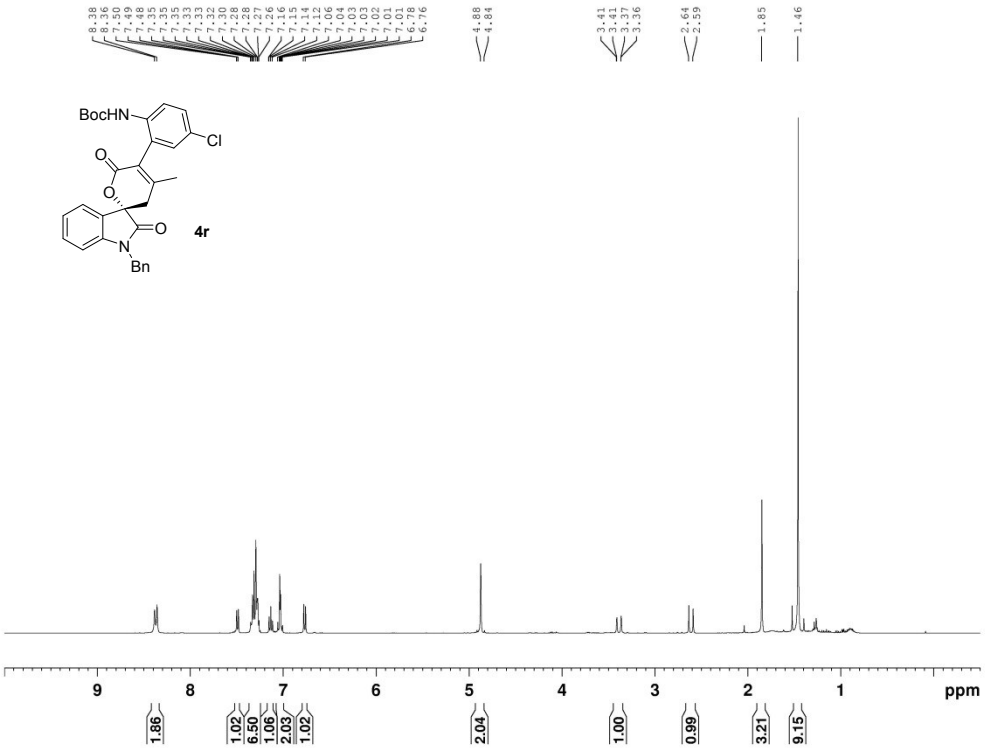

174.19
162.79
158.95
156.55
153.72
151.18
142.12
134.70
134.06
134.03
133.64
129.02
128.05
127.25
127.23
126.58
124.57
124.50
124.48
123.99
117.12
116.89
115.85
115.64
110.07
79.77
78.92
43.91
36.98
28.30
21.32
BocHN
F
O
O
O
O
N
Bn
4o
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

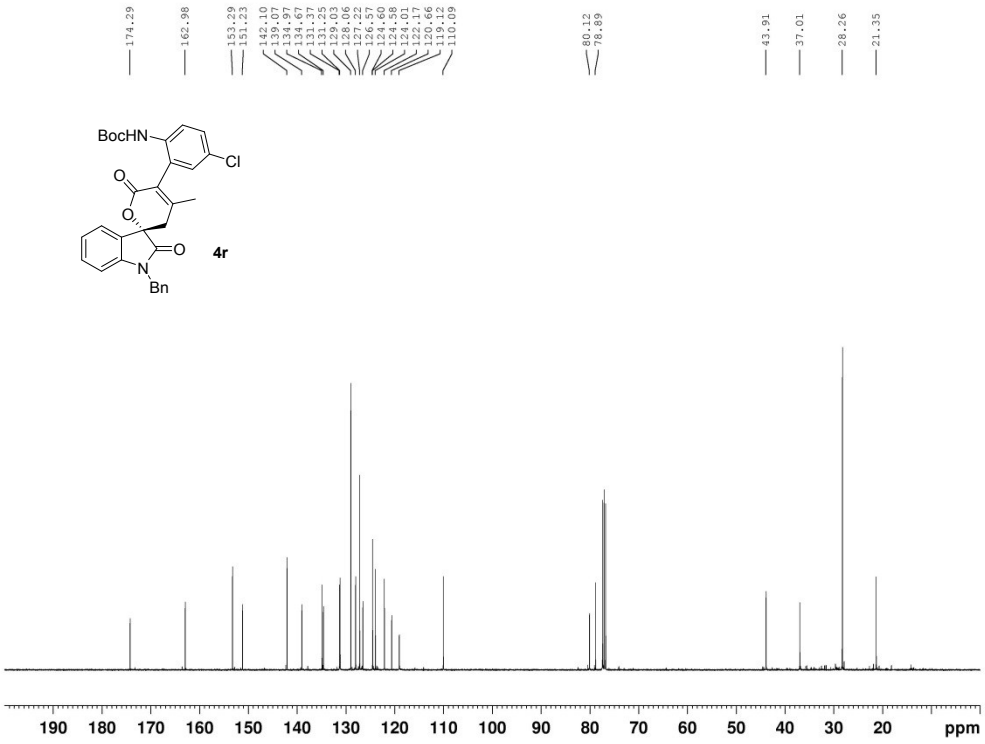

8.24
8.17
8.17
7.34
7.34
7.32
7.32
7.31
7.31
7.29
7.28
7.27
7.16
7.11
7.10
7.06
7.05
7.04
7.04
7.03
7.01
7.01
6.88
6.87
6.86
6.85
6.81
6.80
6.79
6.78
6.67
6.64
4.85
3.76
3.38
3.38
3.33
3.33
2.65
2.60
1.85
1.85
1.44
BocHN
F
O
O
MeO
O
N
Bn
4p
9
8
7
6
5
4
3
2
1
ppm
0.91
0.93
5.36
1.12
1.15
1.01
1.05
1.05
1.95
3.09
1.00
1.00
3.60
9.21

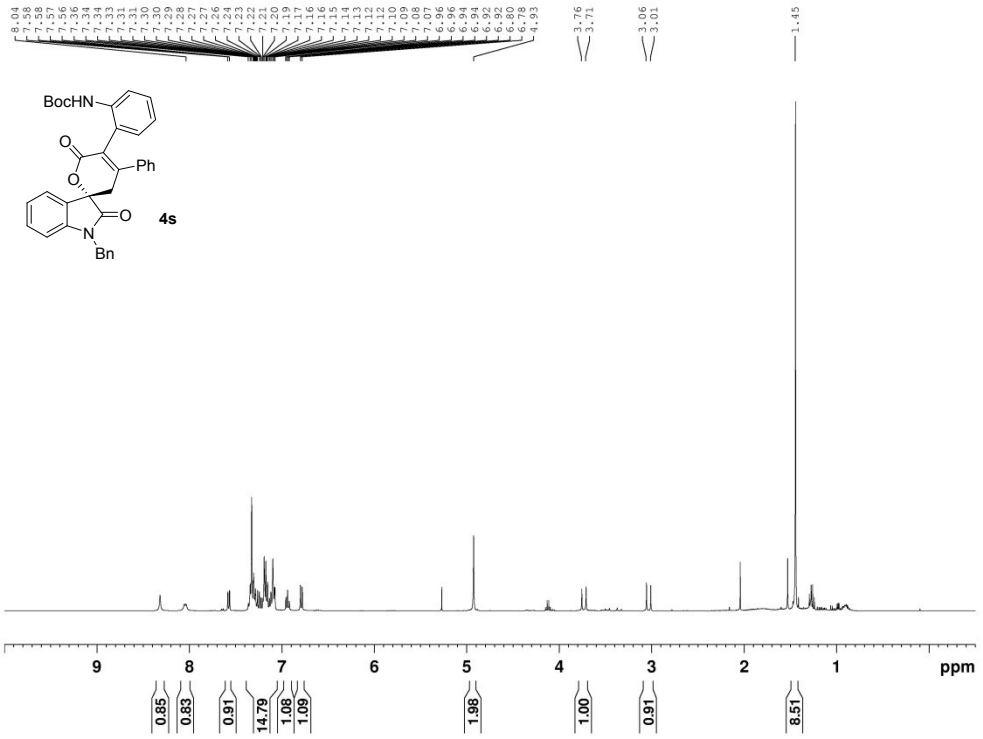

173.94
171.21
162.73
158.92
156.84
156.52
153.72
151.02
135.18
134.78
134.07
134.05
128.99
128.01
127.70
127.22
124.52
124.51
117.08
116.85
115.84
115.80
115.62
111.46
110.75
79.73
79.20
55.87
43.96
37.13
28.28
21.30
BocHN
F
O
O
MeO
O
N
Bn
4p
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

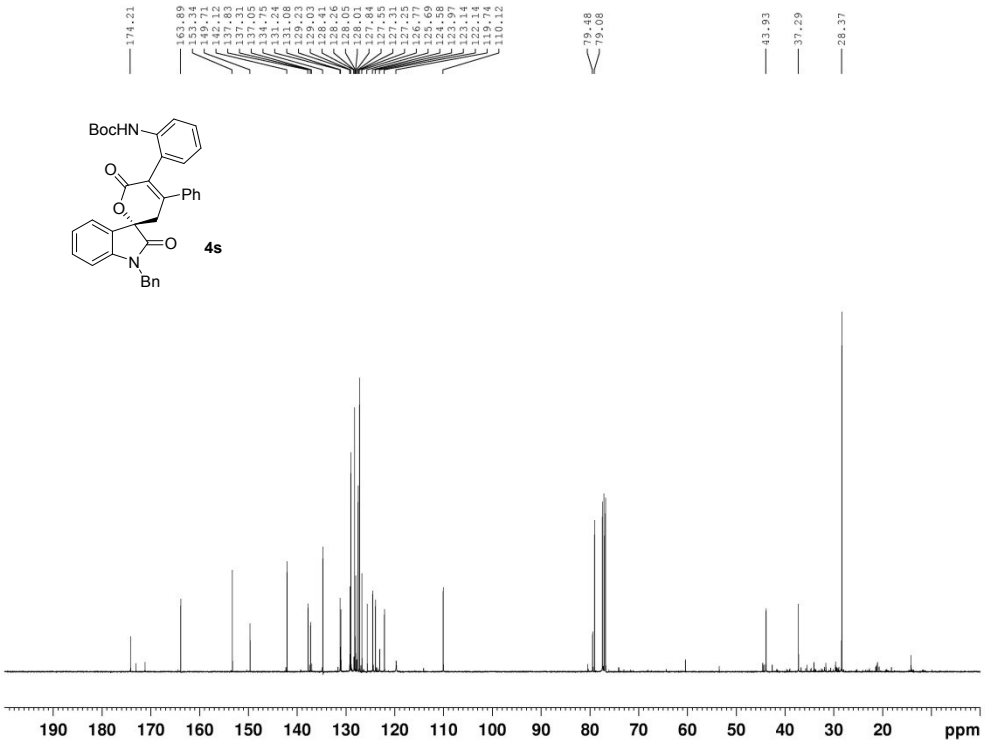

8.42
8.41
8.25
8.23
8.22
8.16
7.94
7.38
7.37
7.36
7.35
7.34
7.33
7.32
7.31
7.30
7.28
7.26
7.08
7.07
7.05
7.05
7.03
7.02
6.89
6.89
6.87
6.86
4.98
4.94
4.92
4.88
3.49
3.48
3.44
3.44
2.69
2.64
1.89
1.88
1.45
BocHN
F
O
O
O2N
O
N
Bn
4q
9
8
7
6
5
4
3
2
1
ppm
0.97
1.85
0.87
5.08
1.15
1.89
1.00
0.92
3.20
7.95

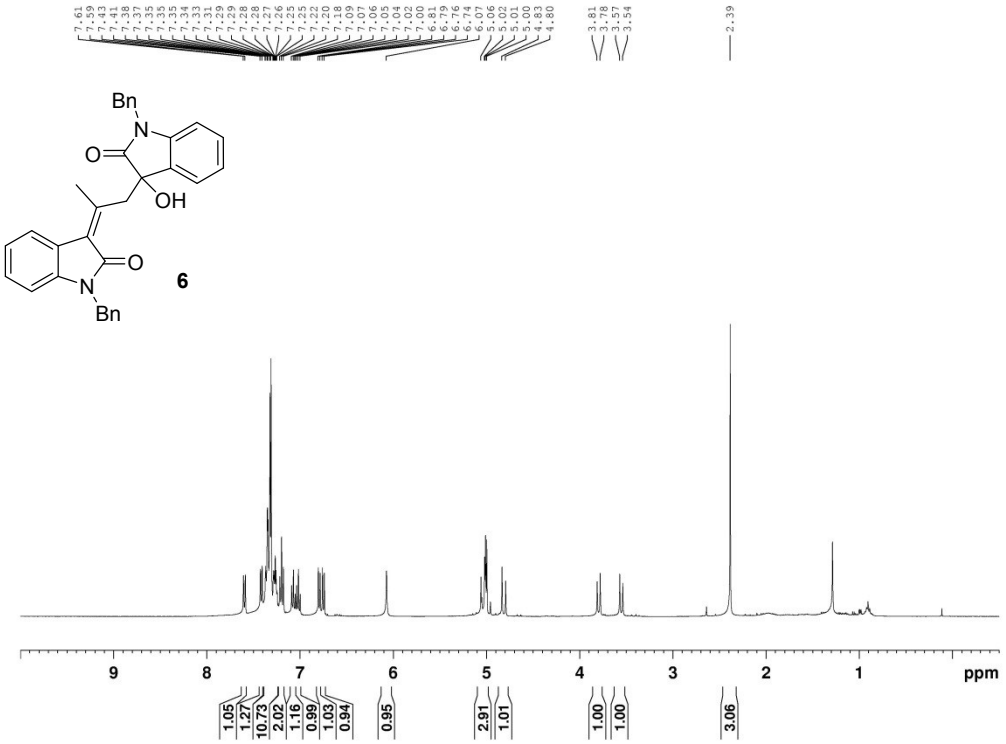

174.42
161.78
159.00
156.59
153.51
151.07
147.59
144.21
133.86
133.84
133.55
129.32
129.28
128.59
127.96
127.46
127.26
127.24
124.50
120.75
117.09
116.87
116.10
115.88
110.07
79.94
78.09
44.38
36.41
28.31
28.29
21.39
BocHN
F
O
O
O2N
O
N
Bn
4q
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

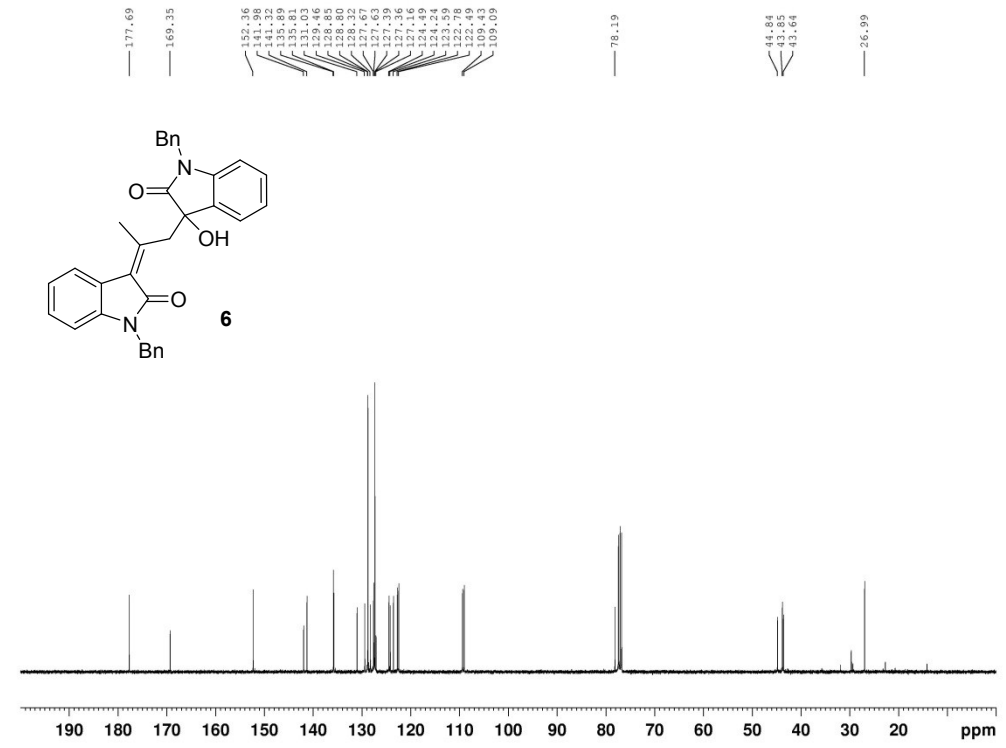

8.38
8.36
7.50
7.49
7.48
7.35
7.35
7.35
7.33
7.32
7.30
7.28
7.28
7.27
7.26
7.16
7.15
7.14
7.12
7.06
7.04
7.03
7.03
7.02
7.01
7.01
6.78
6.76
4.88
4.84
3.41
3.41
3.37
3.36
2.64
2.59
1.85
1.46
BocHN
Cl
O
O
O
O
N
Bn
4r
9
8
7
6
5
4
3
2
1
ppm
1.86
1.02
6.50
1.06
2.03
1.02
2.04
1.00
0.99
3.21
9.15


174.29
162.98
153.29
151.23
142.10
139.07
134.97
134.67
131.37
131.25
129.03
128.06
127.22
126.57
124.60
124.38
123.01
122.17
120.66
119.12
110.09
80.12
78.89
43.91
37.01
28.26
21.35
BocHN
Cl
O
O
O
O
N
Bn
4r
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm


8.04
7.58
7.57
7.56
7.36
7.34
7.33
7.31
7.30
7.29
7.28
7.27
7.26
7.24
7.23
7.22
7.21
7.20
7.19
7.17
7.16
7.15
7.14
7.13
7.12
7.10
7.09
7.08
7.07
6.96
6.94
6.93
6.92
6.80
6.78
4.93
3.76
3.71
3.06
3.01
1.45
BocHN
O
O
Ph
O
N
Bn
4s
9
8
7
6
5
4
3
2
1
ppm
0.85
0.83
0.91
14.79
1.08
1.09
1.98
1.00
0.91
8.51

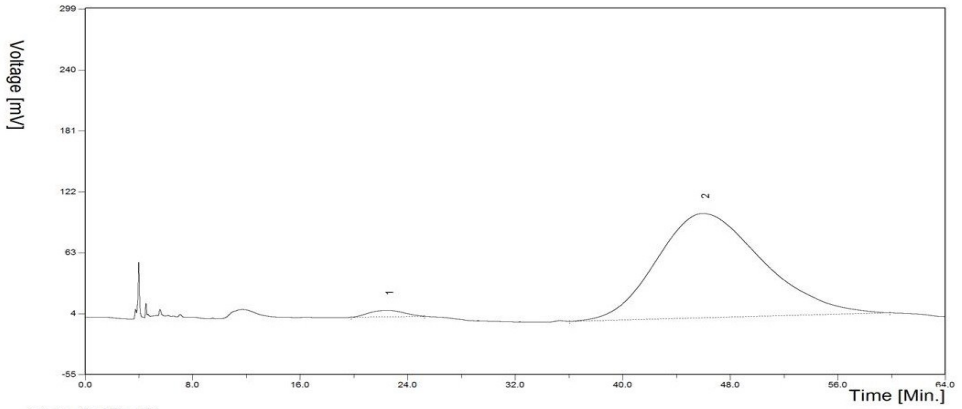

174.21
163.89
153.34
149.71
142.12
137.83
137.31
137.05
134.75
131.24
131.08
129.23
129.03
128.41
128.26
128.05
128.01
127.84
127.55
127.31
127.25
126.77
125.69
124.58
123.97
123.14
119.74
119.14
110.12
79.48
79.08
43.93
37.29
28.37
BocHN
O
O
Ph
O
N
Bn
4s
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm


7.61 7.59 7.43 7.41 7.38 7.37 7.35 7.35 7.35 7.34 7.33 7.31 7.29 7.29 7.28 7.28 7.27 7.26 7.25 7.25 7.22 7.20 7.18 7.09 7.07 7.06 7.05 7.04 7.02 7.00 6.81 6.79 6.76 6.74 6.07 5.06 5.02 5.01 5.00 4.83 4.80 3.81 3.78 3.57 3.54 2.39
Bn
N
O
OH
O
N
Bn
6
9 8 7 6 5 4 3 2 1 ppm
1.05 1.27 10.73 2.02 1.16 0.99 1.03 0.94 0.95 2.91 1.01 1.00 1.00 3.06


177.69 169.35 152.36 141.98 141.32 137.89 135.81 131.03 129.46 128.85 128.80 128.22 127.67 127.63 127.39 127.36 127.16 124.49 124.34 123.59 122.78 122.49 109.43 109.09 78.19 44.84 43.85 43.64 26.99
Bn
N
O
OH
O
N
Bn
6
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 ppm

10. Copies of HPLC Spectra of Racemic and Chiral Products

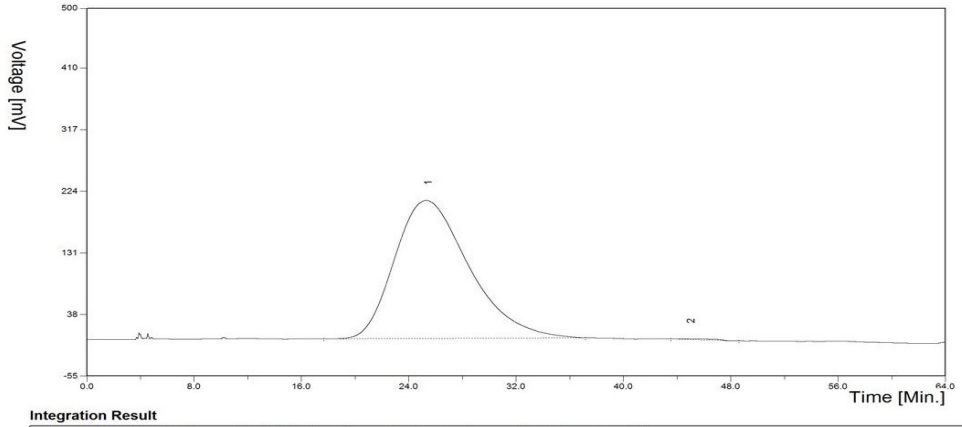
4a



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	22.49	6.20	1109.88	1.9690
2	46.00	100.97	55257.87	98.0310
Total		107.17	56367.75	100

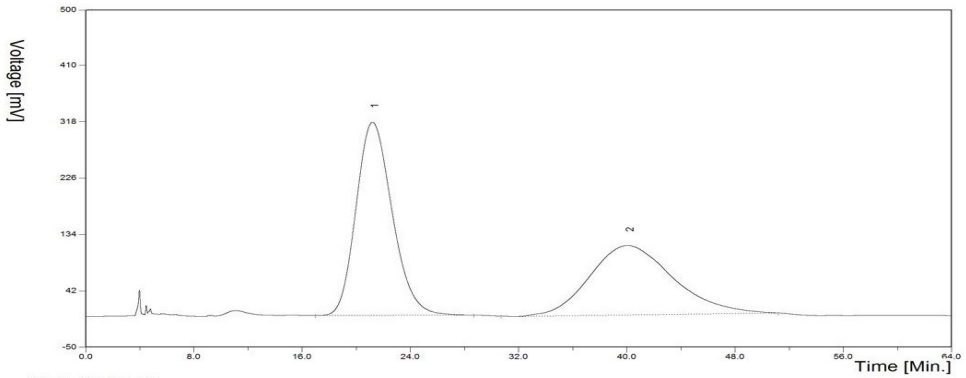
ent-4a



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	25.30	208.24	80261.49	99.7137
2	44.87	1.02	230.46	0.2863
Total		209.26	80491.95	100

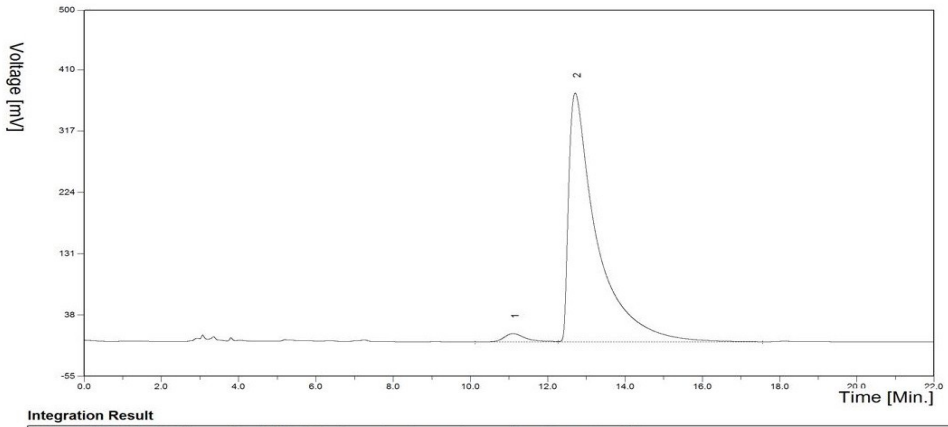
4a + *ent*-4a



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	21.19	315.07	58423.27	54.8273
2	40.05	112.82	48135.52	45.1727
Total		427.89	106558.79	100

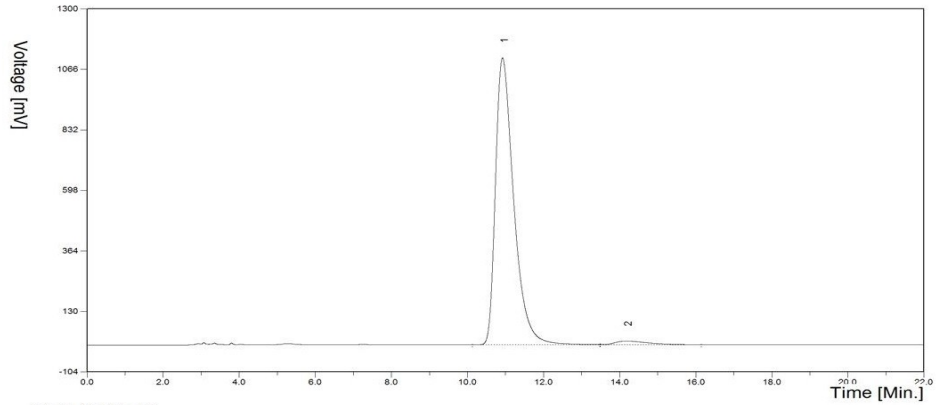
4b



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	11.10	12.36	472.75	2.4269
2	12.71	377.26	19007.34	97.5731
Total		389.62	19480.09	100

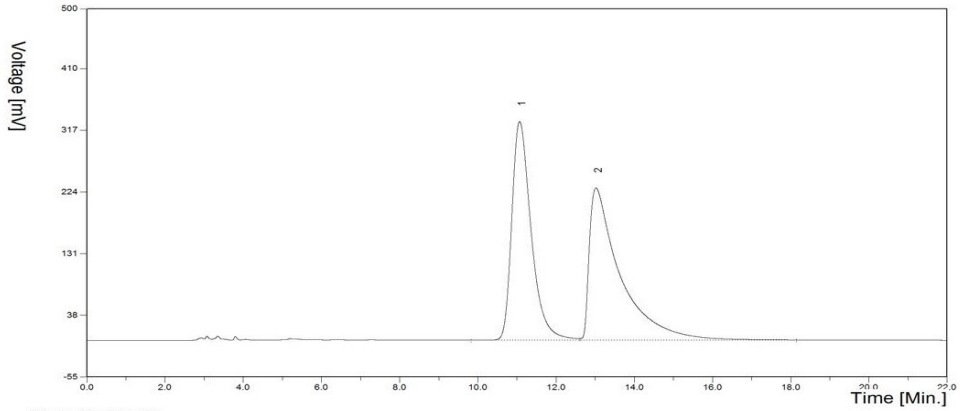
***ent*-4b**



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	10.92	1108.96	36967.40	97.7897
2	14.18	14.10	835.54	2.2103
Total		1123.05	37802.94	100

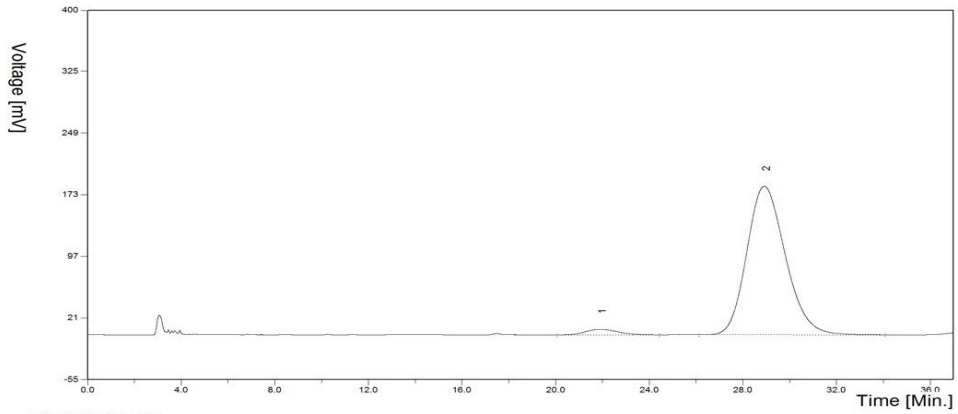
4b + *ent*-4b



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	11.07	329.45	11298.34	47.4351
2	13.02	229.22	12520.18	52.5649
Total		558.67	23818.52	100

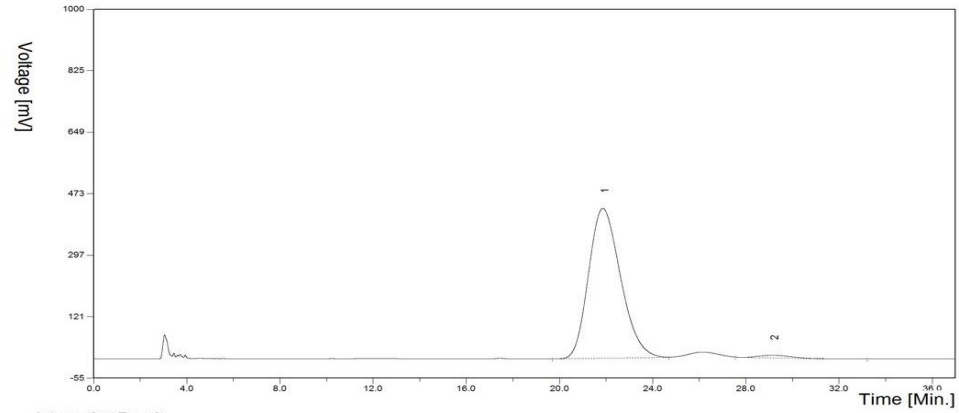
4c



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	21.90	7.03	657.67	3.0426
2	28.91	183.03	20957.31	96.9574
Total		190.06	21614.98	100

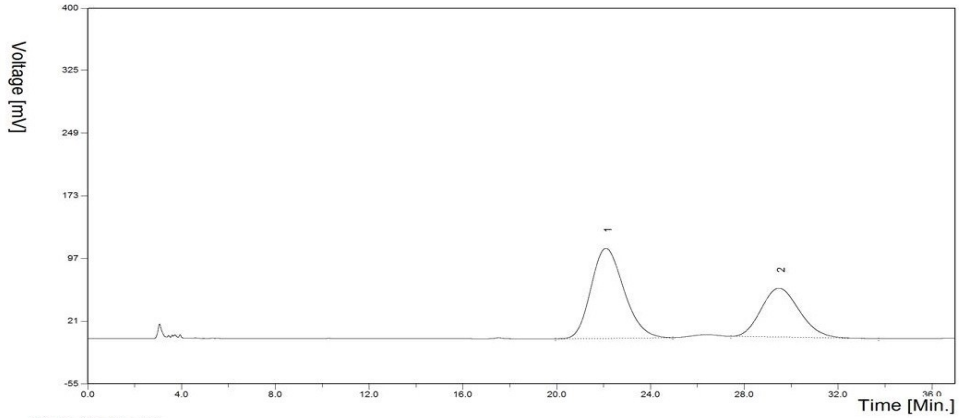
***ent*-4c**



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	21.86	428.83	40889.42	98.9444
2	29.14	6.89	436.23	1.0556
Total		435.72	41325.64	100

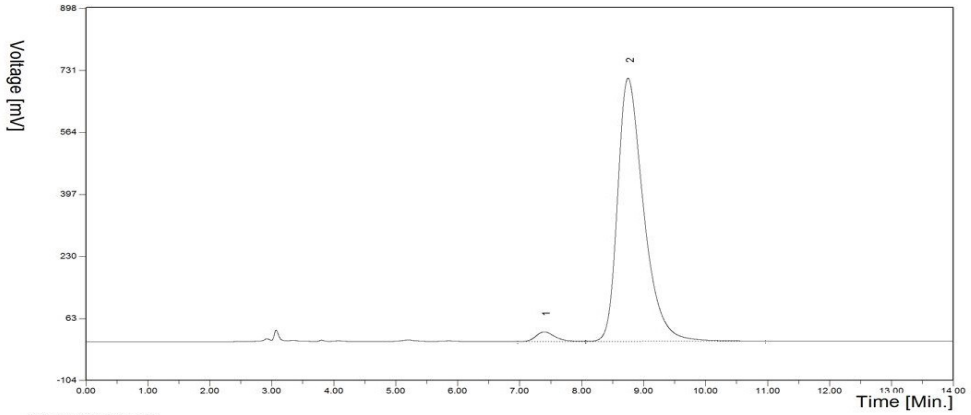
4c + ***ent*-4c**



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	22.10	109.00	10602.89	61.3076
2	29.48	59.24	6691.68	38.6924
Total		168.24	17294.58	100

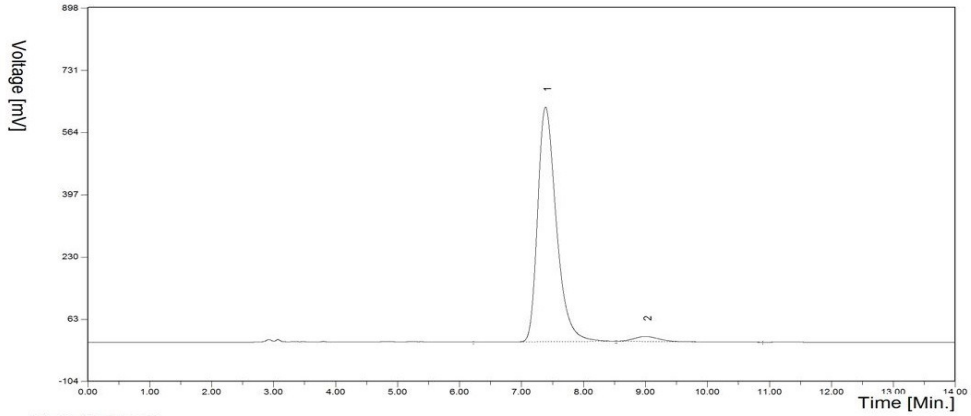
4d



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	7.40	25.89	544.05	2.5736
2	8.75	708.59	20595.94	97.4264
Total		734.47	21139.99	100

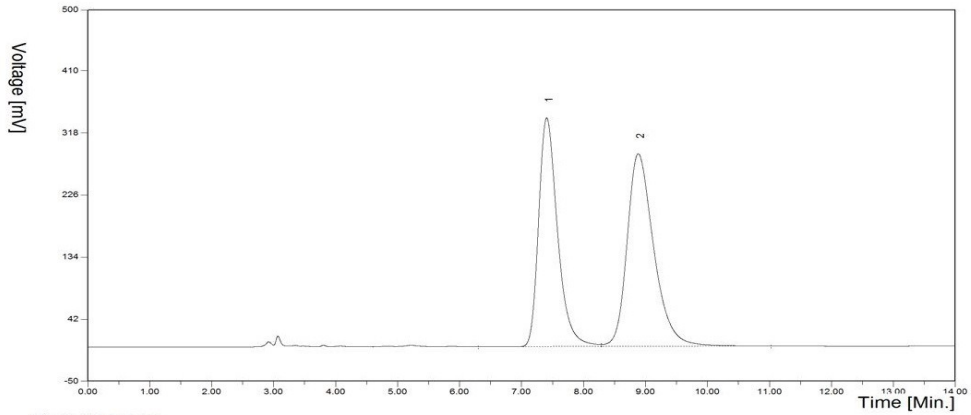
***ent*-4d**



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	7.39	629.57	13129.61	97.5256
2	9.00	13.12	333.12	2.4744
Total		642.69	13462.73	100

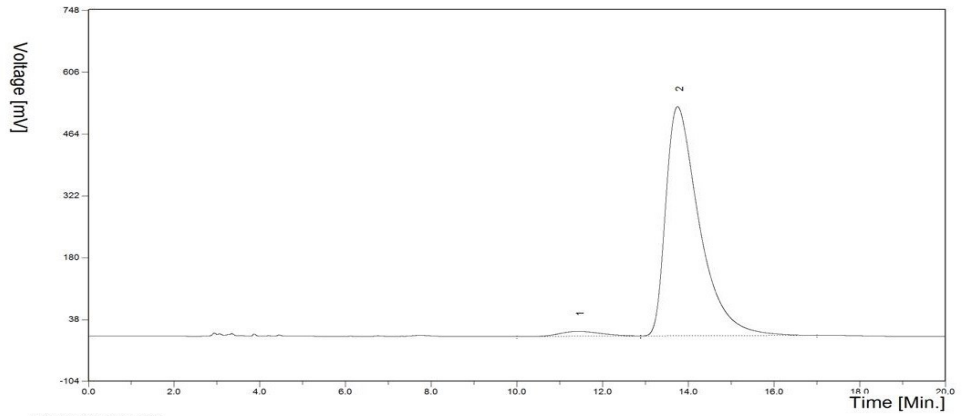
4d + *ent*-4d



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	7.41	338.99	7184.72	45.6176
2	8.88	285.41	8565.16	54.3824
Total		624.40	15749.89	100

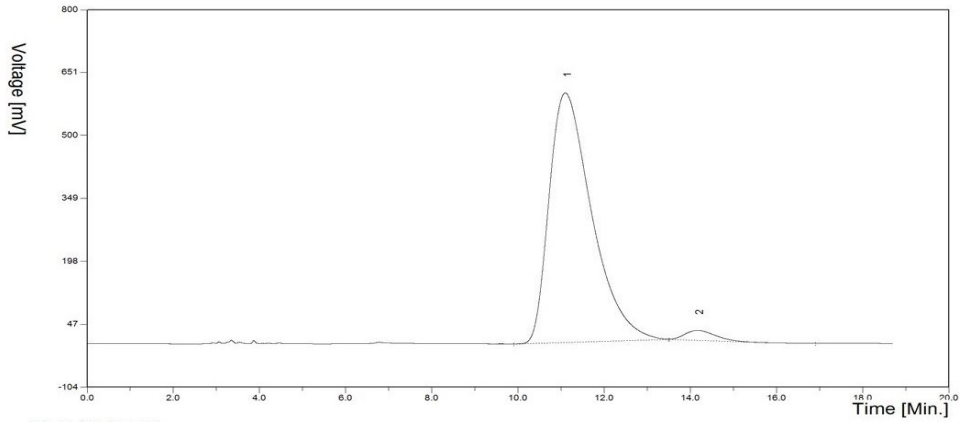
4e



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	11.43	11.32	761.66	2.5909
2	13.75	526.55	28635.70	97.4091
Total		537.87	29397.35	100

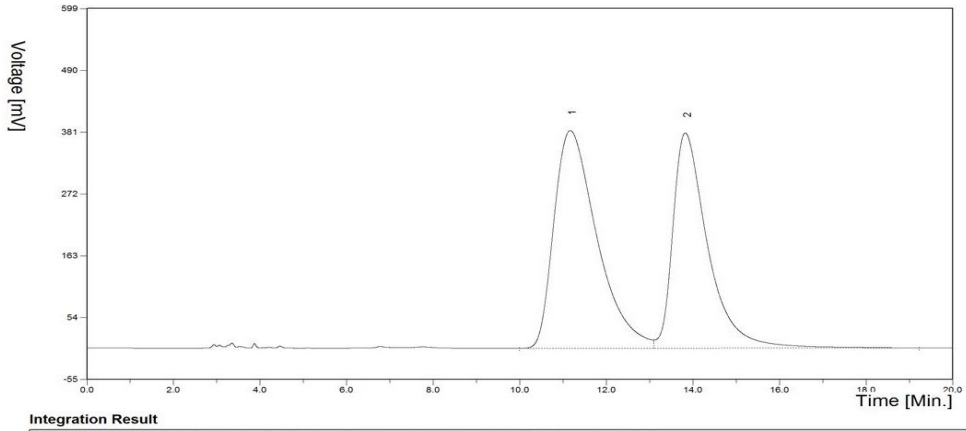
***ent*-4e**



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	11.09	597.62	40947.13	97.7155
2	14.16	23.11	957.31	2.2845
Total		620.73	41904.45	100

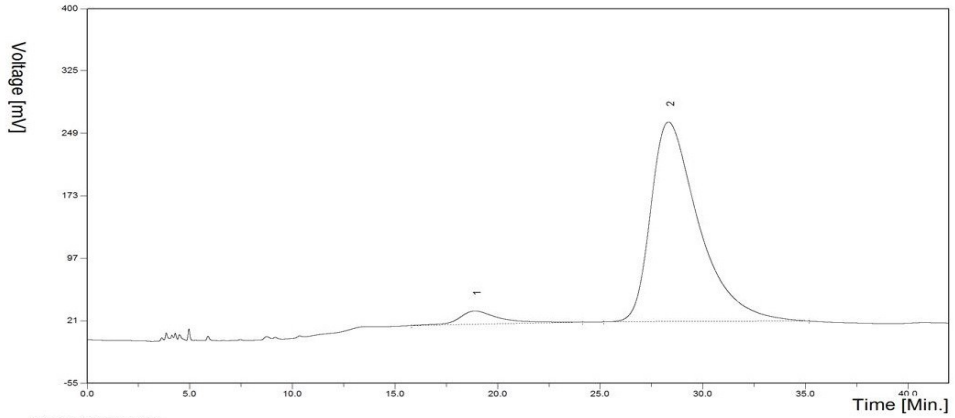
4e + *ent*-4e



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	11.16	384.04	26469.66	55.3790
2	13.82	379.76	21327.61	44.6210
Total		763.80	47797.28	100

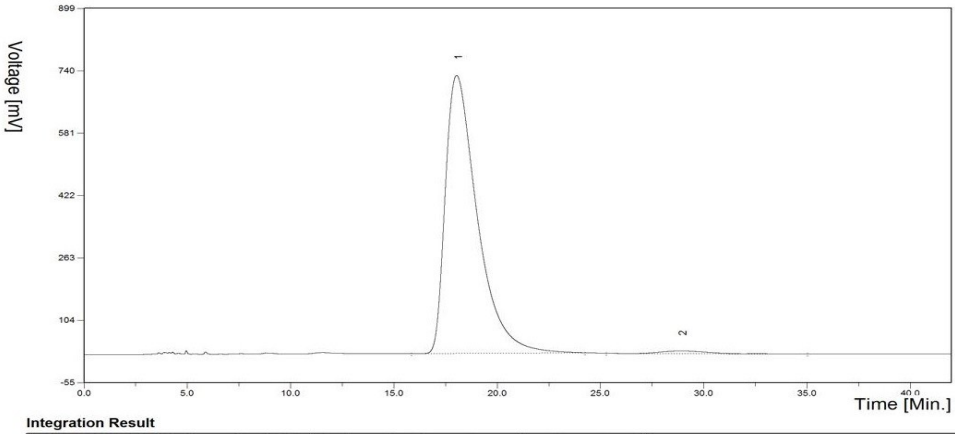
4f



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	18.90	15.99	2151.92	5.1703
2	28.33	242.55	39469.30	94.8297
Total		258.54	41621.22	100

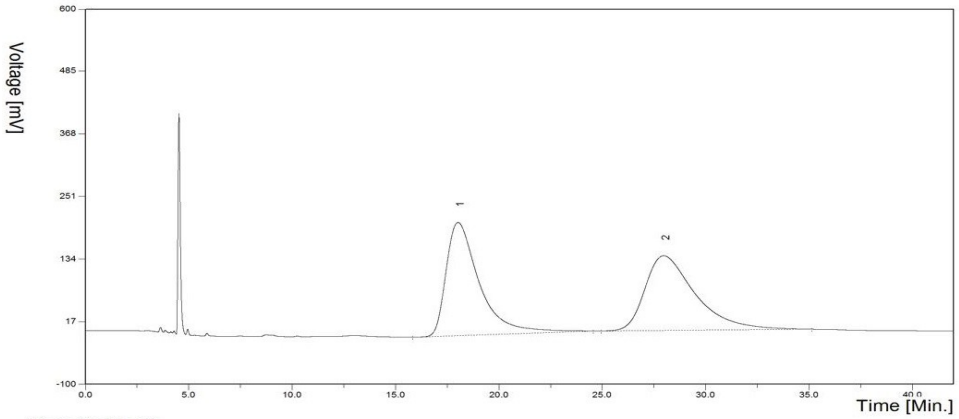
***ent*-4f**



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	18.03	708.73	76146.81	98.7448
2	28.89	6.64	967.91	1.2552
Total		715.37	77114.72	100

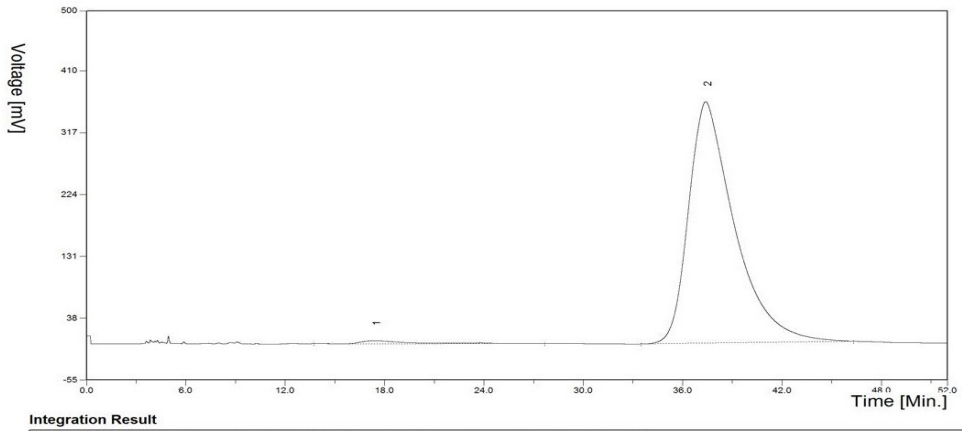
4f + *ent*-4f



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	18.02	211.22	23600.72	50.0895
2	27.97	139.41	23516.35	49.9105
Total		350.64	47117.07	100

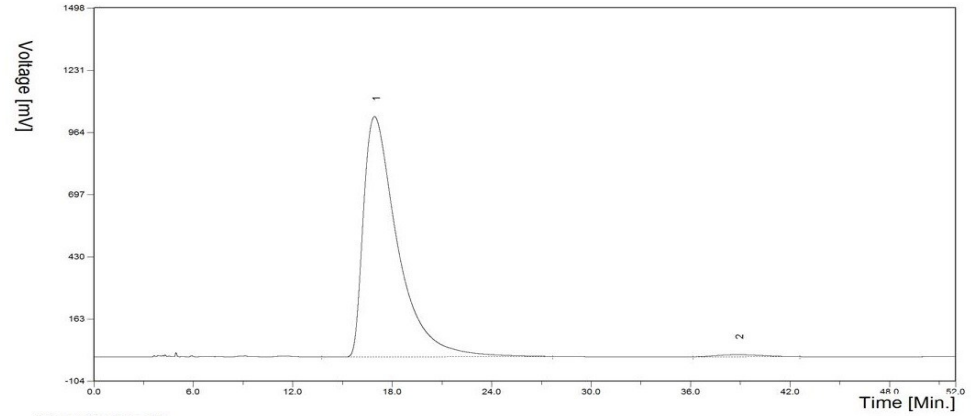
4g



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	17.39	4.32	788.84	1.1184
2	37.39	363.03	69743.91	98.8816
Total		367.35	70532.75	100

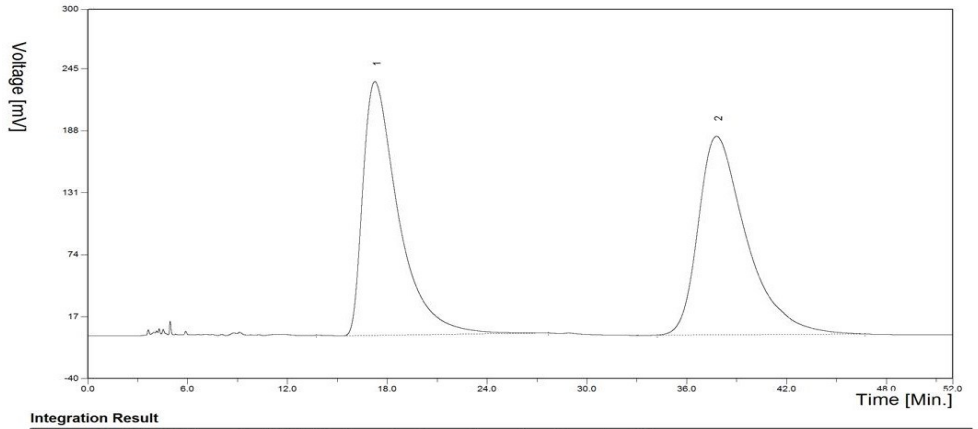
***ent*-4g**



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	16.93	1031.08	147038.34	98.8653
2	38.84	8.99	1687.54	1.1347
Total		1040.07	148725.88	100

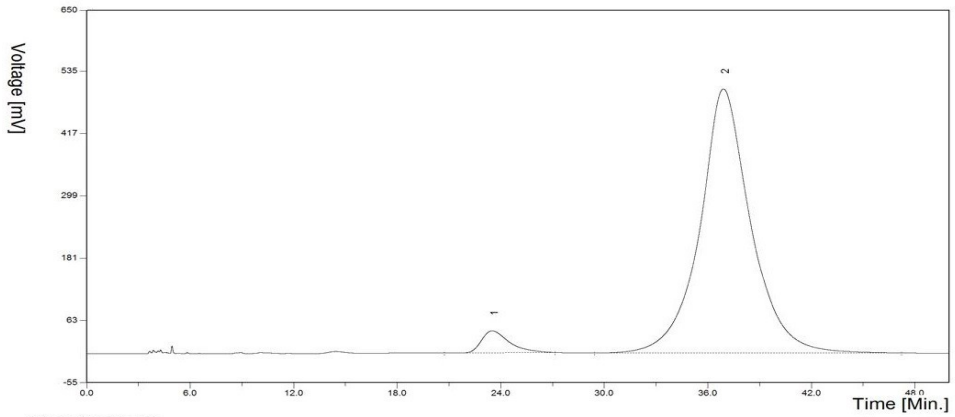
4f + *ent*-4f



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	17.25	232.81	34380.81	48.3359
2	37.79	182.60	36748.05	51.6641
Total		415.41	71128.86	100

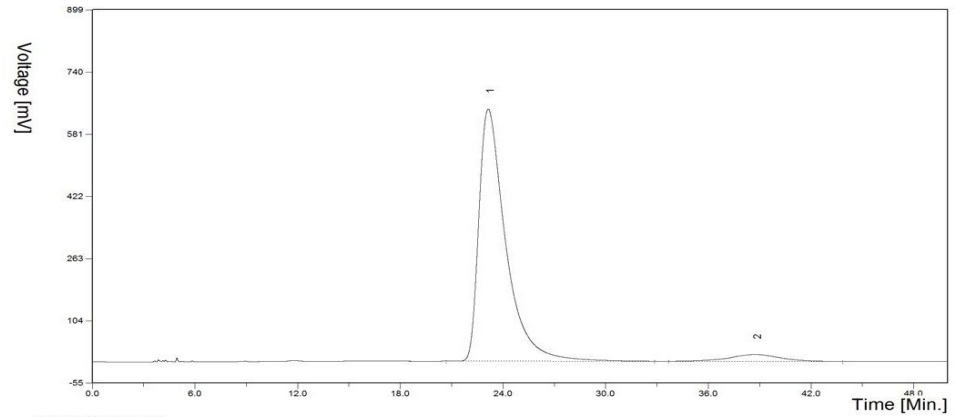
4h



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	23.50	41.66	4617.15	4.3154
2	36.90	499.88	102375.25	95.6846
Total		541.54	106992.40	100

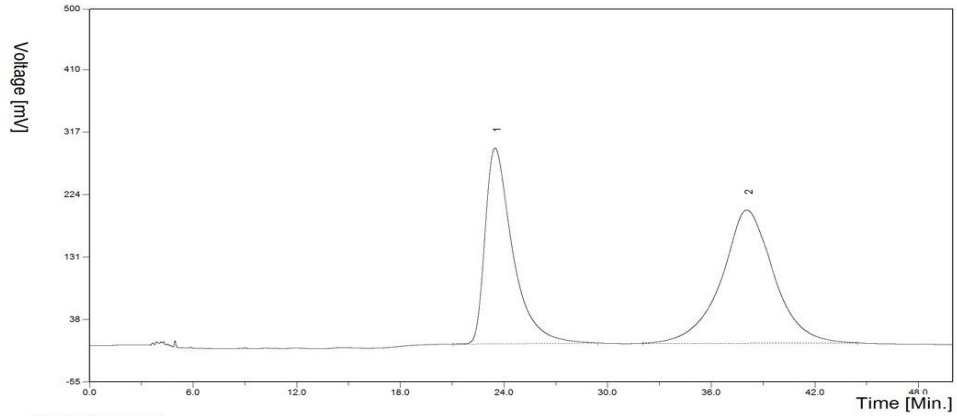
***ent*-4h**



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	23.14	644.40	70112.19	95.1565
2	38.74	17.32	3568.74	4.8435
Total		661.72	73680.93	100

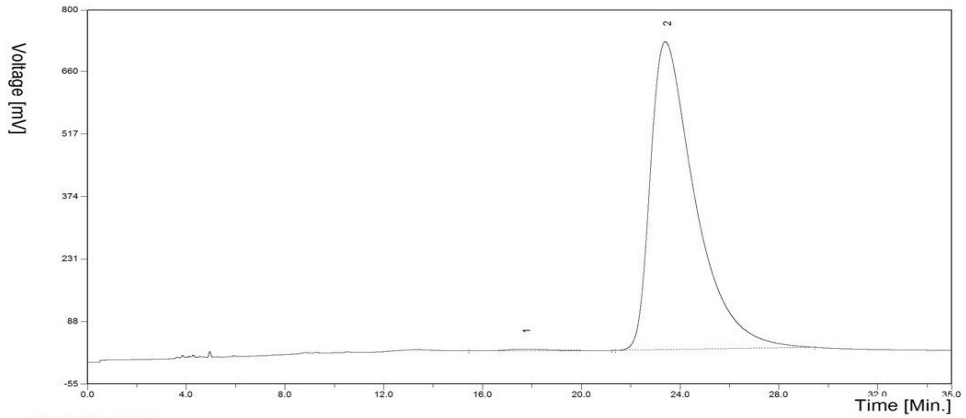
4h + *ent*-4h



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	23.48	291.37	32236.53	43.5988
2	38.06	198.12	41702.59	56.4012
Total		489.49	73939.12	100

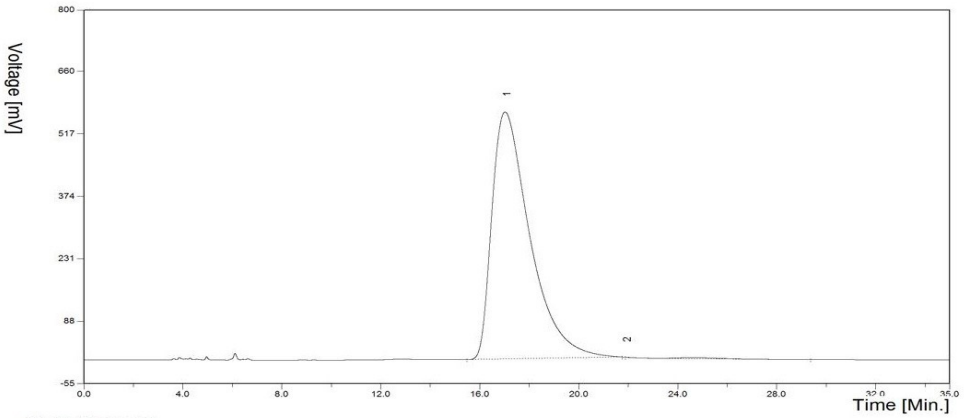
4i



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	17.71	3.84	409.75	0.4608
2	23.40	704.38	88520.11	99.5392
Total		708.22	88929.85	100

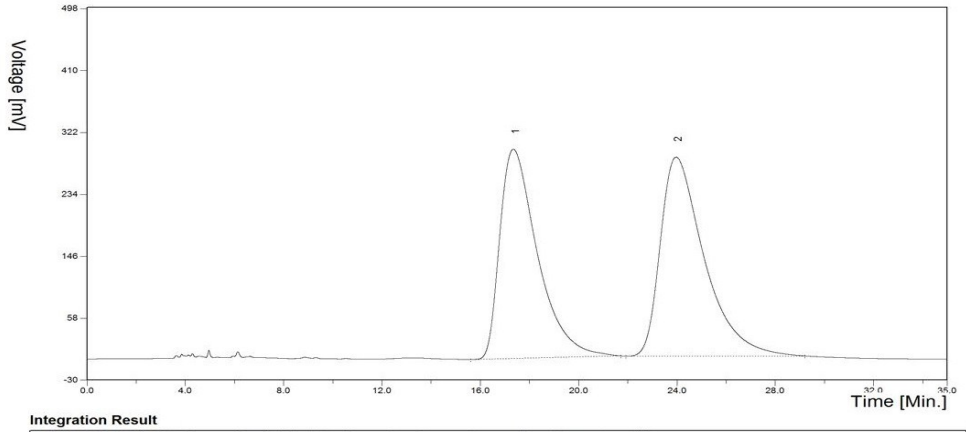
***ent*-4i**



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	17.02	565.52	60210.63	99.7489
2	21.88	0.00	151.57	0.2511
Total		565.52	60362.20	100

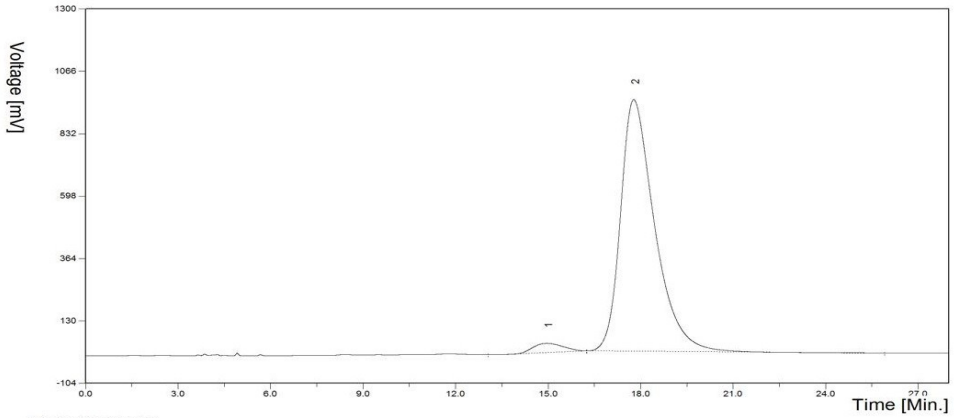
4i + *ent*-4i



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	17.34	297.27	31629.73	47.4625
2	23.97	282.83	35011.76	52.5375
Total		580.09	66641.49	100

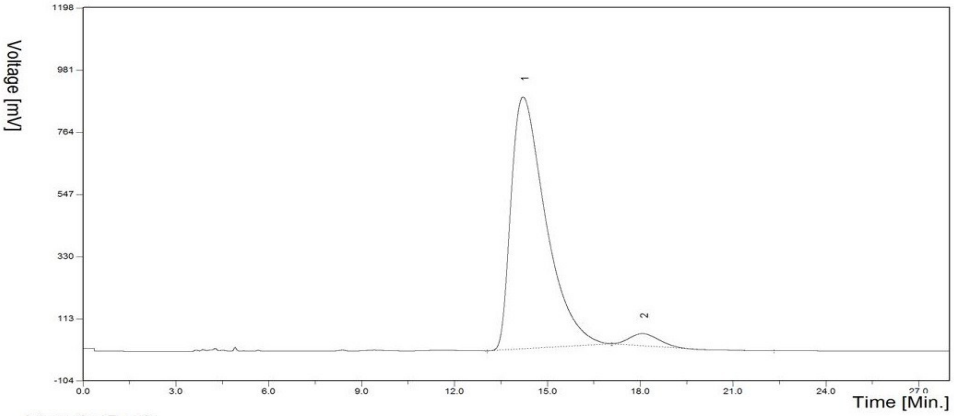
4j



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	14.96	34.12	2186.22	2.9280
2	17.78	943.25	72479.80	97.0720
Total		977.36	74666.02	100

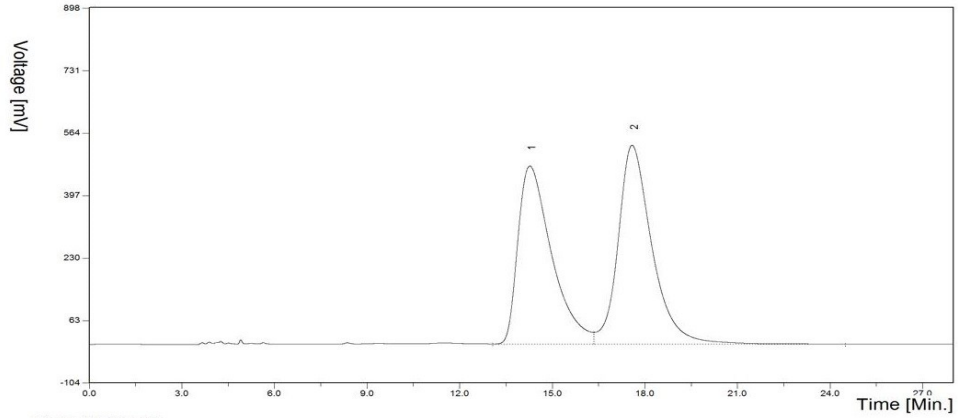
***ent*-4j**



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	14.21	879.31	68391.35	97.6573
2	18.07	39.66	1640.64	2.3427
Total		918.97	70031.99	100

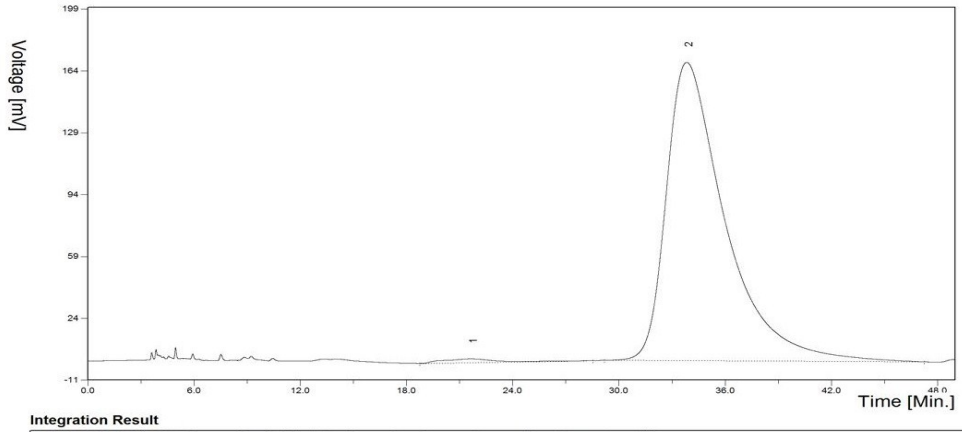
4j + ***ent*-4j**



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	14.27	476.00	36098.27	47.1311
2	17.58	531.36	40492.93	52.8689
Total		1007.36	76591.20	100

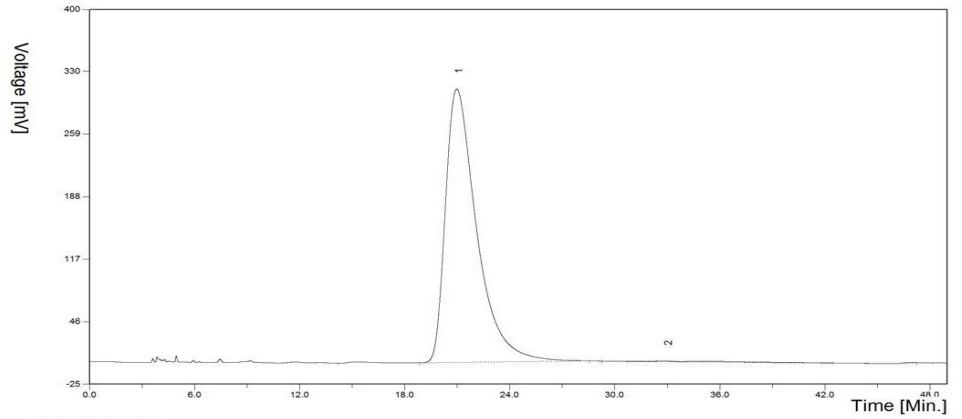
4k



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	21.65	2.13	418.89	1.0640
2	33.83	168.82	38950.86	98.9360
Total		170.95	39369.75	100

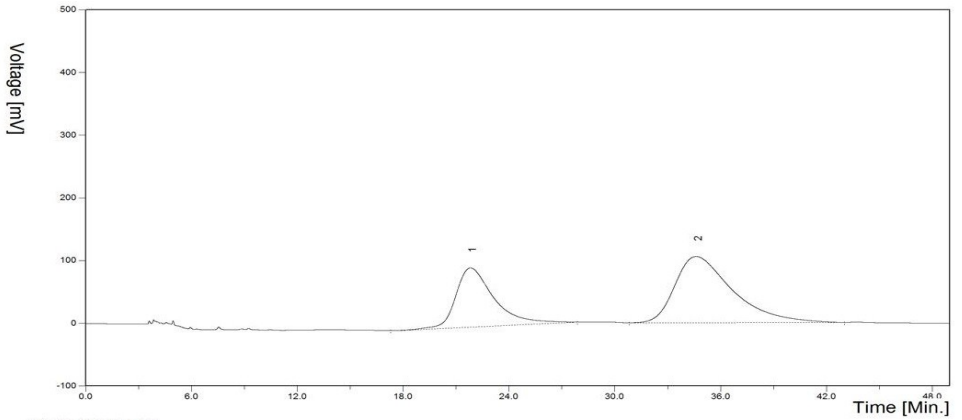
***ent*-4k**



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	20.98	309.93	38398.90	99.1976
2	32.95	0.45	310.61	0.8024
Total		310.38	38709.51	100

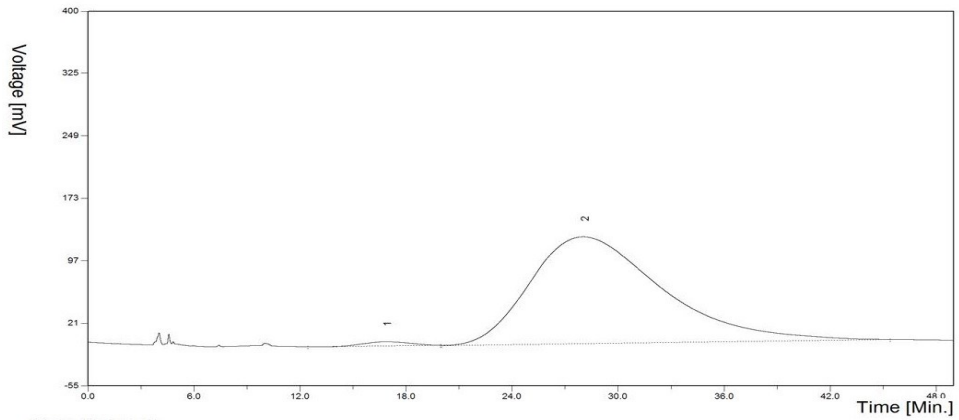
4k + *ent*-4k



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	21.83	94.00	14036.45	37.0461
2	34.62	105.54	23852.67	62.9539
Total		199.54	37889.12	100

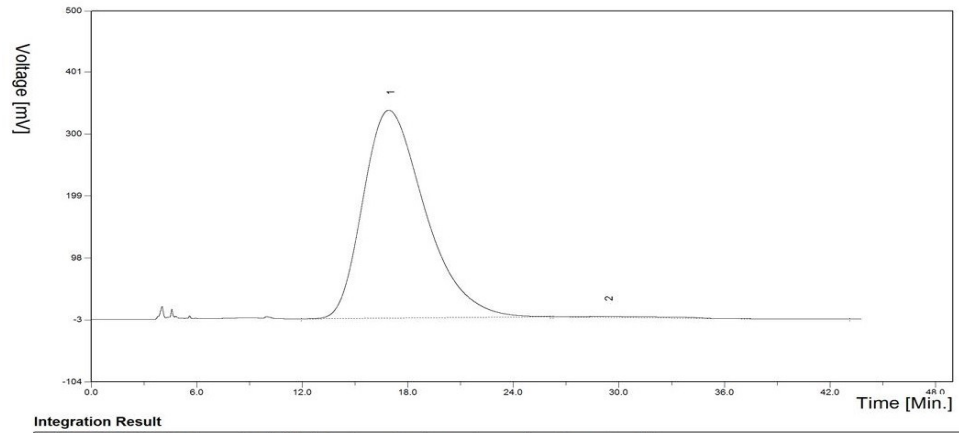
4l



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	16.84	5.03	886.14	1.3006
2	28.02	129.69	67248.59	98.6994
Total		134.72	68134.73	100

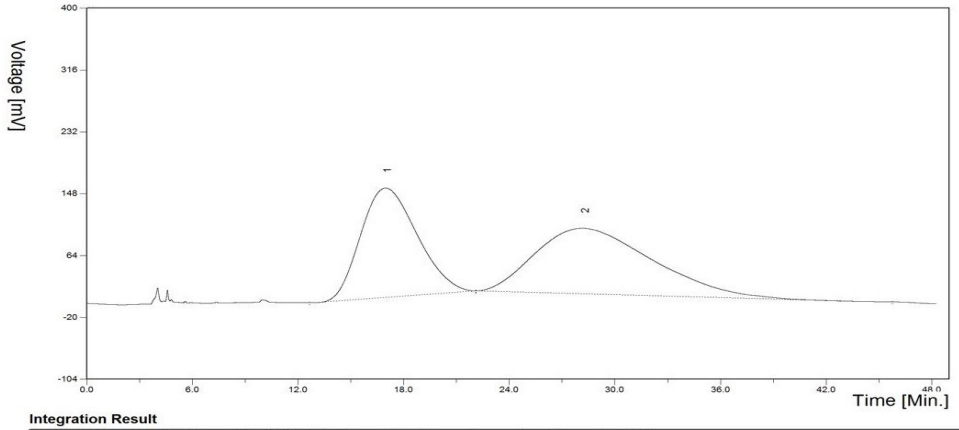
***ent*-4l**



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	16.92	338.43	82836.82	99.8462
2	29.31	0.85	127.64	0.1538
Total		339.27	82964.46	100

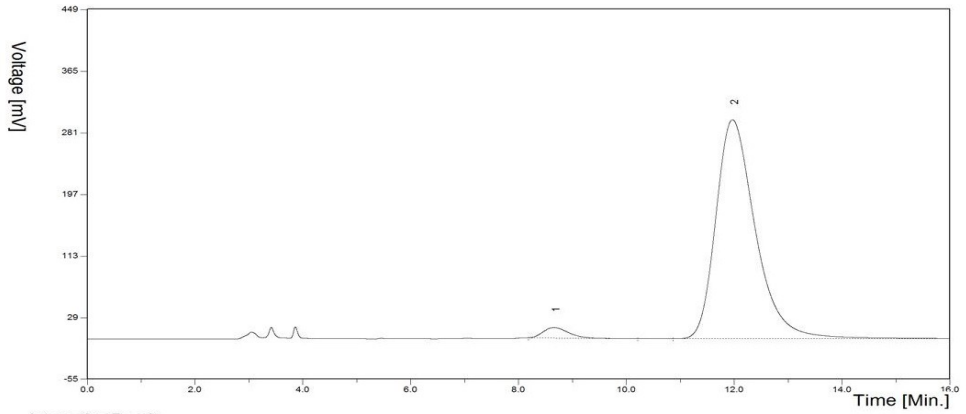
4l + *ent*-4l



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	16.97	148.22	32924.82	44.5838
2	28.20	88.76	40924.44	55.4162
Total		236.98	73849.26	100

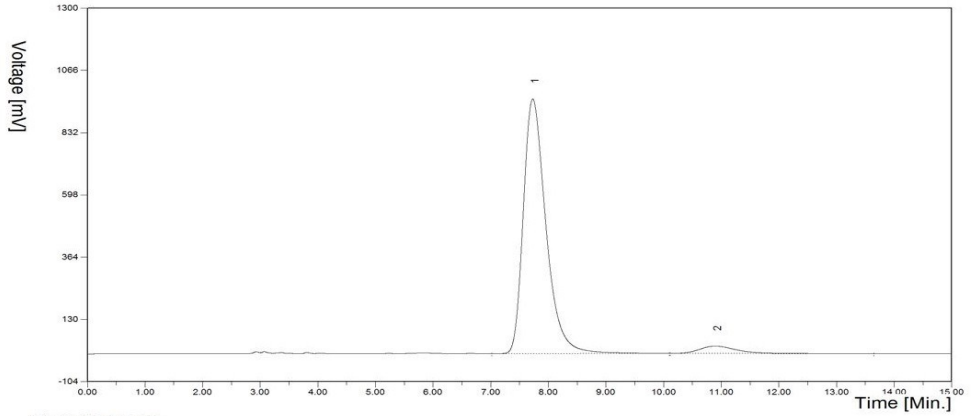
4m



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	8.66	14.39	467.24	2.9818
2	11.97	298.80	15202.39	97.0182
Total		313.19	15669.63	100

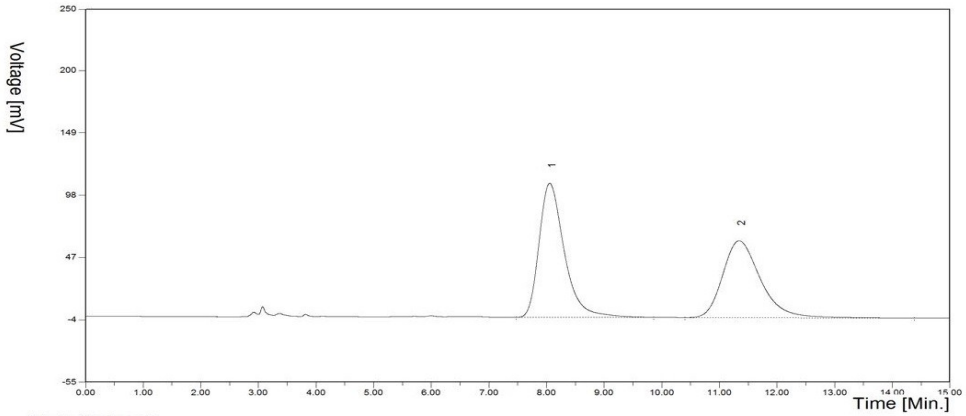
***ent*-4m**



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	7.73	957.31	26107.57	95.4734
2	10.90	27.91	1237.80	4.5266
Total		985.22	27345.38	100

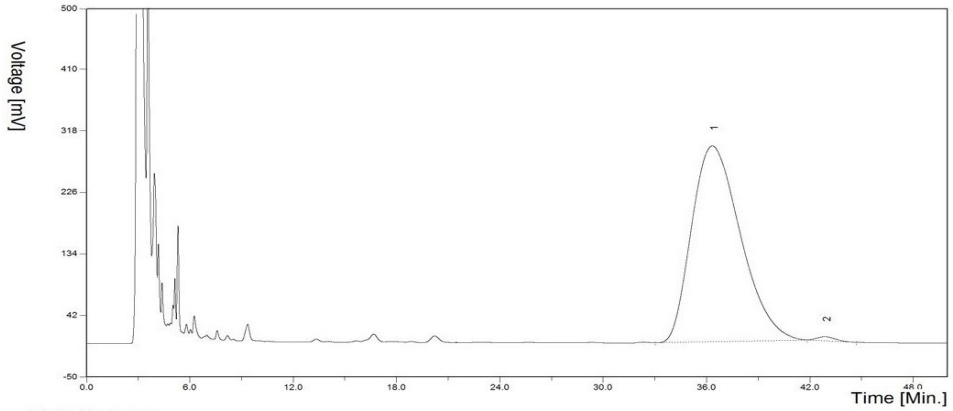
4m + *ent*-4m



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	8.05	109.55	3335.08	53.6970
2	11.34	62.94	2875.85	46.3030
Total		172.49	6210.93	100

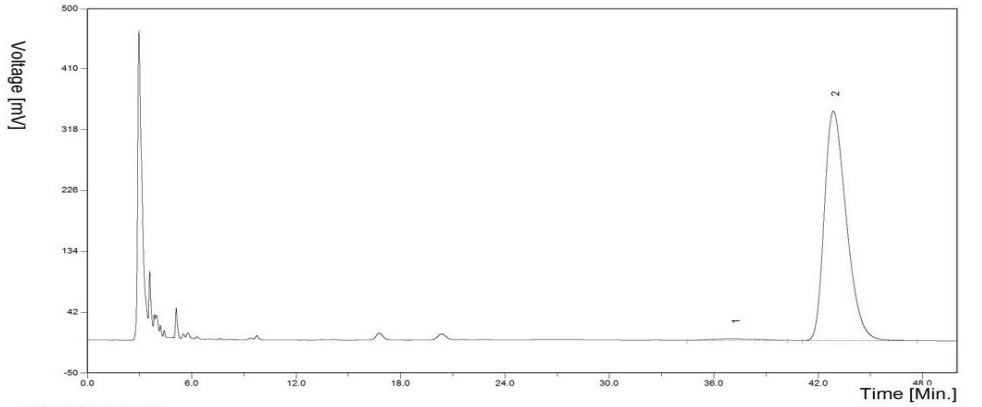
4n



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	36.34	292.64	57756.23	99.2528
2	42.87	6.09	434.80	0.7472
Total		298.73	58191.03	100

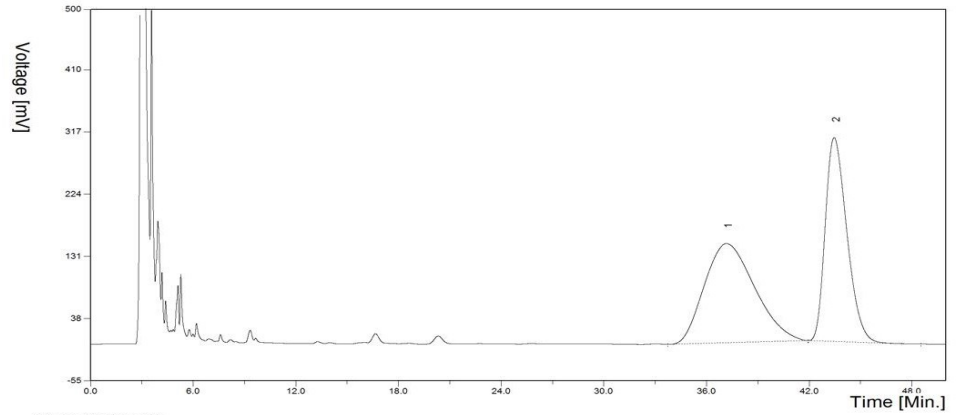
***ent*-4n**



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	37.14	2.30	429.01	1.3923
2	42.87	346.52	30383.93	98.6077
Total		348.82	30812.94	100

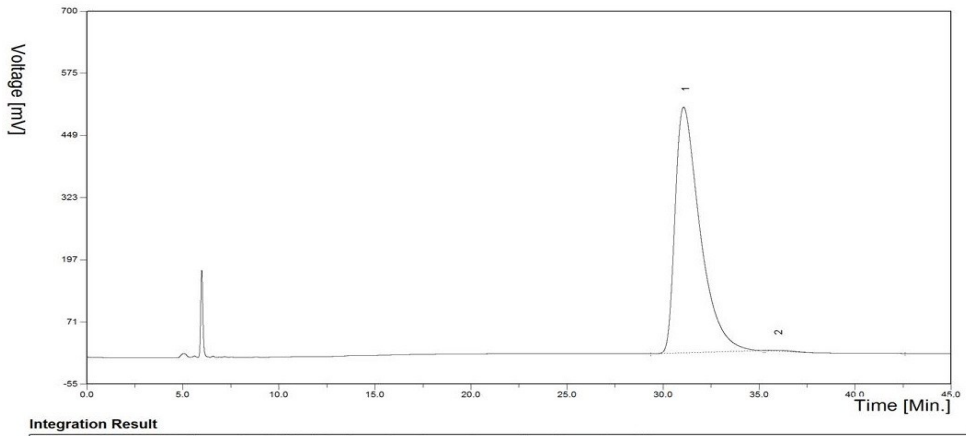
4n + *ent*-4n



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	37.16	148.51	30297.04	53.1351
2	43.46	304.74	26721.87	46.8649
Total		453.25	57018.91	100

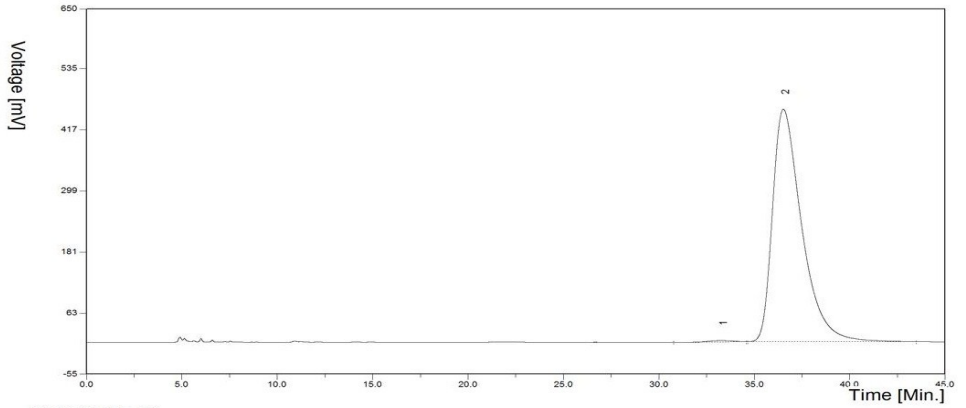
4o



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	31.07	497.47	44793.38	98.8945
2	35.90	1.10	500.71	1.1055
Total		498.57	45294.08	100

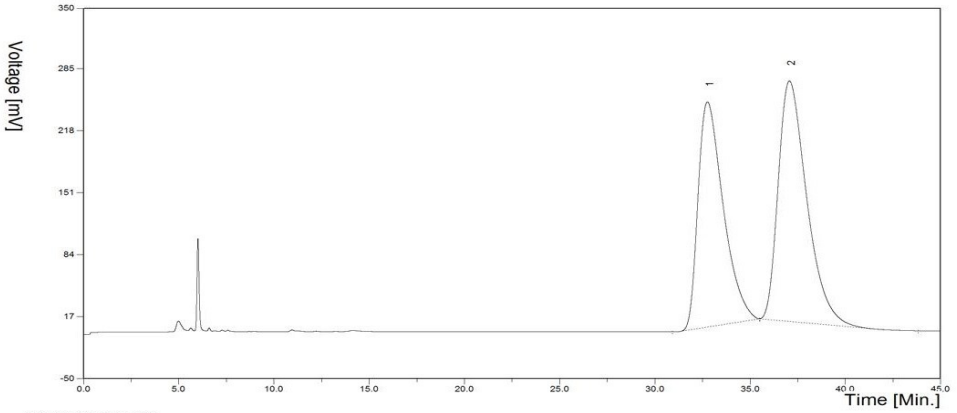
***ent*-4o**



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	33.26	2.46	189.03	0.3945
2	36.53	448.55	47722.75	99.6055
Total		451.01	47911.78	100

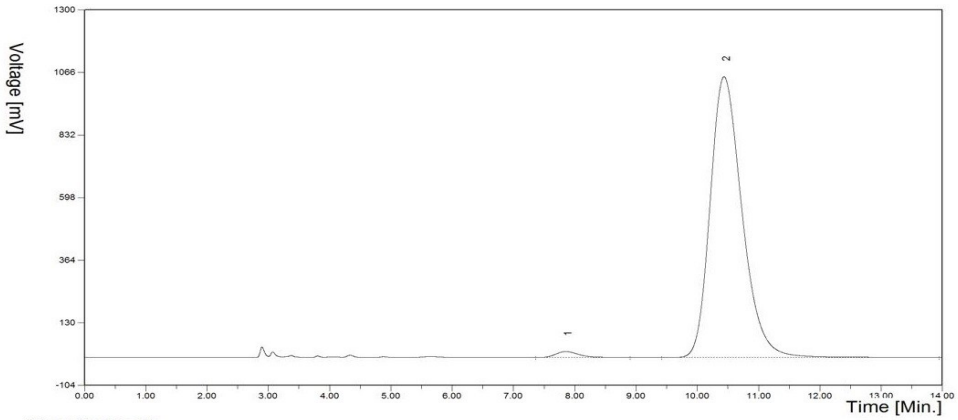
4o + *ent*-4o



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	32.76	242.70	22305.11	45.5718
2	37.06	259.45	26639.91	54.4282
Total		502.15	48945.01	100

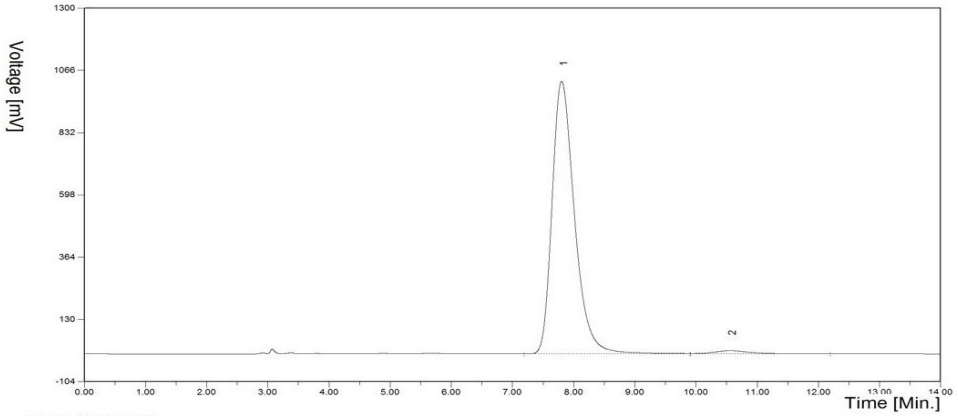
4p



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	7.86	22.14	577.53	1.5009
2	10.44	1049.58	37899.97	98.4991
Total		1071.72	38477.50	100

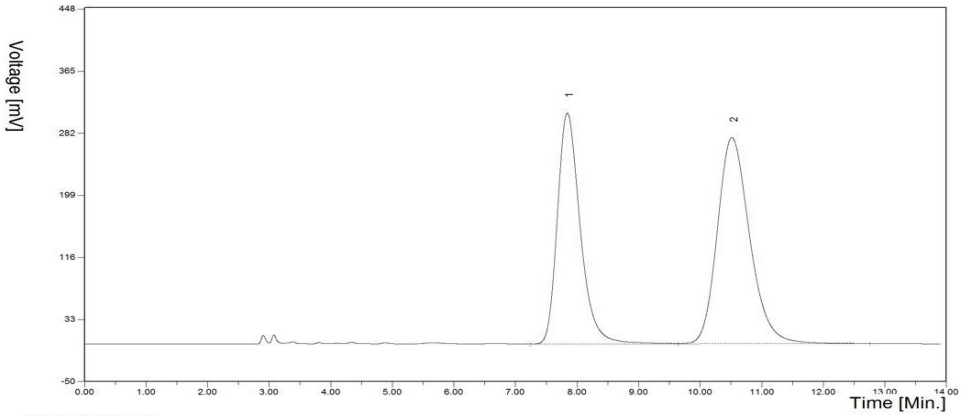
***ent*-4p**



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	7.80	1024.26	26157.38	98.2079
2	10.56	11.69	477.31	1.7921
Total		1035.96	26634.69	100

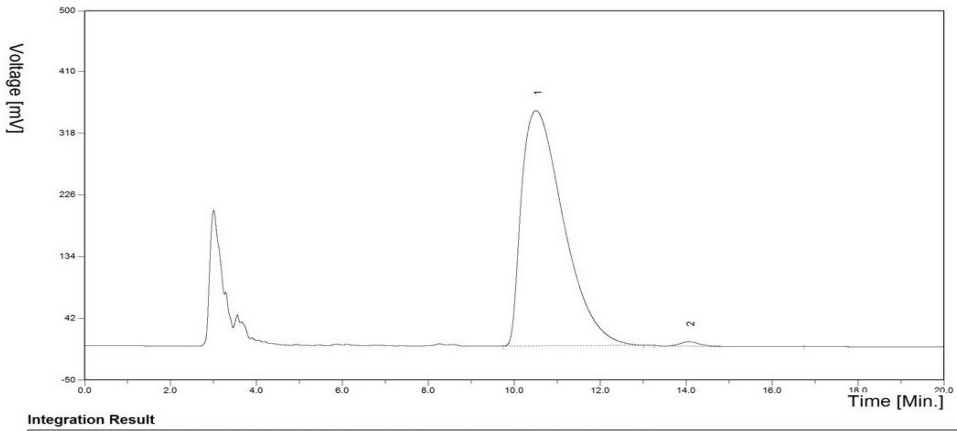
4p + *ent*-4p



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	7.84	308.66	7961.74	44.1941
2	10.52	275.68	10053.66	55.8059
Total		584.34	18015.40	100

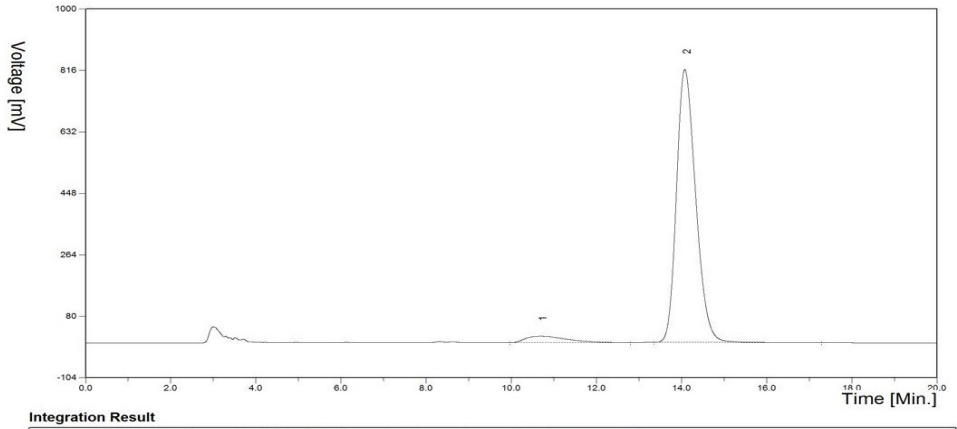
4q



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	10.50	350.53	23803.90	99.5484
2	14.06	5.92	107.98	0.4516
Total		356.45	23911.89	100

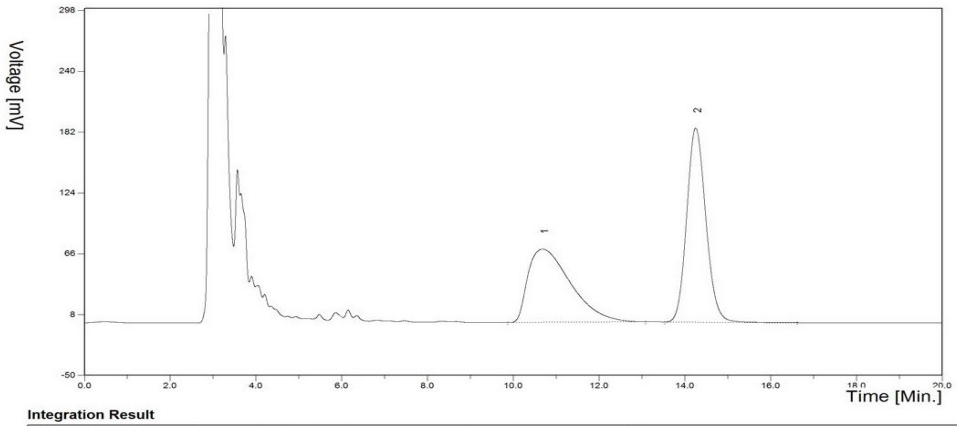
***ent*-4q**



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	10.69	18.98	1299.00	4.8274
2	14.07	817.14	25610.06	95.1726
Total		836.12	26909.06	100

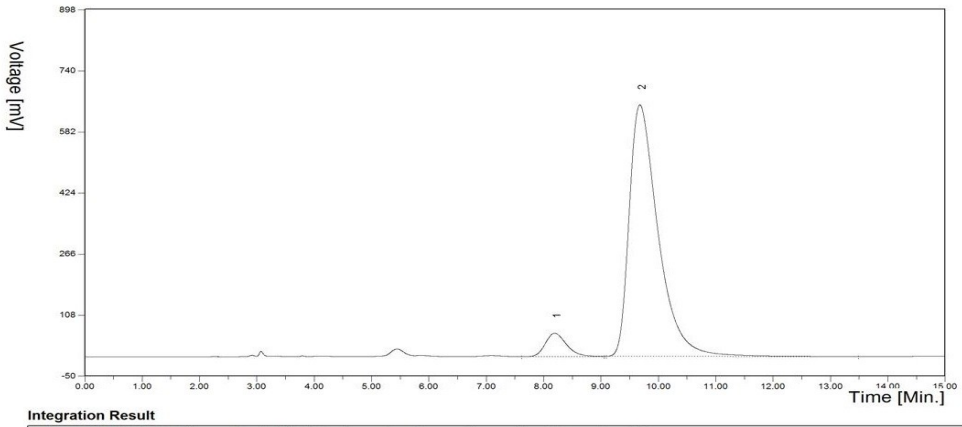
4q + *ent*-4q



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	10.68	69.87	4831.57	45.7329
2	14.25	185.20	5733.20	54.2671
Total		255.07	10564.77	100

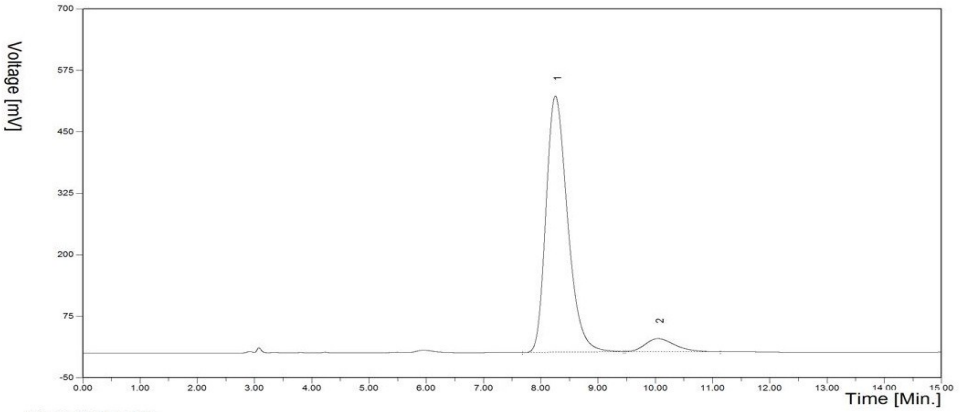
4r



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	8.19	60.11	1532.98	6.2976
2	9.68	650.83	22809.39	93.7024
Total		710.93	24342.36	100

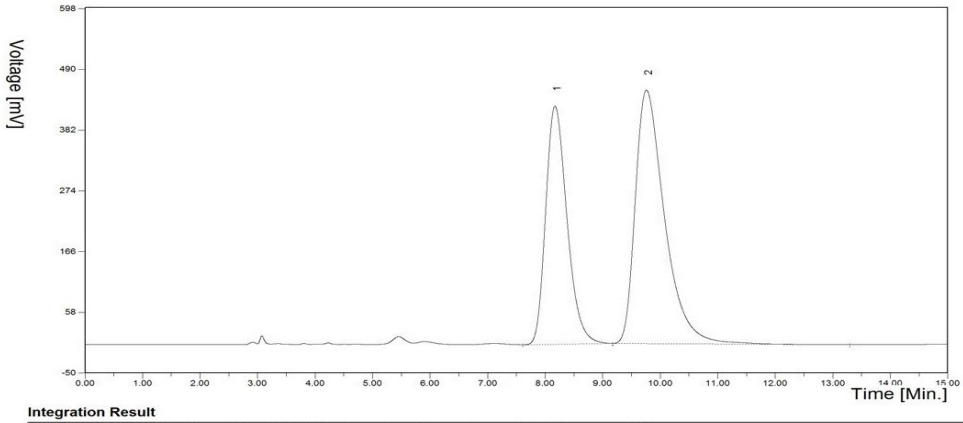
***ent*-4r**



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	8.25	521.02	13612.37	93.5629
2	10.05	26.44	936.53	6.4371
Total		547.47	14548.90	100

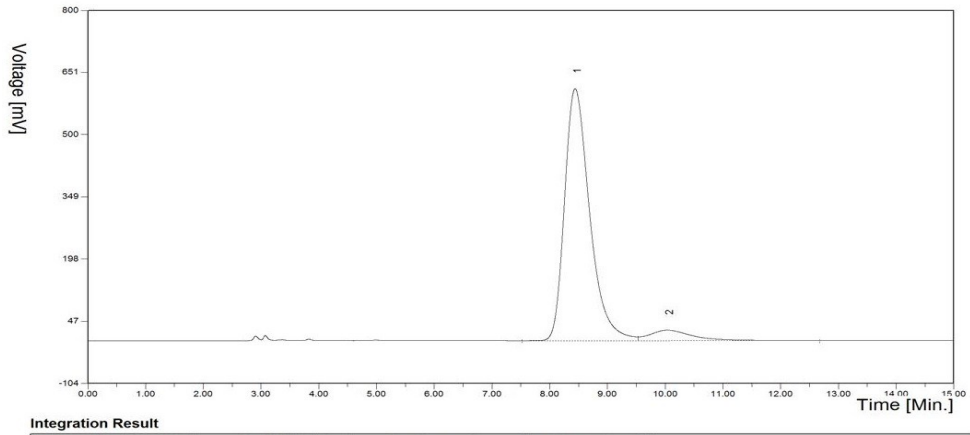
4r + *ent*-4r



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	8.17	423.67	10907.43	40.5887
2	9.76	450.68	15965.67	59.4113
Total		874.35	26873.11	100

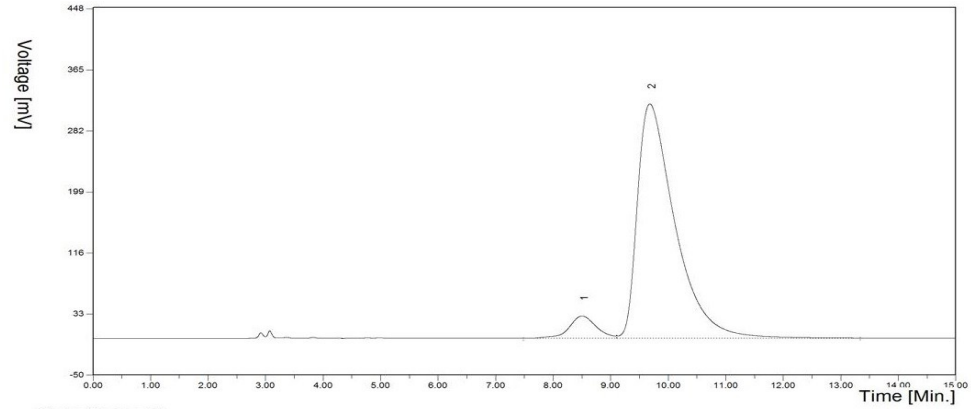
4s



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	8.44	610.88	18459.44	93.5433
2	10.04	25.05	1274.14	6.4567
Total		635.93	19733.58	100

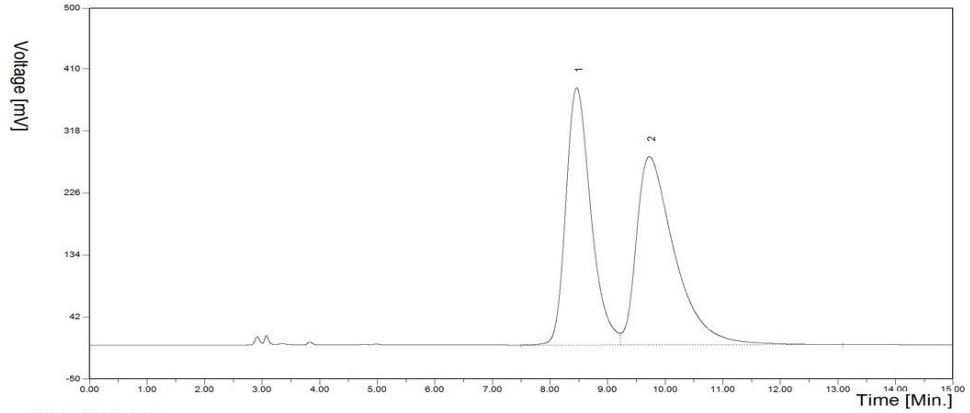
***ent*-4s**



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	8.50	30.47	997.79	6.4533
2	9.68	318.63	14463.93	93.5467
Total		349.10	15461.73	100

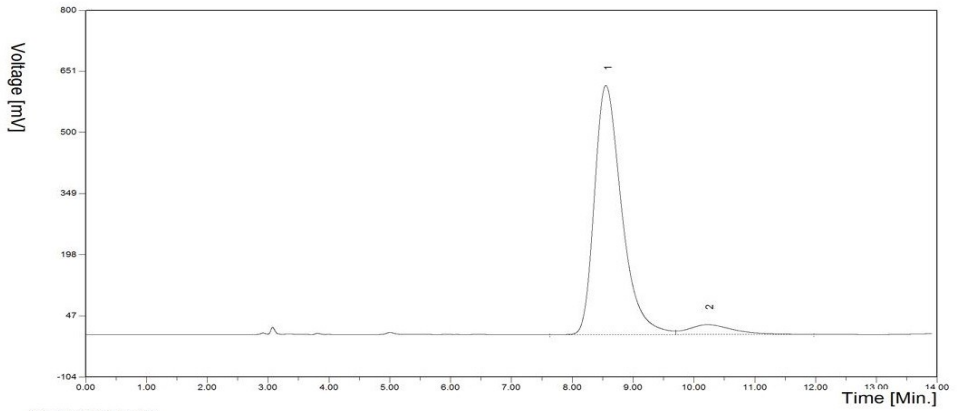
4s + *ent*-4s



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	8.46	381.36	11512.52	47.2482
2	9.73	279.29	12853.53	52.7518
Total		660.65	24366.05	100

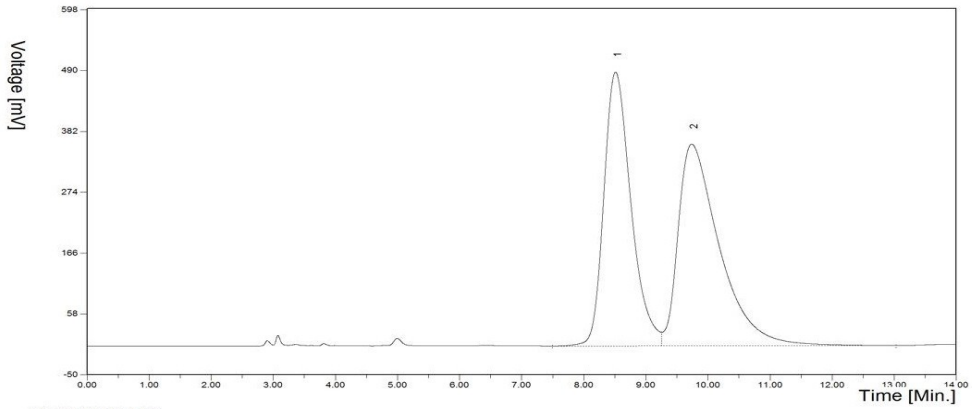
4s from (*Z*)-2d



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	8.55	614.44	19128.16	93.9910
2	10.22	24.19	1222.90	6.0090
Total		638.63	20351.06	100

4s + *ent*-4s



Integration Result

#	Ret. Time(min)	Peak Height(mv)	Area(mv.sec)	Area Percentage(%)
1	8.51	486.20	14768.57	47.1569
2	9.74	357.98	16549.34	52.8431
Total		844.18	31317.91	100