Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

Supporting Information

Dinuclear zinc-catalyzed asymmetric [3+2] cyclization reaction for direct assembly of chiral α-amino-γ-butyrolactones bearing three stereocenters

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General Information

All reactions were carried out under an atmosphere of argon using oven-dried glassware. Super dry solvents, metal catalysts, were purchased from chemical companies and used without further treatment. Flash column chromatography was performed using silica gel (300-400 mesh). ^{1}H NMR ,^{13}C NMR, ^{19}F NMR spectra were recorded in $CDCl_3$ or DMSO-d_6 on a 400 MHz spectrometer; chemical shifts are reported in ppm with the solvent signals as reference, and coupling constants (J) are given in Hertz. The peak information is described as: s = singlet, d = doublet, t = triplet, q = quartet, m= multiplet. High-resolution mass spectra (HRMS) were recorded on a commercial apparatus (ESI Source). α-Hydroxy-1-indanone[1], α-hydroxyacetophenone[2], 3-hydroxychroman-4-one[3] and alkylidene azlactone[4] were synthesized according to the literature.

General Procedure for optimization of the reaction conditions.

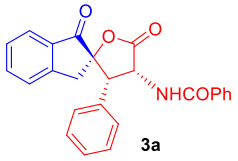
Under a nitrogen atmosphere, a solution of diethylzinc (40 μL, 1.0 M in hexane, 0.04 mmol) was added dropwise to a solution of **L** (0.02 mmol) in solvent (2 mL). After the mixture was stirred for 30 min at room temperature, then, α-hydroxy-1-indanone **1a** (0.2 mmol) and alkylidene azlactone **2a** (0.2 mmol) were added. The reaction mixture was stirred for 24 h at the same temperature. The reaction was quenched with HCl solution (1 M, 2 mL), and the organic layer was extracted with CH_2Cl_2 (3 × 5 mL). The combined organic layer was washed with brine and dried over Na_2SO_4. The solvent was removed under reduced pressure by using a rotary evaporator. The residue was purified by flash chromatography with petroleum ether/ethyl acetate (4/1) to afford the desired product **3a**.

Synthesis of chiral α-amino-γ-butyrolactones.

Under a nitrogen atmosphere, a solution of diethylzinc (40 μL, 1.0 M in hexane, 0.04 mmol) was added dropwise to a solution of **L4** (0.02 mmol) in THF (2 mL). After the mixture was stirred for 30 min at room temperature, then, α-hydroxy-1-indanone **1** or α-hydroxyacetophenone **1** or 3-hydroxychroman-4-one **1** (0.2 mmol) and alkylidene azlactone **2** (0.2 mmol) were added. The reaction mixture was stirred for 24 h at the same temperature. The reaction was quenched with HCl solution (1 M, 2 mL), and the organic layer was extracted with CH_2Cl_2 (3 × 5 mL). The combined organic layer was washed with brine and dried over Na_2SO_4. The solvent was removed under reduced pressure by using a rotary evaporator. The residue was purified by flash chromatography with petroleum ether/ethyl acetate (4/1) to afford the desired product **3**.

Characterization of 3

***N*-((2S,3S,4R)-1',5-dioxo-3-phenyl-1',3',4,5-tetrahydro-3*H*-spiro[furan-2,2'-inden]-4-yl)benzamide (3a):**

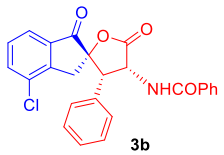


3a

Yellow solid in 70% isolated yield (83mg, >20:1 dr); $[\alpha]_D^{20}$ = +125 (c = 1.0, DMSO, 99% ee); **m.p.** = 112.6-113.4 ℃; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.70 (d, *J* = 7.6 Hz, 1H), 7.84 (d, *J* = 7.6 Hz, 1H), 7.79-7.73 (m, 1H), 7.56-7.43 (m, 5H), 7.39-7.30 (m, 5H), 7.20-7.13 (m, 2H), 6.04-5.97 (m, 1H), 4.35 (d, *J* = 8.8 Hz, 1H), 3.36 (d, *J* = 18.1 Hz, 1H), 3.01 (d, *J* = 18.2 Hz, 1H); **^{13}C NMR** (101 MHz,

DMSO-d_6) δ 201.5 , 173.9, 167.1, 151.1, 136.9, 134.7, 133.3, 132.3, 131.5, 129.2, 128.6 , 128.0, 127.4, 126.9, 124.8 , 88.6 , 52.5 , 49.9 , 36.3; **IR** (neat): 3386, 2919, 1788, 1716, 1655, 1160, 747, 699, 467 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 398.1387, found 398.1384; **HPLC**: Daicel Chiralpak IA, *n*-hexane/*i*-PrOH = 50/50, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 15.50 min and t_{minor} = 9.28min.

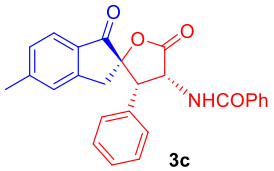
***N*-((2S,3S,4R)-6'-chloro-1',5-dioxo-3-phenyl-1',3',4,5-tetrahydro-3*H*-spiro[furan-2,2'-inden]-4-yl) benzamide (3b):**



3b

Major diastereoisomer of **3b**: Yellow solid in 80% isolated yield (103mg, 5:1 dr); $[\alpha]_D^{20}$ = +79 (c = 1.0, $CDCl_3$, 94% ee); **m.p.** = 222.8-223.6 ℃; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.74 (d, *J* = 7.5 Hz, 1H), 7.91-7.81 (m, 2H), 7.62-7.56 (m, 1H), 7.53-7.42 (m, 3H), 7.40-7.28 (m, 5H), 7.23-7.01 (m, 3H), 6.07-5.89 (m, 1H), 4.43 (d, *J* = 8.8 Hz, 1H), 3.31 (d, *J* = 18.1 Hz, 1H), 2.94 (d, *J* = 18.2 Hz, 1H); **^{13}C NMR** (101 MHz, DMSO-d_6) δ 200.6, 173.7, 167.0, 148.2, 136.2, 134.6, 133.3, 131.4, 130.6, 129.3, 128.9,128.4, 128.0, 127.5, 127.3, 123.7, 88.2, 52.4, 49.8, 35.4; **IR** (neat): 3392, 2926, 1797, 1715, 1667, 1523, 1156, 713, 509 cm^{-1}; **HRMS** (ESI):m/z for $[M+H]^+$: calcd 432.0997, found 432.0995; **HPLC**: Daicel Chiralpak IB, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 14.89 min and t_{minor} = 10.98min.

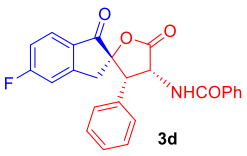
***N*-((2S,3S,4R)-5'-methyl-1',5-dioxo-3-phenyl-1',3',4,5-tetrahydro-3*H*-spiro[furan-2,2'-inden]-4-yl) benzamide (3c):**



3c

Yellow solid in 80% isolated yield (99mg, >20:1 dr); $[\alpha]_D^{20}$ = +77 (c = 1.0, DMSO, 95% ee); **m.p.** = 235.5-236.3 ℃; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.69 (d, *J* = 7.2 Hz, 1H), 7.73 (d, *J* = 7.7 Hz, 1H), 7.53-7.42 (m, 3H), 7.39-7.27 (m, 7H), 7.16 (d, *J* = 5.9 Hz, 2H), 6.08 – 5.93 (m, 1H), 4.30 (d, *J* = 8.6 Hz, 1H), 3.31 (d, *J* = 22.4 Hz, 1H), 2.95 (d, *J* = 18.2 Hz, 1H), 2.39 (s, 3H); **^{13}C NMR** (101 MHz, DMSO-d_6) δ 200.7, 173.9, 167.0, 151.4, 148.2, 134.8, 133.3, 131.5, 129.9, 129.7, 129.3, 128.7, 128.0, 127.5, 127.0, 124.77, 88.77, 52.5, 50.15, 36.1, 21.8; **IR** (neat): 3399, 2926, 1783, 1712, 1671, 1609, 1123, 1085, 709, 496 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 412.1543, found 432.1542; **HPLC**: Daicel Chiralpak IB, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 16.07min and t_{minor} = 12.64min.

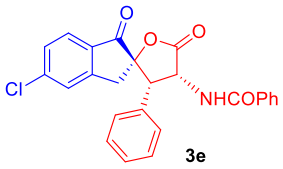
***N*-((2S,3S,4R)-5'-fluoro-1',5-dioxo-3-phenyl-1',3',4,5-tetrahydro-3*H*-spiro[furan-2,2'-inden]-4-yl) benzamide (3d):**



3d

Yellow solid in 76% isolated yield (94mg, >20:1 dr); $[\alpha]_D^{20}$ = +90 (c = 1.0, DMSO, 99% ee); **m.p.** = 239.1-240.2 ℃; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.71 (d, *J* = 7.4 Hz, 1H), 7.98-7.85 (m, 1H), 7.52-7.43 (m, 3H), 7.41-7.29 (m, 7H), 7.17 (d, *J* = 6.6 Hz, 2H), 6.05-5.92 (m, 1H), 4.38 (d, *J* = 8.8 Hz, 1H), 3.36 (d, *J* = 17.9 Hz, 1H), 3.02 (d, *J* = 18.4 Hz, 1H); **^{13}C NMR** (101 MHz, DMSO-d_6) δ 199.7, 173.8, 167.40 (d, *J* = 256.0 Hz), 167.0, 154.46 (d, *J* = 11.3 Hz), 134.7, 133.3, 131.5, 129.2, 128.7, 128.2,128.3 127.4, 127.3, 117.0, 116.7, 113.8, 113.6, 88.6, 52.5, 50.0, 36.3; **^{19}F NMR** (376 MHz, DMSO-d_6) δ -99.98; **IR** (neat):3383, 2929, 1799, 1713, 1662, 1264, 1139, 714, 646,498 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 416.1293, found 416.1292; **HPLC**: Daicel Chiralpak IB, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 14.65 min and t_{minor} = 18.34 min.

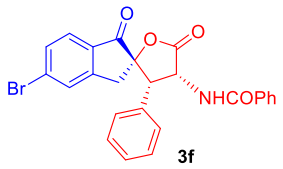
***N*-((2S,3S,4R)-5'-chloro-1',5-dioxo-3-phenyl-1',3',4,5-tetrahydro-3*H*-spiro[furan-2,2'-inden]-4-yl) benzamide (3e):**



3e

Yellow solid in 78% isolated yield (100mg, >20:1 dr); $[\alpha]_D^{20}$ = +97 (c = 1.0, DMSO, 98% ee); **m.p.** = 232.2-233.4 ℃; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.72 (d, *J* = 7.4 Hz, 1H), 7.85 (d, *J* = 8.2 Hz, 1H), 7.65 (s, 1H), 7.59 (d, *J* = 8.1 Hz, 1H), 7.52-7.42 (m, 3H), 7.40-7.29 (m, 5H), 7.17 (d, *J* = 6.5 Hz, 2H), 6.05-5.95 (m, 1H), 4.39 (d, *J* = 8.8 Hz, 1H), 3.35 (d, *J* = 18.3 Hz, 1H), 3.02 (d, *J* = 18.4 Hz, 1H); **^{13}C NMR** (101 MHz, DMSO-d_6) δ 200.3, 173.8, 167.0, 152.9, 141.7, 134.7, 133.3, 131.5, 131.2, 129.3, 129.0, 128.7, 128.0, 127.5, 127.0, 126.4, 88.5, 52.5, 49.9, 36.2; **IR** (neat): 3399, 2988, 1787, 1717, 1667, 1629, 1102, 1084, 713, 464 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 432.0997, found 432.0996; **HPLC**: Daicel Chiralpak IB, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 11.54 min and t_{minor} = 15.50 min.

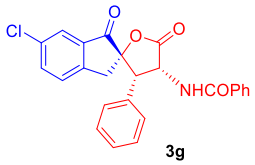
***N*-((2S,3S,4R)-5'-bromo-1',5-dioxo-3-phenyl-1',3',4,5-tetrahydro-3*H*-spiro[furan-2,2'-inden]-4-yl) benzamide (3f):**



3f

Yellow solid in 40% isolated yield (57mg, >20:1 dr); $[\alpha]_D^{20}$ = +66 (c = 1.0, DMSO, 97% ee); **m.p.** = 258.0-259.1 ℃; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.69 (d, *J* = 7.5 Hz, 1H), 7.83-7.70 (m, 3H), 7.52-7.43 (m, 3H), 7.40-7.29 (m, 5H), 7.16 (d, *J* = 6.6 Hz, 2H), 6.07-5.90 (m, 1H), 4.38 (d, *J* = 8.8 Hz, 1H), 3.35 (d, *J* = 19.0 Hz, 1H), 3.02 (d, *J* = 18.4 Hz, 1H); **^{13}C NMR** (101 MHz, DMSO-d_6) δ 200.5, 173.8, 167.0, 153.0, 134.7, 133.4, 131.9, 131.5, 131.2, 130.0, 129.3, 128.7, 128.0, 127.5, 126.4, 88.5, 52.4, 49.9, 36.1; **IR** (neat): 3425, 2918, 1779, 1719, 1667, 1207, 1140, 913, 714, 489 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 498.0311, found 498.0309; **HPLC**: Daicel Chiralpak IB, *n*-hexane/*i*-PrO =80/20, flow rate =1 mL/min, λ = 254 nm, t_{major} = 15.73 min and t_{minor} = 21.68 min.

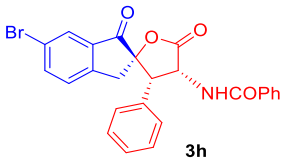
***N*-((2S,3S,4R)-4'-chloro-1',5-dioxo-3-phenyl-1',3',4,5-tetrahydro-3*H*-spiro[furan-2,2'-inden]-4-yl) benzamide (3g):**



3g

Yellow solid in 78% isolated yield (101mg, >20:1 dr); $[\alpha]_D^{20}$ = +109 (c = 1.0, DMSO, 99% ee); **m.p.** = 180.5-181.7 ℃; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.71 (d, *J* = 7.0 Hz, 1H), 7.85 (d, *J* = 8.0 Hz, 1H), 7.65 (s, 1H), 7.59 (d, *J* = 7.8 Hz, 1H), 7.52-7.43 (m, 3H), 7.41-7.27 (m, 5H), 7.21-7.11 (m, 2H), 6.08-5.91 (m, 1H), 4.39 (d, *J* = 8.4 Hz, 1H), 3.35 (d, *J* = 17.9 Hz, 1H), 3.02 (d, *J* = 18.3 Hz, 1H); **^{13}C NMR**(101 MHz, DMSO-d_6) δ 200.3, 173.8, 167.0, 153.0, 141.7, 134.7, 133.3, 131.5, 131.2, 129.3, 129.0, 128.7, 128.0, 127.5, 127.0, 126.4, 88.5, 52.5, 49.9, 36.2; **IR** (neat): 3399, 2923, 1788, 1717, 1667, 1519, 1101, 702, 635, 493 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 432.0997, found 432.0995; **HPLC**: Daicel Chiralpak IB, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 17.12 min and t_{minor} = 13.33 min.

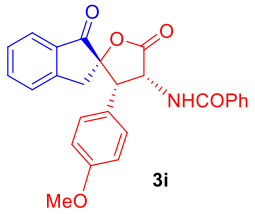
((2S,3S,4R)-4'-bromo-1',5-dioxo-3-phenyl-1',3',4,5-tetrahydro-3*H*-spiro[furan-2,2'-inden]-4-yl)benzamide (3h):



3h

Yellow solid in 39% isolated yield (56mg, >20:1 dr); $[\alpha]_D^{20}$ = +172 (c = 1.0, DMSO, 99% ee); **m.p.** = 236.1-237.4 ℃; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.71 (d, *J* = 7.3 Hz, 1H), 7.99 (s, 1H), 7.92 (d, *J* = 7.8 Hz, 1H), 7.52-7.43 (m, 4H), 7.41-7.28 (m, 5H), 7.19-7.10 (m, 2H), 6.02-5.90 (m, 1H), 4.39 (d, *J* = 8.7 Hz, 1H), 3.31 (d, *J* = 17.6 Hz, 1H), 2.96 (d, *J* = 18.3 Hz, 1H); **^{13}C NMR** (101 MHz, DMSO-d_6) δ 200.3, 173.8, 167.0, 150.1, 139.1, 134.6, 133.3, 131.5, 129.3, 129.1, 128.7, 128.0, 127.5, 127.1, 121.5, 88.7, 52.4, 49.8, 36.1; **IR** (neat): 3384, 2933, 1798, 1714, 1662, 1524, 1132, 1084, 633, 509 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 476.0492, found 476.0491; **HPLC**: Daicel Chiralpak IB, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 13.19 min and t_{minor} = 17.52 min.

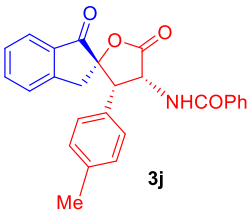
***N*-((2S,3S,4R)-3-(4-methoxyphenyl)-1',5-dioxo-1',3',4,5-tetrahydro-3*H*-spiro[furan-2,2'-inden]-4-yl)benzamide (3i):**



3i

Yellow solid in 85% isolated yield (109mg, >20:1 dr); $[\alpha]_D^{20}$ = +147 (c = 1.0, DMSO, 99% ee); **m.p.** = 207.1-208.4 ℃; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.69 (d, *J* = 7.6 Hz, 1H), 7.84 (d, *J* = 7.6 Hz, 1H), 7.76 (t, *J* = 7.9 Hz, 1H), 7.60-7.45 (m, 5H), 7.41-7.33 (m, 2H), 7.10 (d, *J* = 8.7 Hz, 2H), 6.91 (d, *J* = 8.7 Hz, 2H), 6.05-5.97 (m, 1H), 4.30 (d, *J* = 8.8 Hz, 1H), 3.74 (s, 3H), 3.33 (d, *J* = 18.2 Hz, 1H), 3.03 (d, *J* = 18.2 Hz, 1H); **^{13}C NMR**(101 MHz, DMSO-d_6) δ 201.5, 174.0, 167.0, 158.7, 151.0, 136.8, 133.3, 132.4, 131.5, 130.4, 128.5, 128.1, 127.5, 126.9, 126.6, 124.8, 114.1, 88.8, 55.0, 52.4, 49.4, 36.3; **IR** (neat): 3360, 2917, 1791, 1708, 1662, 1258, 1185, 931, 754, 471 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 428.1492, found 428.1491; **HPLC**:Daicel Chiralpak IB,*n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 17.64 min and t_{minor} = 26.98 min.

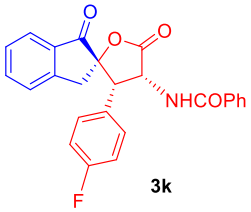
***N*-((2S,3S,4R)-1',5-dioxo-3-(p-tolyl)-1',3',4,5-tetrahydro-3*H*-spiro[furan-2,2'-inden]-4-yl)benzamide (3j):**



3j

Yellow solid in 70% isolated yield (86mg, >20:1 dr); $[\alpha]_D^{20}$ = +120 (c = 1.0, DMSO, 97% ee); **m.p.** = 239.5-240.9 ℃; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.68 (d, *J* = 7.6 Hz, 1H), 7.83 (d, *J* = 7.7 Hz, 1H), 7.76 (t, *J* = 7.3 Hz, 1H), 7.56-7.45 (m, 5H), 7.39-7.33 (m, 2H), 7.16 (d, *J* = 7.9 Hz, 2H), 7.05 (d, *J* = 7.9 Hz, 2H), 6.03-5.93 (m, 1H), 4.29 (d, *J* = 8.8 Hz, 1H), 3.28 (d, *J* = 18.2 Hz, 1H), 2.98 (d, *J* = 18.2 Hz, 1H), 2.29 (s, 3H); **^{13}C NMR** (101 MHz, DMSO-d_6) δ201.5,174.0, 167.0, 151.1, 136.9, 133.3, 132.4, 132.2,131.9,131.6, 129.2, 128.5, 128.1, 127.5, 126.9, 124.8, 88.7, 52.4, 49.6, 36.3, 20.7; **IR** (neat): 3336, 2926, 1796, 1709, 1661, 1340, 1124, 998, 748, 567 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 412.1543, found 412.1542; **HPLC**: Daicel Chiralpak IA, *n*-hexane/*i*-PrOH = 50/50, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 14.53 min and t_{minor} = 10.41 min.

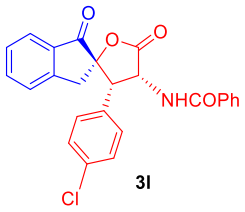
***N*-((2S,3S,4R)-3-(4-fluorophenyl)-1',5-dioxo-1',3',4,5-tetrahydro-3*H*-spiro[furan-2,2'-inden]-4-yl) benzamide (3k):**



3k

Yellow solid in 80% isolated yield (100mg, >20:1 dr); $[\alpha]_D^{20}$ = +148 (c = 1.0, DMSO, 99% ee); **m.p.** = 200.3-201.5 ℃; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.78 (d, *J* = 7.5 Hz, 1H), 7.85 (d, *J* = 7.6 Hz, 1H), 7.78 (t, *J* = 7.5 Hz, 1H), 7.57-7.47 (m, 5H), 7.41-7.35 (m, 2H), 7.24-7.17 (m, 4H), 6.07-5.95 (m, 1H), 4.43 (d, *J* = 8.8 Hz, 1H), 3.39 (d, *J* = 18.1 Hz, 1H), 3.03 (d, *J* = 18.2 Hz, 1H); **^{13}C NMR** (101 MHz, DMSO-d_6) δ 201.3, 173.8, 167.0, 161.58 (d, *J* = 244.1 Hz), 151.1, 136.9, 133.3, 132.4, 131.9, 131.1, 131.1, 128.6, 128.1, 127.5, 126.9, 124.8, 115.6, 115.4, 88.5, 52.5, 49.1, 36.3; ^{19}F NMR (376 MHz, DMSO) δ -114.39. **IR** (neat): 3349, 2921, 1793, 1698, 1337, 1224, 1195, 921, 732, 453 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 416.1293, found 416.1290; **HPLC**: Daicel Chiralpak IA, *n*-hexane/*i*-PrOH = 50/50, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 18.92 min and t_{minor} = 9.89 min.

***N*-((2S,3S,4R)-3-(4-chlorophenyl)-1',5-dioxo-1',3',4,5-tetrahydro-3*H*-spiro[furan-2,2'-inden]-4-yl) benzamide (3l):**

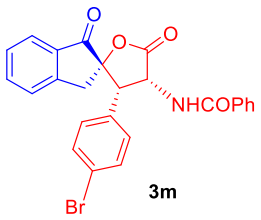


3l

Yellow solid in 72% isolated yield (93mg, >20:1 dr); $[\alpha]_D^{20}$ = +152 (c = 1.0, DMSO, 99% ee); **m.p.** = 216.3-217.4 ℃; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.87 (d, *J* = 7.7 Hz, 1H), 7.70-7.64 (m, 1H), 7.50-7.39

(m, 4H), 7.37-7.29 (m, 5H), 7.09 (d, *J* = 8.4 Hz, 2H), 6.33 (d, *J* = 5.2 Hz, 1H), 6.06-5.98 (m, 1H), 4.31 (d, *J* = 8.3 Hz, 1H), 3.42 (d, *J* = 18.0 Hz, 1H), 3.13 (d, *J* = 18.0 Hz, 1H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 200.2, 174.8, 167.3, 150.2, 136.9, 134.5, 133.2, 132.7, 132.0, 130.1, 129.5, 128.7, 126.8, 126.5, 125.7, 89.0, 53.7, 51.2, 36.6; **IR** (neat): 3350, 2923, 1795, 1703, 1663, 1326, 1220, 1192, 726, 522 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 432.0997 found 432.0995; **HPLC**: Daicel Chiralpak IA, *n*-hexane/*i*-PrOH = 50/50, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 23.54 min and t_{minor} = 10.71 min.

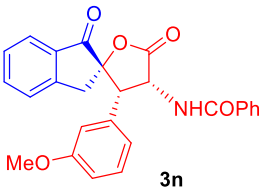
***N*-((2S,3S,4R)-3-(4-bromophenyl)-1',5-dioxo-1',3',4,5-tetrahydro-3*H*-spiro[furan-2,2'-inden]-4-yl) benzamide (3m):**



3m

Yellow solid in 80% isolated yield (111mg, >20:1 dr); $[\alpha]_D^{20}$ = +158 (c = 1.0, $CDCl_3$, 99% ee); **m.p.** = 204.1-205.5 ℃; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.87 (d, *J* = 7.7 Hz, 1H), 7.69-7.64 (m, 1H), 7.50-7.39 (m, 6H), 7.37-7.31 (m, 3H), 7.03 (d, *J* = 8.5 Hz, 2H), 6.33 (d, *J* = 5.5 Hz, 1H), 6.05-5.98 (m, 1H), 4.30 (d, *J* = 8.3 Hz, 1H), 3.41 (d, *J* = 18.0 Hz, 1H), 3.13 (d, *J* = 18.0 Hz, 1H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 200.1, 174.8, 167.3, 150.2, 136.9, 133.7, 133.1, 132.7, 132.5, 132.0, 130.4, 128.7, 126.8, 126.5, 125.7, 122.6, 88.9, 53.7, 51.3, 36.6; **IR**(neat): 3337, 2923, 1795, 1660, 1157, 1069, 725, 515 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 476.0492, found 476.0490; **HPLC**: Daicel Chiralpak IB, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 12.43 min and t_{minor} =26.42 min.

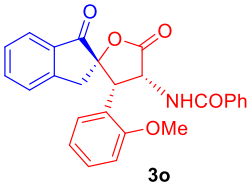
***N*-((2S,3S,4R)-3-(3-methoxyphenyl)-1',5-dioxo-1',3',4,5-tetrahydro-3*H*-spiro[furan-2,2'-inden]-4-yl)benzamide (3n):**



3n

Yellow solid in 75% isolated yield (96mg, >20:1 dr); $[\alpha]_D^{20}$ = +148 (c = 1.0, DMSO, 99% ee); **m.p.** = 180.0-181.4 ℃; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.73 (d, *J* = 7.7 Hz, 1H), 7.84 (d, *J* = 7.5 Hz, 1H), 7.77 (t, *J* = 7.5 Hz, 1H), 7.56-7.45 (m, 5H), 7.39-7.33 (m, 2H), 7.27 (t, *J* = 7.9 Hz, 1H), 6.92-6.87 (m, 1H), 6.76-6.68 (m, 2H), 6.02 (t, *J* = 8.2 Hz, 1H), 4.31 (d, *J* = 8.8 Hz, 1H), 3.72 (s, 3H), 3.41 (d, *J* = 18.3 Hz, 1H), 3.06 (d, *J* = 18.3 Hz, 1H); **^{13}C NMR** (101 MHz, DMSO-d_6) δ 202.0, 174.4, 167.6, 159.7, 151.7, 137.4, 136.7, 133.9, 132.8, 132.0, 130.3, 129.0, 128.6, 128.0, 127.4, 125.3, 121.9, 115.3, 113.8, 89.0, 55.4, 53.0, 50.4, 36.8; **IR** (neat): 3266, 2922, 1783, 1716, 1665, 1326, 1227, 1173, 719, 472 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 428.1492, found 428.1490; **HPLC**: Daicel Chiralpak IA, *n*-hexane/*i*-PrOH = 50/50, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 11.01 min and t_{minor} = 8.60 min.

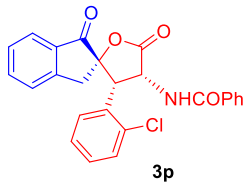
***N*-((2S,3S,4R)-3-(2-methoxyphenyl)-1',5-dioxo-1',3',4,5-tetrahydro-3*H*-spiro[furan-2,2'-inden]-4-yl)benzamide (3o):**



3o

Yellow solid in 88% isolated yield (113mg, >20:1 dr); $[\alpha]_D^{20}$ = +138 (c = 1.0, DMSO, 99% ee); **m.p.** = 126.9-128.6 ℃; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.17 (d, *J* = 14.0 Hz, 1H), 7.87-7.80 (m, 1H), 7.78-7.71 (m, 1H), 7.57- 7.28 (m, 8H), 7.13-6.96 (m, 2H), 6.90-6.75 (m, 1H), 5.87-5.61 (m, 1H), 4.36 (d, *J* = 6.2 Hz, 1H), 3.76 (s, 3H), 3.31 (d, *J* = 22.7 Hz, 2H), 2.90 (d, *J* = 18.1 Hz, 1H); **^{13}C NMR** (101 MHz, DMSO-d_6) δ 202.1, 173.9, 167.3, 157.2, 151.1, 136.8, 133.5 132.3, 131.4, 129.7, 128.5, 128.0, 127.3, 126.8, 124.8, 122.7, 120.6, 110.9, 87.4, 55.0, 51.3, 36.0; **IR** (neat): 3339, 2937, 1783, 1718, 1664, 1334, 1226, 1021, 749, 491 cm^{-1}; **HRMS**. (ESI): m/z for $[M+H]^+$: calcd 428.1492, found 428.1491; **HPLC**: Daicel Chiralpak IB, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 13.92 min and t_{minor} = 15.61 min.

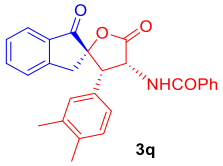
***N*-((3S,4R)-3-(2-chlorophenyl)-1',5-dioxo-1',3',4,5-tetrahydro-3*H*-spiro[furan-2,2'-inden]-4-yl)benzamide (3p):**



3p

Yellow solid in 75% isolated yield (97mg, >20:1 dr); $[\alpha]_D^{20}$ = +175 (c = 1.0, DMSO, 98% ee); **m.p.** = 212.1-213.8 ℃; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.85 (d, *J* = 7.2 Hz, 1H), 7.87 (d, *J* = 7.6 Hz, 1H), 7.79 (t, *J* = 7.4 Hz, 1H), 7.59-7.34 (m, 11H), 6.23-6.05 (m, 1H), 4.76 (d, *J* = 8.8 Hz, 1H), 3.54 (d, *J* = 18.1 Hz, 1H), 3.06 (d, *J* = 18.2 Hz, 1H); **^{13}C NMR** (101 MHz, DMSO-d_6) δ 201.2, 173.5, 167.1, 151.1, 137.1, 134.6, 133.3, 131.8, 131.6, 130.0, 129.7, 128.7, 128.1, 127.8, 127.5, 126.9, 124.9, 87.8, 52.0, 46.0, 36.2; **IR** (neat): 3375, 2926, 1789, 1713, 1667, 1328, 1119, 879, 744, 457 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 432.0997, found 432.0996; **HPLC**: Daicel Chiralpak IA, *n*-hexane/*i*-PrOH = 50/50, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 10.78 min and t_{minor} = 8.78 min.

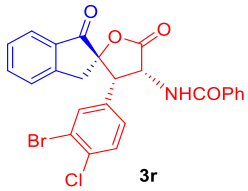
***N*-((3S,4R)-3-(3,4-dimethylphenyl)-1',5-dioxo-1',3',4,5-tetrahydro-3*H*-spiro[furan-2,2'-inden]-4-yl)benzamide (3q):**



3q

Yellow solid in 74% isolated yield (94mg, >20:1 dr); $[\alpha]_D^{20}$ = +115 (c = 1.0, DMSO, 98% ee); **m.p.** = 204.8-206.4 ℃; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.70 (d, *J* = 7.7 Hz, 1H), 7.83 (d, *J* = 7.6 Hz, 1H), 7.78-7.71 (m, 1H), 7.59 -7.44 (m, 6H), 7.40-7.33 (m, 2H), 7.10 (d, *J* = 7.7 Hz, 1H), 6.94 (s, 1H), 6.88 (d, *J* = 7.7 Hz, 1H), 6.05-5.98 (m, 1H), 4.24 (d, *J* = 8.8 Hz, 1H), 3.31 (d, *J* = 18.2 Hz, 1H), 3.01 (d, *J* = 18.2 Hz, 1H), 2.19 (s, 3H), 2.18 (s, 3H); **^{13}C NMR** (101 MHz, DMSO-d_6) δ 201.6, 174.1, 167.0, 151.1, 136.8, 136.5, 135.7, 133.3, 132.3, 132.0, 131.5, 130.2, 129.7, 128.5, 128.1, 127.6, 126.9, 126.7, 124.8, 88.7, 52.3, 49.7, 36.3, 19.4, 19.0; **IR** (neat): 3364, 2923, 1791, 1707, 1668, 1320, 1227, 1168, 756, 466 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 426.1700, found 426.1701; **HPLC**: Daicel Chiralpak IB, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 15.48 min and t_{minor} = 13.85 min.

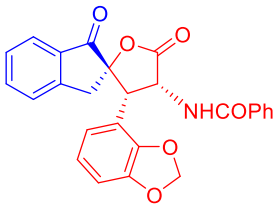
***N*-((2S,3S,4R)-3-(3-bromo-4-chlorophenyl)-1',5-dioxo-1',3',4,5-tetrahydro-3*H*-spiro[furan-2,2'-inden]-4-yl)benzamide (3r):**



3r

Yellow solid in 80% isolated yield (122mg, >20:1 dr); $[\alpha]_D^{20}$ = +115 (c = 1.0, DMSO, 99% ee); **m.p.** = 158.7-160.4 ℃; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.87 (d, *J* = 7.7 Hz, 1H), 7.71-7.65 (m, 1H), 7.50-7.44 (m, 4H), 7.44-7.39 (m, 2H), 7.38 – 7.33 (m, 3H), 7.08 – 7.03 (m, 1H), 6.44 (d, *J* = 5.2 Hz, 1H), 6.04 – 5.95 (m, 1H), 4.33 (d, *J* = 8.3 Hz, 1H), 3.44 (d, *J* = 18.0 Hz, 1H), 3.13 (d, *J* = 18.0 Hz, 1H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 199.9, 174.5, 167.5, 150.1, 137.0, 135.0, 134.8, 134.0, 132.9, 132.6, 132.1, 131.0, 128.8 128.7, 128.5, 126.9, 126.5, 125.7, 123.4, 88.8, 53.9, 51.0, 36.6; **IR** (neat): 3364, 2923, 1791, 1707, 1668, 1320, 1227, 1168, 756, 466 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 510.0102, found 510.0103; **HPLC**: Daicel Chiralpak IB, *n*-hexane/*i*-PrOH = 80/20, flow rate =1mL/min, λ =254 nm, t_{major} = 11.45min and t_{minor} = 24.14min.

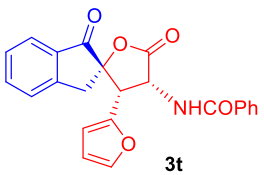
***N*-((2S,3S,4R)-3-(benzo[*d*][1,3]dioxol-4-yl)-1',5-dioxo-1',3',4,5-tetrahydro-3*H*-spiro[furan-2,2'-inden]-4-yl)benzamide (3s):**



3s

Yellow solid in 80% isolated yield (105mg, >20:1 dr); $[\alpha]_D^{20}$ = +74 (c = 1.0, DMSO, 97% ee); **m.p.** = 253.1-254.4 ℃; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.78 (d, *J* = 7.6 Hz, 1H), 7.58 (t, *J* = 7.4 Hz, 1H), 7.44-7.34 (m, 4H), 7.31- 7.23 (m, 3H), 6.67 (d, *J* = 7.9 Hz, 1H), 6.57-6.47 (m, 2H), 6.22 (d, *J* = 5.9 Hz, 1H), 6.02-5.94 (m, 1H), 5.88 (d, *J* = 6.1 Hz, 2H), 4.10 (d, *J* = 8.3 Hz, 1H), 3.34 (d, *J* = 18.0 Hz, 1H), 3.14 (d, *J* = 18.0 Hz, 1H); **^{13}C NMR**(101 MHz, $CDCl_3$) δ 199.4, 174.0, 166.3, 149.3, 147.4, 146.7, 135.7, 132.4, 131.7, 130.8, 127.6, 127.1, 125.9, 125.4, 124.6, 121.7, 107.9, 107.4 ,106.6, 100.4, 88.1, 52.5, 50.4, 35.5; **IR** (neat): 3396, 2930, 1790, 1718, 1660, 1331, 1218, 873, 562, 471 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 442.1285, found 442.1285; **HPLC**: Daicel Chiralpak IB, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} =24.00 min and t_{minor} = 57.42 min.

***N*-((3R,4R)-3-(furan-2-yl)-1',5-dioxo-1',3',4,5-tetrahydro-3*H*-spiro[furan-2,2'-inden]-4-yl)benzamide (3t):**

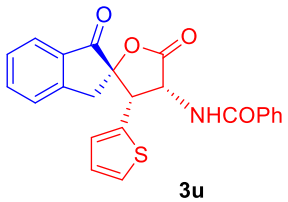


3t

Yellow solid in 74% isolated yield (86mg, >20:1 dr); $[\alpha]_D^{20}$ = +140 (c =1.0, DMSO, 90% ee); **m.p.** = 188.7-190.1 ℃; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.77 (d, *J* = 7.7 Hz, 1H), 7.87-7.75 (m, 2H), 7.71 (s, 1H), 7.66 (d, *J* = 7.4 Hz, 2H), 7.60-7.48 (m, 3H), 7.45-7.37 (m, 2H), 6.49-6.26 (m, 2H), 5.96-5.84 (m, 1H), 4.53 (d, *J* = 8.8 Hz, 1H), 3.38 (d, *J* = 17.2 Hz, 1H), 3.03 (d, *J* = 18.2 Hz, 1H); **^{13}C NMR**(101 MHz,

DMSO-d_6) δ 201.0, 173.2 , 167.3, 151.0, 148.9, 143.9, 136.9, 133.3, 132.4, 131.6, 128.6, 128.1, 127.7, 126.9, 124.8, 111.0, 110.1, 87.5, 51.3, 44.1, 36.0; **IR** (neat): 3441, 2925, 1784, 1707, 1668, 1232, 1164, 786, 597, 467 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 408.1206, found 410.0998; **HPLC**: Daicel Chiralpak IB, *n*-hexane/*i*-PrOH = 50/50, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 12.64 min and t_{minor} = 13.57 min.

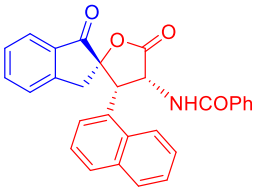
***N*-((3S,4R)-1',5-dioxo-3-(thiophen-2-yl)-1',3',4,5-tetrahydro-3*H*-spiro[furan-2,2'-inden]-4-yl)benzamide (3u):**



3u

Yellow solid in 74% isolated yield (89mg, >20:1 dr); $[\alpha]_D^{20}$ = +207 (c = 1.0, DMSO, 99% ee); **m.p.** = 212.6-213.9 ℃; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.78 (d, *J* = 7.5 Hz, 1H), 7.83 (d, *J* = 7.6 Hz, 1H), 7.79-7.73 (m, 1H), 7.67 -7.61 (m, 2H), 7.58-7.48 (m, 4H), 7.45-7.36 (m, 2H), 7.08-7.01 (m, 1H), 6.99-6.92 (m, 1H), 5.96-5.85 (m, 1H), 4.76 (d, *J* = 8.6 Hz, 1H), 3.43 (d, *J* = 18.3 Hz, 1H), 3.27 (d, *J* = 18.3 Hz, 1H); **^{13}C NMR**(101 MHz, DMSO-d_6) δ 201.0, 173.3, 167.2, 151.2, 136.9, 135.7, 133.3, 132.6, 131.6, 128.6, 128.1, 127.6, 127.3, 126.9, 126.3, 124.7, 88.6, 52.7, 45.6, 36.4; **IR** (neat): 3433, 2926, 1778, 1708, 1670, 1327, 1234,1128, 909, 702, 466 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 402.1158,found 404.0950; **HPLC**: Daicel Chiralpak IB,*n*-hexane/*i*-PrOH = 50/50, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 10.28 min and t_{minor} = 9.33 min.

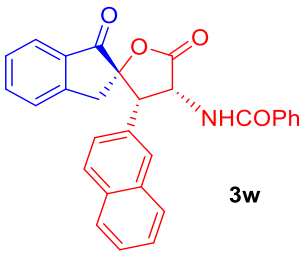
***N*-((3S,4R)-3-(naphthalen-1-yl)-1',5-dioxo-1',3',4,5-tetrahydro-3*H*-spiro[furan-2,2'-inden]-4-yl)benzamide (3v):**



3v

Yellow solid in 72% isolated yield (97mg, >20:1 dr); $[\alpha]_D^{20}$ = +136 (c = 1.0, DMSO, 99% ee); **m.p.** = 167.6-168.9 ℃; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.60 (d, *J* = 8.1 Hz, 1H), 7.98-7.85 (m, 4H), 7.75-7.69 (m, 1H), 7.66-7.60 (m, 1H), 7.57-7.51 (m, 2H), 7.44-7.29 (m, 4H), 7.23-7.15 (m, 4H), 6.42-6.33 (m, 1H), 5.30 (d, *J* = 8.7 Hz, 1H), 3.56 (d, *J* = 18.3 Hz, 1H), 3.11 (d, *J* = 18.3 Hz, 1H); **^{13}C NMR**(101 MHz, DMSO-d_6) δ 201.5, 174.2, 167.4, 151.0, 136.8, 133.4, 132.4, 131.2, 130.8, 128.5, 128.2, 127.8, 127.3, 126.8, 126.2, 125.6, 124.9, 123.2, 88.5, 52.9, 44.0, 36.50; **IR** (neat): 3399, 2970, 1789, 1717, 1662, 1513, 1087, 902, 785, 575 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 468.1570, found 470.1360; **HPLC**: Daicel Chiralpak IB, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 16.22 min and t_{minor} = 20.35min.

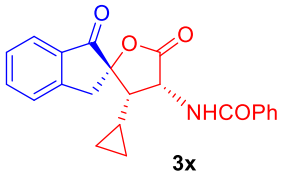
***N*-((3S,4R)-3-(naphthalen-2-yl)-1',5-dioxo-1',3',4,5-tetrahydro-3*H*-spiro[furan-2,2'-inden]-4-yl)benzamide (3w):**



3w

Yellow solid in 71% isolated yield (95mg, >20:1 dr); $[\alpha]_D^{20}$ = +142 (c = 1.0, DMSO, 99% ee); **m.p.** = 207.6-208.9 ℃; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.83 (d, *J* = 7.2 Hz, 1H), 7.97-7.89 (m, 2H), 7.89-7.81 (m, 2H), 7.79-7.69 (m, 2H), 7.57-7.44 (m, 6H), 7.42-7.36 (m, 1H), 7.35-7.30 (m, 1H), 7.30-7.19 (m, 2H), 6.17-6.06 (m, 1H), 4.54 (d, *J* = 8.7 Hz, 1H), 3.39 (d, *J* = 18.3 Hz, 1H), 3.02 (d, *J* = 18.2 Hz, 1H); **^{13}C NMR** (101 MHz, DMSO-d_6) δ 201.5, 174.0, 167.0, 151.2, 136.9, 133.2, 132.8, 132.6, 132.2, 131.4, 128.6, 128.2, 128.0, 127.5, 126.8, 126.3, 124.8, 88.6, 52.6, 50.2, 36.3; **IR** (neat): 3349, 2917, 1791, 1705, 1661, 1345, 1211, 1185, 931, 749, 646, 480 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 468.1570, found 470.1363; **HPLC**: Daicel Chiralpak IA, *n*-hexane/*i*-PrOH = 60/40, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 28.66 min and t_{minor} = 46.62 min.

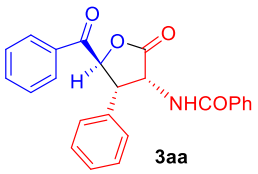
***N*-((3S,4R)-3-cyclopropyl-1',5-dioxo-1',3',4,5-tetrahydro-3*H*-spiro[furan-2,2'-inden]-4-yl)benzamide (3x):**



3x

Yellow solid in 70% isolated yield (76mg, >20:1 dr); $[\alpha]_D^{20}$ = + 58 (c = 1.0, DMSO, 73% ee); **m.p.** = 245.6-246.9 ℃; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 9.14 (d, *J* = 8.5 Hz, 1H), 7.93 (d, *J* = 7.2 Hz, 2H), 7.86-7.75 (m, 2H), 7.70-7.64 (m, 1H), 7.62-7.48 (m, 4H), 5.59-5.48 (m, 1H), 4.08 (d, *J* = 17.8 Hz, 1H), 3.45 (d, *J* = 17.8 Hz, 1H), 2.23 – 2.08 (m, 1H), 0.97 – 0.81 (m, 1H), 0.58 – 0.43 (m, 2H), 0.00 (d, *J* = 2.5 Hz, 2H); **^{13}C NMR** (101 MHz, DMSO-d_6) δ 202.1, 174.2, 166.7, 151.3, 136.8, 133.5, 132.4, 131.7, 128.4, 127.5, 126.8, 124.6, 88.9, 54.9, 51.5, 48.5, 34.6, 8.4, 3.8, 3.4, 2.7; **IR** (neat): 3350, 2922, 1788, 1709, 1661, 1334, 1232, 1073, 998, 713, 572 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 382.1414, found 384.1205; **HPLC**: Daicel Chiralpak IB, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 10.16 min and t_{minor} = 15.48 min.

***N*-((3R,4S,5S)-5-benzoyl-2-oxo-4-phenyltetrahydrofuran-3-yl)benzamide (3aa)**

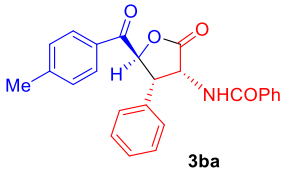


3aa

Yellow solid in 70% isolated yield (81mg, >20:1 dr); $[\alpha]_D^{20}$ = +36 (c = 1.0, CH_2Cl_2, 98% ee); **m.p.** = 90.6-91.9 ℃; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.85 (d, *J* = 7.6 Hz, 2H), 7.59 (t, *J* = 7.4 Hz, 1H), 7.48-7.40 (m, 2H), 7.38-7.27 (m, 6H), 7.25-7.16 (m, 4H), 6.07 (s, 1H), 6.00 (d, *J* = 5.9 Hz, 1H), 5.18-5.10 (m, 1H), 4.26 (d, *J* = 8.6 Hz, 1H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 192.5, 174.3, 167.7, 135.4, 134.8, 133.1, 132.9, 132.0, 129.5, 129.3, 128.6, 127.6, 126.9, 82.7, 52.2, 47.7; **IR** (neat): 3345, 3030, 1792, 1654, 1562, 1151,694, 510, cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 386.1387, found

386.1386; **HPLC**: Daicel Chiralpak IB, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 12.22 min and t_{minor} = 33.33 min.

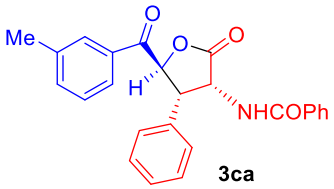
***N*-((3R,4S,5S)-5-(4-methylbenzoyl)-2-oxo-4-phenyltetrahydrofuran-3-yl)benzamide (3ba)**



3ba

Yellow solid in 68% isolated yield (81mg, >20:1 dr); $[\alpha]_D^{20}$ = +56 (c = 1.0, CH_2Cl_2, 99% ee); **m.p.** = 76.6-77.9 ℃; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.75 (d, *J* = 8.2 Hz, 2H), 7.39-7.33 (m, 1H), 7.33-7.27 (m, 5H), 7.26-7.21 (m, 4H), 7.20-7.17 (m, 2H), 6.05 (d, *J* = 0.6 Hz, 1H), 5.94 (d, *J* = 6.2 Hz, 1H), 5.18-5.11 (m, 1H), 4.25 (d, *J* = 8.7 Hz, 1H), 2.37 (s, 3H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 192.1, 174.4, 167.6, 146.0, 135.5, 133.2, 132.0, 130.4, 129.9, 129.5, 128.9 ,128.5, 127.6, 126.8, 82.6, 52.2, 47.8, 21.9; **IR** (neat): 3356, 2927, 1800, 1667, 1494, 1137, 723, 634 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 400.1543, found 400.1542; **HPLC**: Daicel Chiralpak IB, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 10.97 min and t_{minor} = 21.07 min.

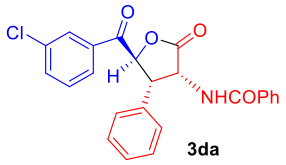
***N*-((3R,4S,5S)-5-(3-methylbenzoyl)-2-oxo-4-phenyltetrahydrofuran-3-yl)benzamide (3ca)**



3ca

Yellow solid in 67% isolated yield (81mg, >20:1 dr); $[\alpha]_D^{20}$ = +36 (c =1.0, CH_2Cl_2, 92% ee); **m.p.** = 77.6-78.9 ℃; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.78 (s, 1H), 7.67 (d, *J* = 7.7 Hz, 1H), 7.50-7.35 (m, 8H), 7.34-7.28 (m, 2H), 7.28 -7.24 (m, 2H), 6.12 (s, 1H), 6.03 (d, *J* = 6.1 Hz, 1H), 5.26-5.18 (m, 1H), 4.33 (d, *J* = 8.7 Hz, 1H), 2.42 (s, 3H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 192.7, 174.3, 167.6, 139.3, 135.5, 133.2, 132.9, 132.0, 129.5, 129.2, 129.0, 128.6 127.6, 126.8, 125.8, 82.7, 52.2, 47.7, 21.4; **IR** (neat): 3337, 2921, 1786, 1656, 1157, 1149, 696, 511 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 400.1543, found 400.1540; **HPLC**: Daicel Chiralpak IB, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 11.74 min and t_{minor} = 25.07 min.

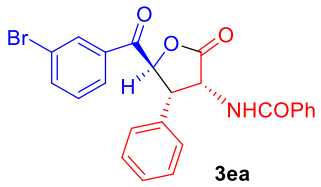
***N*-((3R,4S,5S)-5-(3-chlorobenzoyl)-2-oxo-4-phenyltetrahydrofuran-3-yl)benzamide (3da)**



3da

Yellow solid in 65% isolated yield (82mg, 10:1 dr); $[\alpha]_D^{20}$ = +36 (c = 1.0, CH_2Cl_2, 97% ee); **m.p.** = 100.6-101.9 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98-7.92 (m, 1H), 7.79-7.74 (m, 1H), 7.66-7.61 (m, 1H), 7.49-7.42 (m, 2H), 7.41 -7.35 (m, 5H), 7.32-7.24 (m, 4H), 6.13-6.05 (m, 2H), 5.23-5.15 (m, 1H), 4.34 (d, *J* = 8.9 Hz, 1H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 191.6, 174.0, 167.7, 135.8, 135.1, 134.7, 134.5, 133.0, 132.0, 130.5, 129.6, 128.9, 128.6, 127.6, 126.8, 82.6, 52.2, 47.4; **IR** (neat): 3327, 2919, 1792, 1654, 1533, 1156, 700, 496 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 420.0997, found 420.0993; **HPLC**: Daicel Chiralpak IB, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 11.96 min and t_{minor} = 25.84 min.

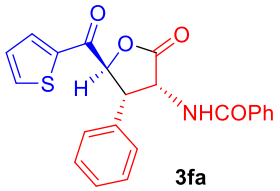
***N*-((3R,4S,5S)-5-(3-bromobenzoyl)-2-oxo-4-phenyltetrahydrofuran-3-yl)benzamide (3ea)**



3ea

Yellow solid in 68% isolated yield (95mg, >20:1 dr); $[\alpha]_D^{20}$ = +36 (c = 1.0, CH_2Cl_2, 97% ee); **m.p.** = 102.6-103.9 ℃; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.13-8.08 (m, 1H), 7.85-7.76 (m, 2H), 7.46-7.35 (m, 7H), 7.33-7.28 (m, 2H), 7.27-7.24 (m, 2H), 6.12-6.03 (m, 2H), 5.22-5.15 (m, 1H), 4.34 (d, *J* = 9.2 Hz, 1H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 191.5, 174.0, 167.7, 137.6, 135.1, 134.7, 133.0, 132.0, 131.8, 130.7, 129.6, 128.8, 128.6, 127.6, 127.1, 126.9, 123.7, 82.6, 52.1, 47.4; **IR** (neat): 3309, 2927, 1782, 1656, 1527, 1152, 688 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 464.0492, found 464.0493; **HPLC**: Daicel Chiralpak IB, *n*-hexane/*i*-PrOH = 80/20, flow rate =1mL/min, λ = 254 nm, t_{major} = 13.10 min and t_{minor} = 28.54 min.

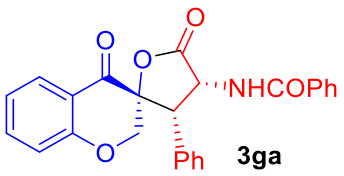
***N*-((3R,4S,5S)-2-oxo-4-phenyl-5-(thiophene-2-carbonyl)tetrahydrofuran-3-yl)benzamide (3fa)**



3fa

Yellow solid in 65% isolated yield (76mg, >20:1 dr); $[\alpha]_D^{20}$ = +56 (c =1.0, CH_2Cl_2, 93% ee); **m.p.** = 111.6-112.9 ℃; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.88 (d, *J* = 7.6 Hz, 1H), 8.17 (d, *J* = 4.6 Hz, 1H), 7.90 (d, *J* = 3.3 Hz, 1H), 7.56 (d, *J* = 7.4 Hz, 2H), 7.52-7.46 (m, 1H), 7.42-7.36 (m, 2H), 7.31-7.21 (m, 6H), 6.30 (d, *J* = 6.0 Hz, 1H), 5.02 (t, *J* = 8.6 Hz, 1H), 4.29-4.17 (m, 1H); **^{13}CNMR** (101MHz, DMSO-d_6) δ 188.0, 173.8, 167.5, 140.6, 137.7, 135.7, 135.2, 133.6, 132.1, 129.7, 129.3, 128.8, 128.1, 127.8, 82.6, 52.4, 48.1; **IR**(neat): 3327, 2923, 1786, 1660, 1409, 700, 503 cm^{-1}; **HRMS**(ESI): m/z for $[M+H]^+$: calcd 392.0951, found 392.0948; **HPLC**: Daicel Chiralpak IB, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 13.69 min and t_{minor} = 28.28 min.

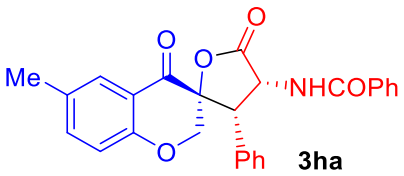
***N*-((3R,3'S,4'R)-4,5'-dioxo-3'-phenyl-4',5'-dihydro-3'H-spiro[chromane-3,2'-furan]-4'-yl)benzamide (3ga)**



3ga

Yellow solid in 88% isolated yield (109mg, 7:1 dr); $[\alpha]_D^{20}$ = +156 (c = 1.0, CH_2Cl_2, 92% ee); **m.p.** = 178.6-179.9 ℃; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.02 (d, *J* = 7.6 Hz, 1H), 7.65-7.50 (m, 1H), 7.46-7.26 (m, 8H), 7.22-7.07 (m, 3H), 6.96 (d, *J* = 8.3 Hz, 1H), 6.40 (d, *J* = 5.5 Hz, 1H), 5.66-5.53 (m, 1H), 4.46 (d, *J* = 11.9 Hz, 1H), 4.35 (d, *J* = 8.2 Hz, 1H), 4.25 (d, *J* = 11.9 Hz, 1H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 188.6, 174.2, 167.3, 161.3, 137.3, 133.1, 132.2, 131.9, 129.3, 128.9, 128.5, 126.9, 122.7, 118.1, 117.9, 82.0, 69.0, 52.2, 49.6; **IR** (neat): 3360, 2917, 1800, 1467, 1154, 1020, 717, 501 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 414.1336, found 414.1334; **HPLC**: Daicel Chiralpak IB, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 11.05 min and t_{minor} = 9.35 min.

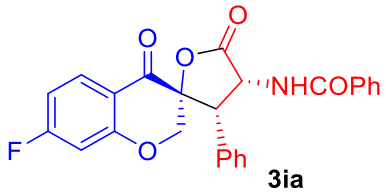
***N*-((3R,3'S,4'R)-6-methyl-4,5'-dioxo-3'-phenyl-4',5'-dihydro-3'H-spiro[chromane-3,2'-furan]-4'-yl)benzamide (3ha)**



3ha

Yellow solid in 70% isolated yield (90mg, 10:1 dr); $[\alpha]_D^{20}$ = +171 (c =1.0,CH_2Cl_2, 96% ee); **m.p.** = 168.6-169.9 ℃; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.81 (d, *J* = 1.1 Hz, 1H), 7.44-7.34 (m, 7H), 7.32-7.26 (m, 2H), 7.16-7.09 (m, 2H), 6.86 (d, *J* = 8.5 Hz, 1H), 6.32 (d, *J* = 5.7 Hz, 1H), 5.65-5.55 (m, 1H), 4.43 (d, *J* = 11.9 Hz, 1H), 4.33 (d, *J* = 8.3 Hz, 1H), 4.22 (d, *J* = 11.9 Hz, 1H), 2.37 (s, 3H); **^{13}C NMR** (101MHz, $CDCl_3$) δ 188.7, 174.2, 167.3, 159.3, 138.5, 133.1, 132.3, 131.9, 129.3, 128.8, 128.5, 128.0, 126.8, 117.7, 82.0, 69.0, 52.1, 49.6, 20.5; **IR** (neat): 3311, 2921, 1798, 1663, 1489, 1156, 696, 504 cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 428.1492, found 428.1490; **HPLC**: Daicel Chiralpak IB, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 12.56 min and t_{minor} = 25.39 min.

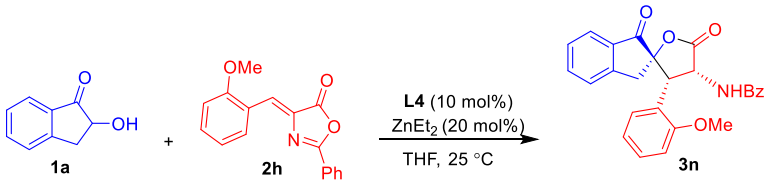
***N*-((3R,3'S,4'R)-7-fluoro-4,5'-dioxo-3'-phenyl-4',5'-dihydro-3'H-spiro[chromane-3,2'-furan]-4'-yl)benzamide (3ia)**



3ia

Yellow solid in 75% isolated yield (97mg, 9:1 dr); $[\alpha]_D^{20}$ = +80 (c = 1.0, CH_2Cl_2, 97% ee); **m.p.** = 182.6-183.2 ℃; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.12-8.00 (m, 1H), 7.42-7.32 (m, 6H), 7.32-7.24 (m, 2H), 7.21-7.07 (m, 2H), 6.96 -6.84 (m, 1H), 6.71-6.61 (m, 1H), 6.37 (d, *J* = 6.0 Hz, 1H), 5.68-5.52 (m, 1H), 4.47 (d, *J* = 12.0 Hz, 1H), 4.35 (d, *J* = 8.3 Hz, 1H), 4.26 (d, *J* = 12.0 Hz, 1H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 187.2, 174.0, 168.24 (d, *J* = 259.2 Hz), 167.3, 162.88 (d, *J* = 13.8 Hz), 133.1, 132.0, 131.3, 129.4, 129.0, 128.5, 126.8, 115.1, 111.6, 111.4, 105.0, 104.7, 81.6, 69.5, 52.2, 49.5; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -97.41; **IR** (neat): 3296, 2917, 1792, 1613, 1250, 1071, 698, 496, cm^{-1}; **HRMS** (ESI): m/z for $[M+H]^+$: calcd 432.1242, found 432.1240; **HPLC**: Daicel Chiralpak IB, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 16.95 min and t_{minor} = 28.86 min.

Gram-scale reaction



Under a nitrogen atmosphere, a solution of diethylzinc (800 μL, 1.0 M in hexane, 0.8 mmol) was added dropwise to a solution of **L4** (0.4 mmol) in MeCN (10 mL). After the mixture was stirred for 30 min at room temperature, then, α-hydroxy-1-indanone **1a** (4.0 mmol) and isatylidene malononitriles **2h** (4.0 mmol) were added. The reaction mixture was stirred for 24 h at the same temperature. The reaction was quenched with HCl solution (1 M, 2 mL), and the organic layer was extracted with EA (3 × 5 mL). The combined organic layer was washed with brine and dried over Na_2SO_4. The solvent was removed under

reduced pressure by using a rotary evaporator. The residue was purified by flash chromatography with petroleum ether/ethyl acetate (4/1) to afford the desired product 1.15g of **3n**.

References

1. K. Matsuo and M. Shindo, Cu(II)-Catalyzed Acylation by Thiol Esters Under Neutral Conditions: Tandem Acylation-Wittig Reaction Leading to a One-Pot Synthesis of Butenolides, *Org. Lett.*, 2010, **12**, 5346-5349.
2. Z.-F. Zhang, X.-C. Yang, H.-J. Lu and M.-C. Wang, Enantioselective Direct Synthesis of syn- and anti-α,β-Dihydroxy γ-Keto Esters Using a Dinuclear Zinc–AzePhenol Complex, *Eur. J. Org. Chem.*, 2018, **2018**, 785-793.
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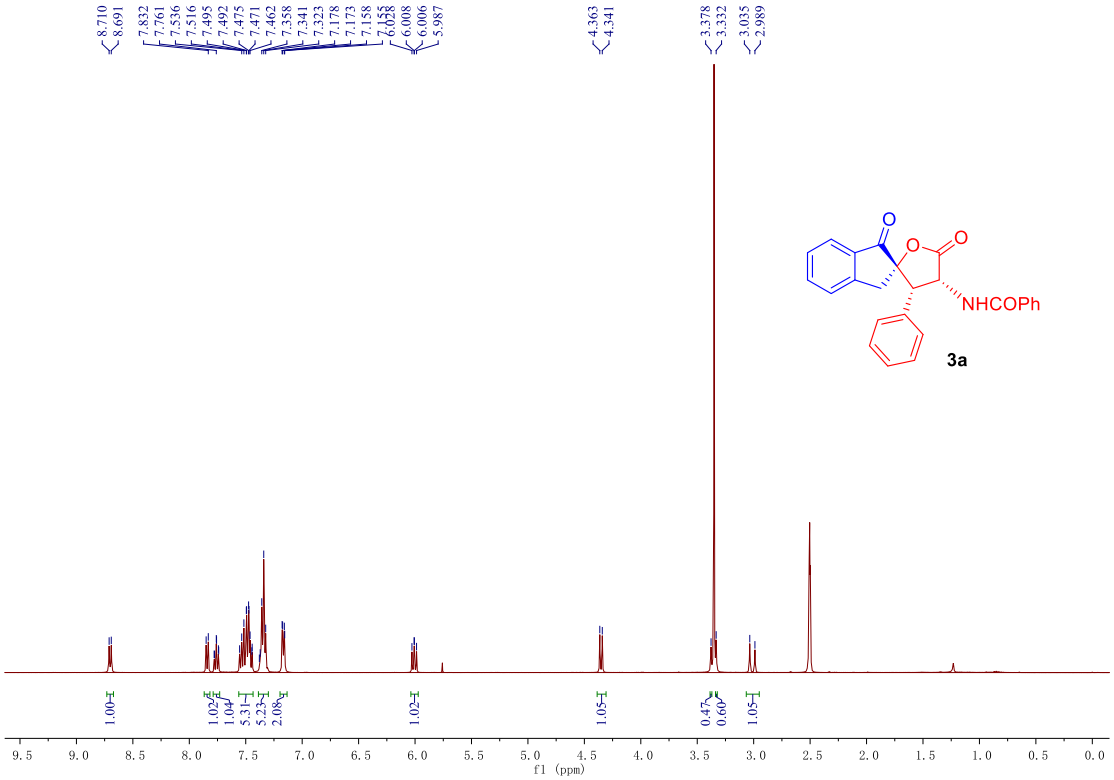
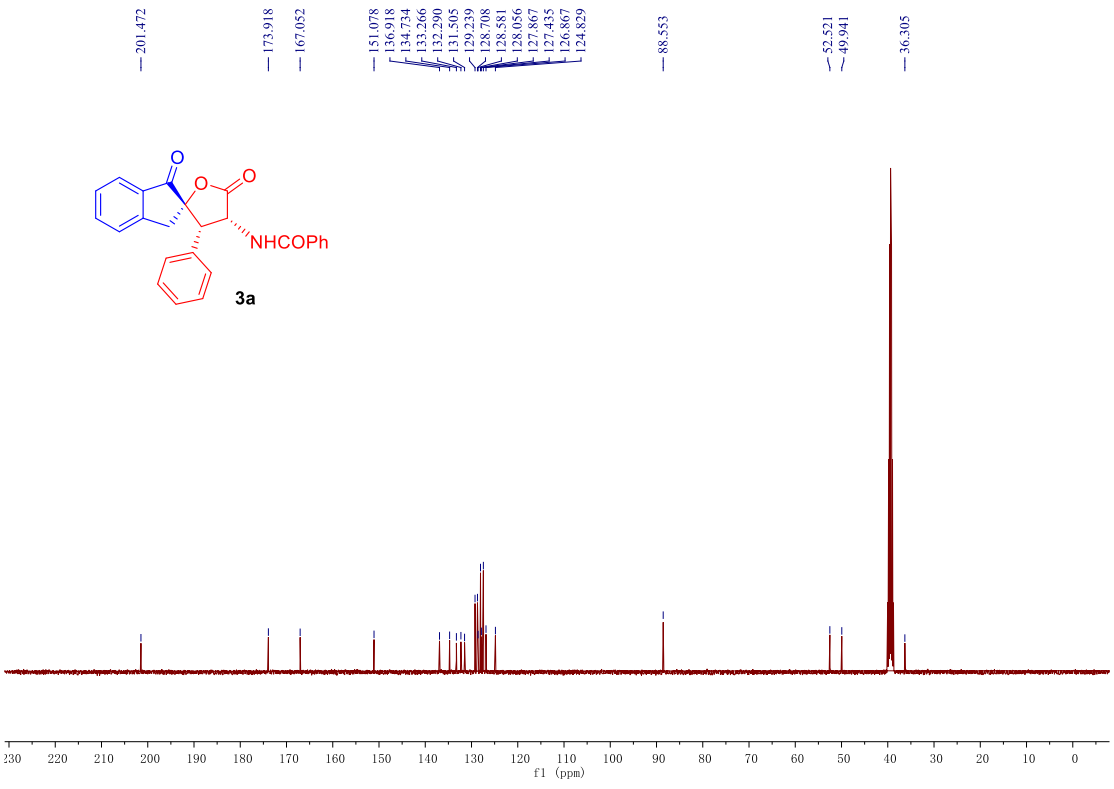
NMR Spectra of compounds



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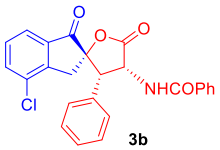
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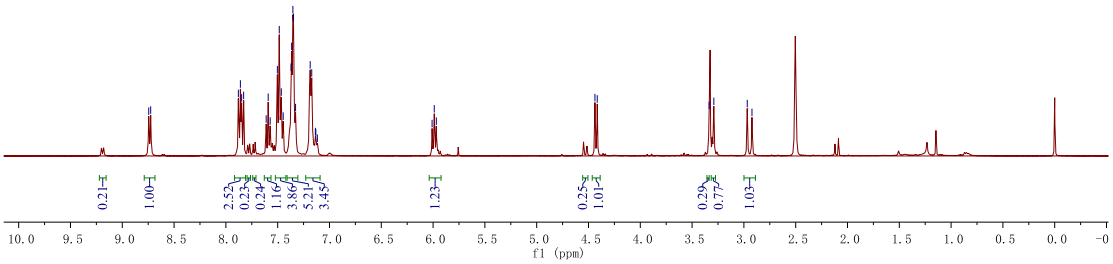
Cl

3b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0.29
0.77
1.03
10.0 9.5 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 -0
f1 (ppm)


200.620
173.692
167.007
148.176
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134.710
134.547
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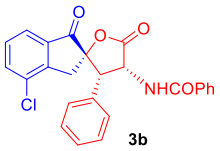
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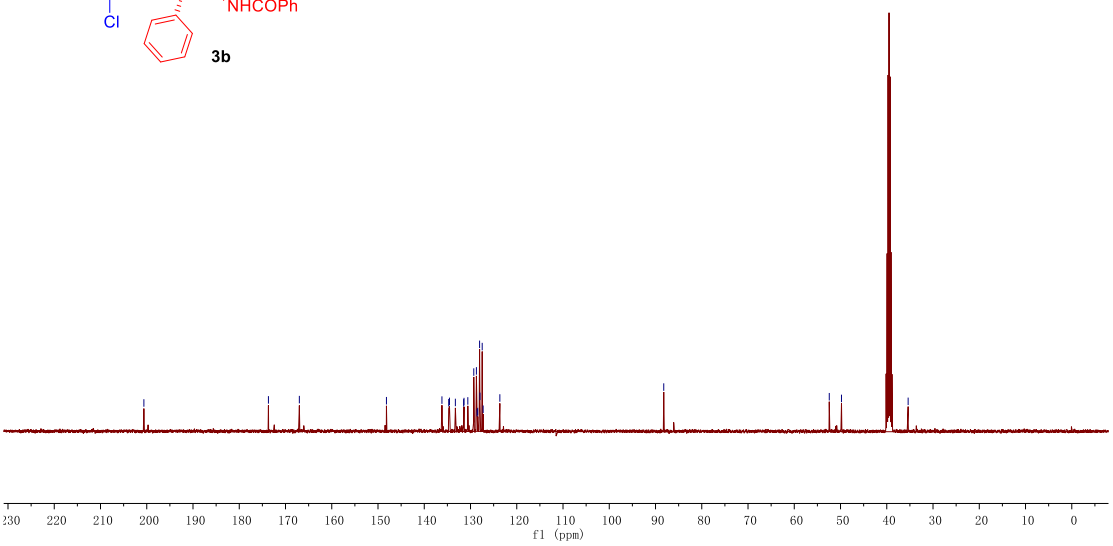
O
O
NHCOPh
Cl

3b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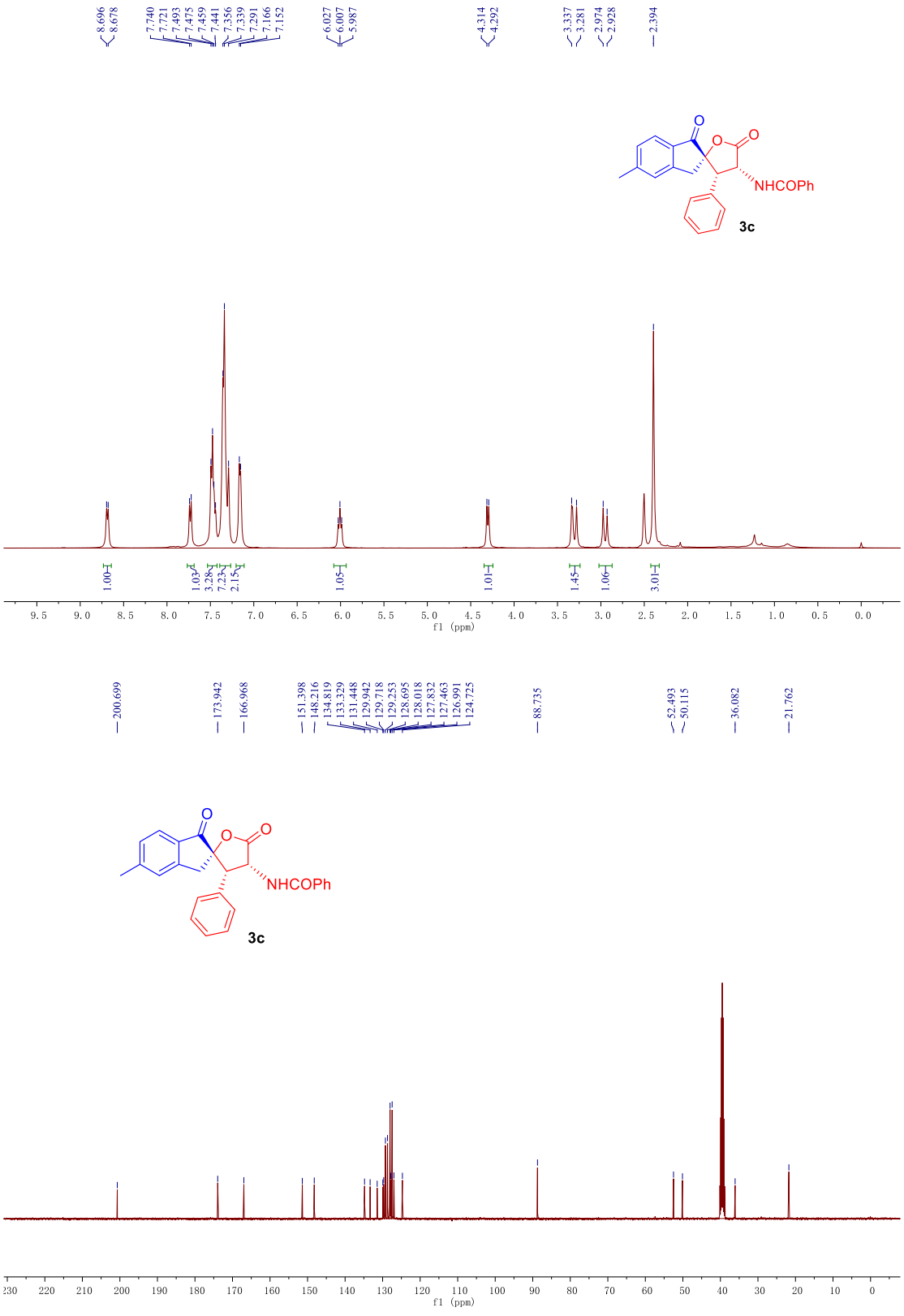
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3.281
2.974
2.928
2.394
NHCOPh
3c
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1.03
3.28
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2.15
1.05
1.01
1.45
1.06
3.01
f1 (ppm)
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173.942
166.968
151.398
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133.329
131.448
129.942
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129.253
128.695
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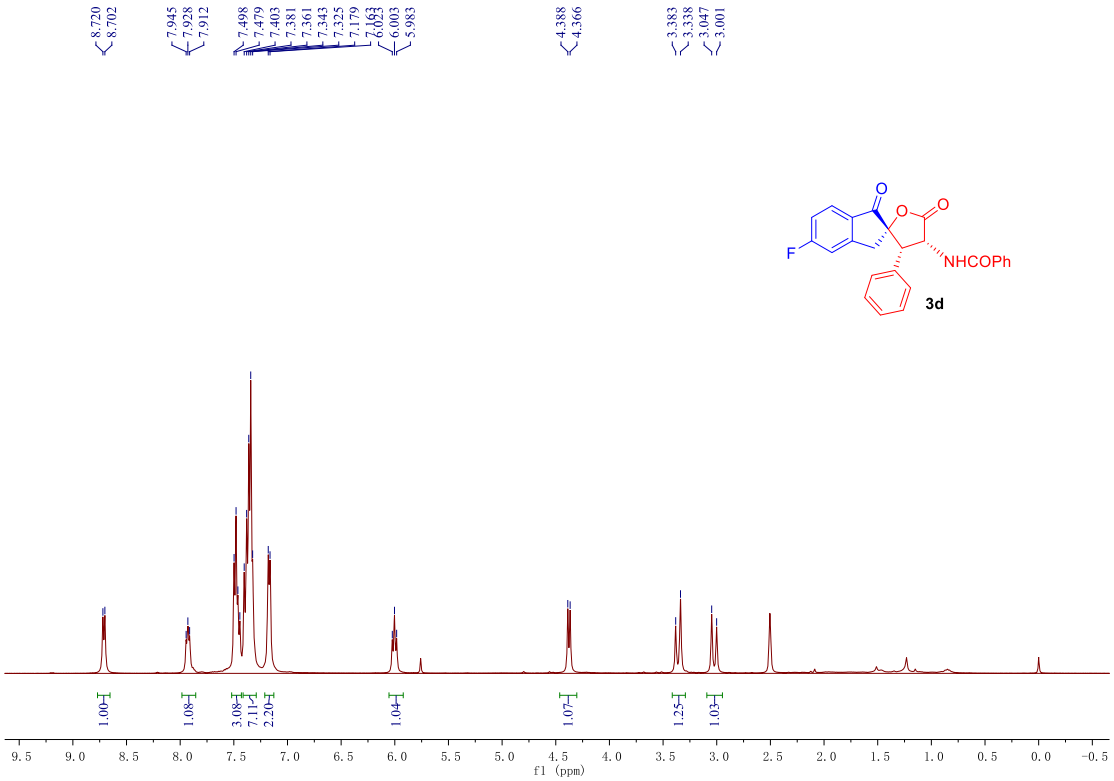
3c
f1 (ppm)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O
O
O
F
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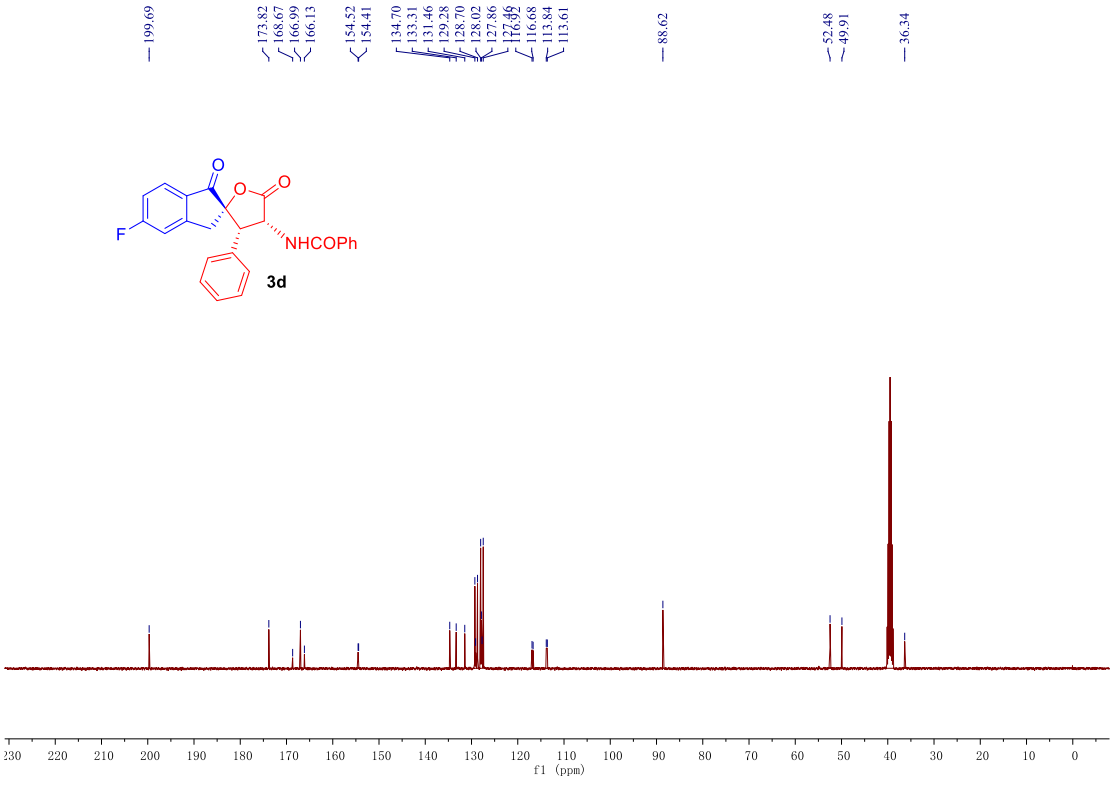
f1 (ppm)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127.86
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49.91
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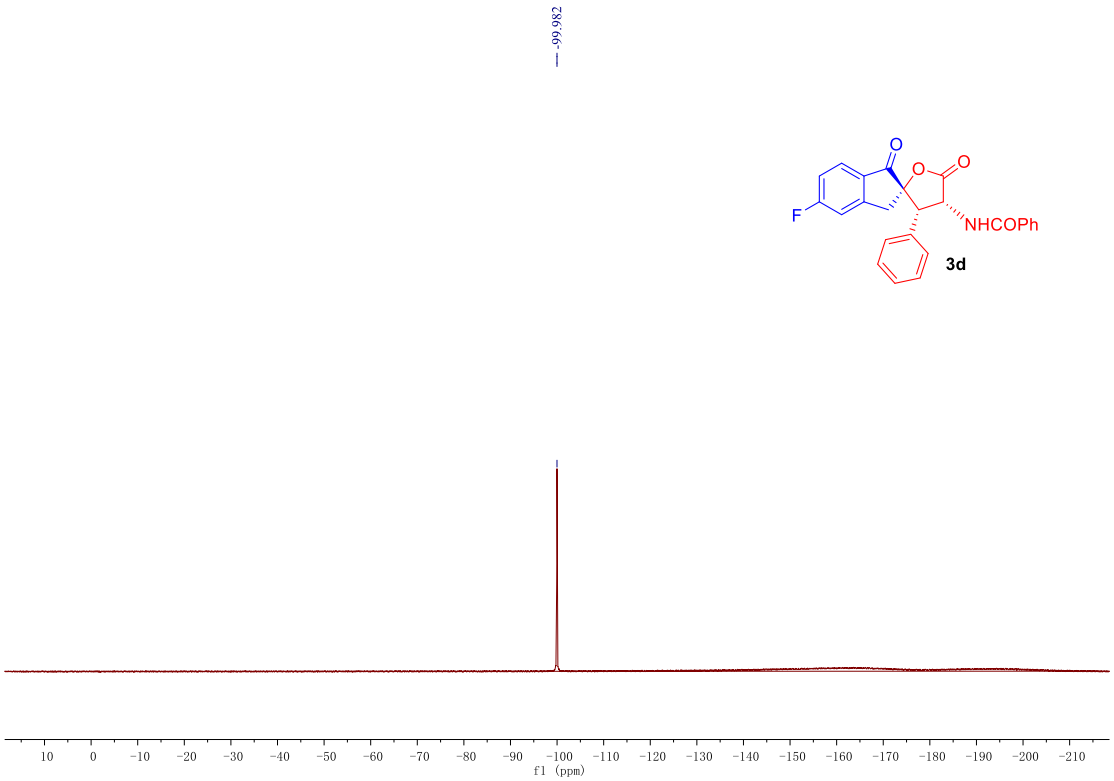
O
O
F
NHCOPh
3d
f1 (ppm)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NHCOPh
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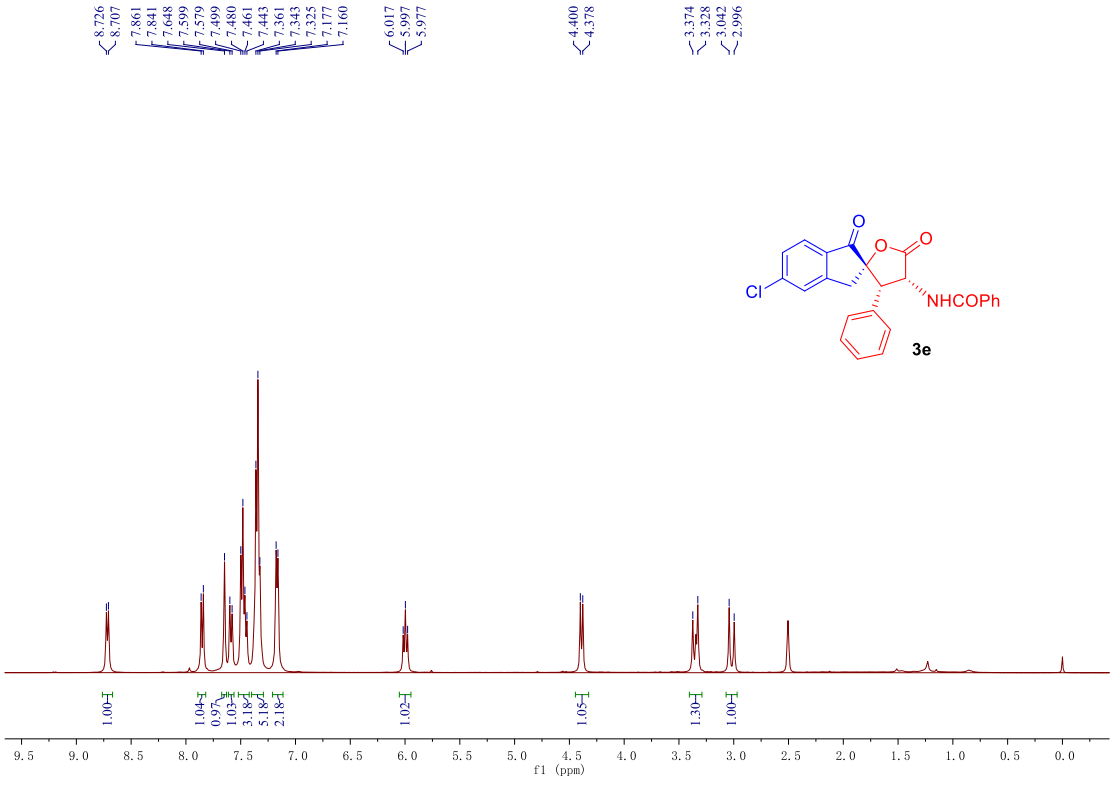
f1 (ppm)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3.328
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3e
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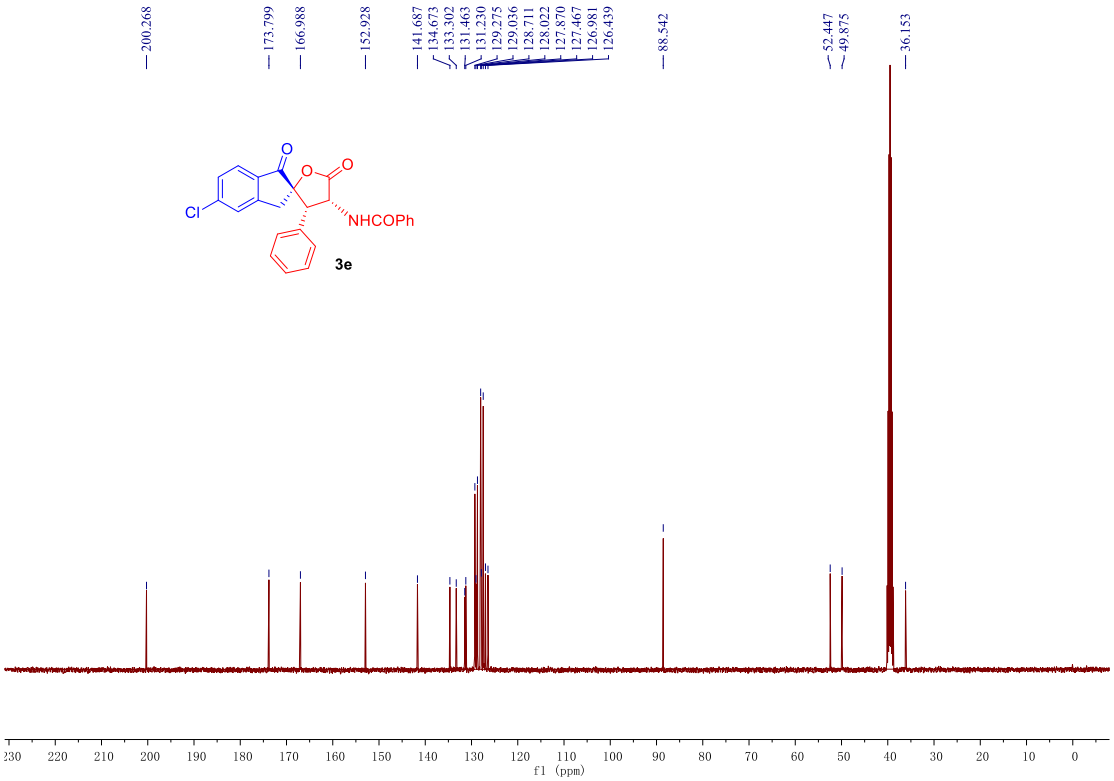
1.04
0.97
1.03
3.18
5.18
2.18
1.02
1.05
1.30
1.00
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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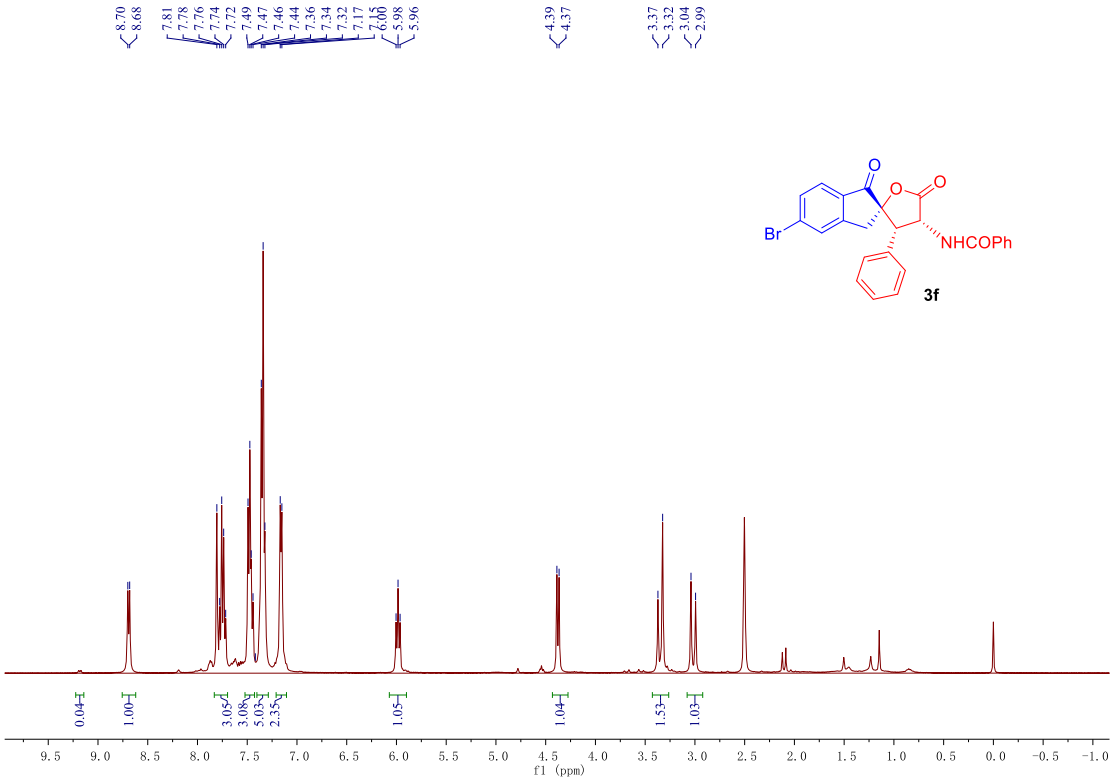
O
O
Cl
NHCOPh
3e
f1 (ppm)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7.17
7.15
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5.98
5.96
4.39
4.37
3.37
3.32
3.04
2.99
O
O
O
Br
NHCOPh
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1.04
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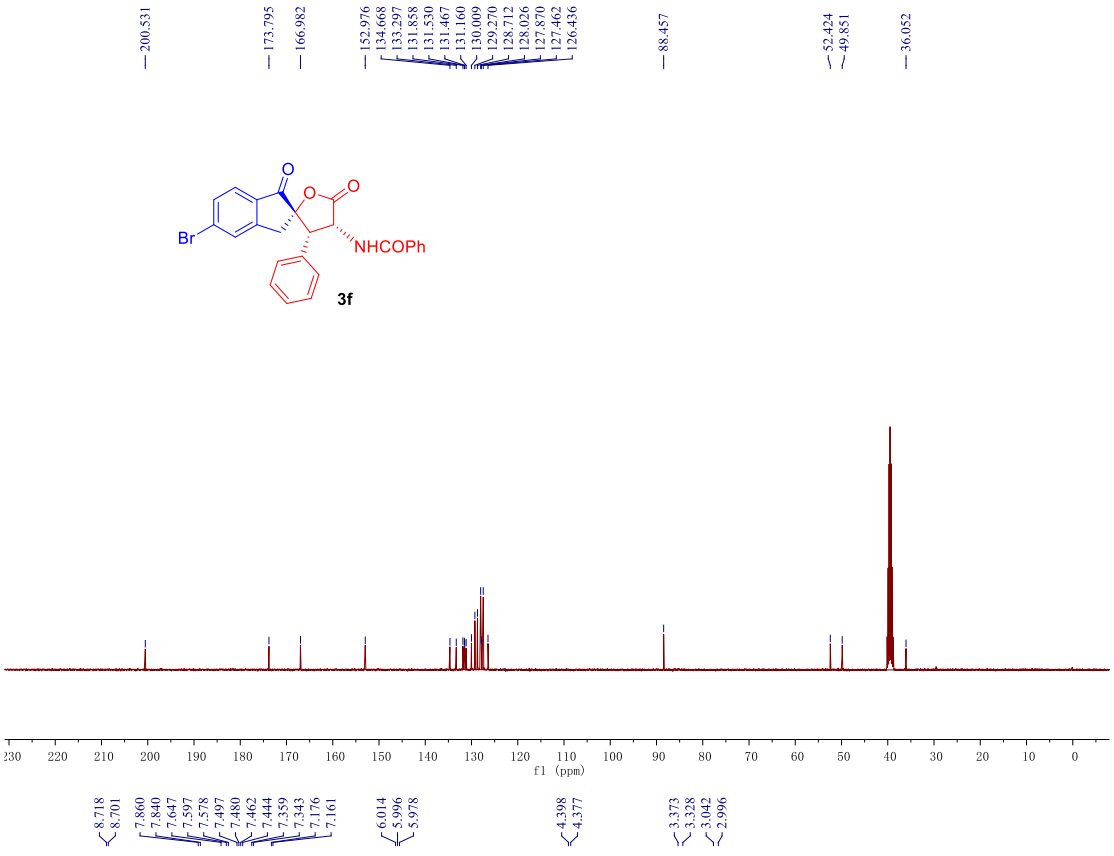
1.03
f1 (ppm)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49.851
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Br
O
O
O
NHCOPh
3f
f1 (ppm)
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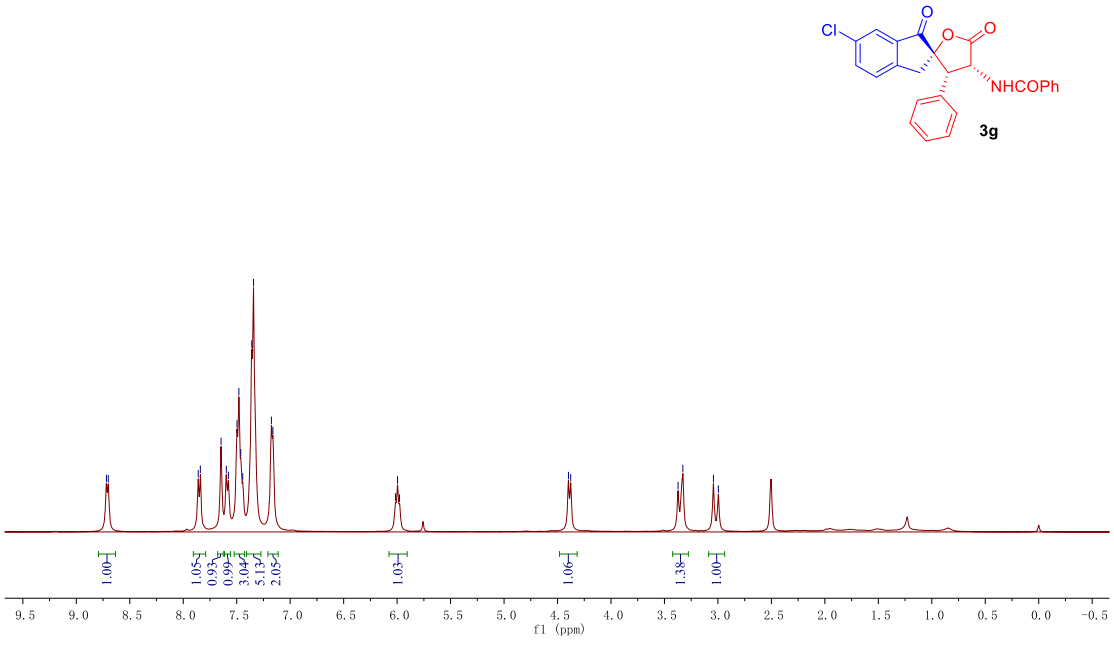
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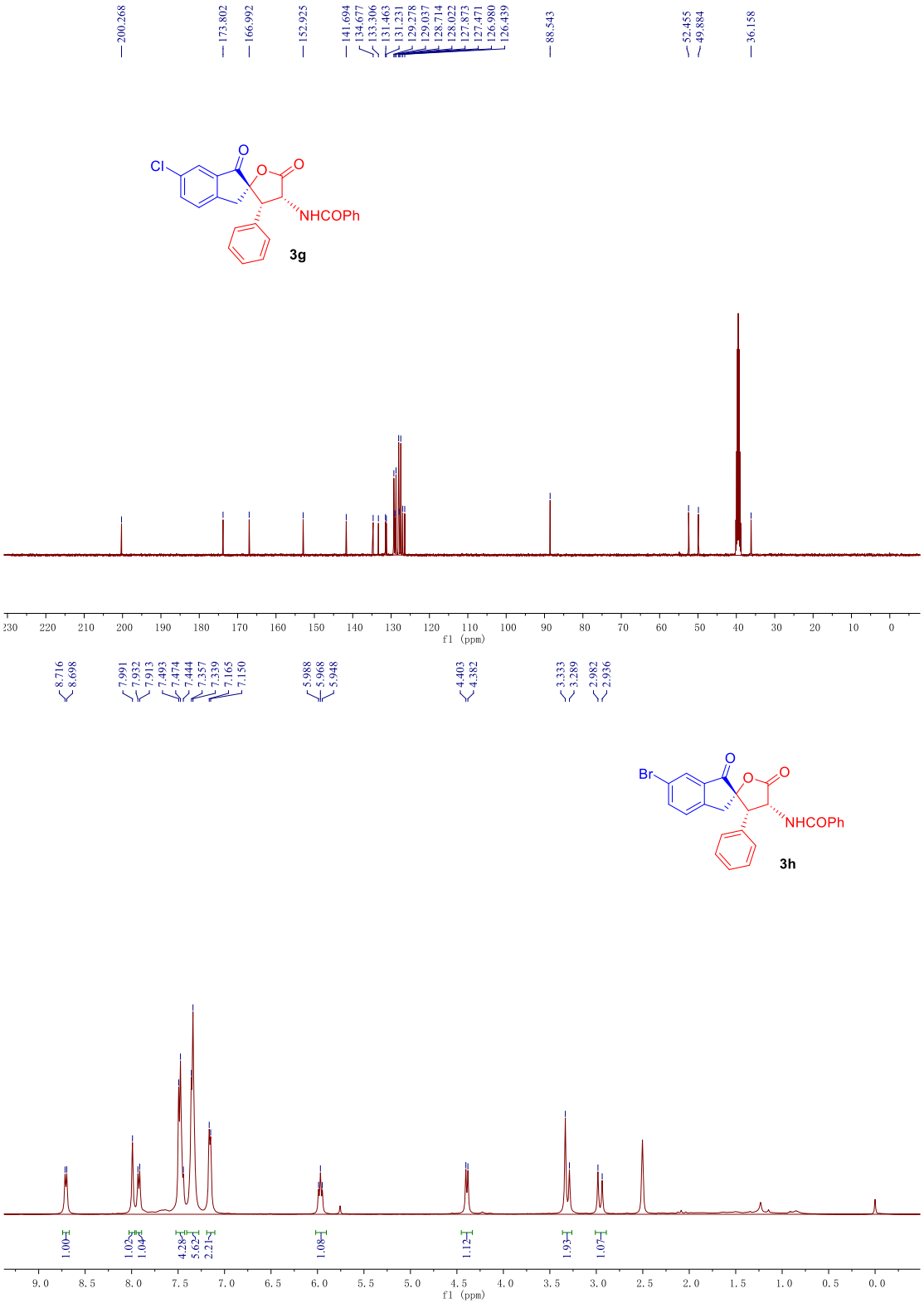
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O
O
O
NHCOPh
3g
f1 (ppm)
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O
O
NHCOPh
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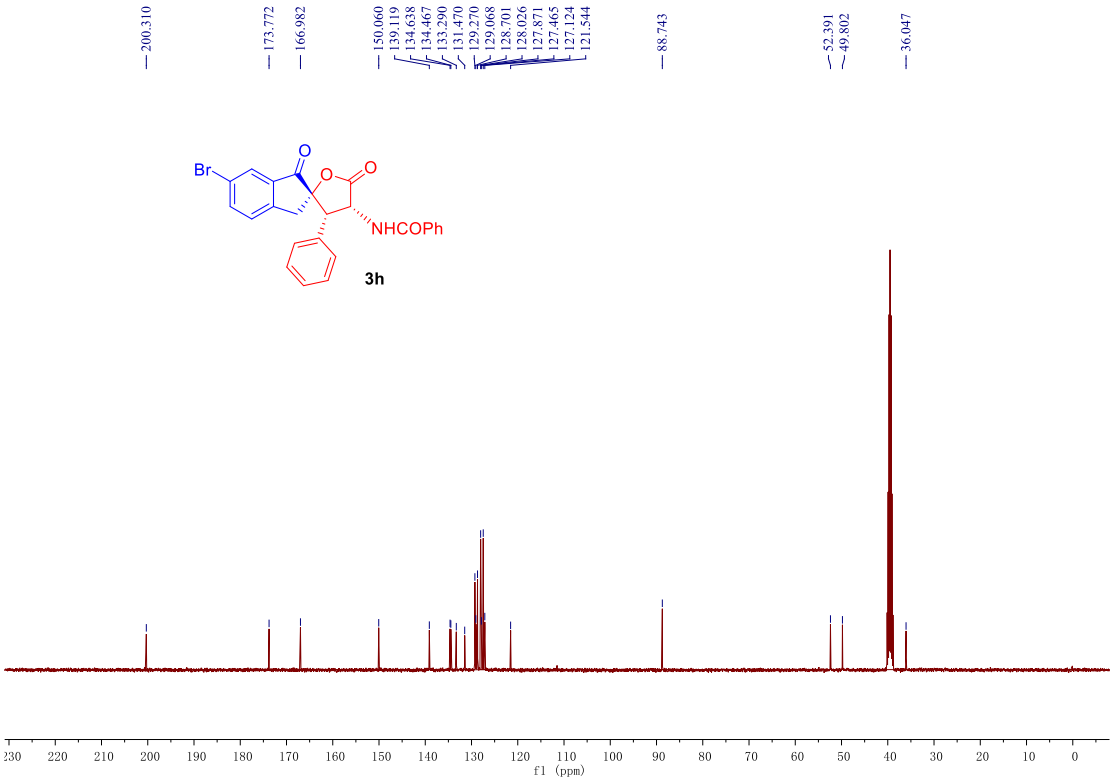
f1 (ppm)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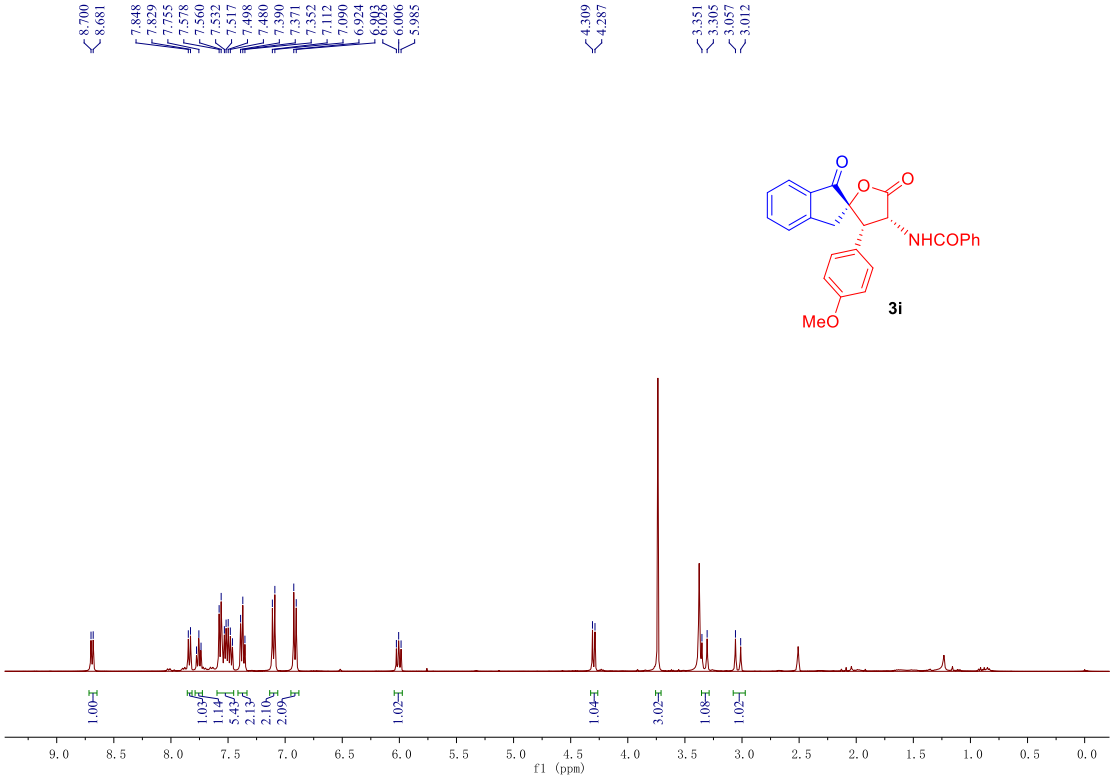
f1 (ppm)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4.287
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3.305
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MeO
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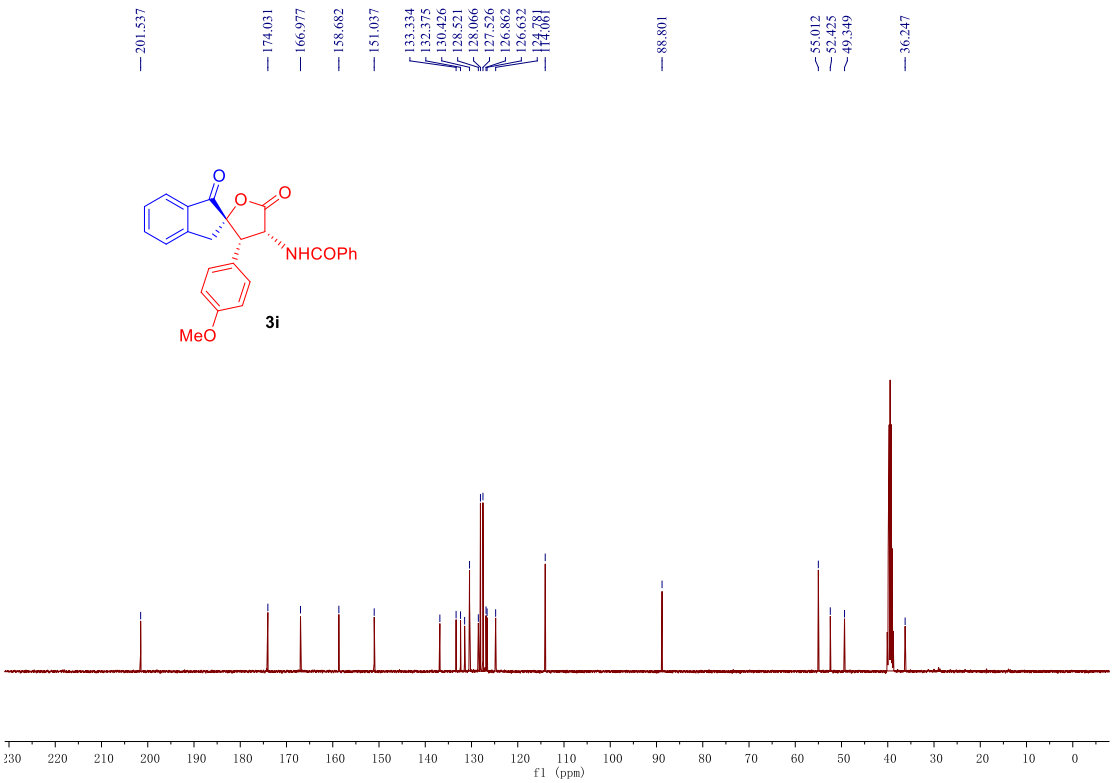
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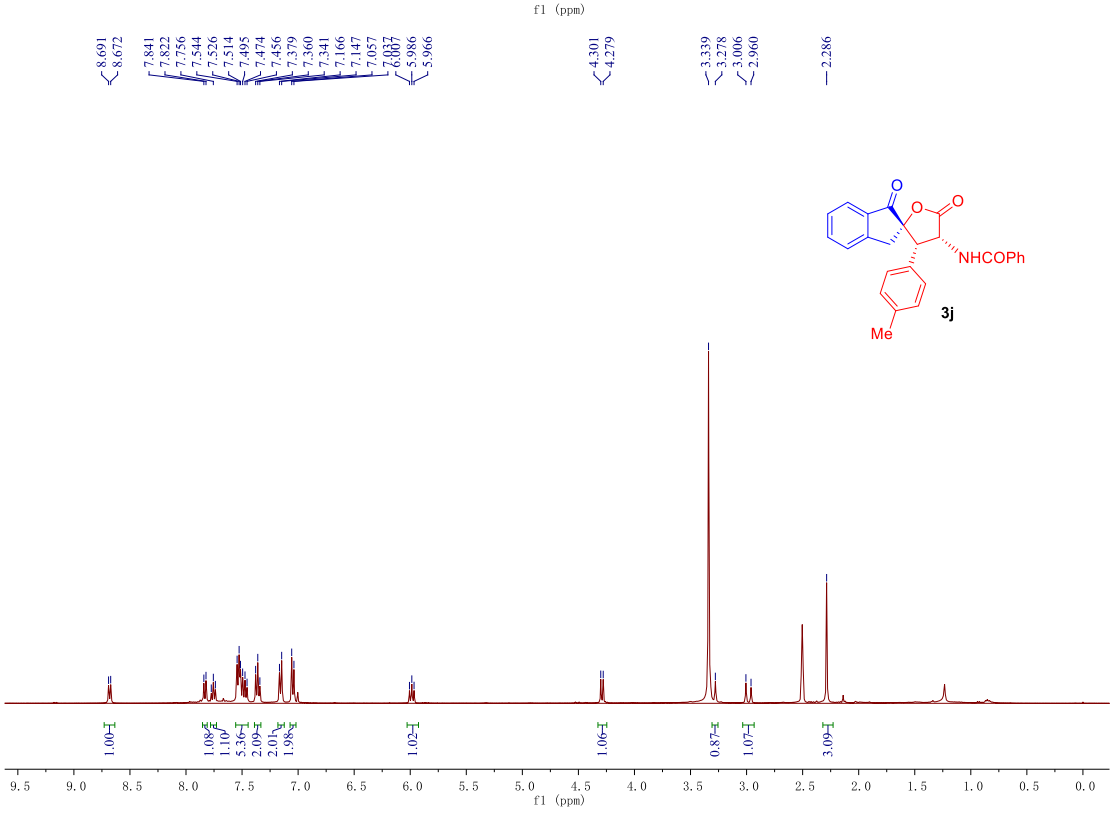
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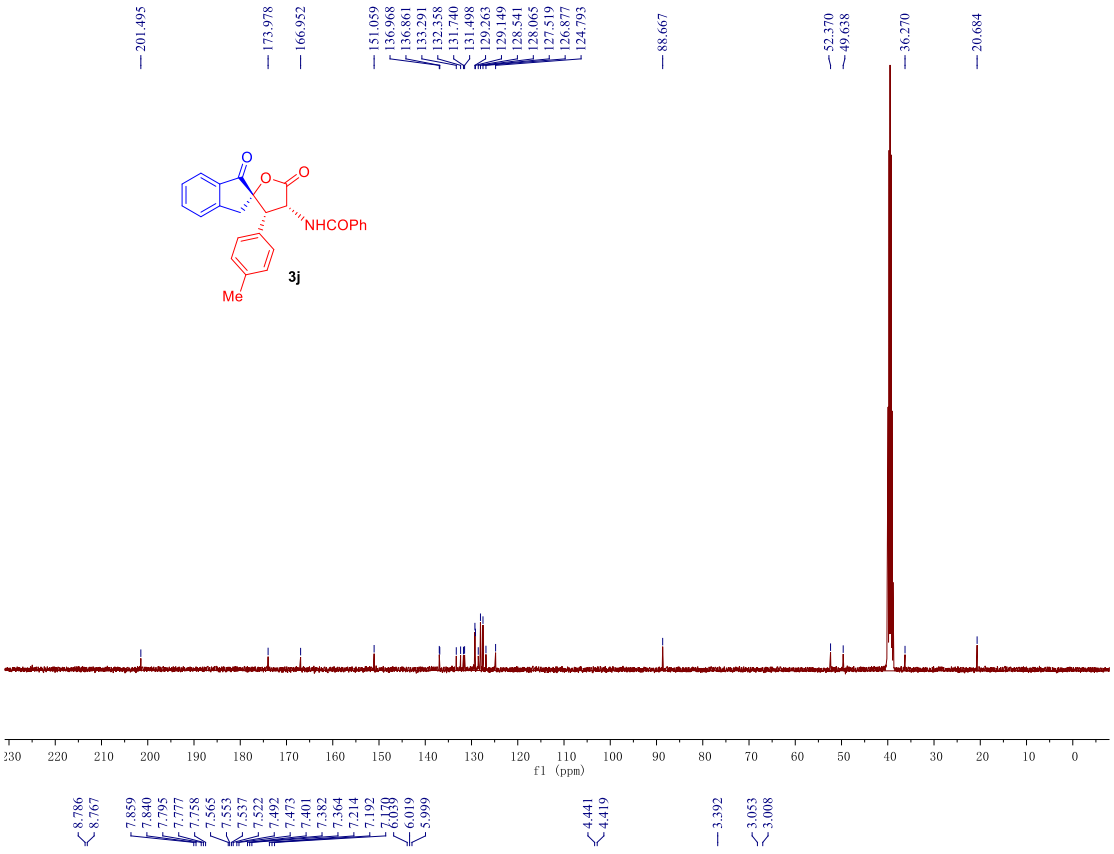
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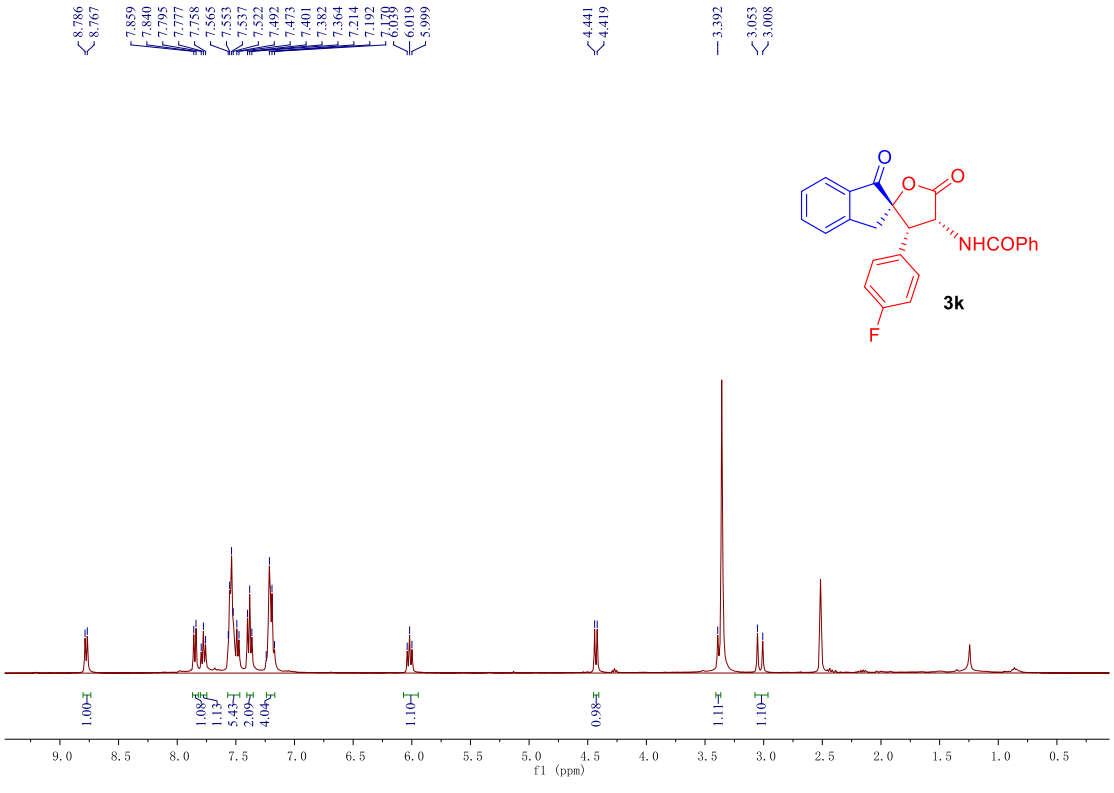
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F
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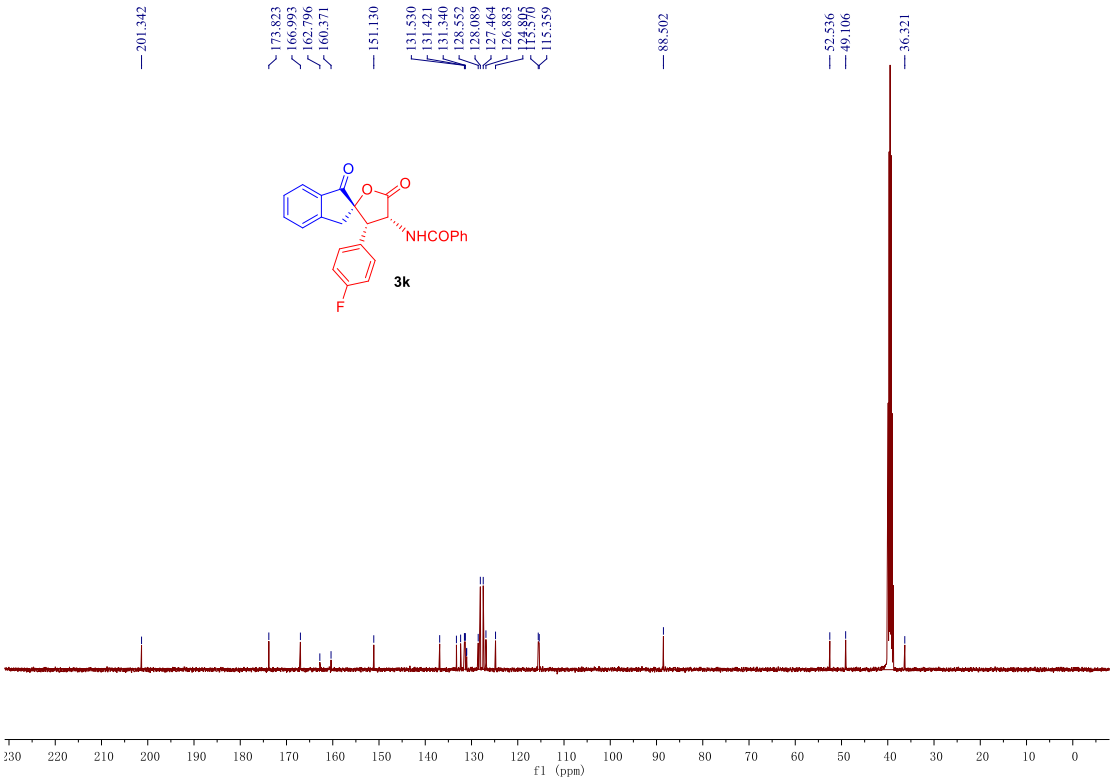
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52.536
49.106
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O
NHCOPh
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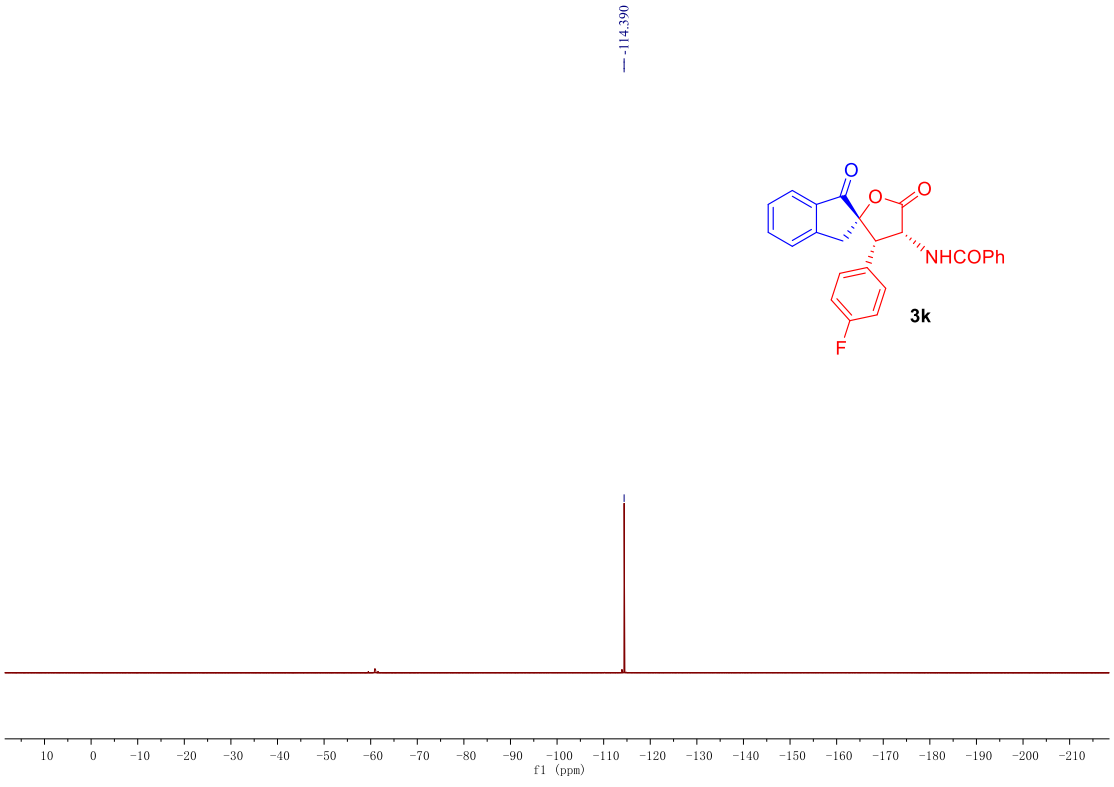
f1 (ppm)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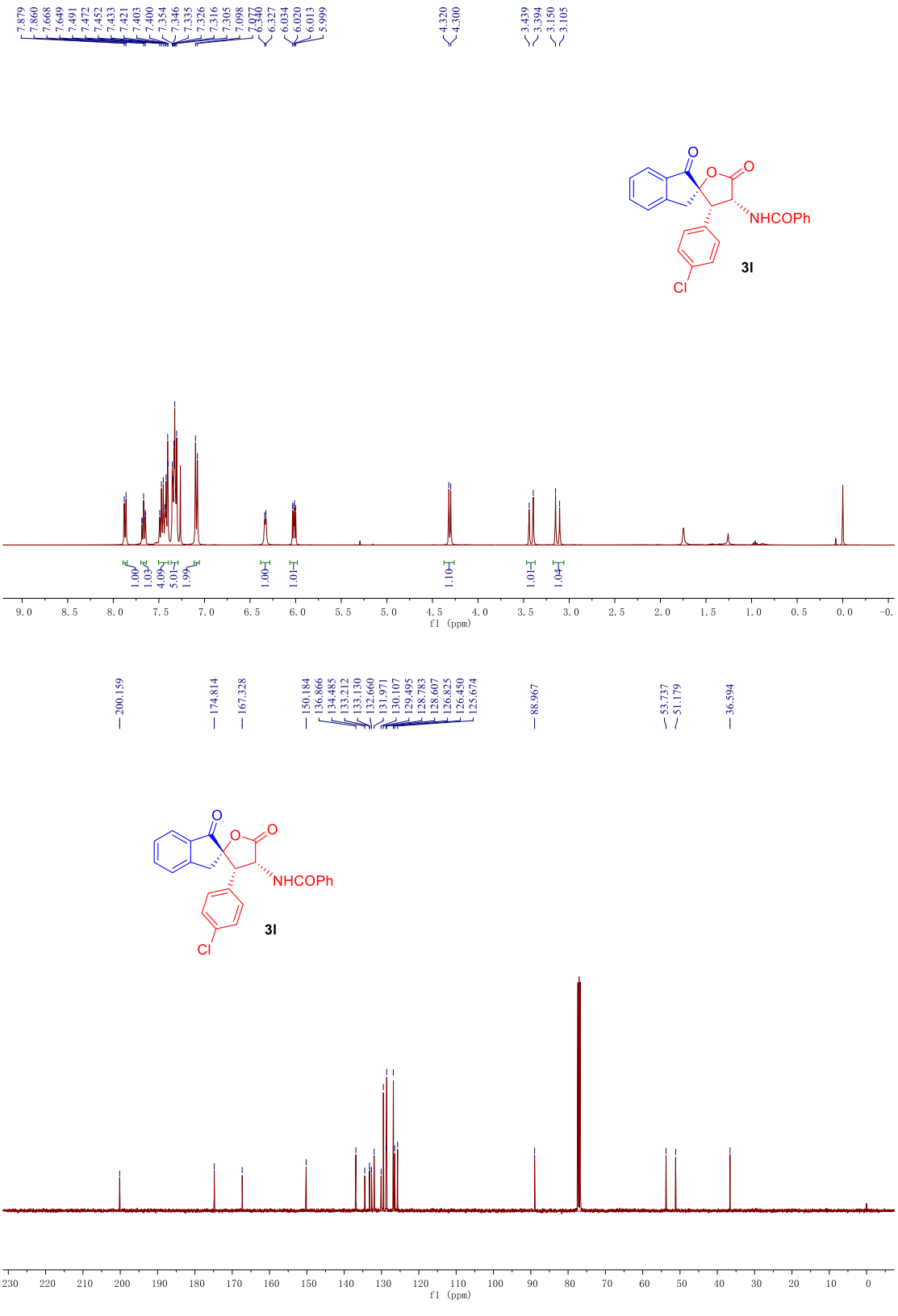
f1 (ppm)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1.01
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f1 (ppm)
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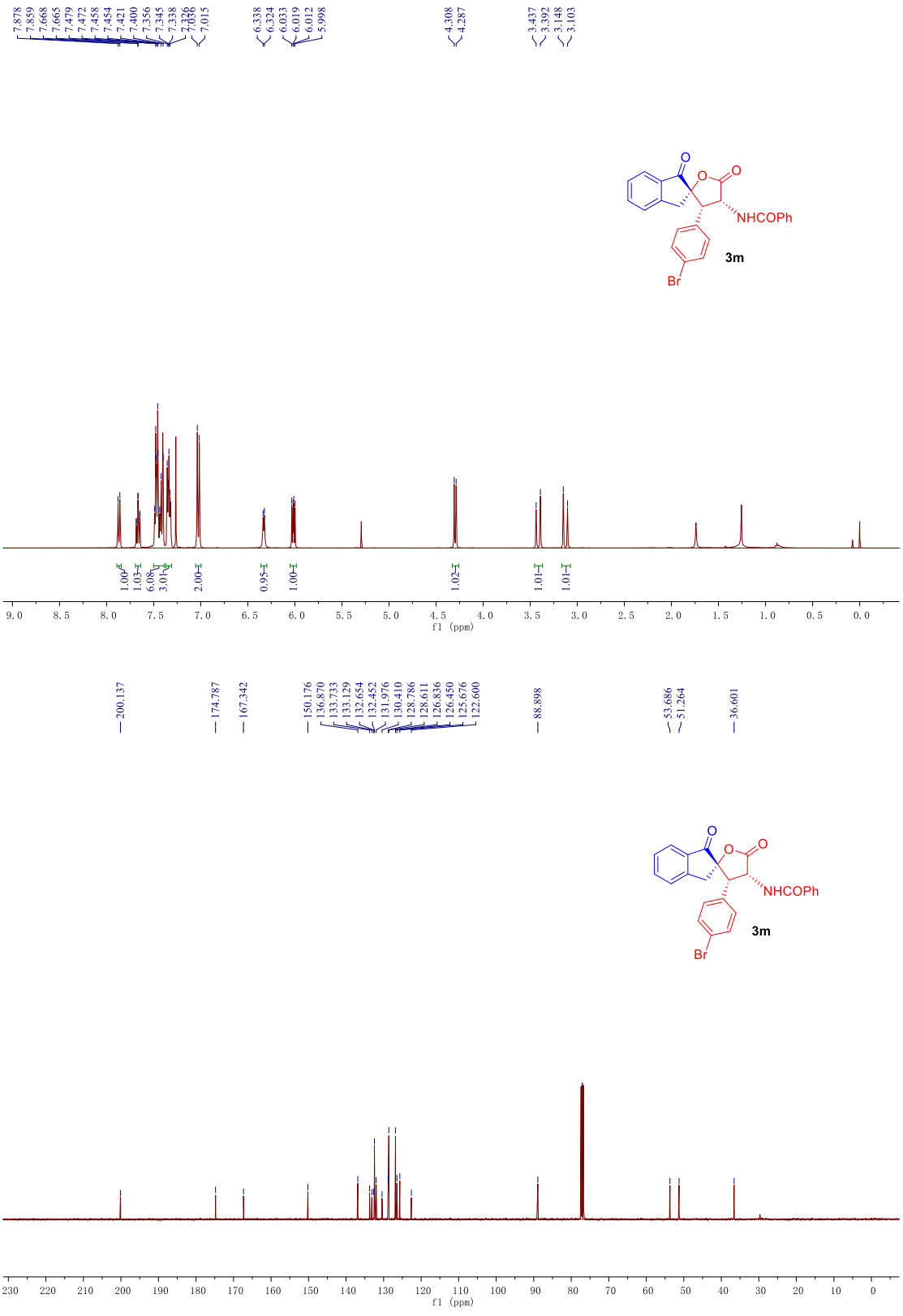
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6.033
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3m
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6.08
3.01
2.00
0.95
1.00
1.02
1.01
1.01
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f1 (ppm)
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167.342
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136.870
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133.129
132.654
132.452
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130.410
128.786
128.611
126.836
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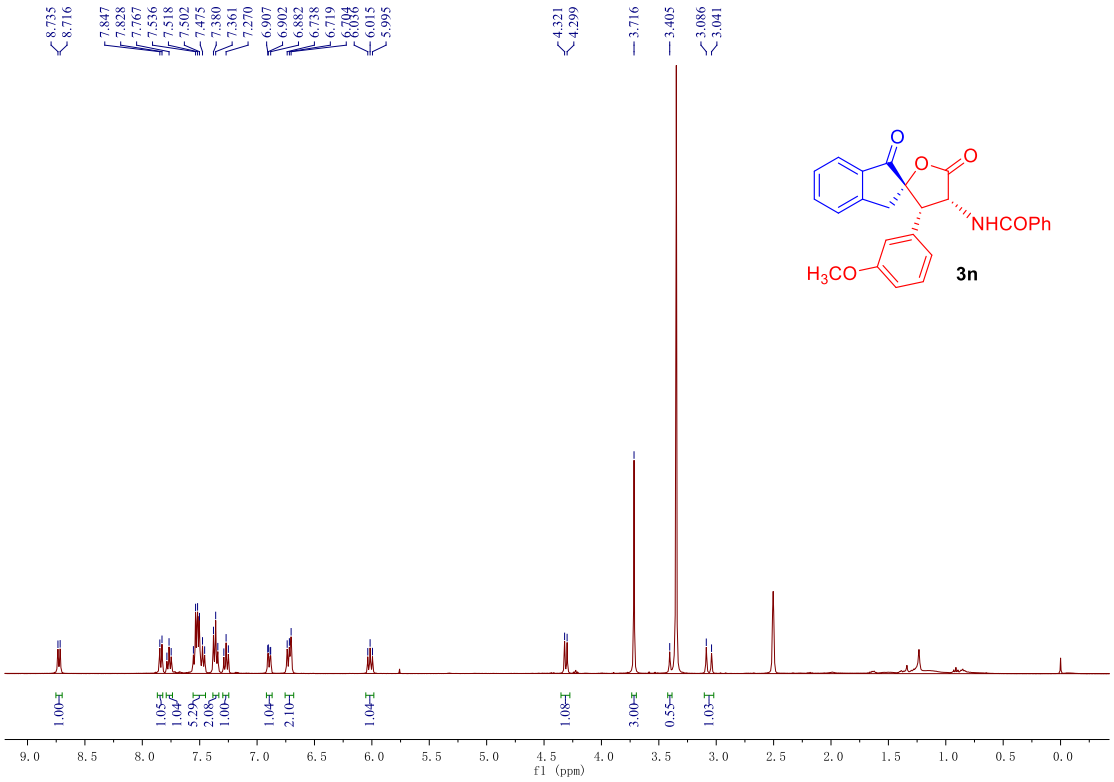
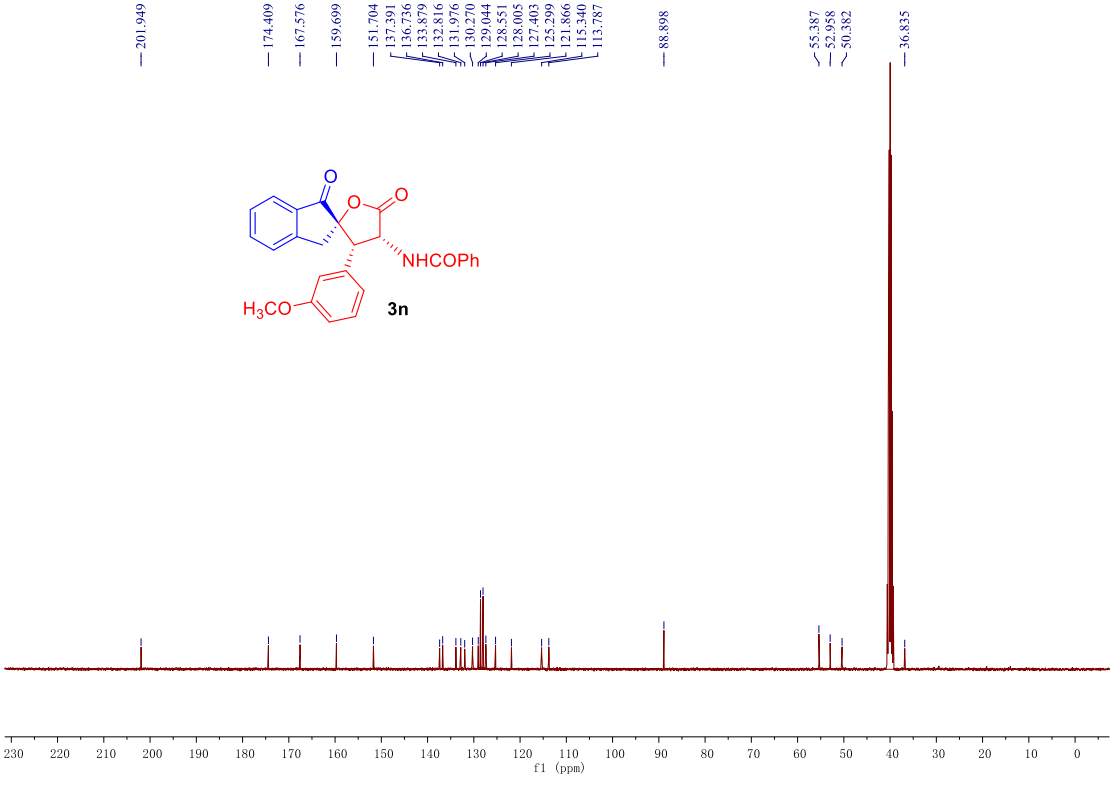
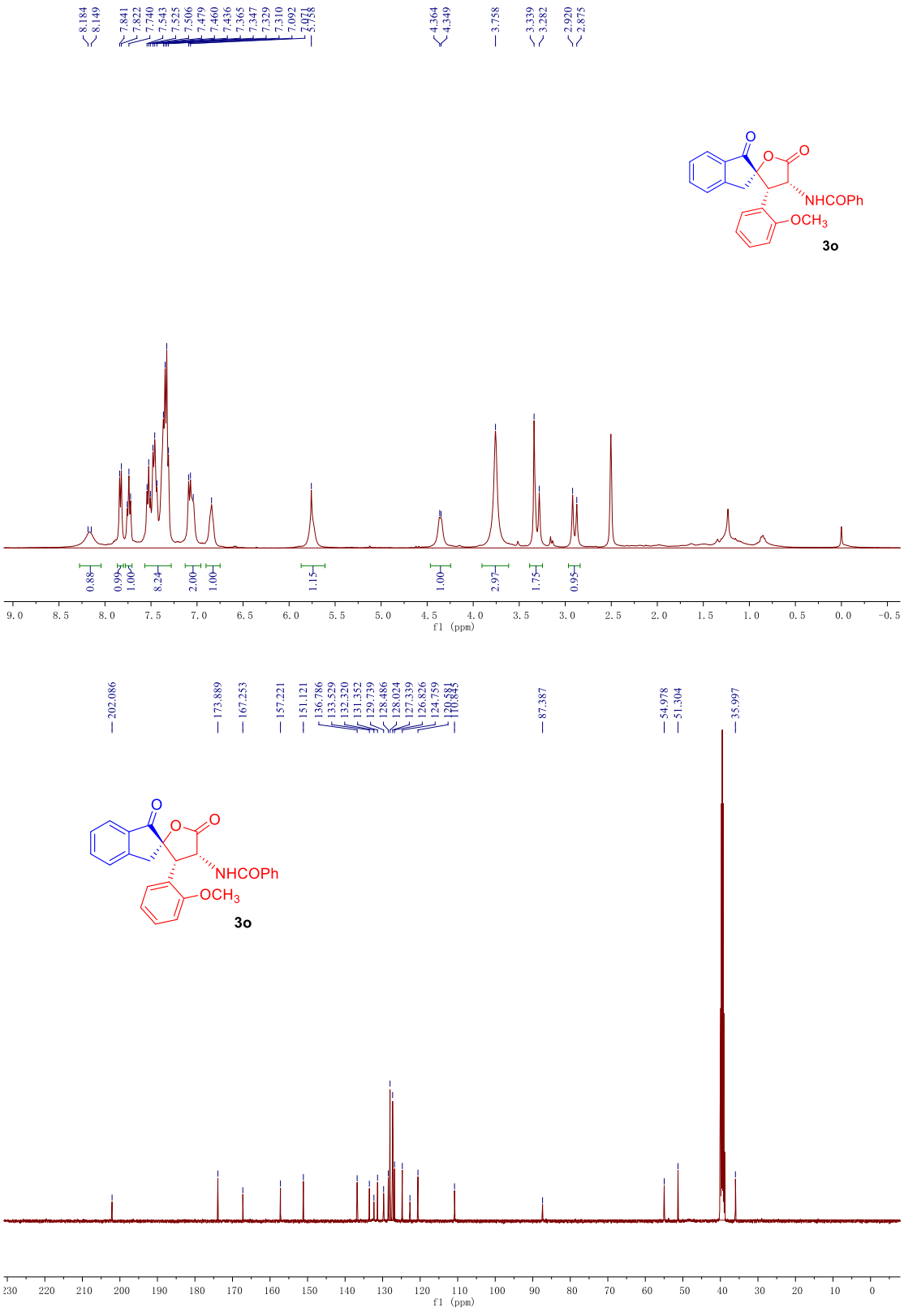
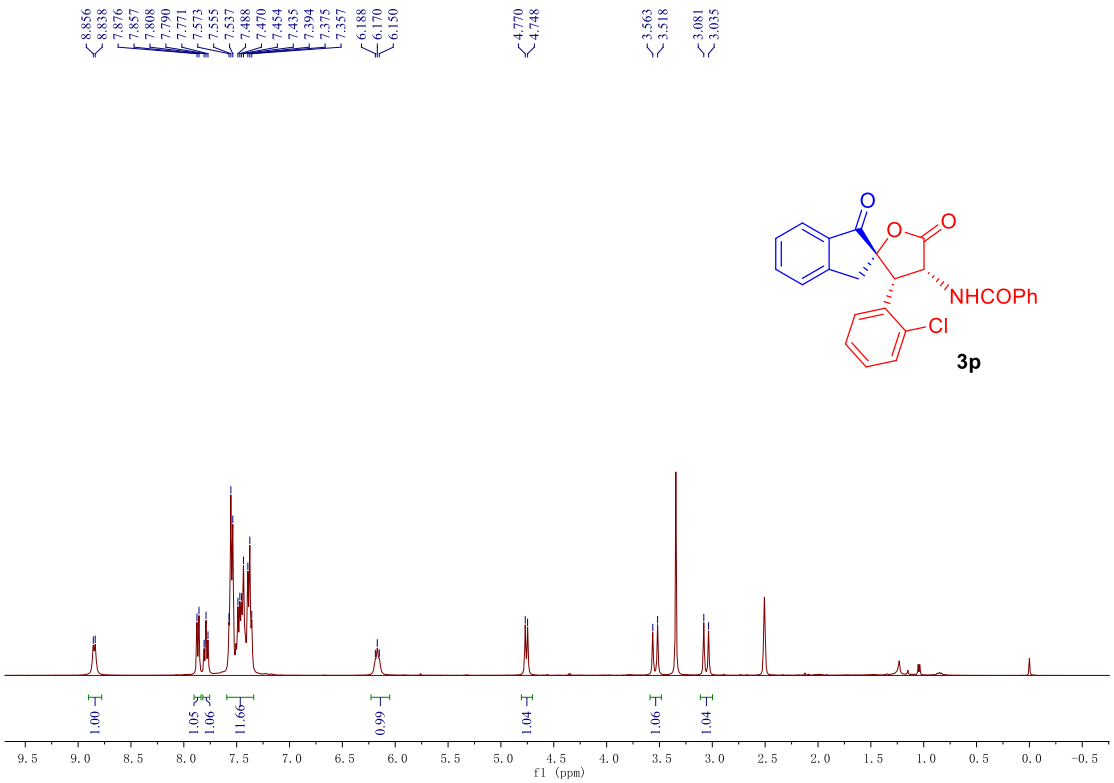
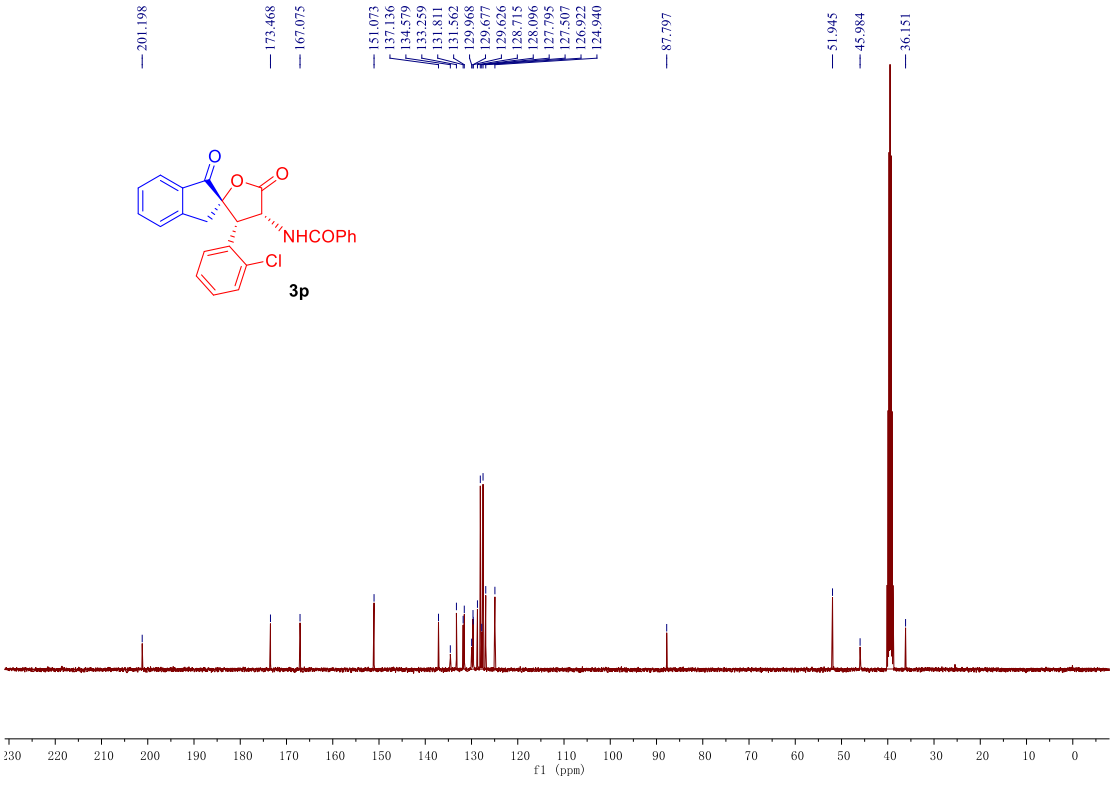
88.898
53.686
51.264
36.601
O
O
O
NHCOPh
3m
Br
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

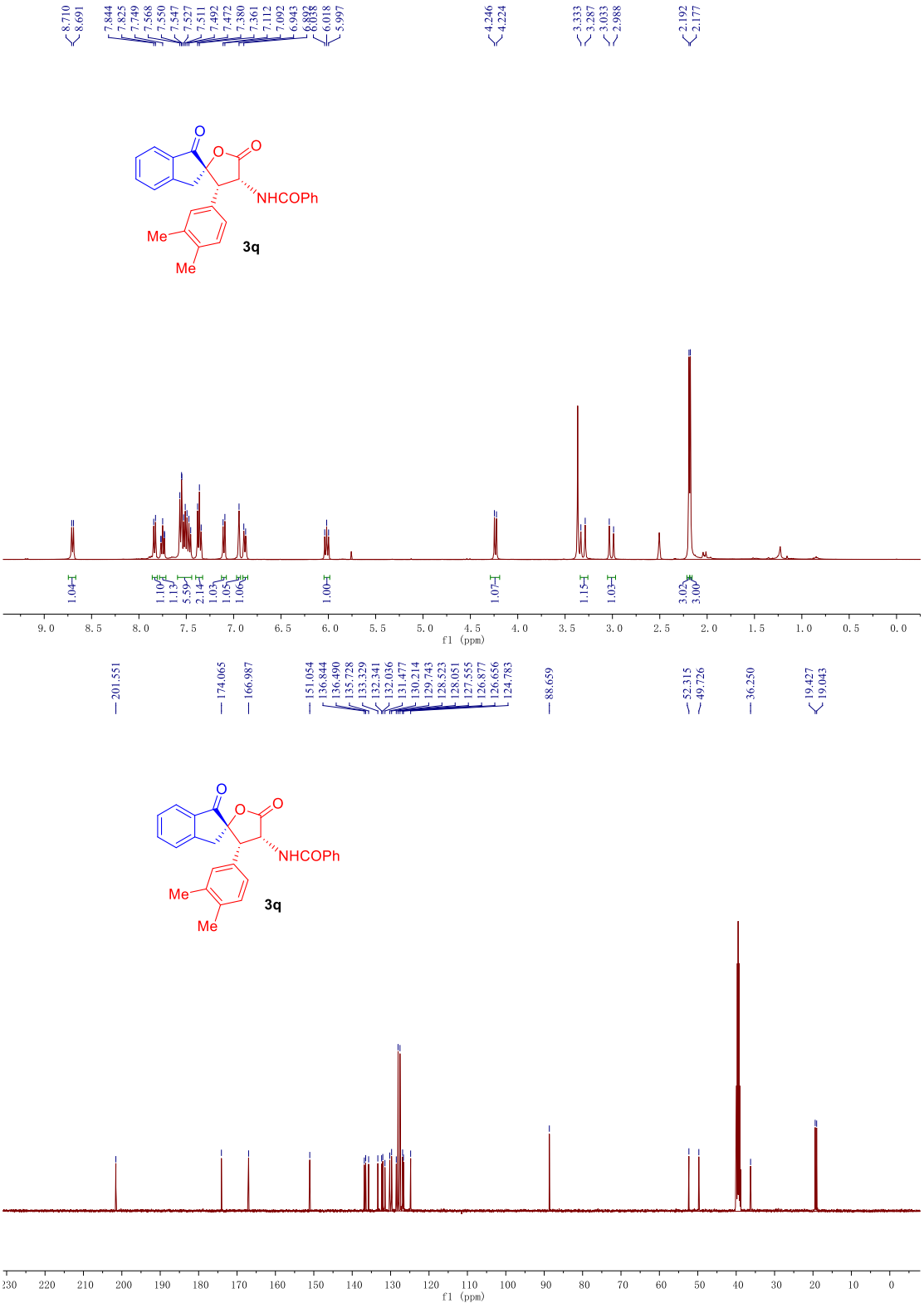

8.735
8.716
7.847
7.828
7.767
7.536
7.518
7.502
7.475
7.380
7.361
7.270
6.907
6.902
6.882
6.738
6.719
6.704
6.036
6.015
5.995
4.321
4.299
3.716
3.405
3.086
3.041
1.00
1.05
1.04
5.29
2.08
1.00
1.04
2.10
1.04
1.08
3.00
0.55
1.03
f1 (ppm)
O
O
O
NHCOPh
H3CO
3n

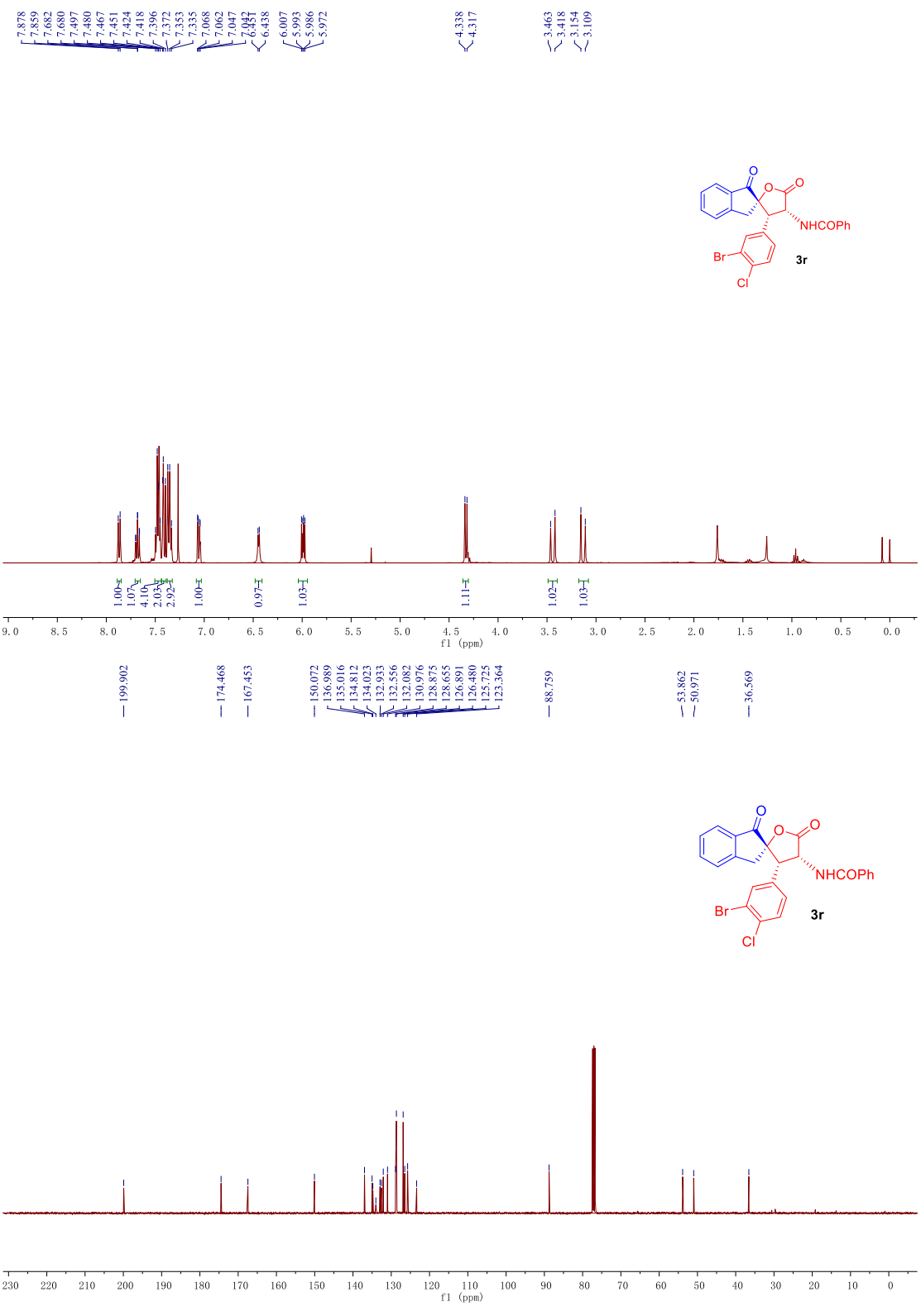

201.949
174.409
167.576
159.699
151.704
137.391
136.736
133.879
132.816
131.976
130.270
129.044
128.551
128.005
127.403
125.299
121.866
115.340
113.787
88.898
55.387
52.958
50.382
36.835
f1 (ppm)
O
O
O
NHCOPh
H3CO
3n


8.184
8.149
7.841
7.822
7.740
7.543
7.525
7.506
7.479
7.460
7.436
7.365
7.347
7.329
7.310
7.092
7.071
5.758
4.364
4.349
3.758
3.339
3.282
2.920
2.875
NHCOPh
OCH3
3o
0.88
0.99
1.00
8.24
2.00
1.00
1.15
1.00
2.97
1.75
0.95
f1 (ppm)
202.086
173.889
167.253
157.221
151.121
136.786
133.529
132.320
131.352
129.739
128.486
128.024
127.339
126.826
124.759
120.884
110.845
87.387
54.978
51.304
35.997
NHCOPh
OCH3
3o
f1 (ppm)

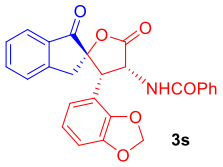

8.856
8.838
7.876
7.857
7.808
7.790
7.771
7.573
7.555
7.537
7.488
7.470
7.454
7.435
7.394
7.375
7.357
6.188
6.170
6.150
4.770
4.748
3.563
3.518
3.081
3.035
O
O
O
NHCOPh
Cl
3p
1.00
1.05
1.06
11.66
0.99
1.04
1.06
1.04
f1 (ppm)


201.198
173.468
167.075
151.073
137.136
134.579
133.259
131.811
131.562
129.968
129.677
129.626
128.715
128.096
127.795
127.507
126.922
124.940
87.797
51.945
45.984
36.151
O
O
O
NHCOPh
Cl
3p
f1 (ppm)

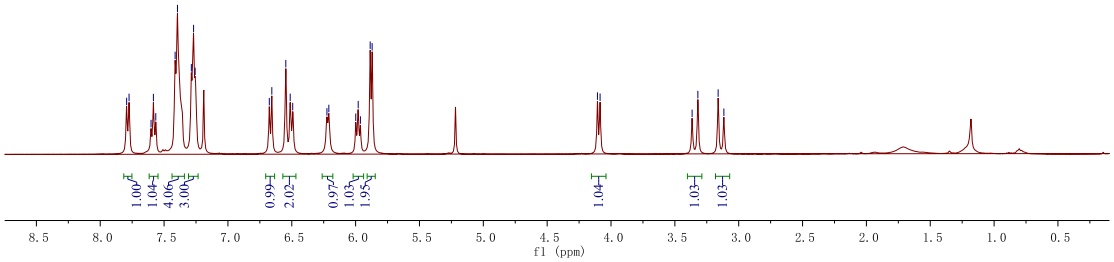

8.710
8.691
7.844
7.825
7.749
7.568
7.550
7.547
7.527
7.511
7.492
7.472
7.380
7.361
7.112
7.092
6.943
6.018
5.997
4.246
4.224
3.333
3.287
3.033
2.988
2.192
2.177
O
O
O
NHCOPh
Me
Me
3q
1.04
1.10
1.13
5.59
2.14
1.03
1.05
1.06
1.00
1.07
1.15
1.03
3.02
3.00
f1 (ppm)
201.551
174.065
166.987
151.054
136.844
136.490
135.728
133.329
132.341
132.036
131.477
130.214
129.743
128.523
128.051
127.555
126.877
126.656
124.783
88.659
52.315
49.726
36.250
19.427
19.043
f1 (ppm)


7.878
7.859
7.682
7.680
7.497
7.480
7.467
7.451
7.424
7.418
7.396
7.372
7.353
7.335
7.068
7.062
7.047
6.438
6.007
5.993
5.986
5.972
4.338
4.317
3.463
3.418
3.154
3.109
O
O
O
NHCOPh
Br
Cl
3r
1.00
1.07
4.10
2.03
2.92
1.00
0.97
1.03
1.11
1.02
1.03
f1 (ppm)
199.902
174.468
167.453
150.072
136.989
135.016
134.812
134.023
132.933
132.556
132.082
130.976
128.875
128.655
126.891
126.480
125.725
123.364
88.759
53.862
50.971
36.569
f1 (ppm)

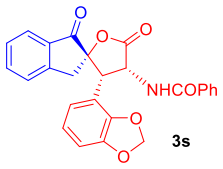

7.793
7.774
7.602
7.584
7.565
7.414
7.395
7.286
7.269
7.257
6.676
6.656
6.547
6.512
6.225
6.210
5.999
5.980
5.962
5.886
5.871
4.106
4.086
3.365
3.320
3.161
3.116


O
O
O
NHCOPh
O
O

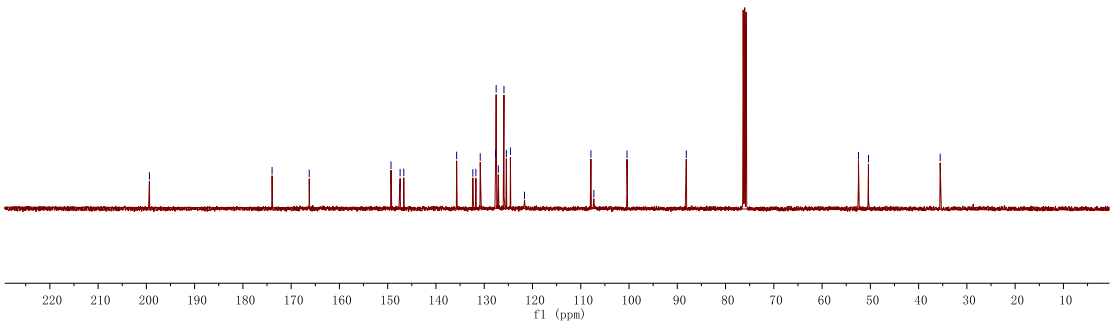
3s


1.00
1.04
4.06
3.00
0.99
2.02
0.97
1.03
1.95
1.04
1.03
1.03
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
f1 (ppm)

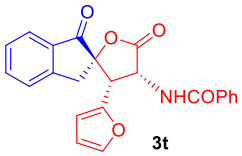

199.369
173.951
166.252
149.317
147.427
146.668
135.717
131.726
130.827
127.640
127.527
127.078
125.909
125.414
124.569
107.882
107.288
100.419
88.136
52.463
50.394
35.532


O
O
O
NHCOPh
O
O

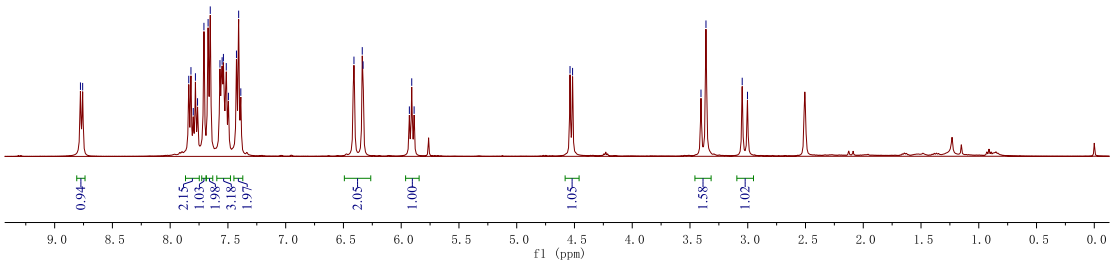
3s


220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

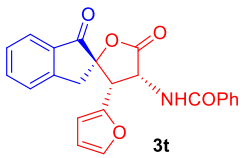

8.777
8.758
7.839
7.820
7.781
7.708
7.672
7.653
7.569
7.550
7.539
7.514
7.496
7.426
7.407
6.337
6.330
5.929
5.909
5.888
4.538
4.516
3.405
3.362
3.048
3.002


O
O
O
NHCOPh
O

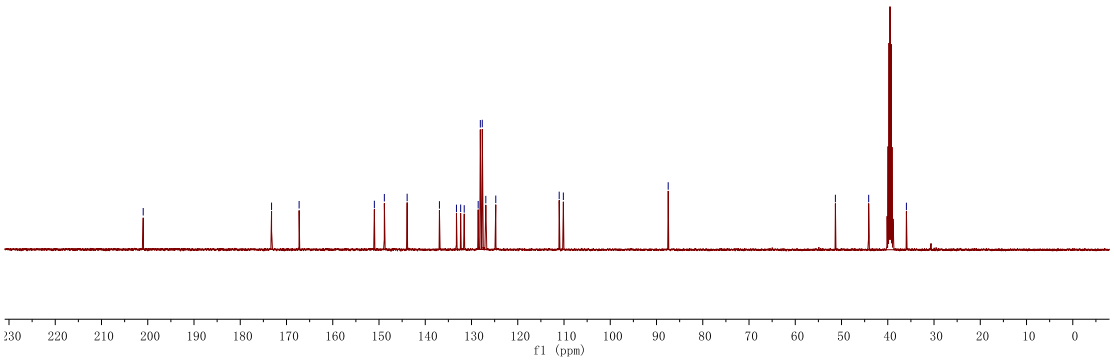
3t

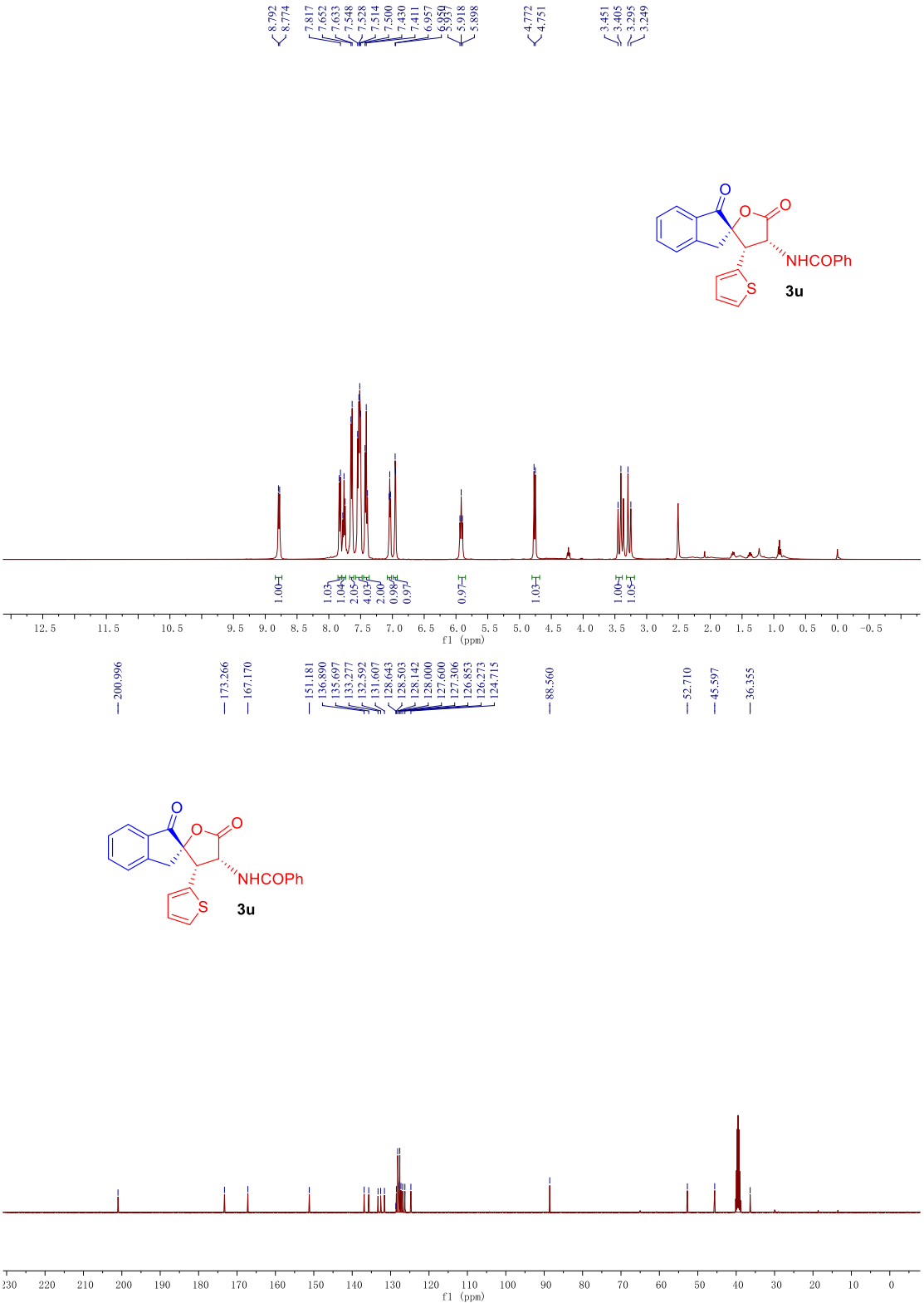

0.94
2.15
1.03
1.98
3.18
1.97
2.05
1.00
1.05
1.58
1.02
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

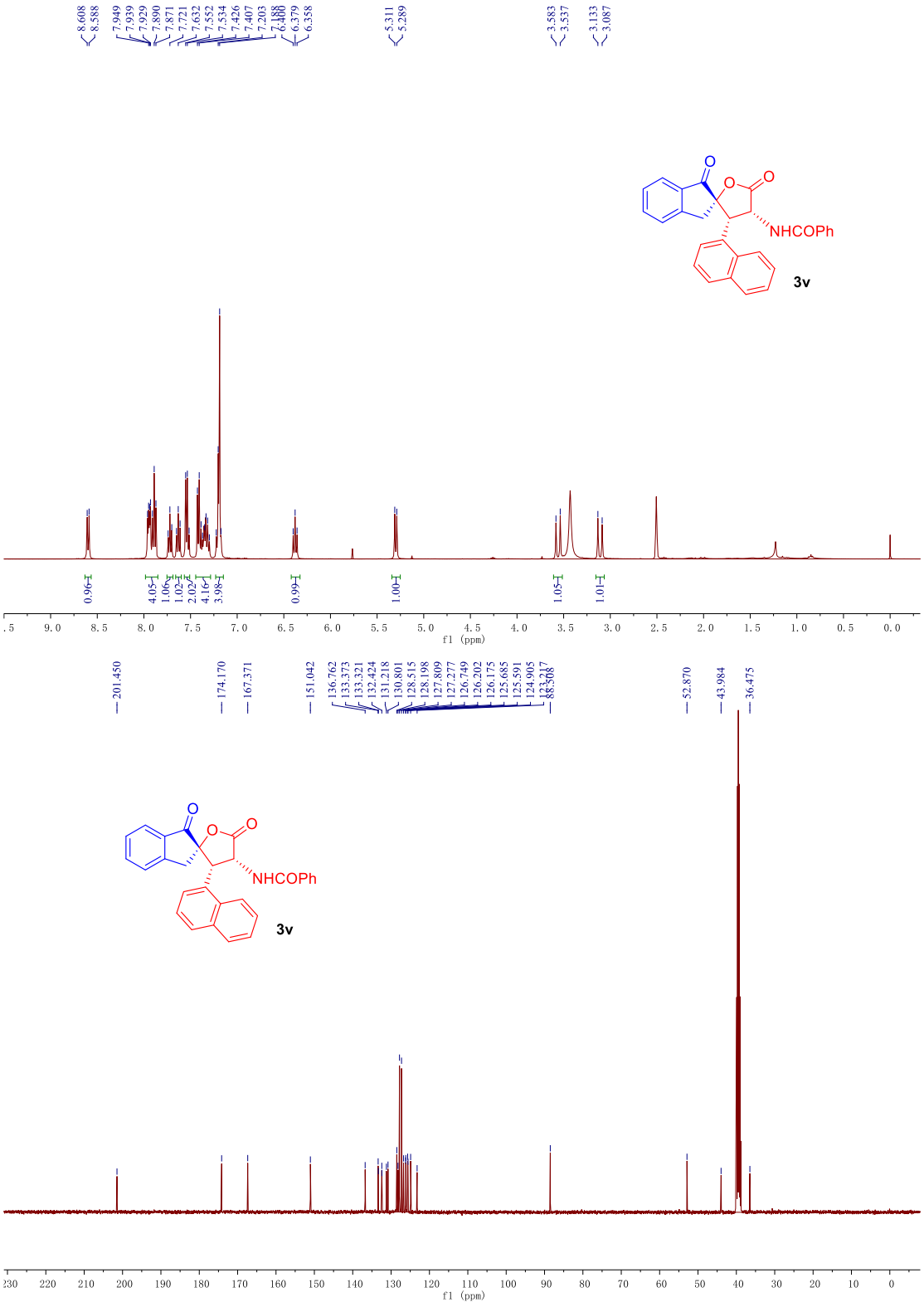

200.984
173.232
167.272
151.004
148.845
143.917
136.934
133.254
132.345
128.558
128.094
127.673
126.908
124.754
111.041
110.142
87.472
51.322
44.129
35.970

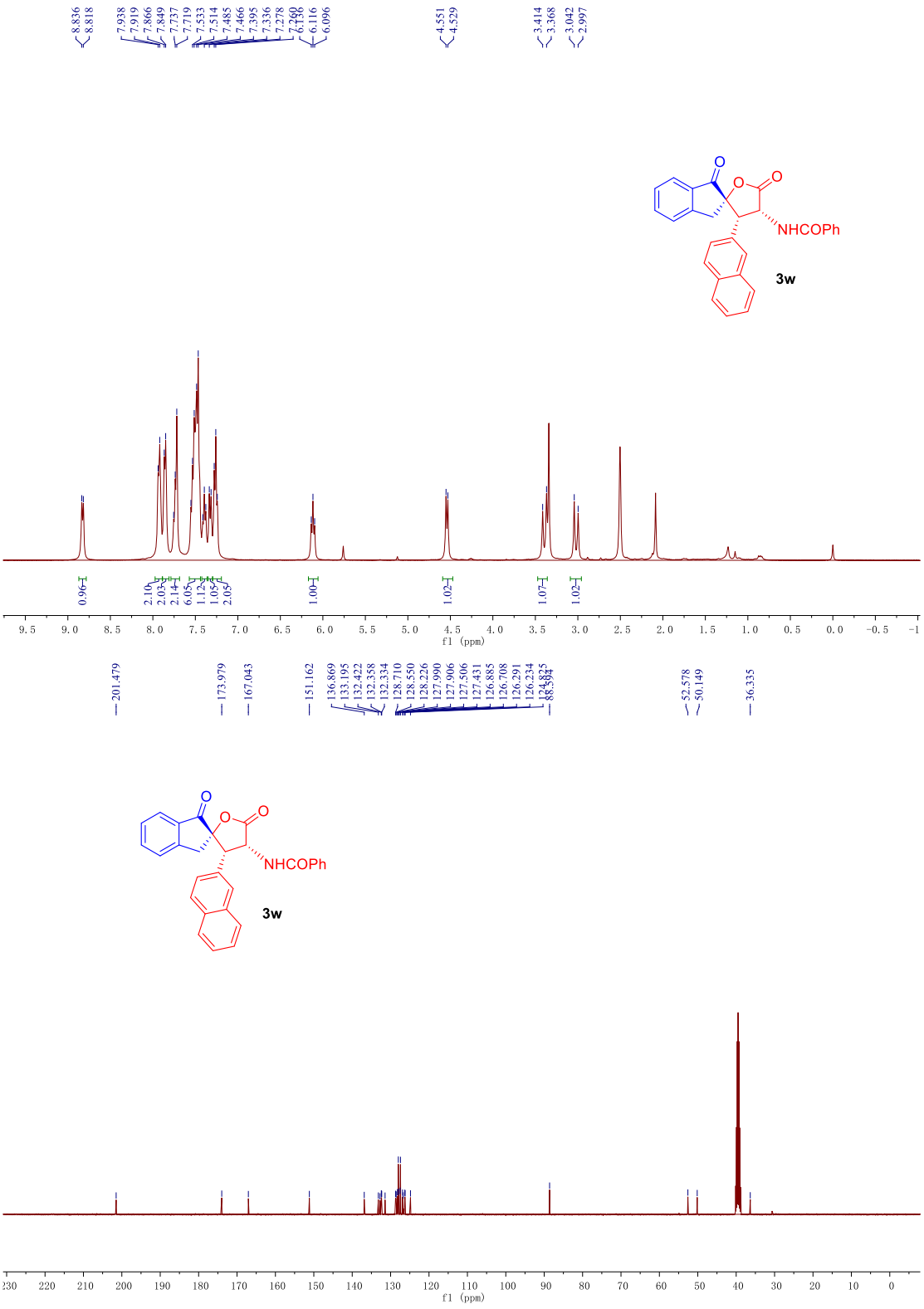

O
O
O
NHCOPh
O

3t

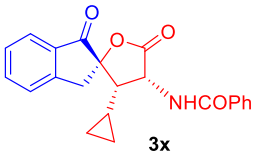

230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


8.792
8.774
7.817
7.652
7.633
7.548
7.528
7.514
7.500
7.430
7.411
6.957
6.950
6.937
5.918
5.898
4.772
4.751
3.451
3.405
3.295
3.249
O
O
O
NHCOPh
S
3u
1.00
1.03
1.04
2.05
4.03
2.00
0.98
0.97
0.97
1.03
1.00
1.05
f1 (ppm)
200.996
173.266
167.170
151.181
136.890
135.697
133.277
132.592
131.607
128.643
128.503
128.142
128.000
127.600
127.306
126.853
126.273
124.715
88.560
52.710
45.597
36.355
f1 (ppm)

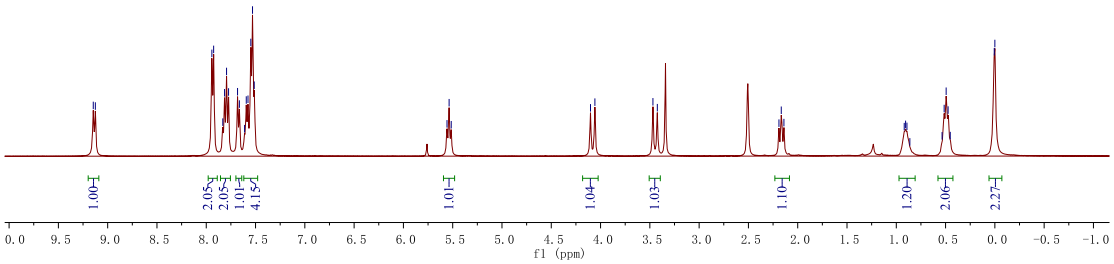

8.608
8.588
7.949
7.939
7.929
7.890
7.871
7.721
7.632
7.552
7.534
7.426
7.407
7.203
6.400
6.379
6.358
5.311
5.289
3.583
3.537
3.133
3.087
NHCOPh
3v
0.96
4.05
1.06
1.02
2.02
4.16
3.98
0.99
1.00
1.05
1.01
f1 (ppm)
201.450
174.170
167.371
151.042
136.762
133.373
133.321
132.424
131.218
130.801
128.515
128.198
127.809
127.277
126.749
126.202
126.175
125.685
125.591
124.905
123.217
88.508
52.870
43.984
36.475
NHCOPh
3v
f1 (ppm)


8.836
8.818
7.938
7.919
7.866
7.849
7.737
7.719
7.533
7.514
7.485
7.466
7.395
7.336
7.278
6.116
6.096
4.551
4.529
3.414
3.368
3.042
2.997
NHCOPh
3w
0.96
2.10
2.03
2.14
6.05
1.12
1.05
2.05
1.00
1.02
1.07
1.02
f1 (ppm)
201.479
173.979
167.043
151.162
136.869
133.195
132.422
132.358
132.334
128.710
128.550
128.226
127.990
127.906
127.506
127.431
126.885
126.708
126.291
126.234
124.825
88.594
52.578
50.149
36.335
NHCOPh
3w
f1 (ppm)

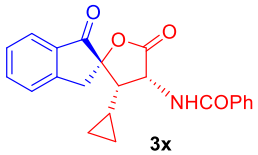

9.146
9.125
7.943
7.925
7.832
7.814
7.794
7.774
7.682
7.664
7.611
7.594
7.577
7.548
7.531
7.513
5.558
5.536
5.515
4.102
4.057
3.469
3.424
2.190
2.167
2.140
0.919
0.906
0.892
0.862
0.514
0.494
0.474
0.006
0.000


O
O
O
NHCOPh

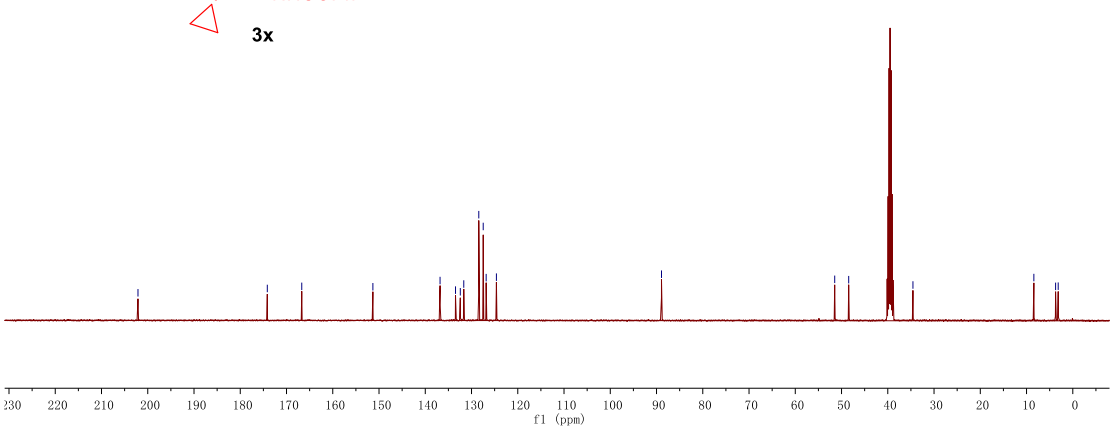
3x


1.00
2.05
2.05
1.01
4.15
1.01
1.04
1.03
1.10
1.20
2.06
2.27
f1 (ppm)

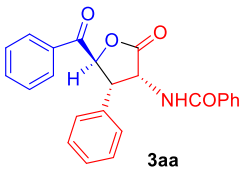

202.113
174.152
166.703
151.325
136.802
133.460
132.423
131.676
128.429
127.471
126.835
124.617
88.925
51.476
48.452
34.560
8.418
3.718
3.154


O
O
O
NHCOPh

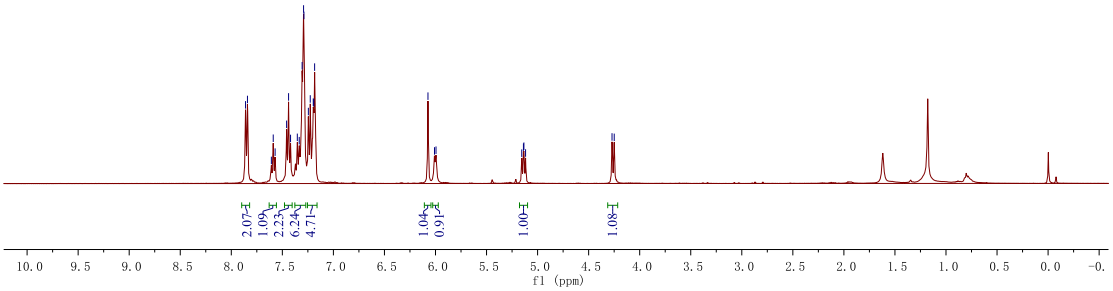
3x


f1 (ppm)

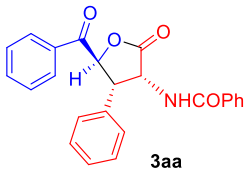

7.861
7.842
7.607
7.589
7.571
7.458
7.439
7.420
7.353
7.334
7.306
7.292
7.289
7.245
7.226
7.197
7.192
7.184
6.074
6.010
5.995
5.155
5.139
5.134
5.118
4.271
4.249


O
O
O
H
NHCOPh

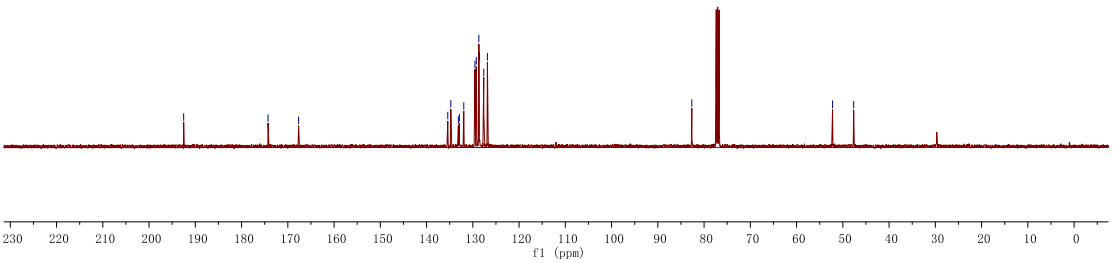
3aa

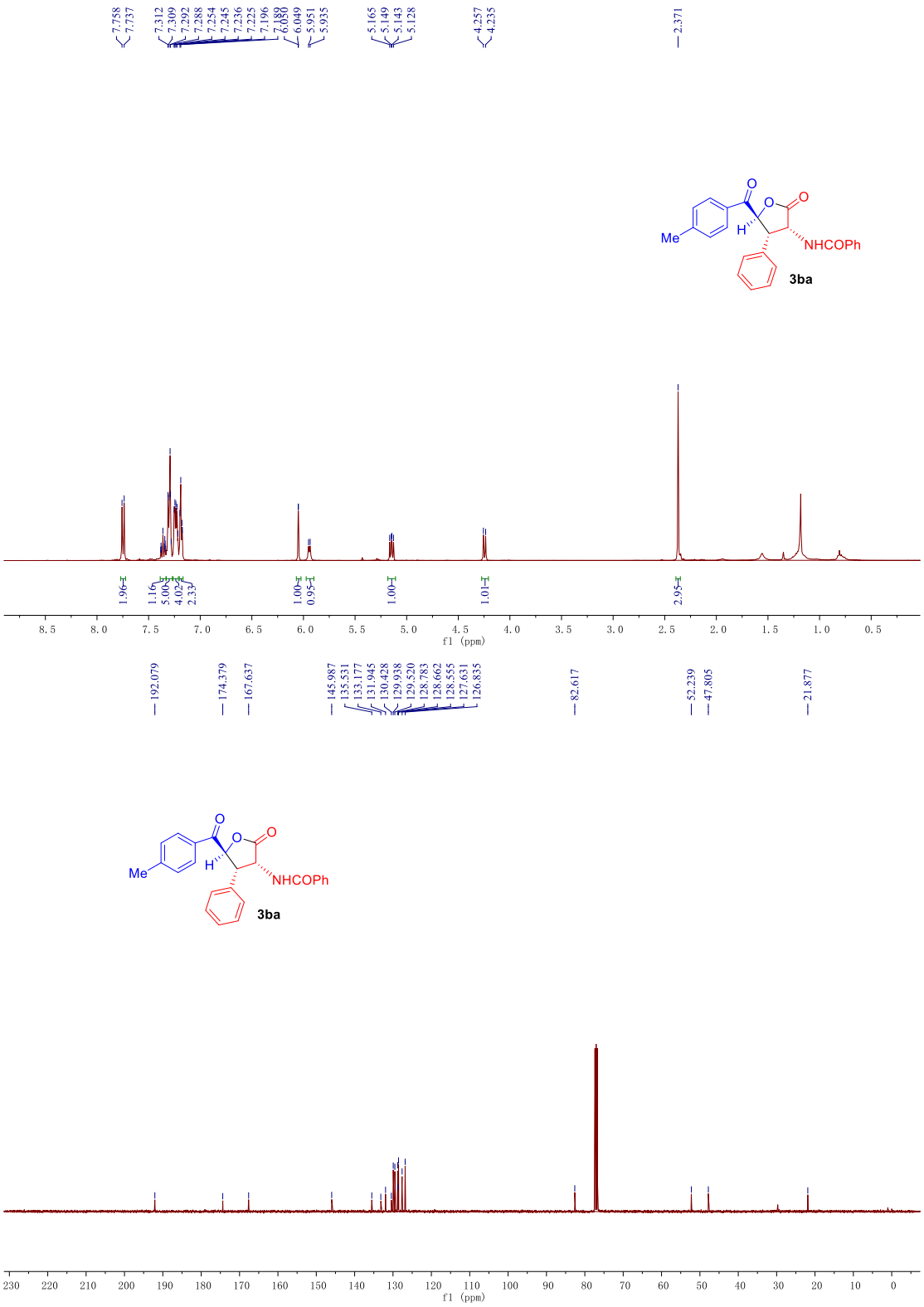

2.07
1.09
2.23
6.24
4.71
1.04
0.91
1.00
1.08
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.
f1 (ppm)

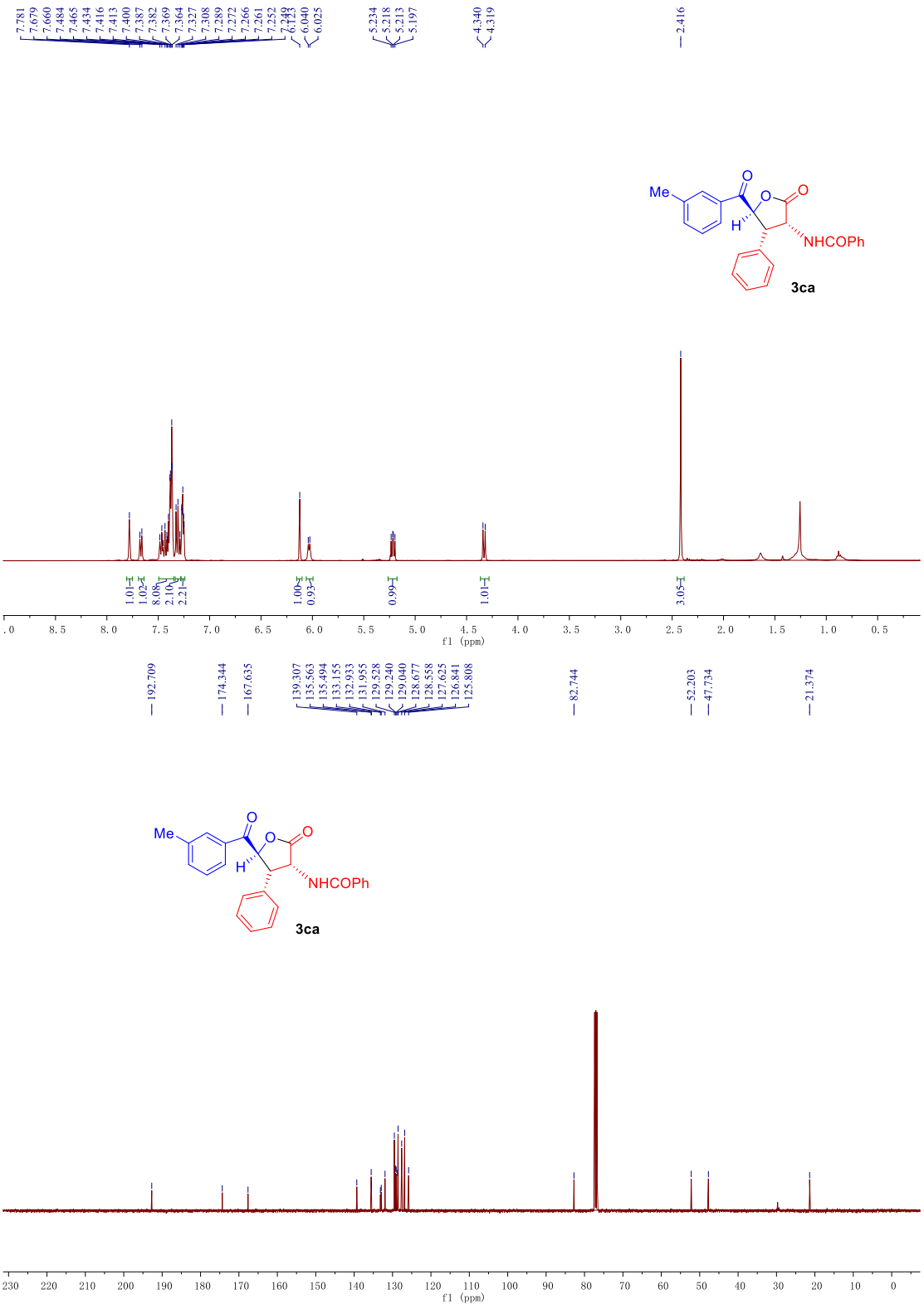

192.514
174.272
167.664
135.415
134.758
133.131
132.914
131.957
129.543
129.253
128.693
128.549
127.636
126.846
82.656
52.222
47.655


O
O
O
H
NHCOPh

3aa


230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


7.758
7.737
7.312
7.309
7.292
7.288
7.254
7.245
7.236
7.225
7.196
7.189
6.050
6.049
5.951
5.935
5.165
5.149
5.143
5.128
4.257
4.235
2.371
O
O
O
H
Me
NHCOPh
3ba
1.96
1.16
5.00
4.02
2.33
1.00
0.95
1.00
1.01
2.95
f1 (ppm)
192.079
174.379
167.637
145.987
135.531
133.177
131.945
130.428
129.938
129.520
128.783
128.662
128.555
127.631
126.835
82.617
52.239
47.805
21.877
f1 (ppm)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7.679
7.660
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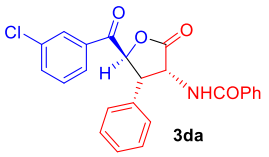
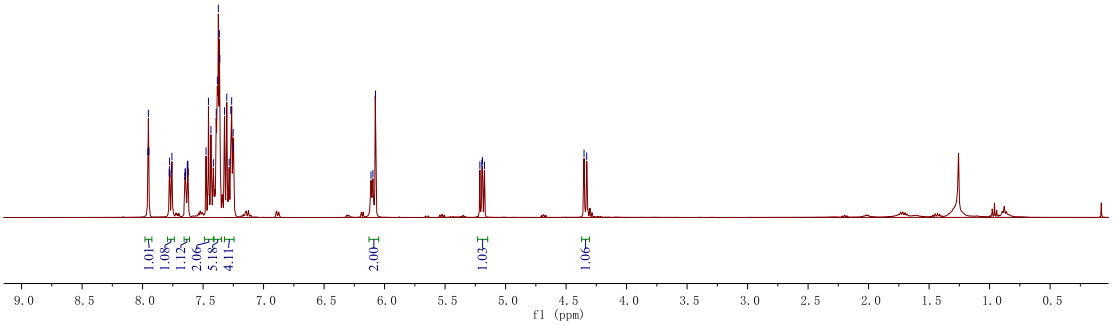
7.465
7.434
7.416
7.413
7.400
7.387
7.382
7.369
7.364
7.327
7.308
7.289
7.272
7.266
7.261
7.252
7.249
7.123
6.040
6.025
5.234
5.218
5.213
5.197
4.340
4.319
2.416
Me
O
O
O
H
NHCOPh
3ca
1.01
1.02
8.08
2.10
2.21
1.00
0.93
0.99
1.01
3.05
f1 (ppm)
192.709
174.344
167.635
139.307
135.563
135.494
133.155
132.933
131.955
129.528
129.240
129.040
128.677
128.558
127.625
126.841
125.808
82.744
52.203
47.734
21.374
Me
O
O
O
H
NHCOPh
3ca
f1 (ppm)


7.957
7.952
7.948
7.777
7.758
7.475
7.456
7.435
7.415
7.391
7.382
7.374
7.365
7.361
7.323
7.304
7.285
7.271
7.264
7.252
7.248
6.112
6.096
6.075
5.212
5.196
5.191
5.175
4.352
4.329


Cl
O
O
O
H
NHCOPh

3da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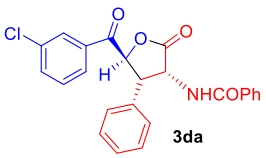
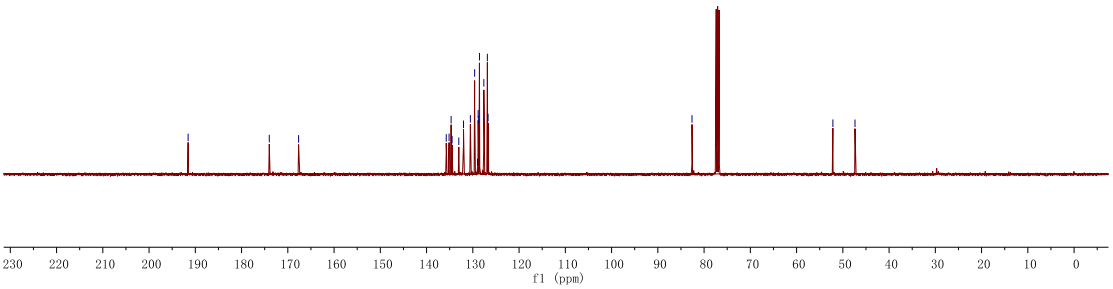
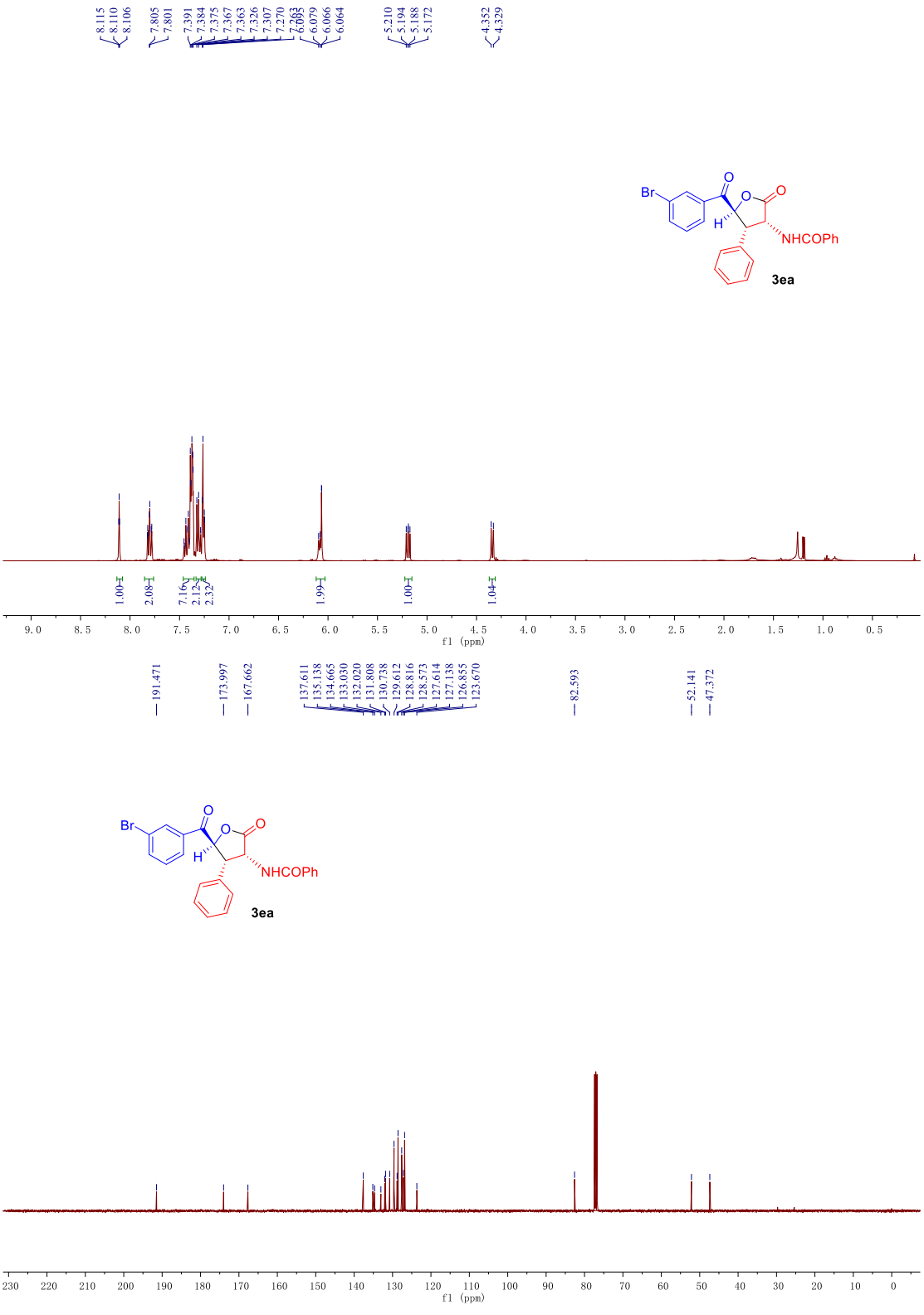
1.08
1.12
2.06
5.18
4.11
2.00
1.03
1.06
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)

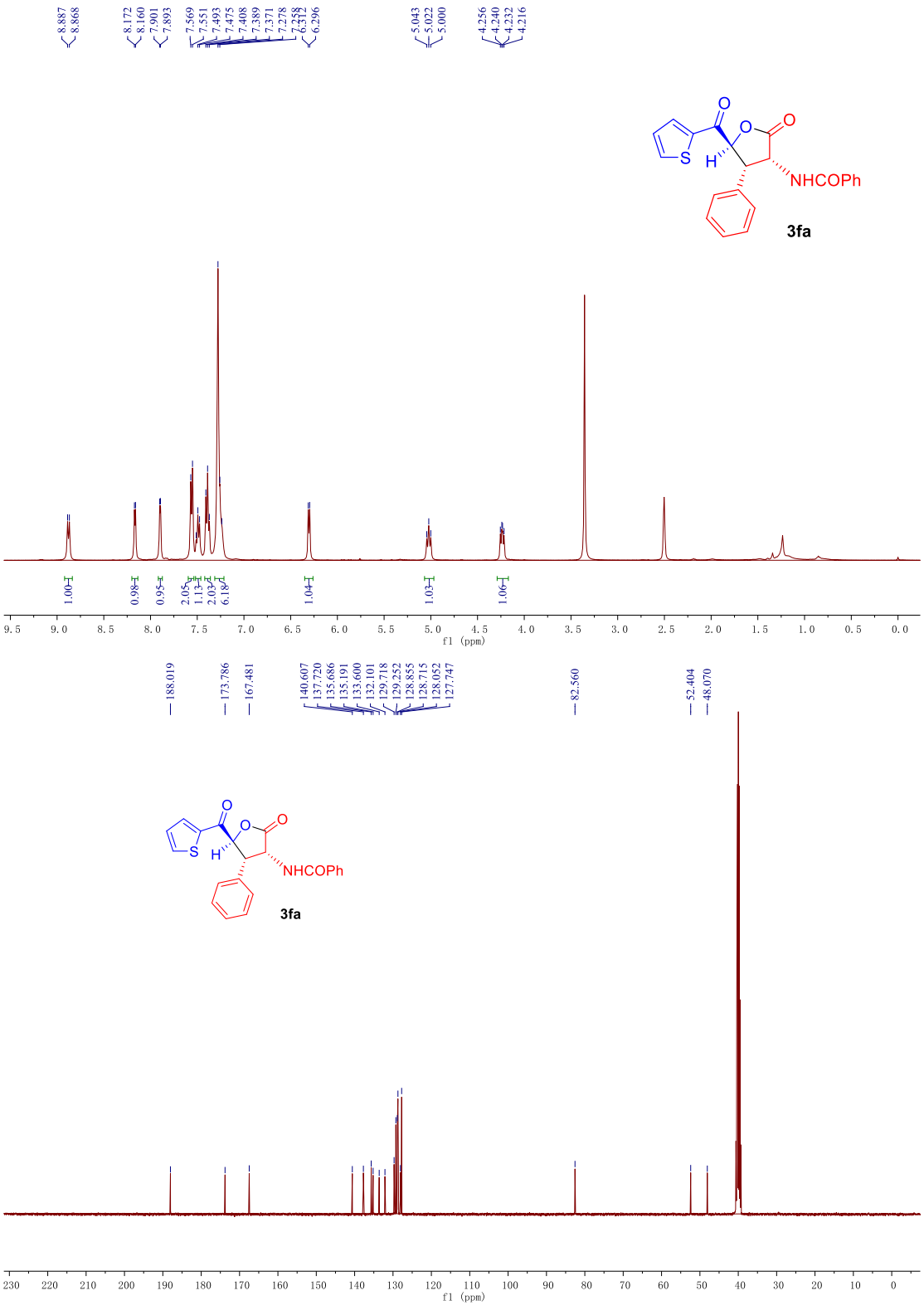

191.559
174.008
167.671
135.747
135.135
134.694
134.486
133.030
132.012
130.532
129.607
128.982
128.845
128.809
128.565
127.616
126.856
126.710
82.610
52.150
47.371

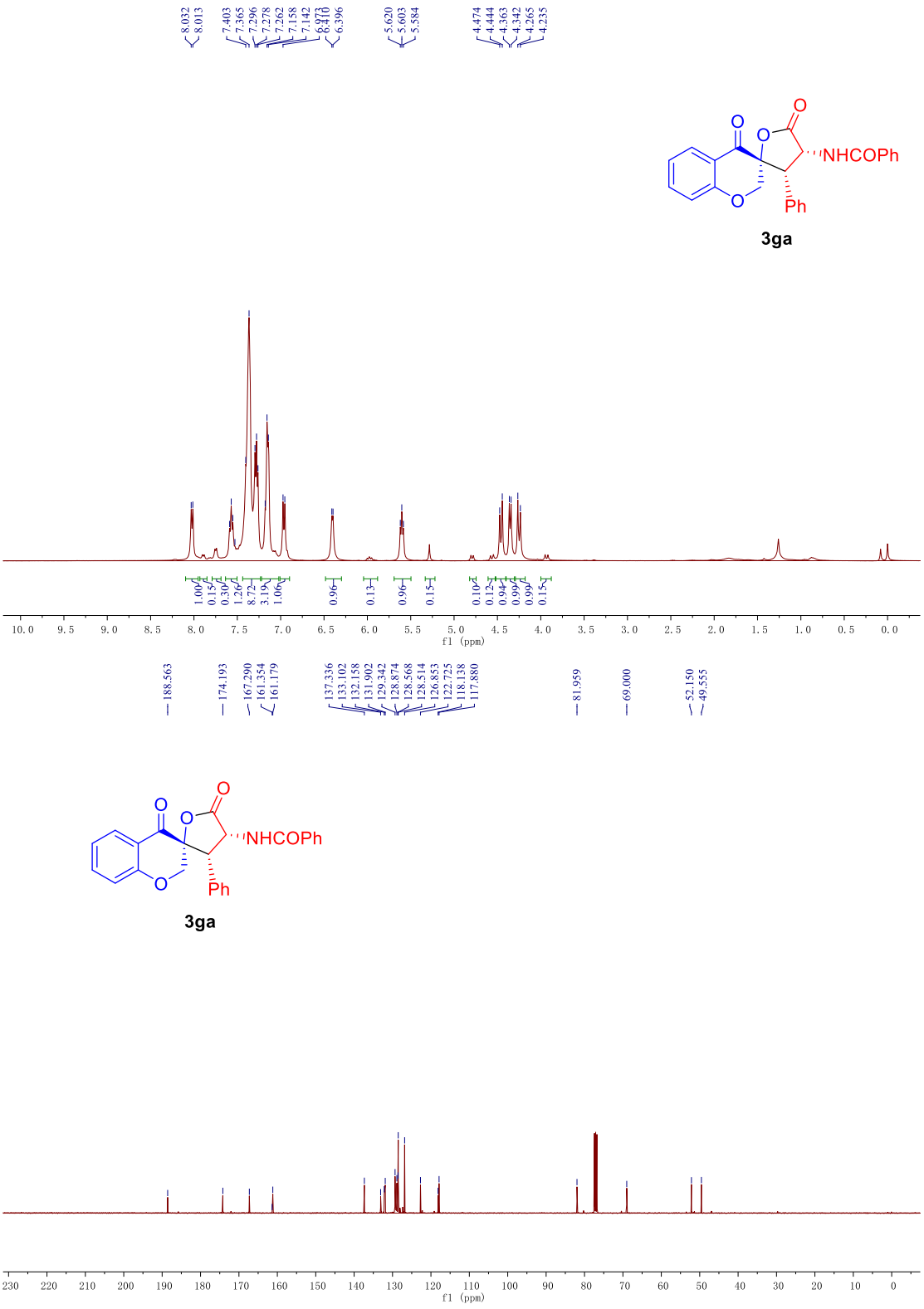

Cl
O
O
O
H
NHCOPh

3da


230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

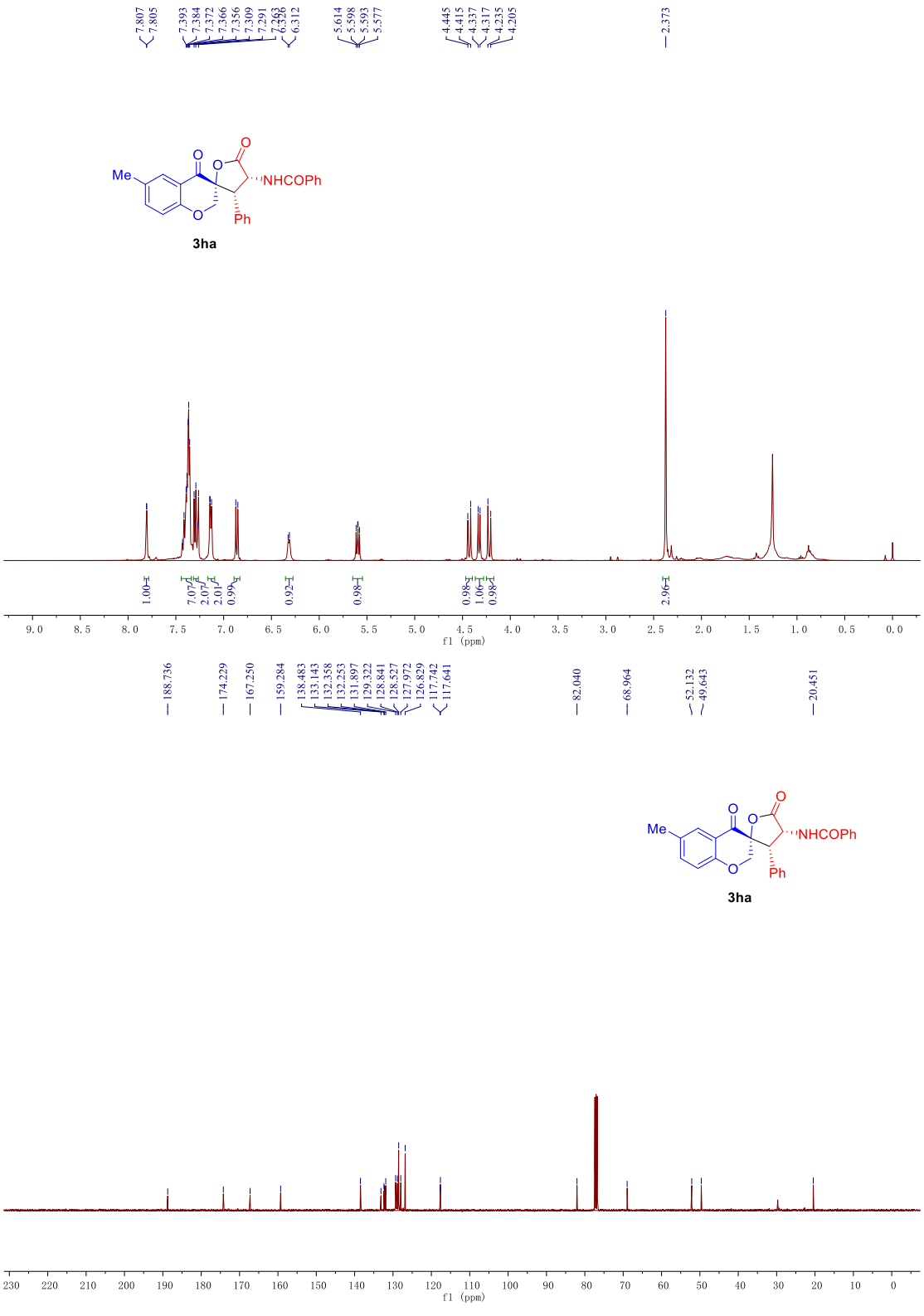

8.115
8.110
8.106
7.805
7.801
7.391
7.384
7.375
7.367
7.363
7.326
7.307
7.270
6.079
6.066
6.064
5.210
5.194
5.188
5.172
4.352
4.329
Br
O
O
O
H
NHCOPh
3ea
1.00
2.08
7.16
2.12
2.32
1.99
1.00
1.04
f1 (ppm)
191.471
173.997
167.662
137.611
135.138
134.665
133.030
132.020
131.808
130.738
129.612
128.816
128.573
127.614
127.138
126.855
123.670
82.593
52.141
47.372
f1 (ppm)


8.887
8.868
8.172
8.160
7.901
7.893
7.569
7.551
7.493
7.475
7.408
7.389
7.371
7.278
6.296
5.043
5.022
5.000
4.256
4.240
4.232
4.216
NHCOPh
3fa
1.00
0.98
0.95
2.05
1.13
2.03
6.18
1.04
1.03
1.06
f1 (ppm)
188.019
173.786
167.481
140.607
137.720
135.686
135.191
133.600
132.101
129.718
129.252
128.855
128.715
128.052
127.747
82.560
52.404
48.070
NHCOPh
3fa
f1 (ppm)

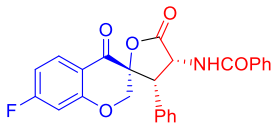

8.032
8.013
7.403
7.365
7.296
7.278
7.262
7.158
7.142
6.413
6.410
6.396
5.620
5.603
5.584
4.474
4.444
4.363
4.342
4.265
4.235
O
O
O
NHCOPh
Ph
1.00
0.15
0.30
1.26
8.72
3.19
1.06
0.96
0.13
0.96
0.15
0.10
0.12
0.94
0.99
0.99
0.15
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)
188.563
174.193
167.290
161.354
161.179
137.336
133.102
132.158
131.902
129.342
128.874
128.568
128.514
126.853
122.725
118.138
117.880
81.959
69.000
52.150
49.555
O
O
O
NHCOPh
Ph
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

3ga

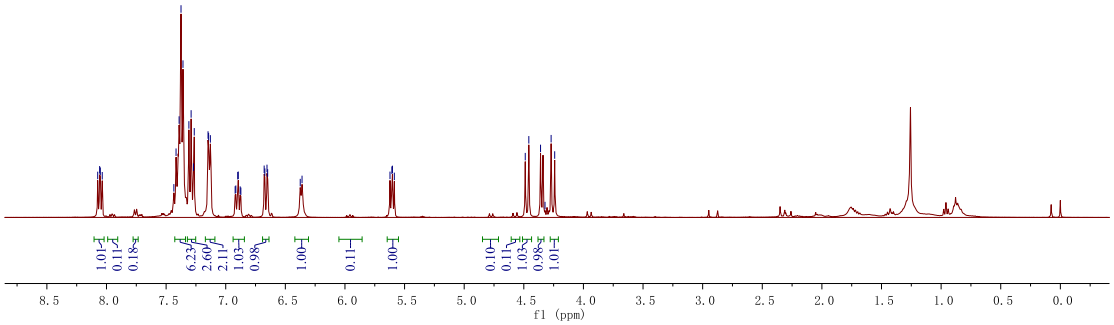
3ga

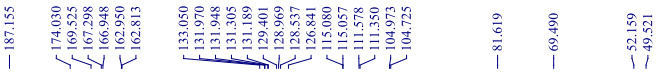

7.807
7.805
7.393
7.384
7.372
7.366
7.356
7.309
7.291
7.263
6.326
6.312
5.614
5.598
5.593
5.577
4.445
4.415
4.337
4.317
4.235
4.205
2.373
Me
O
O
O
NHCOPh
Ph
3ha
1.00
7.07
2.07
2.01
0.99
0.92
0.98
0.98
1.06
0.98
2.96
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)
188.736
174.229
167.250
159.284
138.483
133.143
132.358
132.253
131.897
129.322
128.841
128.527
127.972
126.829
117.742
117.641
82.040
68.964
52.132
49.643
20.451
Me
O
O
O
NHCOPh
Ph
3ha
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

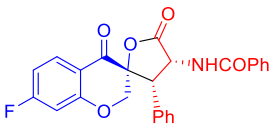

8.074
8.058
8.052
8.036
7.391
7.375
7.359
7.309
7.290
7.264
7.148
7.143
6.360
5.622
5.606
5.602
5.586
4.488
4.458
4.360
4.322
4.271
4.241


O
O
O
NHCOPh
F
O
Ph

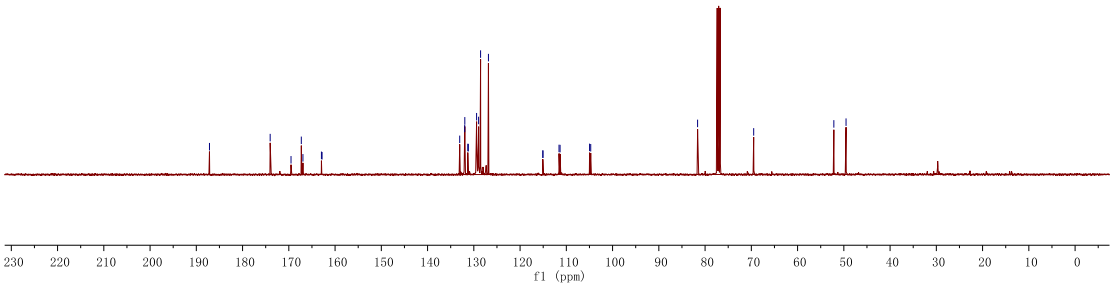
3ia

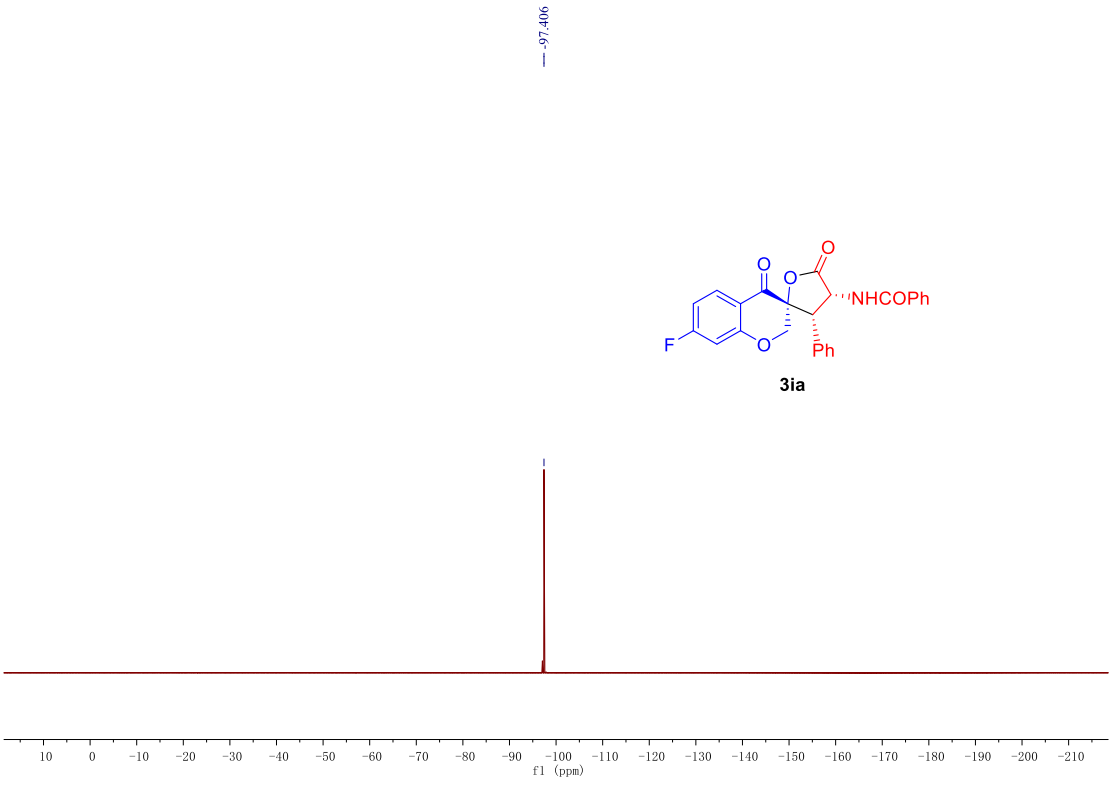

1.01
0.11
0.18
6.23
2.60
2.11
1.03
0.98
1.00
0.11
1.00
0.10
0.11
1.03
0.98
1.01
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


187.155
174.030
169.525
167.298
166.948
162.950
162.813
133.050
131.970
131.948
131.305
131.189
129.401
128.969
128.537
126.841
115.080
115.057
111.578
111.350
104.973
104.725
81.619
69.490
52.159
49.521


O
O
O
NHCOPh
F
O
Ph

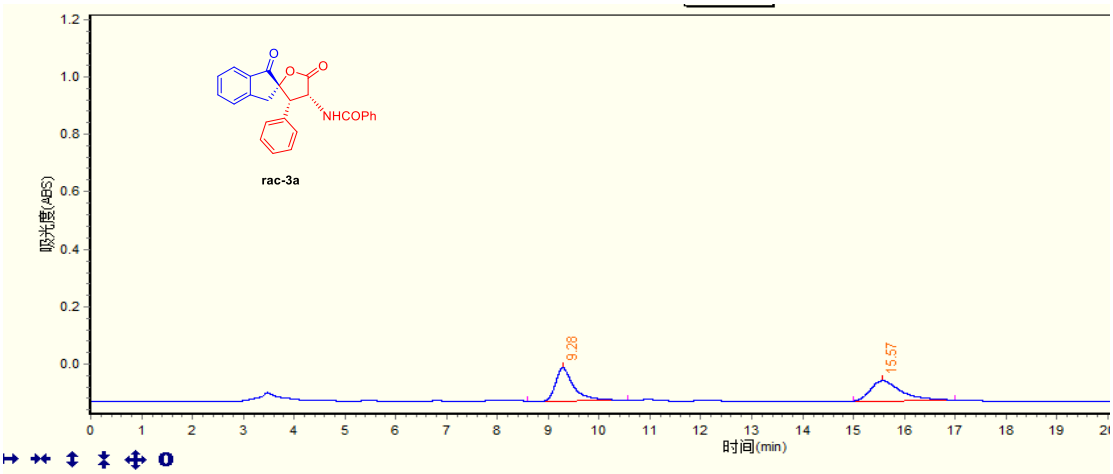
3ia


230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


-97.406
O
O
O
NHCOPh
F
O
Ph
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)

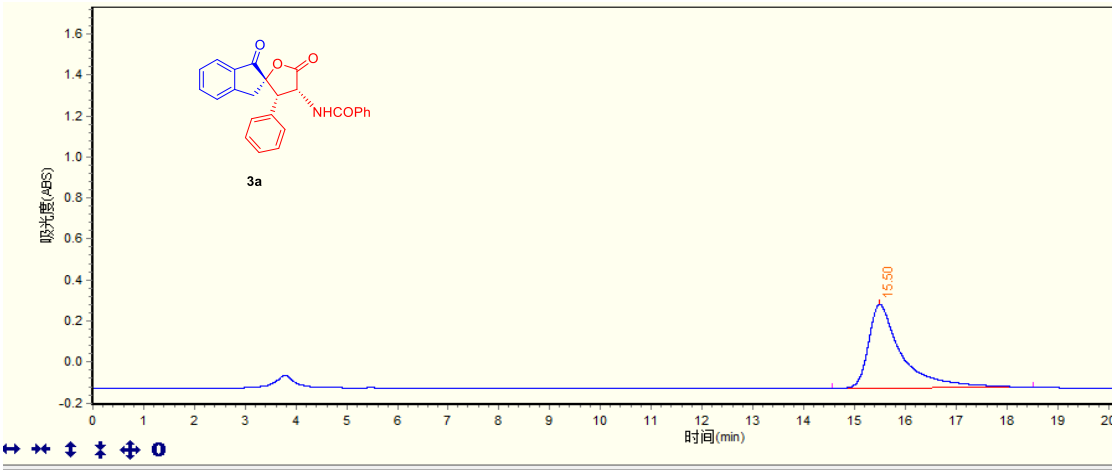
3ia

HPLC spectra of compounds



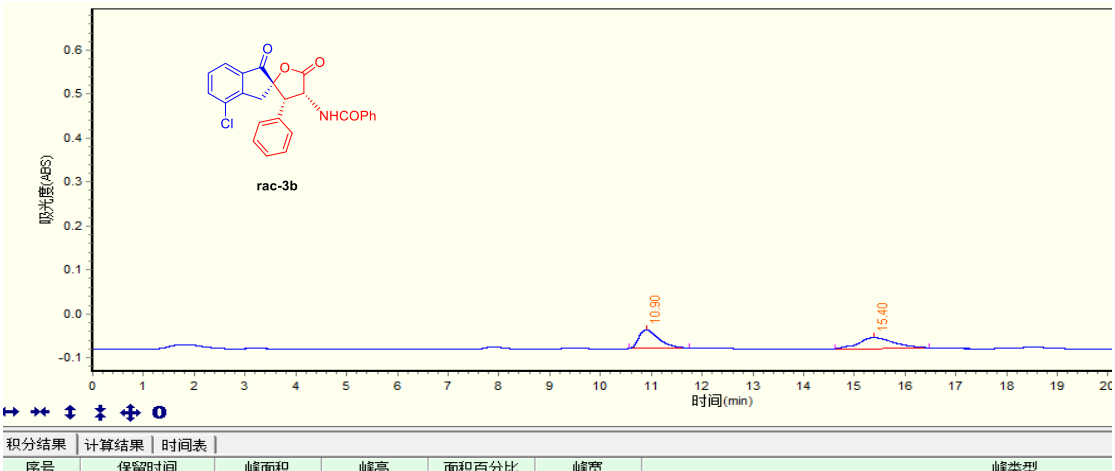
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	9.28	1423487	57506	49.58%	1.973	BB
2	15.57	1447868	34736	50.42%	1.997	BB
总计		2,871,355	92,242	100.00%		



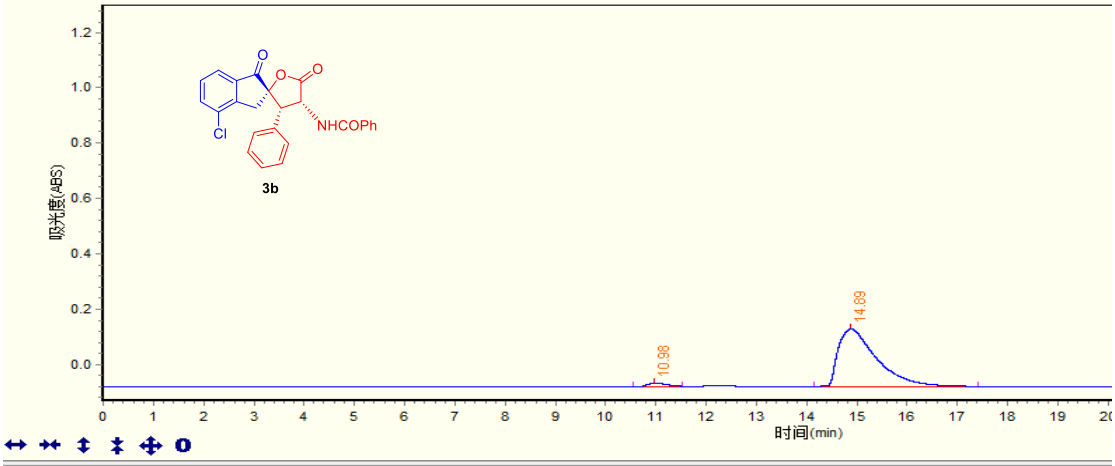
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	15.50	9256798	203991	100.00%	3.958	BB
总计		9,256,798	203,991	100.00%		



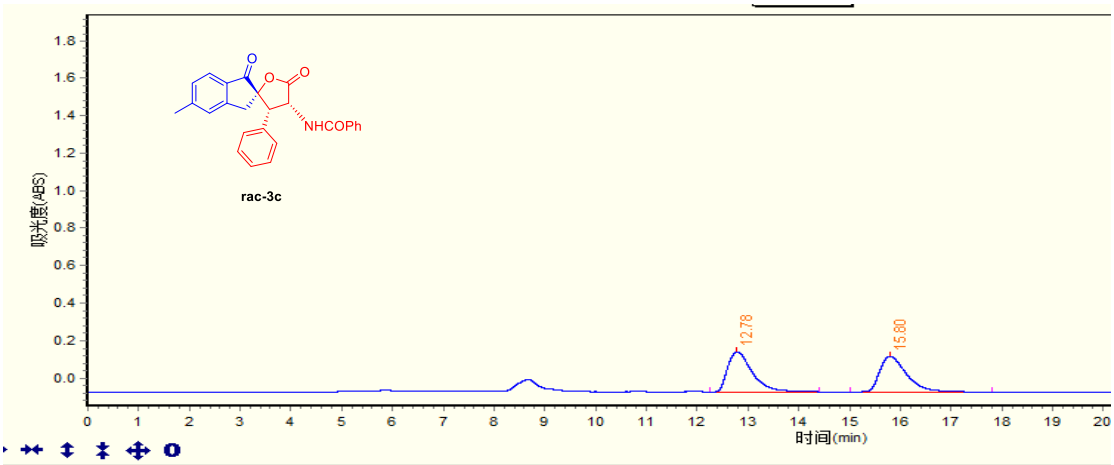
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	10.90	576469	21138	50.12%	1.188	BB
2	15.40	573729	12042	49.88%	1.855	BB
总计		1,150,198	33,180	100.00%		



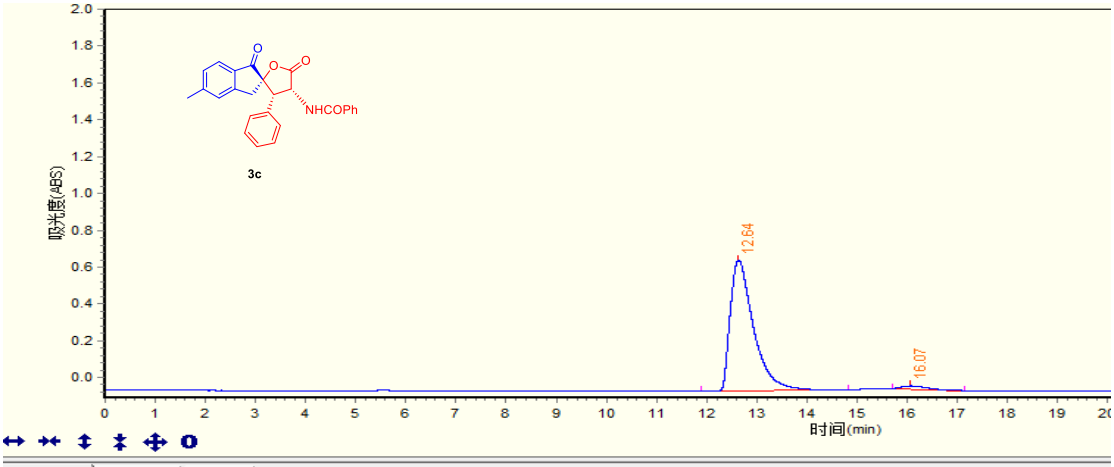
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	
1	10.98	169777	6717	2.97%	0.977	BB
2	14.89	5537069	103735	97.03%	3.265	BB
总计		5,706,846	110,452	100.00%		



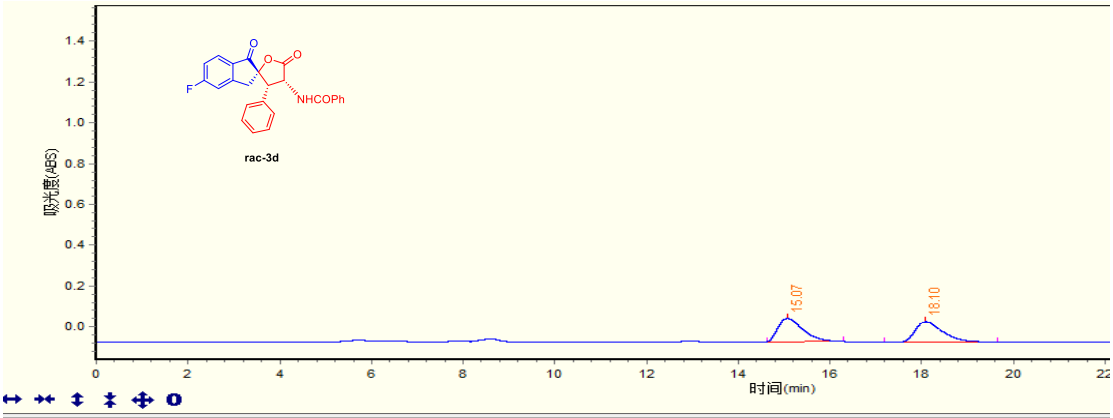
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	
1	12.78	3567288	106861	50.65%	2.145	BB
2	15.80	3475793	94401	49.35%	2.792	BB
计		7,043,081	201,262	100.00%		



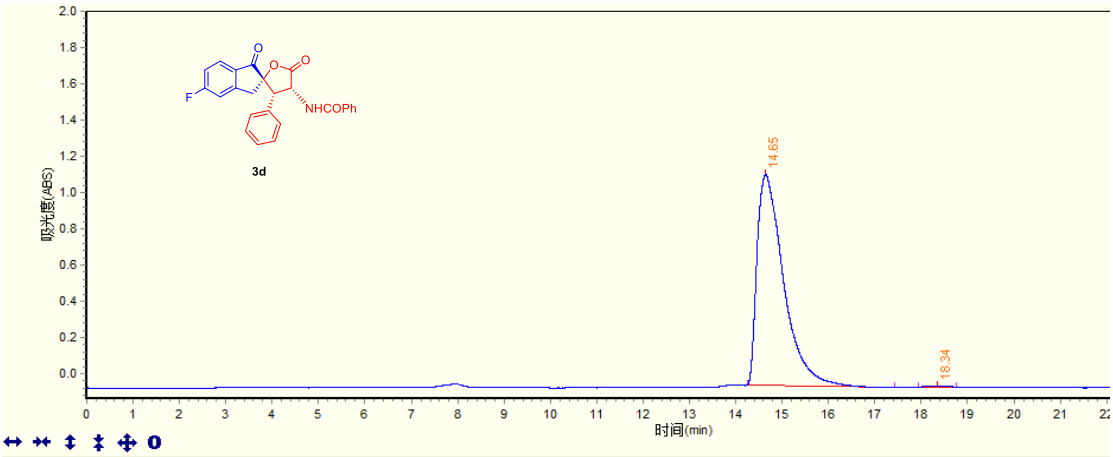
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	
1	12.64	11440314	353878	97.37%	2.936	BB
2	16.07	308541	8940	2.63%	1.438	BB
总计		11,748,855	362,818	100.00%		



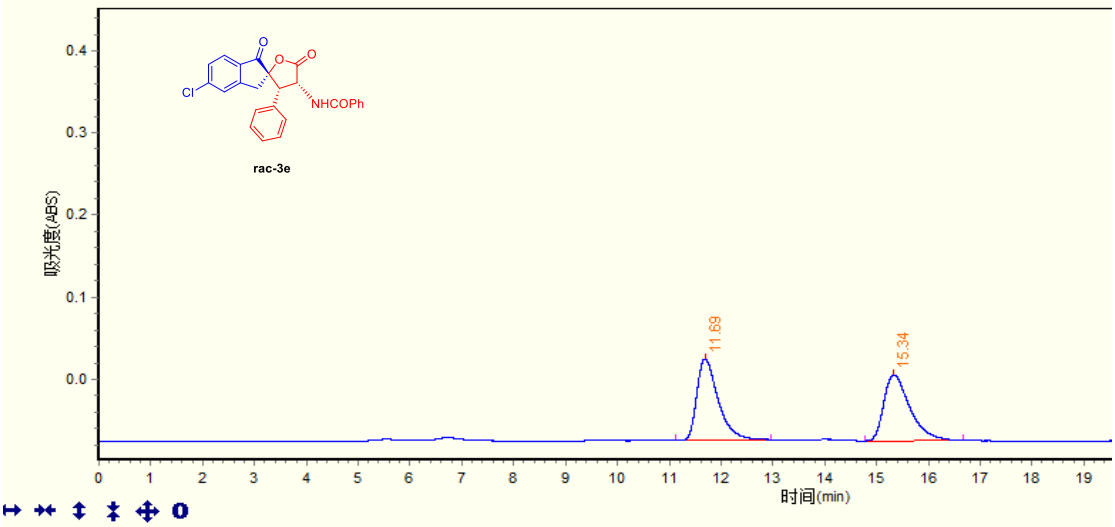
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类
1	15.07	2157008	56660	50.57%	1.666	BB
2	18.10	2108625	49870	49.43%	2.468	BB
总计		4,265,633	106,530	100.00%		



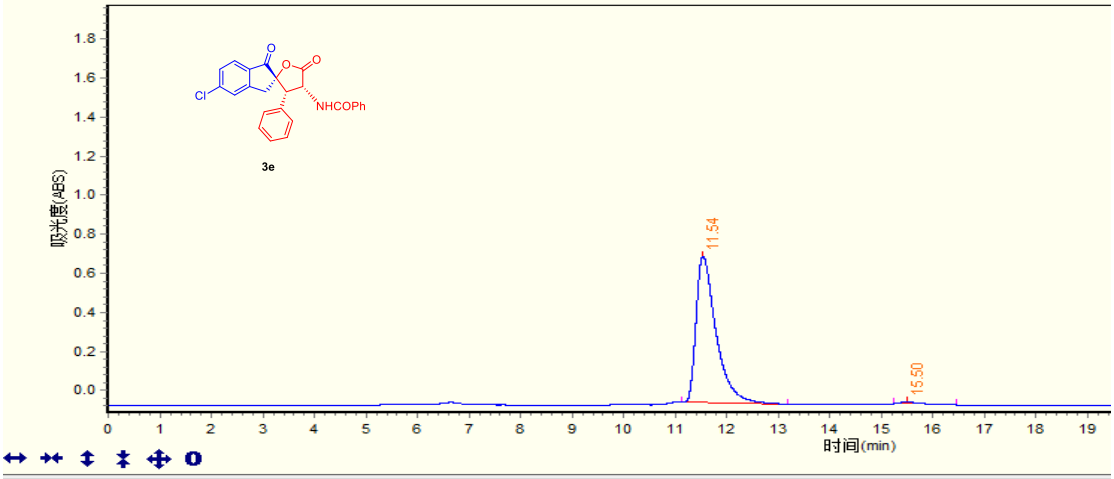
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	14.65	23072111	580581	99.64%	3.173	BB
2	18.34	82933	2854	0.36%	0.819	BB
总计		23,155,044	583,435	100.00%		



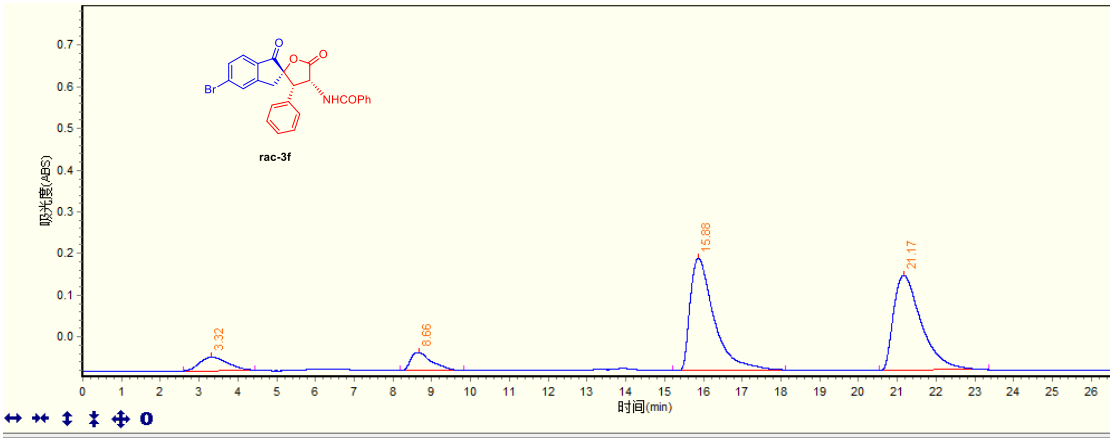
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	
1	11.69	1408981	49401	50.27%	1.84	BB
2	15.34	1393842	39714	49.73%	1.895	BB
总计		2,802,823	89,115	100.00%		



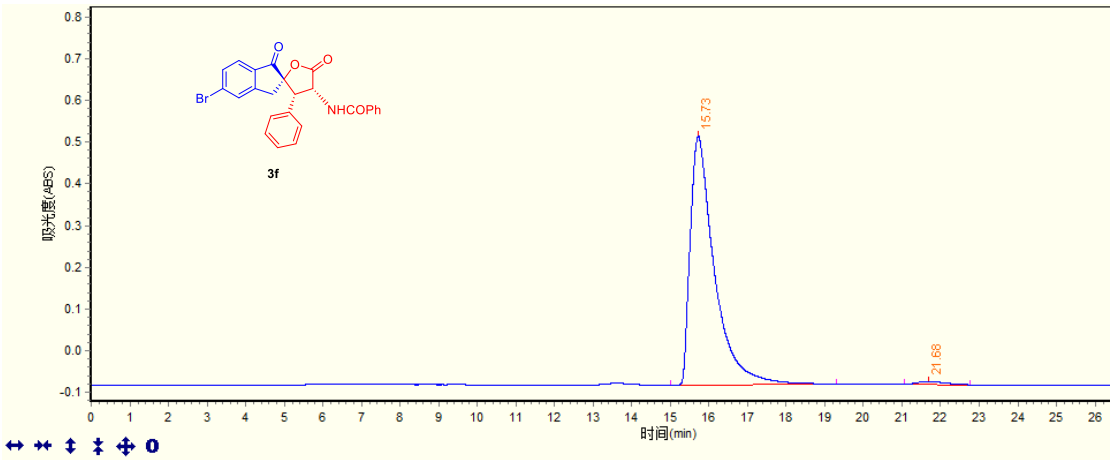
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	
1	11.54	10019761	373700	98.81%	2.057	BB
2	15.50	120906	4530	1.19%	1.217	BB
总计		10,140,667	378,230	100.00%		



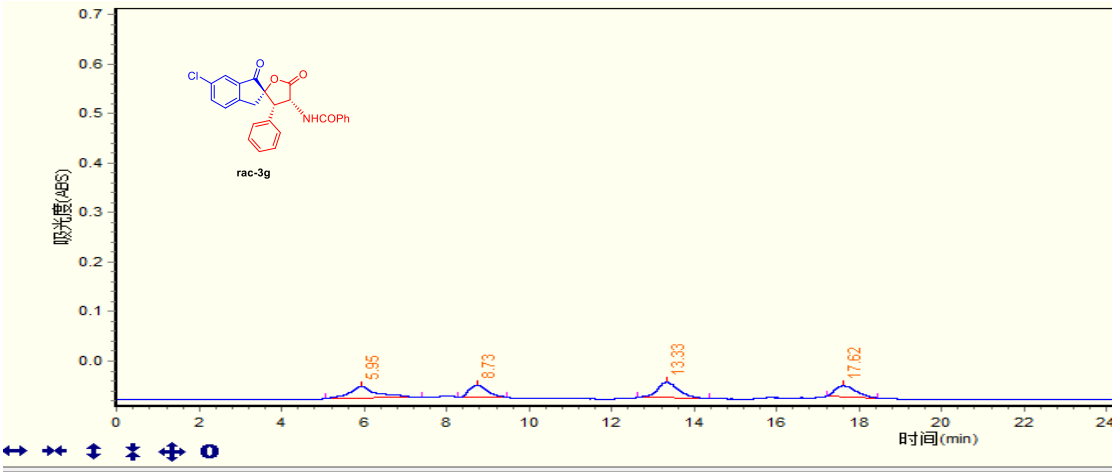
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	3.32	796050	15969	6.09%	1.832	BB
2	8.66	805306	21530	6.16%	1.625	BB
3	15.88	5764145	134818	44.07%	2.903	BB
4	21.17	5713296	114096	43.68%	2.834	BB
总计		13,078,797	286,413	100.00%		



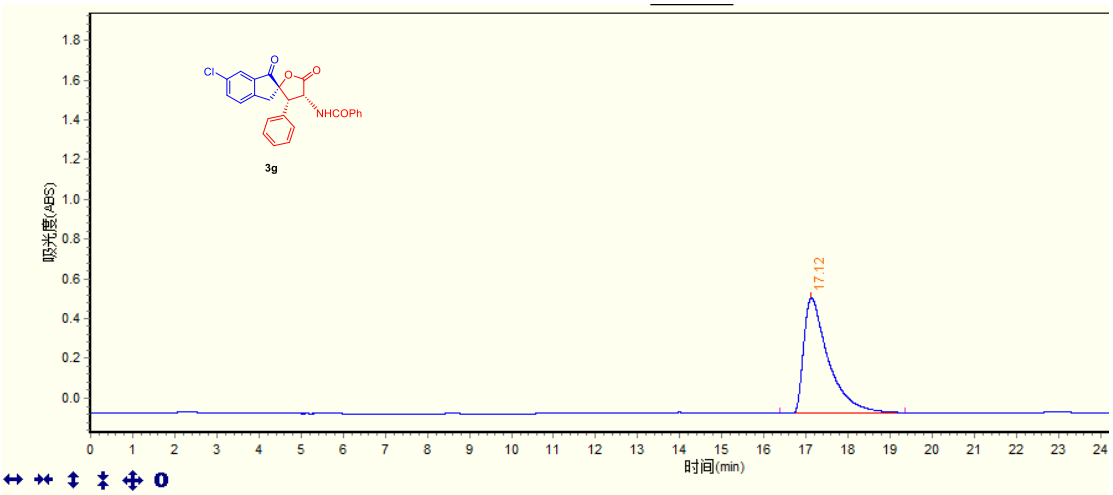
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	15.73	12925032	297827	98.56%	4.296	BB
2	21.68	189270	3894	1.44%	1.718	BB
总计		13,114,302	301,721	100.00%		



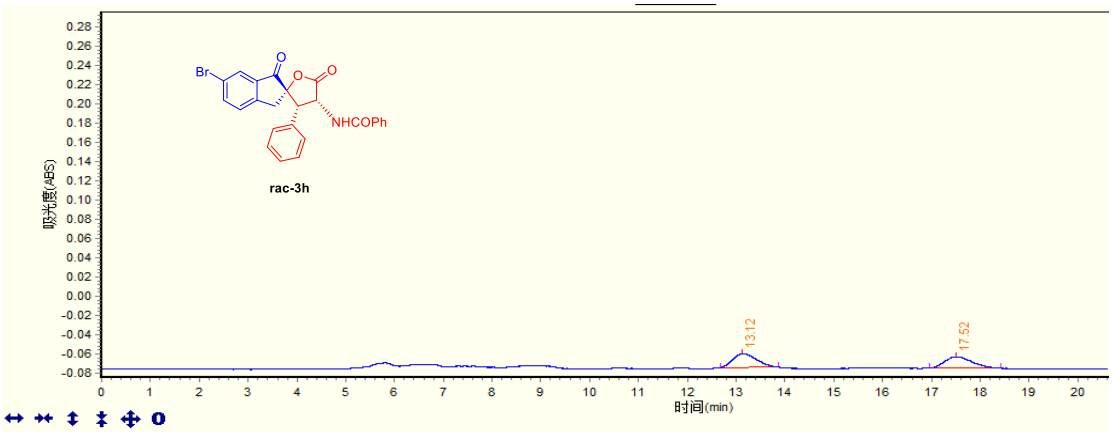
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	
1	5.95	567627	11632	29.95%	2.335	BB
2	8.73	367569	12126	19.39%	1.188	BB
3	13.33	573266	15573	30.25%	1.741	BB
4	17.62	386927	10916	20.41%	1.227	BB
总计		1,895,389	50,247	100.00%		



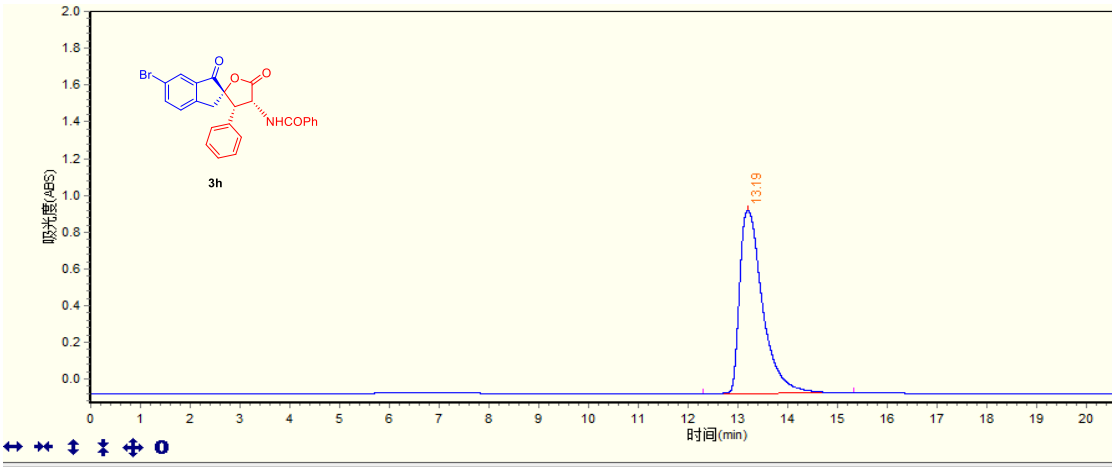
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	17.12	11725668	290520	100.00%	2.969	BB
总计		11,725,668	290,520	100.00%		



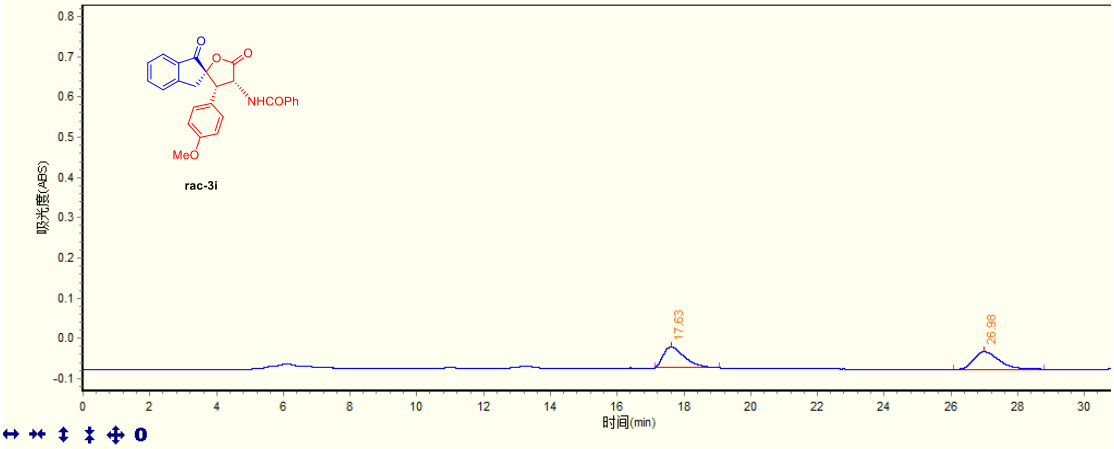
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	13.12	236932	7059	50.84%	1.188	BB
2	17.52	229126	5806	49.16%	1.461	BB
总计		466,058	12,865	100.00%		



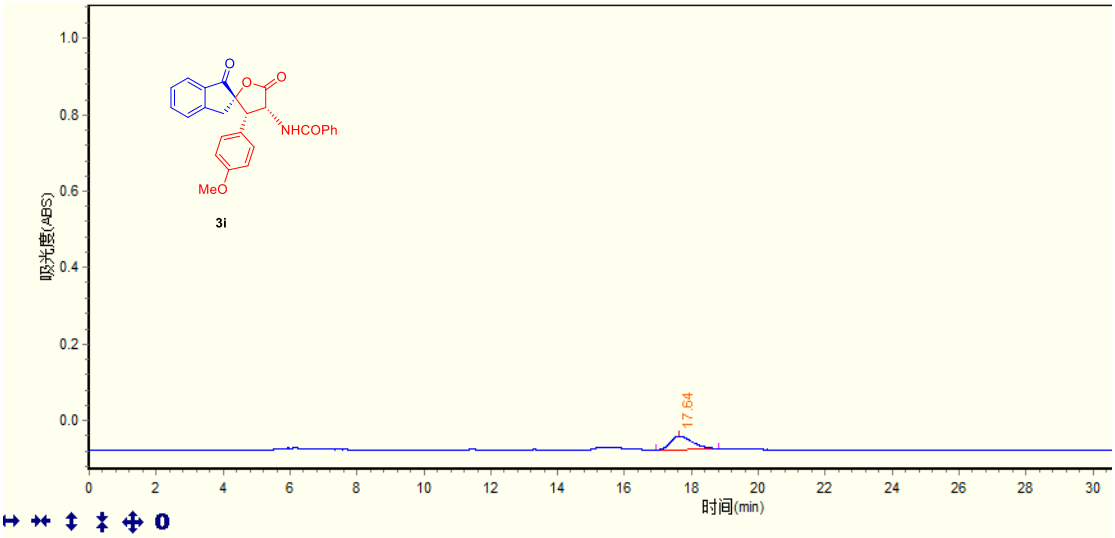
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	13.19	15952700	497708	100.00%	3.023	BB
总计		15,952,700	497,708	100.00%		



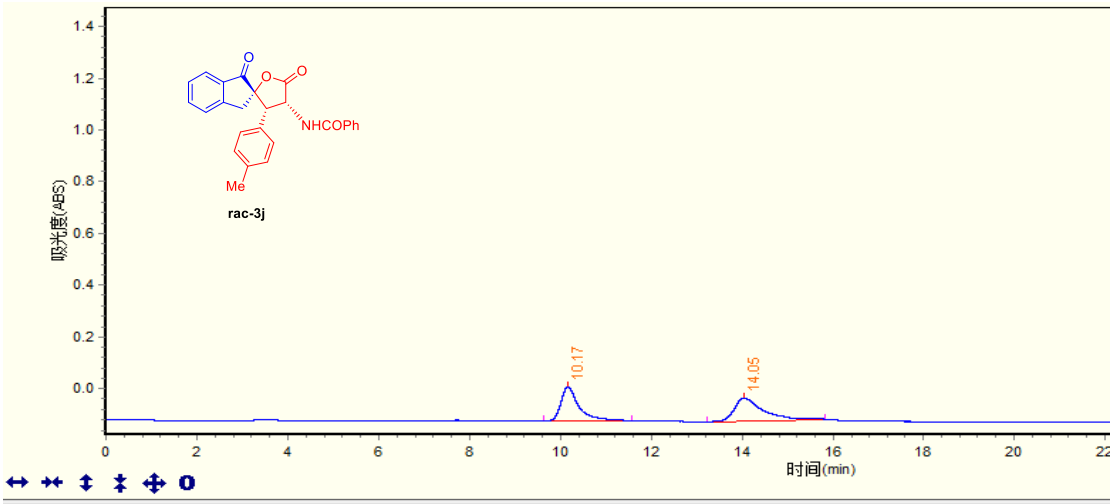
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	17.63	1152897	25861	50.57%	1.926	BB
2	26.98	1126885	21725	49.43%	2.709	BB
总计		2,279,782	47,586	100.00%		



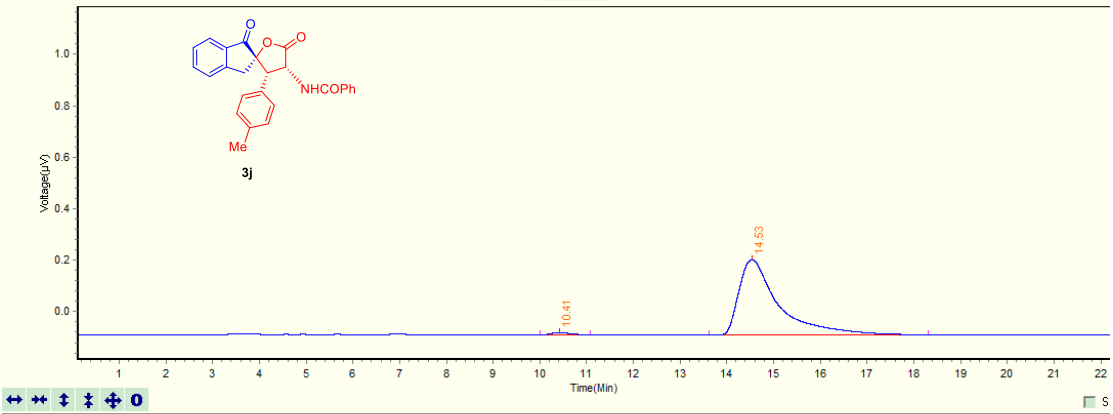
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	17.64	770497	17383	100.00%	1.873	BB
总计		770,497	17,383	100.00%		



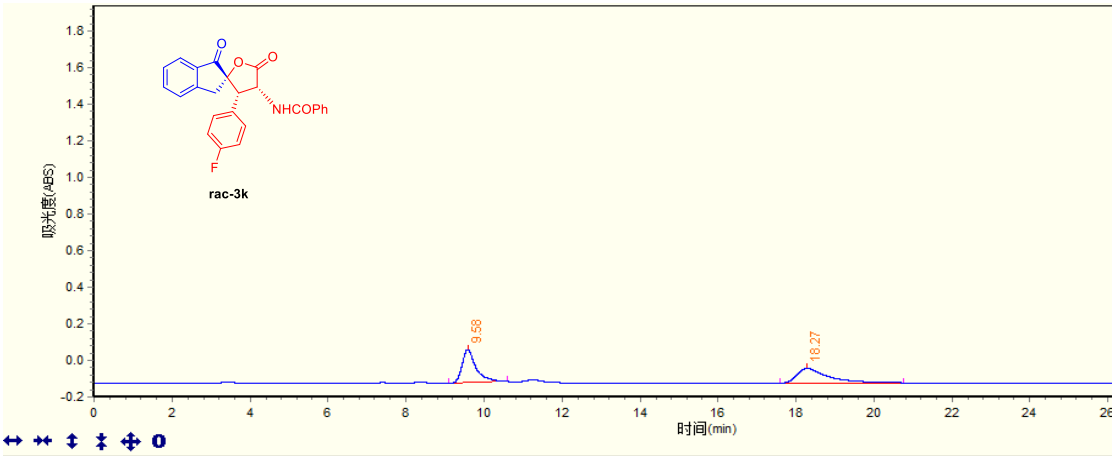
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	
1	10.17	1843642	66288	49.38%	1.939	BB
2	14.05	1889967	44088	50.62%	2.596	BB
总计		3,733,609	110,376	100.00%		



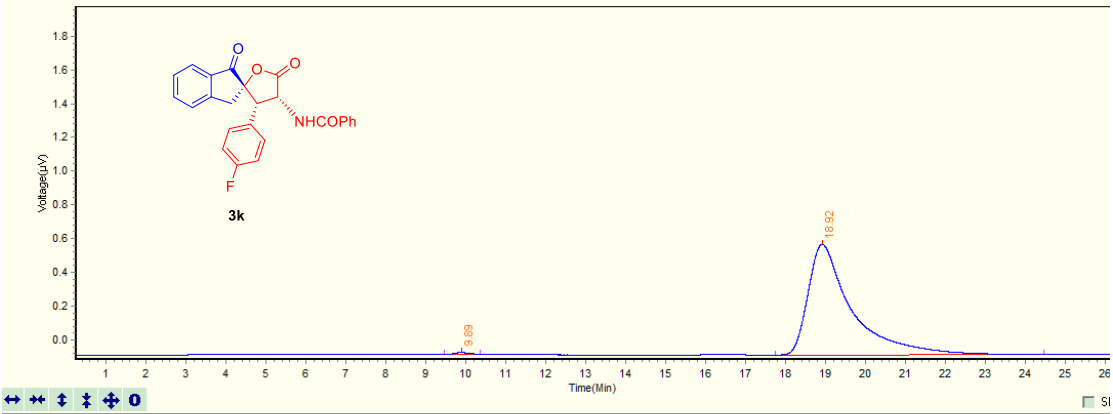
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	Peak Type
1	10.41	127951	4675	1.45%	1.083	BB
2	14.53	8667621	146881	98.55%	4.68	BB
Total		8,795,572	151,556	100.00%		



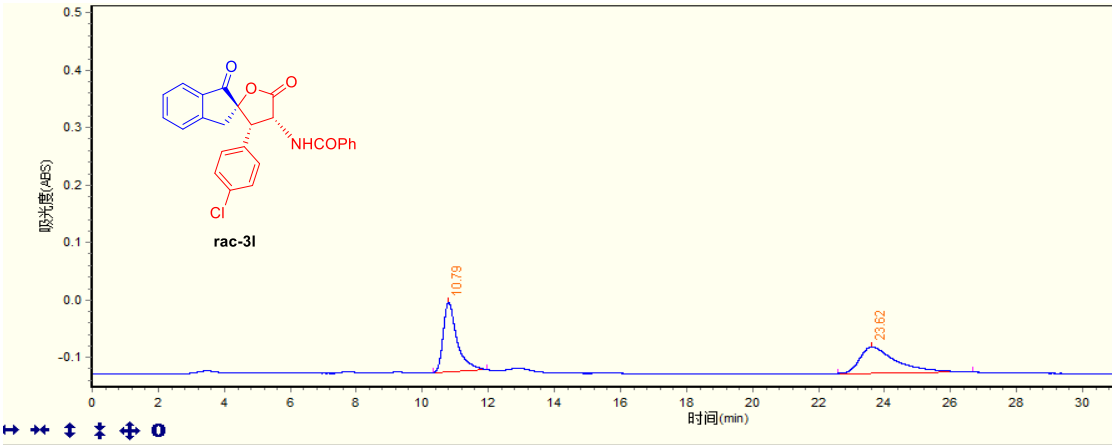
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	9.58	2242969	90382	50.09%	1.505	BB
2	18.27	2234804	39898	49.91%	3.167	BB
总计		4,477,773	130,280	100.00%		



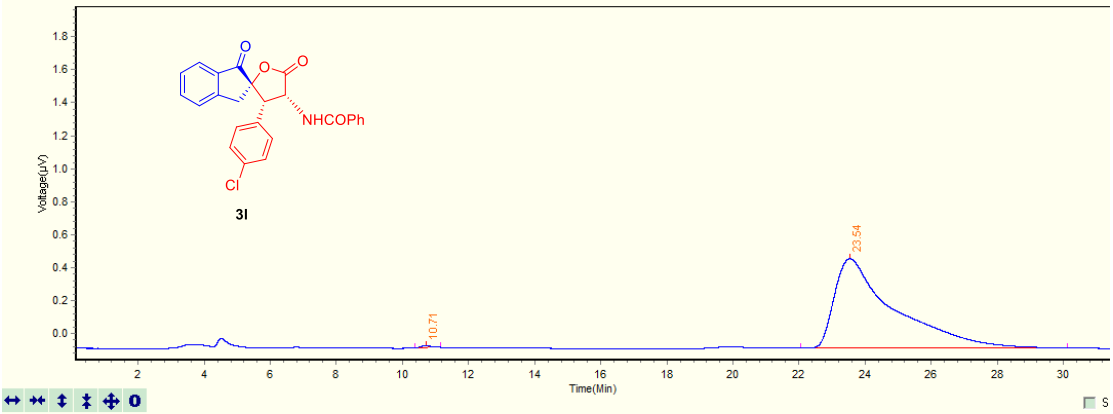
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	Peak Type
1	9.89	148592	5741	0.59%	0.911	BB
2	18.92	24853107	328203	99.41%	6.722	BB
Total		25,001,699	333,944	100.00%		



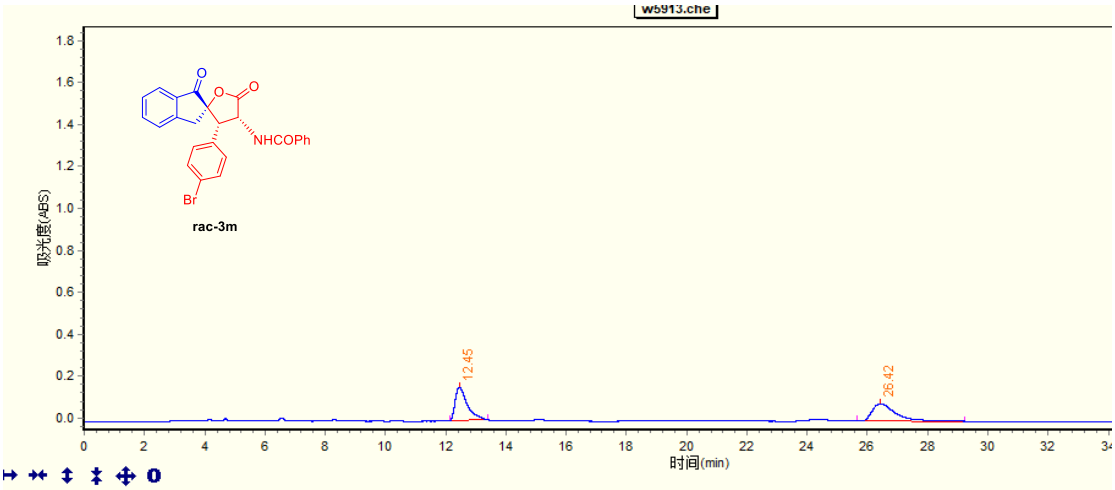
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	10.79	1753703	60696	50.17%	1.62	BB
2	23.62	1741905	22798	49.83%	4.086	BB
总计		3,495,608	83,494	100.00%		



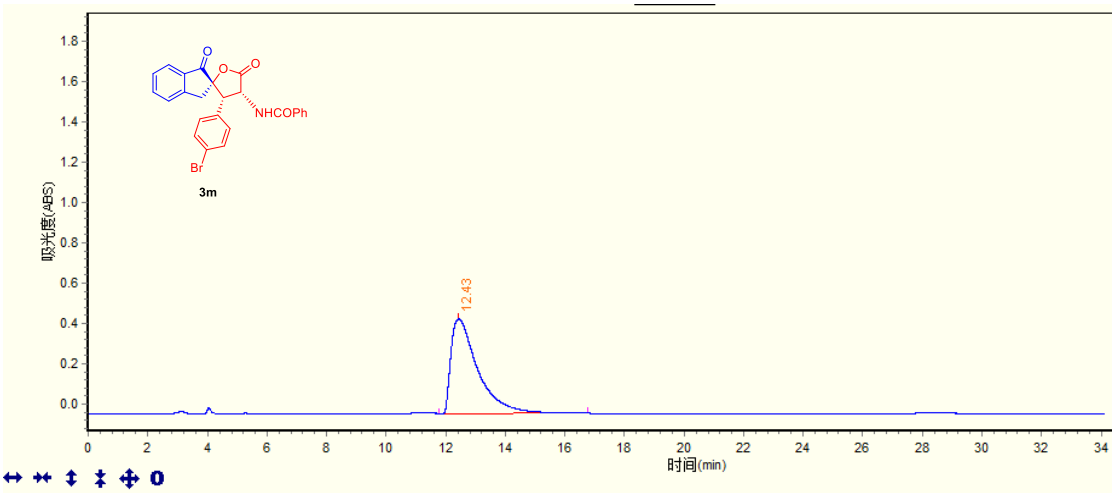
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	Peak Type
1	10.71	129008	5375	0.38%	0.781	BB
2	23.54	33810250	270299	99.62%	8.069	BB
Total		33,939,258	275,674	100.00%		



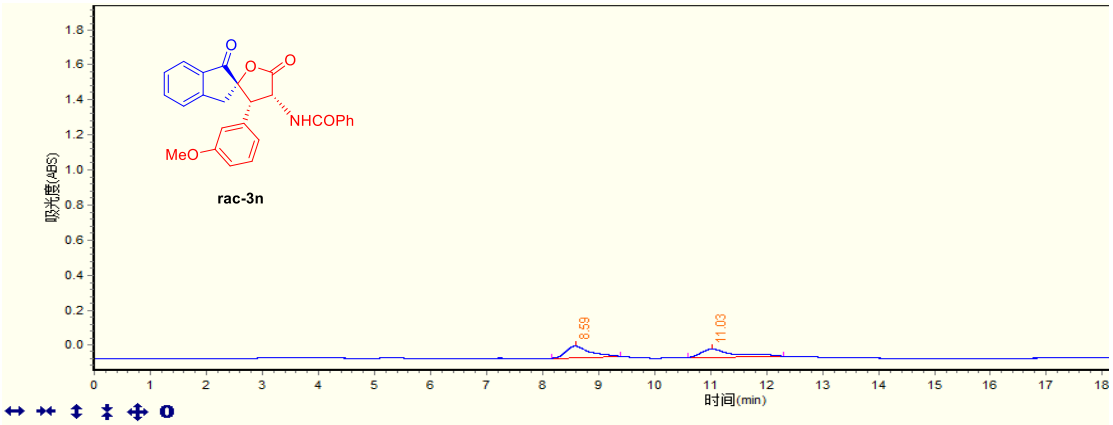
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	12.45	2196193	79661	49.87%	1.258	BB
2	26.42	2207301	41397	50.13%	3.573	BB
总计		4,403,494	121,058	100.00%		



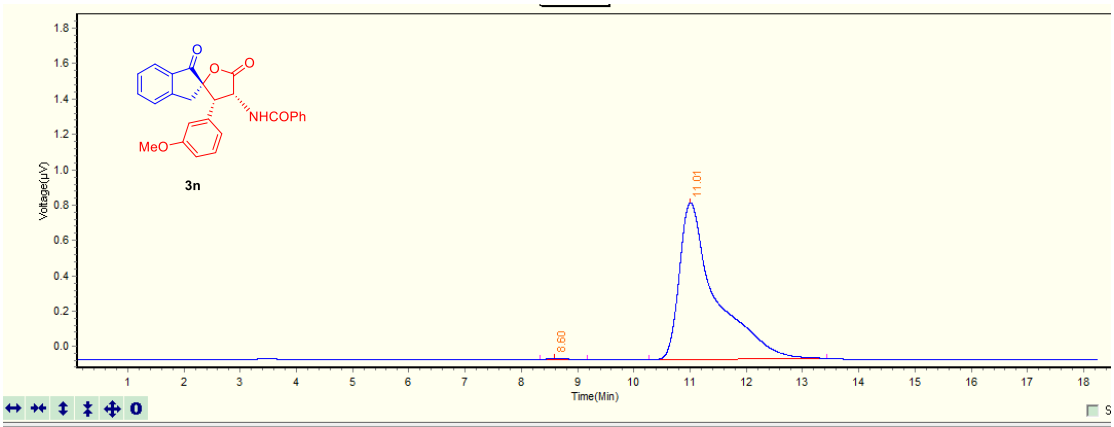
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	12.43	14637914	233635	100.00%	4.993	BB
总计		14,637,914	233,635	100.00%		



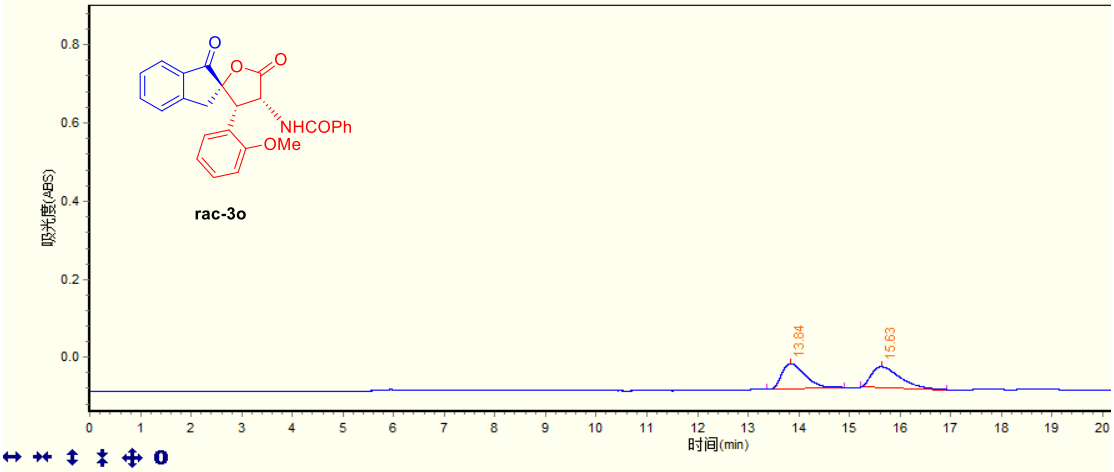
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	8.59	931841	32502	50.45%	1.228	BB
2	11.03	915102	22911	49.55%	1.706	BB
总计		1,846,943	55,413	100.00%		



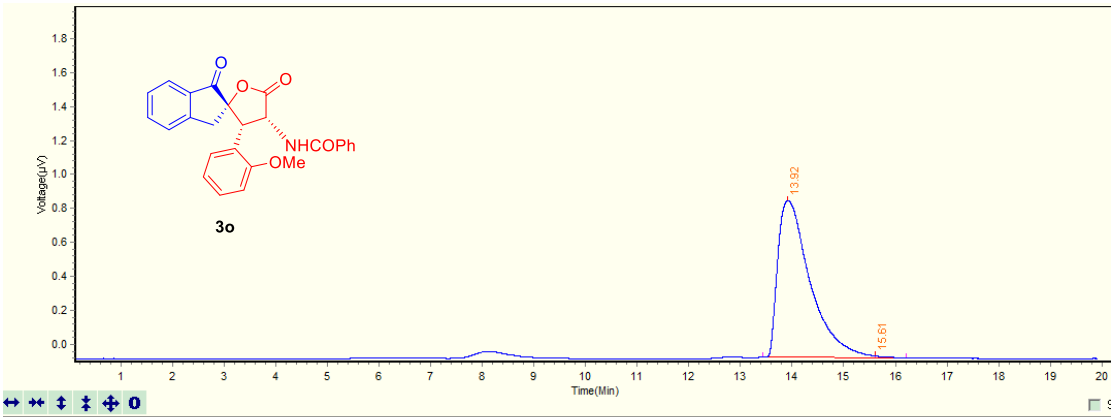
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	Peak Type
1	8.60	73877	3139	0.37%	0.85	BB
2	11.01	19929655	442694	99.63%	3.162	BB
Total		20,003,532	445,833	100.00%		



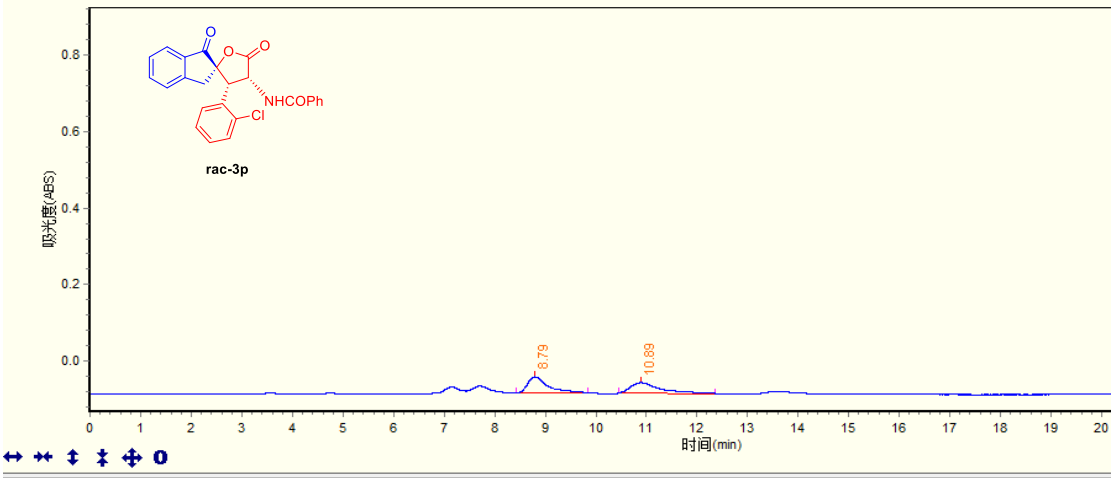
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	13.84	1014846	31949	49.08%	1.509	BB
2	15.63	1052835	26788	50.92%	1.717	BB
总计		2,067,681	58,737	100.00%		



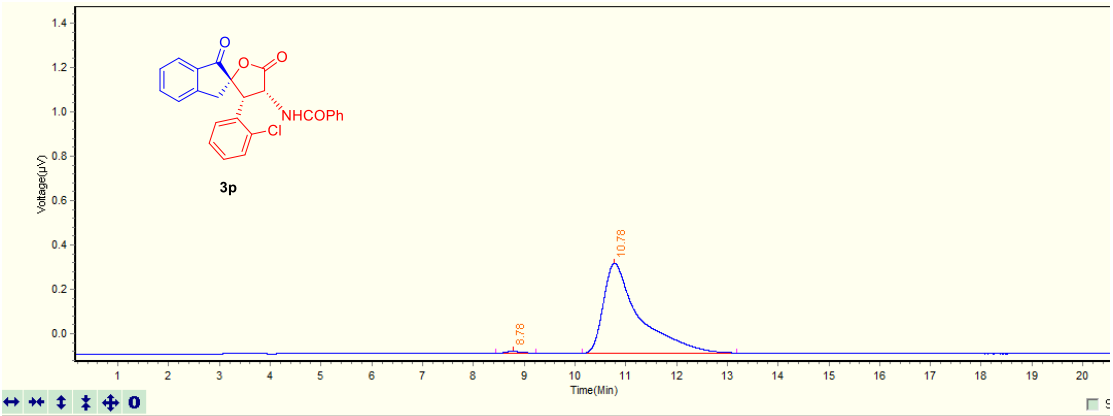
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	Peak Type
1	13.92	20060904	460877	99.74%	2.179	BV
2	15.61	52402	4588	0.26%	0.599	VB
Total		20,113,306	465,465	100.00%		



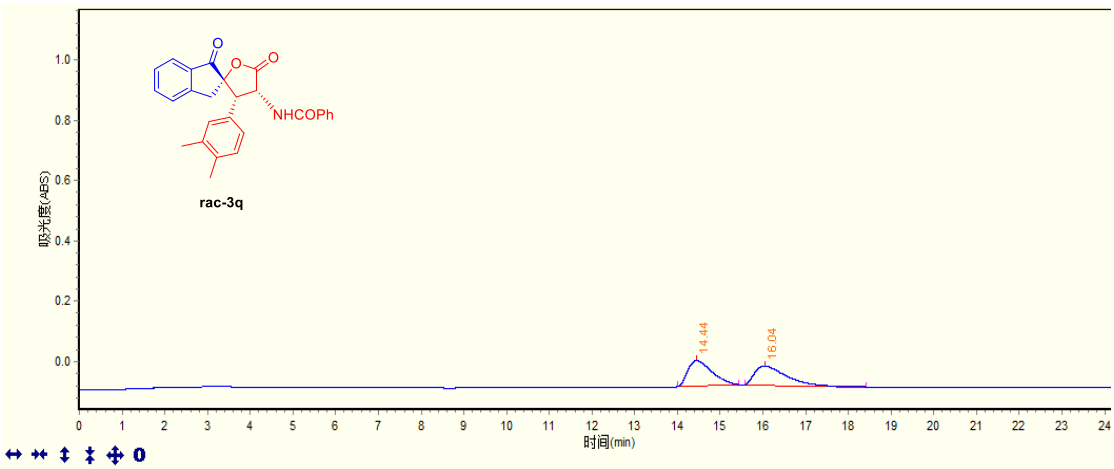
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	8.79	579688	21022	50.83%	1.417	BB
2	10.89	560661	13741	49.17%	1.905	BB
总计		1,140,349	34,763	100.00%		



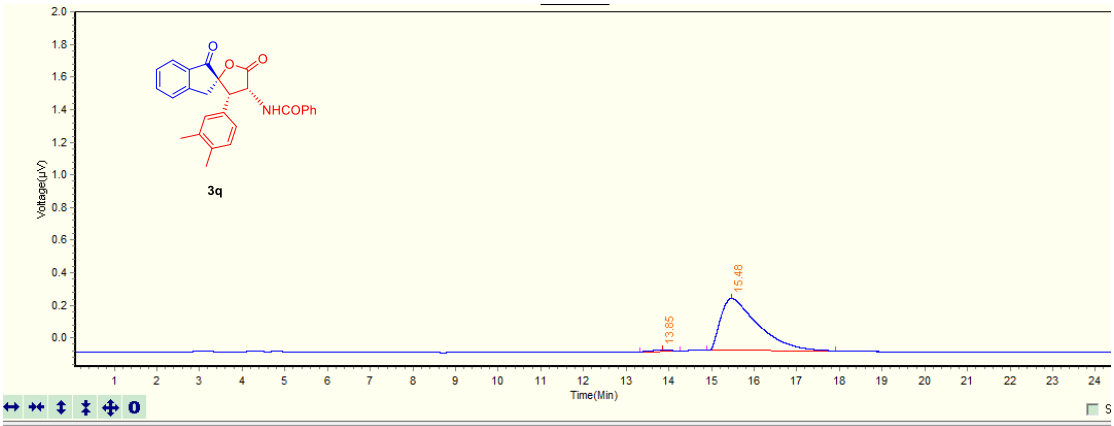
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	Peak Type
1	8.78	99349	4522	0.99%	0.798	BB
2	10.78	9968623	202901	99.01%	3.049	BB
Total		10,067,972	207,423	100.00%		



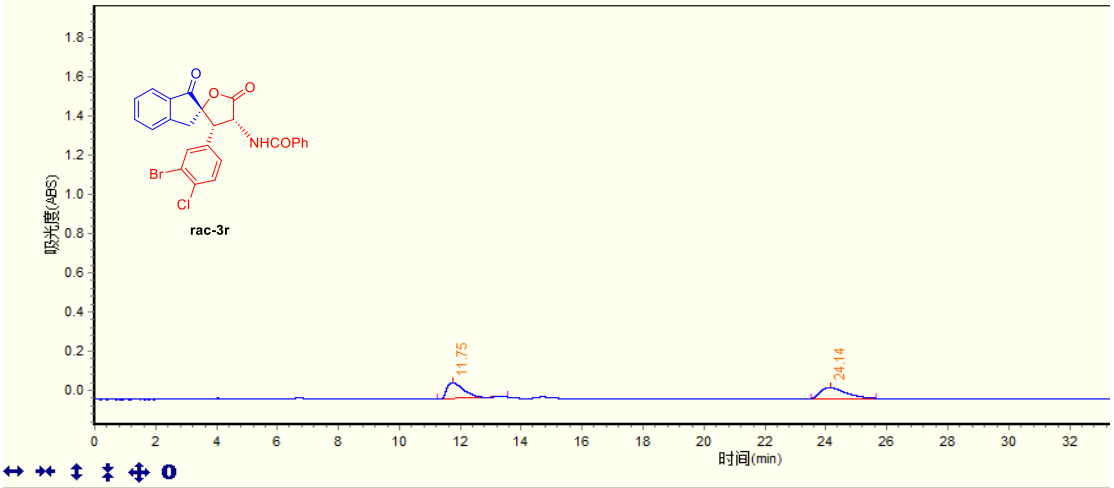
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	14.44	1661195	42347	50.81%	1.429	BB
2	16.04	1608480	31736	49.19%	2.835	BB
总计		3,269,675	74,083	100.00%		



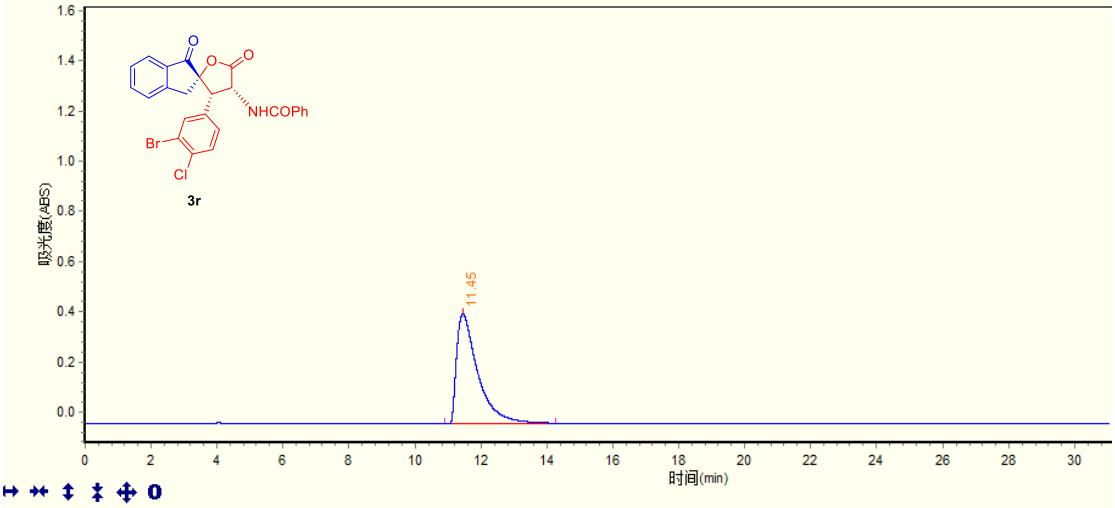
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	Peak Type
1	13.85	118369	3865	1.21%	0.945	BB
2	15.48	9625552	158841	98.79%	3.005	BB
Total		9,743,921	162,706	100.00%		



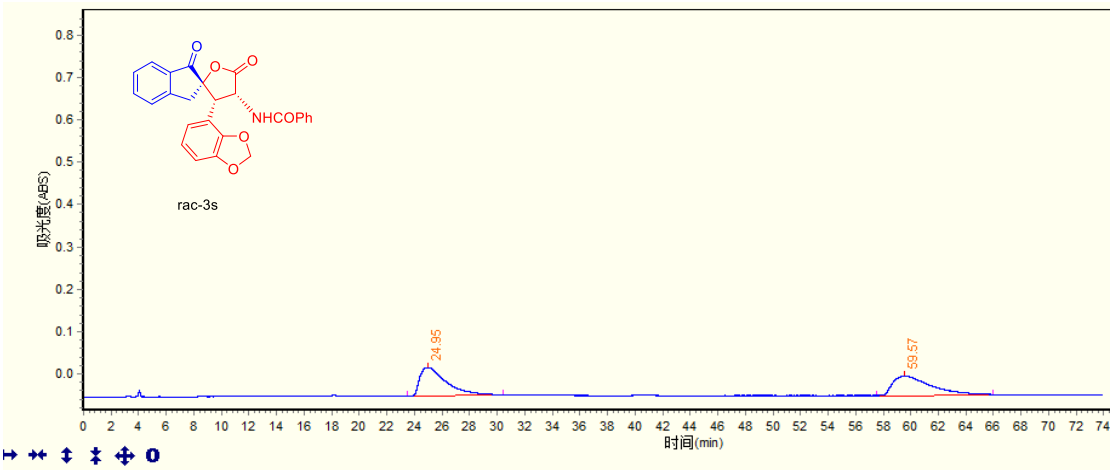
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	11.75	1635138	41277	50.00%	2.308	BB
2	24.14	1635346	28097	50.00%	2.137	BB
总计		3,270,484	69,374	100.00%		



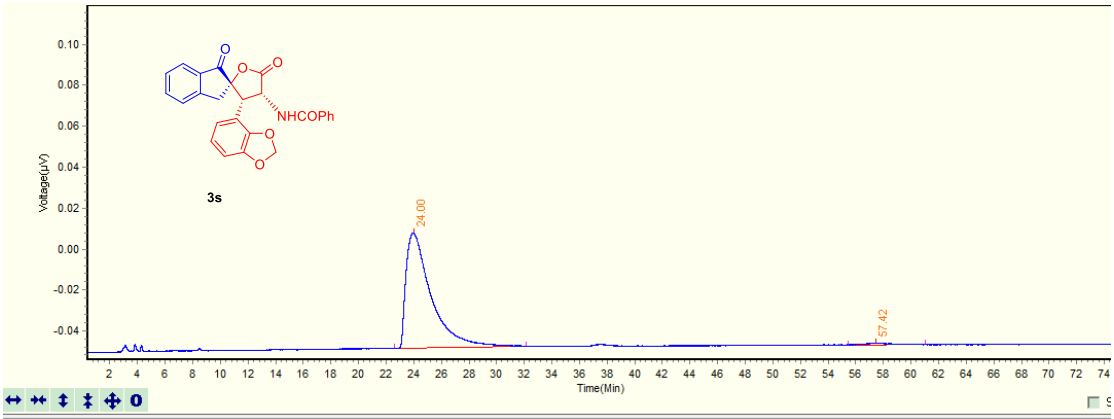
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	11.45	9728754	219175	100.00%	3.363	BB
总计		9,728,754	219,175	100.00%		



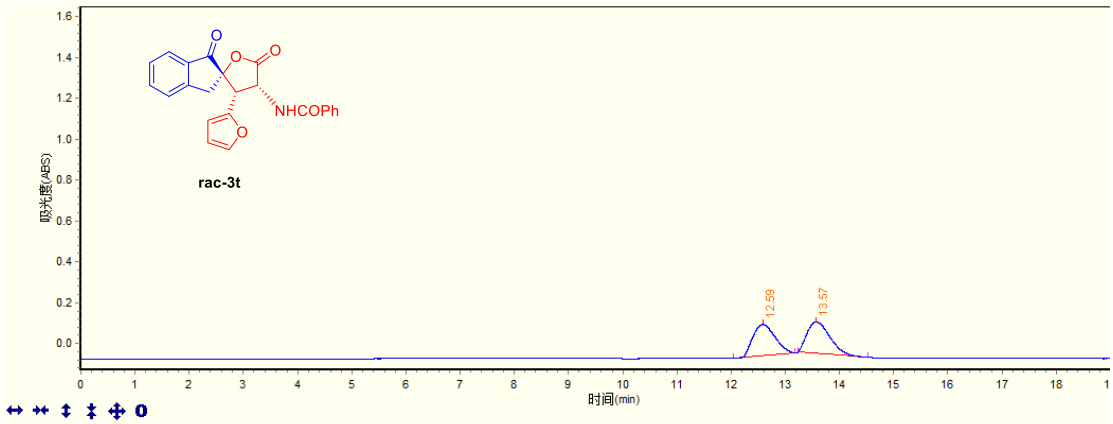
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	24.95	4351991	33161	50.41%	6.948	BB
2	59.57	4280930	22775	49.59%	8.442	BB
总计		8,632,921	55,936	100.00%		



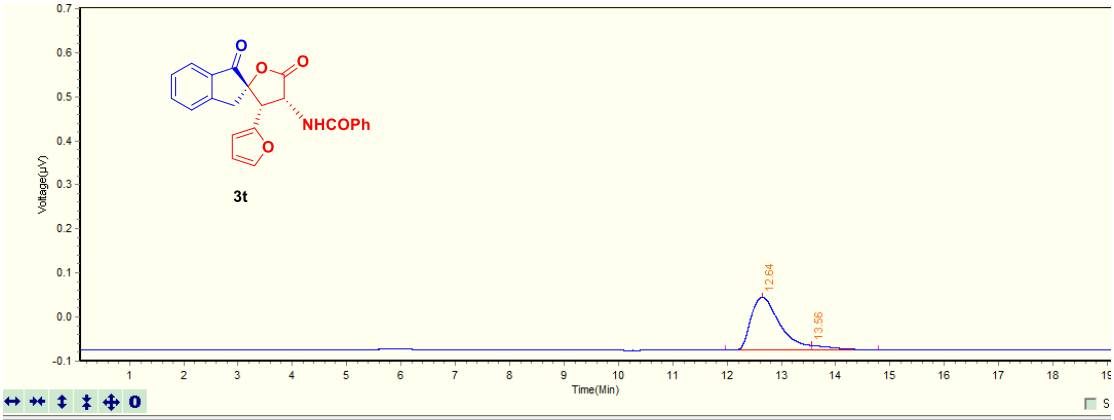
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	Peak Type
1	24.00	3531080	28106	98.47%	9.49	BB
2	57.42	54932	377	1.53%	5.586	BB
Total		3,586,012	28,483	100.00%		



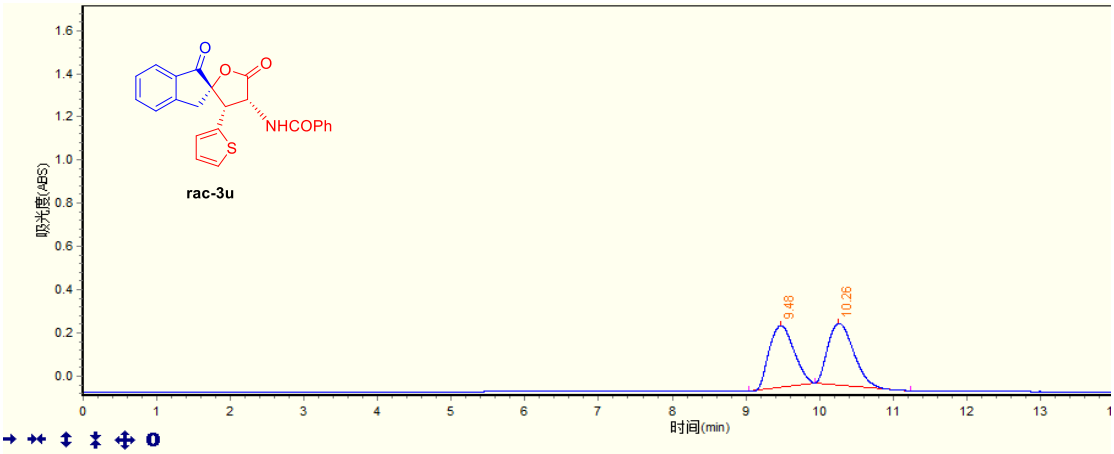
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	12.59	2209201	76919	49.47%	1.134	BB
2	13.57	2256314	77033	50.53%	1.291	BB
总计		4,465,515	153,952	100.00%		



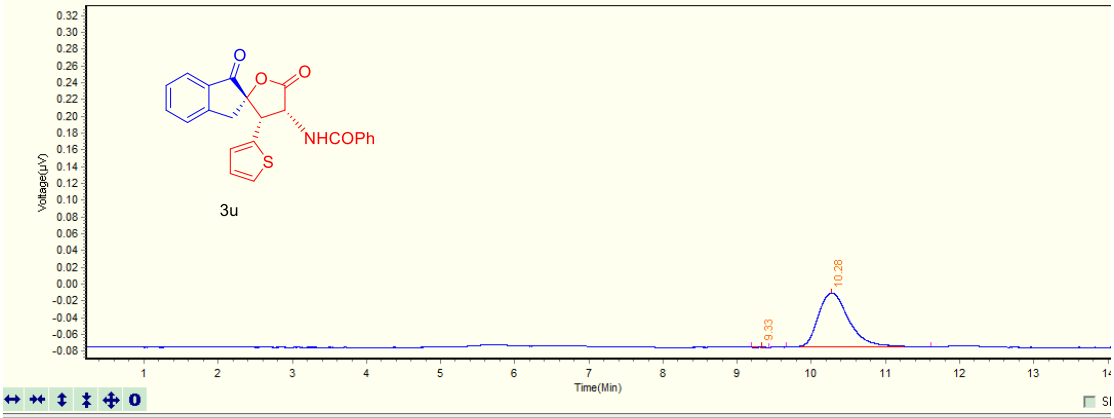
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	Peak Type
1	12.64	2179844	59877	94.70%	1.583	BV
2	13.56	122054	4829	5.30%	1.229	VB
Total		2,301,898	64,706	100.00%		



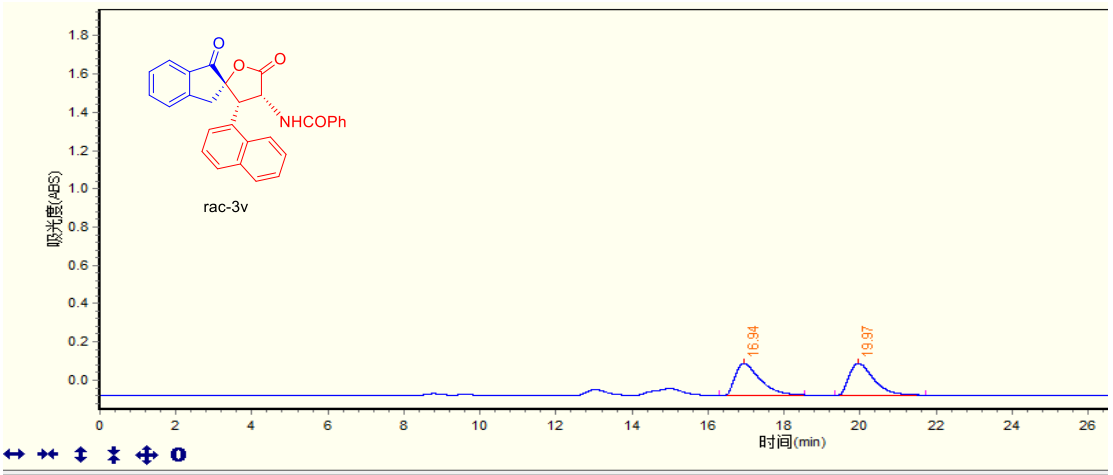
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	9.48	3317397	142788	49.24%	0.898	BB
2	10.26	3419769	141783	50.76%	1.299	BB
总计		6,737,166	284,571	100.00%		



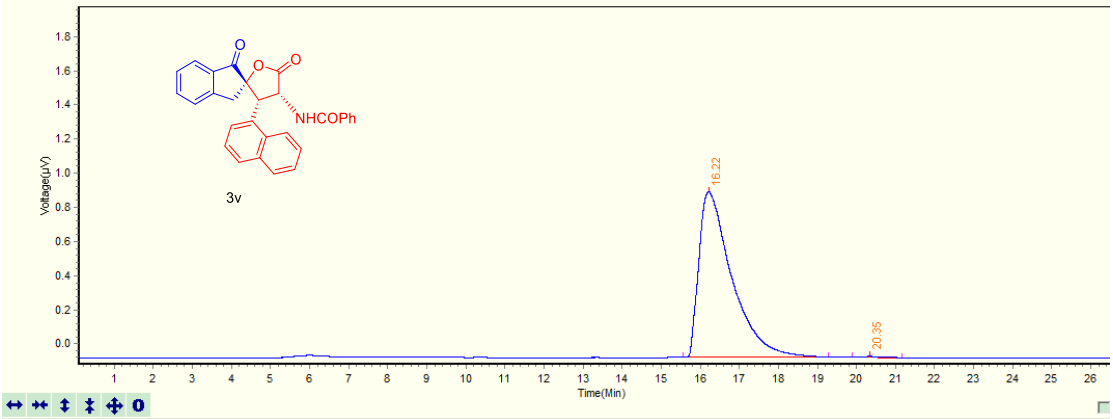
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	Peak Type
1	9.33	290	95	0.03%	0.231	BB
2	10.28	932653	32153	99.97%	1.956	BB
Total		932,943	32,248	100.00%		



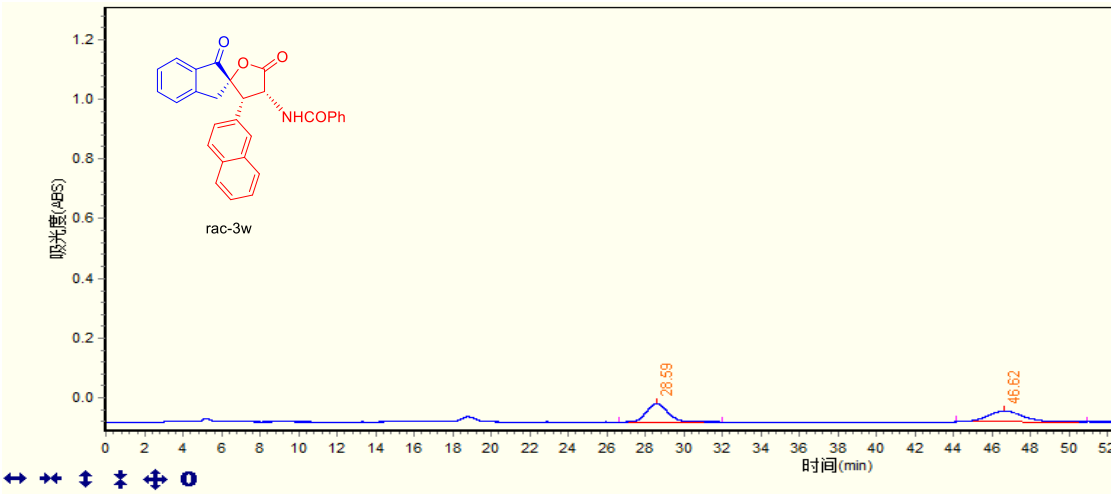
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰
1	16.94	3661532	81850	49.33%	2.245	BB
2	19.97	3761735	83121	50.67%	2.39	BB
总计		7,423,267	164,971	100.00%		



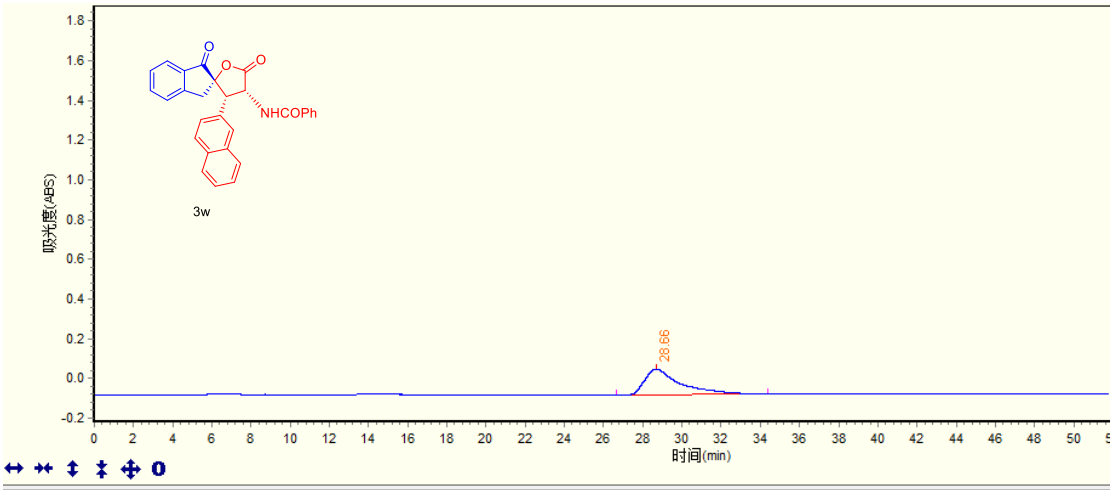
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	Peak Type
1	16.22	28189940	483047	99.57%	3.736	BB
2	20.35	121757	3088	0.43%	1.281	BB
Total		28,311,697	486,135	100.00%		



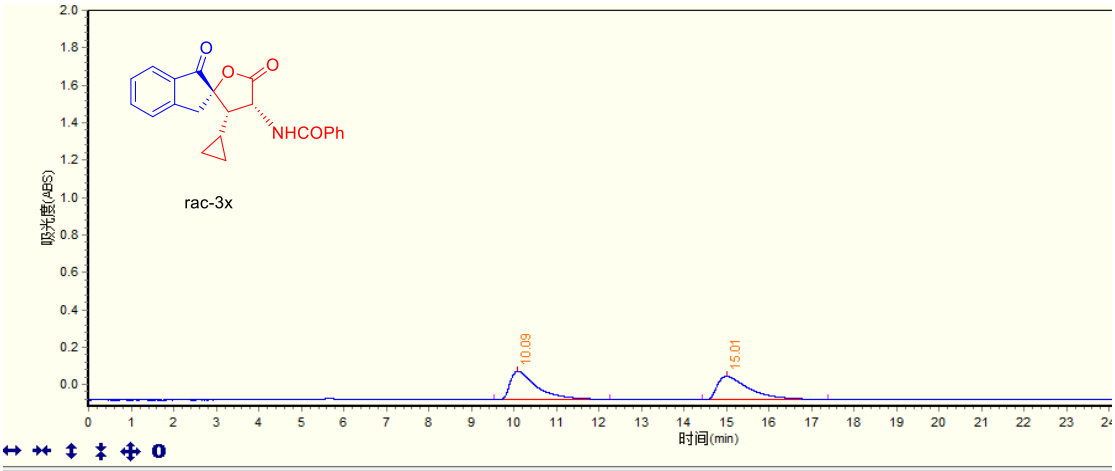
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	
1	28.59	2333347	30895	50.36%	5.358	BB
2	46.62	2299797	18036	49.64%	6.792	BB
总计		4,633,144	48,931	100.00%		



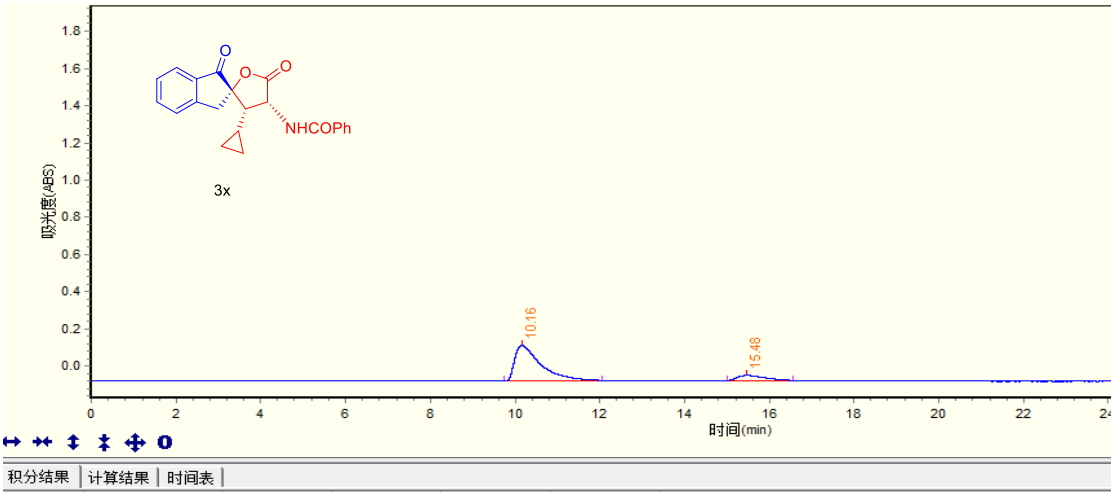
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	28.66	7961476	63735	100.00%	7.699	BB
总计		7,961,476	63,735	100.00%		



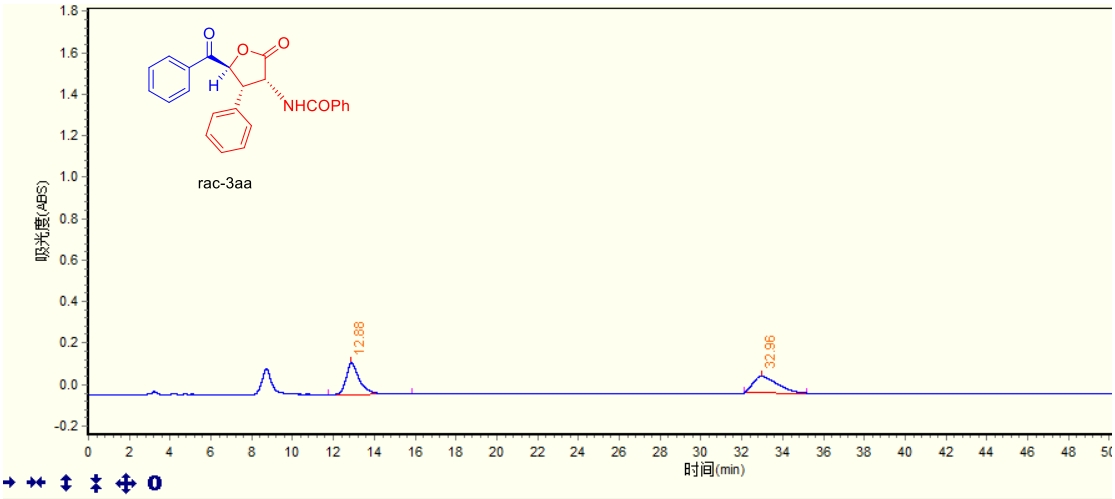
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	10.09	3245519	75519	49.75%	2.705	BB
2	15.01	3278443	62852	50.25%	2.966	BB
总计		6,523,962	138,371	100.00%		



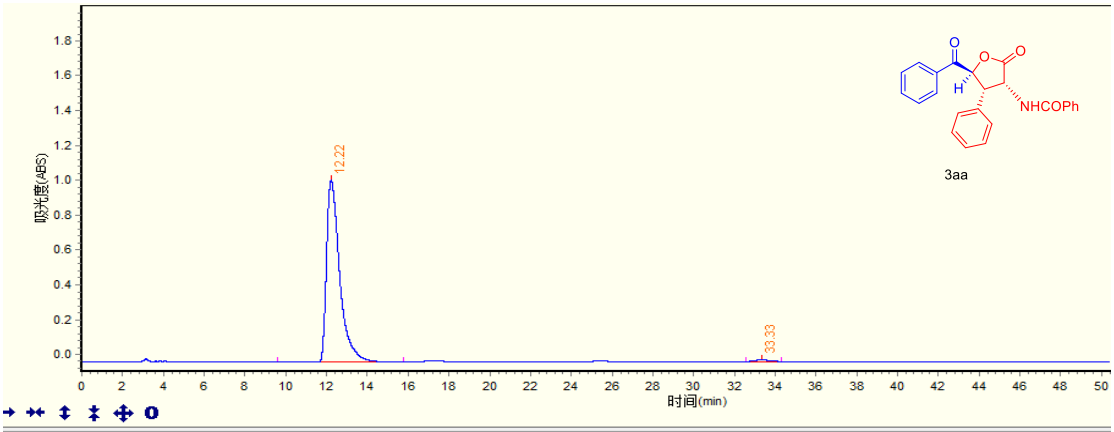
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	10.16	4062677	95328	86.36%	2.313	BB
2	15.48	641799	14359	13.64%	1.552	BB
总计		4,704,476	109,687	100.00%		



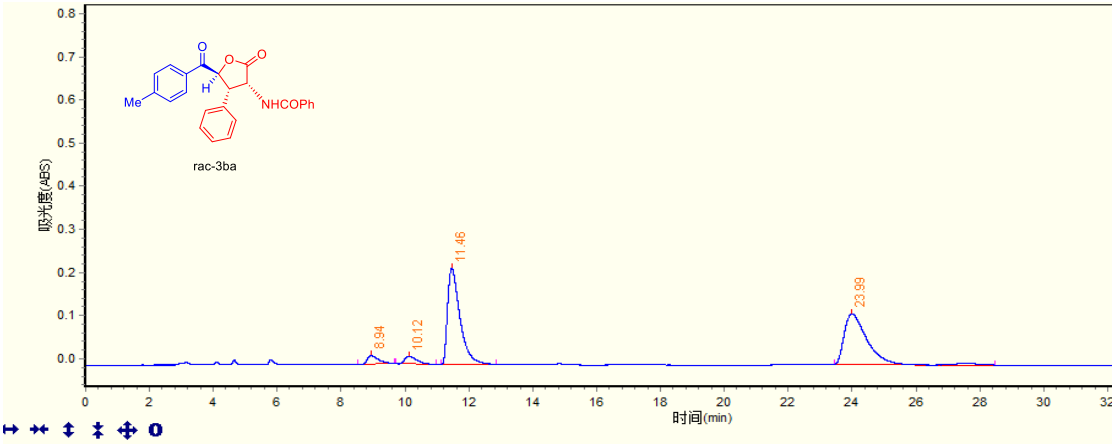
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	12.88	3420363	75765	50.91%	4.098	BB
2	32.96	3297737	40247	49.09%	3.058	BB
总计		6,718,100	116,012	100.00%		



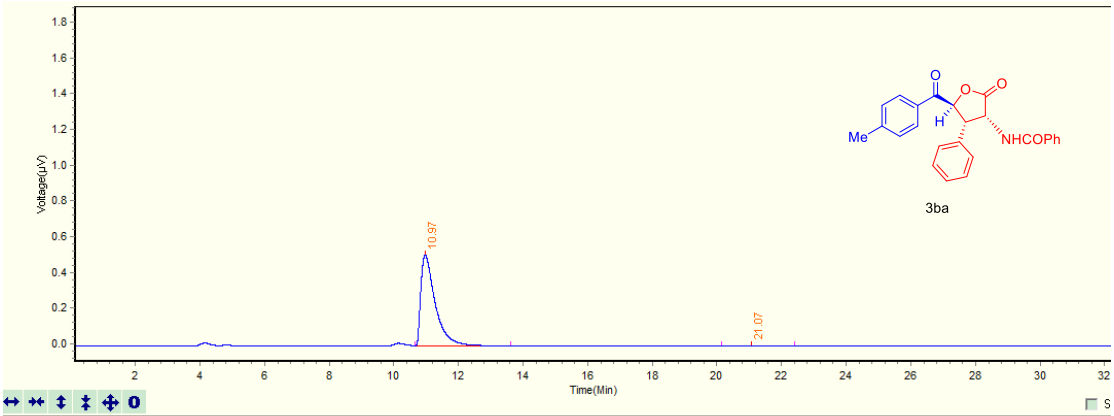
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	12.22	23439092	521411	98.84%	6.177	BB
2	33.33	274592	4771	1.16%	1.739	BB
总计		23,713,684	526,182	100.00%		



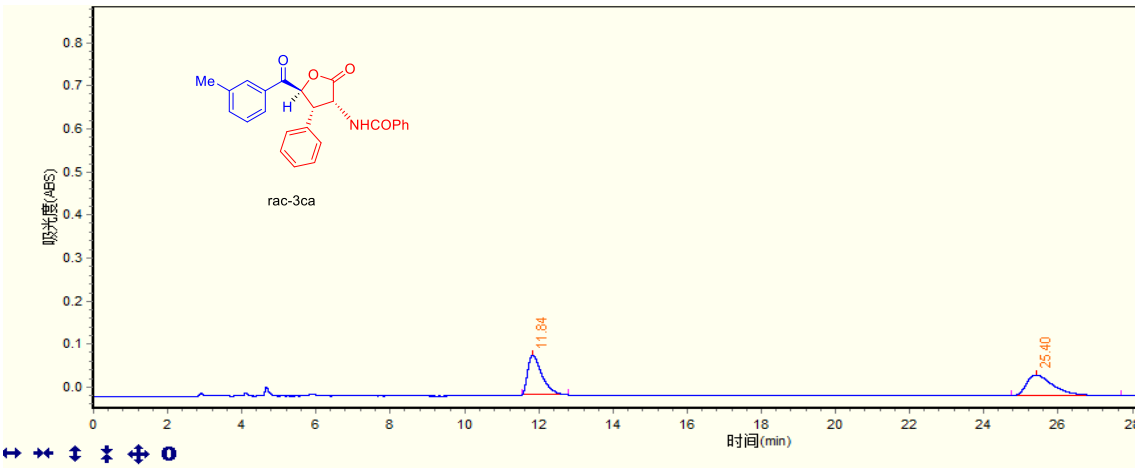
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	8.94	235323	9907	3.67%	1.156	BB
2	10.12	224802	8677	3.51%	1.272	BB
3	11.46	3000157	111223	46.83%	1.733	BB
4	23.99	2946760	58623	45.99%	5.027	BB
总计		6,407,042	188,430	100.00%		



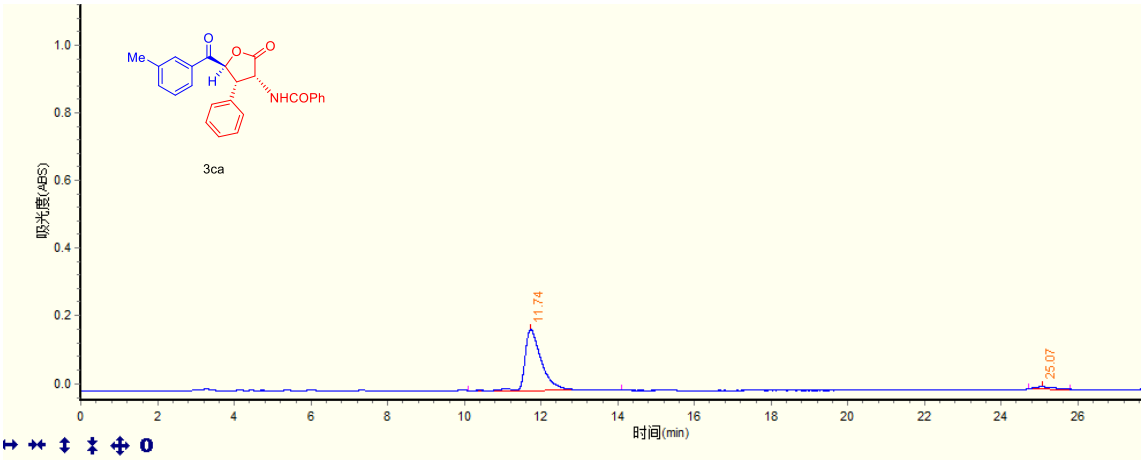
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	Peak Type
1	10.97	7862062	253835	99.73%	2.963	BB
2	21.07	21320	401	0.27%	2.26	BB
Total		7,883,382	254,236	100.00%		



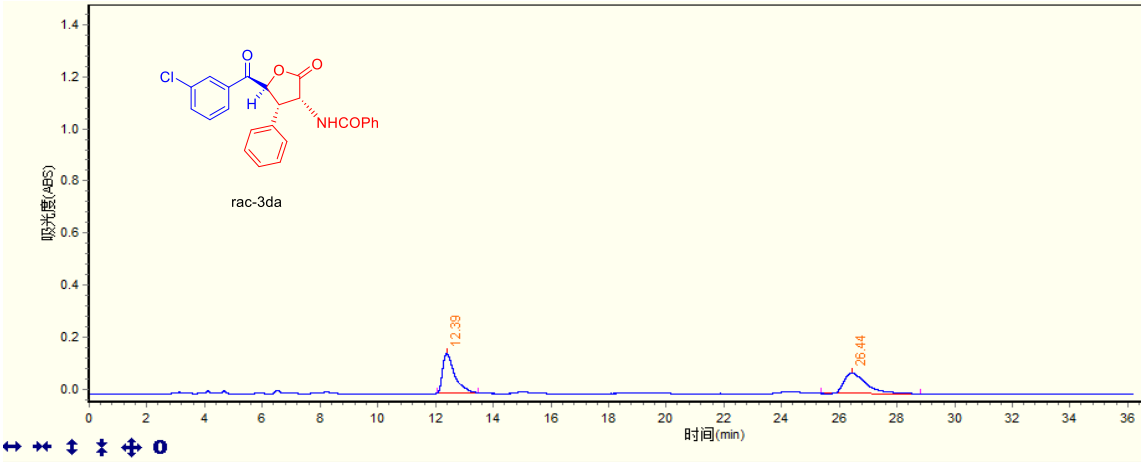
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	11.84	1220695	45821	50.07%	1.24	BB
2	25.40	1217181	24020	49.93%	2.938	BB
总计		2,437,876	69,841	100.00%		



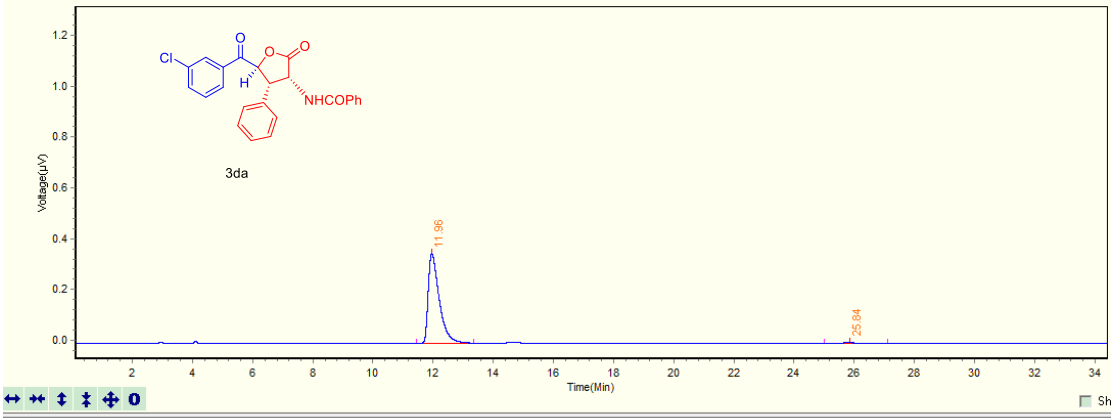
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	11.74	2670051	89559	96.10%	4.028	BB
2	25.07	108272	3093	3.90%	1.083	BB
总计		2,778,323	92,652	100.00%		



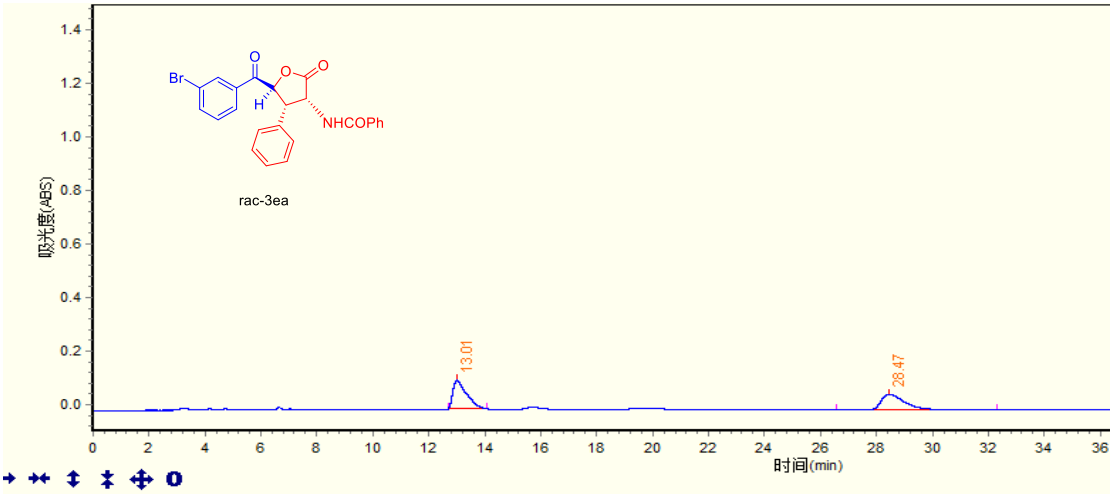
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	12.39	2184083	76155	50.81%	1.421	BB
2	26.44	2114385	39199	49.19%	3.446	BB
总计		4,298,468	115,354	100.00%		



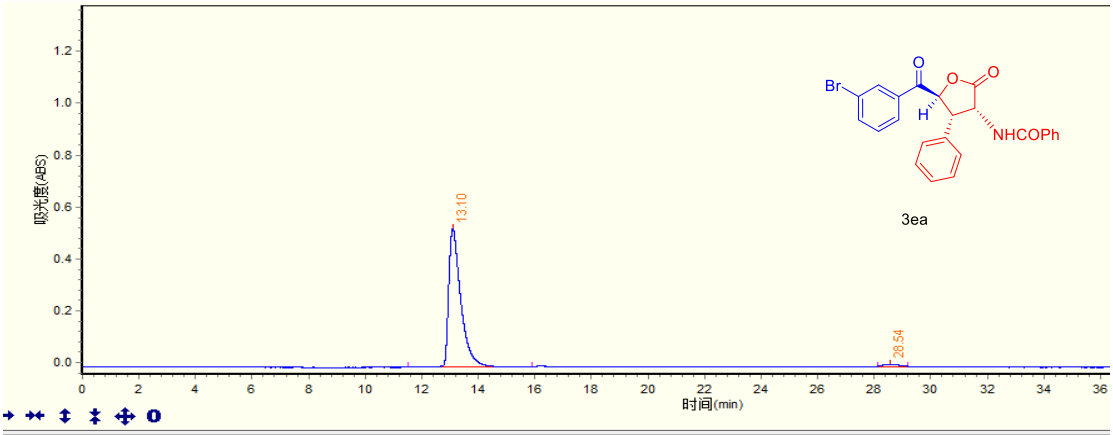
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	Peak Type
1	11.96	4476127	176858	98.21%	1.893	BB
2	25.84	81439	1571	1.79%	2.108	BB
Total		4,557,566	178,429	100.00%		



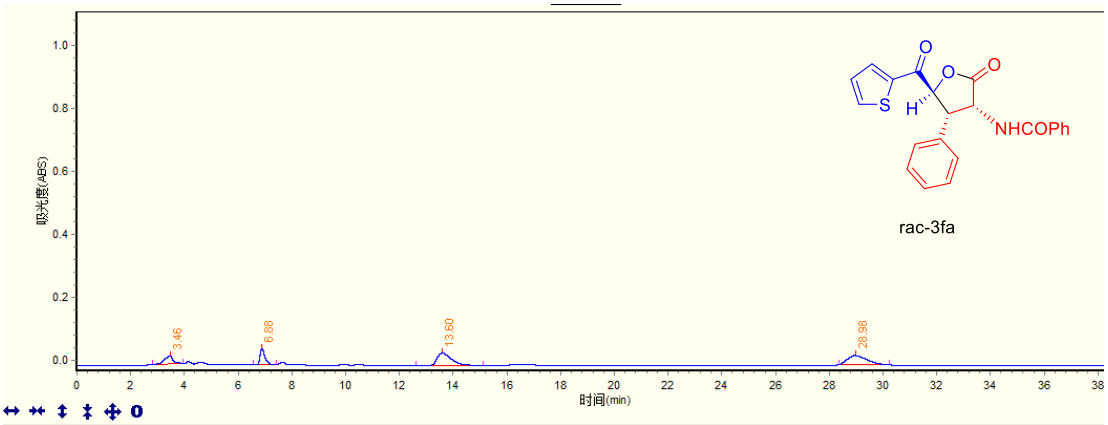
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	
1	13.01	1791332	53297	50.97%	1.372	BB
2	28.47	1722930	29058	49.03%	5.741	BB
总计		3,514,262	82,355	100.00%		



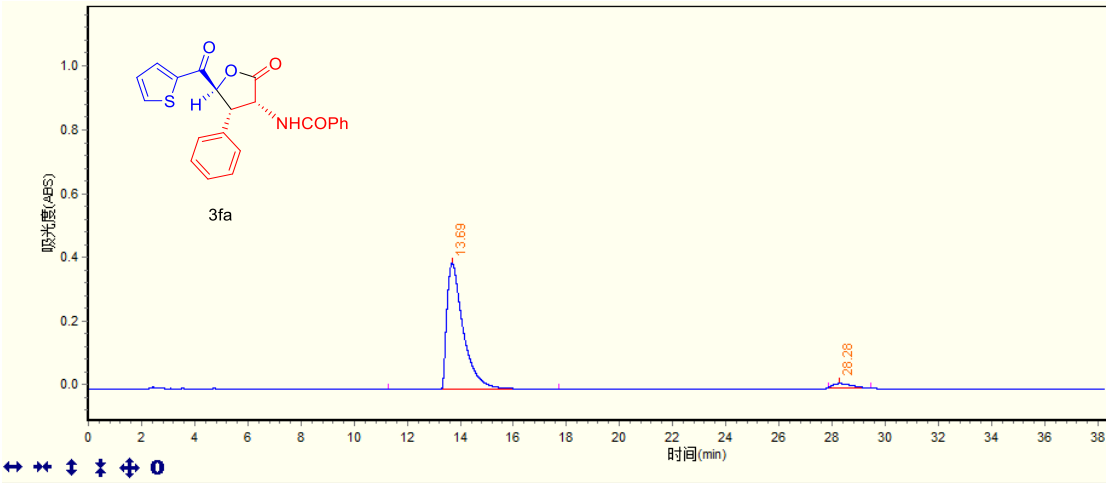
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	13.10	7899784	266278	98.31%	4.384	BB
2	28.54	136197	3694	1.69%	1.063	BB
总计		8,035,981	269,972	100.00%		



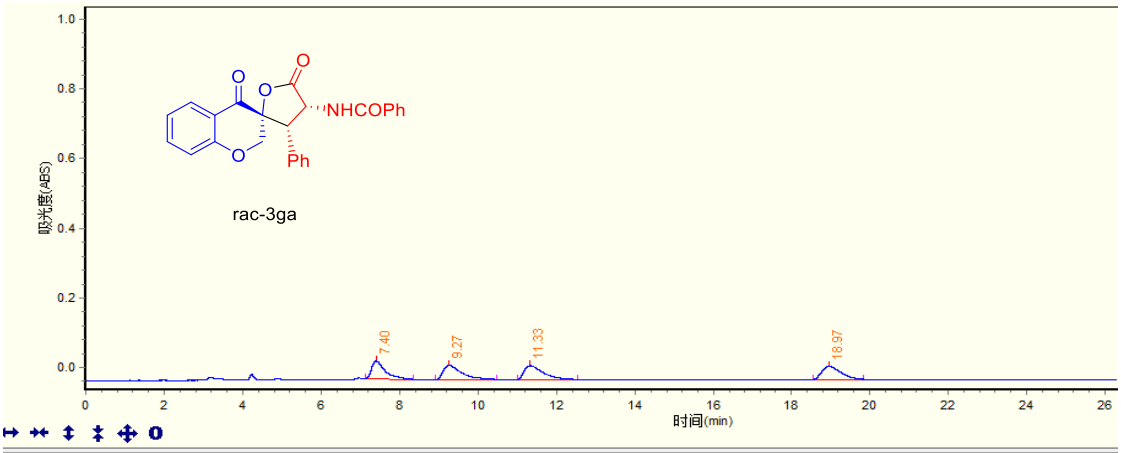
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	3.46	310535	13411	14.79%	1.133	BB
2	6.88	316462	25068	15.07%	0.859	BB
3	13.60	732353	19445	34.87%	2.5	BB
4	28.98	740794	14555	35.27%	1.875	BB
总计		2,100,144	72,479	100.00%		



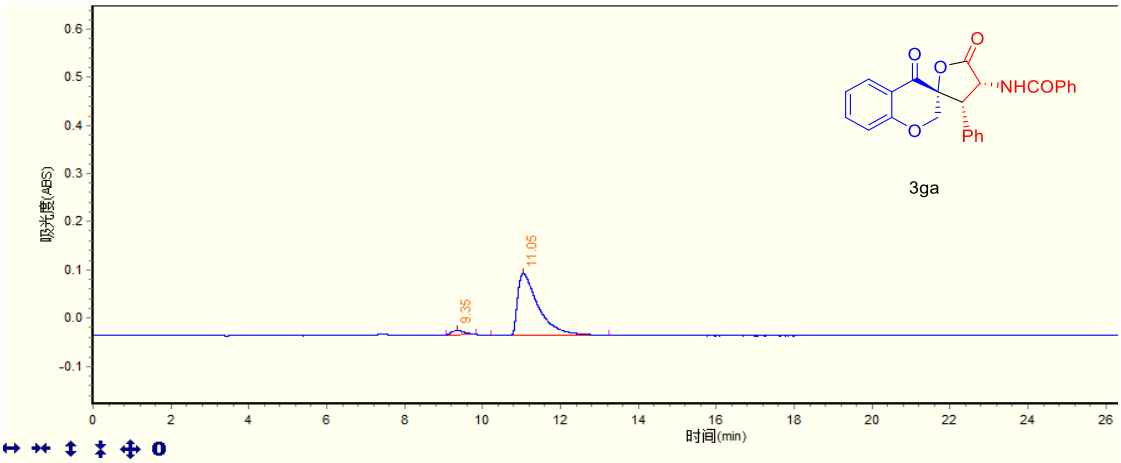
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	13.69	8481874	197464	96.49%	6.419	BB
2	28.28	308528	6261	3.51%	1.593	BB
总计		8,790,402	203,725	100.00%		



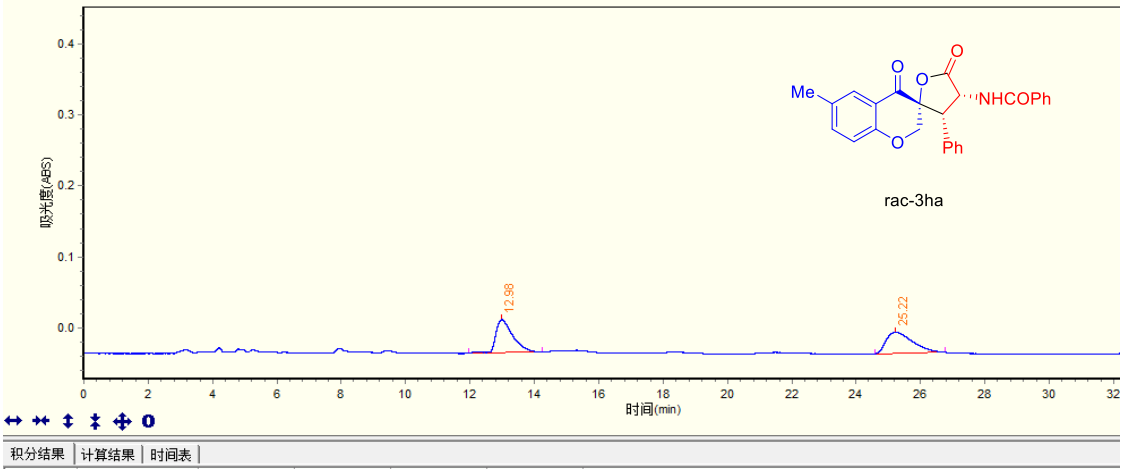
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	7.40	626896	25783	24.38%	1.22	BB
2	9.27	650179	20442	25.29%	1.563	BB
3	11.33	666977	19840	25.94%	1.533	BB
4	18.97	626947	18524	24.39%	1.282	BB
总计		2,570,999	84,589	100.00%		



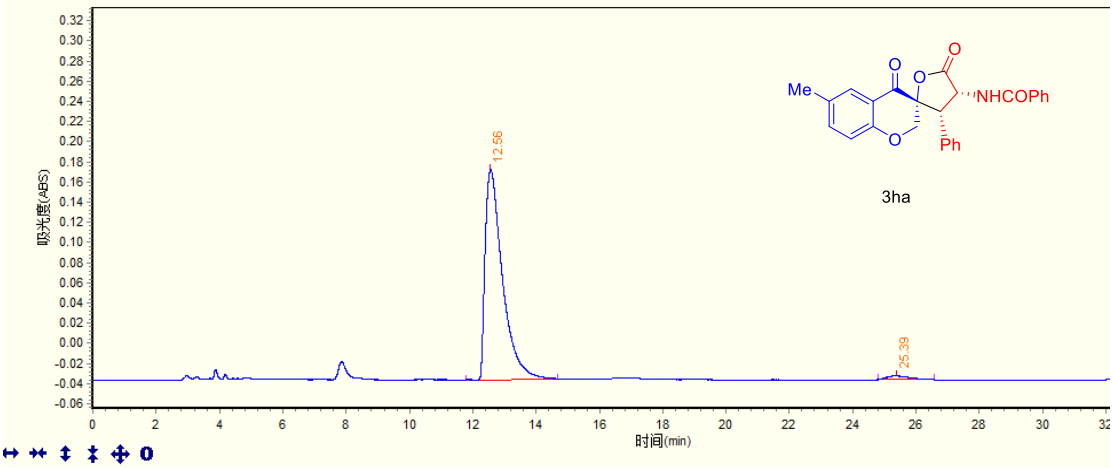
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	9.35	103722	4275	4.20%	0.766	BB
2	11.05	2367492	64308	95.80%	3.032	BB
总计		2,471,214	68,583	100.00%		



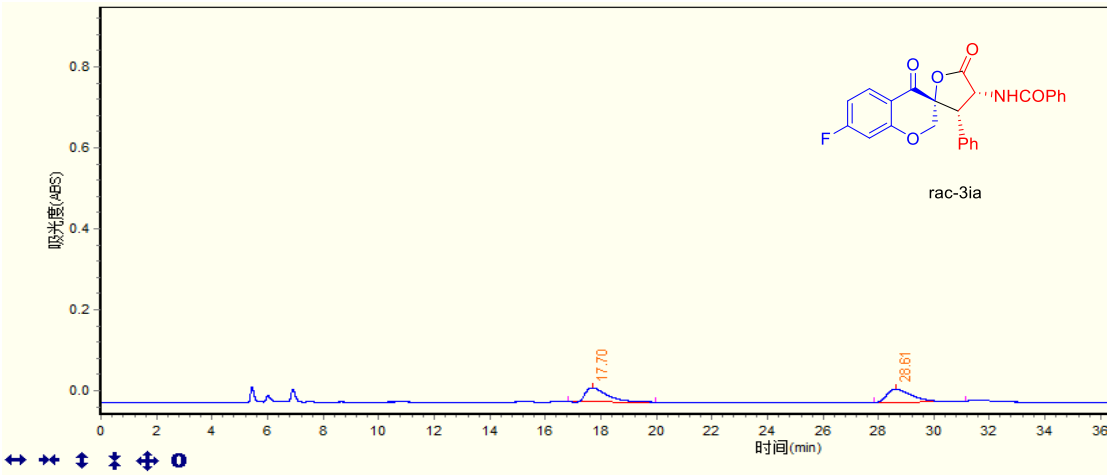
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	12.98	859244	23231	50.34%	2.271	BB
2	25.22	847690	14901	49.66%	2.18	BB
总计		1,706,934	38,132	100.00%		



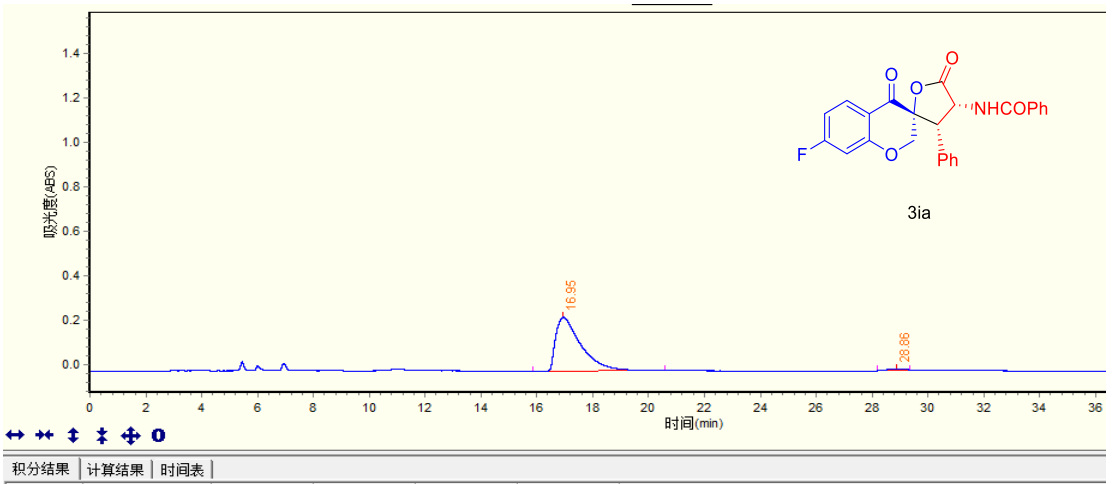
积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	12.56	3937640	104054	97.76%	2.9	BB
2	25.39	90190	1828	2.24%	1.772	BB
总计		4,027,830	105,882	100.00%		



积分结果 | 计算结果 | 时间表

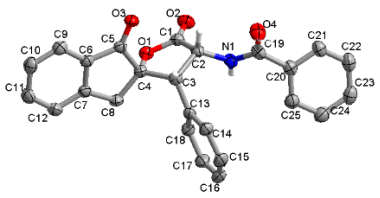
序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰
1	17.70	939142	17448	50.31%	3.148	BB
2	28.61	927395	15762	49.69%	3.296	BB
总计		1,866,537	33,210	100.00%		



积分结果 | 计算结果 | 时间表

序号	保留时间	峰面积	峰高	面积百分比	峰宽	峰类型
1	16.95	7537332	120307	98.54%	4.727	BB
2	28.86	111784	2863	1.46%	1.16	BB
总计		7,649,116	123,170	100.00%		

Single-crystal X-ray diffraction of 3a (CCDC 2074877)



Datablock: 202011247

Bond precision: C-C = 0.0067 A Wavelength=1.54184

Cell: a=9.3096(18) b=10.340(3) c=10.3533(17)
alpha=90 beta=91.294(17) gamma=90
Temperature: 293 K

	Calculated	Reported
Volume	996.4(4)	996.4(4)
Space group	P 21	P 1 21 1
Hall group	P 2yb	P 2yb
Moiety formula	C25 H19 N O4	C25 H19 N O4
Sum formula	C25 H19 N O4	C25 H19 N O4
Mr	397.41	397.41
Dx,g cm-3	1.325	1.325
Z	2	2
Mu (mm-1)	0.732	0.732
F000	416.0	416.0
F000'	417.30	
h,k,lmax	11,12,12	11,12,12
Nref	3559[1888]	3218
Tmin,Tmax	0.896,0.929	0.767,1.000
Tmin'	0.896	

Correction method= # Reported T Limits: Tmin=0.767 Tmax=1.000
AbsCorr = MULTI-SCAN

Data completeness= 1.70/0.90 Theta(max)= 67.074

R(reflections)= 0.0453(2641) wR2(reflections)= 0.1220(3218)

S = 1.110 Npar= 275

The following ALERTS were generated. Each ALERT has the format
test-name_ALERT_alert-type_alert-level.
Click on the hyperlinks for more details of the test.

Alert level C

```
PLAT089_ALERT_3_C Poor Data / Parameter Ratio (Zmax < 18) ........        6.87 Note
PLAT340_ALERT_3_C Low Bond Precision on  C-C Bonds ..............    0.00667 Ang.
PLAT915_ALERT_3_C No Flack x Check Done: Low Friedel Pair Coverage        80 %
```

Alert level G

```
PLAT012_ALERT_1_G No       _shelx_res_checksum Found in CIF ......     Please Check
PLAT199_ALERT_1_G Reported _cell_measurement_temperature ..... (K)        293 Check
PLAT200_ALERT_1_G Reported   _diffrn_ambient_temperature ..... (K)        293 Check
PLAT791_ALERT_4_G Model has Chirality at C2          (Sohnke SpGr)          R Verify
PLAT791_ALERT_4_G Model has Chirality at C3          (Sohnke SpGr)          S Verify
PLAT791_ALERT_4_G Model has Chirality at C4          (Sohnke SpGr)          S Verify
PLAT909_ALERT_3_G Percentage of I>2sig(I) Data at Theta(Max) Still        54% Note
PLAT933_ALERT_2_G Number of OMIT Records in Embedded .res File ...         6 Note
PLAT941_ALERT_3_G Average HKL Measurement Multiplicity ...........       4.2 Low
PLAT978_ALERT_2_G Number C-C Bonds with Positive Residual Density.         0 Info
```

```
  0 ALERT level A = Most likely a serious problem - resolve or explain
  0 ALERT level B = A potentially serious problem, consider carefully
  3 ALERT level C = Check. Ensure it is not caused by an omission or oversight
 10 ALERT level G = General information/check it is not something unexpected

  3 ALERT type 1 CIF construction/syntax error, inconsistent or missing data
  2 ALERT type 2 Indicator that the structure model may be wrong or deficient
  5 ALERT type 3 Indicator that the structure quality may be low
  3 ALERT type 4 Improvement, methodology, query or suggestion
  0 ALERT type 5 Informative message, check
```

It is advisable to attempt to resolve as many as possible of the alerts in all categories. Often the minor alerts point to easily fixed oversights, errors and omissions in your CIF or refinement strategy, so attention to these fine details can be worthwhile. In order to resolve some of the more serious problems it may be necessary to carry out additional measurements or structure refinements. However, the purpose of your study may justify the reported deviations and the more serious of these should normally be commented upon in the discussion or experimental section of a paper or in the "special_details" fields of the CIF. checkCIF was carefully designed to identify outliers and unusual parameters, but every test has its limitations and alerts that are not important in a particular case may appear. Conversely, the absence of alerts does not guarantee there are no aspects of the results needing attention. It is up to the individual to critically assess their own results and, if necessary, seek expert advice.

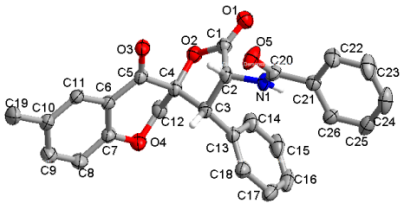
Publication of your CIF in IUCr journals

A basic structural check has been run on your CIF. These basic checks will be run on all CIFs submitted for publication in IUCr journals (*Acta Crystallographica*, *Journal of Applied Crystallography*, *Journal of Synchrotron Radiation*); however, if you intend to submit to *Acta Crystallographica Section C* or *E* or *IUCrData*, you should make sure that full publication checks are run on the final version of your CIF prior to submission.

Publication of your CIF in other journals

Please refer to the *Notes for Authors* of the relevant journal for any special instructions relating to CIF submission.

Single-crystal X-ray diffraction of 3ha (CCDC 2092642)



Datablock: 202106179

Bond precision: C-C = 0.0050 A Wavelength=1.54184

Cell: a=10.8915(3) b=13.7026(6) c=14.8233(10)
alpha=90 beta=90 gamma=90
Temperature: 293 K

	Calculated	Reported
Volume	2212.26(19)	2212.25(19)
Space group	P 21 21 21	P 21 21 21
Hall group	P 2ac 2ab	P 2ac 2ab
Moiety formula	C26 H21 N O5	C26 H21 N O5
Sum formula	C26 H21 N O5	C26 H21 N O5
Mr	427.44	427.44
Dx,g cm-3	1.283	1.283
Z	4	4
Mu (mm-1)	0.731	0.731
F000	896.0	896.0
F000'	898.87	
h,k,lmax	13,16,18	13,16,17
Nref	4280[2432]	4175
Tmin,Tmax	0.900,0.930	0.944,1.000
Tmin'	0.896	

Correction method= # Reported T Limits: Tmin=0.944 Tmax=1.000
AbsCorr = MULTI-SCAN

Data completeness= 1.72/0.98 Theta(max)= 70.932

R(reflections)= 0.0437(3651) wR2(reflections)= 0.1149(4175)

S = 1.046 Npar= 294

The following ALERTS were generated. Each ALERT has the format
test-name_ALERT_alert-type_alert-level.
Click on the hyperlinks for more details of the test.

Alert level C

```
PLAT241_ALERT_2_C High   'MainMol' Ueq as Compared to Neighbors of        C23 Check
PLAT340_ALERT_3_C Low Bond Precision on  C-C Bonds ..............    0.00504 Ang.
PLAT918_ALERT_3_C Reflection(s) with I(obs) much Smaller I(calc) .          1 Check
```

Alert level G

```
PLAT005_ALERT_5_G No Embedded Refinement Details Found  in the CIF     Please Do !
PLAT199_ALERT_1_G Reported _cell_measurement_temperature ..... (K)        293 Check
PLAT200_ALERT_1_G Reported   _diffrn_ambient_temperature ..... (K)        293 Check
PLAT791_ALERT_4_G Model has Chirality at C2          (Sohnke SpGr)          R Verify
PLAT791_ALERT_4_G Model has Chirality at C3          (Sohnke SpGr)          S Verify
PLAT791_ALERT_4_G Model has Chirality at C4          (Sohnke SpGr)          R Verify
PLAT912_ALERT_4_G Missing # of FCF Reflections Above STh/L=  0.600         32 Note
PLAT978_ALERT_2_G Number C-C Bonds with Positive Residual Density.          0 Info
```

```
  0 ALERT level A = Most likely a serious problem - resolve or explain
  0 ALERT level B = A potentially serious problem, consider carefully
  3 ALERT level C = Check. Ensure it is not caused by an omission or oversight
  8 ALERT level G = General information/check it is not something unexpected

  2 ALERT type 1 CIF construction/syntax error, inconsistent or missing data
  2 ALERT type 2 Indicator that the structure model may be wrong or deficient
  2 ALERT type 3 Indicator that the structure quality may be low
  4 ALERT type 4 Improvement, methodology, query or suggestion
  1 ALERT type 5 Informative message, check
```

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Publication of your CIF in IUCr journals

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Publication of your CIF in other journals

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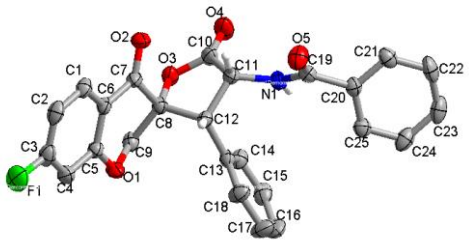
Single-crystal X-ray diffraction of 3ia (CCDC 2097633)



Datablock: 202106190

Bond precision: C-C = 0.0054 A Wavelength=1.54184

Cell: a=9.9904(8) b=9.9960(6) c=10.8047(8)
alpha=90 beta=104.900(8) gamma=90
Temperature: 293 K

	Calculated	Reported
Volume	1042.72(14)	1042.72(14)
Space group	P 21	P 1 21 1
Hall group	P 2yb	P 2yb
Moiety formula	C25 H18 F N O5	C25 H18 F N O5
Sum formula	C25 H18 F N O5	C25 H18 F N O5
Mr	431.40	431.40
Dx,g cm-3	1.374	1.374
Z	2	2
Mu (mm-1)	0.854	0.854
F000	448.0	448.0
F000'	449.55	
h,k,lmax	12,12,13	12,12,13
Nref	4018[2133]	3908
Tmin,Tmax	0.875,0.918	0.923,1.000
Tmin'	0.872	

Correction method= # Reported T Limits: Tmin=0.923 Tmax=1.000
AbsCorr = MULTI-SCAN

Data completeness= 1.83/0.97 Theta(max)= 70.764

R(reflections)= 0.0390(3380) wR2(reflections)= 0.1005(3908)

S = 1.057 Npar= 293

Alert level C

```
PLAT089_ALERT_3_C Poor Data / Parameter Ratio (Zmax < 18) ........        7.20 Note
PLAT340_ALERT_3_C Low Bond Precision on  C-C Bonds ...............    0.00538 Ang.
PLAT420_ALERT_2_C D-H Bond Without Acceptor  N1       --H1       .     Please Check
```

Alert level G

```
PLAT012_ALERT_1_G No       _shelx_res_checksum Found in CIF ......     Please Check
PLAT199_ALERT_1_G Reported _cell_measurement_temperature ..... (K)        293 Check
PLAT200_ALERT_1_G Reported   _diffrn_ambient_temperature ..... (K)        293 Check
PLAT791_ALERT_4_G Model has Chirality at C8          (Sohnke SpGr)          R Verify
PLAT791_ALERT_4_G Model has Chirality at C11         (Sohnke SpGr)          R Verify
PLAT791_ALERT_4_G Model has Chirality at C12         (Sohnke SpGr)          S Verify
PLAT912_ALERT_4_G Missing # of FCF Reflections Above STh/L=  0.600         21 Note
PLAT941_ALERT_3_G Average HKL Measurement Multiplicity ...........        3.7 Low
PLAT978_ALERT_2_G Number C-C Bonds with Positive Residual Density.          2 Info
```

```
   0 ALERT level A = Most likely a serious problem - resolve or explain
   0 ALERT level B = A potentially serious problem, consider carefully
   3 ALERT level C = Check. Ensure it is not caused by an omission or oversight
   9 ALERT level G = General information/check it is not something unexpected

   3 ALERT type 1 CIF construction/syntax error, inconsistent or missing data
   2 ALERT type 2 Indicator that the structure model may be wrong or deficient
   3 ALERT type 3 Indicator that the structure quality may be low
   4 ALERT type 4 Improvement, methodology, query or suggestion
   0 ALERT type 5 Informative message, check
```

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Publication of your CIF in other journals

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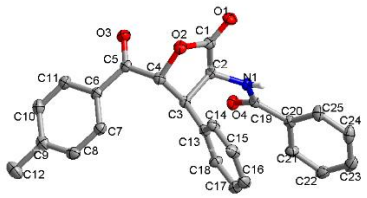
Single-crystal X-ray diffraction of rac-3aa (CCDC 2097681)



Datablock: 20210717b4-1

Bond precision: C-C = 0.0022 A Wavelength=1.54184

Cell: a=14.9905(2) b=10.3667(1) c=25.5652(3)
alpha=90 beta=90 gamma=90
Temperature: 200 K

	Calculated	Reported
Volume	3972.88(8)	3972.88(8)
Space group	P b c a	P b c a
Hall group	-P 2ac 2ab	-P 2ac 2ab
Moiety formula	C25 H21 N O4	C25 H21 N O4
Sum formula	C25 H21 N O4	C25 H21 N O4
Mr	399.43	399.43
Dx,g cm-3	1.336	1.336
Z	8	8
Mu (mm-1)	0.735	0.735
F000	1680.0	1680.0
F000'	1685.22	
h,k,lmax	18,12,31	18,12,31
Nref	3776	3765
Tmin,Tmax	0.969,0.978	0.849,1.000
Tmin'	0.960	

Correction method= # Reported T Limits: Tmin=0.849 Tmax=1.000
AbsCorr = MULTI-SCAN

Data completeness= 0.997 Theta(max)= 70.066

R(reflections)= 0.0385(3052) wR2(reflections)= 0.1053(3765)

S = 1.035 Npar= 272

The following ALERTS were generated. Each ALERT has the format
test-name_ALERT_alert-type_alert-level.
Click on the hyperlinks for more details of the test.

Alert level G

```
PLAT007_ALERT_5_G Number of Unrefined Donor-H Atoms .............          1 Report
PLAT142_ALERT_4_G s.u. on b - Axis Small or Missing .............    0.00010 Ang.
PLAT720_ALERT_4_G Number of Unusual/Non-Standard Labels .........         51 Note
PLAT793_ALERT_4_G Model has Chirality at C007       (Centro SPGR)          S Verify
PLAT793_ALERT_4_G Model has Chirality at C008       (Centro SPGR)          R Verify
PLAT793_ALERT_4_G Model has Chirality at C00B       (Centro SPGR)          R Verify
PLAT941_ALERT_3_G Average HKL Measurement Multiplicity ..........        3.2 Low
```

```
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