



Supporting Information

for

Bifunctional thiourea-catalyzed asymmetric [3 + 2] annulation reactions of 2-isothiocyanato-1-indanones with barbiturate-based olefins

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Characterization data, copies of NMR spectra, and HPLC chromatograms of products

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1. Characterization data of compounds **3**

(2*S*,3'*S*)-1'',3''-Dimethyl-3'-phenyl-5'-thioxo-2''*H*-dispiro[indene-2,2'-pyrrolidine-4',5''-pyrimidine]-1,2'',4'',6''(1''*H*,3*H*,3''*H*)-tetraone (3aa). From **1a** (22.7 mg, 0.12 mmol) and **2a** (24.4 mg, 0.10 mmol), purified by silica gel (200–300 mesh) column chromatography using dichloromethane/ethyl acetate/petroleum ether 1:1:5 as eluent to obtain 35.1 mg (81% yield) of compound **3aa** as a white solid; m.p. 252–254 °C. HPLC (Daicel Chiralpak IB, *n*-hexane/2-propanol 90:10, flow rate 1.0 mL/min, detection at 254 nm): *t_R* = 15.4 min (major), *t_R* = 20.3 min (minor); 97% ee. $[\alpha]_{\text{D}}^{25} = +51.5^{\circ}$ (*c* = 1.60, THF). ¹H NMR (400 MHz, CDCl₃): δ 8.39 (s, 1H, NH), 7.85 (d, *J* = 7.6 Hz, 1H, ArH), 7.64 (t, *J* = 7.2 Hz, 1H, ArH), 7.41 (t, *J* = 7.6 Hz, 2H, ArH), 7.19–7.12 (m, 3H, ArH), 6.82 (d, *J* = 7.2 Hz, 2H, ArH), 5.51 (s, 1H, CH), 4.02 (d, *J* = 18.8 Hz, 1H, CH₂), 3.57 (d, *J* = 18.8 Hz, 1H, CH₂), 3.38 (s, 3H, CH₃), 3.36 (s, 3H, CH₃) ppm. ¹³C NMR (100 MHz, CDCl₃): δ 200.7, 195.7, 165.55, 165.49, 152.4, 150.6, 136.9, 133.8, 132.0, 129.1, 128.3, 128.24, 128.20, 126.6, 125.2, 75.4, 73.0, 55.1, 37.8, 29.7, 29.2 ppm. HRMS (ESI): *m/z* calcd. for C₂₃H₂₀N₃O₄S [M + H]⁺ 434.1169, found 434.1169.

(2*S*,3'*S*)-1'',3'',6-Trimethyl-3'-phenyl-5'-thioxo-2''*H*-dispiro[indene-2,2'-pyrrolidine-4',5''-pyrimidine]-1,2'',4'',6''(1''*H*,3*H*,3''*H*)-tetraone (3ba). From **1b** (24.4 mg, 0.12 mmol) and **2a** (24.4 mg, 0.10 mmol), purified by silica gel (200–300 mesh) column chromatography using dichloromethane/ethyl acetate/petroleum ether 1:1:5 as eluent to obtain 39.9 mg (89% yield) of compound **3ba** as a white solid; m.p. 236–238 °C. HPLC (Daicel Chiralpak ADH,

n-hexane/2-propanol 70:30, flow rate 1.0 mL/min, detection at 254 nm): t_R = 9.3 min (minor), t_R = 14.2 min (major); 88% ee. $[\alpha]_D^{25}$ = +58.7° (c = 0.98, THF). ^1H NMR (400 MHz, CDCl_3): δ 8.42 (s, 1H, NH), 7.65 (s, 1H, ArH), 7.45 (dd, J_1 = 7.8 Hz, J_2 = 1.0 Hz, 1H, ArH), 7.28 (d, J = 8.0 Hz, 1H, ArH), 7.19–7.11 (m, 3H, ArH), 6.81–6.79 (m, 2H, ArH), 5.50 (s, 1H, CH), 3.96 (d, J = 18.4 Hz, 1H, CH_2), 3.50 (d, J = 18.8 Hz, 1H, CH_2), 3.37 (s, 3H, CH_3), 3.36 (s, 3H, CH_3), 2.40 (s, 3H, CH_3) ppm. ^{13}C NMR (100 MHz, CDCl_3): δ 200.8, 195.6, 165.6, 165.5, 150.6, 149.9, 138.5, 138.2, 134.0, 132.1, 129.0, 128.15, 128.09, 126.3, 125.0, 75.7, 73.1, 55.0, 37.5, 29.7, 29.2, 21.1 ppm. HRMS (ESI): m/z calcd. for $\text{C}_{24}\text{H}_{22}\text{N}_3\text{O}_4\text{S}$ $[\text{M} + \text{H}]^+$ 448.1326, found 448.1314.

(2*S*,3'*S*)-6-Methoxy-1'',3''-dimethyl-3'-phenyl-5'-thioxo-2''*H*-dispiro[indene-2,2'-pyrrolidine-4',5''-pyrimidine]-1,2'',4'',6''(1''*H*,3*H*,3''*H*)-tetraone (3ca). From **1c** (26.3 mg, 0.12 mmol) and **2a** (24.4 mg, 0.10 mmol), purified by silica gel (200–300 mesh) column chromatography using dichloromethane/ethyl acetate/petroleum ether 1:1:5 as eluent to obtain 23.1 mg (50% yield) compound **3ca** as a white solid; m.p. 242–244 °C. HPLC (Daicel Chiralpak ADH, *n*-hexane/2-propanol 70:30, flow rate 1.0 mL/min, detection at 254 nm): t_R = 12.1 min (minor), t_R = 26.3 min (major); 56% ee. $[\alpha]_D^{25}$ = +37.5° (c = 0.73, THF). ^1H NMR (400 MHz, CDCl_3): δ 8.19 (s, 1H, NH), 7.29–7.26 (m, 2H, ArH), 7.23 (dd, J_1 = 8.2 Hz, J_2 = 2.6 Hz, 1H, ArH), 7.18–7.12 (m, 3H, ArH), 6.82–6.80 (m, 2H, ArH), 5.52 (s, 1H, CH), 3.95 (d, J = 18.4 Hz, 1H, CH_2), 3.85 (s, 3H, OCH_3), 3.47 (d, J = 18.8 Hz, 1H, CH_2), 3.39 (s, 3H, CH_3), 3.38 (s, 3H, CH_3) ppm. ^{13}C NMR (100 MHz, CDCl_3): δ 200.7, 195.7, 165.6, 165.4, 160.0, 150.6, 145.5, 134.9, 132.1, 129.1, 128.2, 128.1, 127.4, 126.6, 105.9, 76.0, 73.0, 55.7, 55.1, 37.3, 29.7, 29.3 ppm. HRMS (ESI): m/z calcd. for $\text{C}_{24}\text{H}_{22}\text{N}_3\text{O}_5\text{S}$ $[\text{M} + \text{H}]^+$ 464.1275, found 464.1266.

(2*S*,3'*S*)-5-Methoxy-1'',3''-dimethyl-3'-phenyl-5'-thioxo-2''*H*-dispiro[indene-2,2'-pyrrolidine-4',5''-pyrimidine]-1,2'',4'',6''(1''*H*,3*H*,3''*H*)-tetraone (3da). From **1d** (26.3 mg, 0.12 mmol) and **2a** (24.4 mg, 0.10 mmol), purified by silica gel (200–300 mesh) column chromatography using dichloromethane/ethyl acetate/petroleum ether 1:1:5 as eluent to obtain 37.2 mg (80% yield) compound **3da** as a white solid, m.p. 225–227 °C. HPLC (Daicel Chiralpak ADH, *n*-hexane/2-propanol 70:30, flow rate 1.0 mL/min, detection at 254 nm): t_R = 12.0 min (minor), t_R = 26.1 min (major); 82% ee. $[\alpha]_D^{25}$ = +58.5° (c = 0.90, THF). ^1H NMR (400 MHz, CDCl_3): δ 8.49 (s, 1H, NH), 7.29–7.25 (m, 2H, ArH), 7.22 (dd, J_1 = 8.2 Hz, J_2 = 2.6 Hz, 1H, ArH), 7.17–7.12

(m, 3H, ArH), 6.80 (d, $J = 7.2$ Hz, 2H, ArH), 5.49 (s, 1H, CH), 3.94 (d, $J = 18.4$ Hz, 1H, CH₂), 3.85 (s, 3H, OCH₃), 3.47 (d, $J = 18.8$ Hz, 1H, CH₂), 3.38 (s, 3H, CH₃), 3.36 (s, 3H, CH₃) ppm. ¹³C NMR (100 MHz, CDCl₃): δ 200.9, 195.6, 165.6, 165.4, 159.9, 150.6, 145.5, 134.9, 132.0, 129.1, 128.2, 128.0, 127.4, 126.6, 105.9, 76.0, 73.0, 55.7, 55.2, 37.2, 29.7, 29.3 ppm. HRMS (ESI): m/z calcd. for C₂₄H₂₂N₃O₅S [M + H]⁺ 464.1275, found 464.1260.

(2S,3'S)-5-Fluoro-1'',3''-dimethyl-3'-phenyl-5'-thioxo-2''H-dispiro[indene-2,2'-pyrrolidine-4',5''-pyrimidine]-1,2'',4'',6''(1''H,3H,3''H)-tetraone (3ea). From **1e** (24.9 mg, 0.12 mmol) and **2a** (24.4 mg, 0.10 mmol), purified by silica gel (200–300 mesh) column chromatography using dichloromethane/ethyl acetate/petroleum ether 1:1:5 as eluent to obtain 36.2 mg (80% yield) compound **3ea** as a white solid, m.p. 236–238 °C. HPLC (Daicel Chiralpak ADH, *n*-hexane/2-propanol 70:30, flow rate 1.0 mL/min, detection at 254 nm): $t_R = 13.6$ min (major), $t_R = 17.7$ min (minor); 84% ee. $[\alpha]_D^{25} = +59.6^\circ$ ($c = 0.90$, THF). ¹H NMR (400 MHz, CDCl₃): δ 8.61 (s, 1H, NH), 7.81 (dd, $J_1 = 8.4$ Hz, $J_2 = 5.2$ Hz, 1H, ArH), 7.21–7.05 (m, 5H, ArH), 6.81 (d, $J = 7.2$ Hz, 2H, ArH), 5.45 (s, 1H, CH), 4.02 (d, $J = 19.2$ Hz, 1H, CH₂), 3.57 (d, $J = 19.2$ Hz, 1H, CH₂), 3.37 (s, 3H, CH₃), 3.36 (s, 3H, CH₃) ppm. ¹³C NMR (100 MHz, CDCl₃): δ 199.1, 195.7, 168.4 (d, $^1J_{C-F} = 258.7$ Hz), 165.5, 155.5 (d, $^3J_{C-F} = 10.5$ Hz), 150.5, 131.7, 130.3 (d, $^4J_{C-F} = 1.3$ Hz), 129.1, 128.4, 128.1, 127.8 (d, $^3J_{C-F} = 10.8$ Hz), 116.9 (d, $^2J_{C-F} = 23.6$ Hz), 113.4 (d, $^2J_{C-F} = 22.4$ Hz), 75.6, 73.0, 55.3, 37.7, 29.7, 29.3 ppm. HRMS (ESI): m/z calcd. for C₂₃H₁₉FN₃O₄S [M + H]⁺ 452.1075, found 452.1069.

(2S,3'S)-5-Bromo-1'',3''-dimethyl-3'-phenyl-5'-thioxo-2''H-dispiro[indene-2,2'-pyrrolidine-4',5''-pyrimidine]-1,2'',4'',6''(1''H,3H,3''H)-tetraone (3fa). From **1f** (32.2 mg, 0.12 mmol) and **2a** (24.4 mg, 0.10 mmol), purified by silica gel (200–300 mesh) column chromatography using dichloromethane/ethyl acetate/petroleum ether 1:1:5 as eluent to obtain 35.0 mg (68% yield) compound **3fa** as a white solid, m.p. 235–237 °C. HPLC (Daicel Chiralpak ADH, *n*-hexane/2-propanol 70:30, flow rate 1.0 mL/min, detection at 254 nm): $t_R = 14.3$ min (major), $t_R = 18.8$ min (minor); 56% ee. $[\alpha]_D^{25} = +29.9^\circ$ ($c = 0.95$, THF). ¹H NMR (400 MHz, CDCl₃): δ 8.76 (s, 1H, NH), 7.70 (d, $J = 8.0$ Hz, 1H, ArH), 7.57 (s, 1H, ArH), 7.54 (d, $J = 8.0$ Hz, 1H, ArH), 7.22–7.13 (m, 3H, ArH), 6.80 (d, $J = 7.2$ Hz, 2H, ArH), 5.45 (s, 1H, CH), 4.01 (d, $J = 19.2$ Hz, 1H, CH₂), 3.55 (d, $J = 18.8$ Hz, 1H, CH₂), 3.37 (s, 3H, CH₃), 3.36 (s, 3H, CH₃) ppm. ¹³C NMR

(100 MHz, CDCl₃): δ 200.0, 195.8, 165.51, 165.49, 153.9, 150.5, 132.7, 132.6, 132.1, 131.7, 129.9, 129.2, 128.4, 128.1, 126.3, 75.3, 73.0, 55.3, 37.5, 29.7, 29.3 ppm. HRMS (ESI): m/z calcd. for C₂₃H₁₉⁷⁹BrN₃O₄S [M + H]⁺ 512.0274, found 512.0270; calcd. for C₂₃H₁₉⁸¹BrN₃O₄S [M + H]⁺ 514.0254, found 514.0252.

(2S,3'S)-5,6-Dimethoxy-1'',3''-dimethyl-3'-phenyl-5'-thioxo-2''H-dispiro[indene-2,2'-pyrrolidine-4',5''-pyrimidine]-1,2'',4'',6''(1''H,3H,3''H)-tetraone (3ga). From **1g** (29.9 mg, 0.12 mmol) and **2a** (24.4 mg, 0.10 mmol), purified by silica gel (200–300 mesh) column chromatography using dichloromethane/ethyl acetate/petroleum ether 1:1:2 as eluent to obtain 25.2 mg (51% yield) compound **3ga** as a white solid, m.p. 261–263 °C. HPLC (Daicel Chiralpak ADH, *n*-hexane/2-propanol 70:30, flow rate 1.0 mL/min, detection at 254 nm): t_R = 23.8 min (minor), t_R = 47.2 min (major); 47% ee. $[\alpha]_D^{25}$ = +33.9° (c = 0.63, THF). ¹H NMR (400 MHz, CDCl₃): δ 8.54 (d, J = 4.0 Hz, 1H, NH), 7.21 (s, 1H, ArH), 7.19–7.13 (m, 3H, ArH), 6.80–6.78 (m, 2H, ArH), 6.76 (s, 1H, ArH), 5.53 (s, 1H, CH), 3.93 (s, 3H, OCH₃), 3.91 (s, 3H, OCH₃), 3.89 (d, J = 19.2 Hz, 1H, CH₂), 3.43 (d, J = 19.2 Hz, 1H, CH₂), 3.40 (s, 3H, CH₃), 3.38 (s, 3H, CH₃) ppm. ¹³C NMR (176 MHz, CDCl₃): δ 198.7, 195.5, 165.7, 165.5, 157.2, 150.6, 150.0, 148.5, 132.3, 129.1, 128.1, 127.9, 126.5, 107.2, 105.1, 75.7, 73.0, 56.4, 56.2, 54.7, 37.7, 29.7, 29.3 ppm. HRMS (ESI): m/z calcd. for C₂₅H₂₄N₃O₆S [M + H]⁺ 494.1380, found 494.1381.

(2S,3'S)-3'-(4-Fluorophenyl)-1'',3''-dimethyl-5'-thioxo-2''H-dispiro[indene-2,2'-pyrrolidine-4',5''-pyrimidine]-1,2'',4'',6''(1''H,3H,3''H)-tetraone (3ab). From **1a** (22.7 mg, 0.12 mmol) and **2a** (26.2 mg, 0.10 mmol), purified by silica gel (200–300 mesh) column chromatography using dichloromethane/ethyl acetate/petroleum ether 1:1:5 as eluent to obtain 43.9 mg (97% yield) compound **3ab** as a white solid, m.p. 241–243 °C. HPLC (Daicel Chiralpak IC, *n*-hexane/2-propanol 70:30, flow rate 1.0 mL/min, detection at 254 nm): t_R = 13.5 min (major), t_R = 22.6 min (minor); 95% ee. $[\alpha]_D^{25}$ = +67.2° (c = 0.95, THF). ¹H NMR (400 MHz, DMSO): δ 11.57 (s, 1H, NH), 7.87 (d, J = 7.6 Hz, 1H, ArH), 7.64 (td, J_1 = 7.6 Hz, J_2 = 0.8 Hz, 1H, ArH), 7.60 (d, J = 7.6 Hz, 1H, ArH), 7.54 (t, J = 7.4 Hz, 1H, ArH), 7.03–6.98 (m, 2H, ArH), 6.77–6.73 (m, 2H, ArH), 5.30 (s, 1H, CH), 3.84 (d, J = 19.6 Hz, 1H, CH₂), 3.37 (d, J = 19.6 Hz, 1H, CH₂), 3.29 (s, 3H, CH₃), 3.27 (s, 3H, CH₃) ppm. ¹³C NMR (100 MHz, DMSO): δ 201.9, 193.3, 165.2, 164.4, 161.2 (d, ¹ J_{C-F} = 243.9 Hz), 152.6, 150.3, 137.1, 133.6, 129.4 (d, ³ J_{C-F} = 8.1 Hz), 128.42 (d,

$^4J_{\text{C-F}} = 3.3$ Hz), 128.38, 126.9, 124.4, 115.8 (d, $^2J_{\text{C-F}} = 21.3$ Hz), 74.5, 73.1, 52.8, 37.6, 29.3, 28.9 ppm. HRMS (ESI): m/z calcd. for $\text{C}_{23}\text{H}_{19}\text{FN}_3\text{O}_4\text{S}$ [$\text{M} + \text{H}$] $^+$ 452.1075, found 452.1069.

(2*S*,3'*S*)-3'-(4-Chlorophenyl)-1'',3''-dimethyl-5'-thioxo-2''*H*-dispiro[indene-2,2'-pyrrolidine-4',5''-pyrimidine]-1,2'',4'',6''(1''*H*,3*H*,3''*H*)-tetraone (3ac). From **1a** (22.7 mg, 0.12 mmol) and **2c** (27.9 mg, 0.10 mmol), purified by silica gel (200–300 mesh) column chromatography using dichloromethane/ethyl acetate/petroleum ether 1:1:5 as eluent to obtain 43.0 mg (92% yield) compound **3ac** as a white solid, m.p. 237–239 °C. HPLC (Daicel Chiralpak IC, *n*-hexane/2-propanol = 85:15, flow rate 1.0 mL/min, detection at 254 nm): $t_{\text{R}} = 30.9$ min (major), $t_{\text{R}} = 37.9$ min (minor); 96% ee. $[\alpha]_{\text{D}}^{25} = +84.1^\circ$ ($c = 2.35$, THF). ^1H NMR (400 MHz, CDCl_3): δ 8.30 (s, 1H, NH), 7.84 (d, $J = 7.6$ Hz, 1H, ArH), 7.67–7.63 (m, 1H, ArH), 7.42 (t, $J = 7.4$ Hz, 2H, ArH), 7.12 (d, $J = 8.4$ Hz, 2H, ArH), 6.84 (d, $J = 8.4$ Hz, 2H, ArH), 5.48 (s, 1H, CH), 4.00 (d, $J = 18.8$ Hz, 1H, CH_2), 3.58 (d, $J = 19.2$ Hz, 1H, CH_2), 3.374 (s, 3H, CH_3), 3.365 (s, 3H, CH_3) ppm. ^{13}C NMR (100 MHz, CDCl_3): δ 200.5, 195.4, 165.26, 165.25, 152.2, 150.4, 137.1, 134.5, 133.7, 130.4, 130.0, 129.3, 128.5, 126.7, 125.2, 75.2, 73.2, 54.2, 37.8, 29.8, 29.3 ppm. HRMS (ESI): m/z calcd. for $\text{C}_{23}\text{H}_{19}\text{ClN}_3\text{O}_4\text{S}$ [$\text{M} + \text{H}$] $^+$ 468.0779, found 468.0781.

(2*S*,3'*S*)-3'-(4-Bromophenyl)-1'',3''-dimethyl-5'-thioxo-2''*H*-dispiro[indene-2,2'-pyrrolidine-4',5''-pyrimidine]-1,2'',4'',6''(1''*H*,3*H*,3''*H*)-tetraone (3ad). From **1a** (22.7 mg, 0.12 mmol) and **2d** (32.3 mg, 0.10 mmol), purified by silica gel (200–300 mesh) column chromatography using dichloromethane/ethyl acetate/petroleum ether 1:1:5 as eluent to obtain 46.3 mg (90% yield) compound **3ad** as a white solid, m.p. 236–238 °C. HPLC (Daicel Chiralpak IC, *n*-hexane/2-propanol 70:30, flow rate 1.0 mL/min, detection at 254 nm): $t_{\text{R}} = 11.8$ min (minor), $t_{\text{R}} = 13.9$ min (major); 84% ee. $[\alpha]_{\text{D}}^{25} = +53.5^\circ$ ($c = 0.65$, THF). ^1H NMR (400 MHz, CDCl_3): δ 8.23 (s, 1H, NH), 7.84 (d, $J = 7.6$ Hz, 1H, ArH), 7.68–7.64 (m, 1H, ArH), 7.42 (t, $J = 7.6$ Hz, 2H, ArH), 7.28 (d, $J = 8.8$ Hz, 2H, ArH), 6.78 (d, $J = 8.4$ Hz, 2H, ArH), 5.48 (s, 1H, CH), 4.00 (d, $J = 18.8$ Hz, 1H, CH_2), 3.57 (d, $J = 18.8$ Hz, 1H, CH_2), 3.38 (s, 3H, CH_3), 3.37 (s, 3H, CH_3) ppm. ^{13}C NMR (100 MHz, CDCl_3): δ 200.5, 195.3, 165.23, 165.22, 152.1, 150.4, 137.1, 133.7, 132.3, 131.0, 130.2, 128.5, 126.7, 125.3, 122.7, 75.1, 73.1, 54.1, 37.8, 29.8, 29.3 ppm. HRMS (ESI): m/z calcd. for $\text{C}_{23}\text{H}_{19}^{79}\text{BrN}_3\text{O}_4\text{S}$ [$\text{M} + \text{H}$] $^+$ 512.0274, found 512.0290; calcd. for $\text{C}_{23}\text{H}_{19}^{81}\text{BrN}_3\text{O}_4\text{S}$ [$\text{M} + \text{H}$] $^+$ 514.0254, found 514.0271.

(2*S*,3'*S*)-1'',3''-Dimethyl-3'-(4-nitrophenyl)-5'-thioxo-2''*H*-dispiro[indene-2,2'-pyrrolidine-4',5''-pyrimidine]-1,2'',4'',6''(1''*H*,3*H*,3''*H*)-tetraone (3ae). From **1a** (22.7 mg, 0.12 mmol) and **2e** (28.9 mg, 0.10 mmol), purified by silica gel (200–300 mesh) column chromatography using dichloromethane/ethyl acetate/petroleum ether 1:1:5 as eluent to obtain 22.9 mg (48% yield) compound **3ae** as a white solid, m.p. 240–242 °C. HPLC (Daicel Chiralpak ADH, *n*-hexane/2-propanol = 85:15, flow rate 1.0 mL/min, detection at 254 nm): *t_R* = 37.4 min (minor), *t_R* = 47.3 min (major); 89% ee. $[\alpha]_{\text{D}}^{25} = +38.4^{\circ}$ (*c* = 1.15, THF). ¹H NMR (400 MHz, DMSO): δ 11.68 (s, 1H, NH), 8.02 (d, *J* = 8.8 Hz, 2H, ArH), 7.93 (d, *J* = 7.6 Hz, 1H, ArH), 7.83 (td, *J*₁ = 7.6 Hz, *J*₂ = 0.8 Hz, 1H, ArH), 7.64 (d, *J* = 7.6 Hz, 1H, ArH), 7.58 (t, *J* = 7.4 Hz, 1H, ArH), 6.96 (d, *J* = 8.4 Hz, 2H, ArH), 5.48 (s, 1H, CH), 3.79 (d, *J* = 19.2 Hz, 1H, CH₂), 3.39 (d, *J* = 19.6 Hz, 1H, CH₂), 3.33 (s, 3H, CH₃), 3.28 (s, 3H, CH₃) ppm. ¹³C NMR (100 MHz, DMSO): δ 201.5, 192.5, 165.0, 164.1, 152.6, 150.4, 146.5, 140.0, 137.2, 133.5, 128.6, 127.0, 124.7, 124.0, 74.2, 72.9, 52.3, 37.8, 29.4, 29.0 ppm. HRMS (ESI): *m/z* calcd. for C₂₃H₁₉N₄O₆S [M + H]⁺ 479.1020, found 479.1026.

(2*S*,3'*S*)-3'-(4-Methoxyphenyl)-1'',3''-dimethyl-5'-thioxo-2''*H*-dispiro[indene-2,2'-pyrrolidine-4',5''-pyrimidine]-1,2'',4'',6''(1''*H*,3*H*,3''*H*)-tetraone (3af). From **1a** (22.7 mg, 0.12 mmol) and **2f** (27.4 mg, 0.10 mmol), purified by silica gel (200–300 mesh) column chromatography using dichloromethane/ethyl acetate/petroleum ether 1:1:5 as eluent to obtain 45.8 mg (99% yield) compound **3af** as a white solid, m.p. 239–241 °C. HPLC (Daicel Chiralpak IB, *n*-hexane/2-propanol 70:30, flow rate 1.0 mL/min, detection at 254 nm): *t_R* = 7.8 min (major), *t_R* = 9.7 min (minor); 96% ee. $[\alpha]_{\text{D}}^{25} = +72.3^{\circ}$ (*c* = 0.68, THF). ¹H NMR (400 MHz, CDCl₃): δ 8.58 (s, 1H, NH), 7.80 (d, *J* = 8.0 Hz, 1H, ArH), 7.61 (t, *J* = 7.2 Hz, 1H, ArH), 7.39–7.35 (m, 2H, ArH), 6.86 (d, *J* = 8.8 Hz, 2H, ArH), 6.65 (d, *J* = 8.8 Hz, 2H, ArH), 5.36 (s, 1H, CH), 4.03 (d, *J* = 18.8 Hz, 1H, CH₂), 3.67 (s, 3H, OCH₃), 3.59 (d, *J* = 18.8 Hz, 1H, CH₂), 3.34 (s, 3H, CH₃), 3.33 (s, 3H, CH₃) ppm. ¹³C NMR (100 MHz, CDCl₃): δ 200.8, 196.1, 165.77, 165.76, 159.5, 152.3, 150.5, 136.8, 133.8, 130.0, 128.2, 126.6, 125.0, 123.3, 114.4, 75.7, 73.4, 55.4, 55.1, 37.5, 29.6, 29.2 ppm. HRMS (ESI): *m/z* calcd. for C₂₄H₂₂N₃O₅S [M + H]⁺ 464.1275, found 464.1274.

(2*S*,3'*S*)-3'-(3-Bromophenyl)-1'',3''-dimethyl-5'-thioxo-2''*H*-dispiro[indene-2,2'-pyrrolidine-4',5''-pyrimidine]-1,2'',4'',6''(1''*H*,3*H*,3''*H*)-tetraone (3ag). From **1a** (22.7 mg, 0.12 mmol) and **2g** (32.3 mg, 0.10 mmol), purified by silica gel (200–300 mesh) column chromatography using dichloromethane/ethyl acetate/petroleum ether 1:1:5 as eluent to obtain 47.1 mg (92% yield) compound **3ag** as a white solid, m.p. 236–238 °C. HPLC (Daicel Chiralpak IC, *n*-hexane/2-propanol 70:30, flow rate 1.0 mL/min, detection at 254 nm): *t*_R = 11.6 min (major), *t*_R = 20.7 min (minor); 99% ee. [α]_D²⁵ = +56.7° (*c* = 1.23, THF). ¹H NMR (400 MHz, CDCl₃): δ 8.53 (s, 1H, NH), 7.84 (d, *J* = 7.6 Hz, 1H, ArH), 7.67–7.63 (m, 1H, ArH), 7.41 (t, *J* = 7.0 Hz, 2H, ArH), 7.31 (d, *J* = 8.0 Hz, 1H, ArH), 7.05–7.00 (m, 2H, ArH), 6.83 (d, *J* = 7.6 Hz, 1H, ArH), 5.43 (s, 1H, CH), 3.99 (d, *J* = 18.8 Hz, 1H, CH₂), 3.59 (d, *J* = 18.8 Hz, 1H, CH₂), 3.36 (s, 6H, CH₃) ppm. ¹³C NMR (100 MHz, CDCl₃): δ 200.5, 195.2, 165.28, 165.26, 152.1, 150.4, 137.0, 134.1, 133.7, 131.61, 131.58, 130.5, 128.5, 127.4, 126.6, 125.2, 123.0, 75.3, 73.1, 54.4, 37.7, 29.7, 29.3 ppm. HRMS (ESI): *m/z* calcd. for C₂₃H₁₉⁷⁹BrN₃O₄S [M + H]⁺ 512.0274, found 512.0291; calcd. for C₂₃H₁₉⁸¹BrN₃O₄S [M + H]⁺ 514.0254, found 514.0275.

(2*S*,3'*S*)-1'',3''-Dimethyl-5'-thioxo-3'-(*m*-tolyl)-2''*H*-dispiro[indene-2,2'-pyrrolidine-4',5''-pyrimidine]-1,2'',4'',6''(1''*H*,3*H*,3''*H*)-tetraone (3ah). From **1a** (22.7 mg, 0.12 mmol) and **2h** (25.8 mg, 0.10 mmol), purified by silica gel (200–300 mesh) column chromatography using dichloromethane/ethyl acetate/petroleum ether 1:1:5 as eluent to obtain 44.6 mg (>99% yield) compound **3ah** as a white solid, m.p. 235–237 °C. HPLC (Daicel Chiralpak IC, *n*-hexane/2-propanol 70:30, flow rate 1.0 mL/min, detection at 254 nm): *t*_R = 17.4 min (major), *t*_R = 57.8 min (minor); >99% ee. [α]_D²⁵ = +63.1° (*c* = 3.87, THF). ¹H NMR (400 MHz, CDCl₃): δ 8.92 (s, 1H, NH), 7.83 (d, *J* = 8.0 Hz, 1H, ArH), 7.61 (t, *J* = 7.4 Hz, 1H, ArH), 7.38 (t, *J* = 7.4 Hz, 2H, ArH), 7.03 (t, *J* = 7.6 Hz, 1H, ArH), 6.97 (d, *J* = 7.6 Hz, 1H, ArH), 6.67 (d, *J* = 7.6 Hz, 1H, ArH), 6.61 (s, 1H, ArH), 5.38 (s, 1H, CH), 4.01 (d, *J* = 18.8 Hz, 1H, CH₂), 3.59 (d, *J* = 18.8 Hz, 1H, CH₂), 3.329 (s, 3H, CH₃), 3.326 (s, 3H, CH₃), 2.11 (s, 3H, CH₃) ppm. ¹³C NMR (100 MHz, CDCl₃): δ 201.0, 195.8, 165.71, 165.66, 152.4, 150.5, 138.7, 136.8, 133.8, 131.5, 129.3, 129.1, 128.8, 128.2, 126.5, 125.12, 125.05, 75.6, 73.1, 55.7, 37.6, 29.6, 29.1, 21.3 ppm. HRMS (ESI): *m/z* calcd. for C₂₄H₂₂N₃O₄S [M + H]⁺ 448.1326, found 448.1325.

(2*S*,3'*S*)-3'-(3-Methoxyphenyl)-1'',3''-dimethyl-5'-thioxo-2''*H*-dispiro[indene-2,2'-pyrrolidine-4',5''-pyrimidine]-1,2'',4'',6''(1''*H*,3*H*,3''*H*)-tetraone (3ai). From **1a** (22.7 mg, 0.12 mmol) and **2i** (27.4 mg, 0.10 mmol), purified by silica gel (200–300 mesh) column chromatography using dichloromethane/ethyl acetate/petroleum ether 1:1:5 as eluent to obtain 46.2 mg (>99% yield) compound **3ai** as a white solid, m.p. 242–244 °C. HPLC (Daicel Chiralpak ADH, *n*-hexane/2-propanol 70:30, flow rate 1.0 mL/min, detection at 254 nm): *t_R* = 11.3 min (major), *t_R* = 17.6 min (minor); 93% ee. $[\alpha]_{\text{D}}^{25} = +54.3^{\circ}$ (*c* = 1.23, THF). ¹H NMR (400 MHz, CDCl₃): δ 8.61 (s, 1H, NH), 7.85 (d, *J* = 7.2 Hz, 1H, ArH), 7.64 (td, *J*₁ = 7.6 Hz, *J*₂ = 0.8 Hz, 1H, ArH), 7.41 (t, *J* = 7.4 Hz, 2H, ArH), 7.05 (t, *J* = 8.0 Hz, 1H, ArH), 6.68 (dd, *J*₁ = 8.0 Hz, *J*₂ = 2.4 Hz, 1H, ArH), 6.35 (dt, *J*₁ = 7.6 Hz, *J*₂ = 0.8 Hz, 1H, ArH), 6.28–6.27 (m, 1H, ArH), 5.46 (s, 1H, CH), 4.03 (d, *J* = 19.2 Hz, 1H, CH₂), 3.56 (d, *J* = 19.2 Hz, 1H, CH₂), 3.49 (s, 3H, OCH₃), 3.37 (s, 3H, CH₃), 3.36 (s, 3H, CH₃) ppm. ¹³C NMR (176 MHz, CDCl₃): δ 201.0, 195.6, 165.6, 165.4, 159.7, 152.6, 150.6, 136.9, 133.9, 133.4, 130.1, 128.3, 126.7, 125.1, 120.0, 113.8, 113.7, 75.3, 72.9, 55.2, 54.8, 37.9, 29.7, 29.2 ppm. HRMS (ESI): *m/z* calcd. for C₂₄H₂₂N₃O₅S [M + H]⁺ 464.1275, found 464.1267.

(2*S*,3'*S*)-3'-(3,4-Dimethoxyphenyl)-1'',3''-dimethyl-5'-thioxo-2''*H*-dispiro[indene-2,2'-pyrrolidine-4',5''-pyrimidine]-1,2'',4'',6''(1''*H*,3*H*,3''*H*)-tetraone (3aj). From **1a** (22.7 mg, 0.12 mmol) and **2j** (30.4 mg, 0.10 mmol), purified by silica gel (200–300 mesh) column chromatography using dichloromethane/ethyl acetate/petroleum ether 1:1:2 as eluent to obtain 47.8 mg (97% yield) compound **3aj** as a white solid, m.p. 201–203 °C. HPLC (Daicel Chiralpak IC, *n*-hexane/2-propanol 70:30, flow rate 1.0 mL/min, detection at 254 nm): *t_R* = 34.7 min (minor), *t_R* = 43.7 min (major); 94% ee. $[\alpha]_{\text{D}}^{25} = +57.8^{\circ}$ (*c* = 1.18, THF). ¹H NMR (400 MHz, CDCl₃): δ 8.74 (s, 1H, NH), 7.78 (d, *J* = 7.6 Hz, 1H, ArH), 7.63–7.59 (m, 1H, ArH), 7.37 (t, *J* = 7.2 Hz, 2H, ArH), 6.61 (d, *J* = 8.4 Hz, 1H, ArH), 6.42 (dd, *J*₁ = 8.4 Hz, *J*₂ = 2.0 Hz, 1H, ArH), 6.26 (d, *J* = 2.0 Hz, 1H, ArH), 5.36 (s, 1H, CH), 4.04 (d, *J* = 18.8 Hz, 1H, CH₂), 3.73 (s, 3H, OCH₃), 3.55 (d, *J* = 19.2 Hz, 1H, CH₂), 3.43 (s, 3H, OCH₃), 3.37 (s, 3H, CH₃), 3.36 (s, 3H, CH₃) ppm. ¹³C NMR (100 MHz, CDCl₃): δ 201.3, 196.0, 165.70, 165.66, 152.5, 150.5, 148.9, 148.8, 136.8, 133.9, 128.3, 126.6, 124.9, 123.9, 120.5, 111.6, 111.2, 75.4, 73.1, 55.70, 55.66, 55.3, 37.8, 29.7, 29.2 ppm. HRMS (ESI): *m/z* calcd. for C₂₅H₂₄N₃O₆S [M + H]⁺ 494.1380, found 494.1387.

(2*S*,3'*S*)-1'',3''-Dimethyl-5'-thioxo-3'-(*o*-tolyl)-2''*H*-dispiro[indene-2,2'-pyrrolidine-4',5''-pyrimidine]-1,2'',4'',6''(1''*H*,3*H*,3''*H*)-tetraone (3ak). From **1a** (22.7 mg, 0.12 mmol) and **2k** (25.8 mg, 0.10 mmol), purified by silica gel (200–300 mesh) column chromatography using dichloromethane/ethyl acetate/petroleum ether 1:1:5 as eluent to obtain 42.1 mg (94% yield) compound **3ak** as a white solid, m.p. 237–239 °C. HPLC (Daicel Chiralpak IB, *n*-hexane/2-propanol 70:30, flow rate 1.0 mL/min, detection at 254 nm): *t_R* = 8.9 min (major), *t_R* = 11.9 min (minor); 84% ee. $[\alpha]_{\text{D}}^{25} = +95.1^{\circ}$ (*c* = 1.15, THF). ¹H NMR (400 MHz, DMSO): δ 11.52 (s, 1H, NH), 7.69 (d, *J* = 7.6 Hz, 1H, ArH), 7.66–7.62 (m, 1H, ArH), 7.46 (d, *J* = 7.6 Hz, 1H, ArH), 7.42 (d, *J* = 7.6 Hz, 1H, ArH), 7.38 (t, *J* = 7.4 Hz, 1H, ArH), 7.14–7.10 (m, 1H, ArH), 7.05 (td, *J*₁ = 7.4 Hz, *J*₂ = 0.8 Hz, 1H, ArH), 6.99 (d, *J* = 7.2 Hz, 1H, ArH), 5.44 (s, 1H, CH), 4.13 (d, *J* = 18.8 Hz, 1H, CH₂), 3.47 (d, *J* = 18.8 Hz, 1H, CH₂), 3.26 (s, 3H, CH₃), 3.15 (s, 3H, CH₃), 2.09 (s, 3H, CH₃) ppm. ¹³C NMR (100 MHz, DMSO): δ 202.4, 195.4, 166.3, 166.1, 152.0, 149.6, 137.9, 136.8, 133.2, 131.1, 128.9, 128.5, 128.23, 128.16, 126.5, 126.3, 123.8, 75.4, 74.2, 51.2, 36.2, 29.0, 28.8, 19.2 ppm. HRMS (ESI): *m/z* calcd. for C₂₄H₂₂N₃O₄S [M + H]⁺ 448.1326, found 448.1337.

(2*S*,3'*R*)-3'-(2-Bromophenyl)-1'',3''-dimethyl-5'-thioxo-2''*H*-dispiro[indene-2,2'-pyrrolidine-4',5''-pyrimidine]-1,2'',4'',6''(1''*H*,3*H*,3''*H*)-tetraone (3al). From **1a** (22.7 mg, 0.12 mmol) and **2l** (32.3 mg, 0.10 mmol), purified by silica gel (200–300 mesh) column chromatography using dichloromethane/ethyl acetate/petroleum ether 1:1:5 as eluent to obtain 22.0 mg (43% yield) compound **3al** as a white solid, m.p. 242–244 °C. HPLC (Daicel Chiralpak ADH, *n*-hexane/2-propanol 70:30, flow rate 1.0 mL/min, detection at 254 nm): *t_R* = 12.2 min (minor), *t_R* = 14.7 min (major); 76% ee. $[\alpha]_{\text{D}}^{25} = +91.0^{\circ}$ (*c* = 0.90, THF). ¹H NMR (400 MHz, DMSO): δ 11.55 (s, 1H, NH), 7.68 (d, *J* = 7.6 Hz, 1H, ArH), 7.60–7.55 (m, 2H, ArH), 7.40–7.35 (m, 3H, ArH), 7.34–7.30 (m, 1H, ArH), 7.08 (td, *J*₁ = 7.6 Hz, *J*₂ = 1.2 Hz, 1H, ArH), 5.67 (s, 1H, CH), 4.06 (d, *J* = 18.4 Hz, 1H, CH₂), 3.38 (d, *J* = 18.4 Hz, 1H, CH₂), 3.25 (s, 3H, CH₃), 3.16 (s, 3H, CH₃) ppm. ¹³C NMR (100 MHz, DMSO): δ 201.2, 195.1, 165.8, 165.6, 150.8, 149.6, 136.4, 133.6, 133.4, 130.5, 130.0, 129.8, 128.1, 127.9, 126.23, 126.21, 123.8, 75.9, 73.9, 53.9, 35.8, 29.1, 28.8 ppm. HRMS (ESI): *m/z* calcd. for C₂₃H₁₉⁷⁹BrN₃O₄S [M + H]⁺ 512.0274, found 512.0271; calcd. for C₂₃H₁₉⁸¹BrN₃O₄S [M + H]⁺ 514.0254, found 514.0253.

(2S,3'S)-1'',3''-Dimethyl-3'-(naphthalen-1-yl)-5'-thioxo-2''H-dispiro[indene-2,2'-pyrrolidine-4',5''-pyrimidine]-1,2'',4'',6''(1''H,3H,3''H)-tetraone (3am). From **1a** (22.7 mg, 0.12 mmol) and **2m** (29.4 mg, 0.10 mmol), purified by silica gel (200–300 mesh) column chromatography using dichloromethane/ethyl acetate/petroleum ether (1:1:4) as eluent to obtain 33.1 mg (68% yield) compound **3am** as a white solid, m.p. 240–242 °C. HPLC (Daicel Chiralpak ADH, *n*-hexane/2-propanol = 85:15, flow rate 1.0 mL/min, detection at 254 nm): t_R = 26.9 min (minor), t_R = 30.9 min (major); 57% ee. $[\alpha]_D^{25}$ = +70.8° (c = 0.93, THF). ^1H NMR (400 MHz, DMSO): δ 11.63 (s, 1H, NH), 8.04 (d, J = 8.8 Hz, 1H, ArH), 7.76 (d, J = 8.0 Hz, 2H, ArH), 7.73 (d, J = 7.2 Hz, 1H, ArH), 7.56–7.51 (m, 2H, ArH), 7.49 (d, J = 7.6 Hz, 1H, ArH), 7.46–7.40 (m, 3H, ArH), 7.21 (t, J = 7.4 Hz, 1H, ArH), 6.15 (s, 1H, CH), 4.18 (d, J = 18.8 Hz, 1H, CH₂), 3.53 (d, J = 18.4 Hz, 1H, CH₂), 3.32 (s, 3H, CH₃), 3.02 (s, 3H, CH₃) ppm. ^{13}C NMR (100 MHz, DMSO): δ 202.1, 195.3, 166.1, 166.0, 151.9, 149.7, 136.6, 133.4, 133.2, 131.7, 129.4, 128.8, 127.9, 127.1, 126.9, 126.6, 126.4, 125.8, 125.0, 123.8, 121.8, 75.4, 74.5, 48.8, 36.6, 29.0, 28.9 ppm. HRMS (ESI): m/z calcd. for C₂₇H₂₂N₃O₄S [M + H]⁺ 484.1326, found 484.1337.

(2S,3'S)-3'-(Furan-2-yl)-1'',3''-dimethyl-5'-thioxo-2''H-dispiro[indene-2,2'-pyrrolidine-4',5''-pyrimidine]-1,2'',4'',6''(1''H,3H,3''H)-tetraone (3an). From **1a** (22.7 mg, 0.12 mmol) and **2n** (23.4 mg, 0.10 mmol), purified by silica gel (200–300 mesh) column chromatography using dichloromethane/ethyl acetate/petroleum ether (1:1:4) as eluent to obtain 38.9 mg (92% yield) compound **3an** as a white solid, m.p. 245–247 °C. HPLC (Daicel Chiralpak IC, *n*-hexane/2-propanol = 65:35, flow rate 1.0 mL/min, detection at 254 nm): t_R = 12.1 min (major), t_R = 26.7 min (minor); 97% ee. $[\alpha]_D^{25}$ = +65.6° (c = 1.08, THF). ^1H NMR (400 MHz, CDCl₃): δ 8.28 (s, 1H, NH), 7.86 (d, J = 7.2 Hz, 1H, ArH), 7.71–7.67 (m, 1H, ArH), 7.45 (t, J = 7.2 Hz, 2H, ArH), 7.14 (d, J = 1.6 Hz, 1H, ArH), 6.13 (dd, J_1 = 3.2 Hz, J_2 = 2.0 Hz, 1H, ArH), 5.66 (d, J = 3.2 Hz, 1H, ArH), 5.38 (s, 1H, CH), 4.18 (d, J = 19.2 Hz, 1H, CH₂), 3.48 (d, J = 19.2 Hz, 1H, CH₂), 3.42 (s, 3H, CH₃), 3.36 (s, 3H, CH₃) ppm. ^{13}C NMR (100 MHz, CDCl₃): δ 200.8, 195.5, 165.5, 164.8, 152.3, 150.7, 146.0, 142.6, 137.0, 133.7, 128.4, 126.5, 125.2, 110.8, 108.7, 74.4, 71.9, 50.4, 38.0, 29.8, 29.3 ppm. HRMS (ESI): m/z calcd. for C₂₁H₁₈N₃O₅S [M + H]⁺ 424.0962, found 424.0969.

(2*S*,3'*S*)-1'',3''-Dimethyl-3'-(thiophen-2-yl)-5'-thioxo-2''*H*-dispiro[indene-2,2'-pyrrolidine-4',5''-pyrimidine]-1,2'',4'',6''(1''*H*,3*H*,3''*H*)-tetraone (3ao). From **1a** (22.7 mg, 0.12 mmol) and **2o** (25.0 mg, 0.10 mmol), purified by silica gel (200–300 mesh) column chromatography using dichloromethane/ethyl acetate/petroleum ether (1:1:4) as eluent to obtain 36.0 mg (82% yield) compound **3ao** as a white solid, m.p. 232–234 °C. HPLC (Daicel Chiralpak IB, *n*-hexane/2-propanol = 90:10, flow rate 1.0 mL/min, detection at 254 nm): *t_R* = 17.2 min (major), *t_R* = 22.4 min (minor); 92% ee. $[\alpha]_{\text{D}}^{25} = +80.8^{\circ}$ (*c* = 0.55, THF). ¹H NMR (400 MHz, CDCl₃): δ 8.24 (s, 1H, NH), 7.79 (d, *J* = 7.6 Hz, 1H, ArH), 7.63–7.60 (m, 1H, ArH), 7.41–7.36 (m, 2H, ArH), 7.12 (dd, *J*₁ = 5.2 Hz, *J*₂ = 0.8 Hz, 1H, ArH), 6.78 (dd, *J*₁ = 5.2 Hz, *J*₂ = 3.6 Hz, 1H, ArH), 6.73 (d, *J* = 3.2 Hz, 1H, ArH), 5.70 (s, 1H, CH), 4.32 (d, *J* = 18.8 Hz, 1H, CH₂), 3.57 (d, *J* = 18.4 Hz, 1H, CH₂), 3.38 (s, 3H, CH₃), 3.36 (s, 3H, CH₃) ppm. ¹³C NMR (176 MHz, CDCl₃): δ 200.7, 195.6, 165.24, 165.17, 152.2, 150.4, 136.8, 133.7, 132.1, 129.5, 128.3, 126.9, 126.5, 125.0, 75.4, 73.7, 52.0, 38.0, 29.7, 29.3 ppm. HRMS (ESI): *m/z* calcd. for C₂₁H₁₈N₃O₄S₂ [M + H]⁺ 440.0733, found 440.0732.

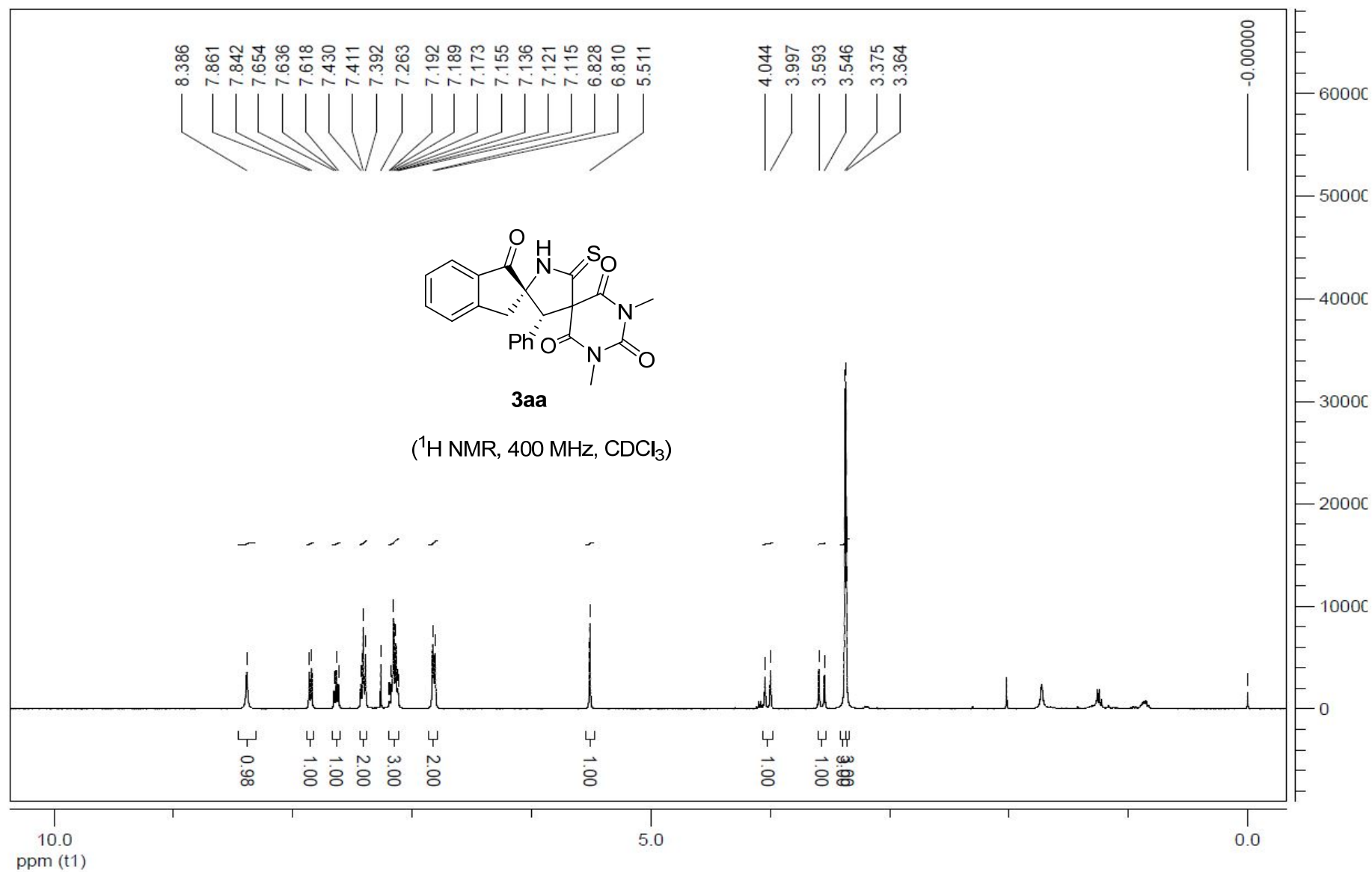
2. Characterization data of compound 4

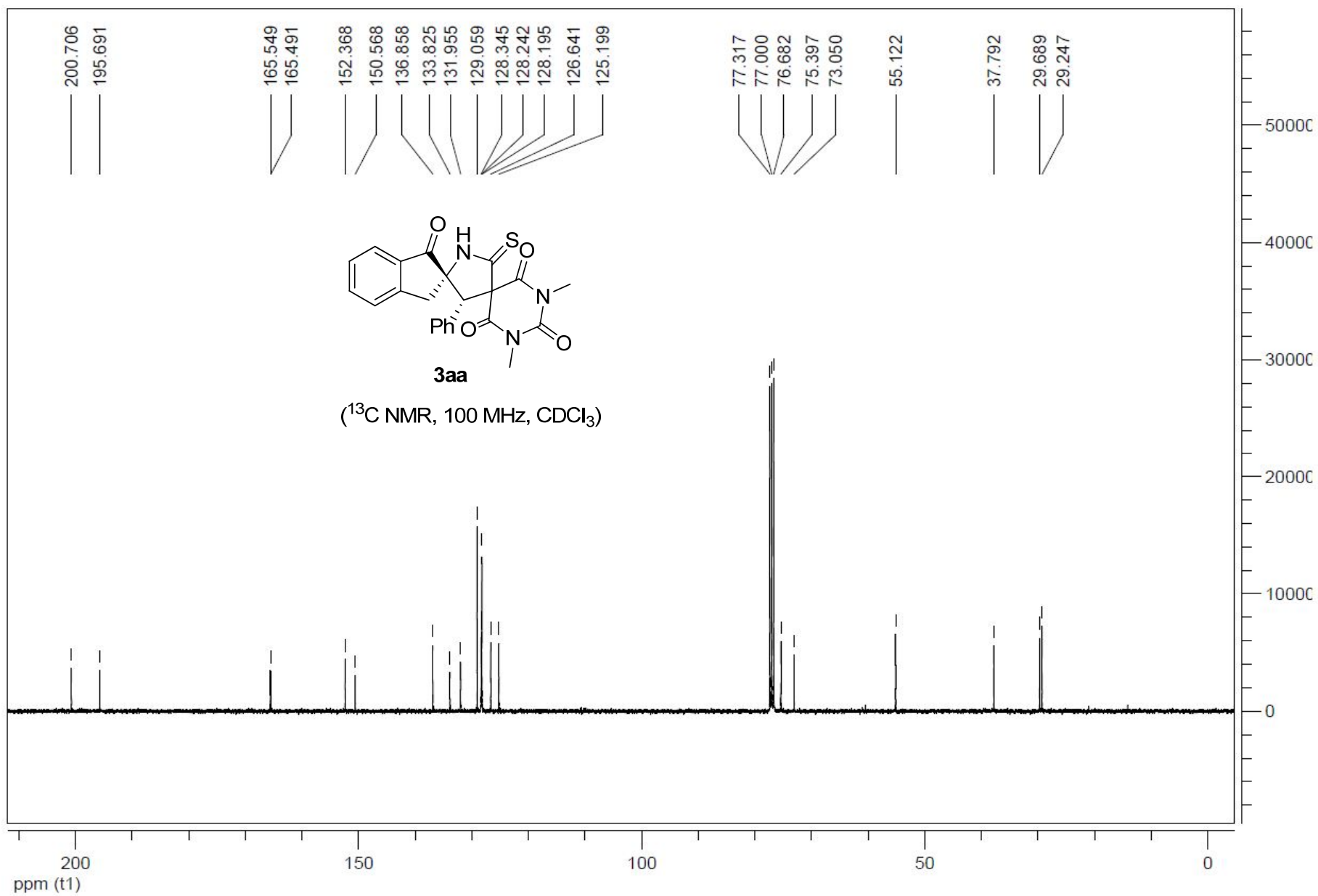
(2*S*,3'*S*)-1'',3''-Dimethyl-3'-(*m*-tolyl)-2''*H*-dispiro[indene-2,2'-pyrrolidine-4',5''-pyrimidine]-1,2'',4'',5'',6''(1''*H*,3*H*,3''*H*)-pentaone (4). From **3ah** (44.8 mg, 0.10 mmol, 1.0 equiv.) and *m*-CPBA (~85%, 60.9 mg, 0.30 mmol, 3.0 equiv.), purified by silica gel (200–300 mesh) column chromatography using ethyl acetate/petroleum ether (1:2) as eluent to obtain 35.1 mg (81% yield) compound **4** as a white solid, m.p. 234–236 °C. HPLC (Daicel Chiralpak ADH, *n*-hexane/2-propanol 70:30, flow rate 1.0 mL/min, detection at 254 nm): *t_R* = 11.7 min (minor), *t_R* = 20.3 min (major); 99% ee. $[\alpha]_{\text{D}}^{25} = +59.7^{\circ}$ (*c* = 0.70, THF). ¹H NMR (400 MHz, CDCl₃): δ 7.80 (d, *J* = 7.6 Hz, 1H, ArH), 7.58 (t, *J* = 7.4 Hz, 1H, ArH), 7.38–7.34 (m, 2H, ArH), 7.01 (t, *J* = 7.6 Hz, 1H, ArH), 6.96 (d, *J* = 7.6 Hz, 1H, ArH), 6.69–6.63 (m, 3H, ArH + NH), 5.16 (s, 1H, CH), 4.00 (d, *J* = 18.4 Hz, 1H, CH₂), 3.44 (d, *J* = 18.4 Hz, 1H, CH₂), 3.37–3.36 (m, 3H, CH₃), 3.32–3.31 (m, 3H, CH₃), 2.11 (s, 3H, CH₃) ppm. ¹³C NMR (100 MHz, CDCl₃): δ 202.3, 168.0, 166.0, 165.8, 152.5, 150.5, 138.7, 136.5, 134.0, 131.7, 129.4, 129.2, 128.8, 128.0, 126.5, 125.1, 124.8, 68.8, 65.3, 55.3, 38.1, 29.5, 29.0, 21.3 ppm. HRMS (ESI): *m/z* calcd. for C₂₄H₂₂N₃O₅ [M + H]⁺ 432.1554, found 432.1545.

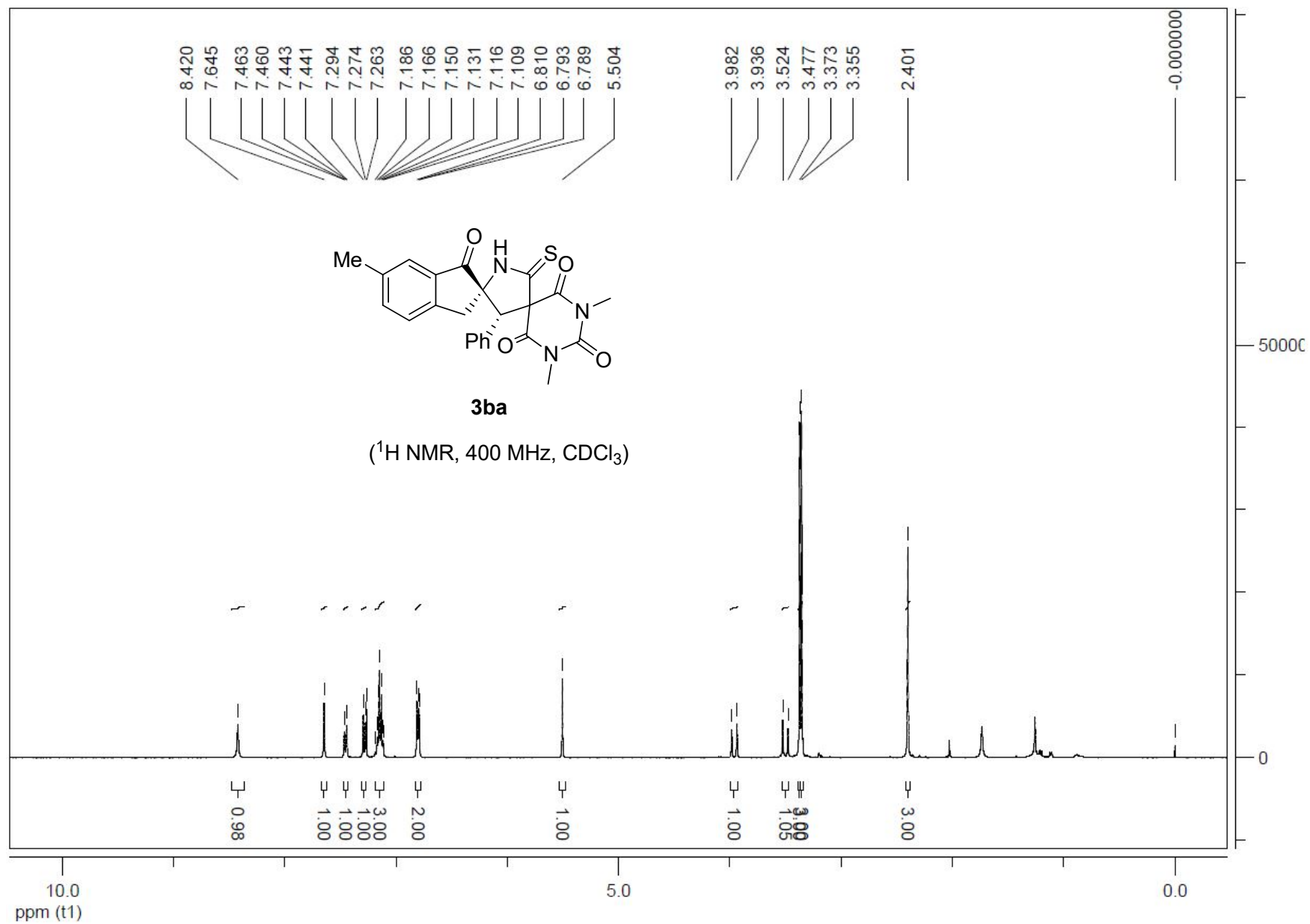
3. Characterization data of compound 5

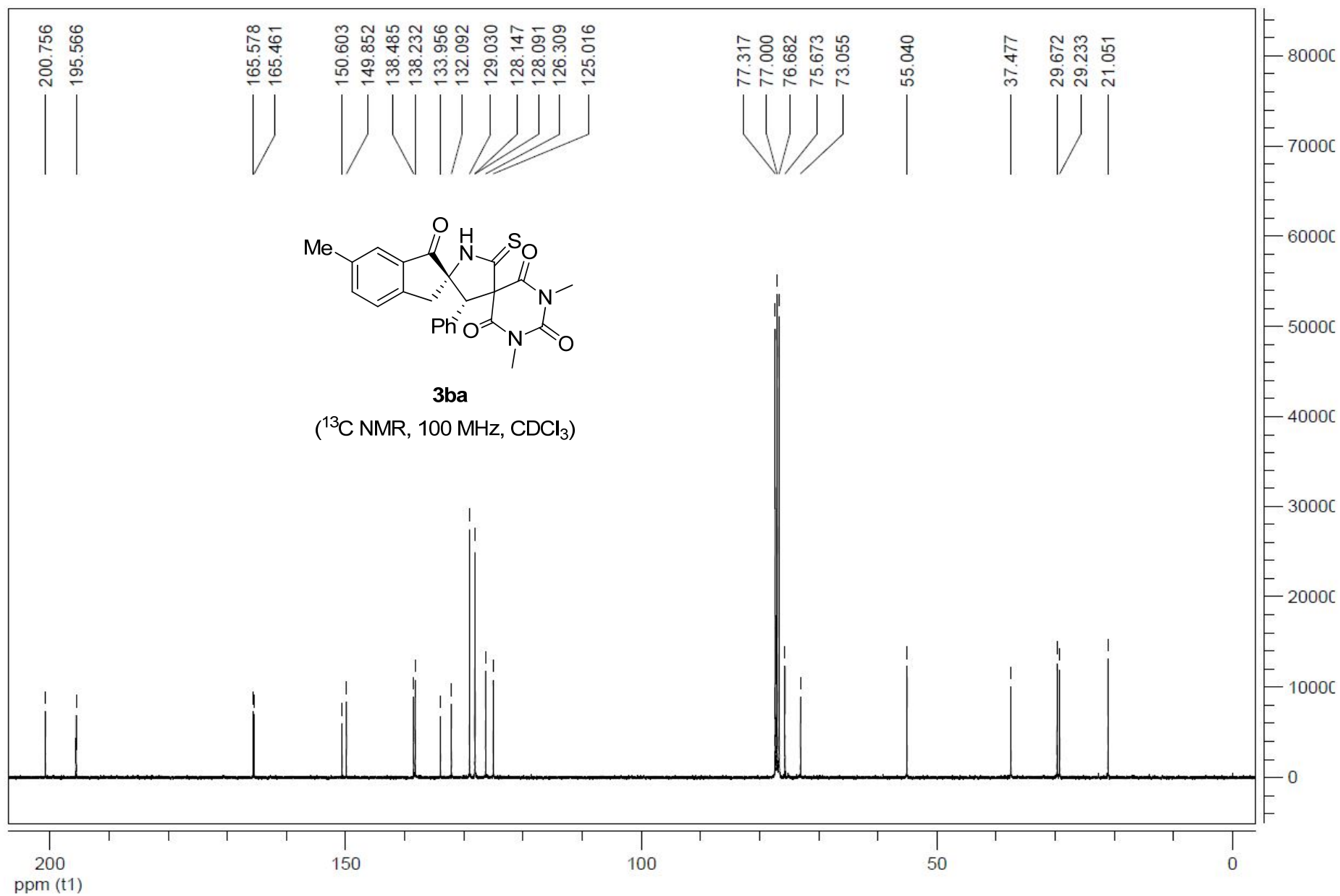
(2*S*,3'*S*)-1'',3''-Dimethyl-5'-(methylthio)-3'-(*m*-tolyl)-2''*H*,3'*H*-dispiro[indene-2,2'-pyrrole-4', 5''-pyrimidine]-1,2'',4'',6''(1''*H*,3*H*,3''*H*)-tetraone (5). From **3ah** (44.8 mg, 0.10 mmol, 1.0 equiv.), dry K₂CO₃ (21.0 mg, 0.23 mmol, 1.50 equiv.) and iodomethane (12.5 μ l, 0.20 mmol, 2.0 equiv.), purified by silica gel (200–300 mesh) column chromatography using ethyl acetate/petroleum ether (1:4) as eluent to obtain 44.0 mg (95% yield) compound **5** as a white solid, m.p. 202–204 °C. HPLC (Daicel Chiralpak ADH, *n*-hexane/2-propanol 70:30, flow rate 1.0 mL/min, detection at 254 nm): *t*_R = 12.8 min (minor), *t*_R = 21.2 min (major); 99% ee. [α]_D²⁵ = +64.8° (*c* = 1.10, THF). ¹H NMR (400 MHz, CDCl₃): δ 7.83 (d, *J* = 7.6 Hz, 1H, ArH), 7.60–7.56 (m, 1H, ArH), 7.41 (d, *J* = 7.6 Hz, 1H, ArH), 7.36 (t, *J* = 7.4 Hz, 1H, ArH), 7.07 (t, *J* = 7.6 Hz, 1H, ArH), 6.99 (d, *J* = 7.6 Hz, 1H, ArH), 6.78–6.75 (m, 2H, ArH), 5.18 (s, 1H, CH), 3.67 (d, *J* = 17.6 Hz, 1H, CH₂), 3.40 (d, *J* = 17.6 Hz, 1H, CH₂), 3.33 (s, 3H, CH₃), 3.32 (s, 3H, CH₃), 2.44 (s, 3H, CH₃), 2.18 (s, 3H, CH₃) ppm. ¹³C NMR (100 MHz, CDCl₃): δ 202.5, 167.6, 166.6, 166.3, 153.1, 150.2, 138.7, 135.6, 134.5, 132.7, 130.0, 129.1, 128.7, 127.6, 126.5, 125.8, 125.0, 86.3, 73.9, 61.0, 37.4, 29.4, 28.9, 21.3, 14.1 ppm. HRMS (ESI): *m/z* calcd. for C₂₅H₂₄N₃O₄S [M + H]⁺ 462.1482, found 462.1478.

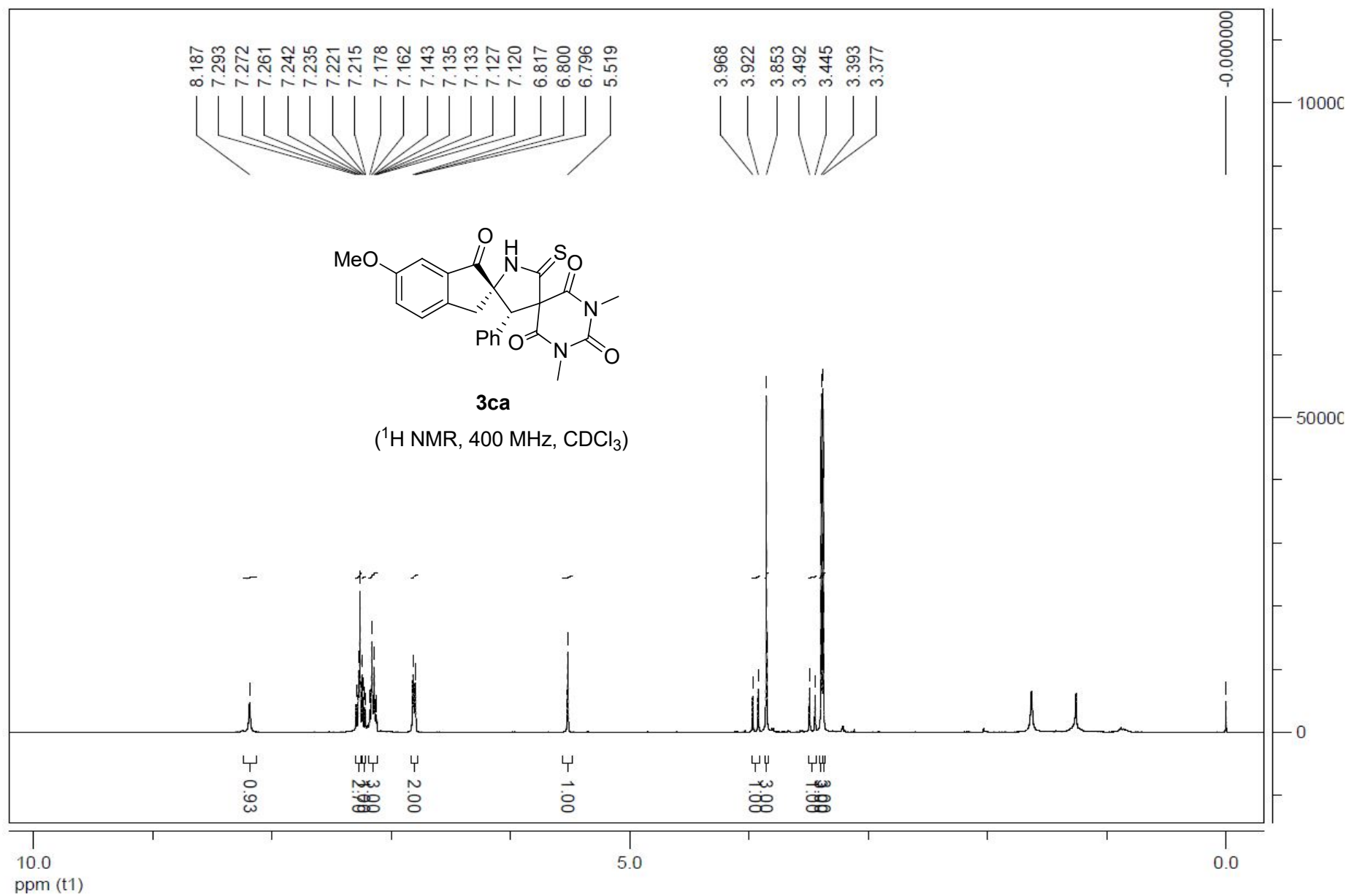
4. Copies of ^1H and ^{13}C spectra of new compounds

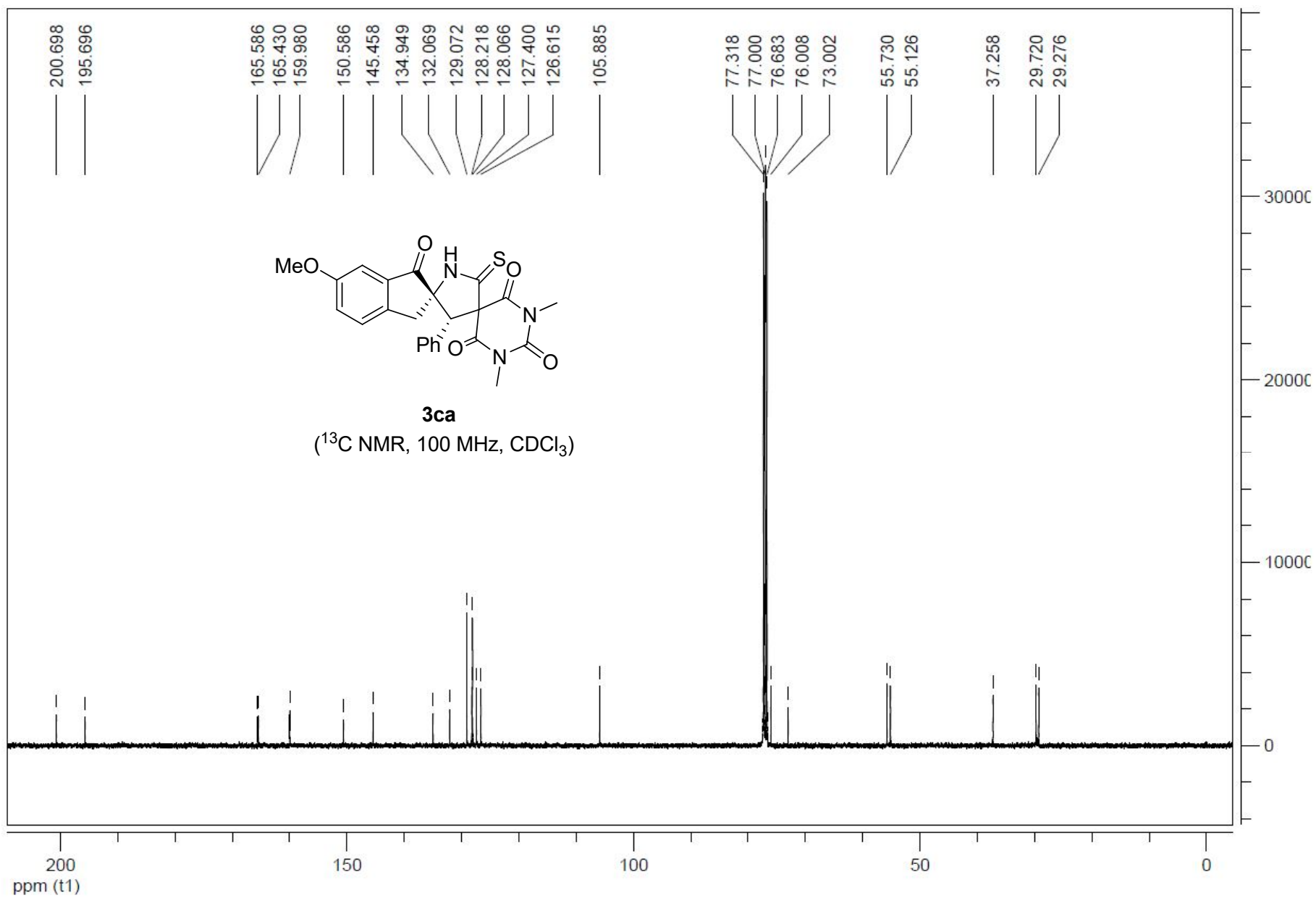


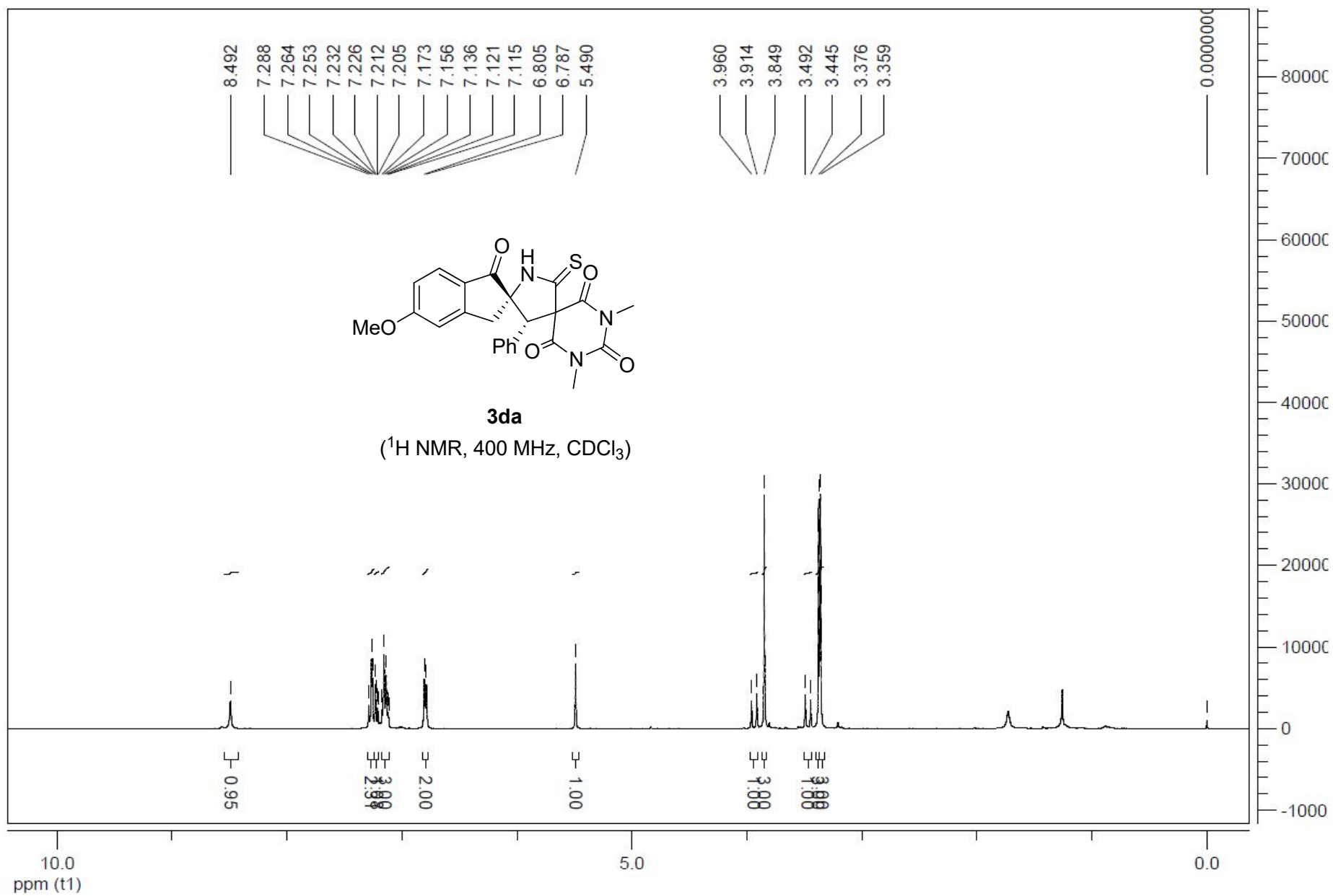


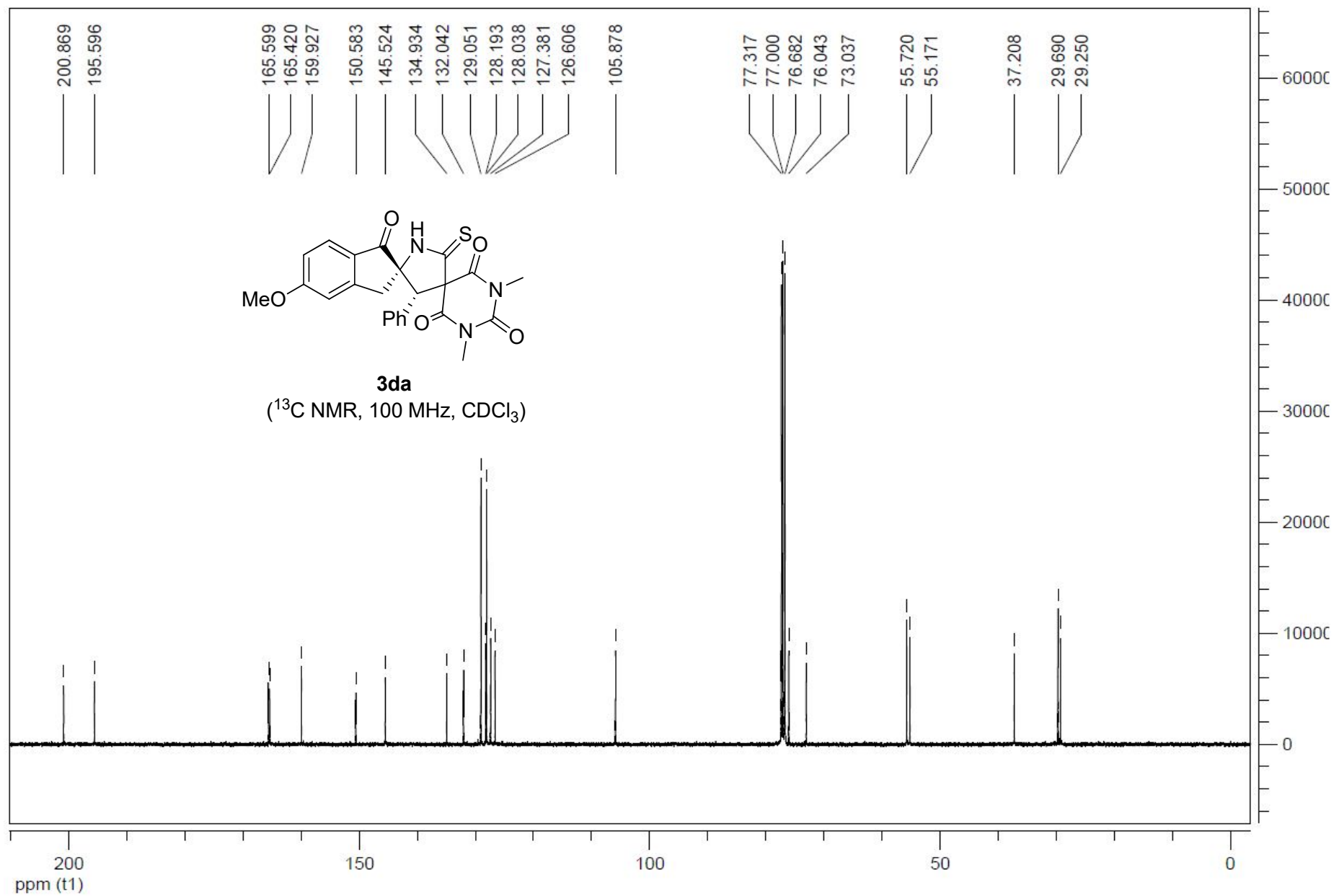


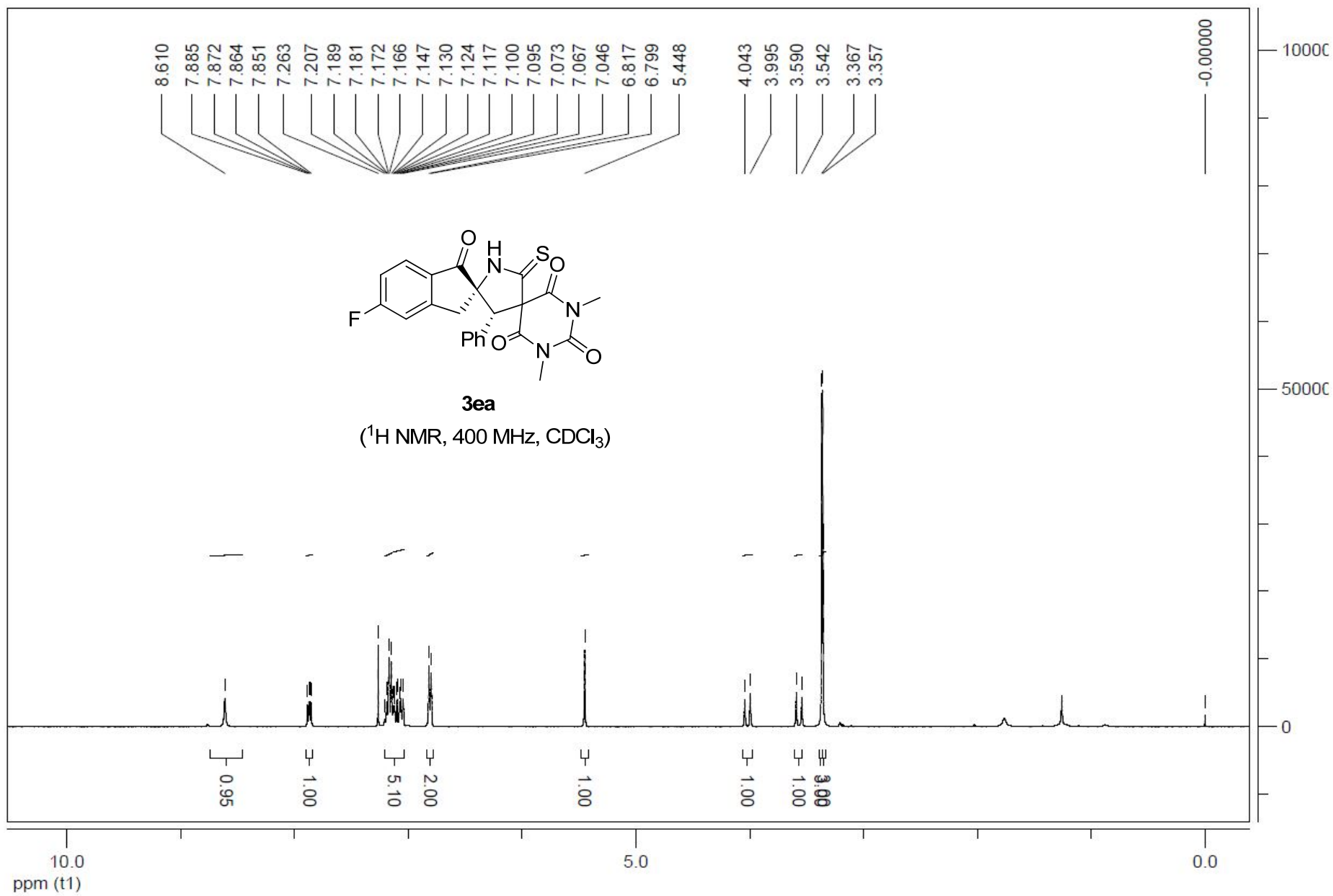


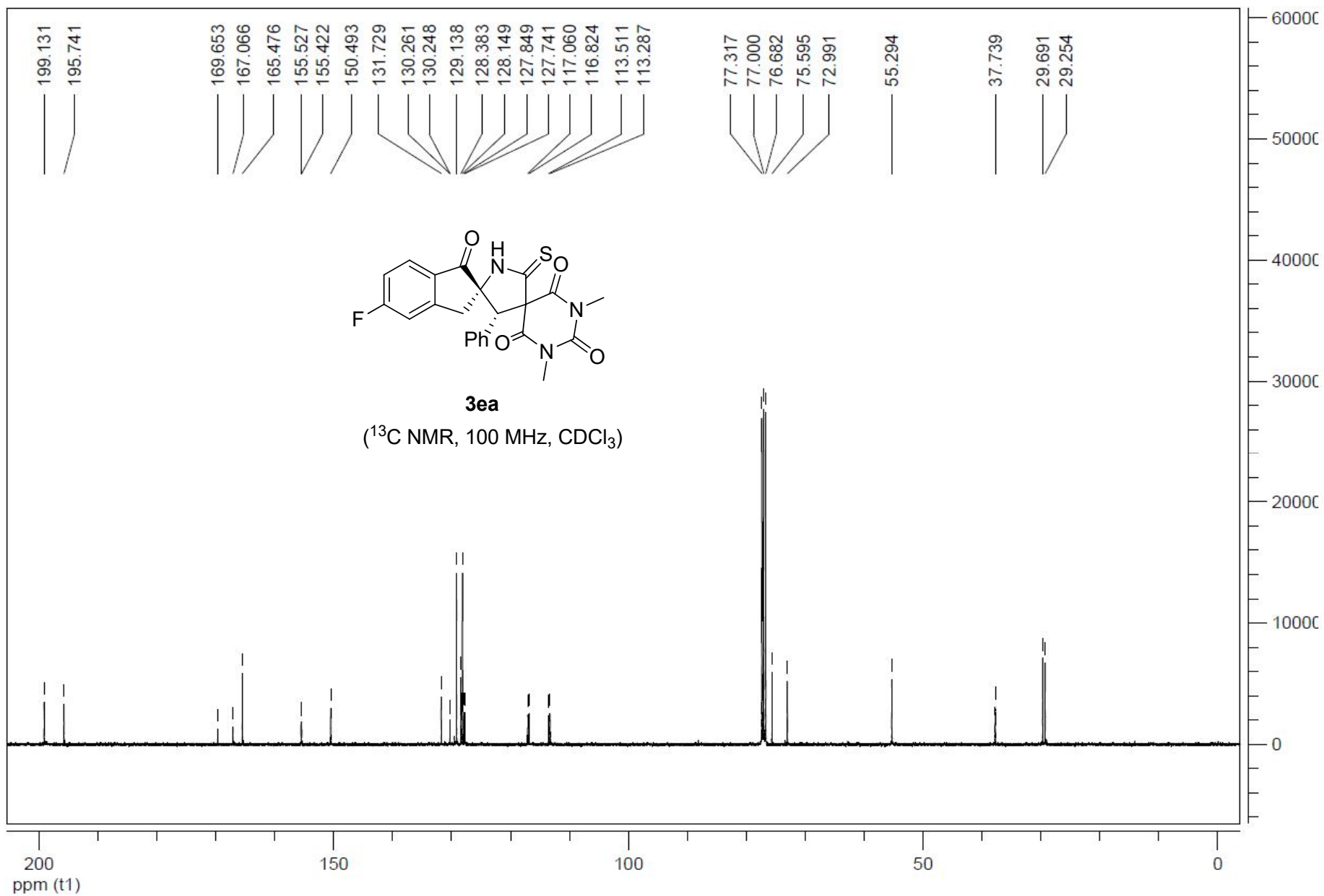


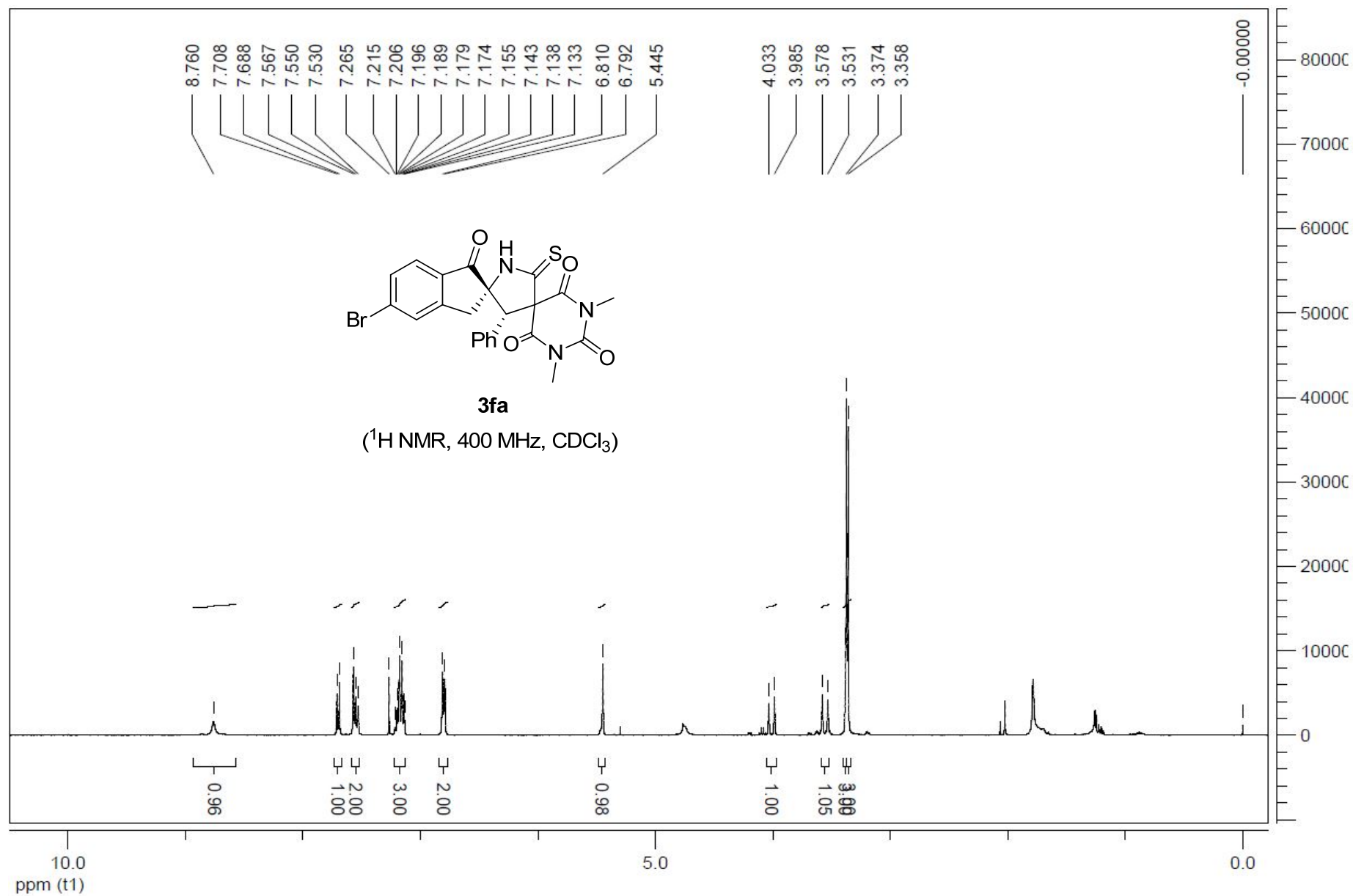


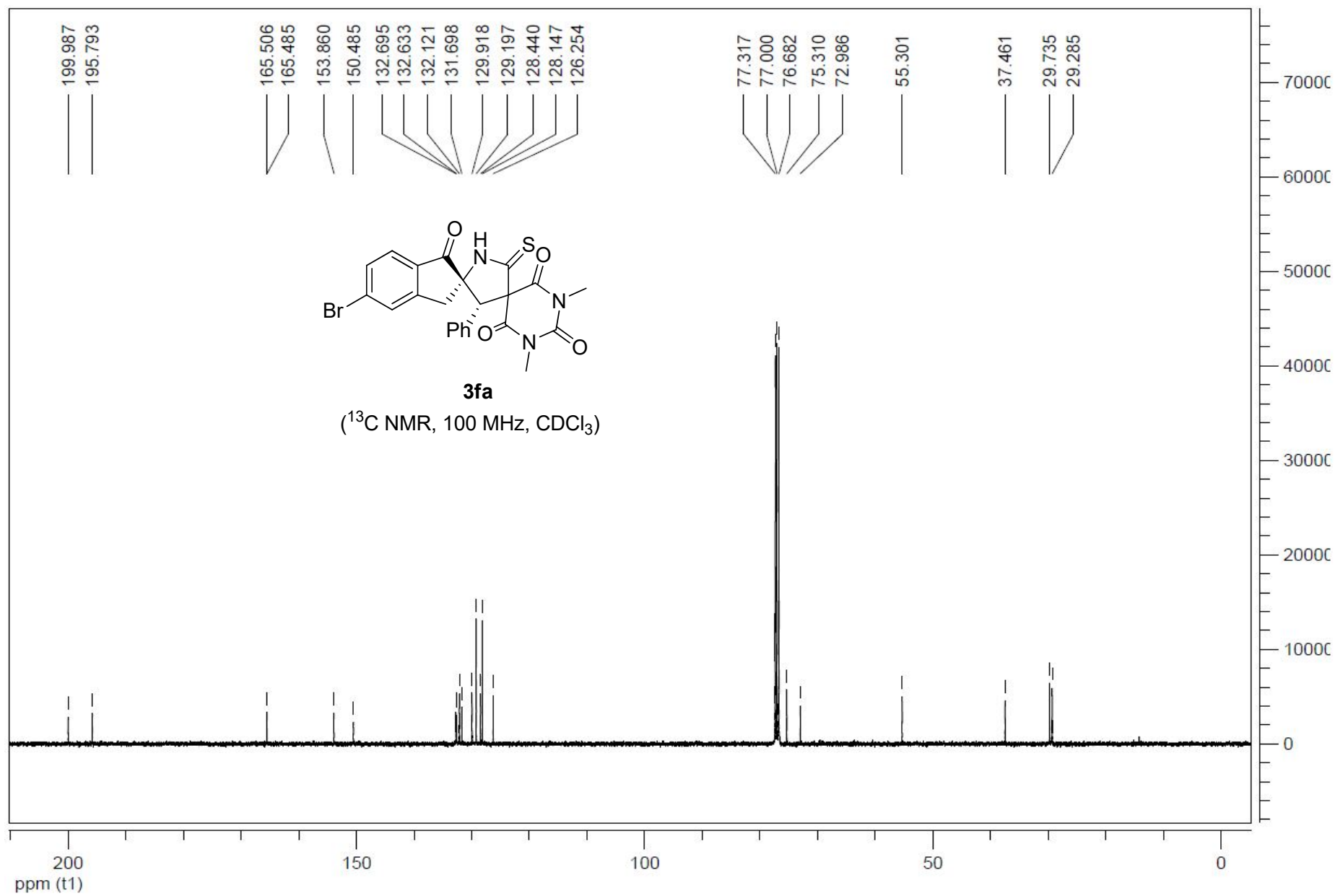


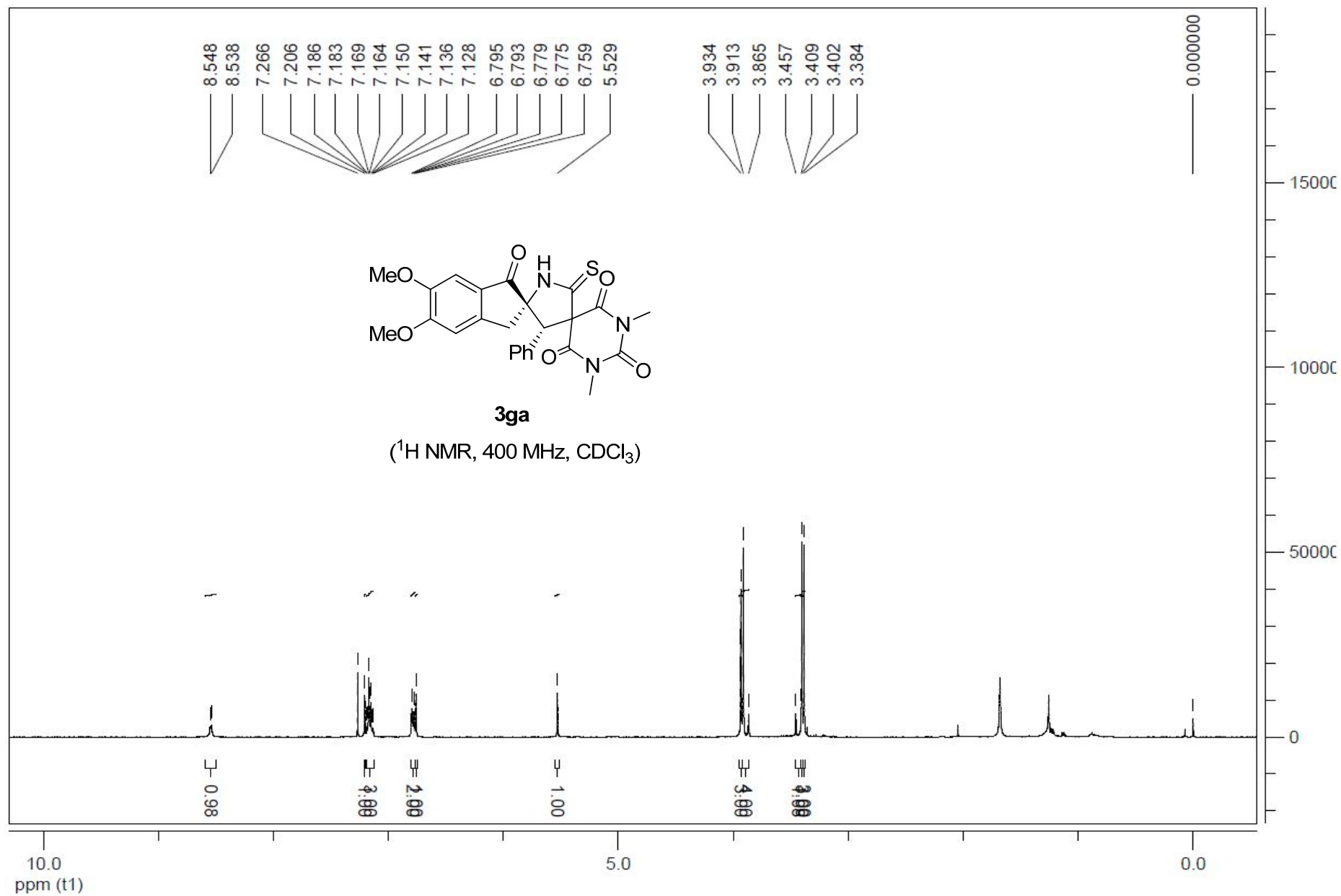


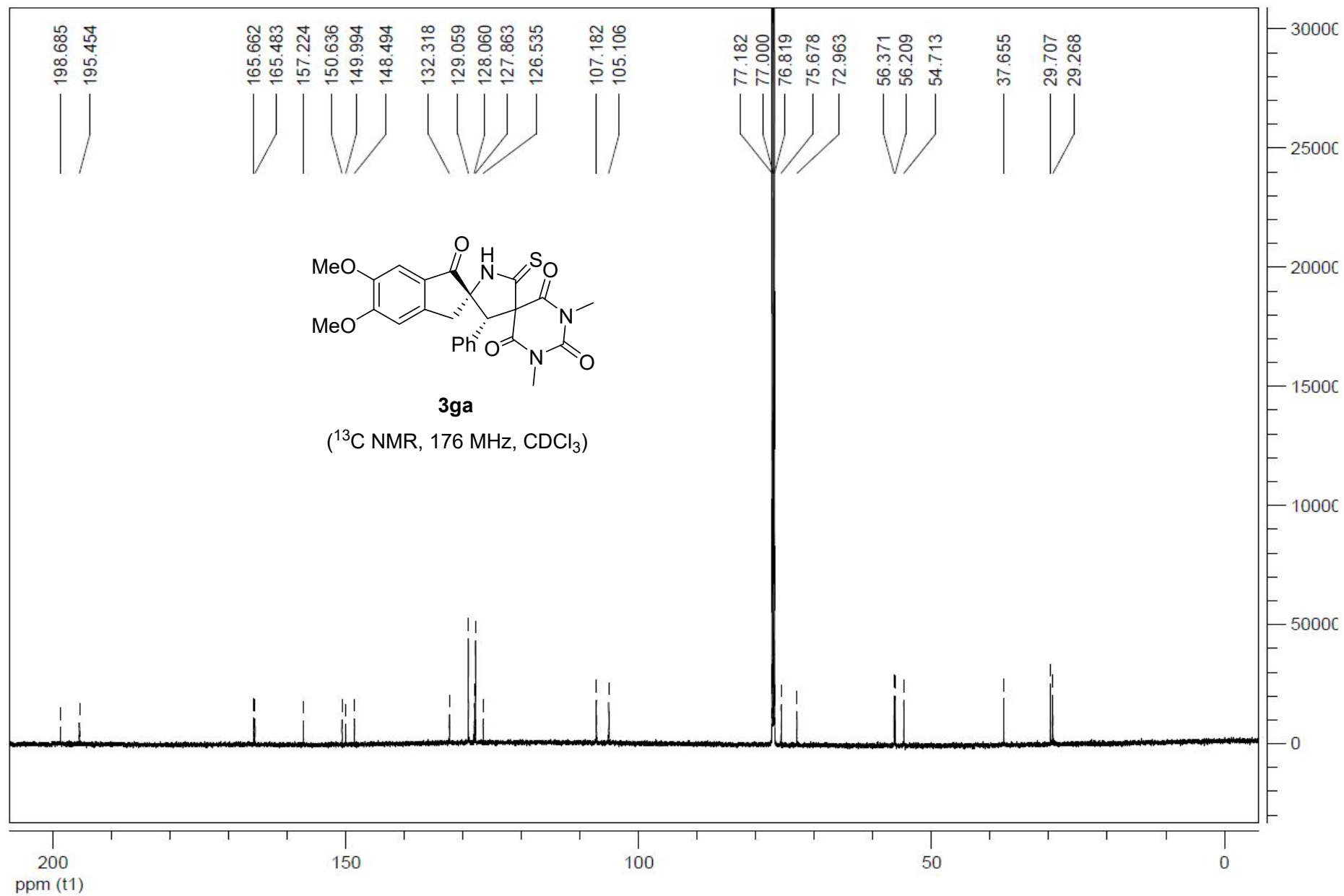


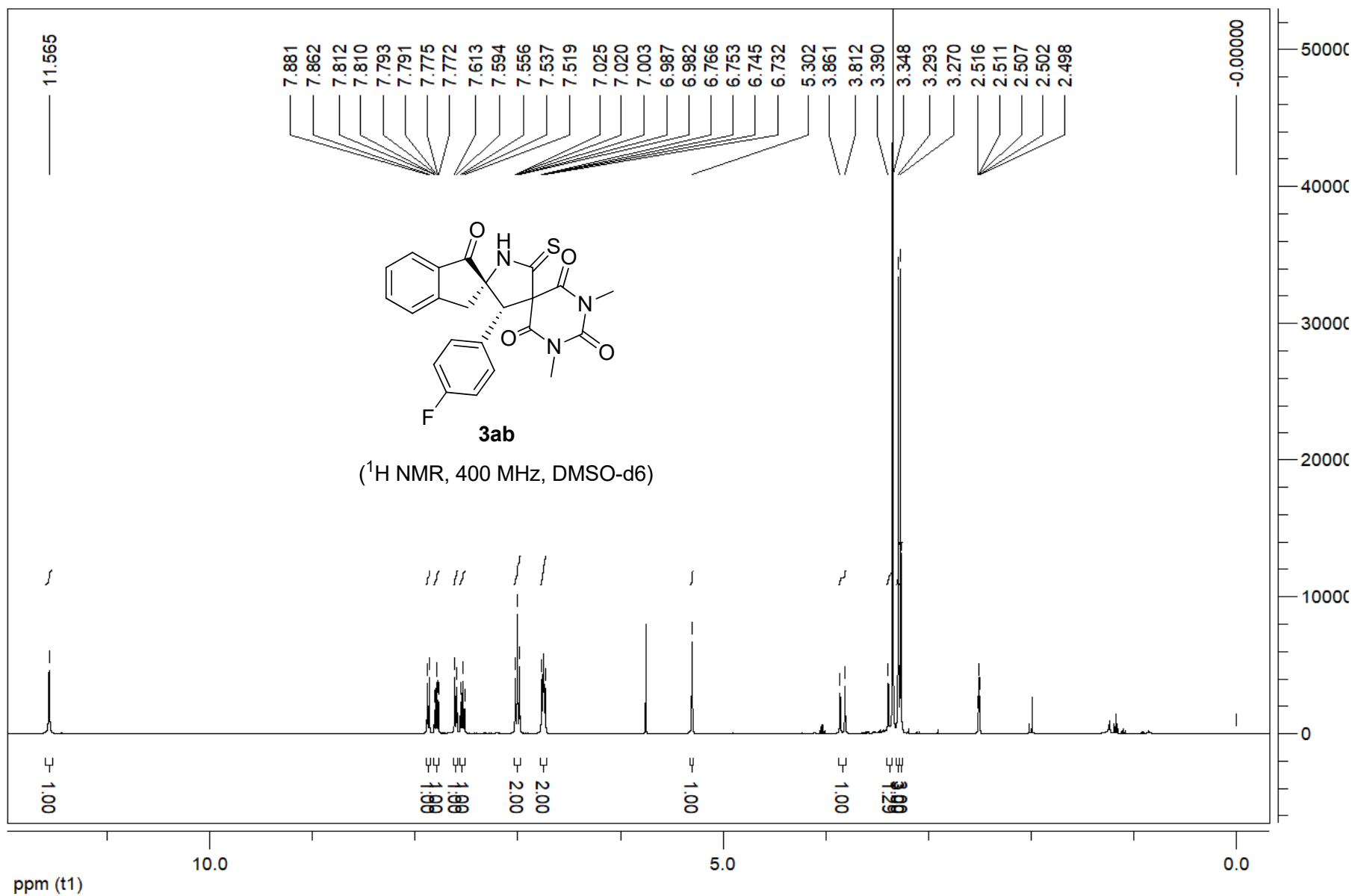


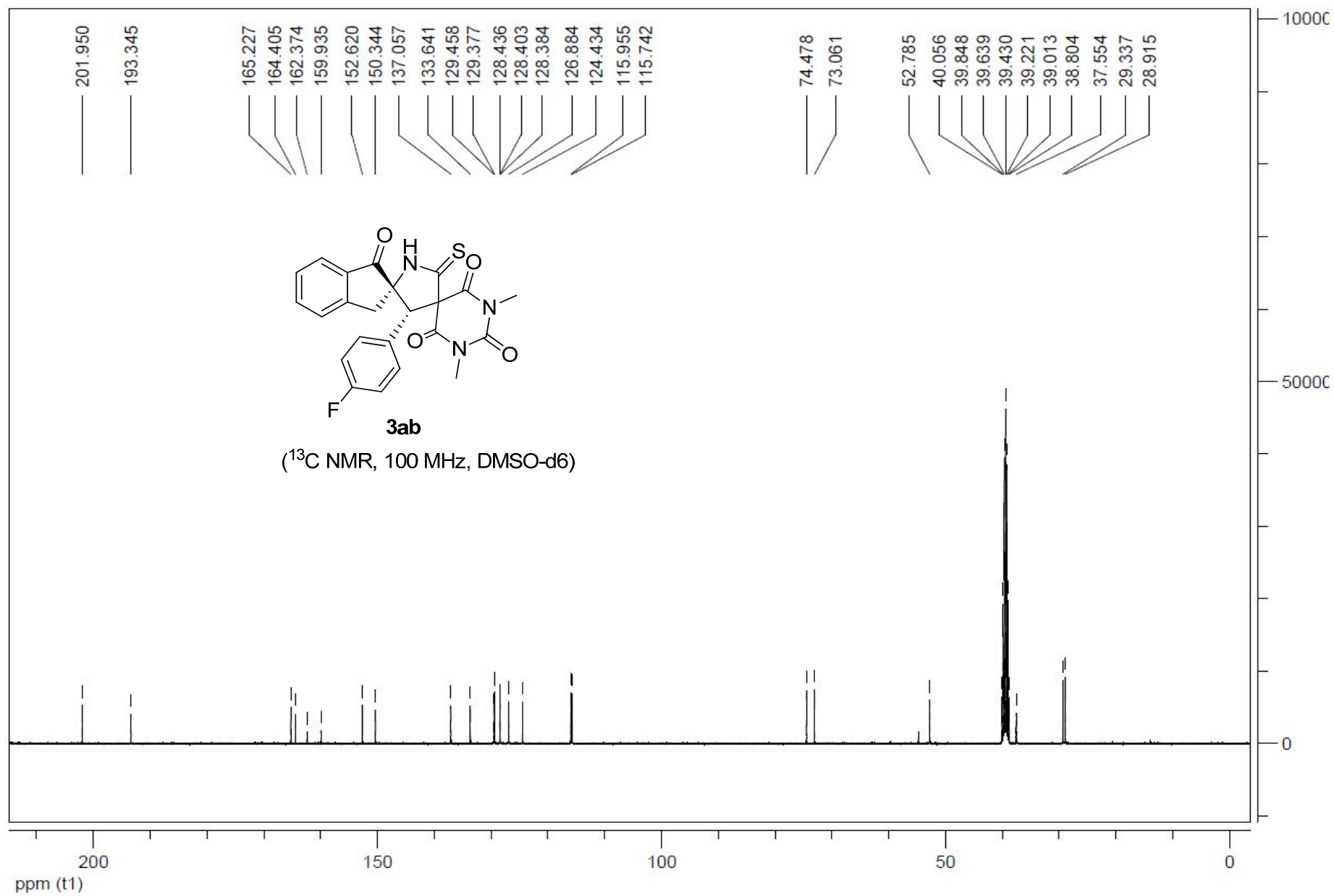


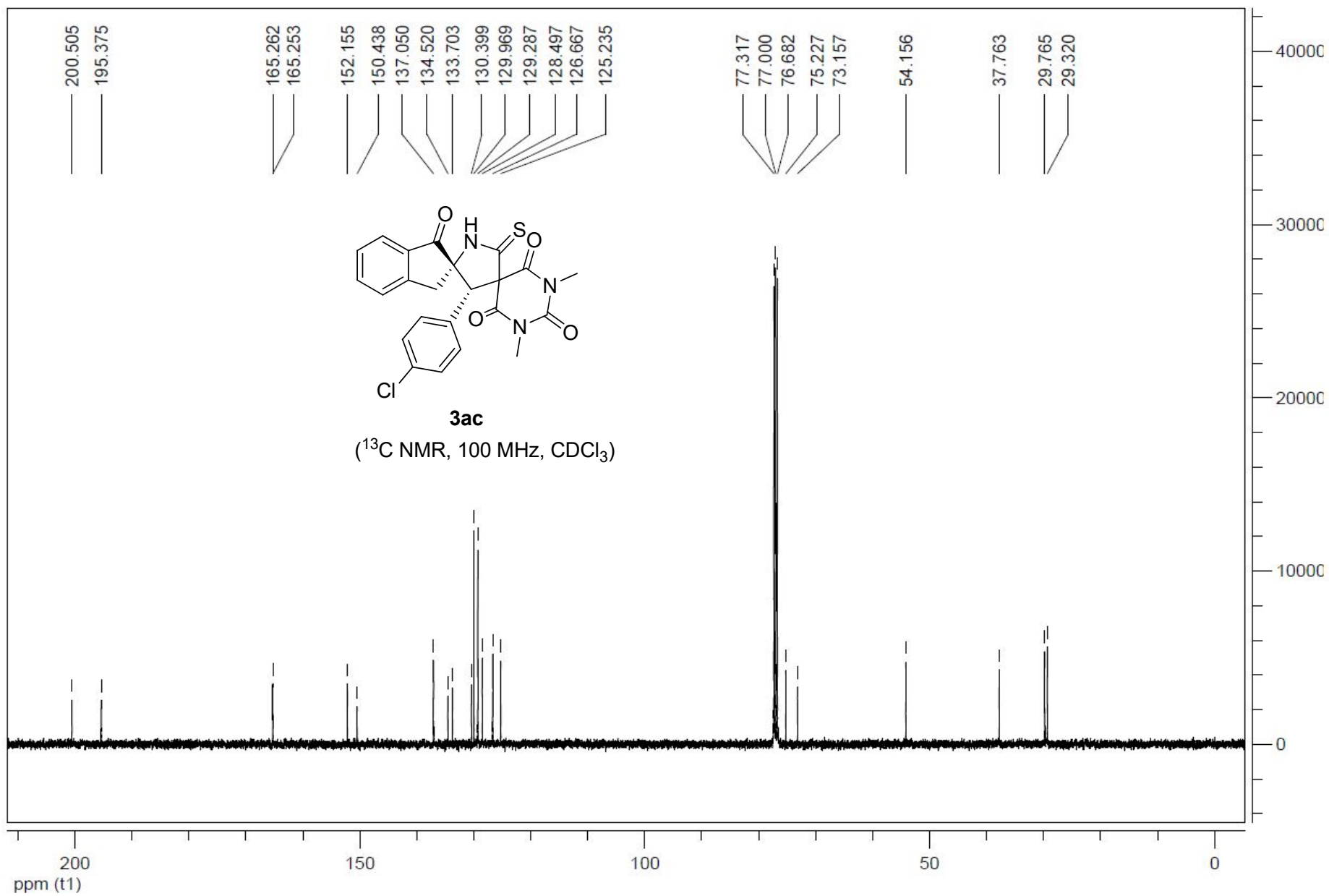


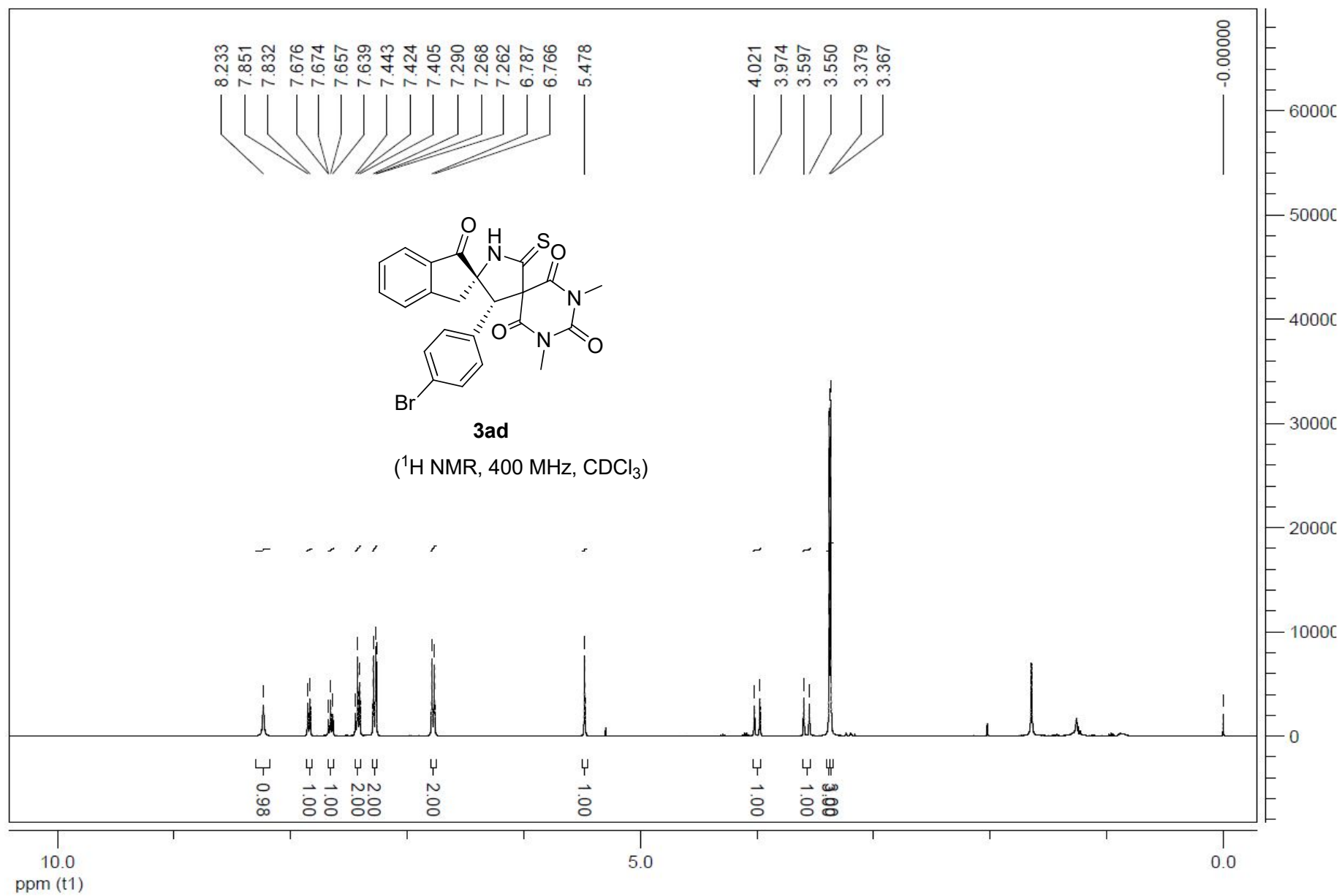


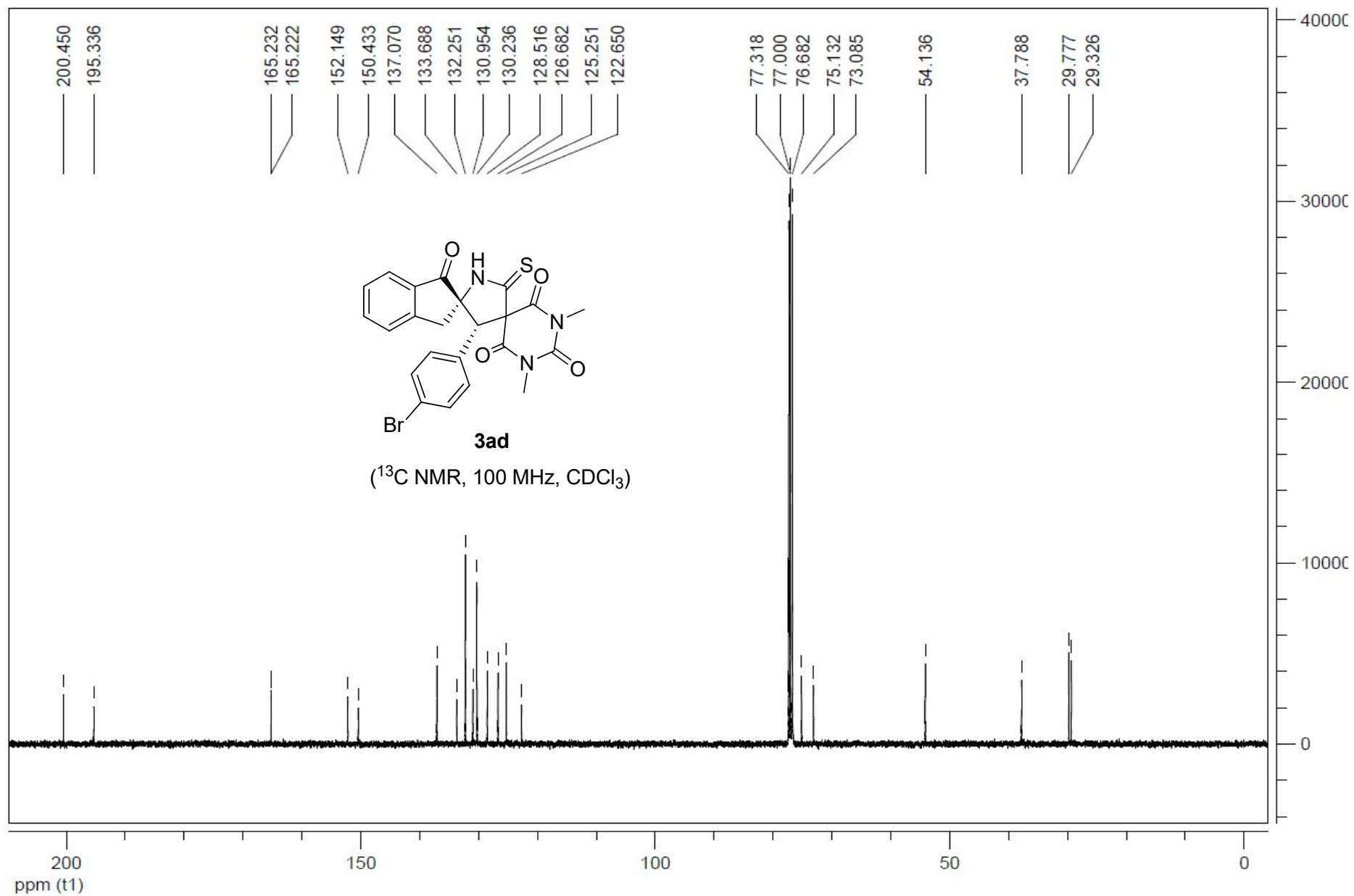


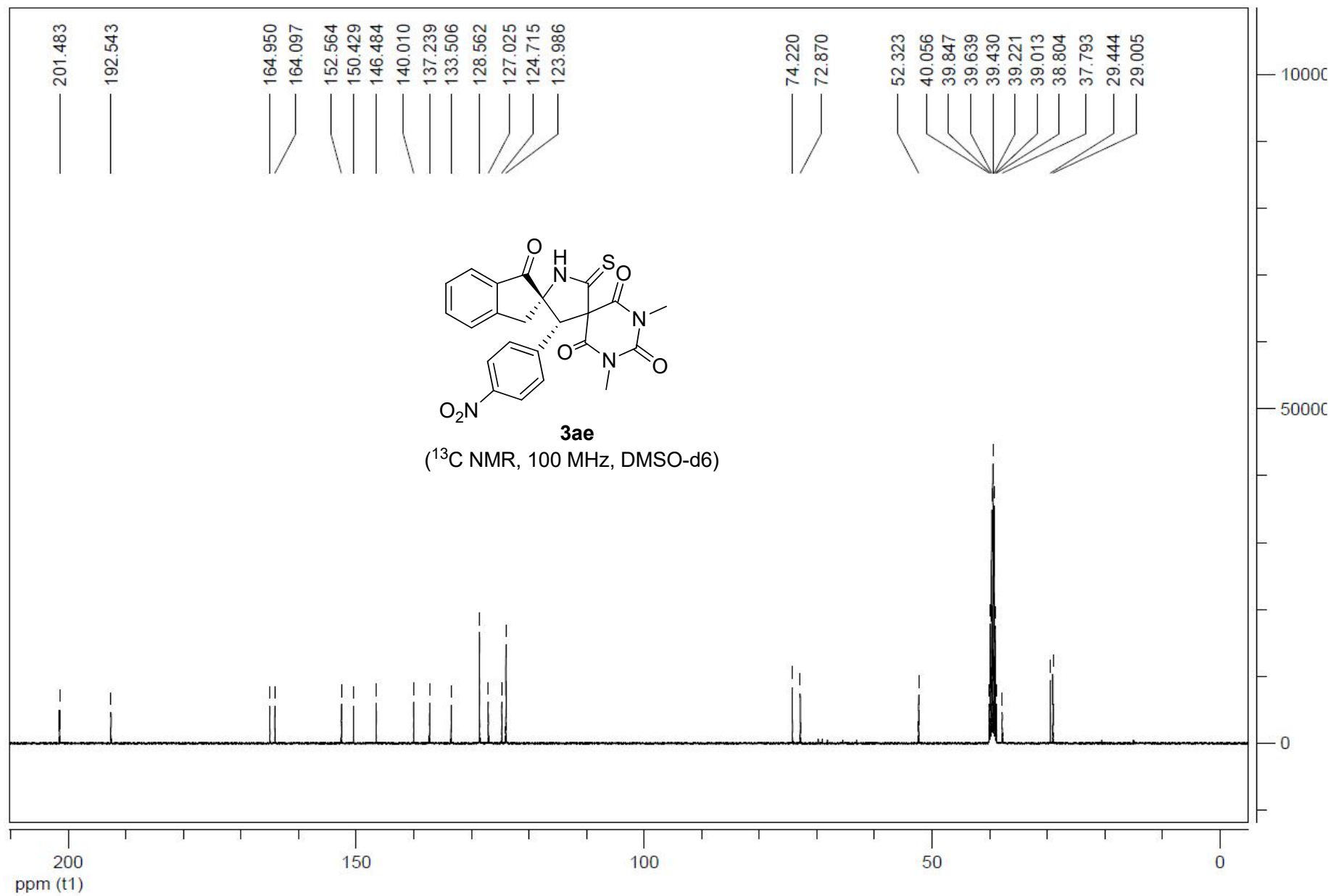


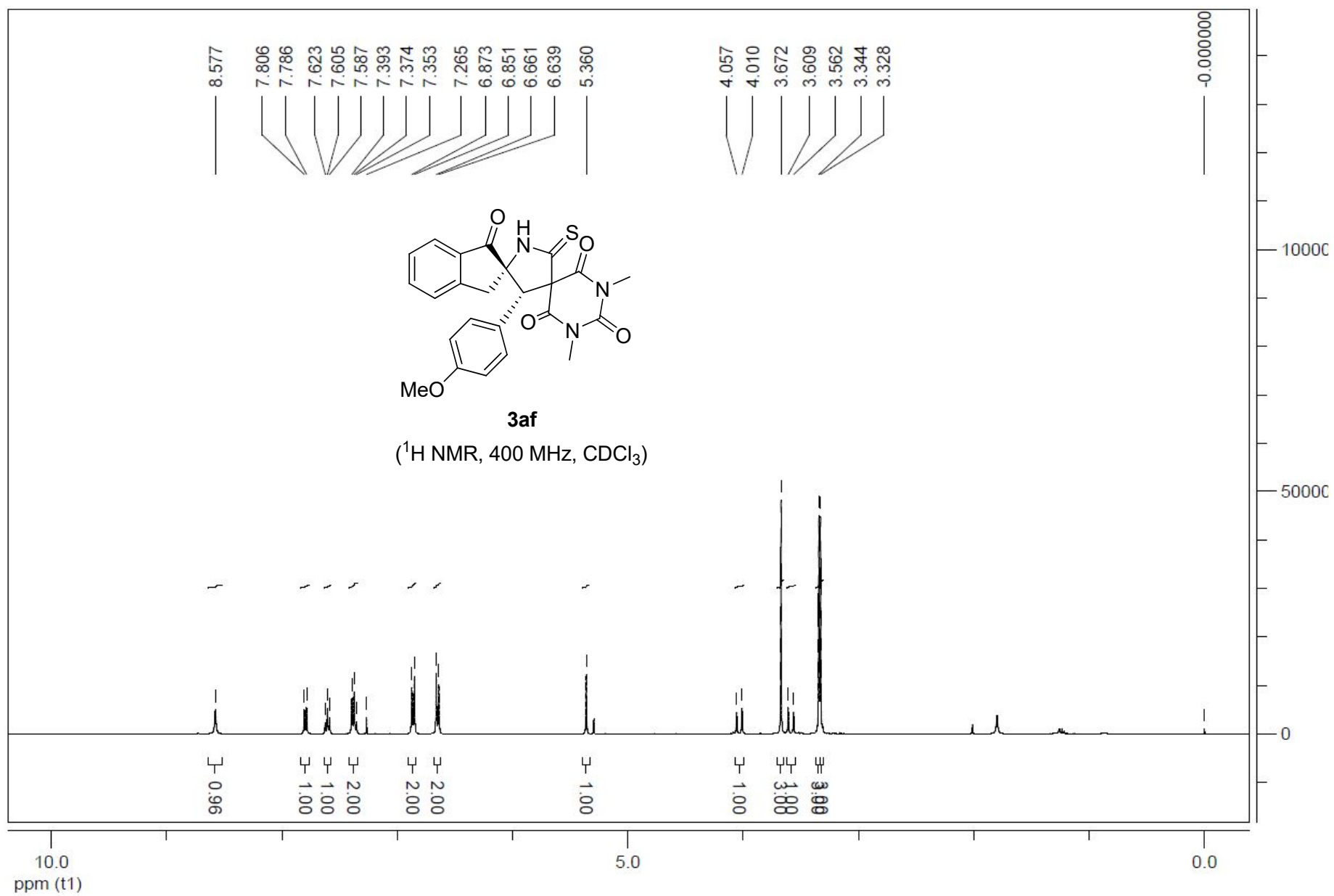


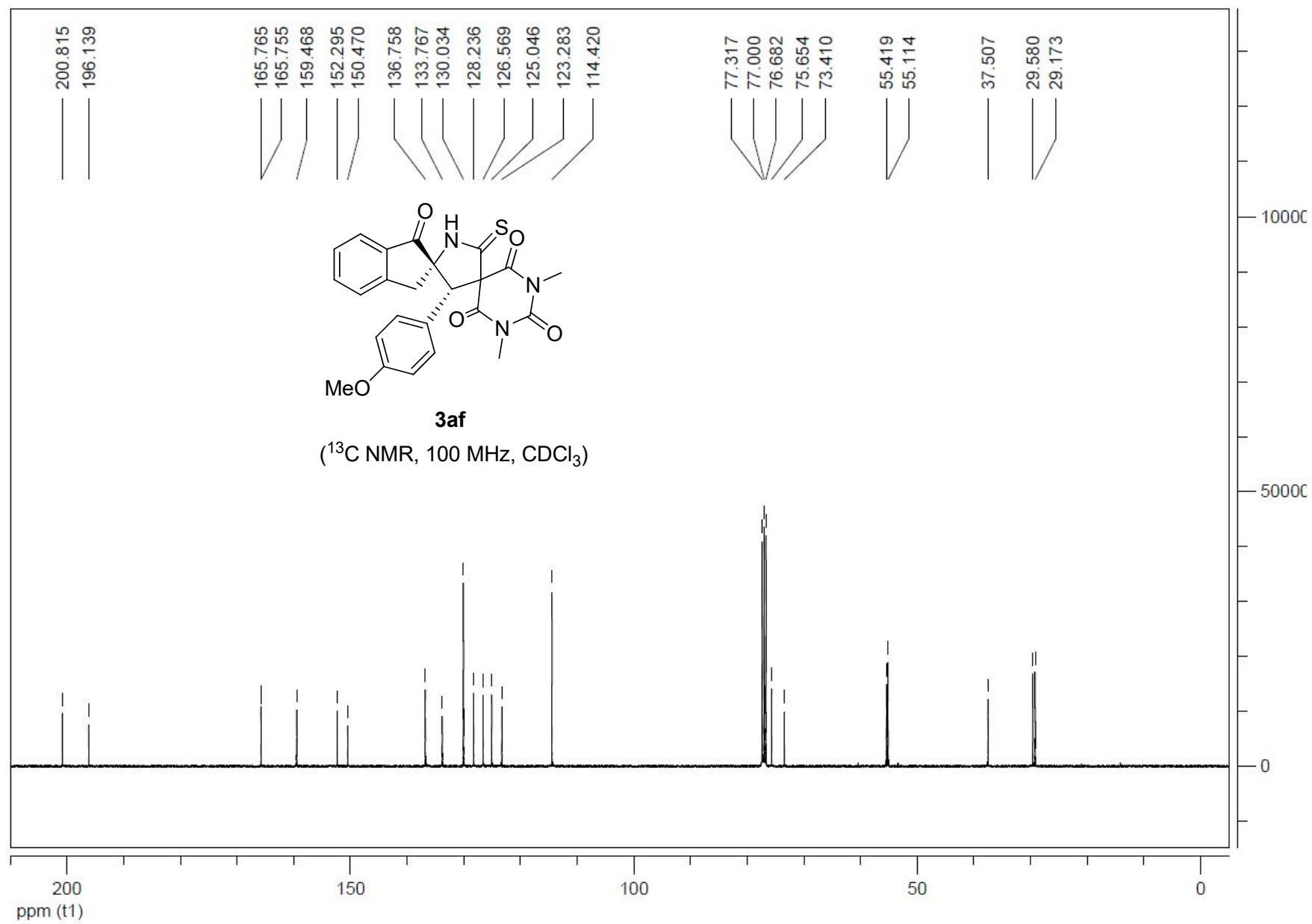


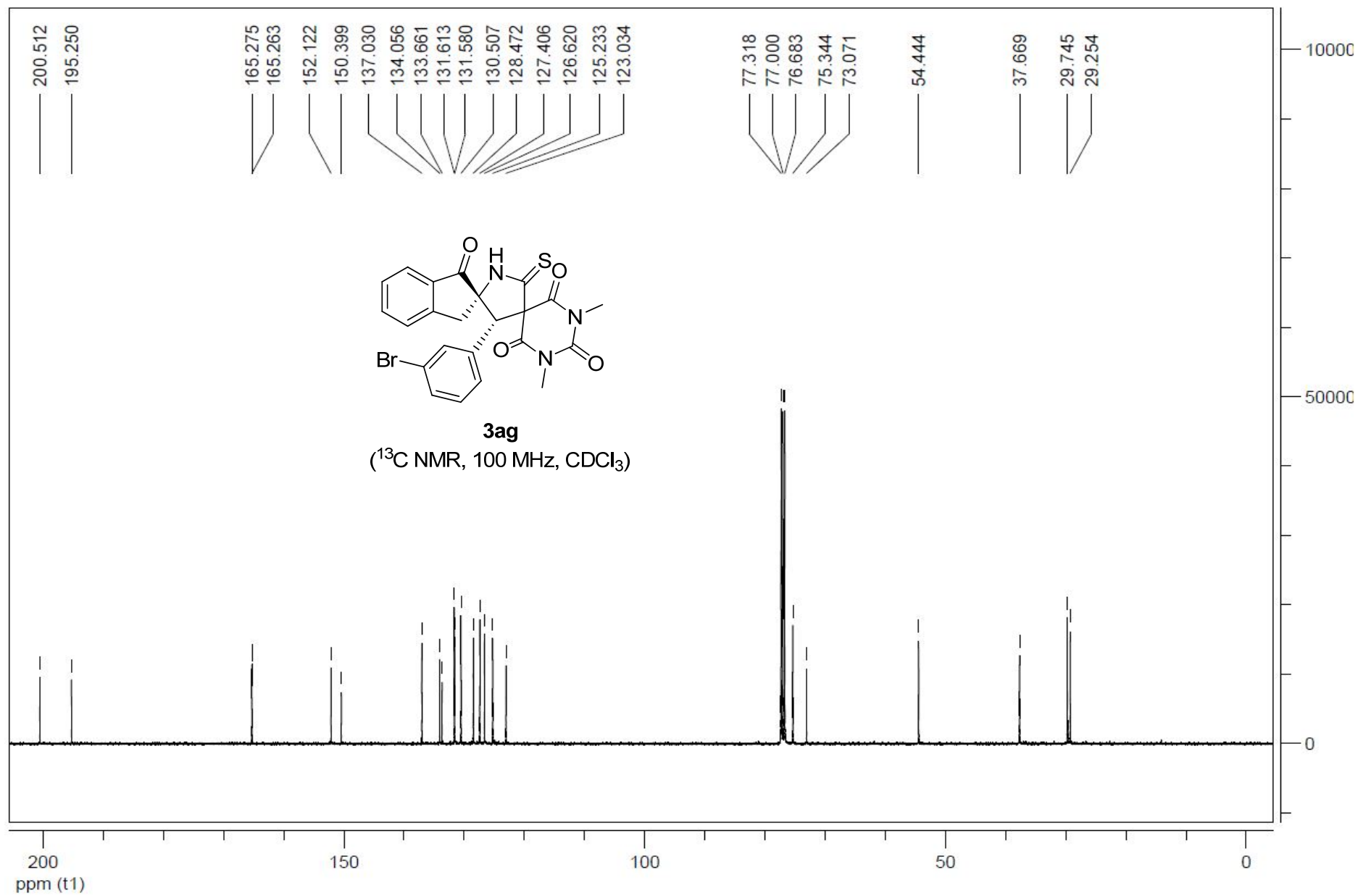


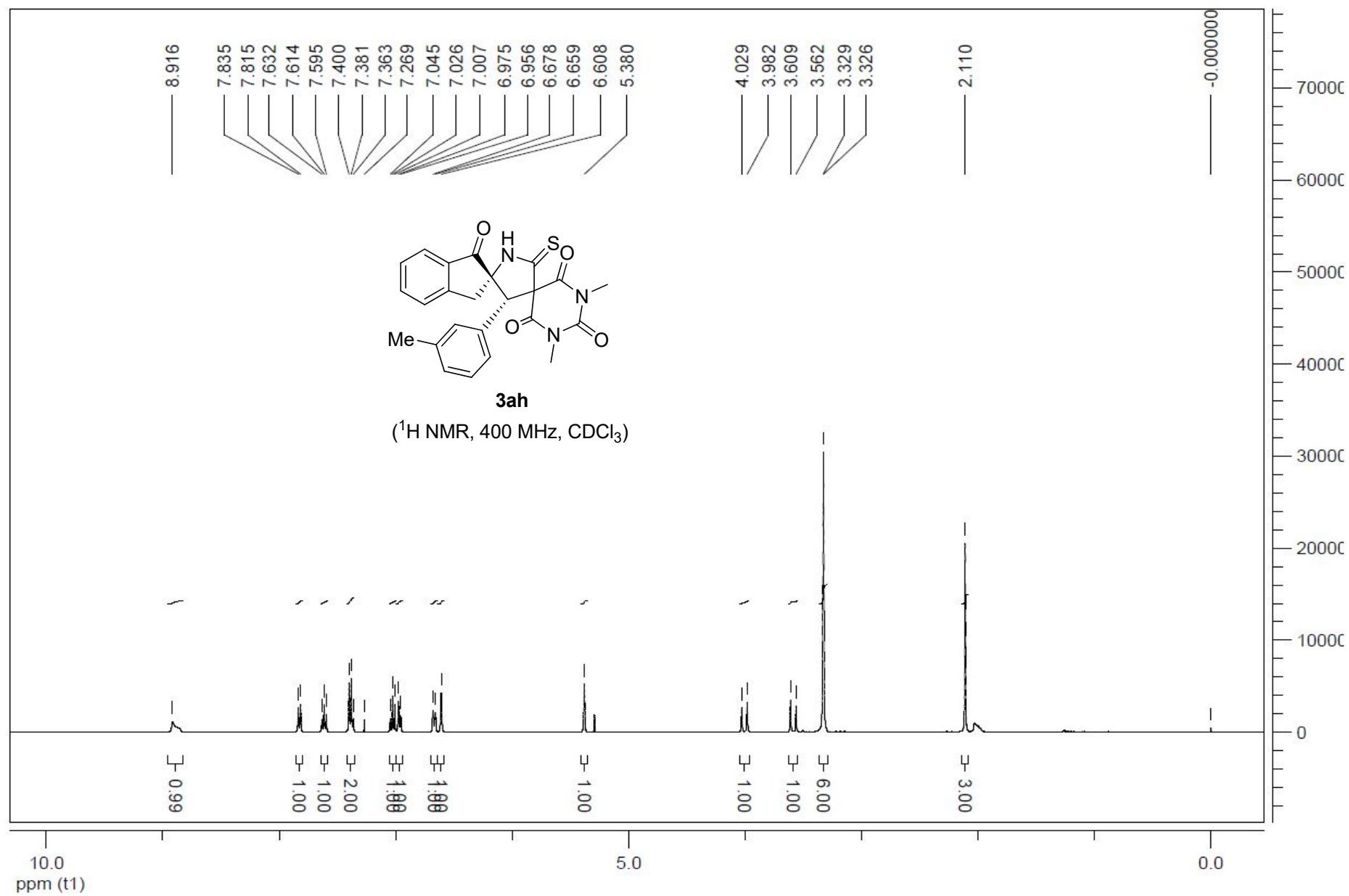


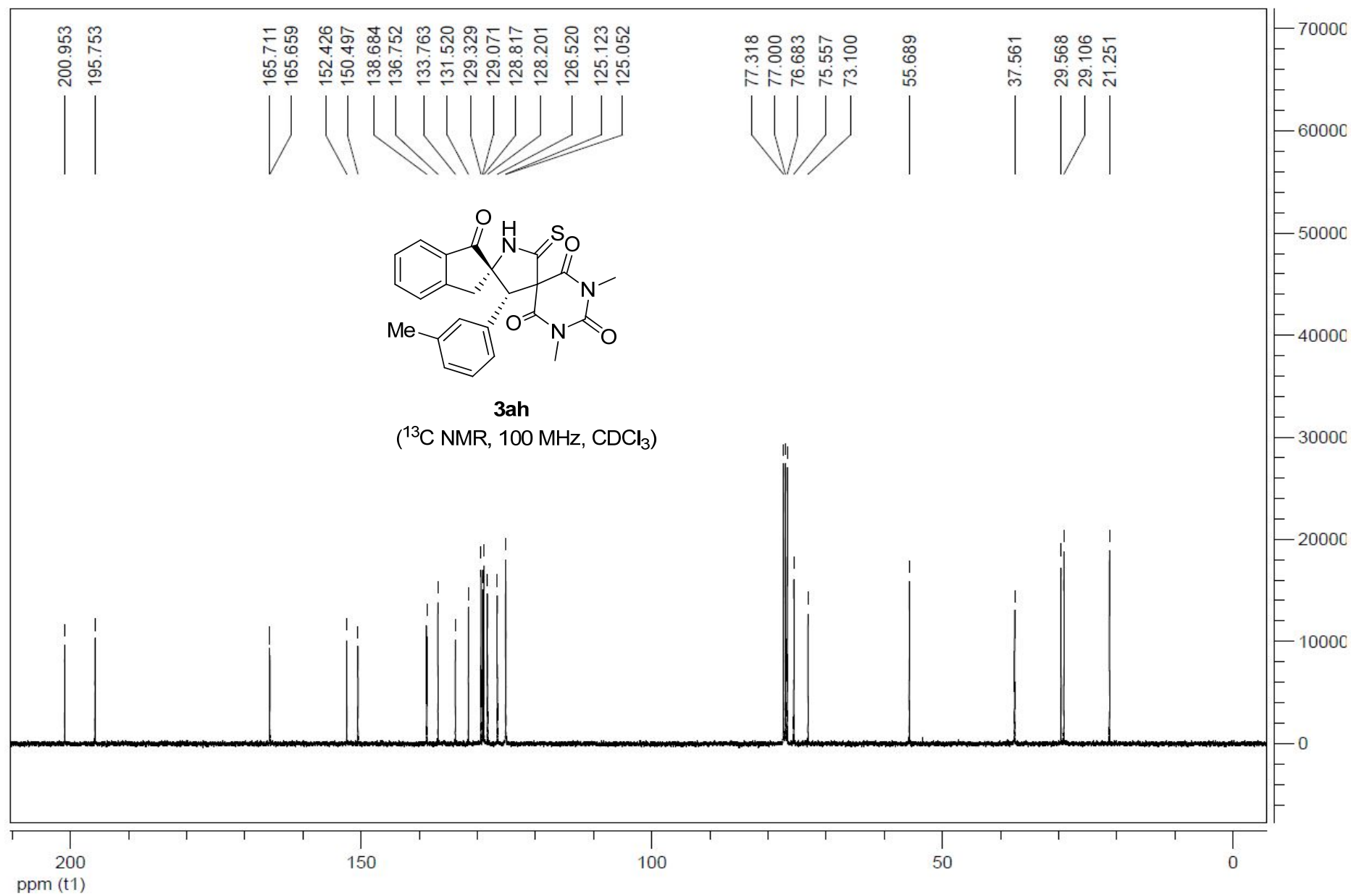


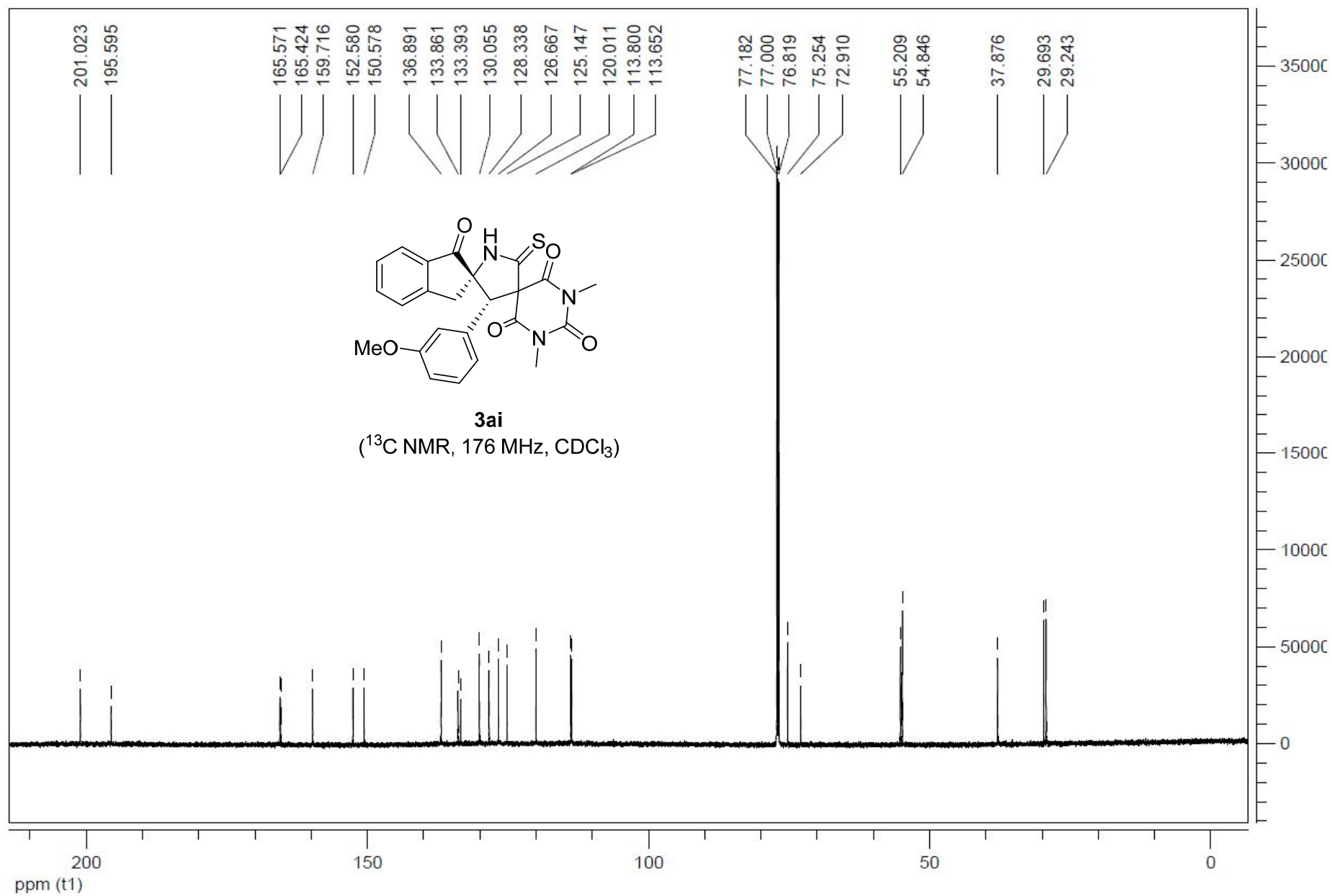


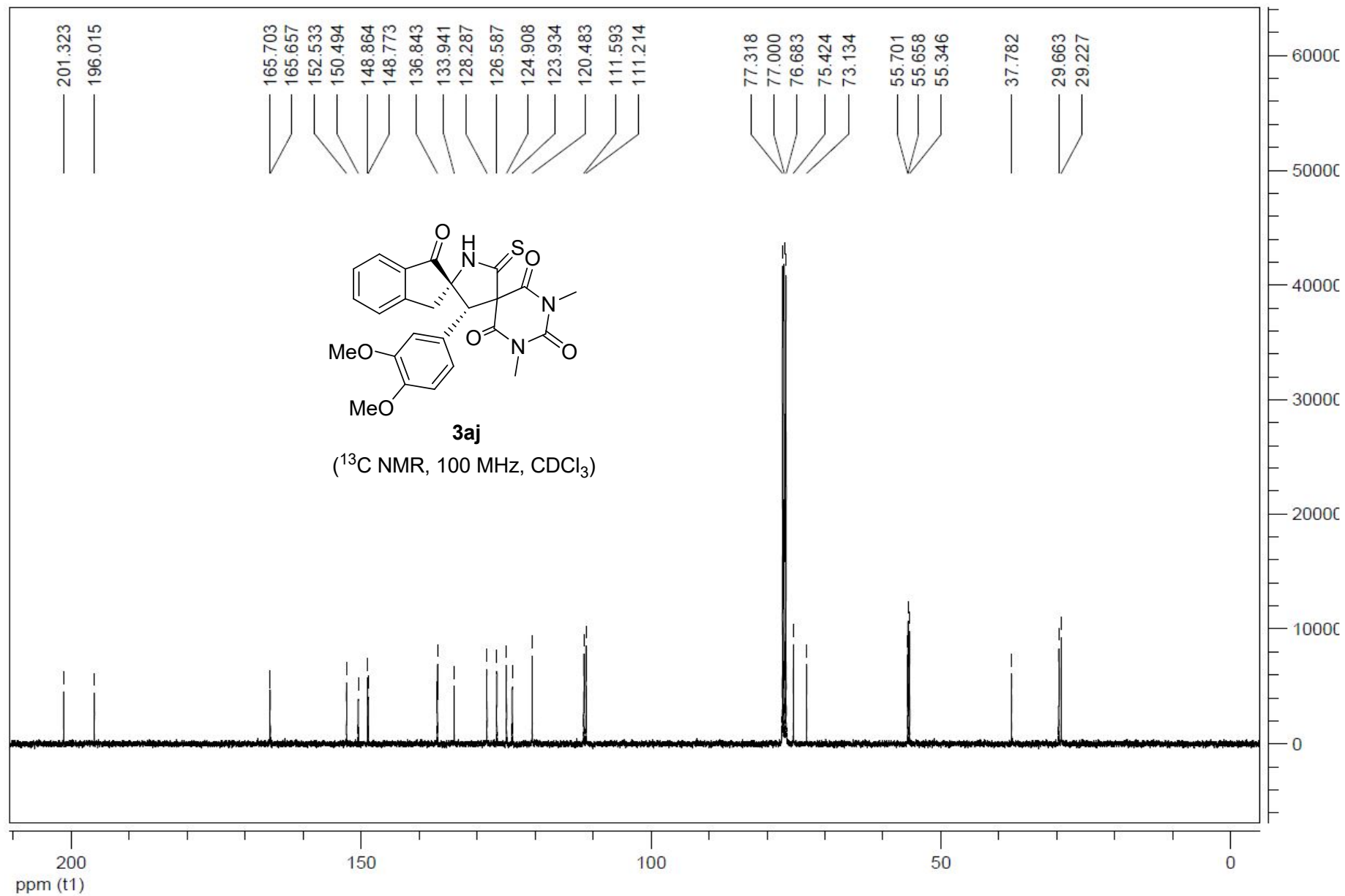


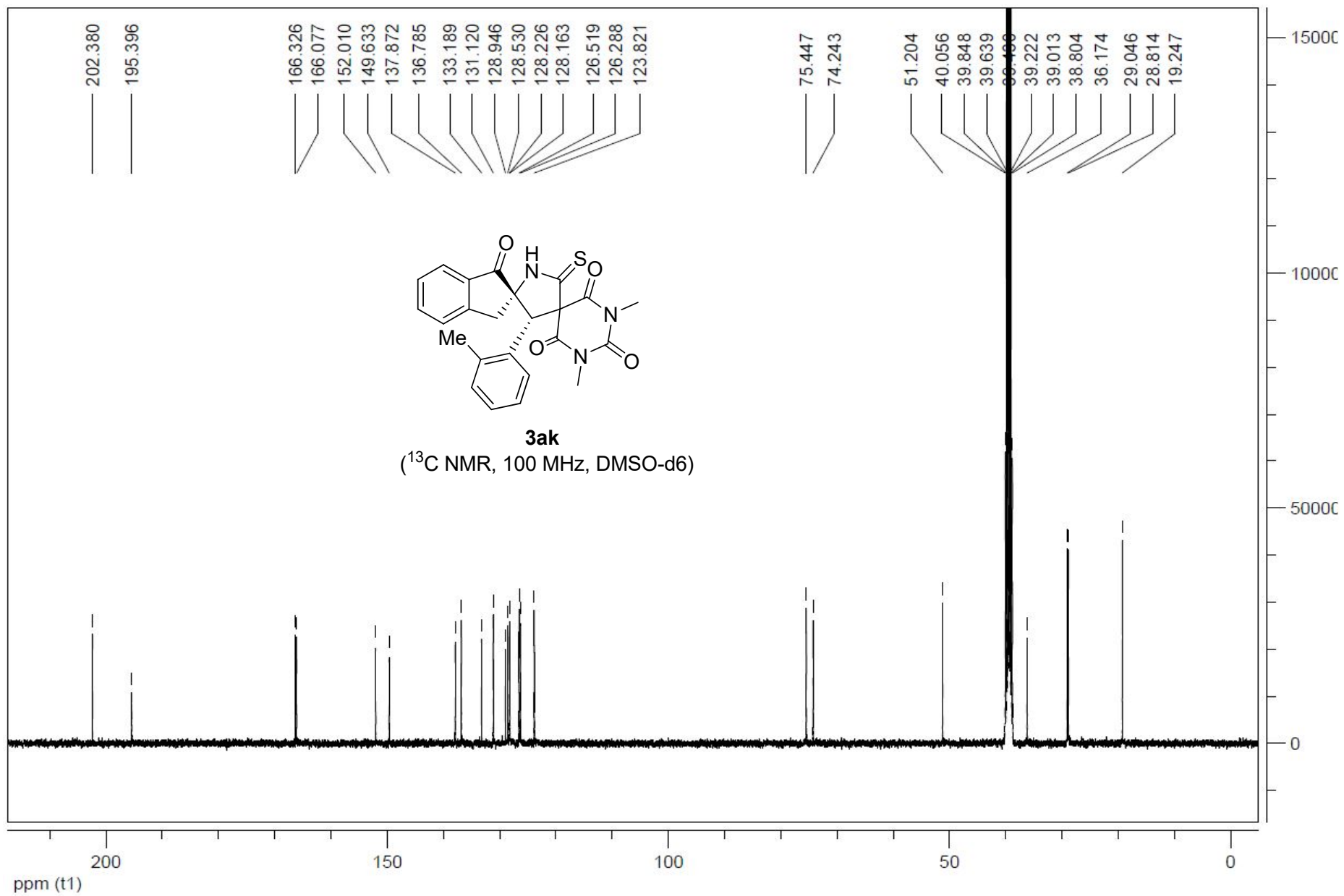


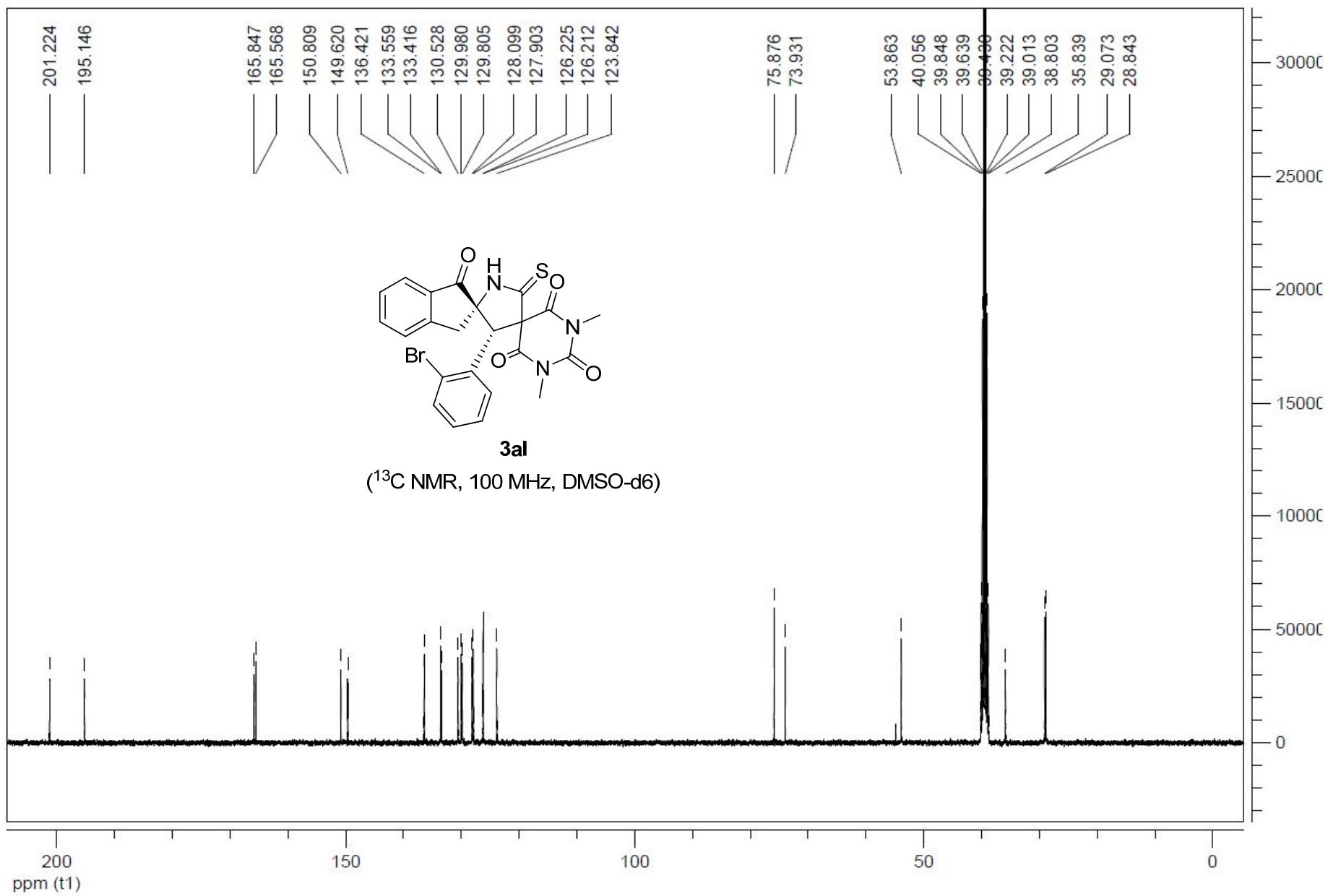


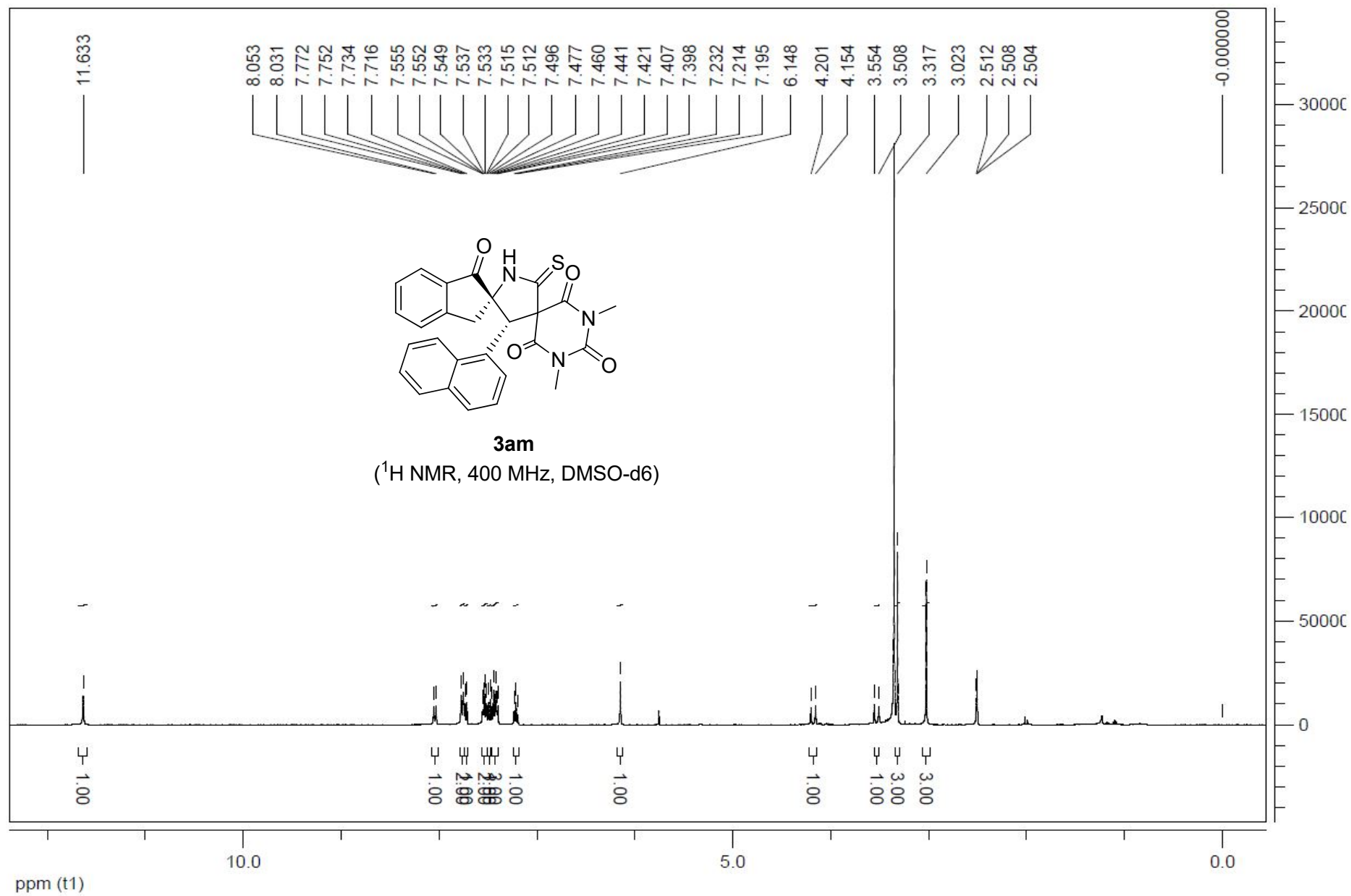


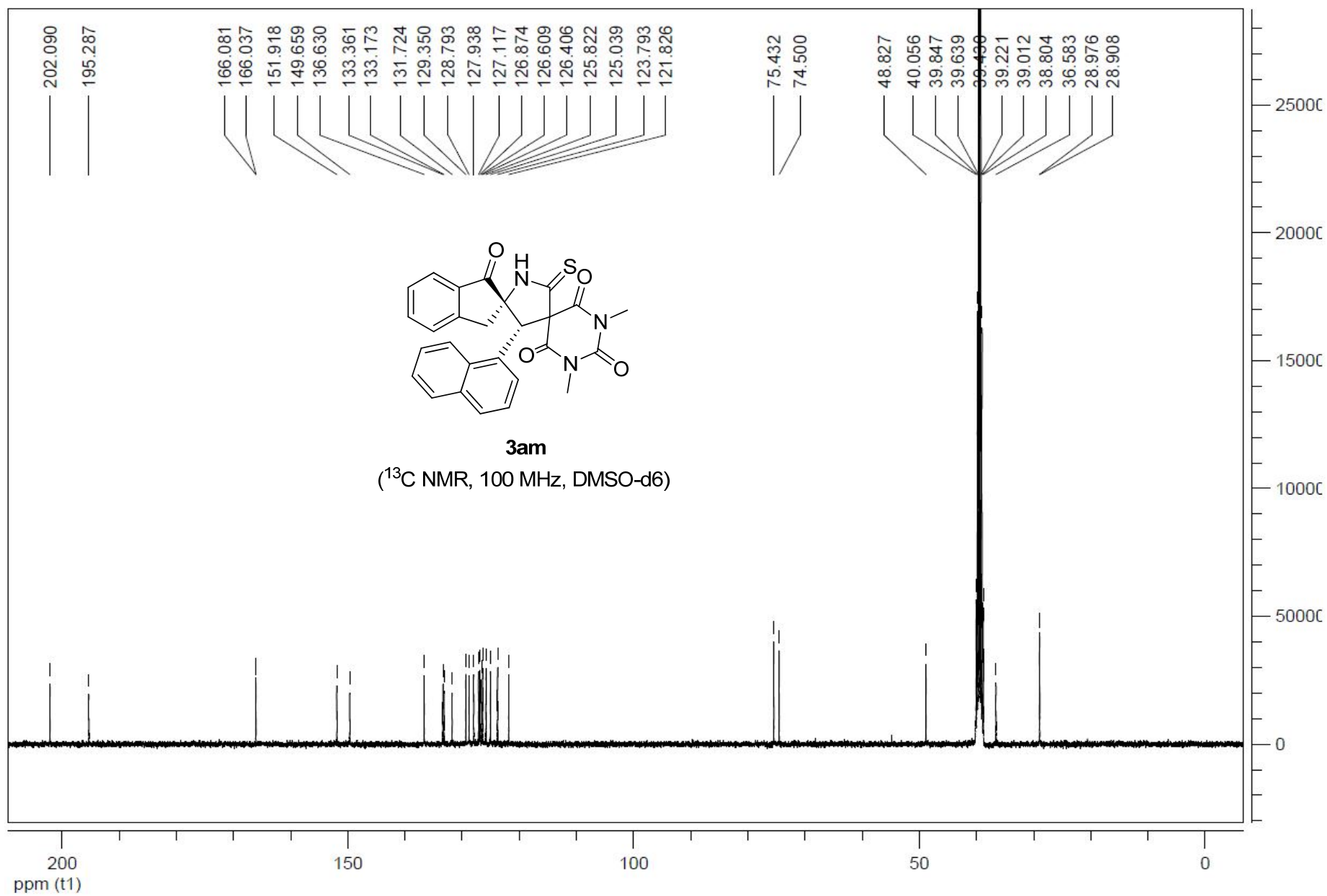


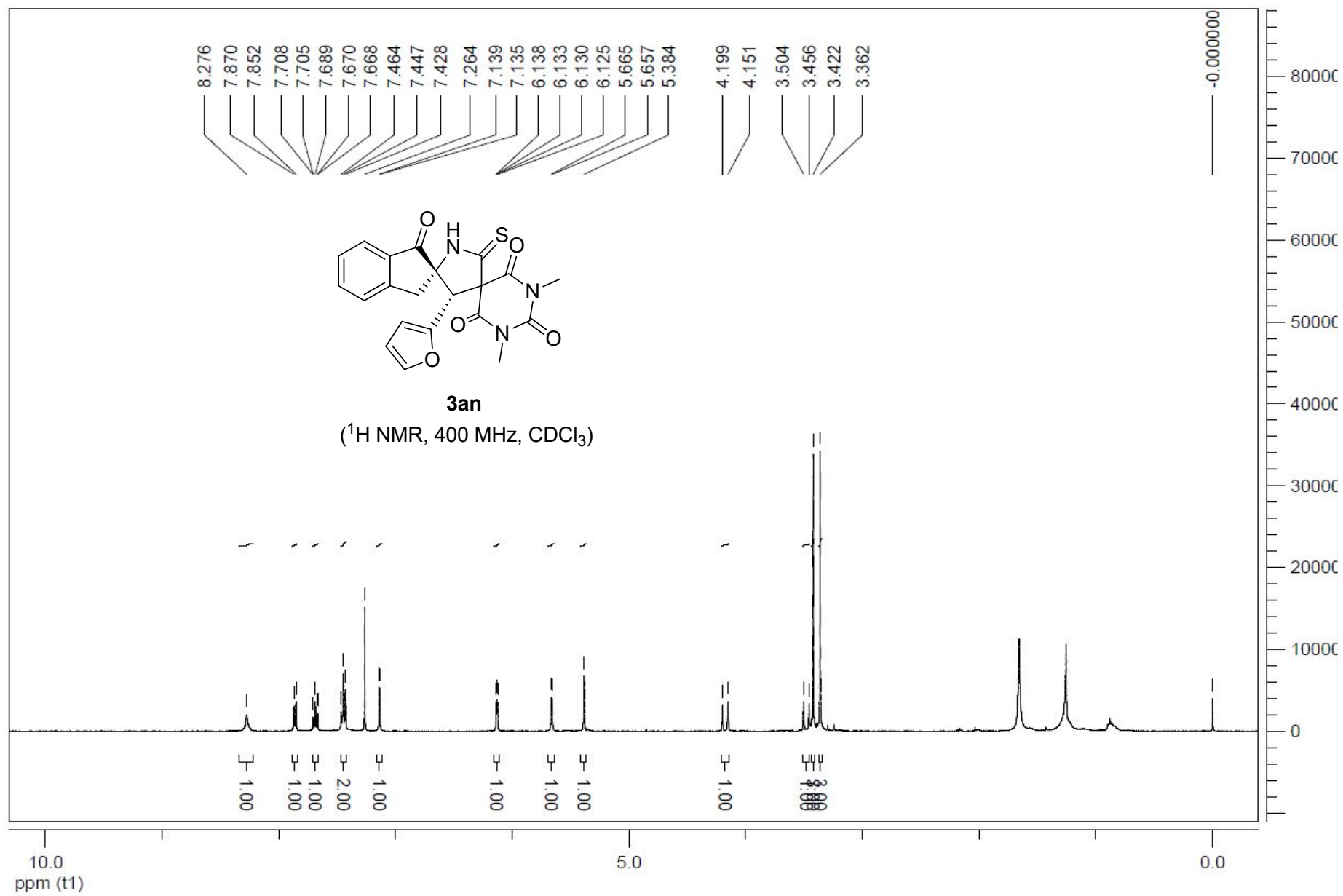


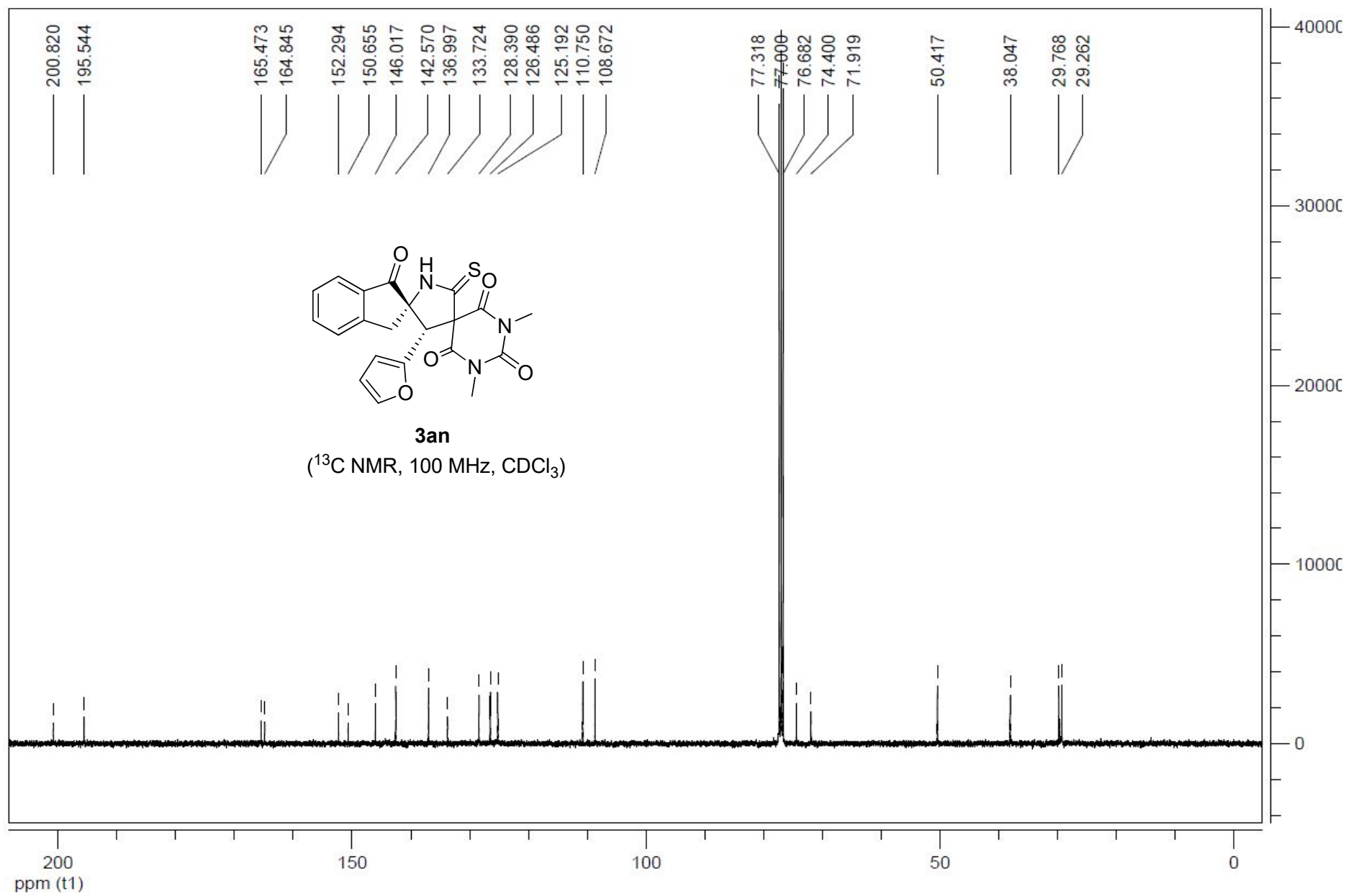


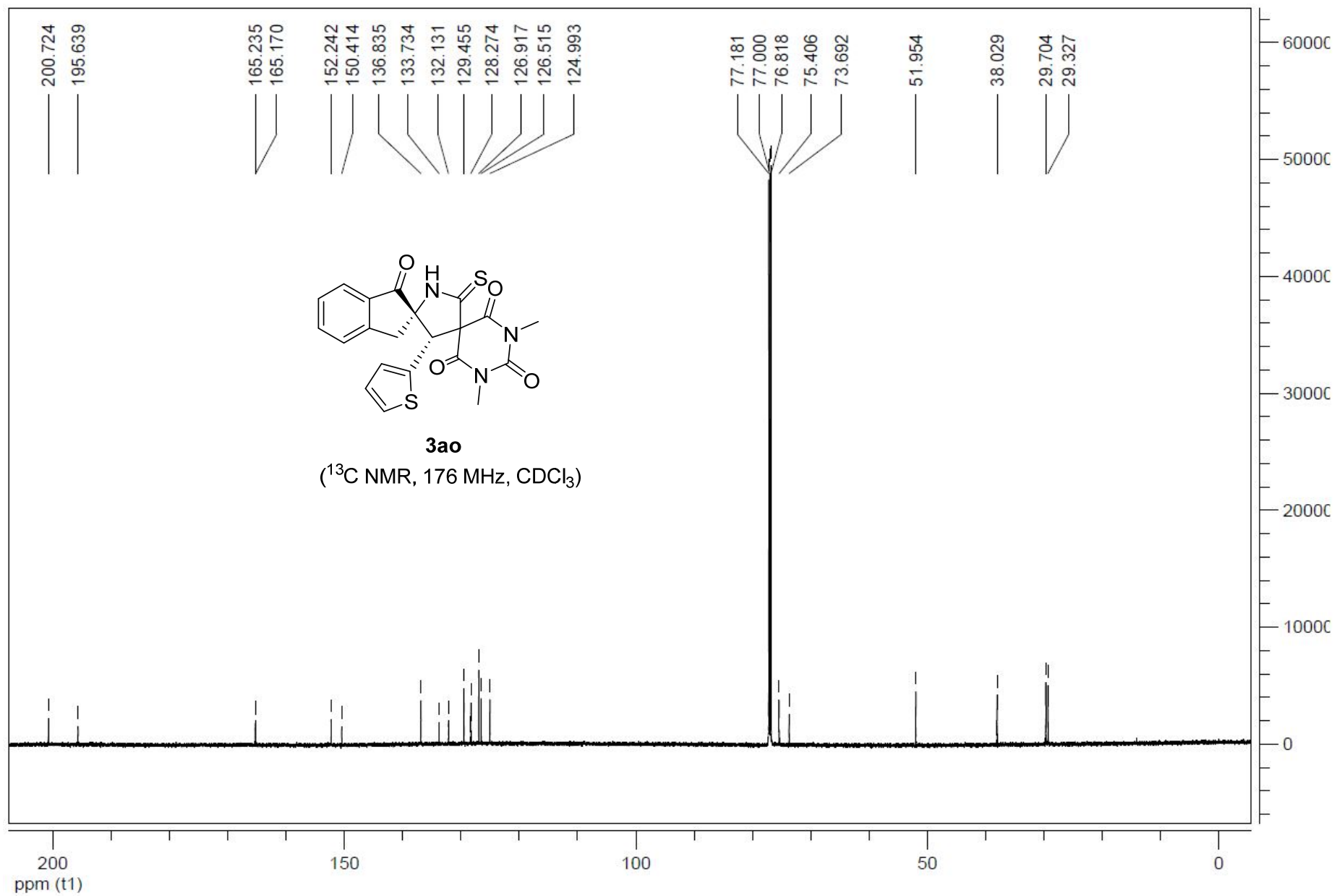


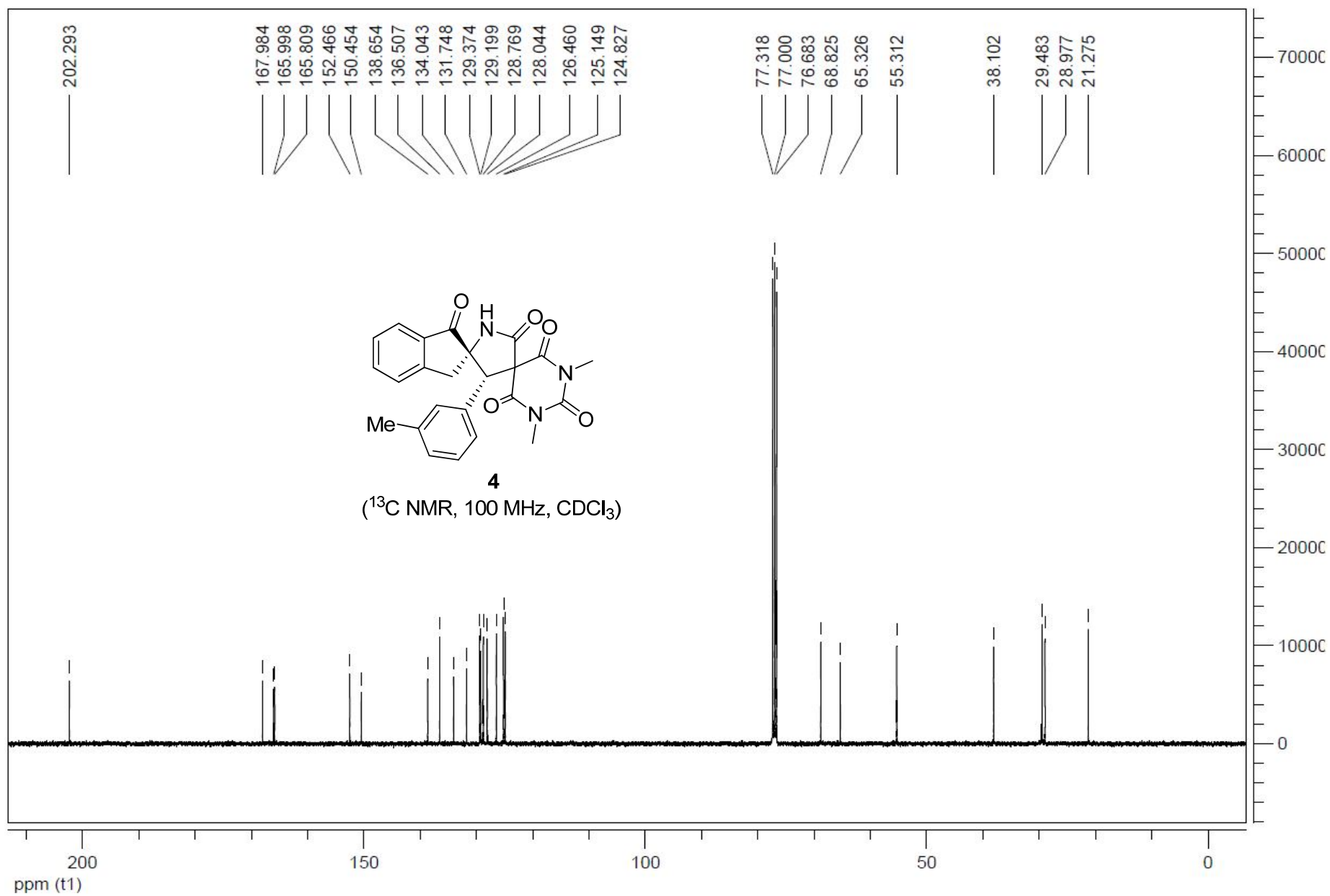


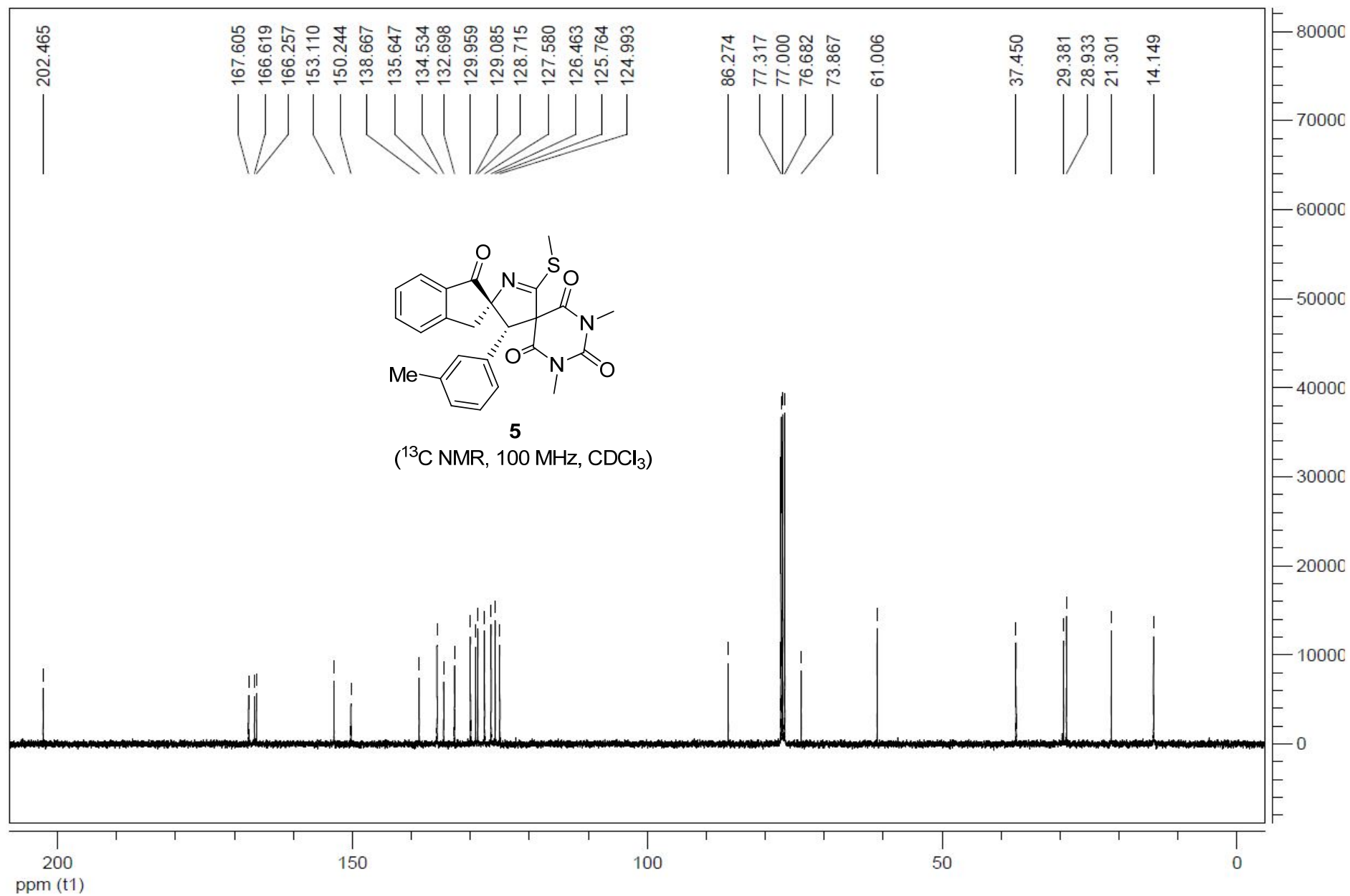




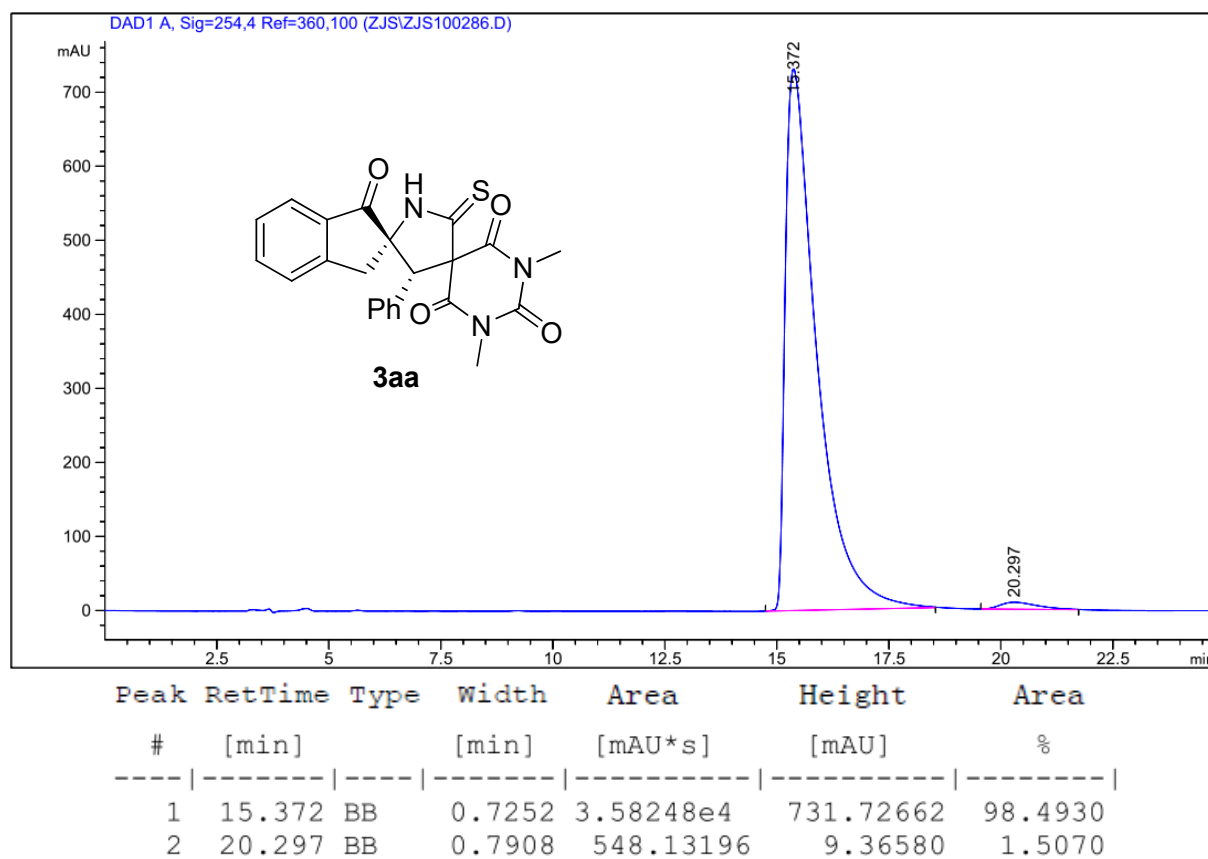
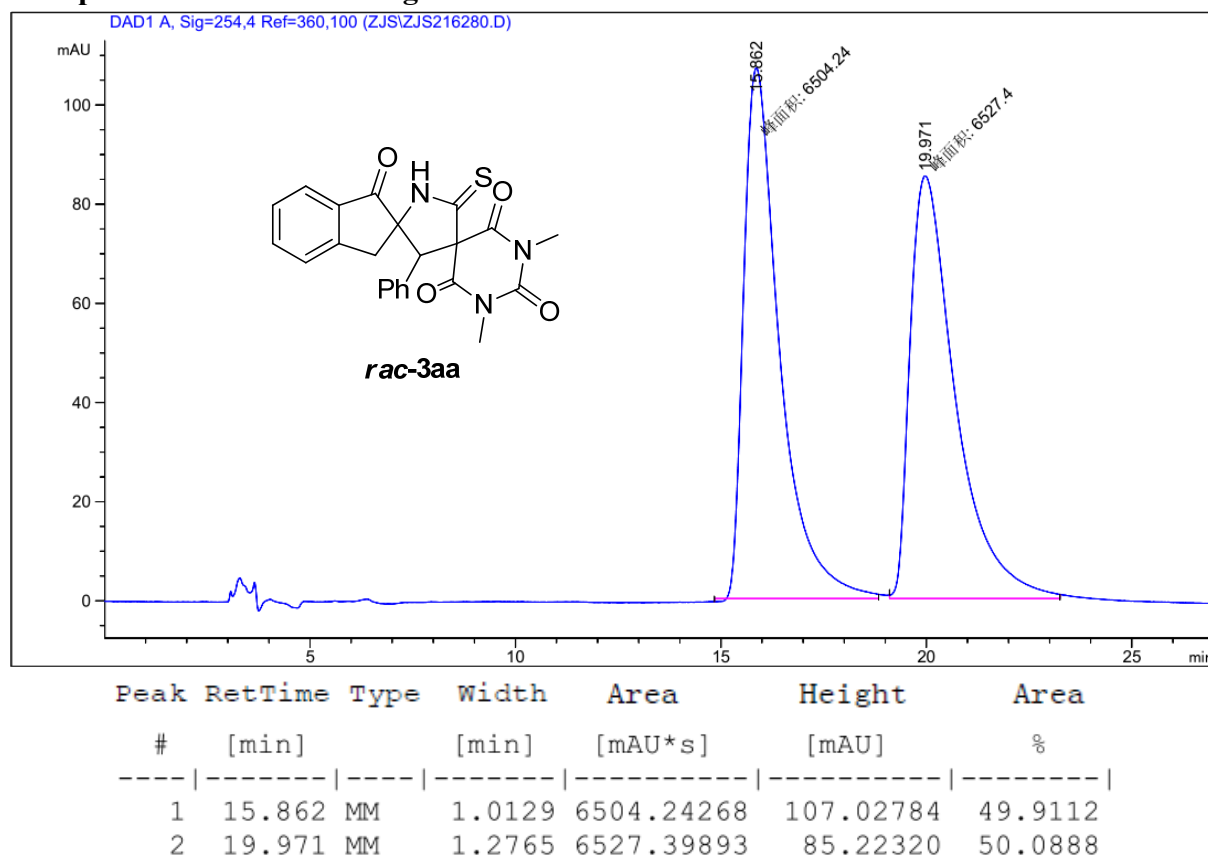


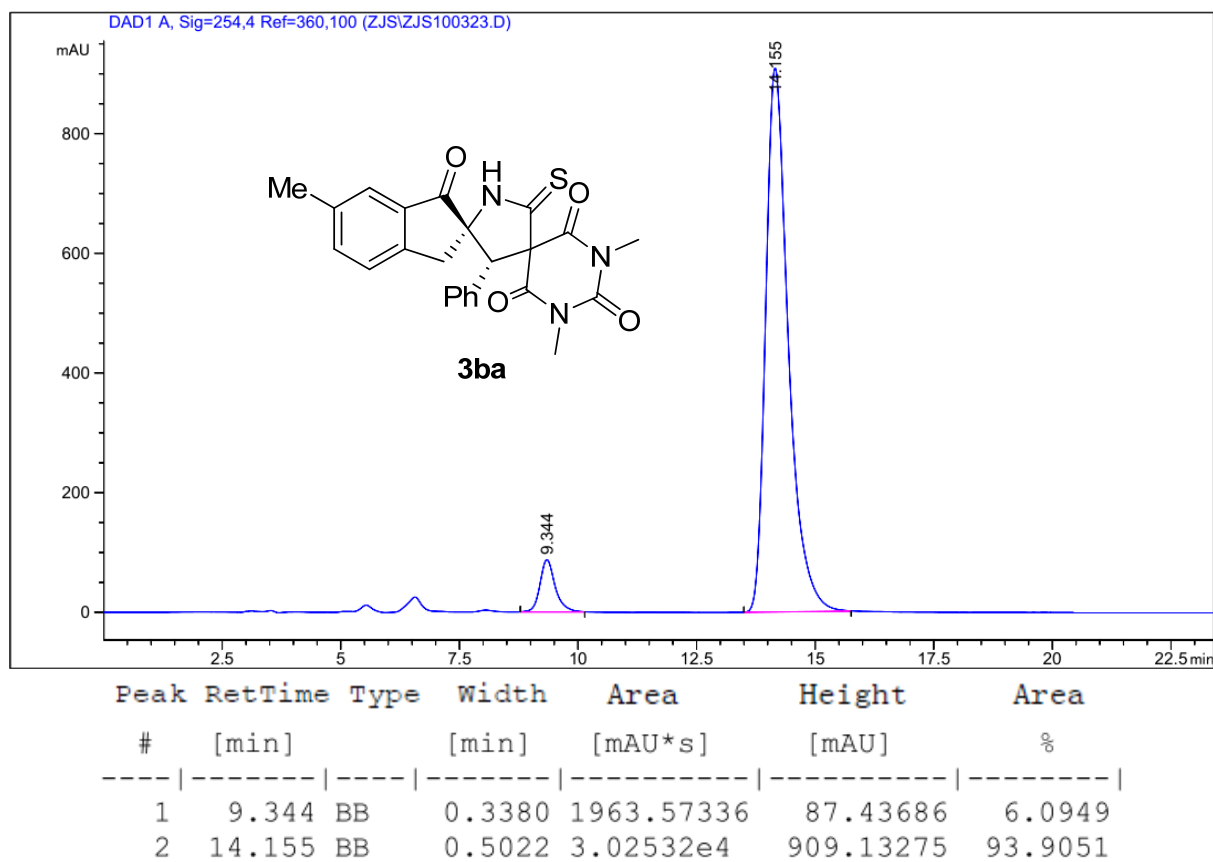
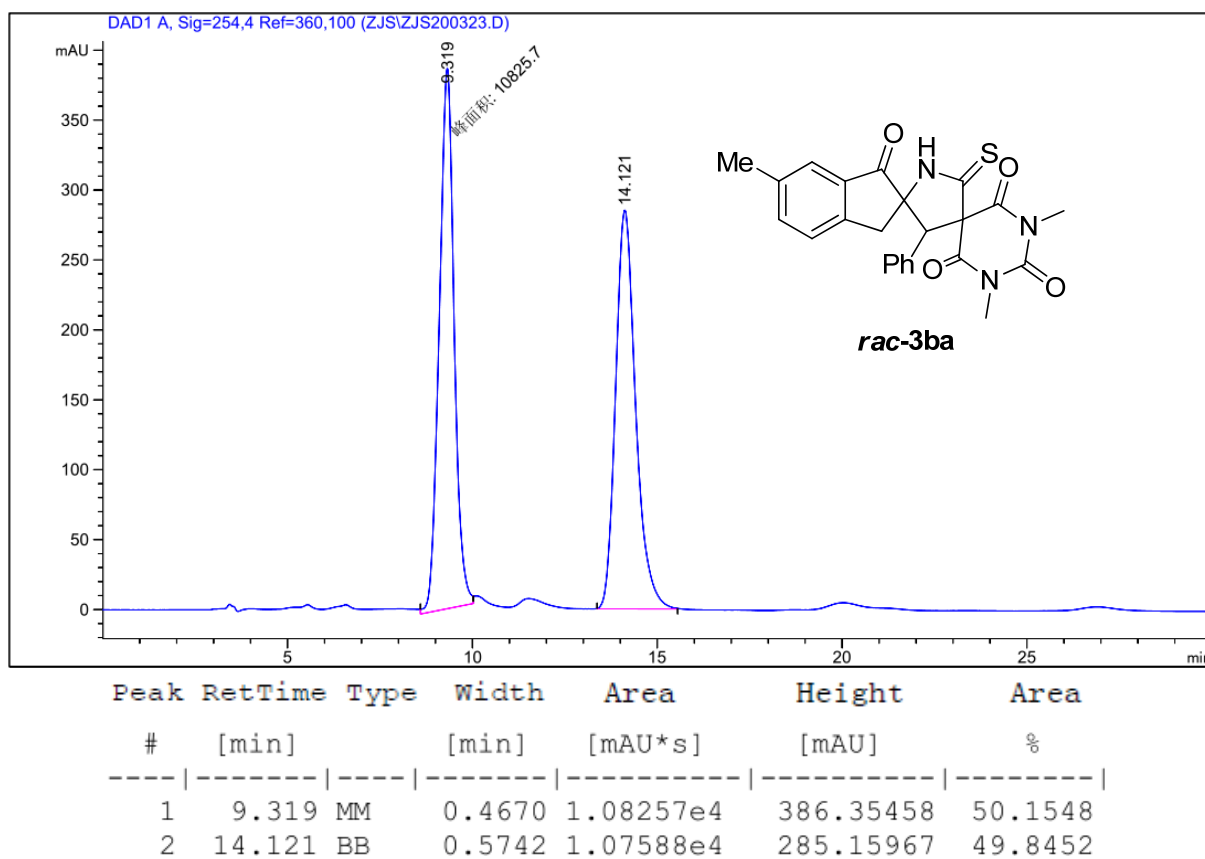


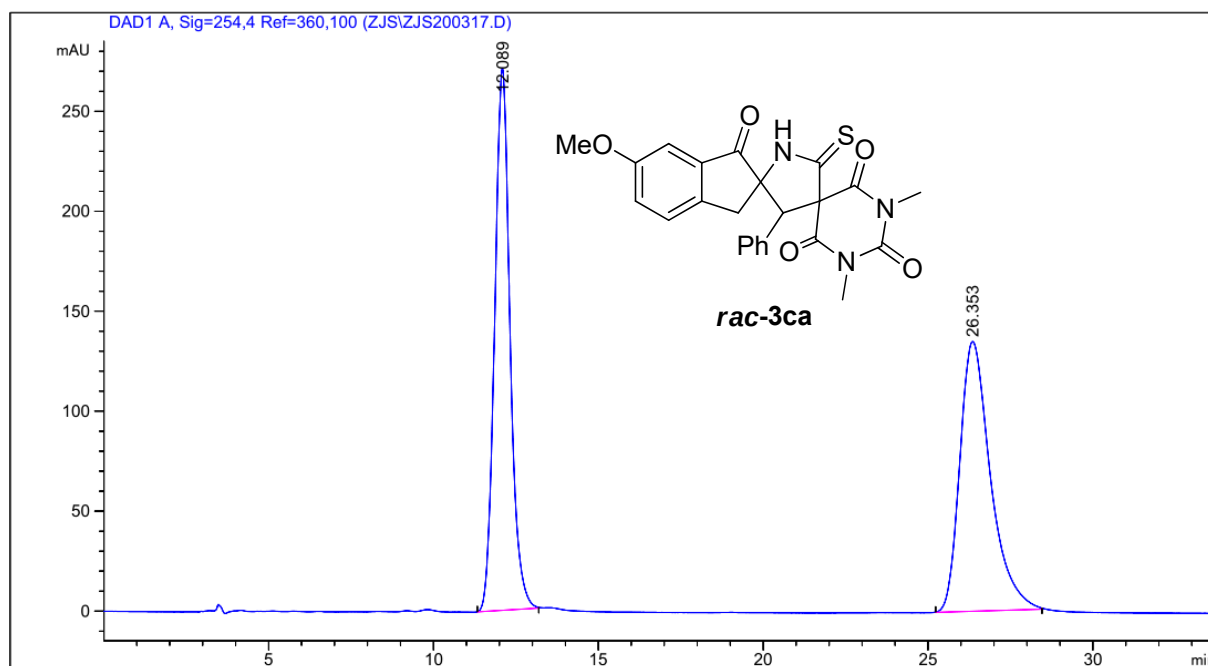




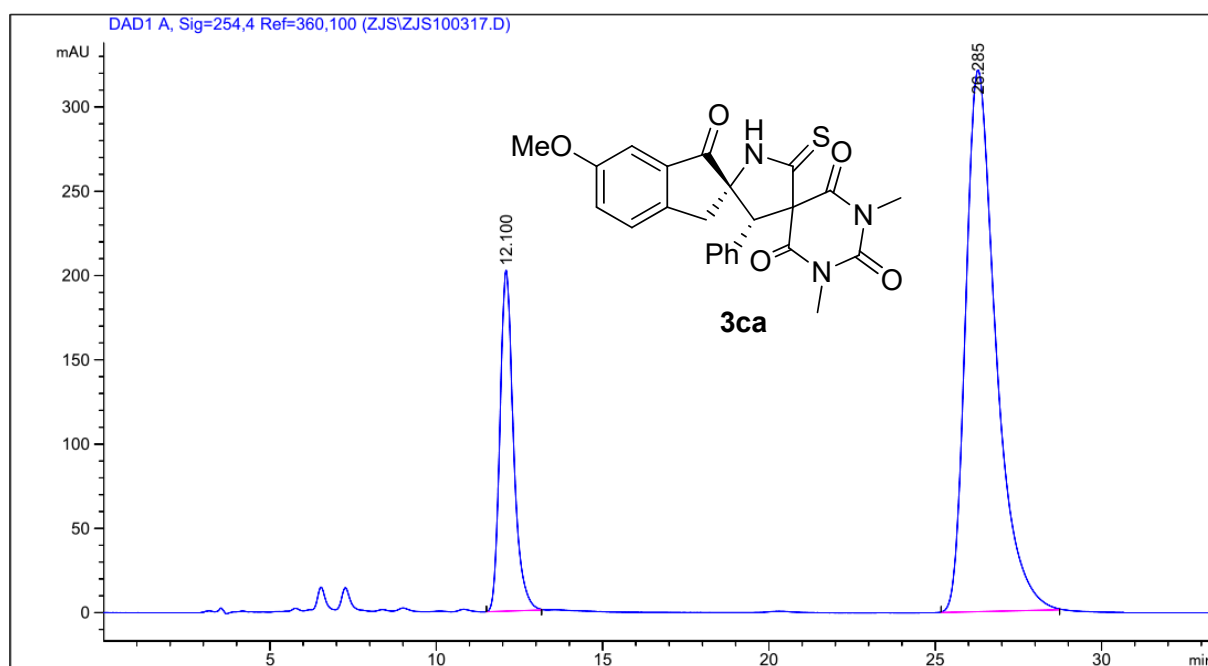
5. Copies of HPLC chromatograms



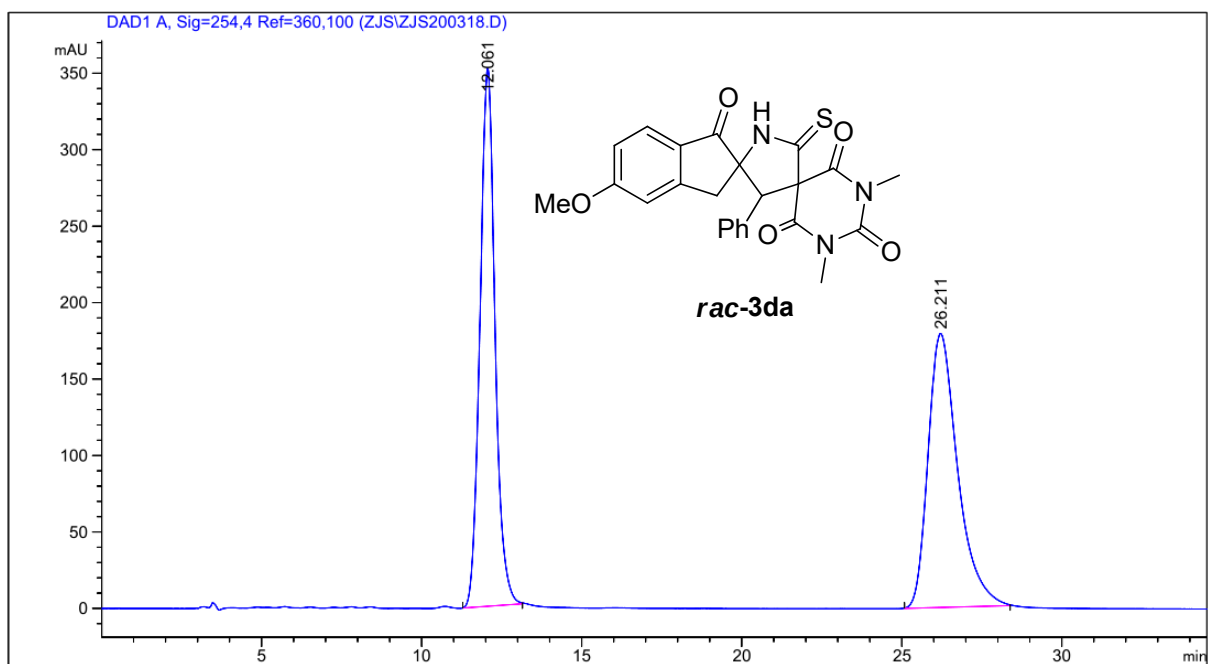




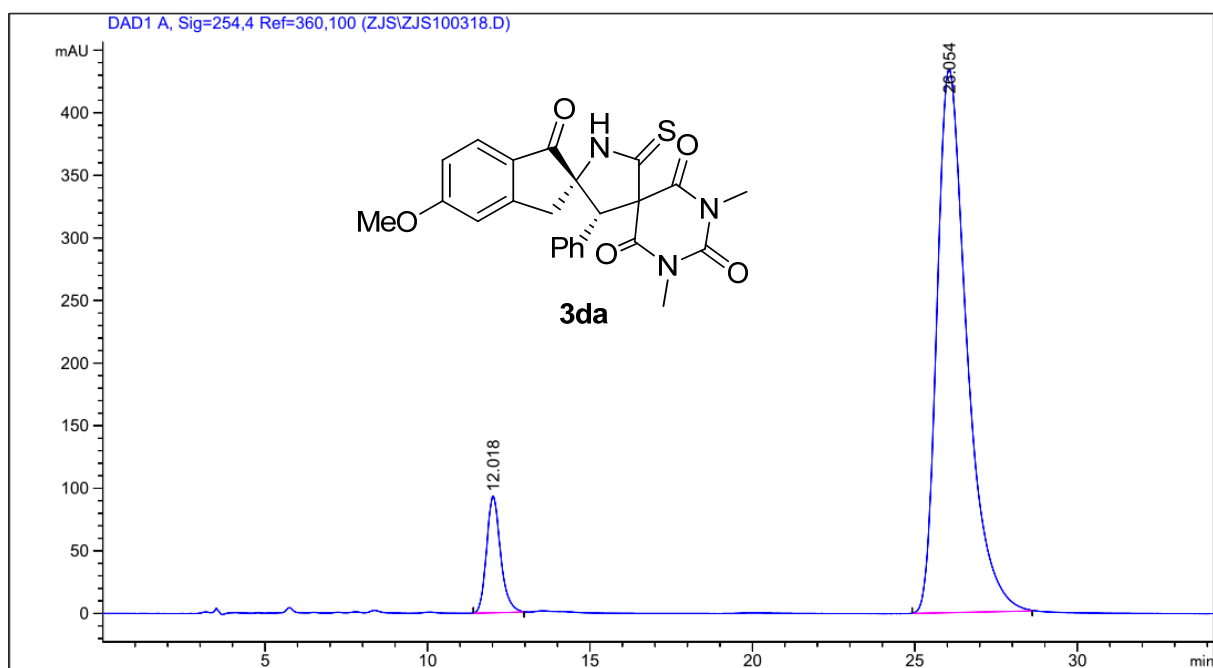
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.089	BB	0.4966	8799.12793	271.16763	50.2979
2	26.353	BB	0.9719	8694.90625	134.91916	49.7021



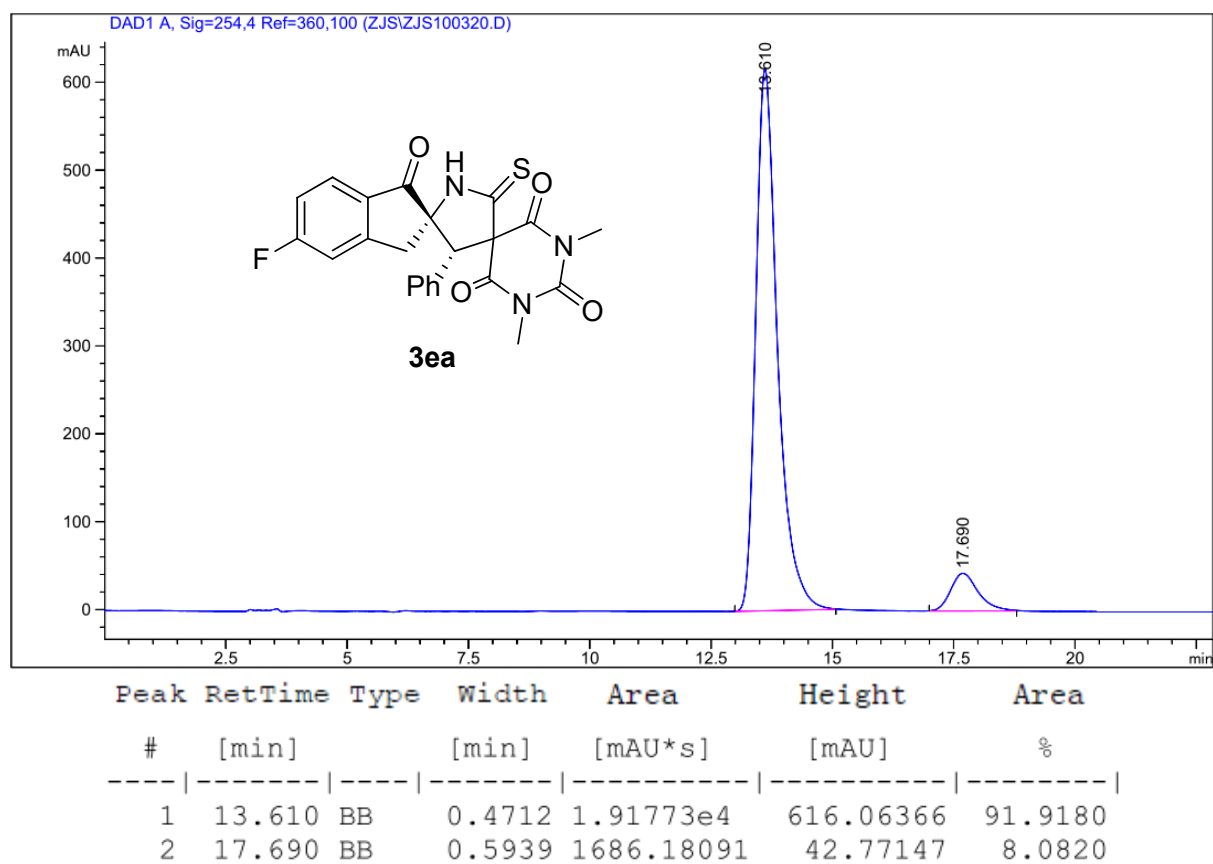
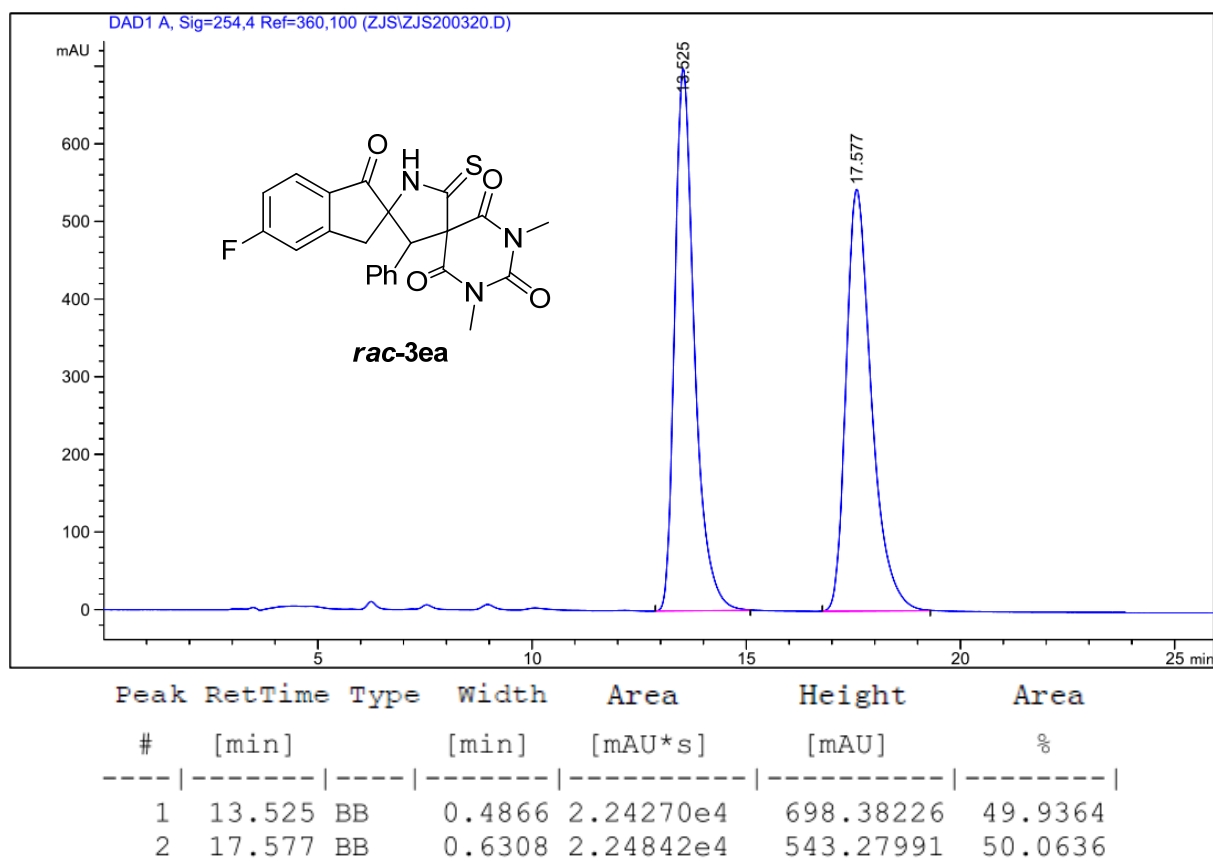
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.100	BB	0.4334	5742.90625	202.14685	22.0987
2	26.285	BB	0.9411	2.02447e4	321.30673	77.9013

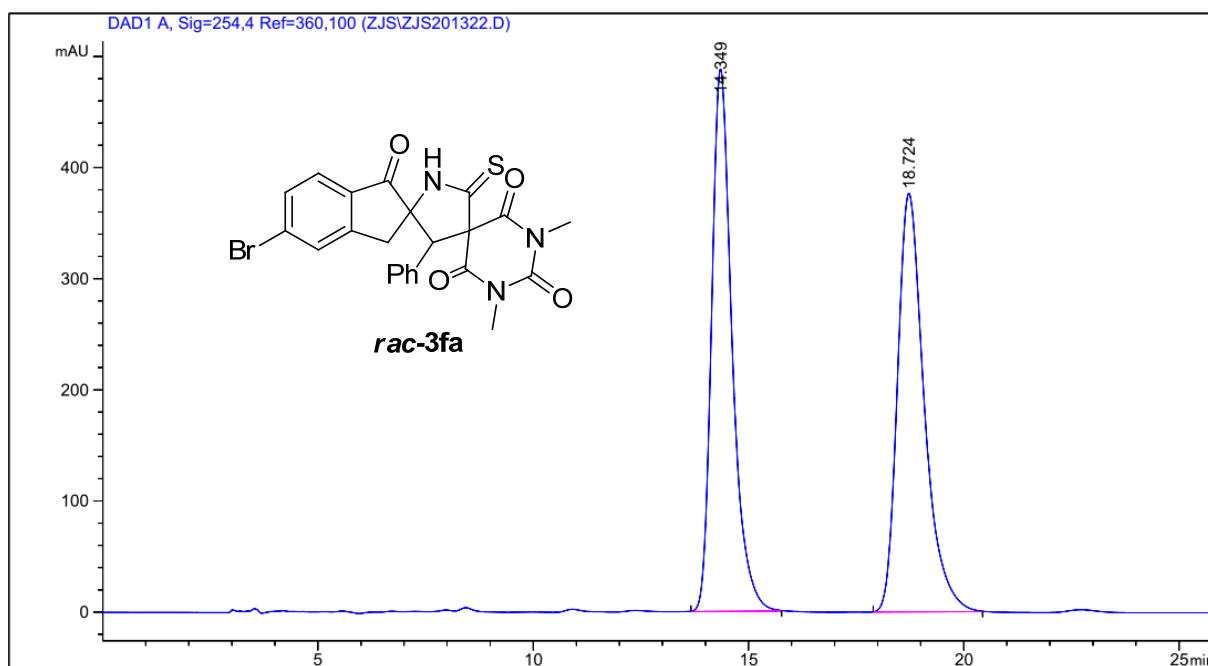


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.061	BB	0.4974	1.15116e4	352.09341	49.9219
2	26.211	BB	0.9780	1.15476e4	179.14830	50.0781

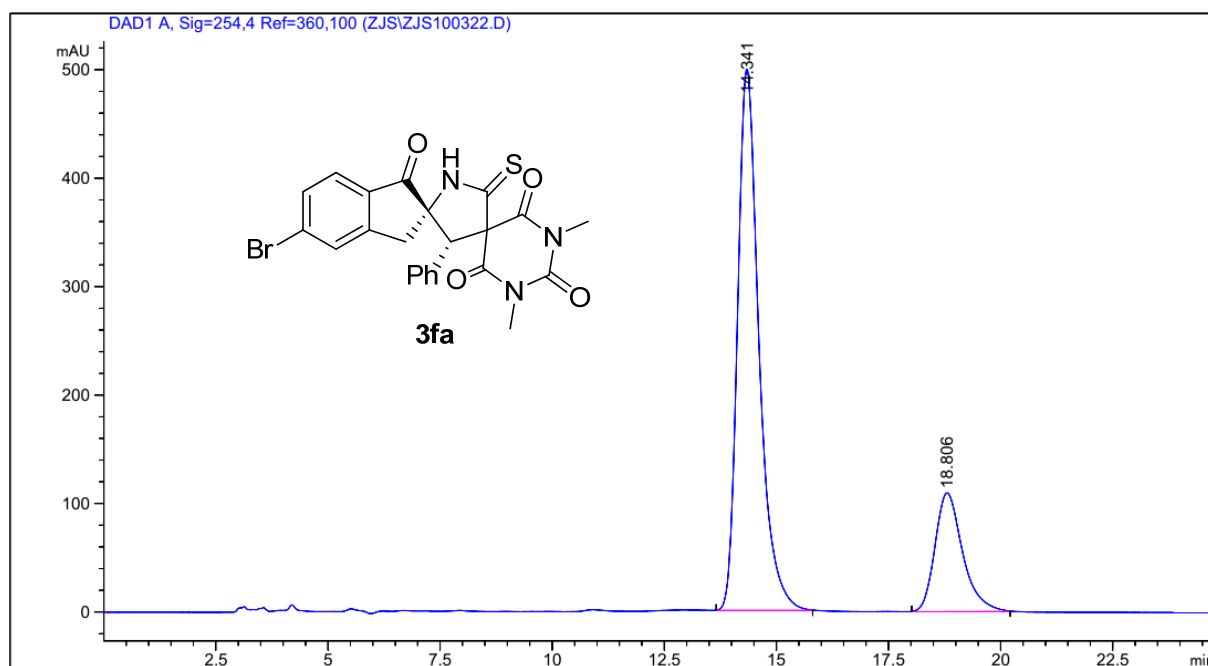


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.018	BB	0.4597	2807.75073	93.14551	9.1983
2	26.054	BB	0.9587	2.77168e4	434.22656	90.8017

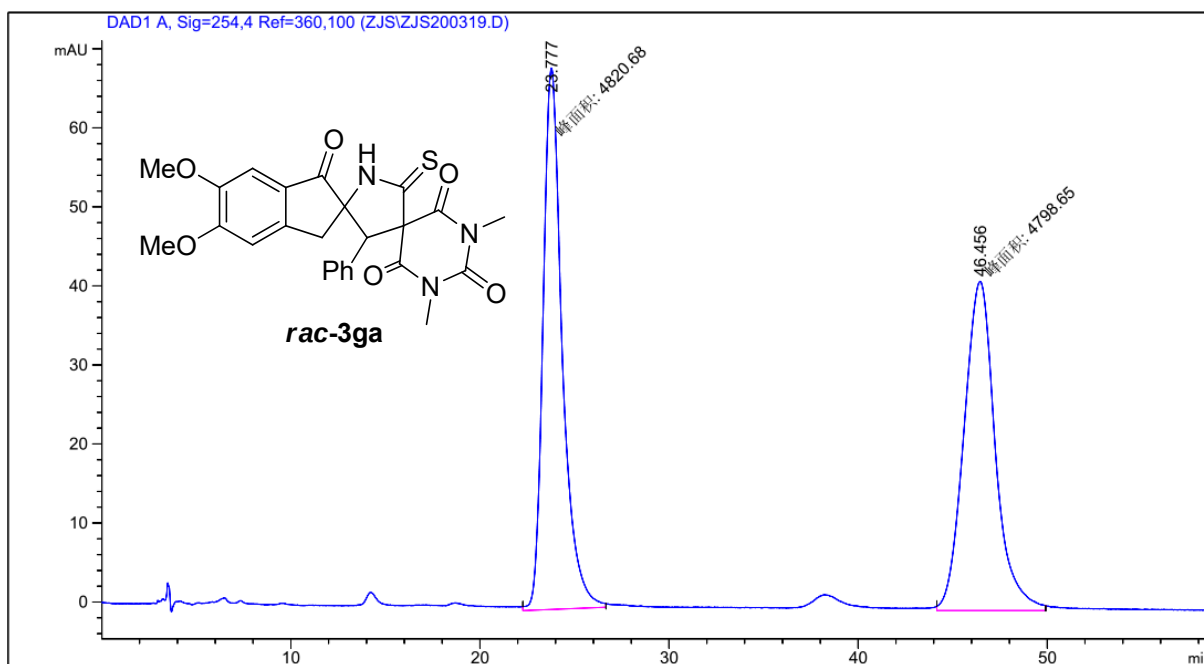




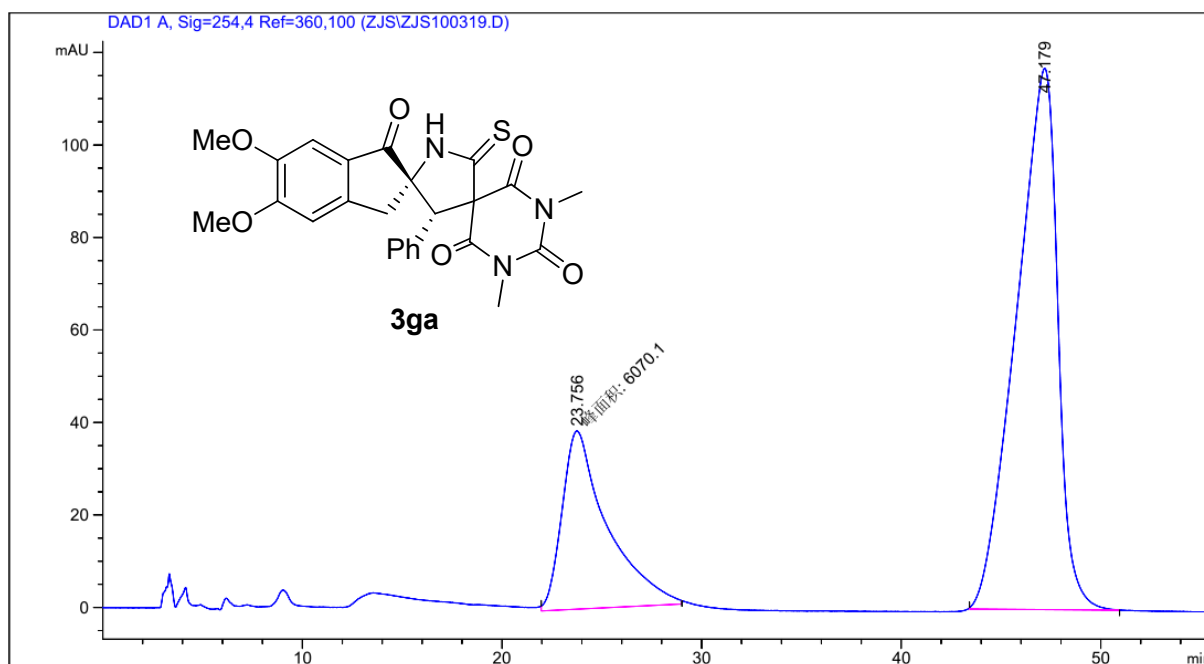
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.349	BB	0.5007	1.60945e4	488.06161	49.7357
2	18.724	BB	0.6518	1.62656e4	376.69672	50.2643



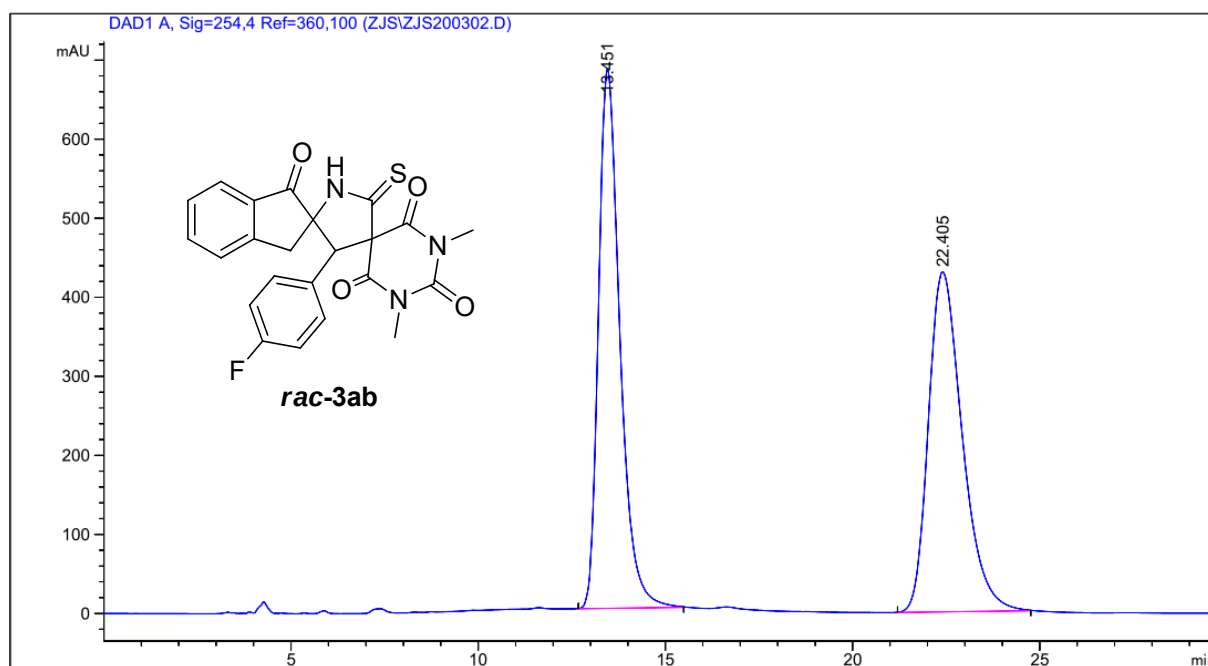
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.341	BB	0.5002	1.65249e4	499.19998	77.9135
2	18.806	BB	0.6534	4684.39844	109.44051	22.0865



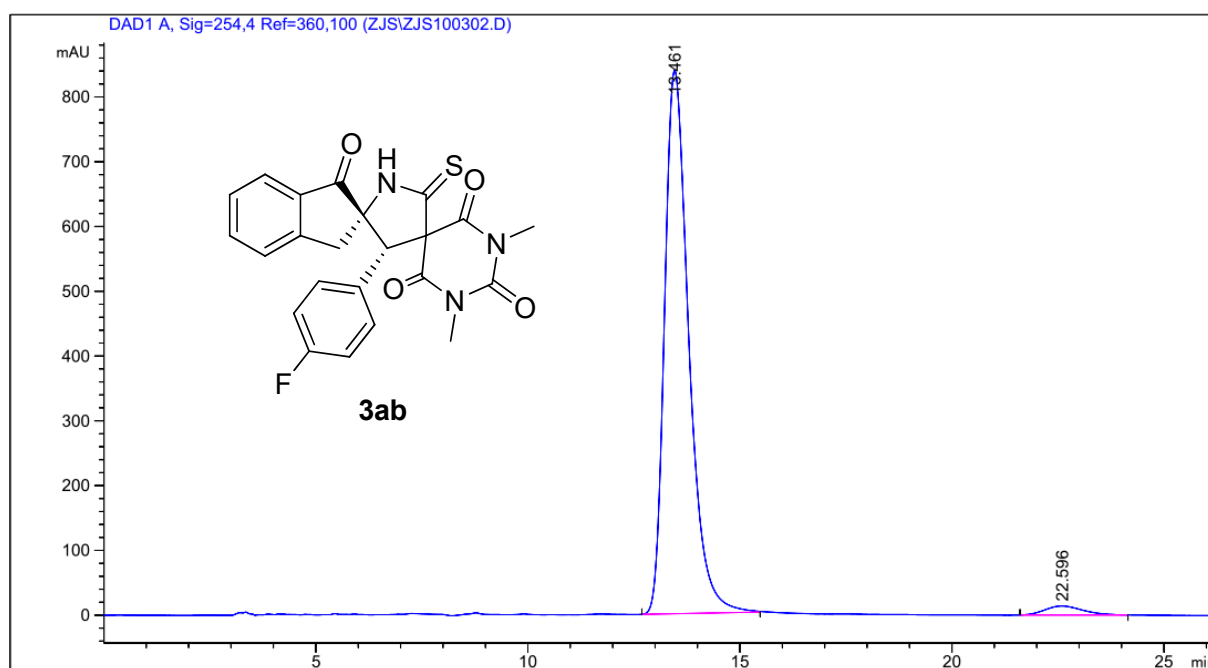
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	23.777	MM	1.1725	4820.68408	68.52416	50.1146
2	46.456	MM	1.9190	4798.64502	41.67612	49.8854



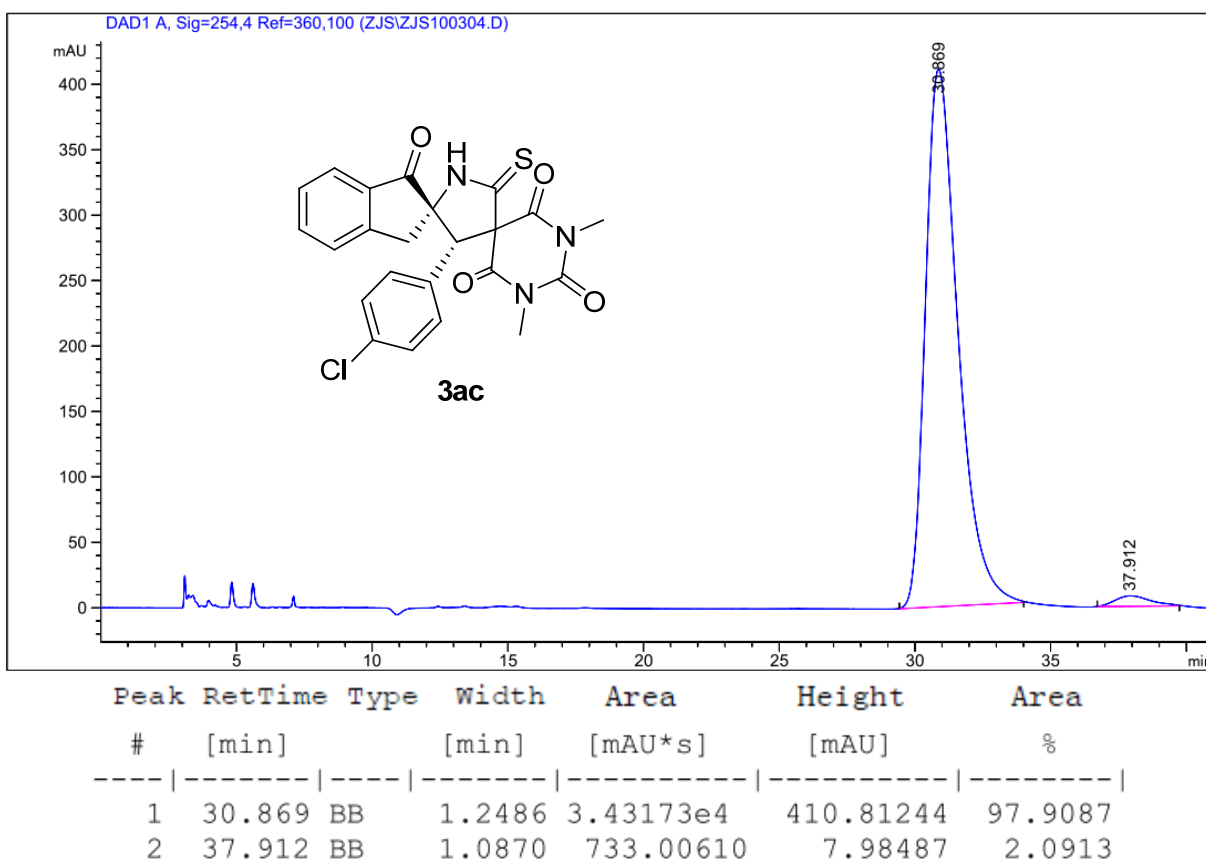
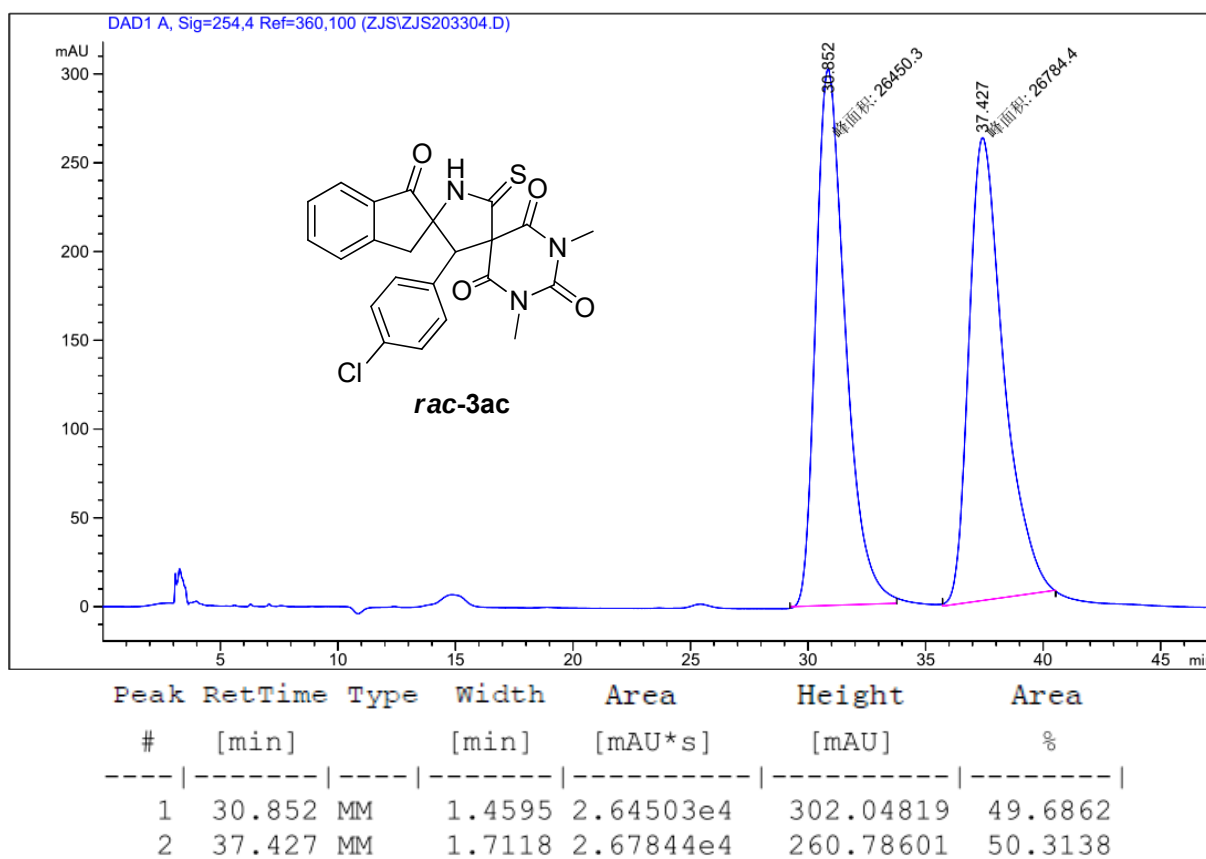
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	23.756	MM	2.6244	6070.09961	38.54853	26.4741
2	47.179	BB	1.7366	1.68583e4	117.03114	73.5259

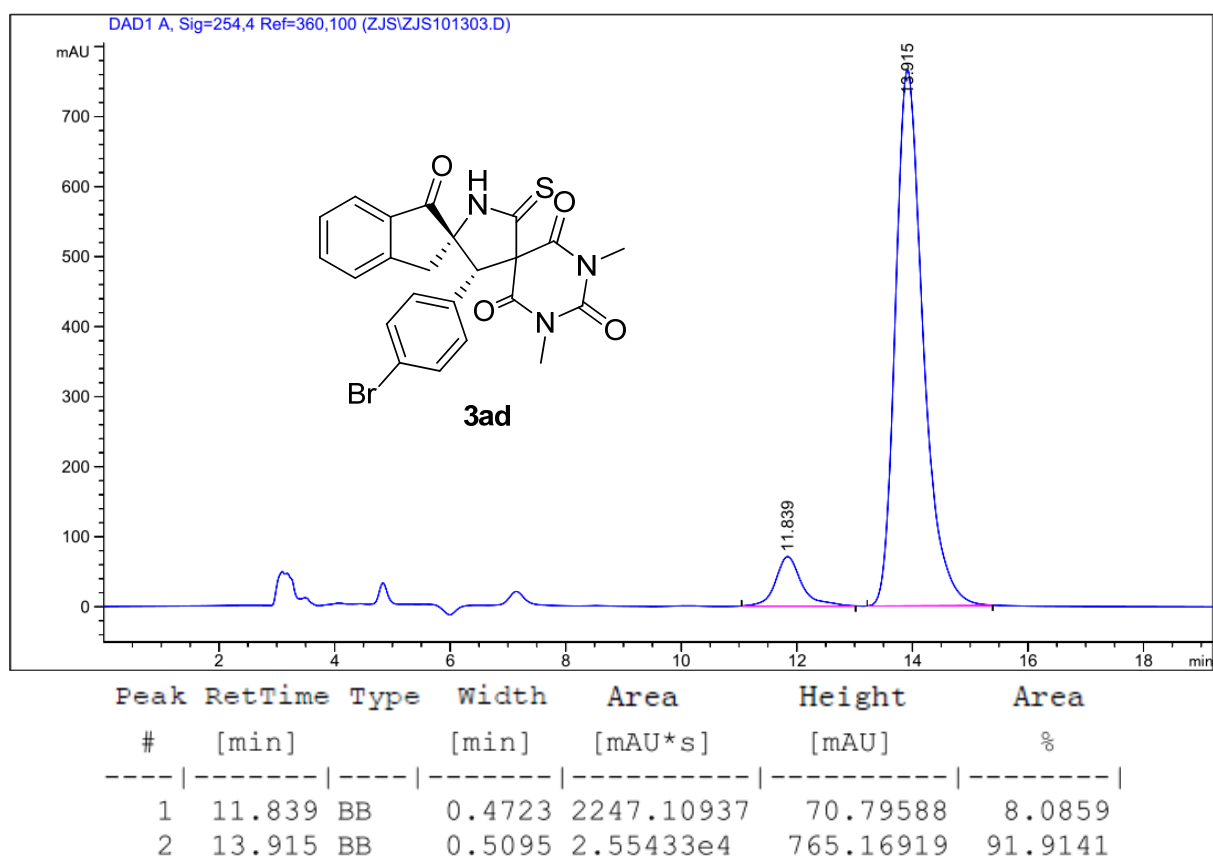
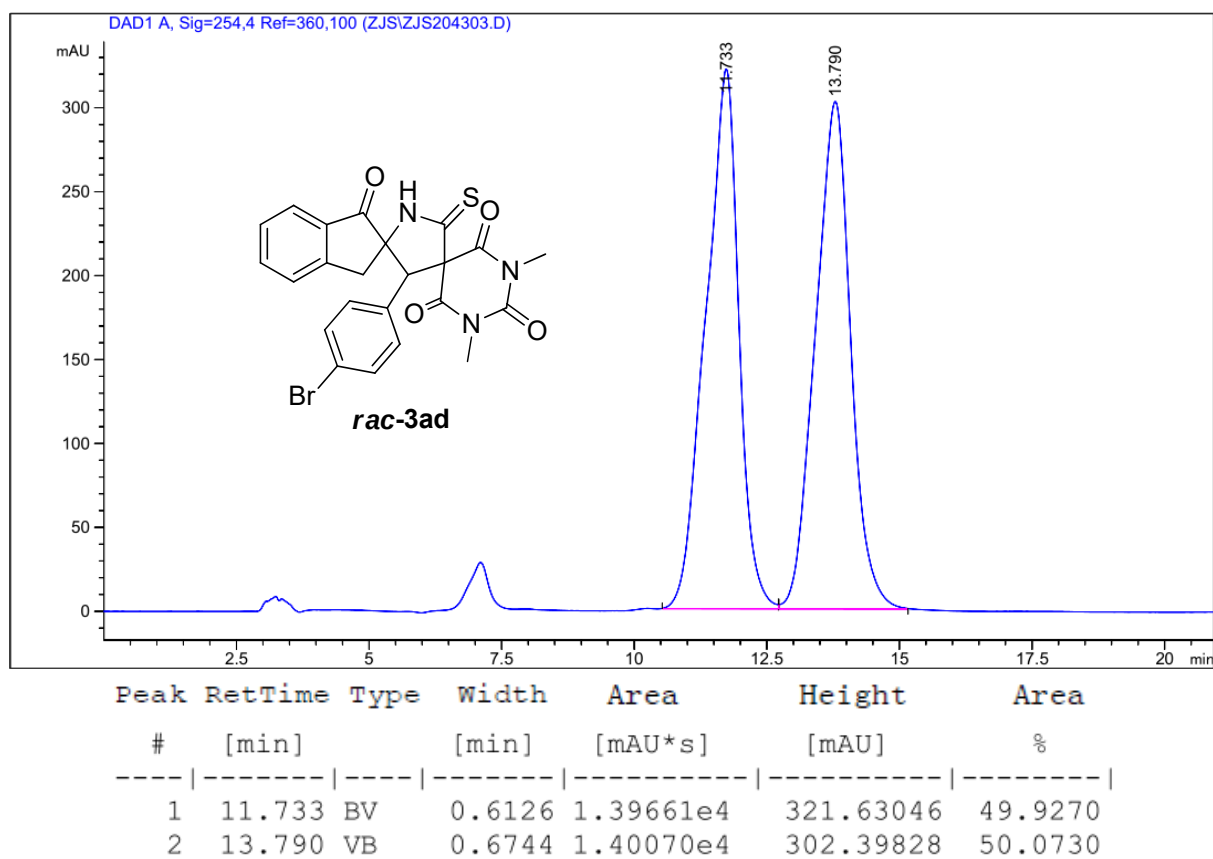


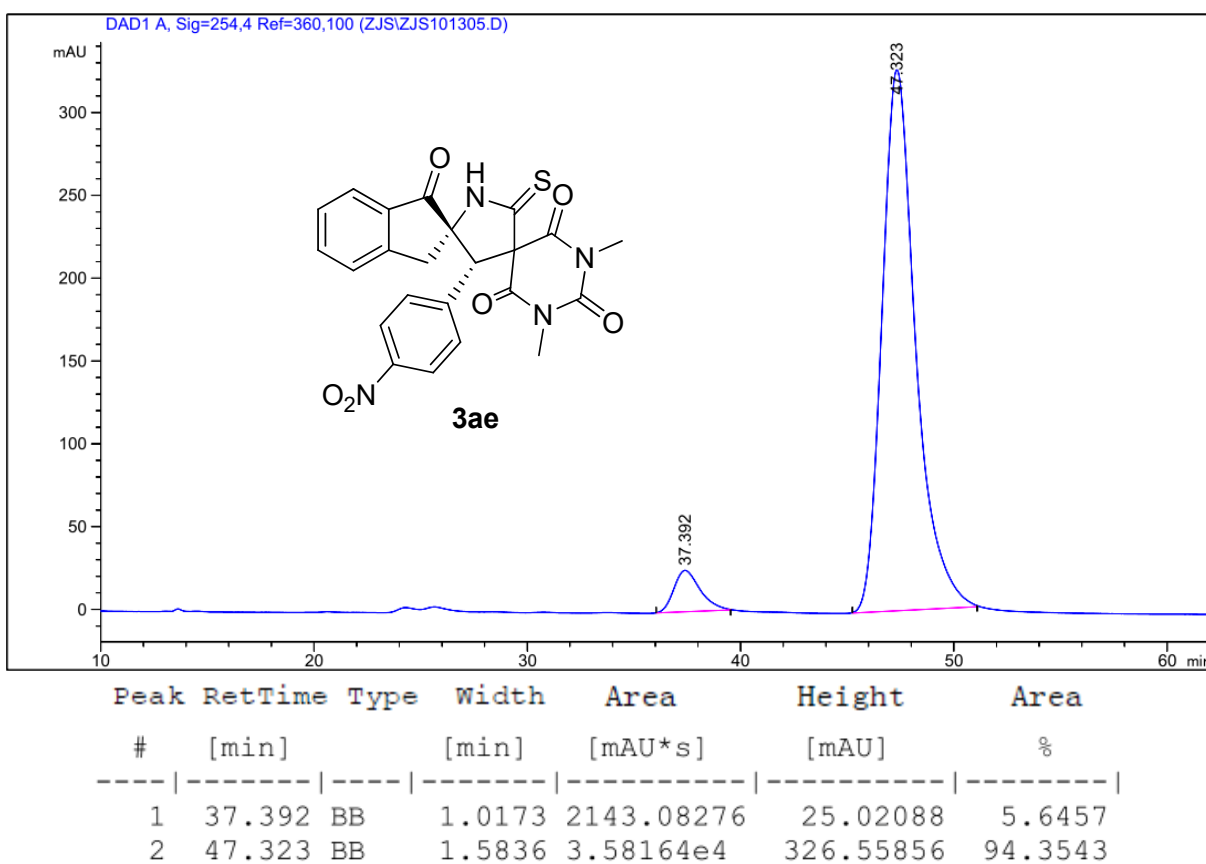
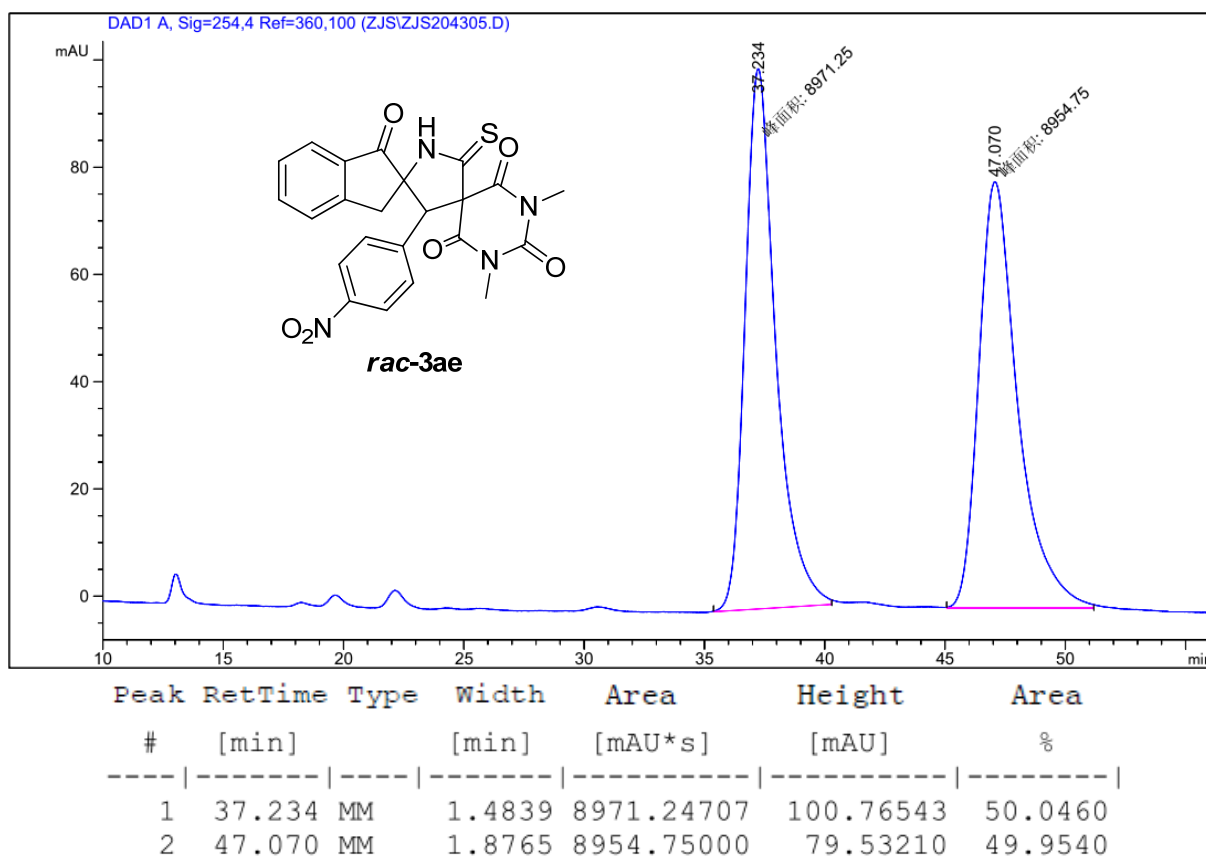
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.451	BB	0.6055	2.70965e4	682.02148	50.0609
2	22.405	BB	0.9609	2.70306e4	430.25720	49.9391

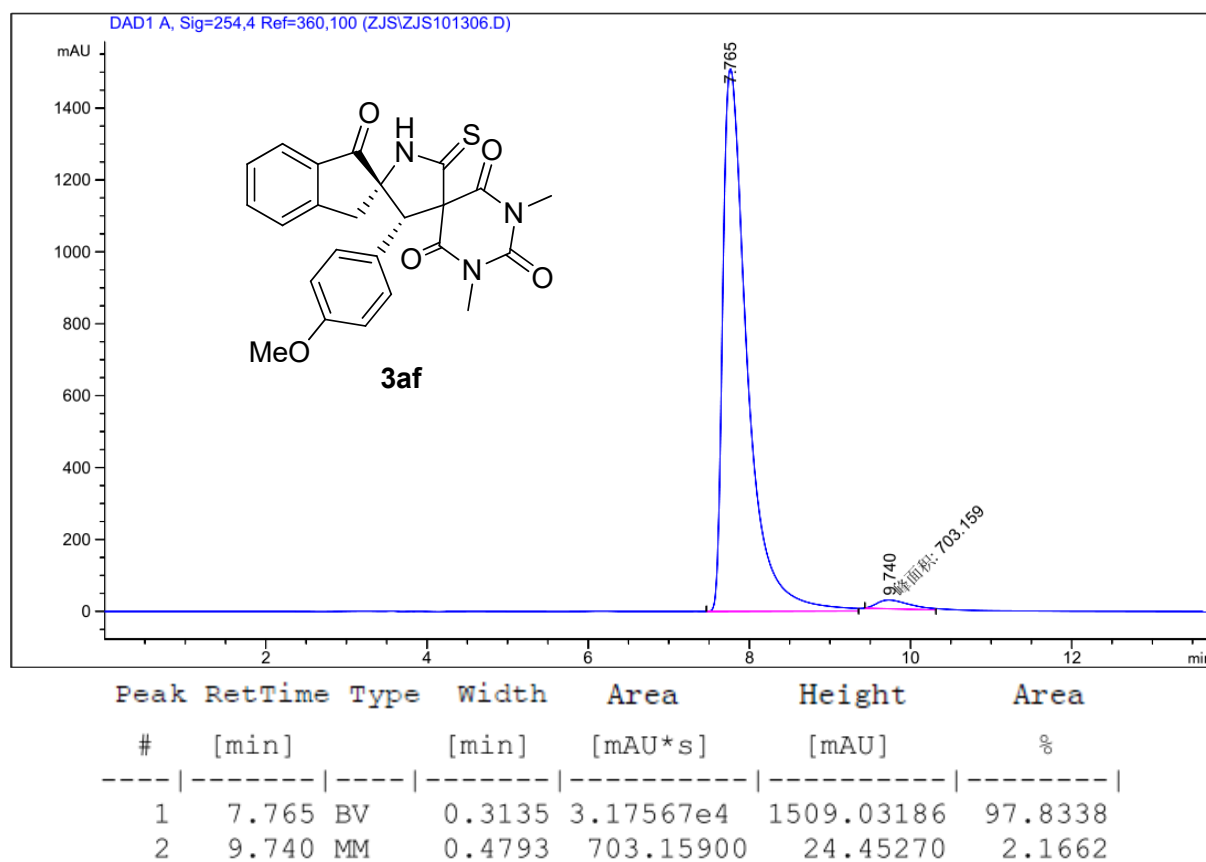
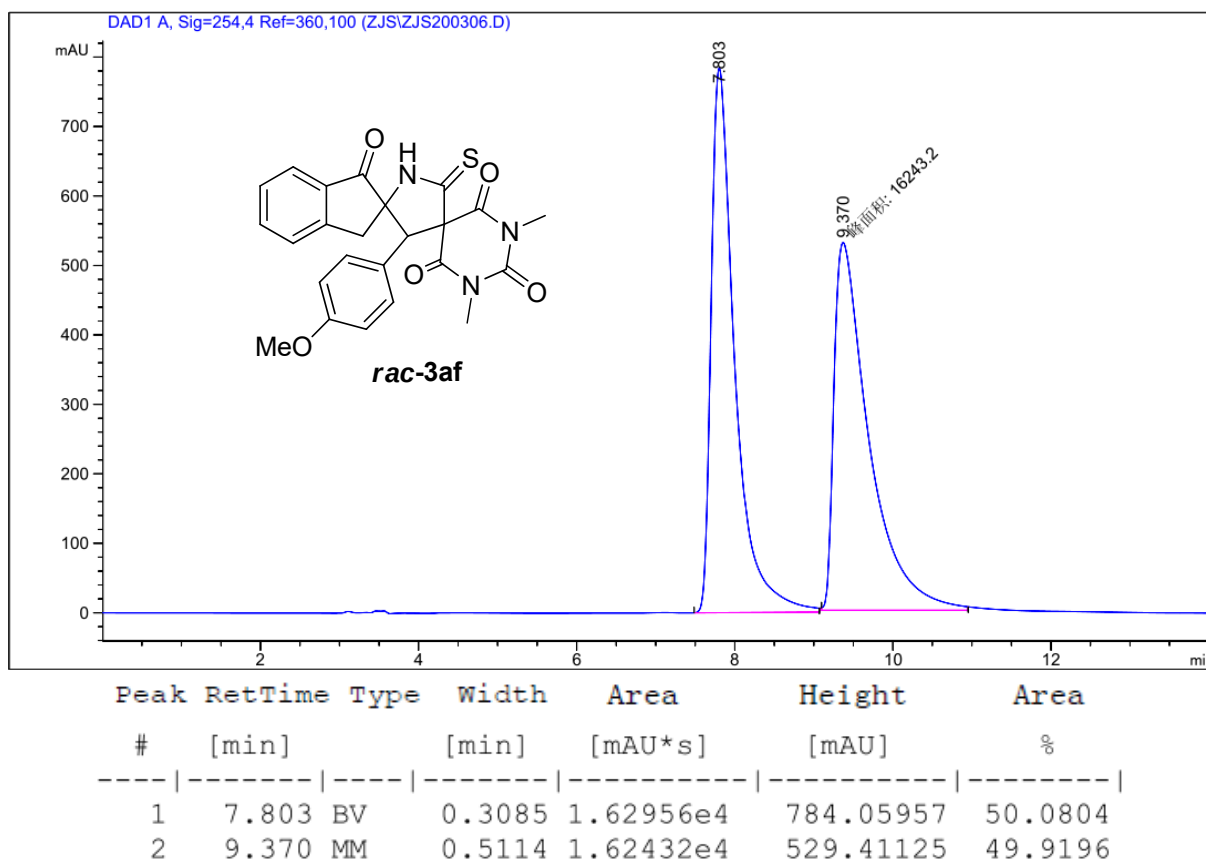


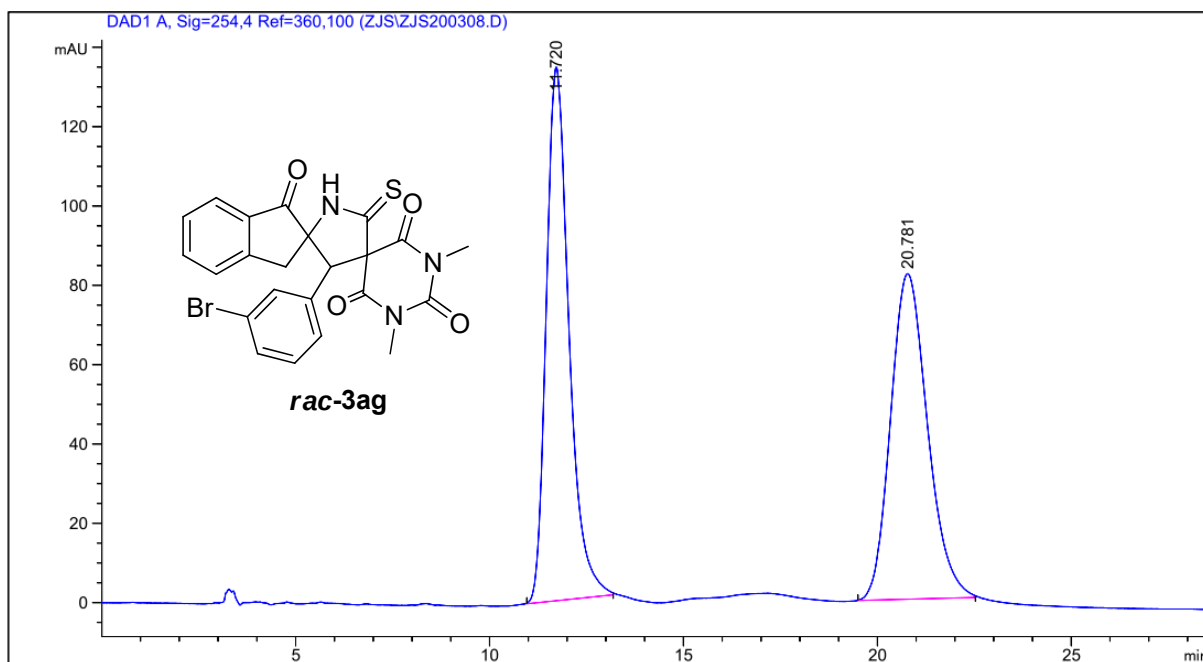
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.461	BB	0.6039	3.32203e4	839.00397	97.4370
2	22.596	BB	0.7459	873.82336	13.96633	2.5630



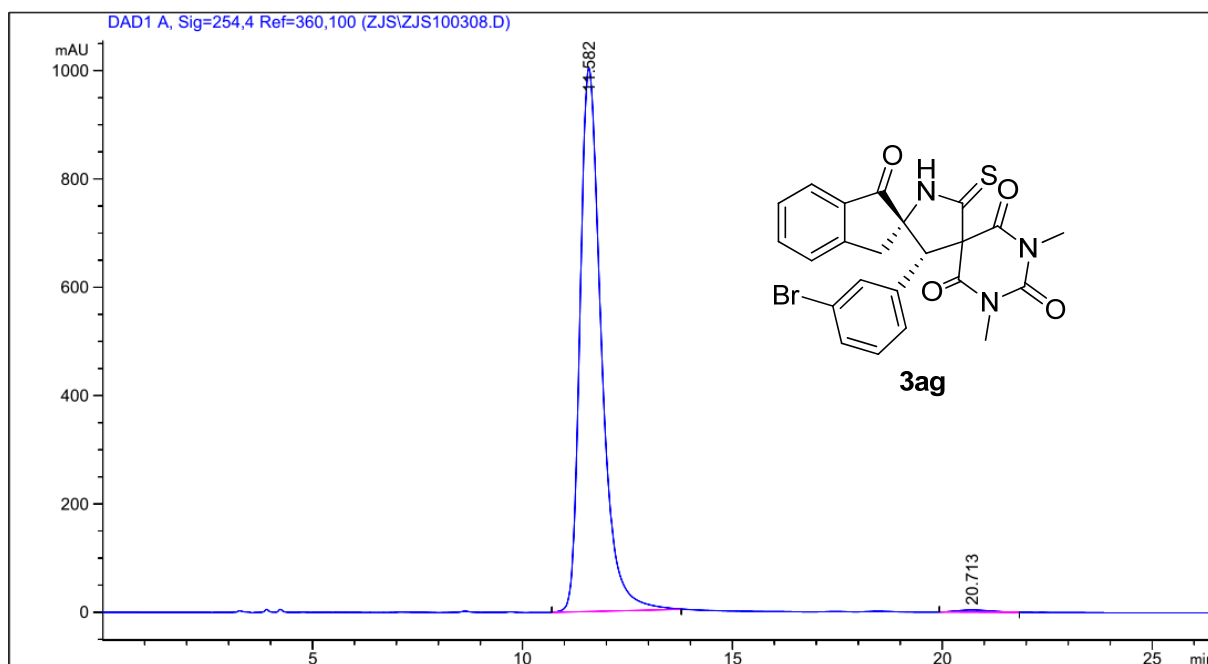




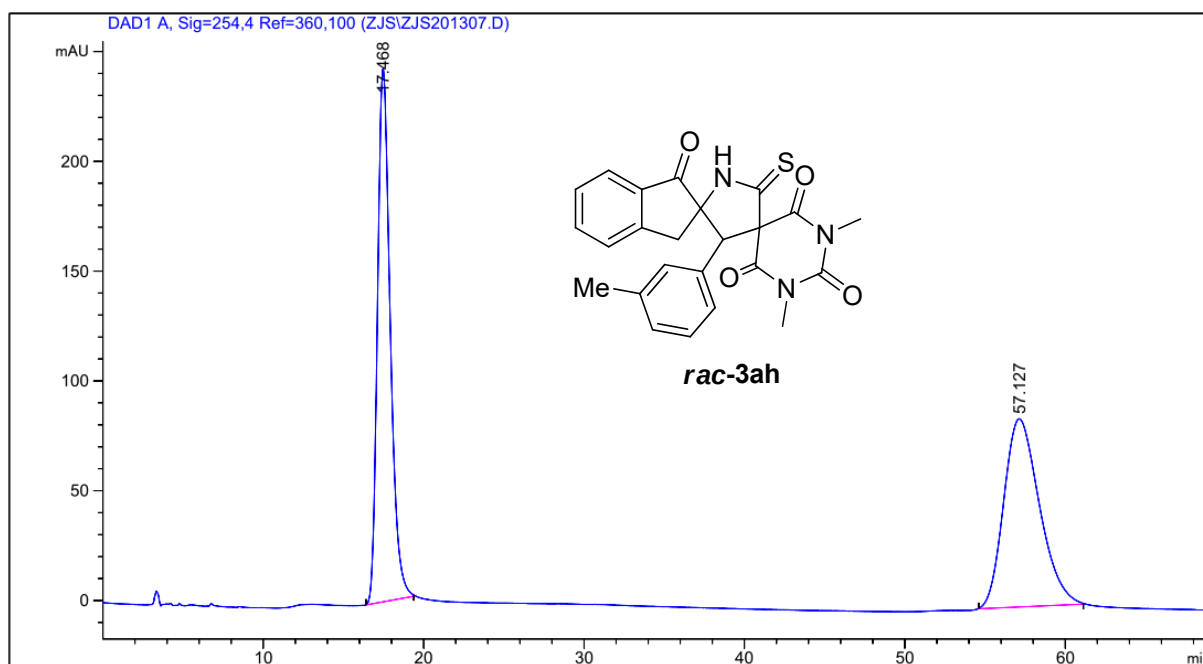




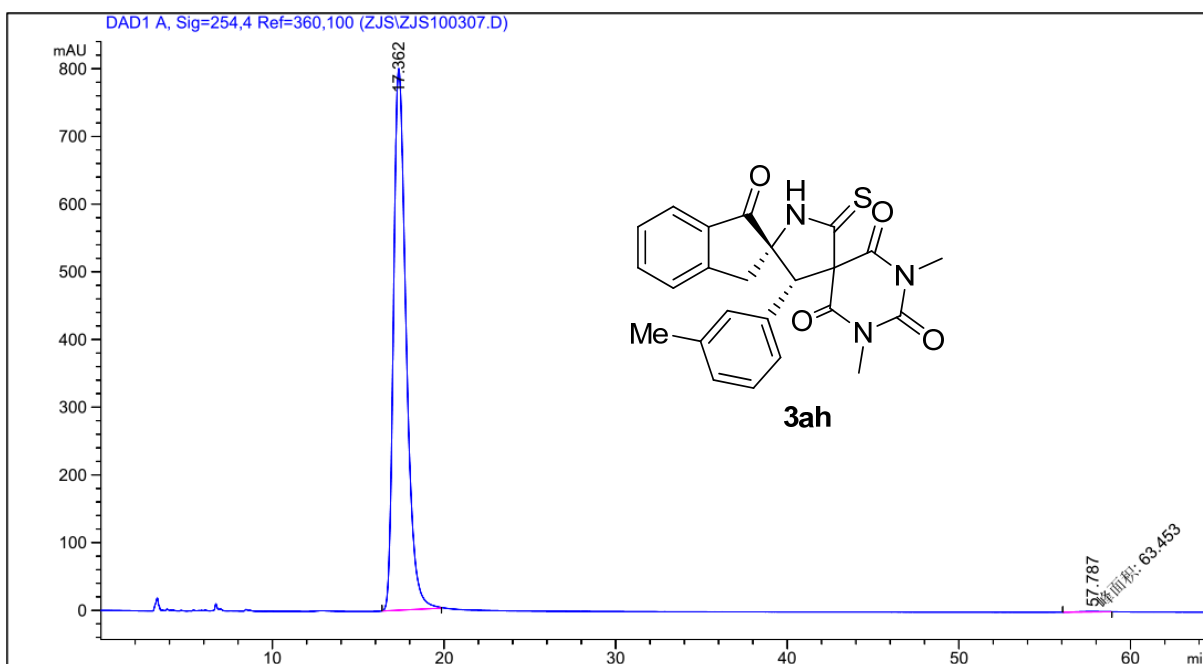
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.720	BB	0.6210	5475.66895	134.50122	50.2172
2	20.781	BB	1.0038	5428.31006	82.05406	49.7828



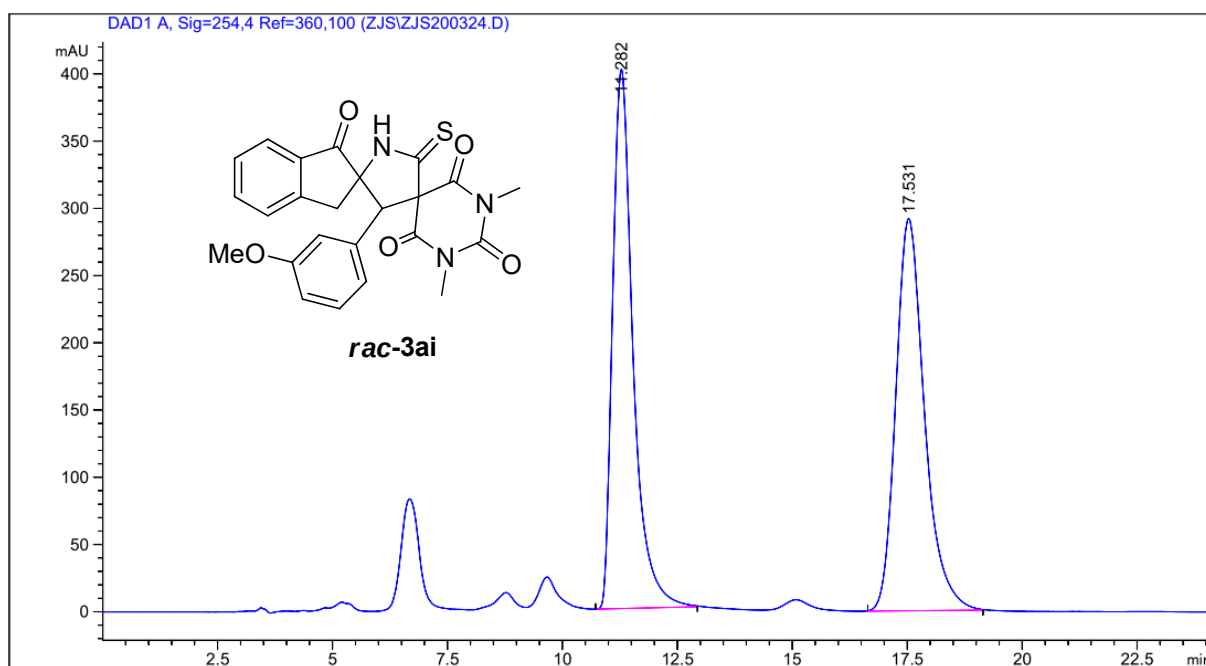
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.582	BB	0.5387	3.54959e4	1003.45917	99.3638
2	20.713	BB	0.6622	227.28185	4.02885	0.6362



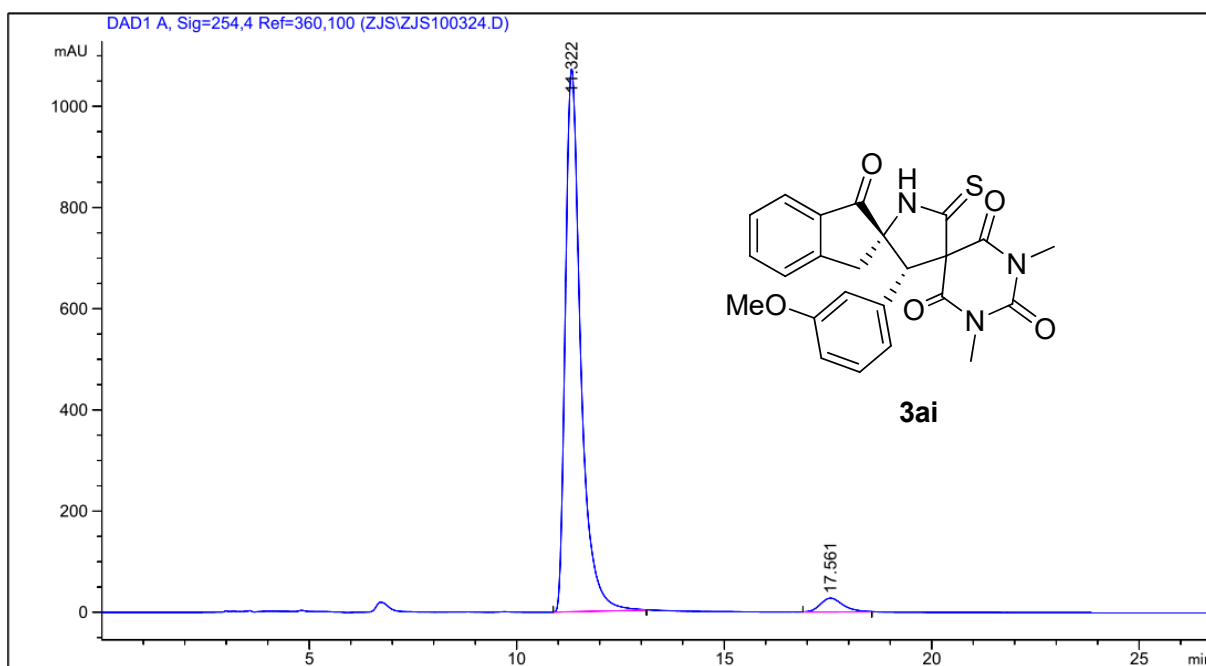
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	17.468	BB	0.8448	1.33741e4	242.72838	50.2835
2	57.127	BB	1.8523	1.32233e4	85.69221	49.7165



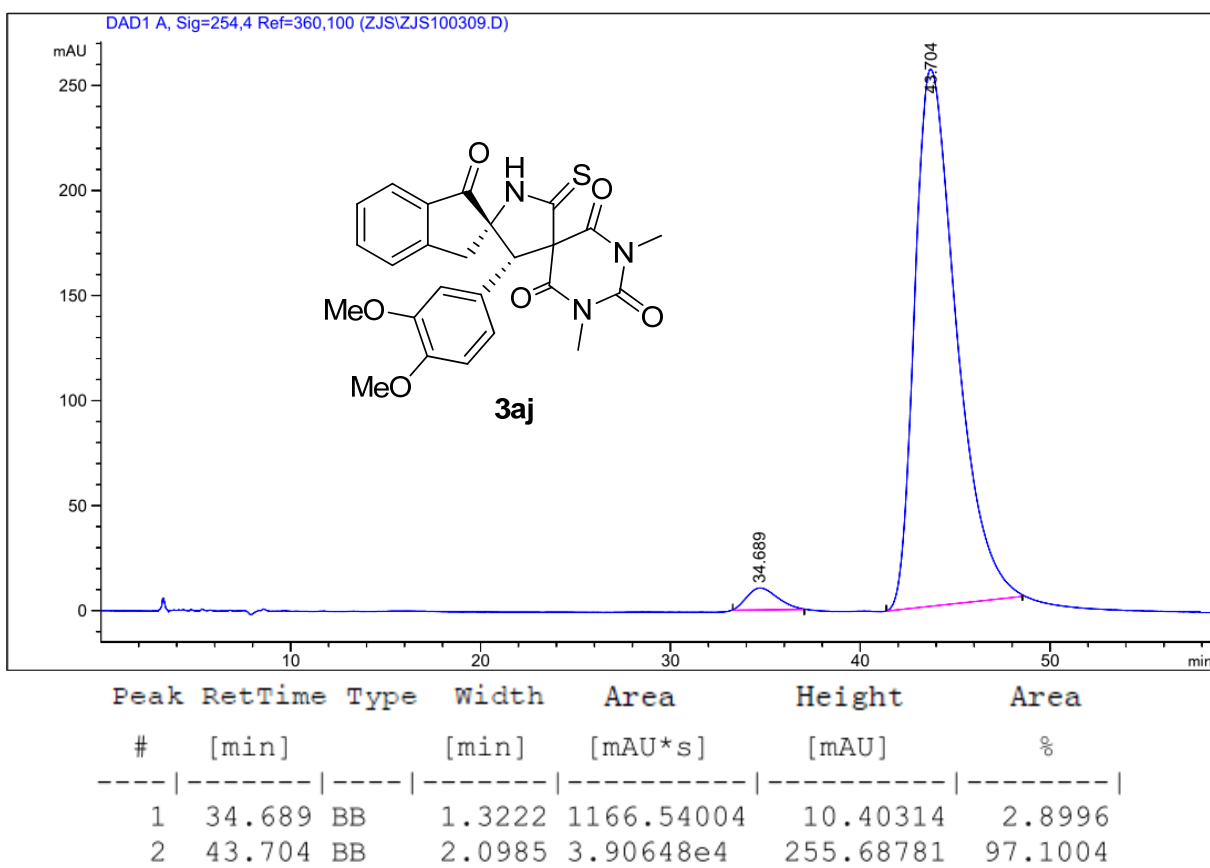
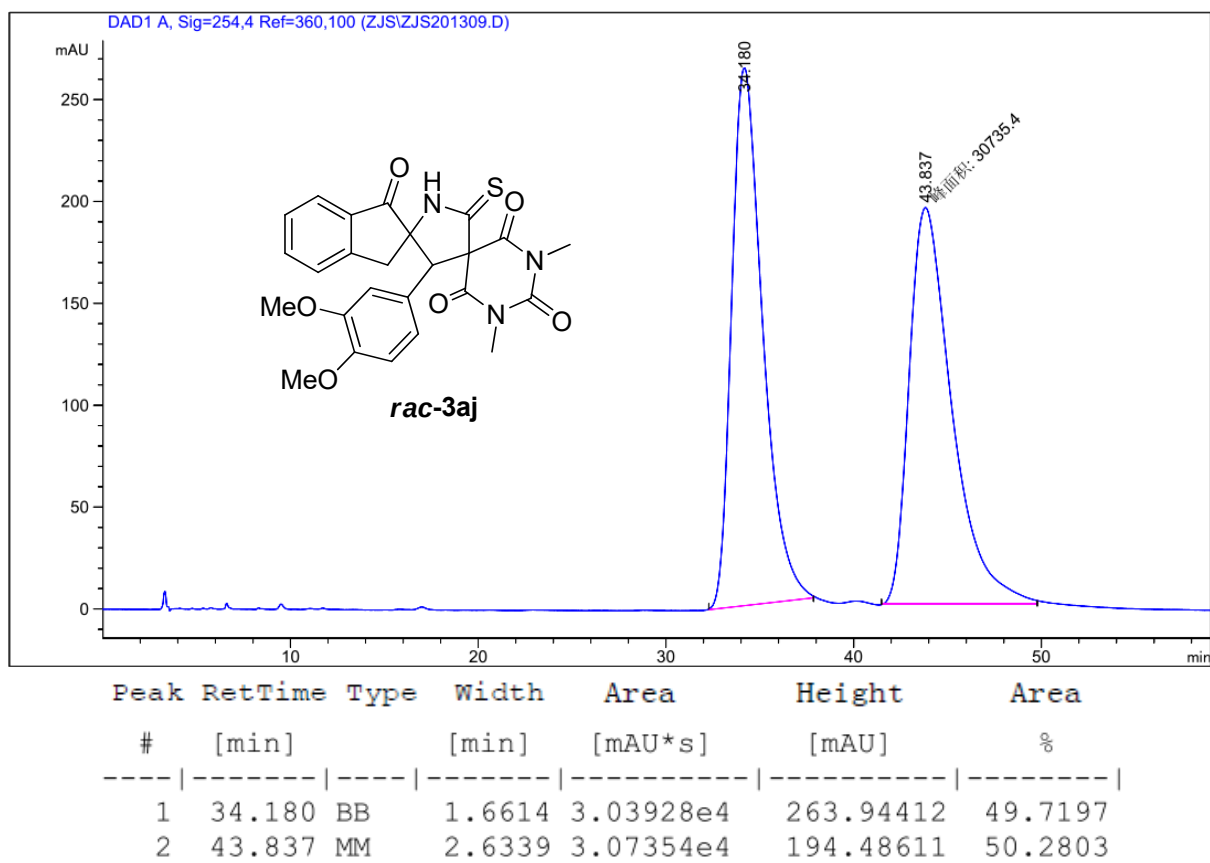
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	17.362	BB	0.7837	4.08604e4	800.21143	99.8449
2	57.787	MM	1.6904	63.45302	6.25603e-1	0.1551

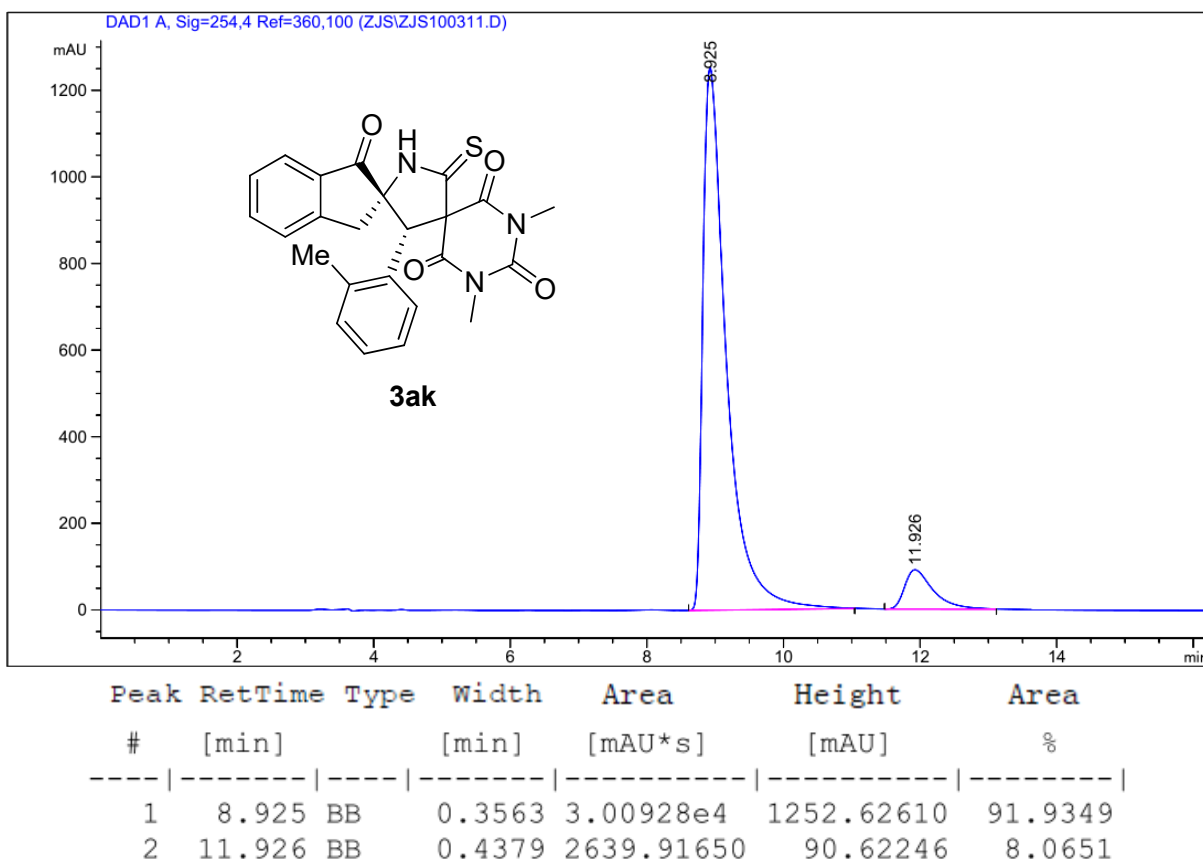
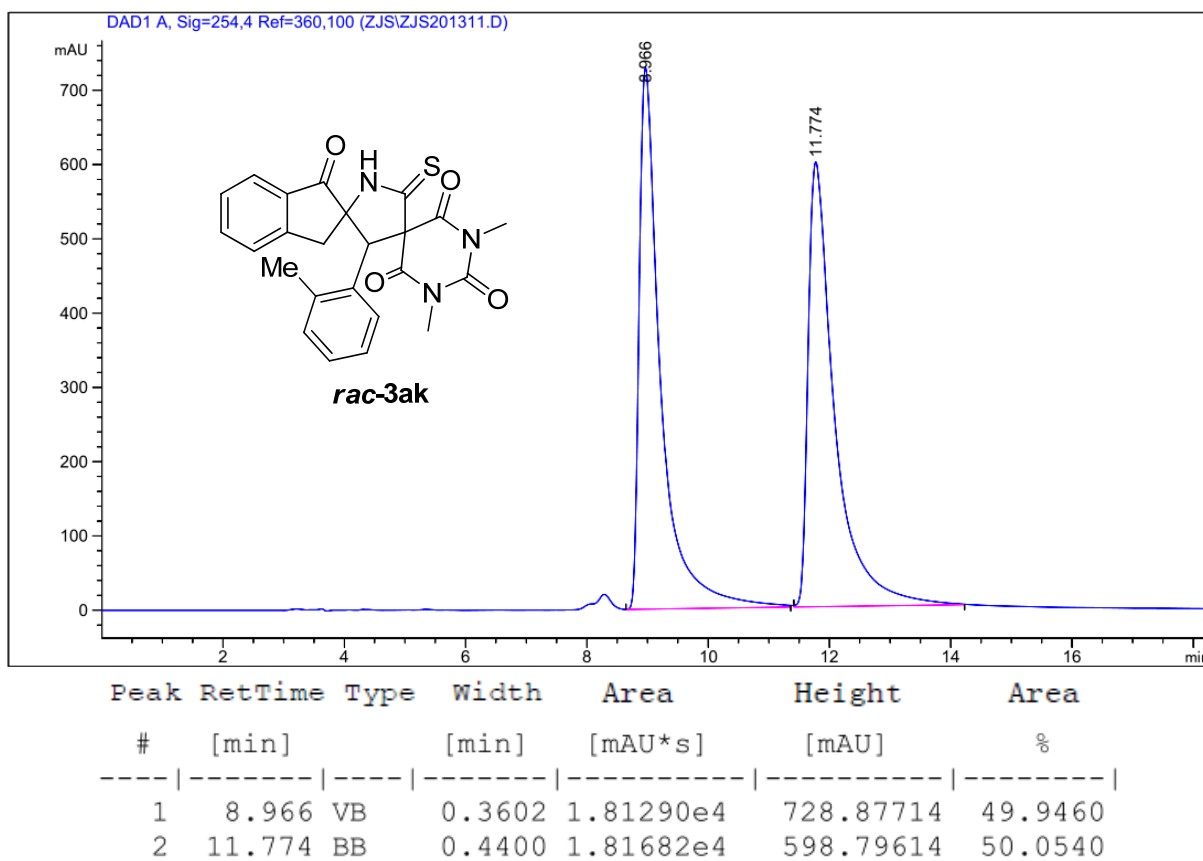


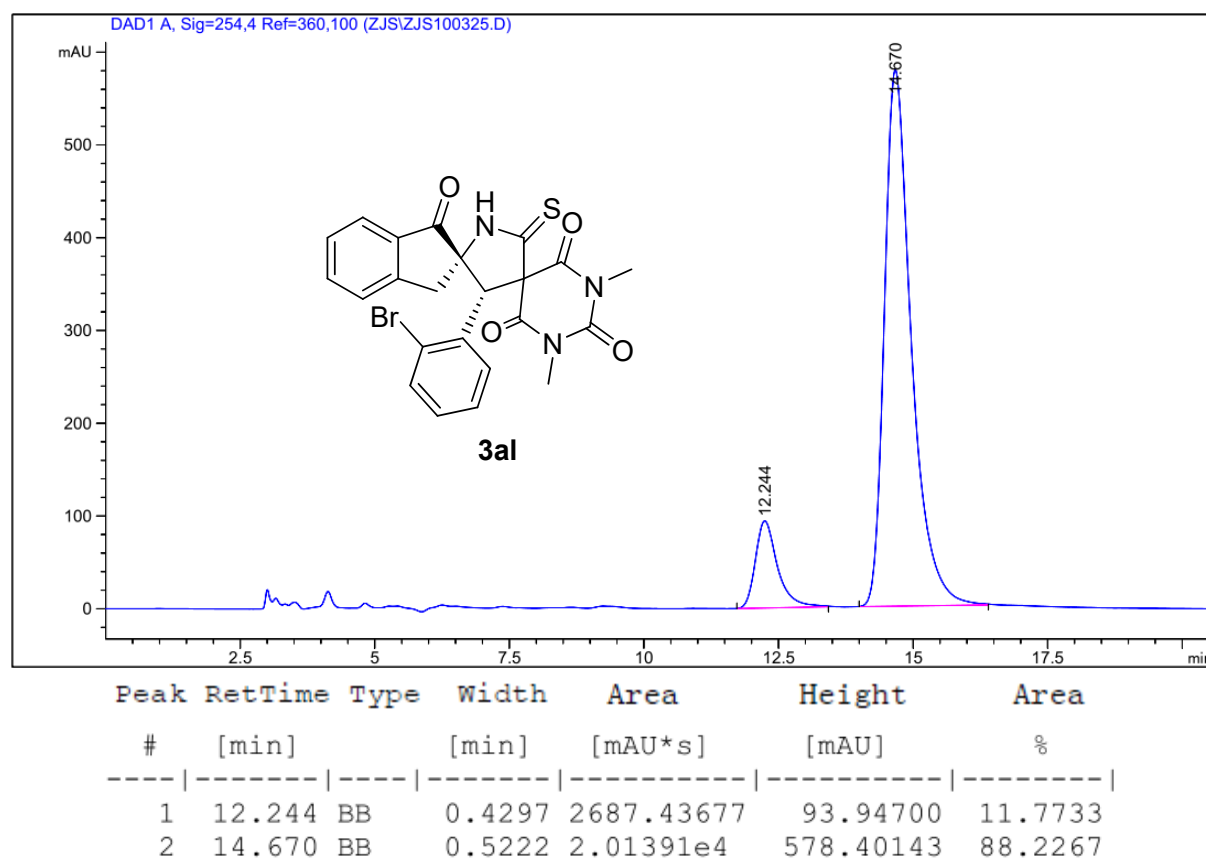
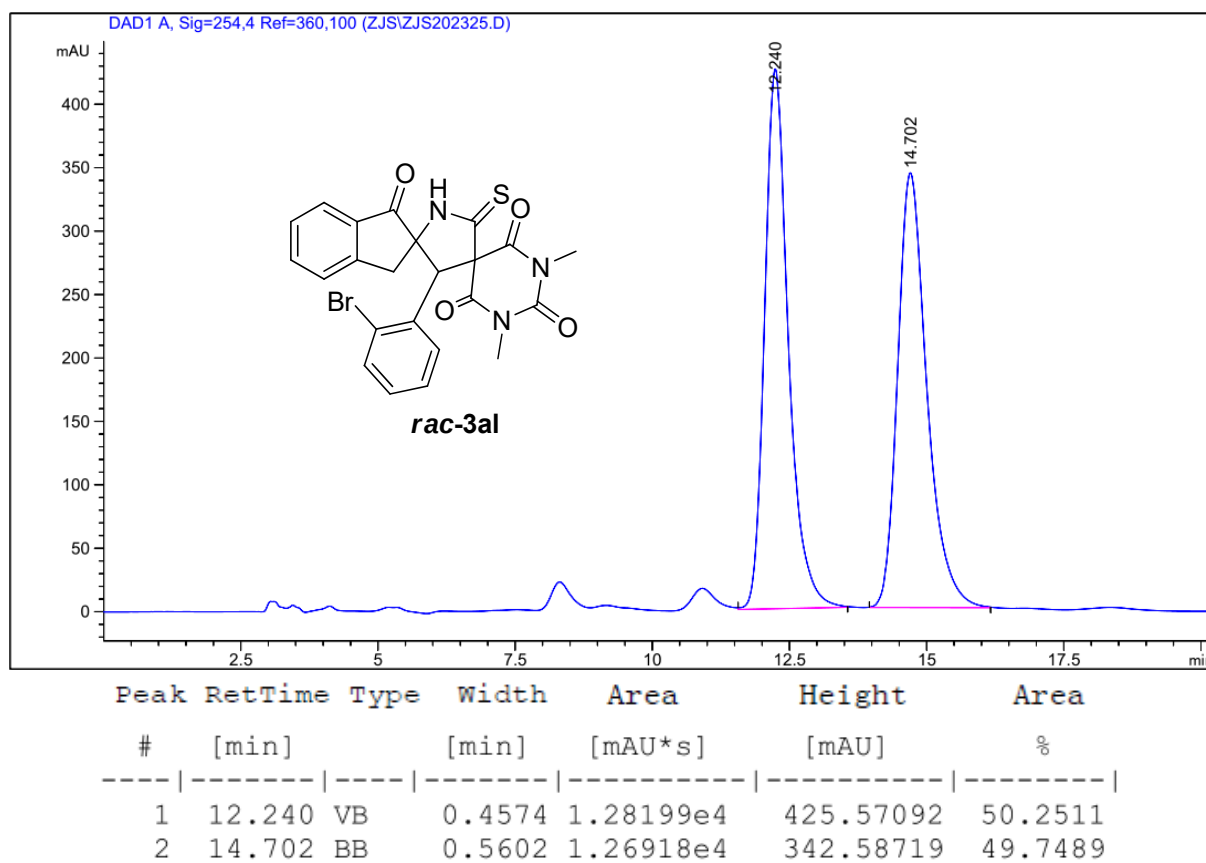
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.282	BB	0.4736	1.23585e4	400.96426	49.3913
2	17.531	BB	0.6587	1.26631e4	291.54507	50.6087

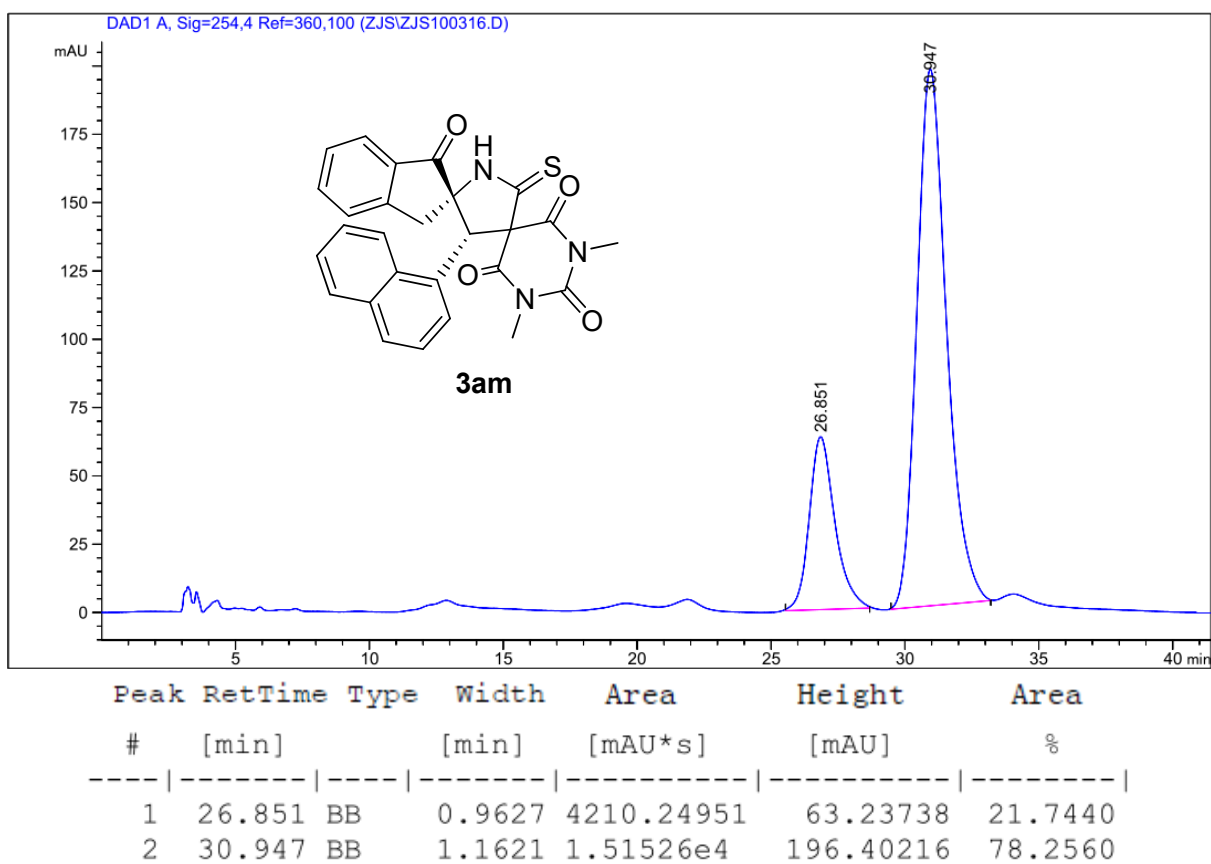
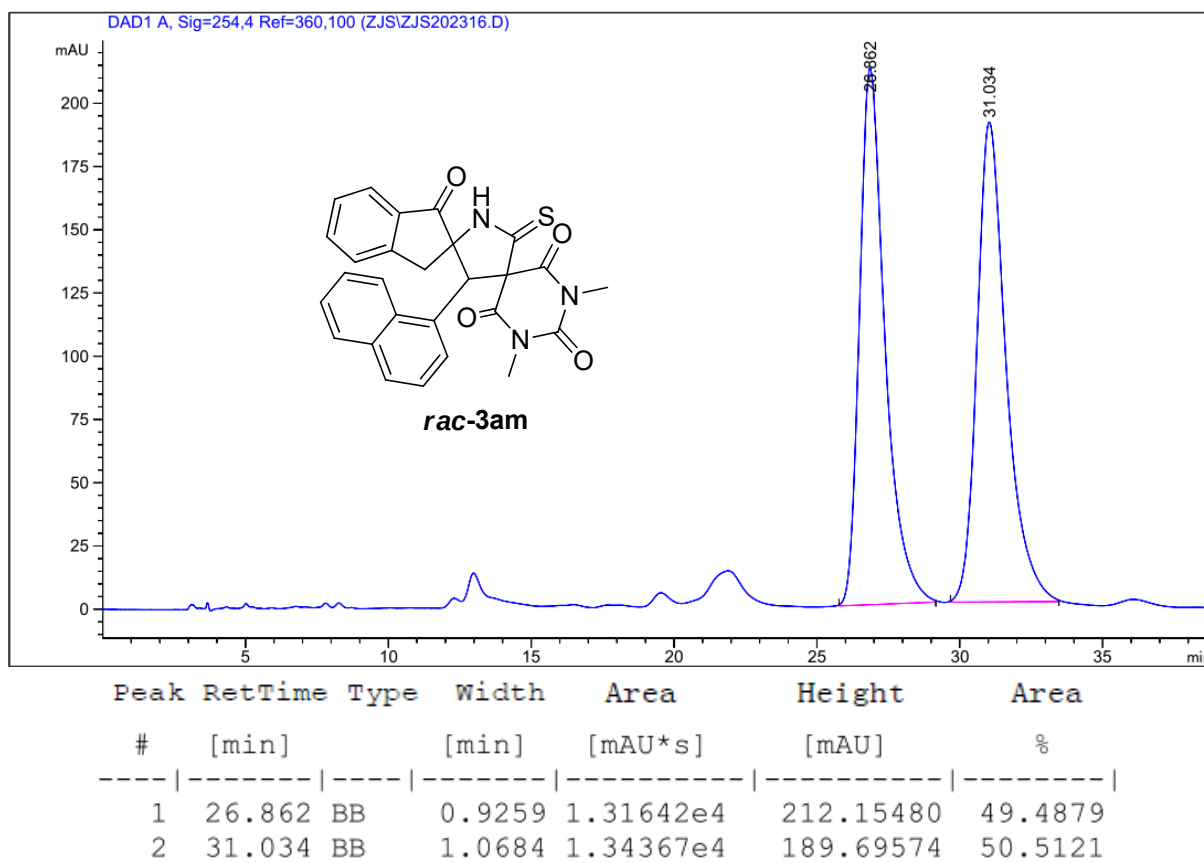


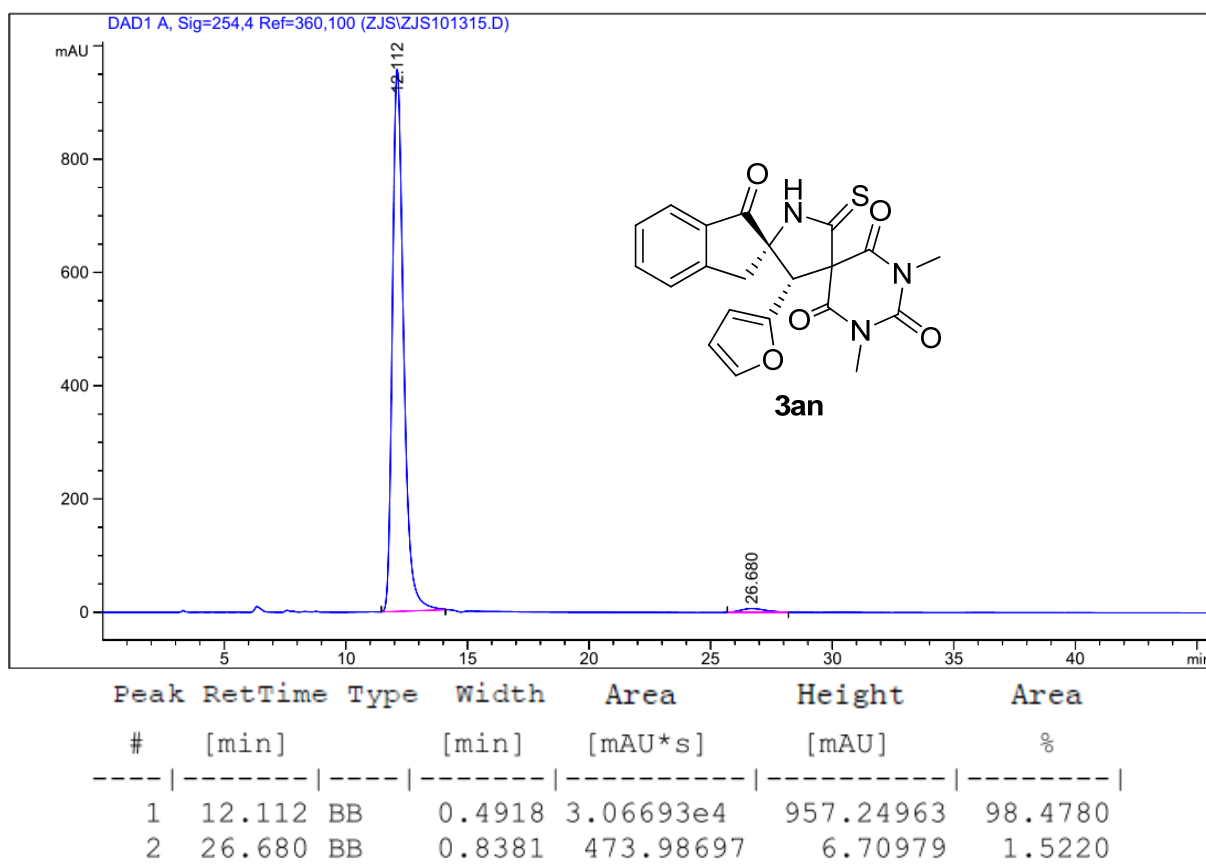
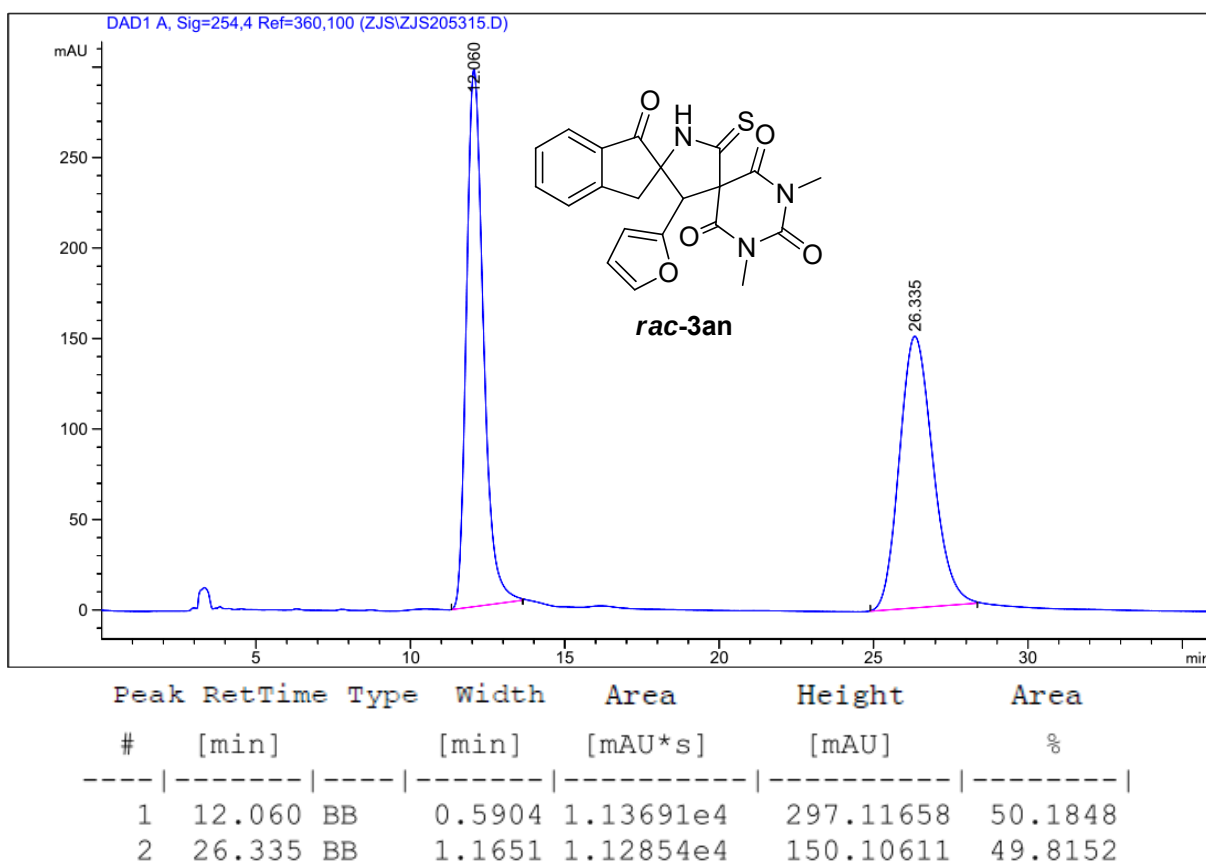
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.322	BB	0.3931	2.76977e4	1073.25452	96.3710
2	17.561	BB	0.5718	1043.01343	27.29837	3.6290

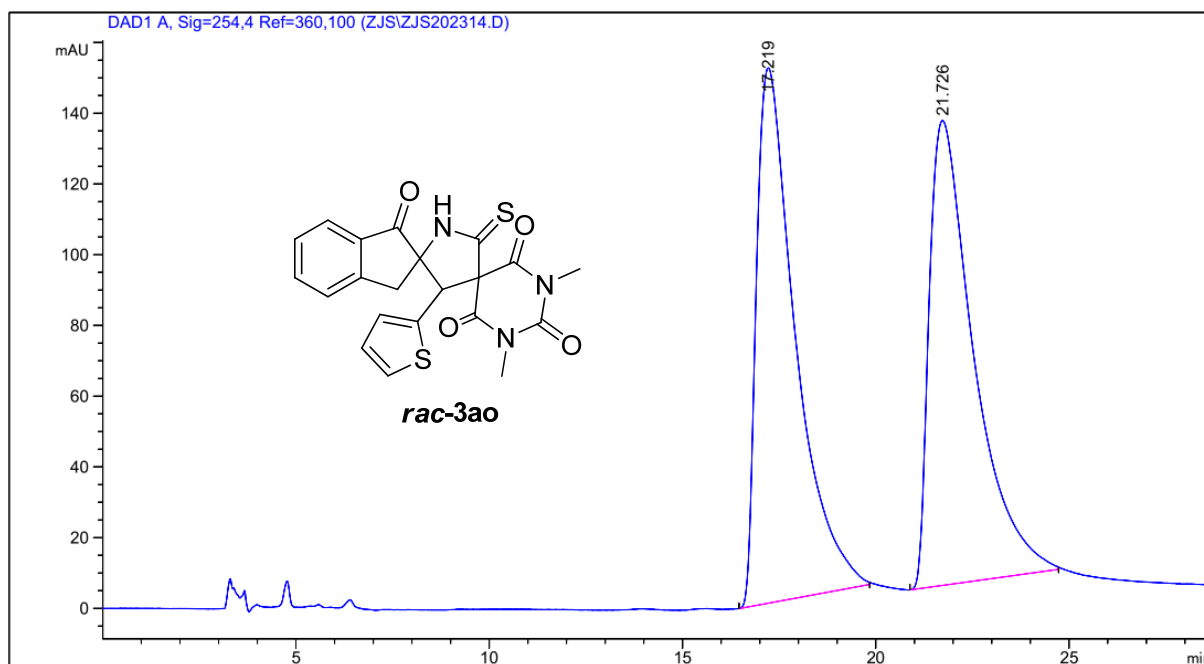




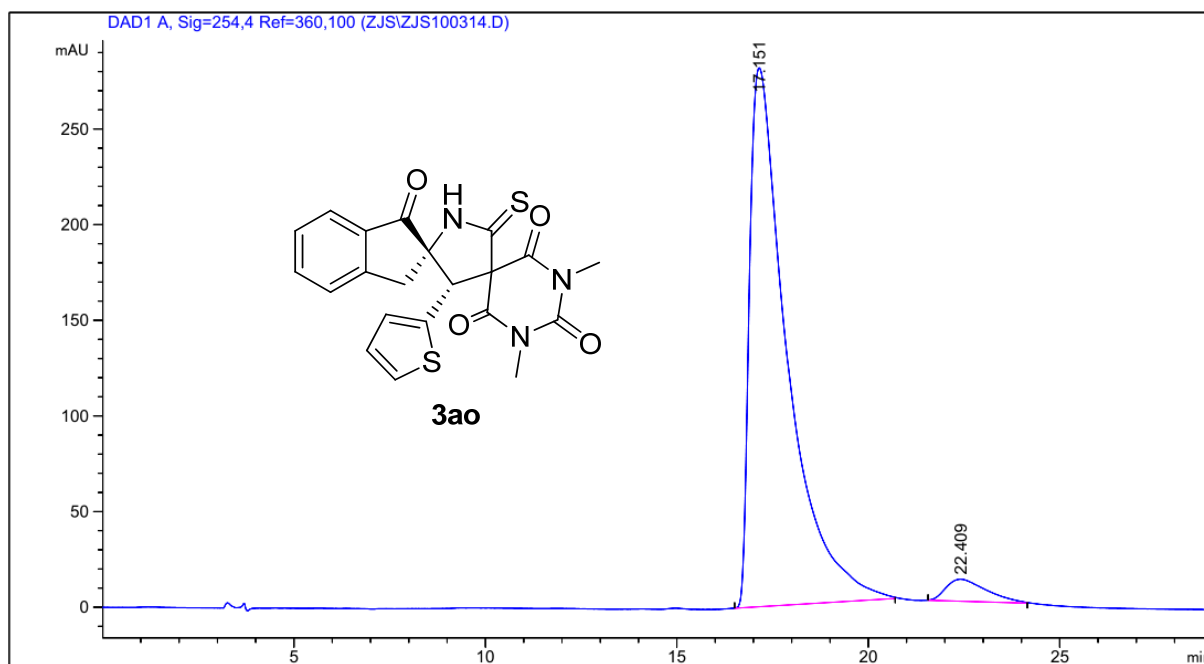




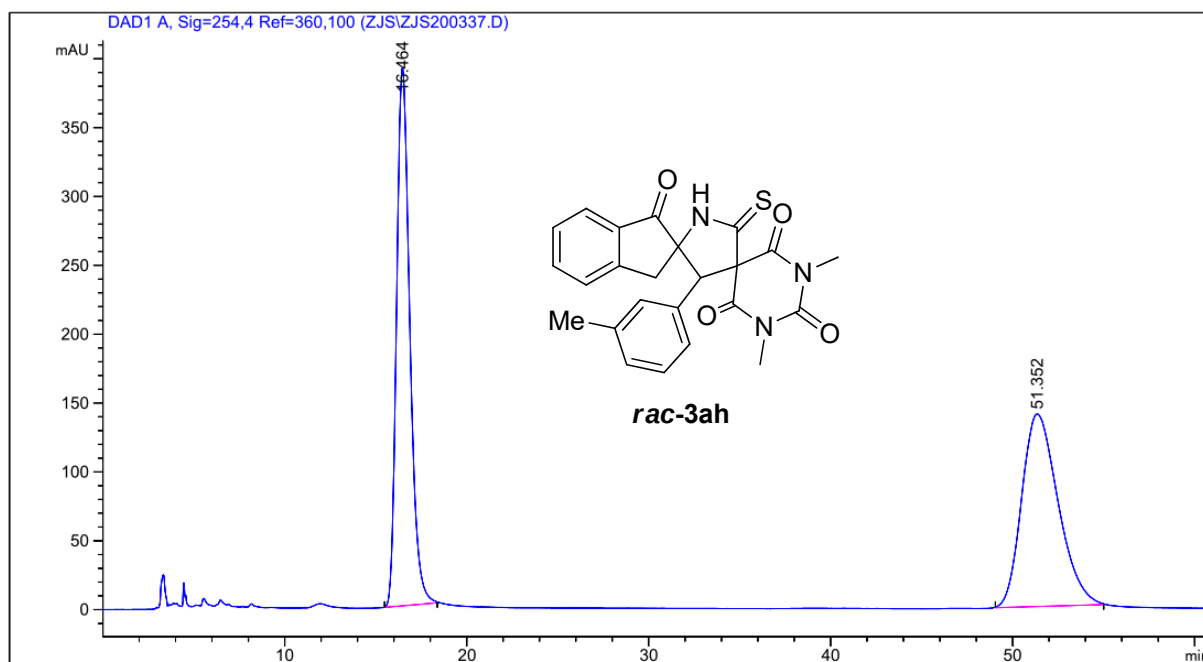




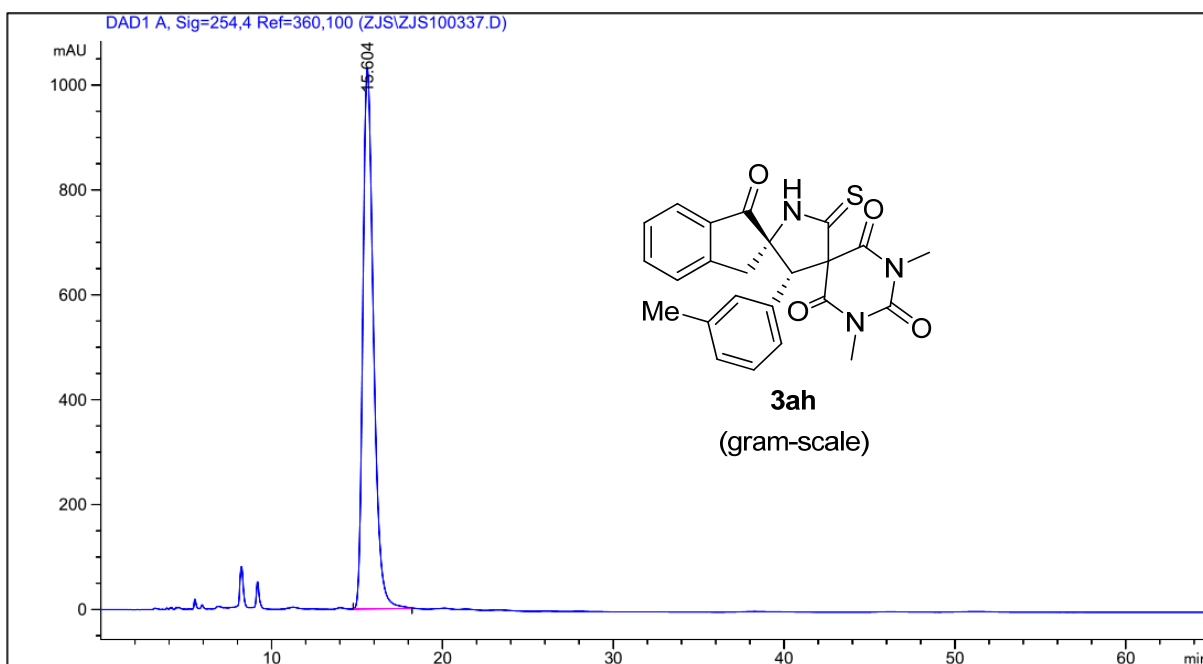
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	17.219	BB	1.0225	1.06188e4	151.34993	50.2965
2	21.726	BB	1.1594	1.04936e4	131.44218	49.7035



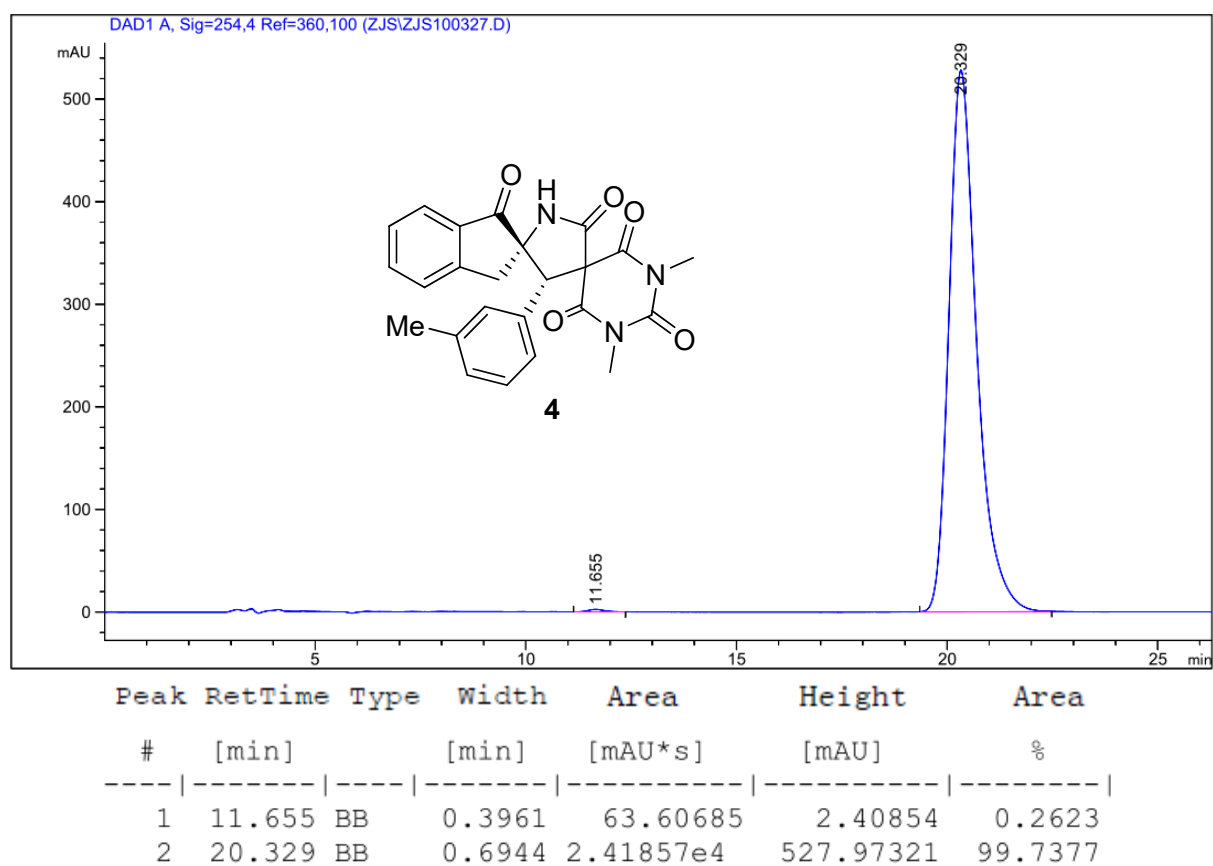
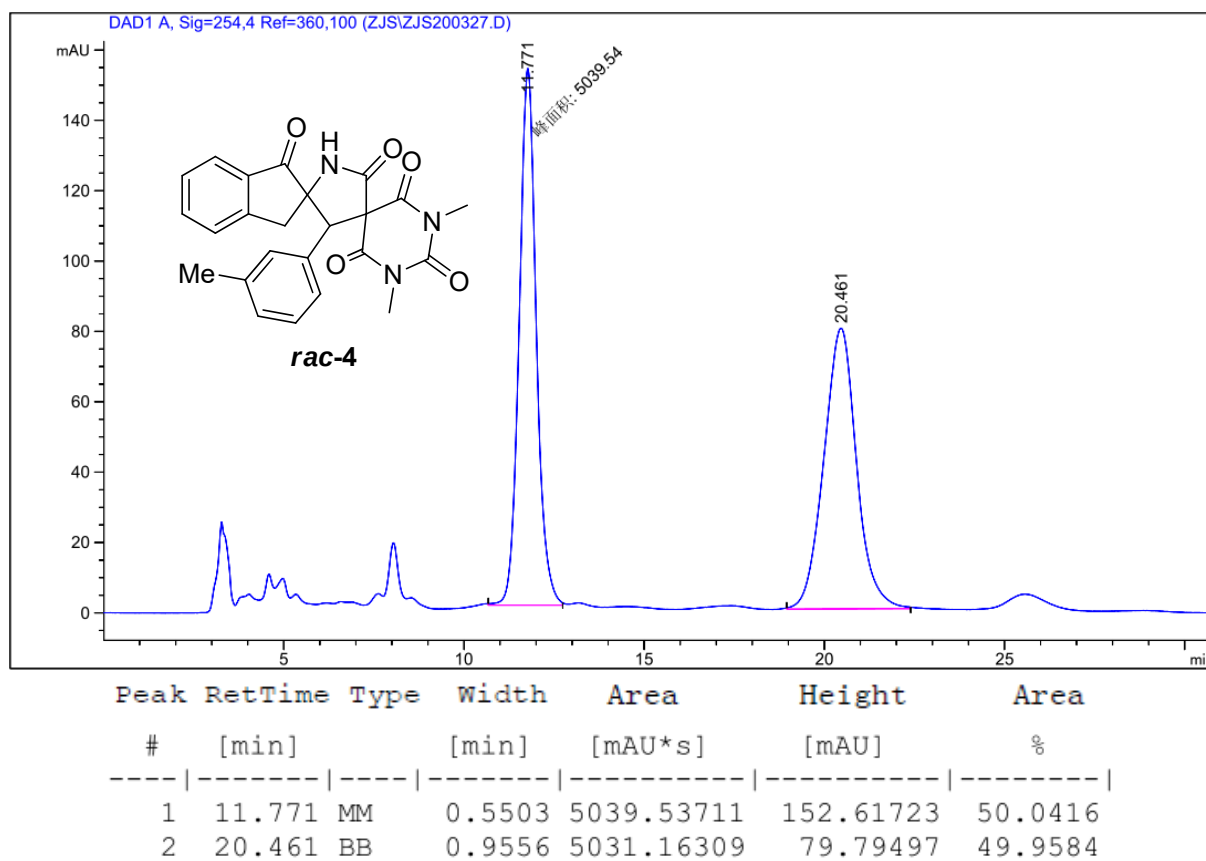
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	17.151	BB	0.9918	1.92646e4	281.71320	95.8100
2	22.409	BB	0.8811	842.48981	11.49396	4.1900

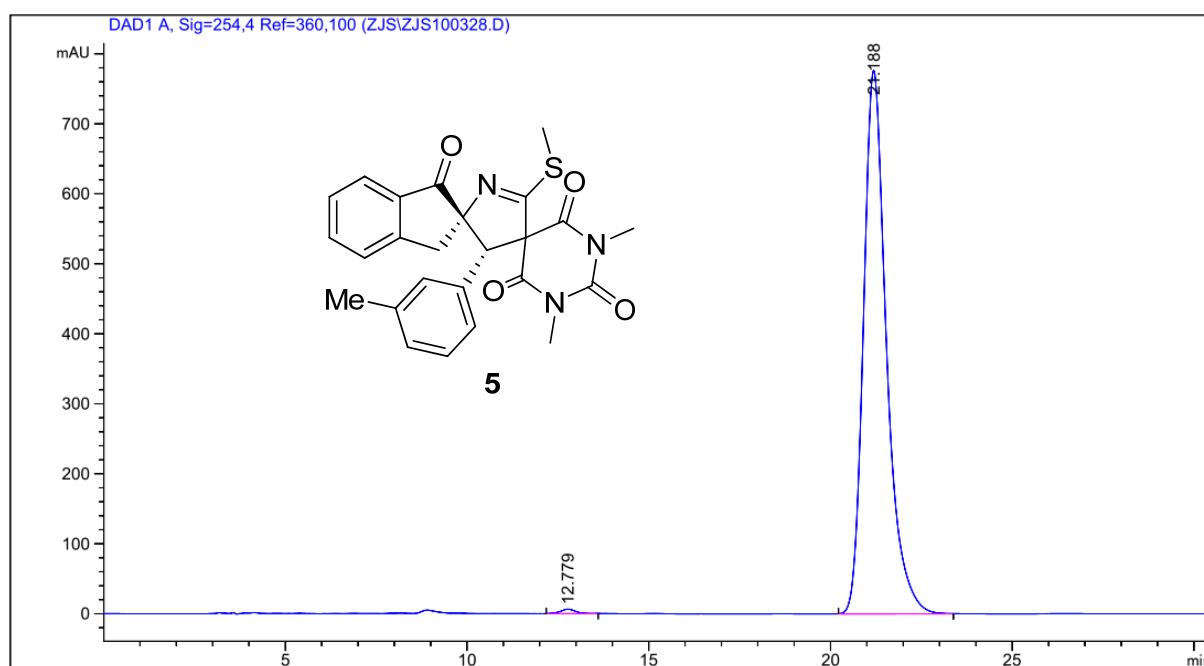
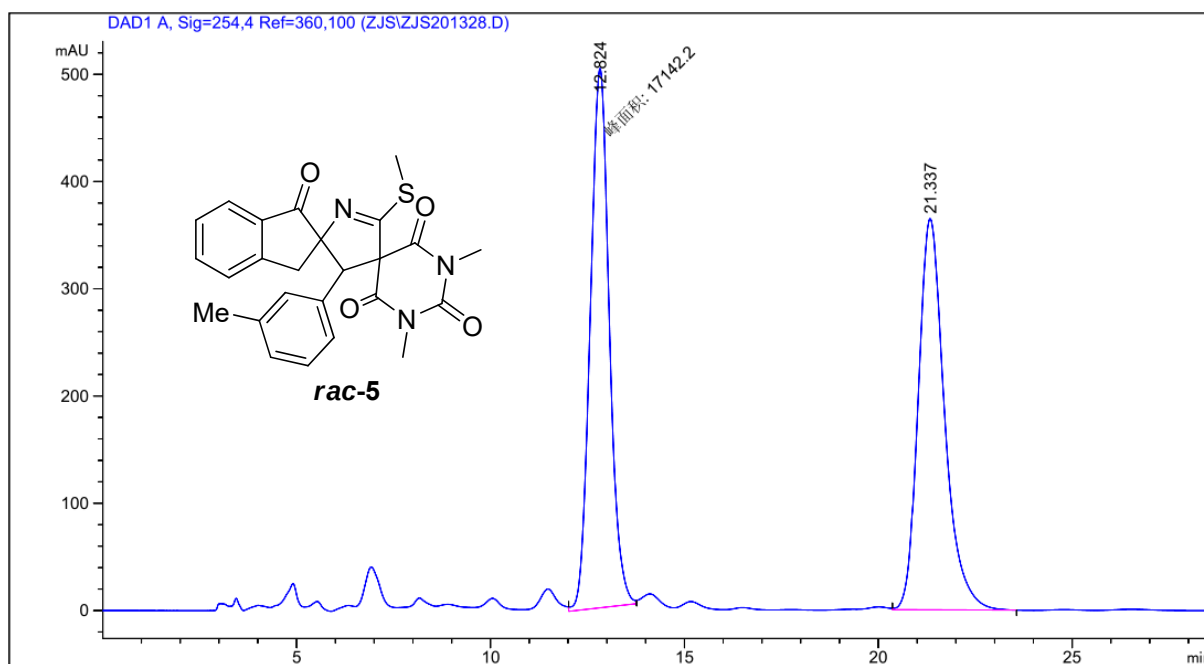


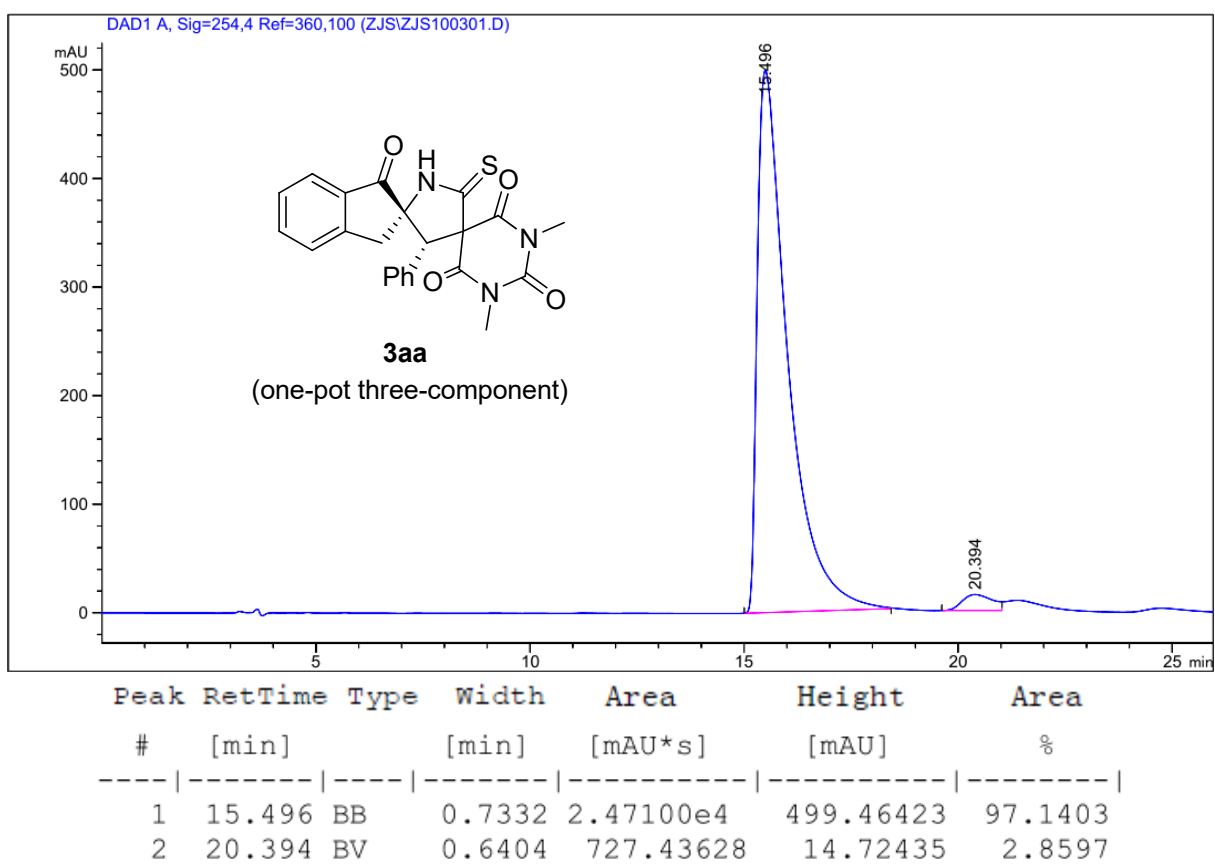
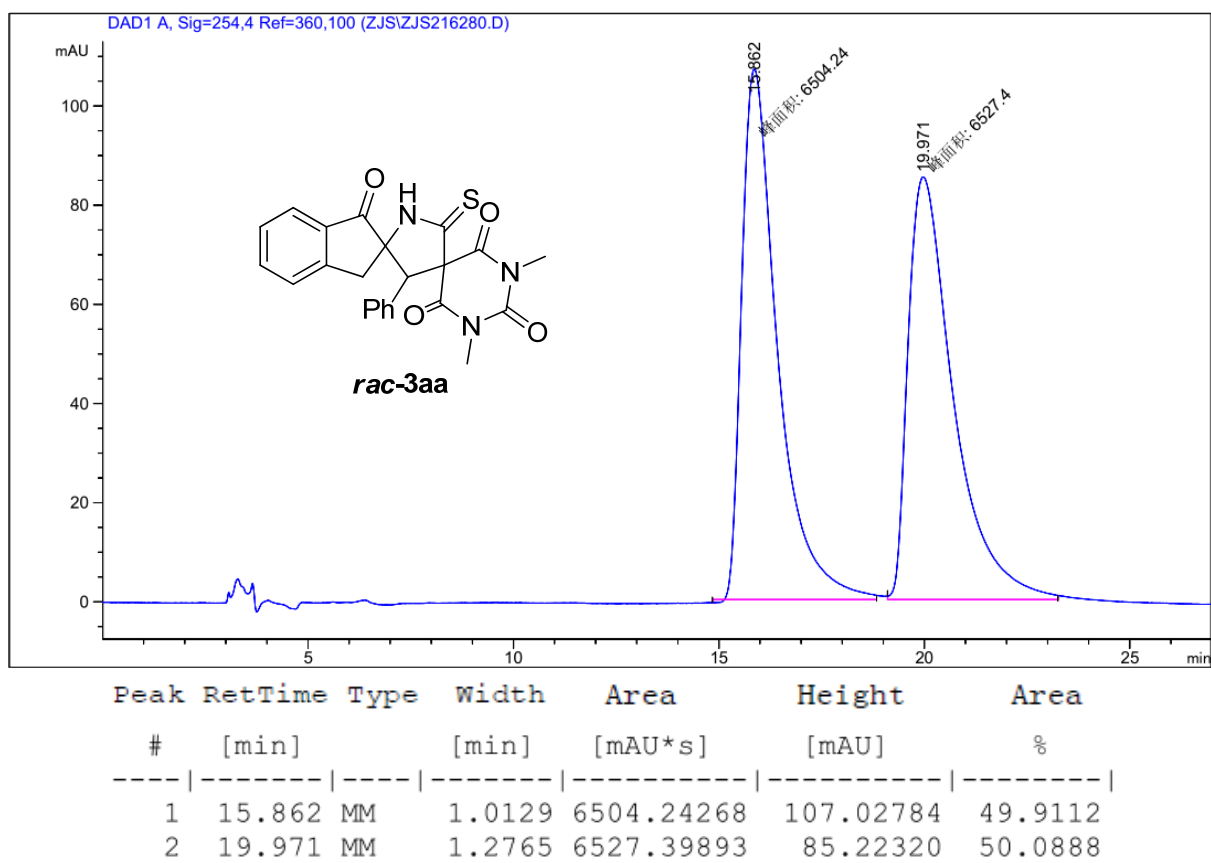
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	16.464	BB	0.7721	1.96879e4	390.59589	50.3143
2	51.352	BB	1.8564	1.94419e4	139.80742	49.6857

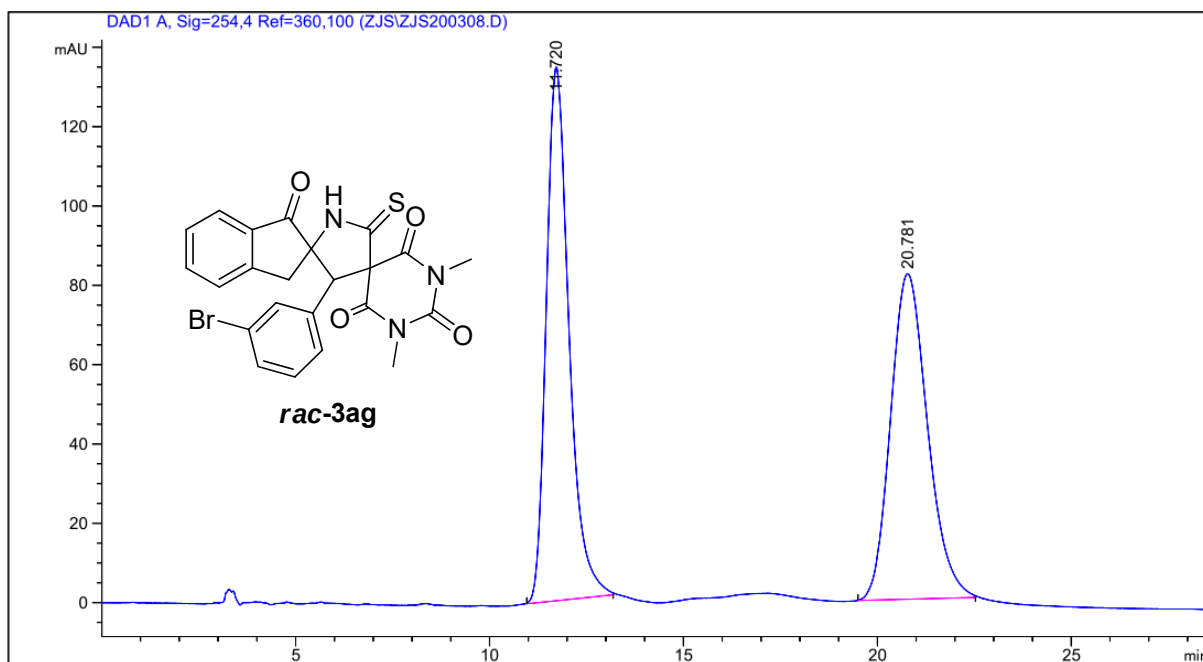


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	15.604	BB	0.6679	4.46888e4	1030.59180	100.0000

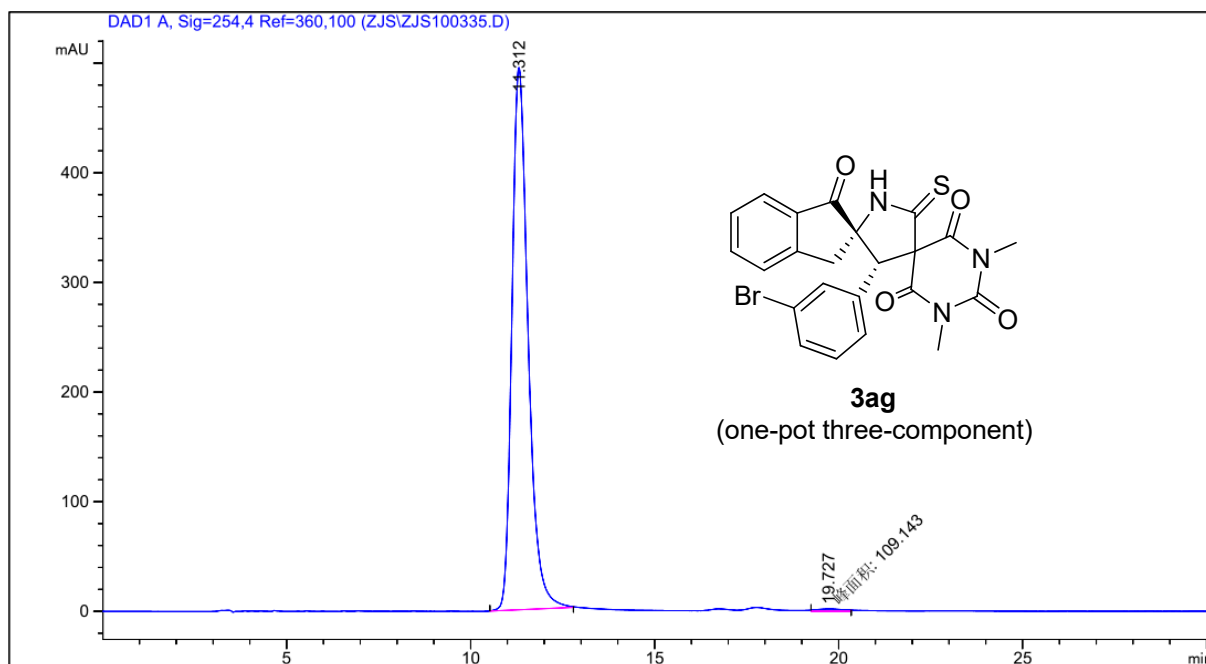








Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.720	BB	0.6210	5475.66895	134.50122	50.2172
2	20.781	BB	1.0038	5428.31006	82.05406	49.7828



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.312	BB	0.4647	1.51225e4	494.66156	99.2834
2	19.727	MM	0.8546	109.14272	2.12848	0.7166