Parallel Synthesis of a Desketoraloxifene Analogue Library via Iodocyclization/Palladium-Catalyzed Coupling

Chul-Hee Cho,[†] Dai-Il Jung,[†,‡] Benjamin Neuenswander,[§] and Richard C. Larock[†,*]

[†]Department of Chemistry, Iowa State University, Ames, Iowa 50011, United States

[‡]Department of Chemistry, Dong-A University, Saha-Gu, Busan 604-714, Korea

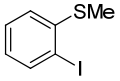
[§]NIH Center of Excellence in Chemical Methodologies and Library Development, University of Kansas, Lawrence, Kansas 66047, United States

Supporting Information

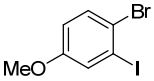
Contents

The ^{1}H (400 MHz) and ^{13}C NMR (100 MHz) spectra were recorded in $CDCl_3$ as the solvent using tetramethylsilane (TMS) as an internal standard, unless otherwise stated. Chemical shifts are reported in δ units (ppm) by assigning the TMS resonance in the ^{1}H NMR spectrum as 0.00 ppm and the $CDCl_3$ resonance in the ^{13}C NMR spectrum as 77.23 ppm. All coupling constants, *J*, are reported in Hertz (Hz). Analytical thin layer chromatography (TLC) was performed using commercially prepared 60-mesh silica gel plates, and visualization was effected with short wavelength UV light (254 nm). All melting points are uncorrected. High resolution mass spectra (HRMS) were obtained using a Waters/Micromass LCT Premier TOF instrument. Commercially available reagents were used without further purification unless otherwise stated. The organic solvents (*e.g.* Et_2O, EtOAc, $CHCl_3$, MeOH, EtOH, CH_3CN, DMF, hexane, toluene, *etc*.) were used as anhydrous solvents. THF and CH_2Cl_2 were distilled from sodium/benzophenone and CaH_2 respectively under an atmosphere of argon prior to use. The palladium catalysts, such as $PdCl_2(PPh_3)_2$ and $Pd(PPh_3)_4$, were donated by Johnson Matthey Inc. and Kawaken Fine Chemicals Co. Ltd. The 4-[(tetrahydro-2*H*-pyran-2-yl)oxy]benzeneboronic acid was donated by Frontier Scientific Co. Ltd.

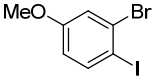
◈ **Preparation of starting materials 1**



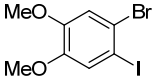
1{*1*}



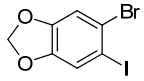
1{*2*}



1{*3*}



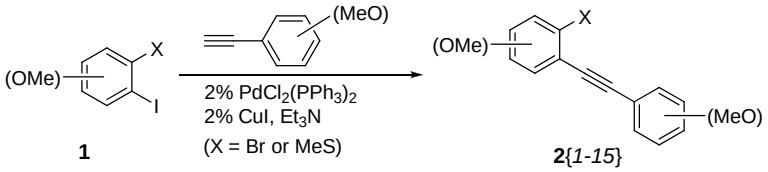
1{*4*}



1{*5*}

1-Iodo-2-(methylthio)benzene [**1**{*1*}] was obtained commercially. 1-Bromo-2-iodo-4-methoxybenzene [**1**{*2*}], 1-bromo-2-iodo-4,5-dimethoxybenzene [**1**{*4*}], and 5-bromo-6-iodo-1,3-benzodioxole [**1**{*5*}] were prepared according to a published procedure as a single isomer through regioselective bromination of 3-iodoanisole, 1-iodo-3,4-dimethoxybenzene, and 1-iodo-3,4-(methylenedioxy)benzene, respectively, using Br_2.[1] 3-Bromo-4-iodoanisole [**1**{*3*}] was prepared according to a published procedure through regioselective iodination of 3-bromoanisole, 1-(tosyloxy)benziodoxolone and I_2.[2]

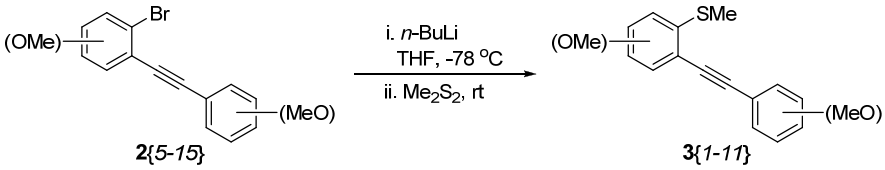
◈ Preparation of the Bromoalkynes 2



1 **2**{*1-15*}

To a solution of dihalobenzene **1** (10.0 mmol), 2 mol % $PdCl_2(PPh_3)_2$ and 2 mol % CuI in Et_3N (20 mL), the terminal alkyne (10.5 mmol) was added. The reaction mixture was stirred vigorous at 50 °C for *ca*. 5-8 h under an Ar atmosphere. The resulting mixture was diluted with EtOAc (2 × 200 mL). The separated organic layer was washed with water and brine, dried over $MgSO_4$, and concentrated *in vacuo*. The crude product was purified by column chromatography on silica gel using ethyl acetate/hexanes as the eluent to afford the corresponding products **2**. Products **2**{*1-14*} have been reported in our previous publications.[3-6]

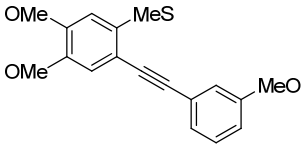
◈ General procedure for methylthiolation to form compounds 3



2{*5-15*} **3**{*1-11*}

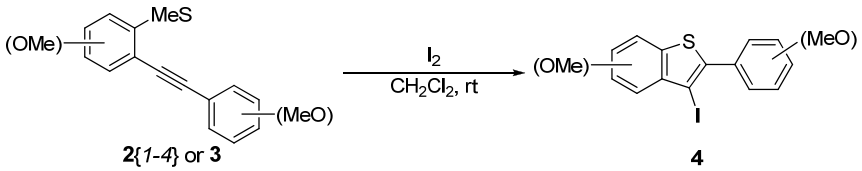
The bromoalkyne **2** (8.0 mmol) was dissolved in dry THF (80 mL) under an Ar atmosphere and cooled to -78 °C for 0.5 h. Then, 2.0 equiv of *n*-BuLi (2.0 M solution in cyclohexane, 8.0 mmol) was added dropwise to the stirred solution. After the addition was complete, the reaction was stirred for 1 h at -78 °C. Dimethyl disulfide (9.6 mmol) was then added and the reaction mixture was stirred further at this temperature under an Ar atmosphere before being allowed to warm to room temperature for 2 h. The resulting mixture was diluted with EtOAc (2 × 160 mL). The separated organic layer was washed with water and brine, dried over $MgSO_4$, and concentrated *in vacuo*. The crude product was purified by column chromatography on silica gel using ethyl acetate/hexanes as the eluent to afford the corresponding products **3**. Products **3**{*1-7,9-11*} have been reported in our previous publications.[3,5]

Compound 3{*8*}



The product was obtained as a yellow oil (63% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.53 (s, 3H), 3.82 (s, 3H), 3.88 (s, 3H), 3.92 (s, 3H), 6.81 (s, 1H), 6.89 (dd, *J* = 2.5, 8.5 Hz, 1H), 7.03 (s, 1H), 7.07-7.10 (m, 1H), 7.16 (d, *J* = 7.6 Hz, 1H), 7.23-7.28 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 17.1, 55.5, 56.2, 56.3, 87.4, 94.0, 111.1, 114.90, 114.91, 115.4, 116.4, 124.2, 124.6, 129.5, 133.3, 147.2, 149.9, 159.5; HRMS calcd for $C_{18}H_{18}O_3S$ [M^+], 314.0977, found 314.0983.

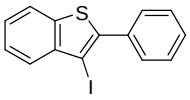
◈ **General procedure for iodocyclization using I_2 to prepare compounds 4**



2{*1-4*} or **3** **4**

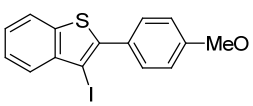
To a solution of 5.0 mmol of the alkynes **2**{*1-4*} and **3**{*1-11*} in CH_2Cl_2 (20 mL) was added gradually 1.2 equiv of I_2 dissolved in CH_2Cl_2 (30 mL). The reaction mixture was allowed to stir at room temperature for up to 10 min. The reaction was monitored by TLC to establish completion. The remaining I_2 was removed by washing with satd aq $Na_2S_2O_3$. The mixture was then extracted by EtOAc (2 × 100 mL). The combined organic layers were dried over anhydrous $MgSO_4$ and concentrated under a vacuum to yield the crude product, which was purified by flash chromatography using EtOAc/hexanes as the eluent to afford the corresponding products **4**.

3-Iodobenzo[*b*]thiophene 4{*1*}



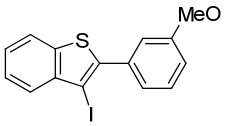
The product was obtained as pale yellow oil that solidified upon standing to an ivory solid (91% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.31-7.52 (m, 5H), 7.60-7.88 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 79.6, 122.3, 125.6, 125.7, 126.5, 128.7 (×2), 129.1, 130.2 (×2), 134.8, 139.1, 142.1, 142.4.

3-Iodobenzo[*b*]thiophene 4{*2*}[3]



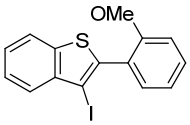
The product was obtained as a white solid (96% yield): mp 84-85 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.80 (s, 3H), 6.95 (d, *J* = 8.7 Hz, 2H), 7.32 (t, *J* = 7.8 Hz, 1H), 7.41 (t, *J* = 7.8 Hz, 1H), 7.59 (d, *J* = 8.7 Hz, 2H), 7.71 (d, *J* = 7.8 Hz, 1H), 7.77 (d, *J* = 8.0 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.5, 79.1, 114.0 (×2), 122.2, 125.4, 125.5, 126.2, 126.9, 131.4 (×2), 138.9, 142.0, 142.2, 160.2; HRMS calcd for $C_{15}H_{11}IOS$ [M^+], 365.9575, found 365.9578.

3-Iodobenzo[*b*]thiophene 4{*3*}



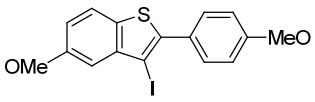
The product was obtained as a pale yellow solid (88% yield): mp 73-74 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.90 (s, 3H), 6.98-7.04 (m, 1H), 7.27-7.32 (m, 2H), 7.38-7.44 (m, 2H), 7.49 (t, *J* = 8.1 Hz, 1H), 7.80 (d, *J* = 7.7 Hz, 1H), 7.86 (d, *J* = 8.1 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.6, 79.6, 114.9, 115.6, 122.3, 122.6, 125.6, 125.7, 126.5, 129.7, 136.0, 139.0, 142.0, 142.1, 159.6; HRMS calcd for $C_{15}H_{11}IOS$ [M^+], 365.9575, found 365.9577.

3-Iodobenzo[*b*]thiophene 4{*4*}[3]



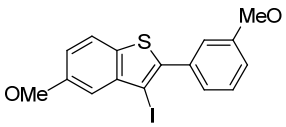
The product was obtained as a pale yellow solid (89% yield): mp 105-106 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.73 (s, 3H), 6.92 (d, *J* = 8.2 Hz, 1H), 7.00 (d, *J* = 7.5 Hz, 1H), 7.27-7.41 (m, 4H), 7.71 (d, *J* = 7.9 Hz, 1H), 7.77 (d, *J* = 8.1 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.7, 82.9, 111.5, 120.5, 122.2, 123.5, 125.2, 125.3, 126.0, 130.8, 132.5, 139.5, 139.7, 141.3, 157.1; HRMS calcd for $C_{15}H_{11}IOS$ [M^+], 365.9575, found 365.9575.

3-Iodobenzo[*b*]thiophene 4{*5*}[3,5]



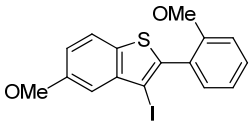
The product was obtained as a pale yellow solid (94% yield): mp 114-115 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.83 (s, 3H), 3.90 (s, 3H), 6.95-7.00 (m, 3H), 7.24 (d, *J* = 2.4 Hz, 1H), 7.58-7.60 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.5, 55.8, 78.8, 108.4, 114.0 (×2), 115.7, 123.0, 127.1, 131.1 (×2), 131.3, 143.2, 143.5, 158.6, 160.2; HRMS calcd for $C_{16}H_{13}IO_2S$ [M^+], 395.9681, found 395.9684.

3-Iodobenzo[*b*]thiophene 4{*6*}[3,5]



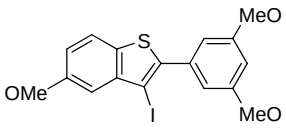
The product was obtained as a yellow oil (89% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.87 (s, 3H), 3.94 (s, 3H), 6.96-7.05 (m, 2H), 7.23-7.29 (m, 3H), 7.38 (t, *J* = 8.1 Hz, 1H), 7.65 (d, *J* = 8.8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.6, 55.9, 79.3, 108.6, 114.9, 115.5, 116.1, 122.6, 123.1, 129.7, 131.2, 136.1, 143.2, 143.4, 158.7, 159.8; HRMS calcd for $C_{16}H_{13}IO_2S$ [M^+], 395.9681, found 395.9686.

3-Iodobenzo[*b*]thiophene 4{*7*}[3,5]



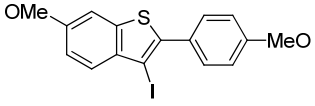
The product was obtained as a yellow oil (94% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.77 (s, 3H), 3.88 (s, 3H), 6.92-7.05 (m, 3H), 7.24 (d, *J* = 2.0 Hz, 1H), 7.34-7.42 (m, 2H), 7.60 (d, *J* = 8.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.7, 55.8, 82.6, 108.1, 111.5, 115.7, 120.5, 123.0, 123.7, 130.8, 131.7, 132.5, 141.0, 142.5, 157.1, 158.4; HRMS calcd for $C_{16}H_{13}IO_2S$ [M^+], 395.9681, found 395.9677.

3-Iodobenzo[*b*]thiophene 4{*8*}[3,5]



The product was obtained as a yellow solid (88% yield): mp 135-136 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.85 (s, 6H), 3.93 (s, 3H), 6.54 (t, *J* = 2.2 Hz, 1H), 6.83 (d, *J* = 2.3 Hz, 2H), 7.02 (dd, *J* = 2.4, 8.7 Hz, 1H), 7.27 (d, *J* = 2.4 Hz, 1H), 7.64 (d, *J* = 8.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.7 (×2), 55.9, 79.2, 101.3, 108.2 (×2), 108.6, 116.1, 123.1, 131.1, 136.5, 143.1, 143.4, 158.7, 160.7 (×2); HRMS calcd for $C_{17}H_{15}IO_3S$ [M^+], 425.9787, found 425.9795.

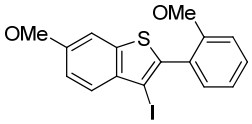
3-Iodobenzo[*b*]thiophene 4{*9*}[3,5]



The product was obtained as a yellow solid (95% yield): mp 112-113 °C (uncorrected); ^{1}H NMR

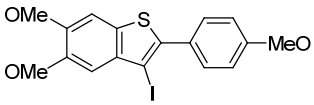
(400 MHz, $CDCl_3$) δ 3.85 (s, 3H), 3.87 (s, 3H), 6.98 (d, *J* = 8.5 Hz, 2H), 7.05 (dd, *J* = 1.9, 8.8 Hz, 1H), 7.24 (d, *J* = 2.0 Hz, 1H), 7.59 (d, *J* = 8.6 Hz, 2H), 7.66 (d, *J* = 8.8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.5, 55.9, 78.2, 104.7, 114.1 (×2), 115.3, 126.9, 127.1, 131.4 (×2), 136.2, 139.9, 158.3, 160.0; HRMS calcd for $C_{16}H_{13}IO_2S$ [M^+], 395.9681, found 395.9686.

3-Iodobenzo[*b*]thiophene 4{*10*}[3]



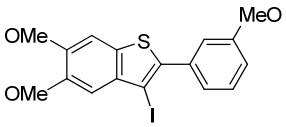
The product was obtained as a colorless oil (93% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.78 (s, 3H), 3.83 (s, 3H), 6.96 (d, *J* = 8.2 Hz, 1H), 6.99-7.06 (m, 2H), 7.24 (d, *J* = 2.3 Hz, 1H), 7.35-7.43 (m, 2H), 7.65 (d, *J* = 8.9 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.7, 55.9, 82.0, 104.6, 111.5, 115.1, 120.5, 123.7, 126.6, 130.7, 132.7, 135.5, 136.9, 140.6, 157.2, 158.2; HRMS calcd for $C_{16}H_{13}IO_2S$ [M^+], 395.9681, found 395.9686.

3-Iodobenzo[*b*]thiophene 4{*11*}[3,5]



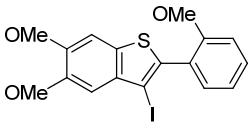
The product was obtained as a pale yellow solid (89% yield): mp 140-142 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.86 (s, 3H), 3.96 (s, 3H), 4.01 (s, 3H), 6.98 (d, *J* = 8.8 Hz, 2H), 7.21 (s, 1H), 7.22 (s, 1H), 7.59 (d, *J* = 8.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.5, 56.3, 56.5, 78.2, 103.6, 107.5, 114.0 (×2), 127.2, 130.3, 131.3 (×2), 135.7, 140.2, 149.0, 149.1, 160.0; HRMS calcd for $C_{17}H_{15}IO_3S$ [M^+], 425.9787, found 425.9795.

3-Iodobenzo[*b*]thiophene 4{*12*}



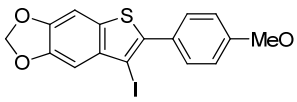
The product was obtained as a pale yellow solid (85% yield): mp 134-136 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.86 (s, 3H), 3.96 (s, 3H), 4.01 (s, 3H), 6.93-6.97 (m, 1H), 7.21-7.27 (m, 4H), 7.36 (t, *J* = 8.2 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.6, 56.4, 56.5, 78.6, 103.6, 107.6, 114.5, 115.5, 122.5, 129.7, 131.1, 135.8, 136.1, 140.0, 149.25, 149.3, 159.6; HRMS calcd for $C_{17}H_{15}IO_3S$ [M^+], 425.9787, found 425.9791.

3-Iodobenzo[*b*]thiophene 4{*13*}[3]



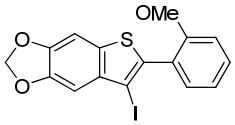
The product was obtained as a yellow solid (83% yield): mp 144-145 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.81 (s, 3H), 3.94 (s, 3H), 4.01 (s, 3H), 6.96-7.07 (m, 2H), 7.21 (s, 1H), 7.23 (s, 1H), 7.35-7.43 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.8, 56.3, 56.5, 81.9, 103.6, 107.3, 111.5, 120.5, 123.8, 130.7, 131.7, 132.7, 135.1, 137.5, 148.98, 149.02, 157.2; HRMS calcd for $C_{17}H_{15}IO_3S$ [M^+], 425.9787, found 425.9795.

3-Iodobenzo[*b*]thiophene 4{*14*}[3]



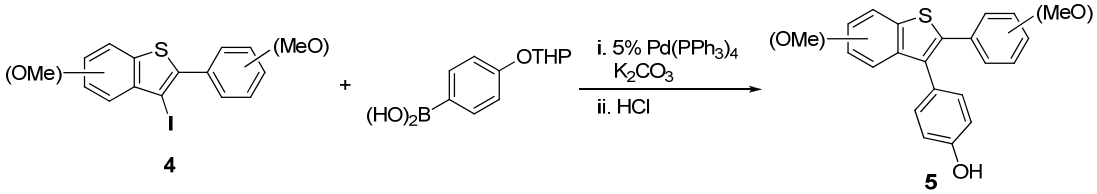
The product was obtained as a white solid (94% yield): mp 163-164 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.86 (s, 3H), 6.04 (s, 2H), 6.98 (d, *J* = 8.7 Hz, 2H), 7.14 (s, 1H), 7.23 (s, 1H), 7.57 (d, *J* = 8.7 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.6, 78.3, 101.3, 101.8, 105.4, 114.1 (×2), 127.2, 131.3 (×2), 132.4, 137.1, 140.7, 147.4, 147.7, 160.1; HRMS calcd for $C_{16}H_{11}IO_3S$ [M^+], 409.9474, found 409.9479.

3-Iodobenzo[*b*]thiophene 4{*15*}[3]



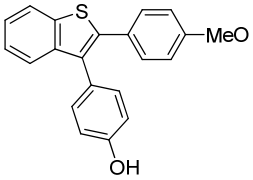
The product was obtained as a yellow solid (85% yield): mp 135-136.5 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.77 (s, 3H), 5.97 (s, 2H), 6.94 (d, *J* = 8.2 Hz, 1H), 7.00 (t, *J* = 7.5 Hz, 1H), 7.11 (s, 1H), 7.21 (s, 1H), 7.33-7.37 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.7, 82.0, 101.2, 101.6, 105.1, 111.4, 120.4, 123.7, 130.7, 132.6, 133.0, 136.3, 137.9, 147.3, 147.5, 157.1; HRMS calcd for $C_{16}H_{11}IO_3S$ [M^+], 409.9474, found 409.9479.

◈ **General procedure for Suzuki-Miyaura coupling to prepare compounds 5**



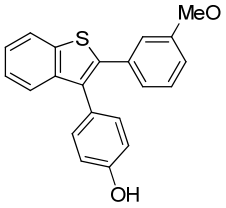
To a solution of **4** (1.0 mmol) and 5 mol % of $Pd(PPh_3)_4$ in toluene (10 mL) was added K_2CO_3 (2.5 mmol) under an Ar atmosphere. To the resulting mixture was added the THP-protected phenylboronic acid (1.5 mmol) dissolved in ethanol (2 mL) and water (0.5 mL) and the mixture was heated at 80 °C for 6-8 h with vigorous stirring. After concentration of the solvent under reduced pressure, to the crude compounds in THF (0.1 M conc.) was added 10% aq HCl at room temperature and then the mixture was stirred for 1 h. The mixture was then extracted by EtOAc (2 × 20 mL) and the aqueous phase was also extracted with EtOAc or CH_2Cl_2. The combined organic layers were dried over anhydrous $MgSO_4$ and concentrated under a vacuum to yield the crude product, which was purified by flash chromatography using EtOAc/hexanes as the eluent to afford the corresponding products **5**.

Compound 5*{2}*



The product was obtained as pale yellow oil that solidified upon standing to an ivory solid (92% yield): mp 201-202 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.79 (s, 3H), 5.16 (br s, 1H), 6.79 (d, *J* = 8.7 Hz, 2H), 6.85 (d, *J* = 8.4 Hz, 2H), 7.20 (d, *J* = 8.4 Hz, 2H), 7.26 (d, *J* = 8.7 Hz, 2H), 7.29-7.34 (m, 2H), 7.54-7.57 (m, 1H), 7.83-7.86 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.5, 114.0 (×2), 115.9 (×2), 122.2, 123.3, 124.4, 124.5, 127.0, 128.2, 130.9 (×2), 131.9 (×2), 132.1, 138.7, 139.2, 141.3, 155.1, 159.3; HRMS calcd for $C_{22}H_{17}O_4S$ [M+HCOO$^+$], 377.0848, found 377.0848.

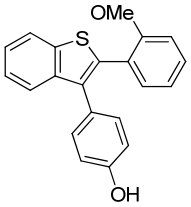
Compound 5*{3}*



The product was obtained as pale yellow oil that solidified upon standing to an ivory solid (84% yield): mp 145-146 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.62 (s, 3H), 5.62 (br s, 1H), 6.78 (dd, *J* = 2.6, 8.2 Hz, 1H), 6.84-6.88 (m, 3H), 6.96 (d, *J* = 7.7 Hz, 1H), 7.13-7.23 (m, 3H), 7.30-7.35 (m, 2H), 7.56-7.59 (m, 1H), 7.82-7.87 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.3, 114.0, 114.8, 115.9 (×2), 122.3, 123.5, 124.6, 124.7, 128.0, 129.6, 131.9 (×2), 133.2, 135.8, 138.9, 139.1,

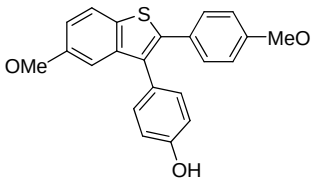
141.2, 155.2, 159.4; HRMS calcd for $C_{21}H_{16}O_2S$ [M^+], 332.0871, found 332.0869.

Compound 5{*4*}



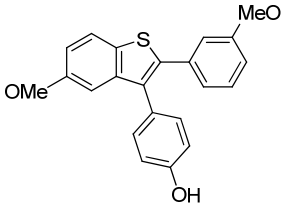
The product was obtained as a pale yellow oil (89% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.56 (s, 3H), 5.05 (br s, 1H), 6.76 (d, *J* = 8.6 Hz, 2H), 6.82-6.89 (m, 2H), 7.16 (d, *J* = 8.6 Hz, 2H), 7.21-7.29 (m, 2H), 7.31-7.36 (m, 2H), 7.66-7.72 (m, 1H), 7.83-7.87 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.5, 111.4, 115.3 (×2), 120.6, 122.3, 123.3, 123.4, 124.3, 124.4, 128.7, 129.8, 131.2 (×2), 132.8, 134.7, 135.5, 139.9, 140.0, 154.6, 157.2; HRMS calcd for $C_{22}H_{17}O_4S$ [M+$HCOO^+$], 377.0848, found 377.0851.

Compound 5{*5*}[5]



The product was obtained as a pale yellow oil (89% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.78 (s, 3H), 3.78 (s, 3H), 5.12 (br s, 1H), 6.78 (d, *J* = 8.8 Hz, 2H), 6.87 (d, *J* = 8.5 Hz, 2H), 6.96-7.03 (m, 2H), 7.20 (d, *J* = 8.5 Hz, 2H), 7.23 (d, *J* = 8.8 Hz, 2H), 7.70 (d, *J* = 8.6 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.5, 55.8, 105.8, 114.0 (×2), 114.3, 115.9 (×2), 122.9, 127.1, 128.3, 130.8 (×2), 131.1, 131.85 (×2), 131.89, 140.7, 142.4, 155.0, 157.8, 159.2; HRMS calcd for $C_{22}H_{18}O_3S$ [M^+], 362.0977, found 362.0983.

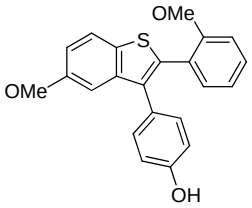
Compound 5{*6*}[5]



The product was obtained as pale yellow oil that solidified upon standing to an ivory solid (86% yield): mp 142-143 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.62 (s, 3H), 3.78 (s, 3H), 5.45 (br s, 1H), 6.77 (dd, *J* = 2.5, 8.2 Hz, 1H), 6.82-6.85 (m, 1H), 6.86 (d, *J* = 8.6 Hz, 2H), 6.93 (d, *J* = 8.2

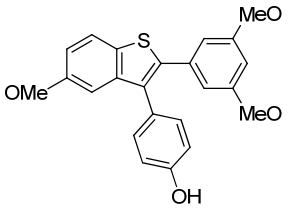
Hz, 1H), 6.98-7.05 (m, 2H), 7.15 (t, *J* = 7.8 Hz, 1H), 7.19 (d, *J* = 8.6 Hz, 2H), 7.71 (d, *J* = 8.6 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.3, 55.8, 105.9, 114.0, 114.71, 114.74, 115.9 (×2), 122.2, 123.0, 128.1, 129.6, 131.3, 131.8 (×2), 132.9, 135.9, 140.5, 142.2, 155.1, 157.8, 159.3; HRMS calcd for $C_{22}H_{18}O_3S$ [M^+], 362.0977, found 362.0983.

Compound 5{*7*}[5]



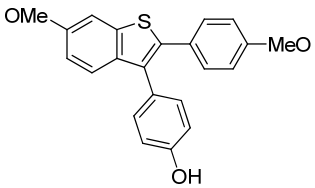
The product was obtained as a pale yellow oil (91% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.54 (s, 3H), 3.79 (s, 3H), 5.74 (br s, 1H), 6.76 (d, *J* = 8.7 Hz, 2H), 6.79-6.89 (m, 2H), 6.99 (dd, *J* = 2.5, 8.7 Hz, 1H), 7.14 (d, *J* = 8.7 Hz, 2H), 7.14-7.16 (m, 1H), 7.20-7.27 (m, 2H), 7.71 (d, *J* = 8.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.5, 55.8, 105.8, 111.4, 114.4, 115.4 (×2), 120.5, 123.0, 123.5, 128.6, 129.7, 131.1 (×2), 132.3, 132.7, 134.5, 136.8, 141.0, 154.8, 157.1, 157.6; HRMS calcd for $C_{22}H_{18}O_3S$ [M^+], 362.0977, found 362.0983.

Compound 5{*8*}[5]



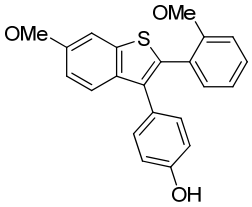
The product was obtained as pale yellow oil that solidified upon standing to an ivory solid (83% yield): mp 172-174 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.63 (s, 6H), 3.79 (s, 3H), 5.13 (br s, 1H), 6.35 (br s, 1H), 6.48 (d, *J* = 2.2 Hz, 2H), 6.88 (d, *J* = 7.9 Hz, 2H), 6.98-7.04 (m, 2H), 7.21 (d, *J* = 7.9 Hz, 2H), 7.72 (d, *J* = 8.5 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.4 (×2), 55.8, 100.4, 105.8, 107.7 (×2), 114.8, 115.9 (×2), 123.0, 128.0, 131.2, 131.8 (×2), 133.1, 136.4, 140.5, 142.2, 155.4, 157.8, 160.5 (×2); HRMS calcd for $C_{24}H_{21}O_6S$ [M+$HCOO^+$], 437.1059, found 437.1044.

Compound 5{*9*}[5]



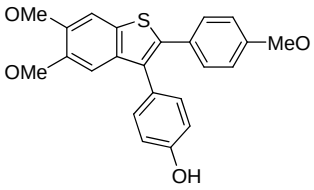
The product was obtained as pale yellow oil that solidified upon standing to an ivory solid (81% yield): mp 185-186 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.78 (s, 3H), 3.89 (s, 3H), 5.04 (br s, 1H), 6.78 (d, *J* = 8.9 Hz, 2H), 6.86 (d, *J* = 8.6 Hz, 2H), 6.94 (dd, *J* = 2.4, 8.9 Hz, 1H), 7.19 (d, *J* = 8.6 Hz, 2H), 7.23 (d, *J* = 8.9 Hz, 2H), 7.33 (d, *J* = 2.4 Hz, 1H), 7.44 (d, *J* = 8.9 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.5, 55.9, 104.8, 114.0 (×2), 114.4, 115.8 (×2), 124.0, 127.2, 128.4, 130.8 (×2), 131.6, 131.9 (×2), 135.4, 136.5, 139.9, 154.9, 157.5, 159.0; HRMS calcd for $C_{22}H_{18}O_3S$ [M^+], 362.0977, found 362.0990.

Compound 5{*10*}[5]



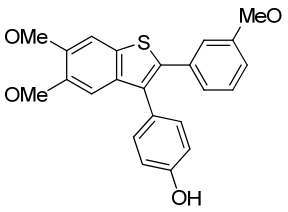
The product was obtained as pale yellow oil that solidified upon standing to an ivory solid (83% yield): mp 98-99 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.54 (s, 3H), 3.86 (s, 3H), 5.53 (br s, 1H), 6.74 (d, *J* = 8.5 Hz, 2H), 6.80-6.86 (m, 2H), 6.95 (dd, *J* = 2.3, 8.9 Hz, 1H), 7.12 (d, *J* = 8.5 Hz, 2H), 7.16-7.24 (m, 2H), 7.33 (d, *J* = 2.3 Hz, 1H), 7.56 (d, *J* = 8.9 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.5, 55.9, 104.8, 111.4, 114.2, 115.3 (×2), 120.6, 123.5, 124.0, 128.7, 129.5, 131.1 (×2), 132.6, 132.8, 134.18, 134.20, 141.2, 154.7, 157.1, 157.4; HRMS calcd for $C_{22}H_{18}O_3S$ [M^+], 362.0977, found 362.0986.

Compound 5{*11*}[5]



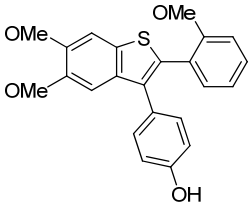
The product was obtained as a yellow solid (78% yield): mp 157-158 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.79 (s, 3H), 3.84 (s, 3H), 3.97 (s, 3H), 5.09 (br s, 1H), 6.78 (d, *J* = 8.8 Hz, 2H), 6.88 (d, *J* = 8.5 Hz, 2H), 6.97 (s, 1H), 7.20 (d, *J* = 8.5 Hz, 2H), 7.24 (d, *J* = 8.8 Hz, 2H), 7.29 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.5, 56.3, 56.4, 103.9, 104.7, 114.0 (×2), 116.0 (×2), 127.2, 128.5, 130.7 (×2), 131.2, 131.8 (×2), 134.8, 137.4, 148.4, 148.4, 155.0, 159.0; HRMS calcd for $C_{24}H_{21}O_6S$ [$M+HCOO^+$], 437.1059, found 437.1047.

Compound 5{*12*}



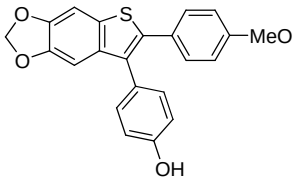
The product was obtained as a yellow solid (77% yield): mp 123-124.5 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.63 (s, 3H), 3.83 (s, 3H), 3.97 (s, 3H), 5.17 (br s, 1H), 6.76 (dd, *J* = 2.4, 8.2 Hz, 1H), 6.80 (br s, 1H), 6.86-6.93 (m, 1H), 6.88 (d, *J* = 8.4 Hz, 2H), 6.98 (s, 1H), 7.15 (t, *J* = 7.9 Hz, 1H), 7.21 (d, *J* = 8.4 Hz, 2H), 7.30 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.3, 56.3, 56.5, 104.1, 105.0, 113.7, 114.7, 116.0 (×2), 116.4, 122.1, 128.5, 129.5, 131.6, 131.8 (×2), 132.9, 134.8, 136.1, 148.6, 148.7, 155.2, 159.5; HRMS calcd for $C_{23}H_{20}O_4S$ [M^+], 392.1082, found 392.1084.

Compound 5{*13*}



The product was obtained as a yellow oil (84% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.56 (s, 3H), 3.84 (s, 3H), 3.95 (s, 3H), 5.50 (br s, 1H), 6.76-6.88 (m, 4H), 7.12 (s, 1H), 7.14-7.28 (m, 4H), 7.30 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.5, 56.3, 56.4, 103.9, 104.7, 111.4, 115.4 (×2), 120.5, 123.6, 128.9, 129.5, 131.0 (×2), 132.5, 132.8, 133.47, 133.51, 134.3, 148.15, 148.22, 154.8, 157.1; HRMS calcd for $C_{23}H_{20}O_4S$ [M^+], 392.1082, found 392.1092.

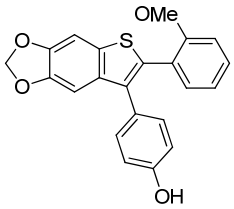
Compound 5{*14*}



The product was obtained as pale yellow oil that solidified upon standing to an ivory solid (85% yield): mp 202-203 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.78 (s, 3H), 4.89 (br s, 1H), 5.99 (s, 2H), 6.77 (d, *J* = 9.0 Hz, 2H), 6.86 (d, *J* = 8.6 Hz, 2H), 6.94 (s, 1H), 7.17 (d, *J* = 8.6 Hz, 2H), 7.19 (s, 1H), 7.21 (d, *J* = 9.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.5, 101.4, 101.5, 102.3, 114.0 (×2), 115.5, 115.9 (×2), 127.1, 128.4, 130.6 (×2), 131.8 (×2), 132.0, 136.0, 137.6, 146.6, 146.9,

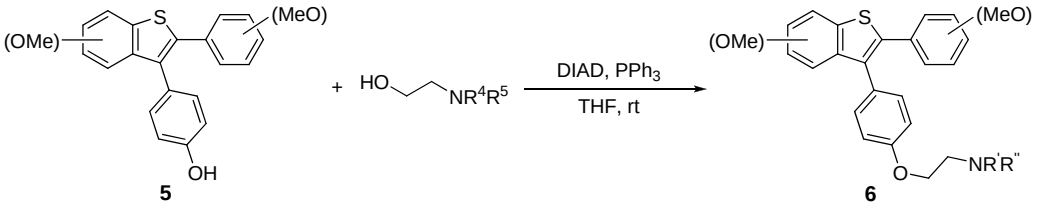
155.0, 159.1; HRMS calcd for $C_{22}H_{16}O_4S$ [M^+], 376.0769, found 376.0777.

Compound 5{*15*}



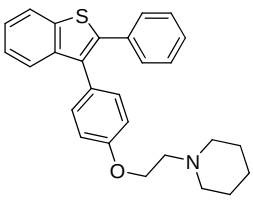
The product was obtained as a pale yellow oil (87% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.55 (s, 3H), 5.48 (br s, 1H), 5.96 (s, 2H), 6.75 (d, *J* = 7.9 Hz, 2H), 6.77-6.87 (m, 2H), 7.08 (s, 1H), 7.11 (d, *J* = 7.9 Hz, 2H), 7.16-7.26 (m, 2H), 7.23 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.5, 101.4, 101.5, 102.3, 111.4, 115.3 (×2), 120.5, 123.5, 128.7, 129.5, 131.1 (×2), 132.7, 133.3, 133.6, 134.5, 134.6, 146.5, 146.7, 154.7, 157.0; HRMS calcd for $C_{44}H_{36}ONO_8S_2$ [2M+NH_4^+], 770.1882, found 770.1857.

◈ **General Procedure for the Mitsunobu reaction to prepare compounds 6**



To a solution of **5** (0.2 mmol), PPh_3 (0.4 mmol), and the alkylaminoethanol (0.3 mmol) in anhydrous THF (2 mL) was added diisopropyl azodicarboxylate (DIAD) (0.3 mmol) with stirring at 0-5 °C. The resulting solution was stirred at room temperature for *ca*. 24-32 h (monitored by TLC until completion) and concentrated *in vacuo*. The crude product was purified by column chromatography on silica gel using methanol/ethyl acetate/hexanes as the eluent to afford the corresponding products **6**.

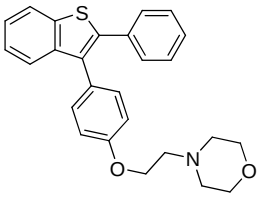
Compound 6{*1*}



The product was obtained as a pale yellow oil (83% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.41-1.50 (m, 2H), 1.59-1.66 (m, 4H), 2.53 (br s, 4H), 2.80 (t, *J* = 6.0 Hz, 2H), 4.14 (t, *J* = 6.0 Hz, 2H), 6.94 (d,

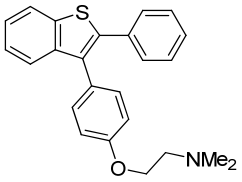
J = 8.8 Hz, 2H), 7.20-7.25 (m, 4H), 7.31-7.34 (m, 3H), 7.43-7.56 (m ,3H), 7.83-7.88 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 24.4, 26.2 (×2), 55.3 (×2), 58.2, 66.2, 114.9, 122.2, 123.5, 124.5, 124.6, 128.6 (×2), 128.7 (×2), 132.2 (×2), 132.3 (×2), 133.0, 133.2, 134.6, 138.9, 139.2, 141.2, 158.3; HRMS calcd for $C_{27}H_{28}NOS$ [M+H$^+$], 414.1892, found 414.1894.

Compound 6{*2*}



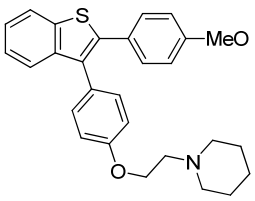
The product was obtained as a pale yellow oil (78% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.60 (t, *J* = 4.4 Hz, 4H), 2.83 (t, *J* = 5.7 Hz, 2H), 3.75 (t, *J* = 4.6 Hz, 4H), 4.14 (t, *J* = 5.7 Hz, 2H), 6.93 (d, *J* = 8.7 Hz, 2H), 7.20-7.23 (m, 2H), 7.29-7.34 (m, 3H), 7.42-7.54 (m, 3H), 7.63-7.70 (m, 2H), 7.85-7.88 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 54.3 (×2), 57.9, 66.0, 67.1 (×2), 114.9 (×2), 122.2, 123.5, 124.5, 124.6, 127.8, 128.5 (×2), 128.6, 128.7, 129.8 (×2), 131.7 (×2), 134.5, 138.9, 139.3, 141.2, 158.2; HRMS calcd for $C_{26}H_{26}NO_2S$ [M+H$^+$], 416.1684, found 416.1682.

Compound 6{*4*}



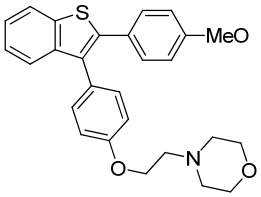
The product was obtained as a pale yellow oil (79% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.36 (s, 6H), 2.76 (t, *J* = 5.8 Hz, 2H), 4.10 (t, *J* = 5.8 Hz, 2H), 6.96 (d, *J* = 8.6 Hz, 2H), 7.22-7.26 (m, 4H), 7.30-7.35 (m, 4H), 7.58-7.70 (m, 2H), 7.85-7.88 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 46.2 (×2), 58.6, 66.2, 115.0 (×2), 122.3, 123.6, 124.6, 124.7, 127.8, 128.5 (×2), 129.8 (×2), 131.7 (×2), 132.3, 133.1, 134.6, 139.0, 139.3, 141.3, 158.4; HRMS calcd for $C_{24}H_{24}NOS$ [M+H$^+$], 374.1579, found 374.1576.

Compound 6{*5*}



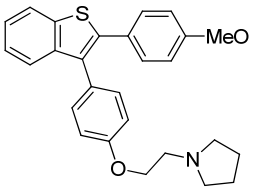
The product was obtained as a pale yellow oil (83% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.39-1.50 (m, 2H), 1.55-1.66 (m, 4H), 2.50-2.58 (m, 4H), 2.81 (t, *J* = 6.0 Hz, 2H), 3.79 (s, 3H), 4.15 (t, *J* = 6.0 Hz, 2H), 6.79 (d, *J* = 8.8 Hz, 2H), 6.94 (d, *J* = 8.6 Hz, 2H), 7.21-7.27 (m, 4H), 7.30-7.34 (m, 2H), 7.54-7.58 (m, 1H), 7.82-7.86 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 24.4, 26.2 (×2), 55.3 (×2), 55.4, 58.3, 66.2, 114.0 (×2), 115.0, 122.2, 123.3, 124.4, 124.5, 127.0, 128.1, 130.9 (×2), 131.7 (×2), 132.4, 138.7, 139.2, 141.4, 158.3, 159.3; HRMS calcd for $C_{28}H_{29}NO_2S$ [M^+], 443.1919, found 443.1911.

Compound 6{*6*}



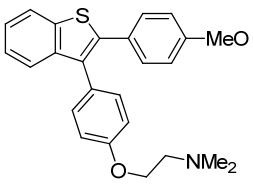
The product was obtained as a pale yellow oil (73% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.61 (t, *J* = 4.6 Hz, 4H), 2.84 (t, *J* = 5.8 Hz, 2H), 3.76 (t, *J* = 4.6 Hz, 4H), 3.78 (s, 3H), 4.15 (t, *J* = 5.8 Hz, 2H), 6.79 (d, *J* = 8.8 Hz, 2H), 6.95 (d, *J* = 8.7 Hz, 2H), 7.23-7.26 (m, 4H), 7.29-7.34 (m, 2H), 7.55-7.58 (m, 1H), 7.83-7.86 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 54.3 (×2), 55.4, 57.9, 66.0, 67.1 (×2), 114.0 (×2), 114.9 (×2), 122.2, 123.3, 124.4, 124.5, 126.9, 128.2, 130.9 (×2), 131.7 (×2), 133.2, 138.6, 139.2, 141.3, 158.1, 159.3; HRMS calcd for $C_{27}H_{27}NO_3S$ [M^+], 445.1712, found 445.1716.

Compound 6{*7*}



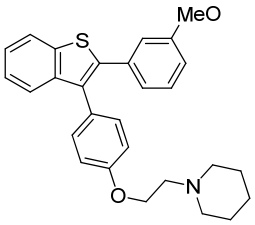
The product was obtained as a pale yellow oil (85% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.83 (br s, 4H), 2.62-2.70 (m, 4H), 2.95 (t, *J* = 6.0 Hz, 2H), 3.78 (s, 3H), 4.15 (t, *J* = 6.0 Hz, 2H), 6.79 (d, *J* = 8.9 Hz, 2H), 6.95 (d, *J* = 8.7 Hz, 2H), 7.23 (d, *J* = 8.7 Hz, 2H), 7.26 (d, *J* = 8.9 Hz, 2H), 7.29-7.34 (m, 2H), 7.54-7.58 (m, 1H), 7.82-7.86 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 23.7 (×2), 55.0 (×2), 55.3, 55.4, 67.2, 114.0 (×2), 115.0 (×2), 122.2, 123.3, 124.4, 124.5, 127.0, 128.1, 130.9 (×2), 131.7 (×2), 132.2, 138.6, 139.2, 141.4, 158.3, 159.3; HRMS calcd for $C_{27}H_{27}NO_2S$ [M^+], 429.1762, found 429.1765.

Compound 6{*8*}



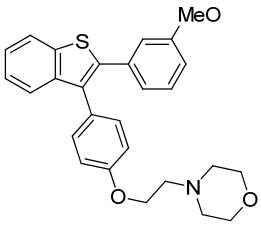
The product was obtained as a pale yellow oil (81% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.36 (s, 6H), 2.76 (t, *J* = 6.0 Hz, 2H), 3.78 (s, 3H), 4.10 (t, *J* = 6.0 Hz, 2H), 6.78 (d, *J* = 8.8 Hz, 2H), 6.96 (d, *J* = 8.6 Hz, 2H), 7.21-7.27 (m, 4H), 7.30-7.34 (m, 2H), 7.54-7.58 (m, 1H), 7.82-7.86 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 46.2 (×2), 55.4, 58.6, 66.2, 114.0 (×2), 114.9 (×2), 122.1, 123.3, 124.4, 124.5, 127.0, 128.1, 130.9 (×2), 131.6 (×2), 132.1, 138.6, 139.1, 141.3, 158.3, 159.2; HRMS calcd for $C_{25}H_{25}NO_2S$ [M^+], 403.1606, found 403.1611.

Compound 6{*9*}



The product was obtained as a pale yellow oil (78% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.41-1.50 (m, 2H), 1.59-1.66 (m, 4H), 2.50-2.56 (m, 4H), 2.80 (t, *J* = 6.1 Hz, 2H), 3.63 (s, 3H), 4.14 (t, *J* = 6.1 Hz, 2H), 6.78 (dd, *J* = 2.4, 8.2 Hz, 1H), 6.86 (t, *J* = 2.2 Hz, 1H), 6.95-6.97 (m, 1H), 6.95 (d, *J* = 8.6 Hz, 2H), 7.17 (t, *J* = 7.9 Hz, 1H), 7.25 (d, *J* = 8.6 Hz, 2H), 7.31-7.37 (m, 2H), 7.57-7.62 (m, 1H), 7.84-7.88 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 24.4, 26.2 (×2), 55.2, 55.3 (×2), 58.2, 66.3, 114.0, 114.8, 115.0 (×2), 122.2, 122.3, 123.5, 124.6, 124.7, 128.0, 129.5, 131.6 (×2), 133.3, 135.8, 138.9, 139.1, 141.3, 158.4, 159.5; HRMS calcd for $C_{28}H_{29}NO_2S$ [M^+], 443.1919, found 443.1916.

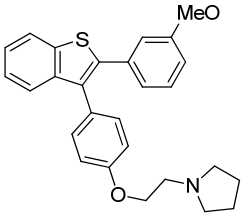
Compound 6{*10*}



The product was obtained as a pale yellow oil (73% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.61 (br s, 4H), 2.84 (t, *J* = 5.7 Hz, 2H), 3.64 (s, 3H), 3.76 (t, *J* = 4.4 Hz, 4H), 4.15 (t, *J* = 5.7 Hz, 2H), 6.79 (dd, *J*

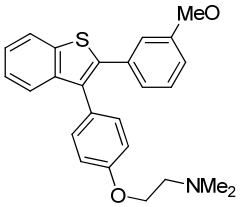
= 2.4, 8.2 Hz, 1H), 6.86 (br s, 1H), 6.93-6.97 (m, 1H), 6.95 (d, *J* = 8.6 Hz, 2H), 7.17 (t, *J* = 8.0 Hz, 1H), 7.26 (d, *J* = 8.6 Hz, 2H), 7.30-7.36 (m, 2H), 7.56-7.61 (m, 1H), 7.83-7.88 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 54.4 (×2), 55.3, 57.9, 66.1, 67.2 (×2), 113.9, 114.9, 115.0 (×2), 122.2, 122.3, 123.5, 124.6, 124.7, 128.2, 129.5, 131.7 (×2), 133.2, 135.8, 138.9, 139.1, 141.2, 158.3, 159.5.

Compound 6{*11*}



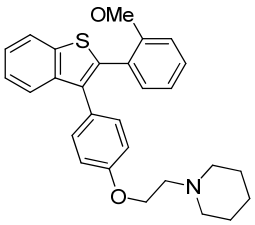
The product was obtained as a pale yellow oil (76% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.80-1.85 (m, 4H), 2.61-2.68 (m, 4H), 2.93 (t, *J* = 6.0 Hz, 2H), 3.63 (s, 3H), 4.14 (t, *J* = 6.0 Hz, 2H), 6.78 (dd, *J* = 2.4, 8.2 Hz, 1H), 6.86 (br s, 1H), 6.93-6.97 (m, 1H), 6.95 (d, *J* = 8.6 Hz, 2H), 7.17 (t, *J* = 8.0 Hz, 1H), 7.25 (d, *J* = 8.6 Hz, 2H), 7.30-7.36 (m, 2H), 7.56-7.61 (m, 1H), 7.83-7.88 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 23.7 (×2), 55.0 (×2), 55.2, 55.4, 67.3, 114.0, 114.8, 115.0 (×2), 122.20, 122.23, 123.6, 124.6, 124.7, 128.0, 129.5, 131.6 (×2), 133.2, 135.8, 138.9, 139.1, 141.3, 158.4, 159.4.

Compound 6{*12*}



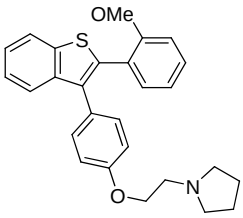
The product was obtained as a pale yellow oil (69% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.36 (s, 6H), 2.76 (t, *J* = 5.7 Hz, 2H), 3.62 (s, 3H), 4.10 (t, *J* = 5.7 Hz, 2H), 6.78 (dd, *J* = 2.5, 8.2 Hz, 1H), 6.86 (br s, 1H), 6.93-6.97 (m, 1H), 6.96 (d, *J* = 8.6 Hz, 2H), 7.16 (t, *J* = 8.0 Hz, 1H), 7.25 (d, *J* = 8.6 Hz, 2H), 7.30-7.36 (m, 2H), 7.56-7.61 (m, 1H), 7.83-7.88 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 46.1 (×2), 55.2, 58.5, 66.2, 114.0, 114.8, 115.0 (×2), 122.19, 122.22, 123.5, 124.5, 124.7, 128.0, 129.5, 131.6 (×2), 133.2, 135.8, 138.8, 139.1, 141.2, 158.4, 159.4.

Compound 6{*13*}



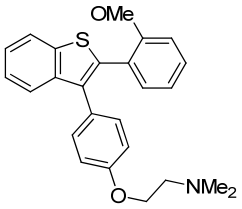
The product was obtained as a pale yellow oil (76% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.40-1.48 (m, 2H), 1.57-1.65 (m, 4H), 2.48-2.54 (m, 4H), 2.77 (t, *J* = 6.1 Hz, 2H), 3.57 (s, 3H), 4.10 (t, *J* = 6.1 Hz, 2H), 6.81-6.90 (m, 4H), 7.17-7.28 (m, 4H), 7.31-7.34 (m, 2H), 7.68-7.72 (m, 1H), 7.83-7.87 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 24.4, 26.1 (×2), 55.3 (×2), 55.5, 58.2, 66.2, 111.4, 114.5 (×2), 120.5, 122.2, 123.3, 123.5, 124.2, 124.3, 128.7, 129.7, 131.0 (×2), 132.8, 134.7, 135.5, 139.9, 140.1, 157.3, 158.0; HRMS calcd for $C_{28}H_{29}NO_2S$ [M^+], 443.1919, found 443.1917.

Compound 6{*15*}



The product was obtained as a pale yellow oil (67% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.75-1.85 (m, 4H), 2.60-2.66 (m, 4H), 2.93 (t, *J* = 6.0 Hz, 2H), 3.56 (s, 3H), 4.10 (t, *J* = 6.0 Hz, 2H), 6.81-6.90 (m, 2H), 6.87 (d, *J* = 8.8 Hz, 2H), 7.20-7.29 (m, 2H), 7.21 (d, *J* = 8.8 Hz, 2H), 7.31-7.34 (m, 2H), 7.68-7.72 (m, 1H), 7.83-7.87 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 23.7 (×2), 54.9 (×2), 55.3, 55.5, 67.2, 111.4, 114.5 (×2), 120.6, 122.2, 123.3, 123.5, 124.2, 124.3, 128.6, 129.7, 131.0 (×2), 132.8, 134.7, 135.5, 139.9, 140.1, 157.3, 158.0.

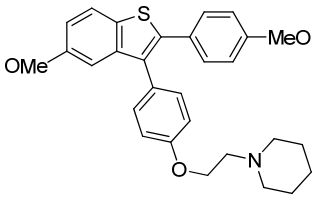
Compound 6{*16*}



The product was obtained as a pale yellow oil (71% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.34 (s, 6H), 2.73 (t, *J* = 5.8 Hz, 2H), 3.56 (s, 3H), 4.05 (t, *J* = 5.8 Hz, 2H), 6.81-6.90 (m, 2H), 6.87 (d, *J* = 8.8 Hz, 2H), 7.20-7.29 (m, 2H), 7.21 (d, *J* = 8.8 Hz, 2H), 7.31-7.34 (m, 2H), 7.68-7.72 (m, 1H), 7.83-7.87 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 46.1 (×2), 55.5, 58.5, 66.1, 111.4, 114.5 (×2), 120.6,

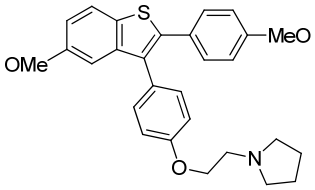
122.2, 123.3, 123.5, 124.26, 124.34, 128.7, 129.7, 131.0 (×2), 132.8, 134.7, 135.5, 139.9, 140.1, 157.3, 158.0.

Compound 6{*17*}[5]



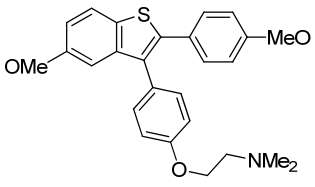
The product was obtained as a pale yellow oil (87% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.41-1.50 (m, 2H), 1.59-1.66 (m, 4H), 2.50-2.58 (m, 4H), 2.81 (t, *J* = 6.0 Hz, 2H), 3.779 (s, 3H), 3.780 (s, 3H), 4.15 (t, *J* = 6.0 Hz, 2H), 6.78 (d, *J* = 8.8 Hz, 2H), 6.95 (d, *J* = 8.8 Hz, 2H), 6.95-7.03 (m, 2H), 7.20-7.27 (m, 4H), 7.70 (d, *J* = 8.6 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 24.4, 26.2 (×2), 55.3 (×2), 55.4, 55.8, 58.3, 66.1, 105.7, 114.0 (×2), 114.4, 115.0 (×2), 122.9, 127.1, 128.2, 130.8 (×2), 131.0, 131.6 (×2), 132.0, 140.6, 142.4, 157.8, 158.2, 159.2; HRMS calcd for $C_{29}H_{32}NO_3S$ [M+H$^+$], 474.2103, found 474.2050.

Compound 6{*19*}



The product was obtained as a pale yellow oil (81% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.78-1.86 (m, 4H), 2.63-2.68 (m, 4H), 2.95 (t, *J* = 5.7 Hz, 2H), 3.779 (s, 3H), 3.780 (s, 3H), 4.16 (t, *J* = 5.7 Hz, 2H), 6.78 (d, *J* = 8.8 Hz, 2H), 6.93-7.03 (m, 4H), 7.20-7.25 (m, 4H), 7.70 (d, *J* = 8.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 23.7 (×2), 55.0 (×2), 55.35, 55.38, 55.7, 67.2, 105.8, 114.0 (×2), 114.3, 115.0 (×2), 122.8, 127.1, 128.2, 130.8 (×2), 131.0, 131.6 (×2), 132.0, 140.6, 142.4, 157.8, 158.3, 159.2; HRMS calcd for $C_{28}H_{29}NO_3S$ [M$^+$], 459.1868, found 459.1876.

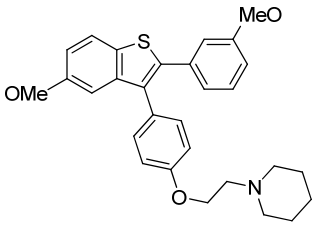
Compound 6{*20*}



The product was obtained as a pale yellow oil (81% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.37 (s,

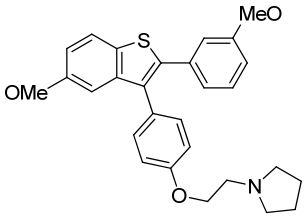
6H), 2.77 (t, *J* = 5.7 Hz, 2H), 3.769 (s, 3H), 3.770 (s, 3H), 4.10 (t, *J* = 5.7 Hz, 2H), 6.77 (d, *J* = 8.8 Hz, 2H), 6.95 (d, *J* = 8.8 Hz, 2H), 6.95-7.03 (m, 2H), 7.20-7.25 (m, 4H), 7.69 (d, *J* = 8.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 46.2 (×2), 55.4, 55.7, 58.6, 66.2, 105.8, 114.0 (×2), 114.3, 115.0 (×2), 122.8, 127.1, 128.2, 130.8 (×2), 131.0, 131.6 (×2), 132.0, 140.6, 142.4, 157.8, 158.2, 159.3.

Compound 6{*21*}[5]



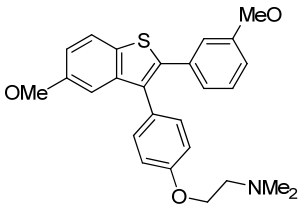
The product was obtained as a pale yellow oil (86% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.41-1.49 (m, 2H), 1.59-1.66 (m, 4H), 2.50-2.58 (m, 4H), 2.81 (t, *J* = 6.0 Hz, 2H), 3.63 (s, 3H), 3.78 (s, 3H), 4.15 (t, *J* = 6.0 Hz, 2H), 6.76-6.84 (m, 2H), 6.90-6.95 (m, 1H), 6.95 (d, *J* = 8.7 Hz, 2H), 6.98-7.04 (m, 2H), 7.16 (t, *J* = 8.0 Hz, 1H), 7.24 (d, *J* = 8.7 Hz, 2H), 7.72 (d, *J* = 8.6 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 24.4, 26.2 (×2), 55.25, 55.33 (×2), 55.8, 58.2, 66.2, 105.8, 114.0, 114.7, 114.8, 115.1 (×2), 122.1, 123.0, 128.1, 129.5, 131.6 (×2), 132.3, 133.0, 135.9, 140.5, 142.3, 157.9, 158.4, 159.4; HRMS calcd for $C_{29}H_{31}NO_3S$ [M^+], 473.2025, found 473.2031.

Compound 6{*23*}



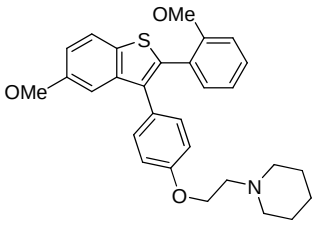
The product was obtained as a pale yellow oil (71% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.81-1.85 (m, 4H), 2.63-2.68 (m, 4H), 2.94 (t, *J* = 6.0 Hz, 2H), 3.62 (s, 3H), 3.78 (s, 3H), 4.15 (t, *J* = 6.0 Hz, 2H), 6.76-6.87 (m, 2H), 6.90-7.05 (m, 3H), 6.97 (d, *J* = 8.7 Hz, 2H), 7.16 (t, *J* = 7.8 Hz, 1H), 7.25 (d, *J* = 8.7 Hz, 2H), 7.72 (d, *J* = 8.6 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 23.7 (×2), 55.0 (×2), 55.2, 55.3, 55.7, 67.3, 105.8, 114.0, 114.7, 114.8, 115.1 (×2), 122.1, 122.9, 128.1, 129.5, 131.2, 131.5 (×2), 133.0, 135.9, 140.4, 142.3, 157.9, 158.4, 159.4.

Compound 6{*24*}



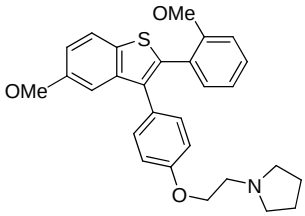
The product was obtained as a pale yellow oil (82% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.36 (s, 6H), 2.76 (t, *J* = 5.7 Hz, 2H), 3.62 (s, 3H), 3.77 (s, 3H), 4.10 (t, *J* = 5.7 Hz, 2H), 6.75-6.83 (m, 1H), 6.83 (br s, 1H), 6.90-7.04 (m, 3H), 6.96 (d, *J* = 8.7 Hz, 2H), 7.15 (t, *J* = 7.9 Hz, 1H), 7.25 (d, *J* = 8.7 Hz, 2H), 7.71 (d, *J* = 8.6 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 46.1 (×2), 55.2, 55.7, 58.5, 66.3, 105.9, 114.0, 114.7, 114.8, 115.1 (×2), 122.1, 122.9, 128.2, 129.5, 131.3, 131.5 (×2), 133.0, 135.9, 140.5, 142.3, 157.9, 158.4, 159.4; HRMS calcd for $C_{26}H_{28}NO_3S$ [M+H$^+$], 434.1790, found 434.1790.

Compound 6{*25*}[5]



The product was obtained as a pale yellow oil (87% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.40-1.49 (m, 2H), 1.55-1.65 (m, 4H), 2.50-2.55 (m, 4H), 2.78 (t, *J* = 6.1 Hz, 2H), 3.56 (s, 3H), 3.80 (s, 3H), 4.10 (t, *J* = 6.1 Hz, 2H), 6.81-6.89 (m, 4H), 7.00 (dd, *J* = 2.5, 8.7 Hz, 1H), 7.15-7.27 (m, 5H), 7.72 (d, *J* = 8.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 24.4, 26.1 (×2), 55.3 (×2), 55.5, 55.8, 58.2, 66.2, 105.8, 111.4, 114.4, 114.6 (×2), 120.5, 122.9, 123.6, 128.8, 129.7, 130.9 (×2), 132.3, 132.8, 134.6, 136.9, 141.1, 157.2, 157.8, 158.0; HRMS calcd for $C_{29}H_{32}NO_3S$ [M+H$^+$], 474.2103, found 474.2095.

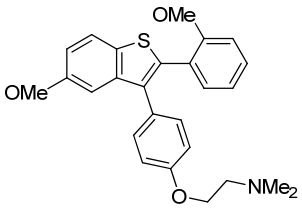
Compound 6{*27*}



The product was obtained as a pale yellow oil (83% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.80-1.85 (br s, 4H), 2.61-2.66 (m, 4H), 2.91 (t, *J* = 6.0 Hz, 2H), 3.56 (s, 3H), 3.80 (s, 3H), 4.10 (t, *J* = 6.0 Hz, 2H), 6.81-6.90 (m, 4H), 7.00 (dd, *J* = 2.5, 8.7 Hz, 1H), 7.15-7.27 (m, 5H), 7.72 (d, *J* = 8.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 23.7 (×2), 55.0 (×2), 55.4, 55.5, 55.8, 67.2, 105.7, 111.4, 114.4,

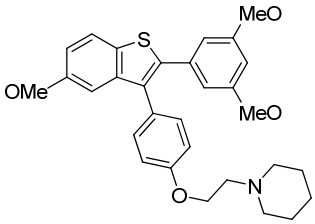
114.5 (×2), 115.5, 120.5, 122.9, 128.7, 129.7, 130.9 (×2), 132.3, 132.8, 134.6, 136.8, 141.1, 157.1, 157.7, 157.9; HRMS calcd for $C_{28}H_{30}NO_3S$ [M+H$^+$], 460.1946, found 460.1946.

Compound 6{*28*}



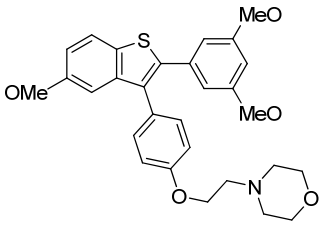
The product was obtained as a pale yellow oil (83% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.34 (s, 6H), 2.72 (t, *J* = 5.7 Hz, 2H), 3.54 (s, 3H), 3.79 (s, 3H), 4.05 (t, *J* = 5.7 Hz, 2H), 6.80-6.89 (m, 4H), 6.99 (dd, *J* = 2.5, 8.7 Hz, 1H), 7.15-7.27 (m, 5H), 7.71 (d, *J* = 8.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 46.1 (×2), 55.5, 55.8, 58.6, 66.1, 105.7, 111.4, 114.4, 114.5 (×2), 120.5, 122.9, 123.6, 128.8, 129.6, 130.8 (×2), 132.3, 132.7, 134.5, 136.8, 141.1, 157.1, 157.7, 157.9; HRMS calcd for $C_{26}H_{27}NO_3S$ [M$^+$], 433.1712, found 433.1720.

Compound 6{*29*}[5]



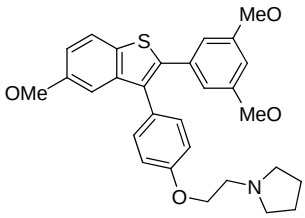
The product was obtained as a pale yellow oil (77% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.41-1.50 (m, 2H), 1.60-1.66 (m, 4H), 2.50-2.58 (m, 4H), 2.80 (t, *J* = 6.0 Hz, 2H), 3.62 (s, 6H), 3.78 (s, 3H), 4.14 (t, *J* = 6.0 Hz, 2H), 6.34 (t, *J* = 2.2 Hz, 1H), 6.47 (d, *J* = 2.2 Hz, 2H), 6.96 (d, *J* = 8.8 Hz, 2H), 6.98-7.04 (m, 2H), 7.25 (d, *J* = 8.8 Hz, 2H), 7.71 (d, *J* = 8.5 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 24.4, 26.2 (×2), 55.3 (×2), 55.4 (×2), 55.7, 58.2, 66.3, 100.5, 105.9, 107.7 (×2), 114.8, 115.1 (×2), 122.9, 128.2, 131.2, 131.5 (×2), 133.2, 136.4, 140.5, 142.3, 157.9, 158.4, 160.6 (×2); HRMS calcd for $C_{30}H_{33}NO_4S$ [M$^+$], 503.2130, found 503.2132.

Compound 6{*30*}



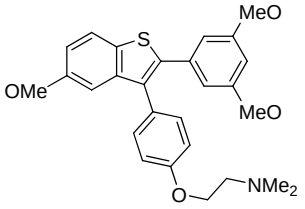
The product was obtained as a pale yellow oil (78% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.58-2.64 (m, 4H), 2.84 (t, *J* = 5.7 Hz, 2H), 3.63 (s, 6H), 3.76 (t, *J* = 4.6 Hz, 4H), 3.78 (s, 3H), 4.15 (t, *J* = 5.7 Hz, 2H), 6.34 (t, *J* = 2.2 Hz, 1H), 6.47 (d, *J* = 2.2 Hz, 2H), 6.96 (d, *J* = 8.6 Hz, 2H), 6.96-7.04 (m, 2H), 7.26 (d, *J* = 8.6 Hz, 2H), 7.72 (d, *J* = 8.5 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 54.4 (×2), 55.4 (×2), 55.8, 57.9, 66.1, 67.2 (×2), 100.5, 106.0, 107.7 (×2), 114.8, 115.1 (×2), 123.0, 128.4, 131.2, 131.6 (×2), 133.1, 136.4, 140.6, 142.3, 157.9, 158.3, 160.6 (×2).

Compound 6{*31*}



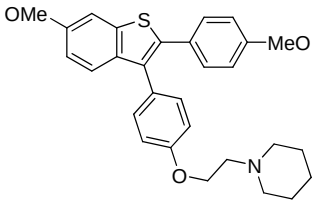
The product was obtained as a pale yellow oil (73% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.81-1.87 (m, 4H), 2.67-2.72 (m, 4H), 2.97 (t, *J* = 5.9 Hz, 2H), 3.62 (s, 6H), 3.78 (s, 3H), 4.17 (t, *J* = 5.9 Hz, 2H), 6.34 (t, *J* = 2.3 Hz, 1H), 6.47 (d, *J* = 2.3 Hz, 2H), 6.96 (d, *J* = 8.7 Hz, 2H), 6.98-7.04 (m, 2H), 7.26 (d, *J* = 8.7 Hz, 2H), 7.71 (d, *J* = 8.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 23.7 (×2), 54.9 (×2), 55.2, 55.4 (×2), 55.8, 67.2, 100.5, 105.9, 107.7 (×2), 114.9, 115.1 (×2), 123.0, 128.3, 131.2, 131.6 (×2), 133.2, 136.4, 140.5, 142.3, 157.9, 158.4, 160.6 (×2).

Compound 6{*32*}



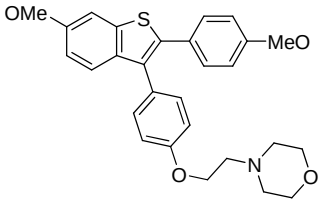
The product was obtained as a pale yellow oil (73% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.38 (s, 6H), 2.78 (t, *J* = 5.6 Hz, 2H), 3.62 (s, 6H), 3.78 (s, 3H), 4.11 (t, *J* = 5.6 Hz, 2H), 6.34 (t, *J* = 2.2 Hz, 1H), 6.47 (d, *J* = 2.2 Hz, 2H), 6.96 (d, *J* = 8.6 Hz, 2H), 6.96-7.04 (m, 2H), 7.26 (d, *J* = 8.6 Hz, 2H), 7.71 (d, *J* = 8.5 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 46.1 (×2), 55.4 (×2), 55.8, 58.5, 66.3, 100.5, 105.9, 107.7 (×2), 114.8, 115.1 (×2), 122.9, 128.3, 131.2, 131.6 (×2), 133.2, 136.4, 140.5, 142.3, 157.9, 158.4, 160.6 (×2).

Compound 6{*33*}[5]



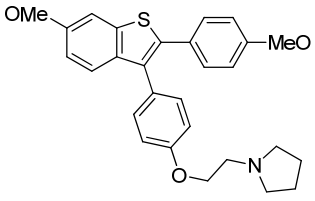
The product was obtained as a pale yellow oil (83% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.40-1.50 (m, 2H), 1.58-1.66 (m, 4H), 2.52-2.57 (m, 4H), 2.81 (t, *J* = 6.0 Hz, 2H), 3.79 (s, 3H), 3.89 (s, 3H), 4.15 (t, *J* = 6.0 Hz, 2H), 6.78 (d, *J* = 8.9 Hz, 2H), 6.90-6.97 (m, 1H), 6.92 (d, *J* = 8.9 Hz, 2H), 7.22 (d, *J* = 8.8 Hz, 4H), 7.32 (d, *J* = 2.3 Hz, 1H), 7.44 (d, *J* = 8.9 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 24.4, 26.1 (×2), 55.3 (×2), 55.4, 55.9, 58.2, 66.1, 104.8, 114.0 (×2), 114.3, 114.9 (×2), 124.0, 127.2, 128.2, 130.7 (×2), 131.6 (×2), 131.7, 135.5, 136.4, 139.9, 157.5, 158.2, 159.0; HRMS calcd for $C_{29}H_{31}NO_3S$ [M+H$^+$], 473.2025, found 474.2105.

Compound 6{*34*}



The product was obtained as a pale yellow oil (78% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.58-2.64 (m, 4H), 2.84 (t, *J* = 5.7 Hz, 2H), 3.76 (t, *J* = 4.6 Hz, 4H), 3.78 (s, 3H), 3.88 (s, 3H), 4.15 (t, *J* = 5.7 Hz, 2H), 6.78 (d, *J* = 8.8 Hz, 2H), 6.91-6.96 (m, 1H), 6.93 (d, *J* = 8.6 Hz, 2H), 7.22 (d, *J* = 8.8 Hz, 2H), 7.23 (d, *J* = 8.6 Hz, 2H), 7.32 (d, *J* = 2.2 Hz, 1H), 7.44 (d, *J* = 8.8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 54.3 (×2), 55.4, 55.9, 57.9, 66.0, 67.1 (×2), 104.9, 114.0 (×2), 114.4, 115.0 (×2), 124.0, 127.2, 128.5, 130.7 (×2), 131.6 (×2), 131.7, 135.5, 136.5, 140.0, 157.6, 158.1, 159.1.

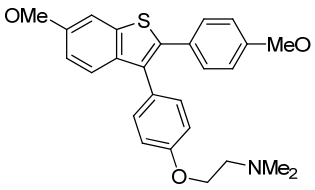
Compound 6{*35*}



The product was obtained as a pale yellow oil (75% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.81-1.85 (m, 4H), 2.63-2.70 (m, 4H), 2.94 (t, *J* = 6.0 Hz, 2H), 3.77 (s, 3H), 3.87 (s, 3H), 4.15 (t, *J* = 6.0 Hz, 2H), 6.77 (d, *J* = 8.8 Hz, 2H), 6.90-6.96 (m, 1H), 6.94 (d, *J* = 8.6 Hz, 2H), 7.21 (d, *J* = 8.8 Hz, 2H), 7.22 (d, *J* = 8.6 Hz, 2H), 7.31 (d, *J* = 2.2 Hz, 1H), 7.44 (d, *J* = 8.8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$)

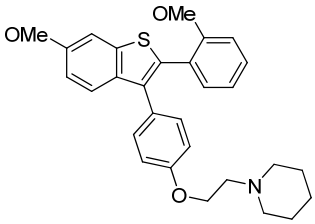
δ 23.8 (×2), 54.9 (×2), 55.3, 55.4, 55.9, 67.2, 104.9, 114.0 (×2), 114.3, 115.0 (×2), 124.0, 127.2, 128.3, 130.7 (×2), 131.6 (×2), 131.8, 135.5, 136.5, 140.0, 157.6, 158.3, 159.1.

Compound 6{*36*}



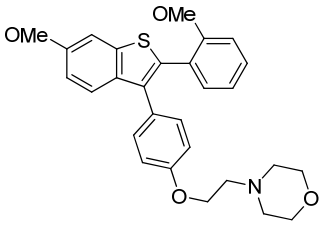
The product was obtained as a pale yellow oil (76% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.37 (s, 6H), 2.77 (t, *J* = 5.7 Hz, 2H), 3.78 (s, 3H), 3.88 (s, 3H),4.10 (t, *J* = 5.7 Hz, 2H), 6.77 (d, *J* = 8.6 Hz, 2H), 6.91-6.96 (m, 1H), 6.93 (d, *J* = 8.6 Hz, 2H), 7.22 (d, *J* = 8.6 Hz, 2H), 7.23 (d, *J* = 8.6 Hz, 2H), 7.32 (d, *J* = 2.3 Hz, 1H), 7.44 (d, *J* = 8.8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 46.1 (×2), 55.4, 55.9, 58.5, 66.2, 104.9, 114.0 (×2), 114.3, 114.9 (×2), 124.0, 127.2, 128.3, 130.7 (×2), 131.6 (×2), 131.7, 135.5, 136.5, 140.0, 157.6, 158.2, 159.1.

Compound 6{*37*}



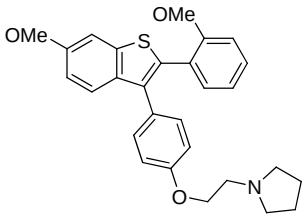
The product was obtained as a pale yellow oil (78% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.40-1.50 (m, 2H), 1.56-1.65 (m, 4H), 2.50-2.56 (m, 4H), 2.78 (t, *J* = 6.0 Hz, 2H), 3.58 (s, 3H), 3.90 (s, 3H), 4.10 (t, *J* = 6.0 Hz, 2H), 6.82-6.88 (m, 2H), 6.87 (d, *J* = 8.9 Hz, 2H), 6.92-6.97 (m, 1H), 7.18 (d, *J* = 8.9 Hz, 2H), 7.18-7.27 (m, 2H), 7.32-7.34 (m, 1H), 7.58 (d, *J* = 8.9 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 24.4, 26.1 (×2), 55.2 (×2), 55.5, 55.9, 58.2, 66.1, 104.8, 111.5, 114.2, 114.5 (×2), 120.6, 123.7, 124.1, 128.7, 129.5, 131.0 (×2), 132.7, 132.9, 134.3, 134.3, 141.3, 157.3, 157.5, 158.0; HRMS calcd for $C_{29}H_{31}NO_3S$ [M^+], 473.2025, found 473.2019.

Compound 6{*38*}



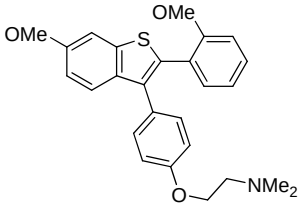
The product was obtained as a pale yellow oil (77% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.56-2.63 (m, 4H), 2.81 (t, *J* = 5.6 Hz, 2H), 3.58 (s, 3H), 3.74 (t, *J* = 4.5 Hz, 4H), 3.88 (s, 3H), 4.10 (t, *J* = 5.6 Hz, 2H), 6.82-6.88 (m, 2H), 6.87 (d, *J* = 8.6 Hz, 2H), 6.96 (dd, *J* = 2.3, 8.9 Hz, 1H), 7.19 (d, *J* = 8.6 Hz, 2H), 7.21-7.27 (m, 2H), 7.33 (d, *J* = 2.1 Hz, 1H), 7.58 (d, *J* = 8.9 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 54.3 (×2), 55.5, 55.9, 57.9, 65.9, 67.1 (×2), 104.8, 111.4, 114.2, 114.5 (×2), 120.6, 123.6, 124.0, 128.7, 129.5, 131.0 (×2), 132.7, 132.9, 134.20, 134.22, 141.2, 157.2, 157.5, 158.0.

Compound 6{*39*}



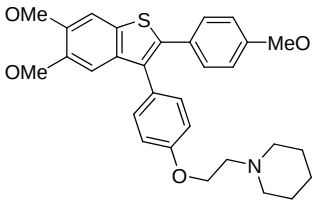
The product was obtained as a pale yellow oil (81% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.79-1.83 (m, 4H), 2.60-2.66 (m, 4H), 2.90 (t, *J* = 6.0 Hz, 2H), 3.58 (s, 3H), 3.89 (s, 3H), 4.10 (t, *J* = 6.0 Hz, 2H), 6.82-6.88 (m, 2H), 6.87 (d, *J* = 8.9 Hz, 2H), 6.96 (dd, *J* = 2.3, 8.9 Hz, 1H), 7.19 (d, *J* = 8.9 Hz, 2H), 7.18-7.27 (m, 2H), 7.34 (d, *J* = 2.3 Hz, 1H), 7.58 (d, *J* = 8.9 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 23.7 (×2), 55.0 (×2), 55.4, 55.5, 55.9, 67.2, 104.7, 111.4, 114.2, 114.5 (×2), 120.6, 123.6, 124.1, 128.8, 129.5, 130.9 (×2), 132.6, 132.9, 134.2, 134.3, 141.2, 157.2, 157.5, 158.0.

Compound 6{*40*}



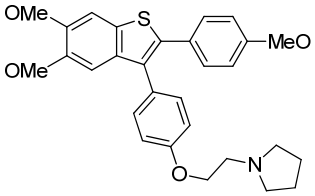
The product was obtained as a pale yellow oil (82% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.36 (s, 6H), 2.75 (t, *J* = 5.6 Hz, 2H), 3.57 (s, 3H), 3.89 (s, 3H), 4.07 (t, *J* = 5.6 Hz, 2H), 6.82-6.88 (m, 2H), 6.86 (d, *J* = 8.9 Hz, 2H), 6.96 (dd, *J* = 2.3, 8.9 Hz, 1H), 7.19 (d, *J* = 8.9 Hz, 2H), 7.17-7.27 (m, 2H), 7.32-7.35 (m, 1H), 7.57 (d, *J* = 8.9 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 46.1 (×2), 55.5, 55.9, 58.5, 66.1, 104.8, 111.5, 114.2, 114.5 (×2), 120.6, 123.7, 124.1, 128.9, 129.5, 131.0 (×2), 132.7, 132.9, 134.25, 134.30, 141.3, 157.3, 157.6, 157.9.

Compound 6{*41*}[5]



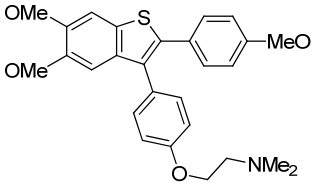
The product was obtained as a pale yellow oil (76% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.41-1.50 (m, 2H), 1.59-1.66 (m, 4H), 2.55-2.60 (m, 4H), 2.84 (t, *J* = 6.0 Hz, 2H), 3.78 (s, 3H), 3.83 (s, 3H), 3.97 (s, 3H), 4.16 (t, *J* = 6.0 Hz, 2H), 6.77 (d, *J* = 8.8 Hz, 2H), 6.94 (d, *J* = 8.8 Hz, 2H), 6.98 (s, 1H), 7.20 (d, *J* = 8.8 Hz, 2H), 7.23 (d, *J* = 8.8 Hz, 2H), 7.29 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 23.7, 26.2 (×2), 55.0, 55.41, 55.43 (×2), 56.3, 56.4, 67.3, 104.0, 104.8, 114.0 (×2), 115.1 (×2), 127.3, 128.4, 130.7 (×2), 131.2, 131.5 (×2), 131.9, 134.9, 137.3, 148.40, 148.43, 158.3, 159.0; HRMS calcd for $C_{30}H_{34}NO_4S$ [M+H$^+$], 504.2209, found 504.2146.

Compound 6{*43*}



The product was obtained as a pale yellow oil (79% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.76-1.86 (m, 4H), 2.65-2.71 (m, 4H), 2.96 (t, *J* = 6.0 Hz, 2H), 3.78 (s, 3H), 3.83 (s, 3H), 3.97 (s, 3H), 4.16 (t, *J* = 6.0 Hz, 2H), 6.77 (d, *J* = 8.7 Hz, 2H), 6.96 (d, *J* = 8.7 Hz, 2H), 6.98 (s, 1H), 7.20 (d, *J* = 8.8 Hz, 2H), 7.24 (d, *J* = 8.8 Hz, 2H), 7.29 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 23.7 (×2), 55.0 (×2), 55.3, 55.4, 56.3, 56.4, 67.3, 104.0, 104.8, 114.0 (×2), 115.1 (×2), 127.3, 128.4, 130.7 (×2), 131.2, 131.5 (×2), 131.9, 134.9, 137.3, 148.40, 148.43, 158.3, 159.0; HRMS calcd for $C_{29}H_{31}NO_4S$ [M$^+$], 489.1974, found 489.1981.

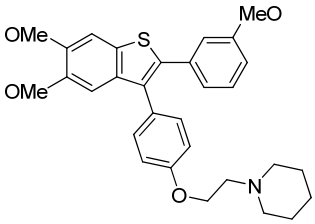
Compound 6{*44*}



The product was obtained as a pale yellow oil (69% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.38 (s, 6H), 2.79 (t, *J* = 5.7 Hz, 2H), 3.78 (s, 3H), 3.83 (s, 3H), 3.97 (s, 3H), 4.12 (t, *J* = 5.7 Hz, 2H), 6.77 (d, *J* = 8.6 Hz, 2H), 6.96 (d, *J* = 8.6 Hz, 2H), 6.98 (s, 1H), 7.20 (d, *J* = 8.6 Hz, 2H), 7.24 (d, *J* = 8.6 Hz, 2H),

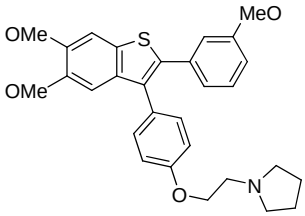
7.29 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 46.1 (×2), 55.4, 56.2, 56.4, 58.6, 66.1, 104.0, 104.8, 114.0 (×2), 115.0 (×2), 127.3, 128.5, 130.7 (×2), 131.2, 131.5 (×2), 131.9, 134.9, 137.4, 148.40, 148.43, 158.2, 159.0.

Compound 6{*45*}



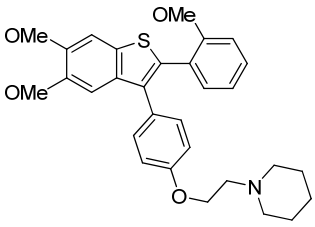
The product was obtained as a pale yellow oil (79% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.46 (br s, 2H), 1.59-1.66 (m, 4H), 2.52-2.58 (m, 4H), 2.82 (t, *J* = 5.9 Hz, 2H), 3.62 (s, 3H), 3.84 (s, 3H), 3.97 (s, 3H), 4.16 (t, *J* = 5.9 Hz, 2H), 6.73-6.83 (m, 2H), 6.89 (d, *J* = 7.6 Hz, 1H), 6.96 (d, *J* = 8.6 Hz, 2H), 6.98 (s, 1H), 7.15 (t, *J* = 8.0 Hz, 1H), 7.24 (d, *J* = 8.6 Hz, 2H), 7.30 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 24.3, 26.1 (×2), 55.2, 55.3 (×2), 56.3, 56.4, 58.2, 66.2, 103.9, 104.9, 113.6, 114.6, 115.1 (×2), 122.0, 128.4, 129.5, 131.5 (×2), 133.0, 134.8, 136.1, 137.2, 148.5, 148.7, 158.4, 159.5; HRMS calcd for $C_{30}H_{33}NO_4S$ [M^+], 503.2130, found 503.2134.

Compound 6{*47*}



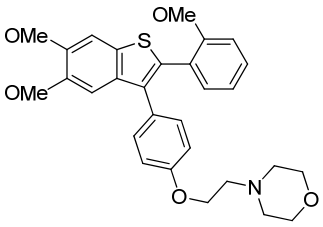
The product was obtained as a pale yellow oil (73% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.88-1.92 (m, 4H), 2.81-2.86 (m, 4H), 3.08 (t, *J* = 5.8 Hz, 2H), 3.63 (s, 3H), 3.84 (s, 3H), 3.98 (s, 3H), 4.22 (t, *J* = 5.8 Hz, 2H), 6.73-6.83 (m, 2H), 6.89 (d, *J* = 7.6 Hz, 1H), 6.96 (d, *J* = 8.7 Hz, 2H), 6.98 (s, 1H), 7.15 (t, *J* = 7.9 Hz, 1H), 7.24 (d, *J* = 8.7 Hz, 2H), 7.30 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 23.7 (×2), 55.0 (×2), 55.2, 55.3, 56.3, 56.5, 68.7, 104.0, 104.9, 113.6, 114.7, 115.1 (×2), 122.0, 128.6, 129.5, 131.6 (×2), 131.8, 132.9, 134.8, 136.1, 137.2, 148.6, 148.7, 158.2, 159.5; HRMS calcd for $C_{29}H_{31}NO_4S$ [M^+], 489.1974, found 489.1982.

Compound 6{*49*}



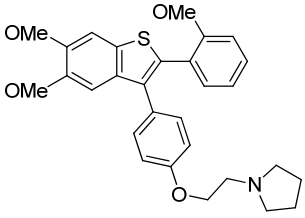
The product was obtained as a pale yellow oil (77% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.40-1.49 (m, 2H), 1.55-1.65 (m, 4H), 2.48-2.54 (m, 4H), 2.78 (t, *J* = 6.1 Hz, 2H), 3.57 (s, 3H), 3.86 (s, 3H), 3.97 (s, 3H), 4.10 (t, *J* = 6.1 Hz, 2H), 6.81-6.89 (m, 2H), 6.88 (d, *J* = 8.7 Hz, 2H), 7.12 (s, 1H), 7.21 (d, *J* = 8.7 Hz, 2H), 7.22-7.27 (m, 2H), 7.30 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 24.4, 26.1 (×2), 55.3 (×2), 55.5, 56.3, 56.4, 58.2, 66.1, 103.8, 104.7, 111.3, 114.6 (×2), 120.5, 123.6, 128.9, 129.4, 130.8 (×2), 132.4, 132.8, 133.4, 133.5, 134.4, 148.2, 148.3, 157.2, 157.9; HRMS calcd for $C_{30}H_{34}NO_4S$ [M+H$^+$], 504.2209, found 504.2209.

Compound 6{*50*}



The product was obtained as a pale yellow oil (72% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.55-2.60 (m, 4H), 2.80 (t, *J* = 5.7 Hz, 2H), 3.56 (s, 3H), 3.73 (t, *J* = 4.5 Hz, 4H), 3.85 (s, 3H), 3.96 (s, 3H), 4.10 (t, *J* = 5.7 Hz, 2H), 6.81-6.89 (m, 2H), 6.87 (d, *J* = 8.8 Hz, 2H), 7.11 (s, 1H), 7.20 (d, *J* = 8.8 Hz, 2H), 7.23-7.27 (m, 2H), 7.30 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 54.3 (×2), 55.5, 56.3, 56.4, 57.9, 66.0, 67.1 (×2), 104.0, 104.8, 111.4, 114.6 (×2), 120.5, 123.7, 129.1, 129.4, 130.8 (×2), 132.5, 132.8, 133.52, 133.53, 134.3, 148.3, 148.4, 157.2, 157.8.

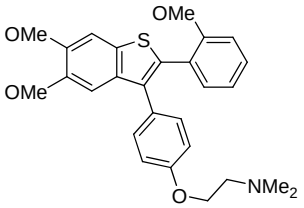
Compound 6{*51*}



The product was obtained as a pale yellow oil (68% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.80-1.84 (m, 4H), 2.61-2.66 (m, 4H), 2.92 (t, *J* = 5.9 Hz, 2H), 3.57 (s, 3H), 3.86 (s, 3H), 3.97 (s, 3H), 4.11 (t, *J*

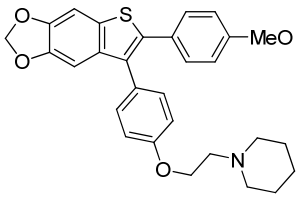
= 5.9 Hz, 2H), 6.81-6.90 (m, 2H), 6.88 (d, *J* = 8.7 Hz, 2H), 7.12 (s, 1H), 7.21 (d, *J* = 8.7 Hz, 2H), 7.22-7.27 (m, 2H), 7.30 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 23.7 (×2), 55.0 (×2), 55.4, 55.5, 56.3, 56.5, 67.3, 104.0, 104.9, 111.4, 114.6 (×2), 120.6, 123.7, 129.0, 129.5, 130.9 (×2), 132.5, 132.9, 133.5, 133.7, 134.5, 148.3, 148.4, 157.3, 158.0.

Compound 6{*52*}



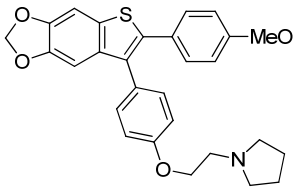
The product was obtained as a pale yellow oil (71% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.34 (s, 6H), 2.73 (t, *J* = 5.7 Hz, 2H), 3.56 (s, 3H), 3.85 (s, 3H), 3.96 (s, 3H), 4.06 (t, *J* = 5.7 Hz, 2H), 6.81-6.90 (m, 2H), 6.88 (d, *J* = 8.7 Hz, 2H), 7.12 (s, 1H), 7.21 (d, *J* = 8.7 Hz, 2H), 7.22-7.27 (m, 2H), 7.30 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 46.1 (×2), 55.5, 56.3, 56.4, 58.6, 66.2, 104.0, 104.9, 111.4, 114.6 (×2), 120.5, 123.7, 129.0, 129.4, 130.8 (×2), 132.5, 132.8, 133.5, 133.6, 134.4, 148.3, 148.4, 157.2, 157.9.

Compound 6{*53*}



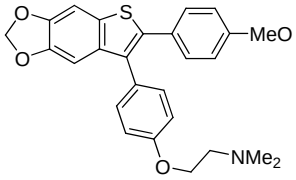
The product was obtained as a pale yellow oil (81% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.41-1.50 (m, 2H), 1.58-1.66 (m, 4H), 2.50-2.56 (m, 4H), 2.84 (t, *J* = 6.0 Hz, 2H), 3.79 (s, 3H), 4.16 (t, *J* = 6.0 Hz, 2H), 5.98 (s, 2H), 6.77 (d, *J* = 8.9 Hz, 2H), 6.94 (d, *J* = 8.7 Hz, 2H), 6.95 (s, 1H), 7.19 (d, *J* = 8.9 Hz, 2H), 7.20 (d, *J* = 8.7 Hz, 2H), 7.22 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 23.8, 26.2 (×2), 55.3 (×2), 55.4, 58.3, 67.2, 101.4, 101.5, 102.3, 114.0 (×2), 114.9, 115.0 (×2), 127.1, 128.2, 130.6 (×2), 131.6 (×2), 132.0, 136.0, 137.5, 146.6, 146.9, 158.3, 159.0; HRMS calcd for $C_{29}H_{29}NO_4S$ [M^+], 487.1817, found 487.1817.

Compound 6{*55*}



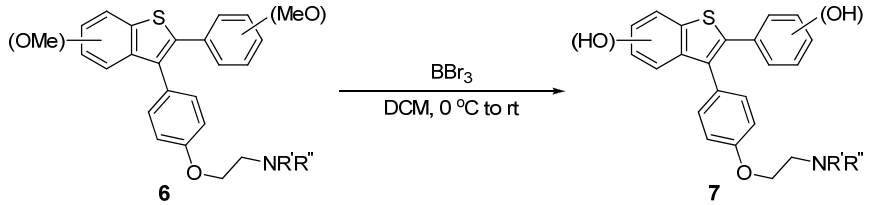
The product was obtained as a pale yellow oil (69% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.81-1.85 (m, 4H), 2.63-2.68 (m, 4H), 2.94 (t, *J* = 6.0 Hz, 2H), 3.78 (s, 3H), 4.15 (t, *J* = 6.0 Hz, 2H), 5.98 (s, 2H), 6.77 (d, *J* = 8.9 Hz, 2H), 6.94 (d, *J* = 8.7 Hz, 2H), 6.95 (s, 1H), 7.19 (d, *J* = 8.9 Hz, 2H), 7.20 (d, *J* = 8.7 Hz, 2H), 7.22 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 23.7 (×2), 55.0 (×2), 55.36, 55.42, 67.2, 101.4, 101.5, 102.3, 114.0 (×2), 114.9, 115.0 (×2), 127.1, 128.2, 130.6 (×2), 131.6 (×2), 132.0, 136.0, 137.5, 146.6, 146.9, 158.3, 159.0; HRMS calcd for $C_{28}H_{28}NO_4S$ [M+H$^+$], 474.1739, found 474.1754.

Compound 6{*56*}



The product was obtained as a pale yellow oil (79% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.37 (s, 6H), 2.77 (t, *J* = 5.6 Hz, 2H), 3.77 (s, 3H), 4.10 (t, *J* = 5.6 Hz, 2H), 5.98 (s, 2H), 6.76 (d, *J* = 8.8 Hz, 2H), 6.94 (d, *J* = 8.6 Hz, 2H), 6.95 (s, 1H), 7.19 (d, *J* = 8.8 Hz, 2H), 7.20 (d, *J* = 8.6 Hz, 2H), 7.22 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 46.2 (×2), 55.4, 58.6, 66.2, 101.4, 101.5, 102.4, 114.0 (×2), 114.9, 115.0 (×2), 127.2, 128.3, 130.6 (×2), 131.6 (×2), 132.1, 136.1, 137.6, 146.6, 146.9, 158.3, 159.1.

◈ **General Procedure for Demethylation to Prepare Compounds 7**

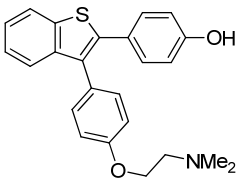


6 **7**

To a solution of **6** (0.10 mmol) in anhydrous CH_2Cl_2 (2 mL) cooled in an ice water bath under N_2 was added BBr_3 (1.0 M sol'n in CH_2Cl_2; 2.0 or 4.0 or 6.0 equiv) was added while stirring. The solution turned orange in color. This solution was stirred for 3 h after slowly warming to room

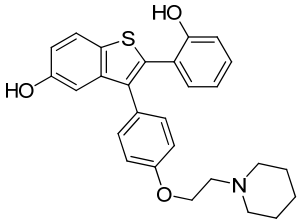
temperature. The reaction was quenched with satd aq $NaHCO_3$ (2 × 2 mL) and the product was extracted with 5% $CH_3OH/CHCl_3$ (3 × 5 mL). The combined organic layers were dried over anhydrous $MgSO_4$ and concentrated under a vacuum to yield the crude product, which was purified by column chromatography using 5-10% $CH_3OH/CHCl_3$ as the eluent to provide desketoraloxifene analogues **7**.

Compound 7{*4*}



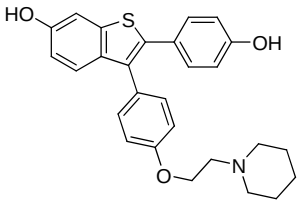
The product was obtained as a white solid (56% yield): ^{1}H NMR (400 MHz, DMSO-d_6) δ 2.25 (s, 6H), 2.67 (t, *J* = 5.7 Hz, 2H), 4.09 (t, *J* = 5.8 Hz, 2H), 6.70 (d, *J* = 8.7 Hz, 2H), 7.01 (d, *J* = 8.7 Hz, 2H), 7.11 (d, *J* = 8.7 Hz, 2H), 7.20 (d, *J* = 8.7 Hz, 2H), 7.32-7.38 (m, 2H), 7.42-7.45 (m, 1H), 7.95-7.99 (m, 1H), 9.71 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 45.4 (×2), 57.6, 65.6, 114.7 (×2), 115.4 (×2), 122.2, 122.5, 124.2, 124.3, 124.6, 127.0, 130.3 (×2), 131.1, 131.2 (×2), 137.4, 138.8, 140.6, 157.3, 157.7; HRMS calcd for $C_{24}H_{24}NO_2S$ [M+H$^+$], 390.1528, found 390.1528.

Compound 7{*19*}[5]



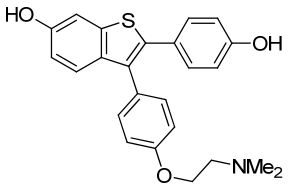
The product was obtained as a white solid (52% yield): ^{1}H NMR (400 MHz, DMSO-d_6) δ 1.33-1.42 (m, 2H), 1.45-1.55 (m, 4H), 2.48-2.52 (m, 4H), 2.68-2.74 (m, 2H), 4.07 (t, *J* = 5.6 Hz, 2H), 6.68 (t, *J* = 7.6 Hz, 1H), 6.84 (d, *J* = 8.1 Hz, 1H), 6.88 (dd, *J* = 2.3, 8.6 Hz, 1H), 6.92 (d, *J* = 8.8 Hz, 2H), 6.95 (d, *J* = 2.1 Hz, 1H), 7.01 (dd, *J* = 1.5, 7.6 Hz, 1H), 7.07-7.14 (m, 1H), 7.17 (d, *J* = 8.8 Hz, 2H), 7.73 (d, *J* = 8.6 Hz, 1H), 9.36 (s, 1H), 9.61 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 23.6, 25.2 (×2), 54.2 (×2), 57.2, 65.1, 107.3, 114.3 (×2), 114.6, 115.7, 118.6, 120.7, 122.7, 127.6, 129.4, 129.5, 130.6 (×2), 132.0, 133.2, 136.5, 140.7, 154.9, 155.4, 157.3; HRMS calcd for $C_{27}H_{28}NO_3S$ [M+H$^+$], 446.1790, found 446.1787.

Compound 7{*24*}[5]



The product was obtained as a white solid (78% yield): ^{1}H NMR (400 MHz, DMSO-d_6) δ 1.34-1.43 (m, 2H), 1.48-1.57 (m, 4H), 2.50-2.53 (m, 4H), 2.70-2.76 (m, 2H), 4.10 (t, *J* = 5.7 Hz, 2H), 6.67 (d, *J* = 8.7 Hz, 2H), 6.84 (dd, *J* = 2.2, 8.7 Hz, 1H), 6.99 (d, *J* = 8.7 Hz, 2H), 7.05 (d, *J* = 8.7 Hz, 2H), 7.17 (d, *J* = 8.7 Hz, 2H), 7.23 (d, *J* = 8.7 Hz, 1H), 7.28 (d, *J* = 2.2 Hz, 1H), 9.62 (s, 1H), 9.65 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 23.7, 25.3 (×2), 54.3 (×2), 57.2, 65.3, 107.0, 114.6, 114.7 (×2), 115.3 (×2), 123.2, 124.6, 127.4, 130.1 (×2), 130.7, 131.0 (×2), 133.5, 134.8, 138.8, 155.1, 156.9, 157.6; HRMS calcd for $C_{27}H_{27}NO_3S$ [M+H$^+$], 446.1790, found 446.1793.

Compound 7{*27*}



The product was obtained as a white solid (47% yield): ^{1}H NMR (400 MHz, DMSO-d_6) δ 2.22 (s, 6H), 2.62 (t, *J* = 5.7 Hz, 2H), 4.07 (t, *J* = 5.8 Hz, 2H), 6.67 (d, *J* = 8.7 Hz, 2H), 6.84 (dd, *J* = 2.2, 8.7 Hz, 1H), 6.99 (d, *J* = 8.7 Hz, 2H), 7.05 (d, *J* = 8.7 Hz, 2H), 7.17 (d, *J* = 8.7 Hz, 2H), 7.23 (d, *J* = 8.7 Hz, 1H), 7.28 (d, *J* = 2.2 Hz, 1H), 9.67 (br s, 2H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 45.7 (×2), 57.3, 65.7, 107.0, 114.7 (1 peak overlap), 114.7 (×2), 115.4 (×2), 123.3, 124.6, 127.3, 130.1 (×2), 130.8, 131.1 (×2), 133.5, 134.8, 138.9, 155.1, 156.1, 157.6; HRMS calcd for $C_{24}H_{23}NO_3S$ [M+H$^+$], 406.1477, found 406.1471.

◈ References

1. Fürstner, A.; Kennedy, J. W. J. Total Syntheses of the Tylophora Alkaloids Cryptopleurine, (-)-Antofine, (-)-Tylophorine, and (-)-Ficuseptine C. *Chem. Eur. J.* **2006**, *12*, 7398-7410.

2. Muraki, T.; H. Togo, H.; Yokoyama, M. Reactivity and Synthetic Utility of 1-(Arenesulfonyloxy)benziodoxolones. *J. Org. Chem.* **1999**, *64*, 2883-2889.

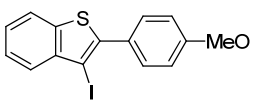
3. Cho, C.-H.; Neuenswander, B.; Lushington, G. H.; Larock, R. C., Solution-Phase Parallel Synthesis of a Multi-substituted Benzo[*b*]thiophene Library. *J. Comb. Chem.* **2009,** *11*, 900-906.

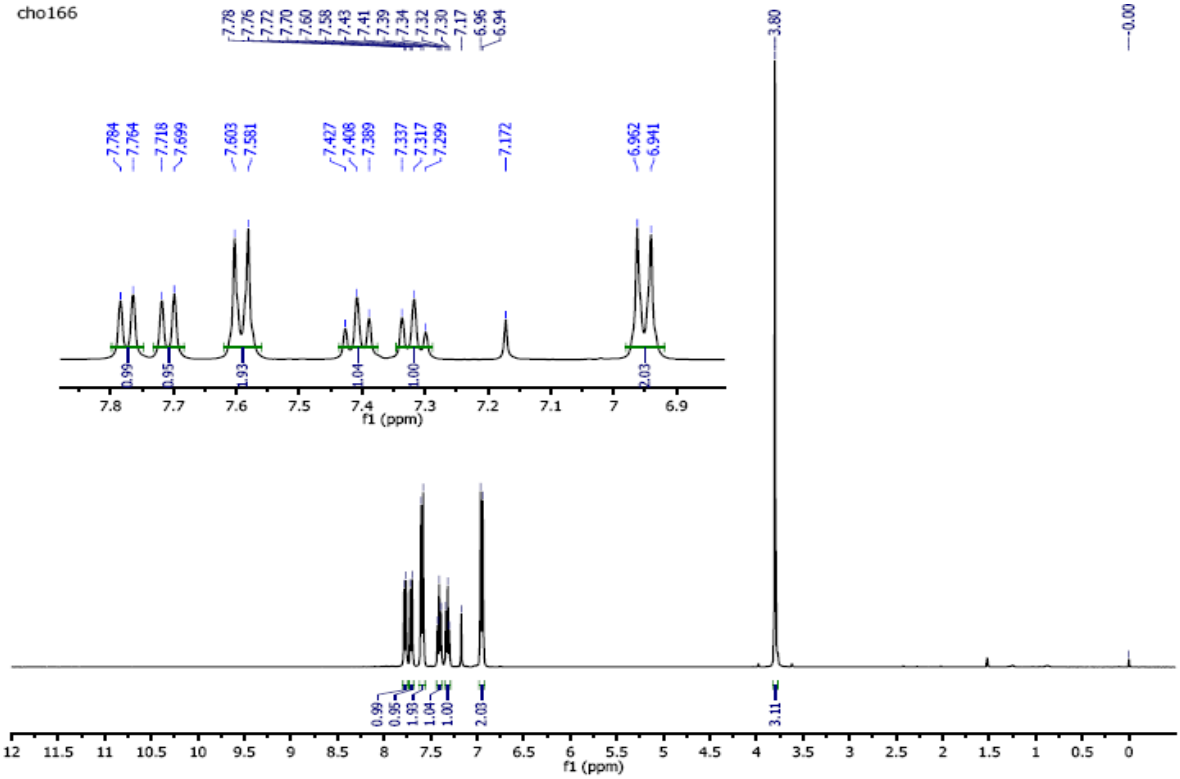
4. Cho, C.-H.; Neuenswander, B.; Larock, R. C., Diverse Methyl Sulfone-Containing Benzo[*b*]thiophene Library via Iodocyclization and Palladium-Catalyzed Coupling. *J. Comb. Chem.* **2010,** *12*, 278-285.

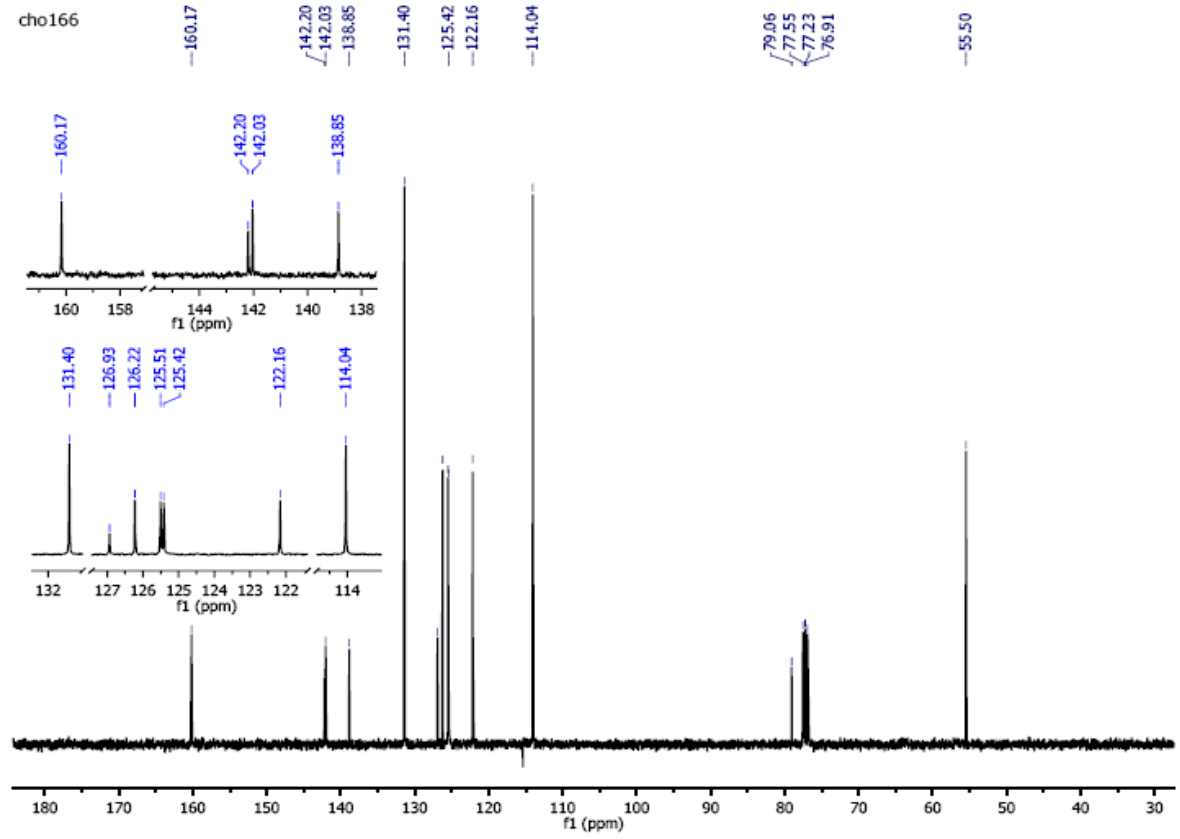
5. Cho, C.-H.; Larock, R. C. A Convenient Synthetic Route to Furan Esters and Lactones by Palladium-Catalyzed Carboalkoxylation or Cyclocarbonylation of Hydroxyl-Substituted 3-Iodofurans. *Tetrahedron Lett.* **2010**, *51*, 3417-3421.

6. Yue, D.; Larock, R. C. Synthesis of 2,3-Disubstituted Benzo[*b*]thiophenes via Palladium-Catalyzed Coupling and Electrophilic Cyclization of Terminal Acetylenes. *J. Org. Chem.* **2002**, *67*, 1905-1909.

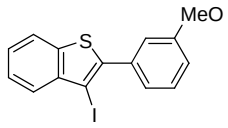
3-Iodobenzo[*b*]thiophene 4{*2*}

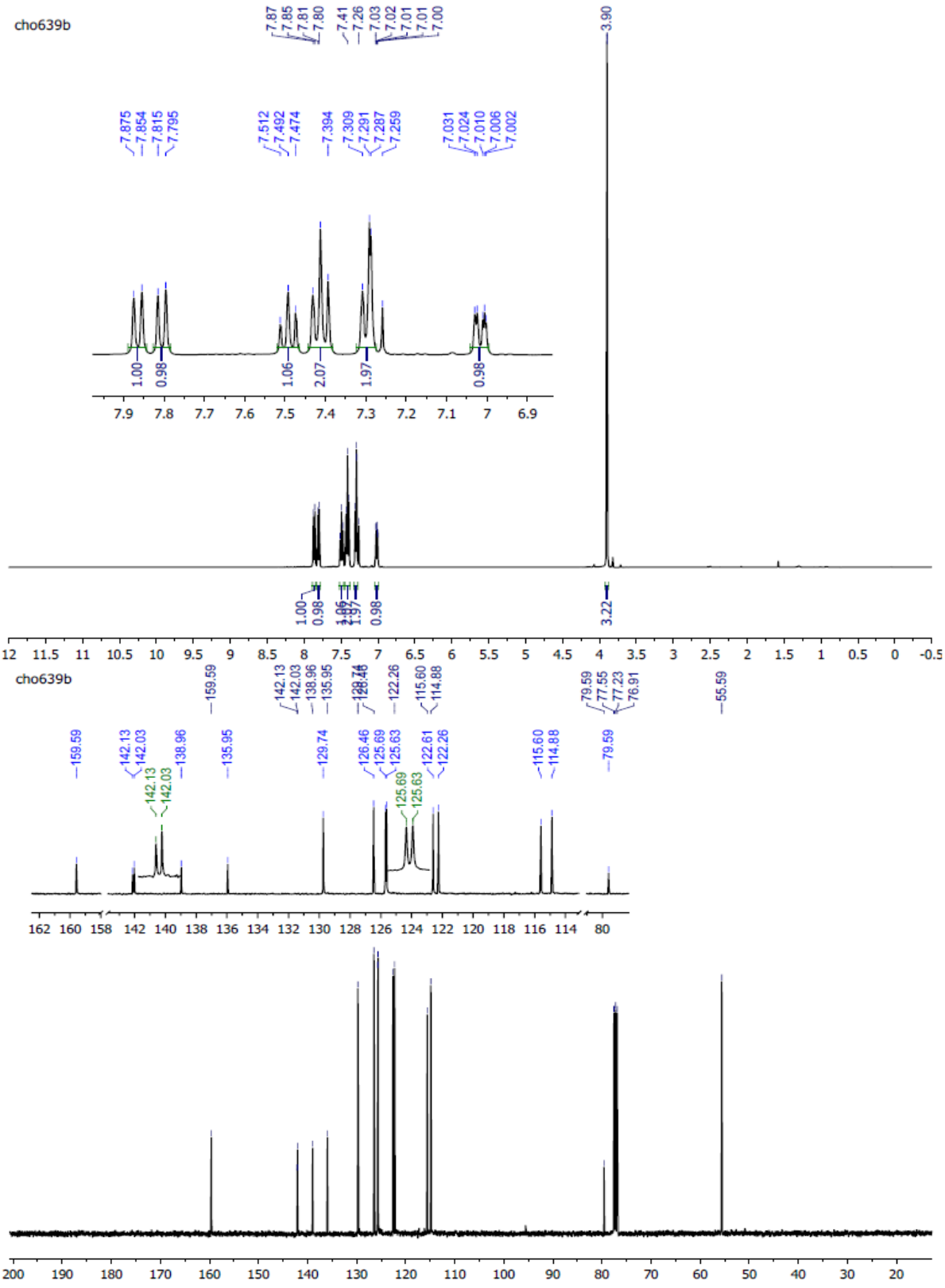




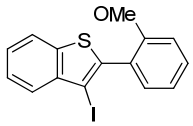


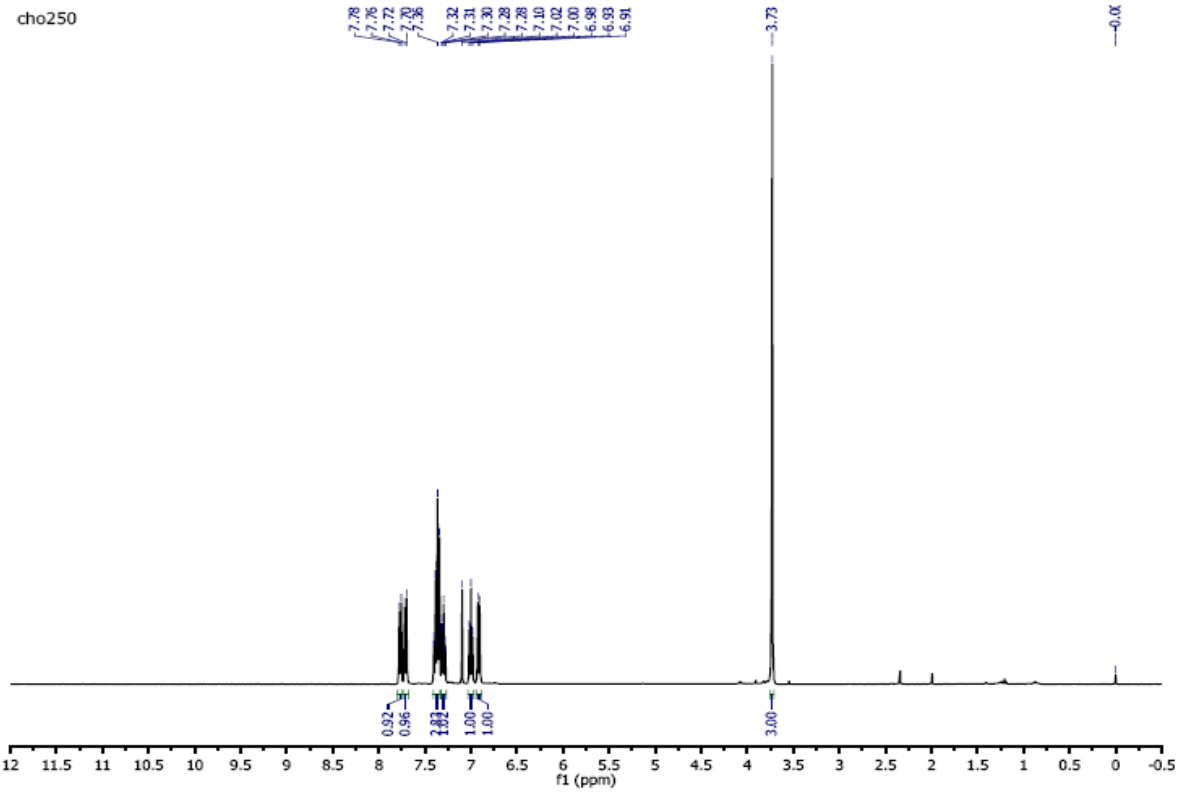
3-Iodobenzo[*b*]thiophene 4{*3*}

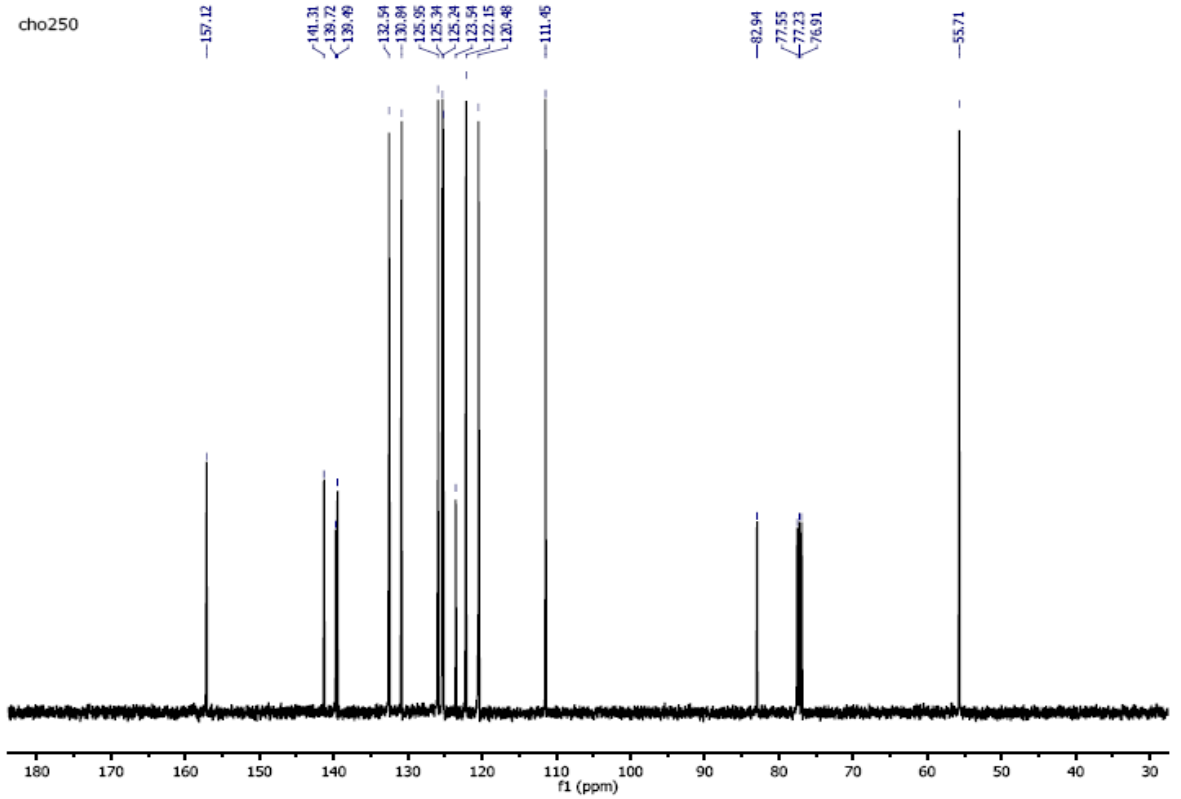




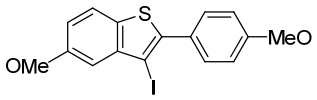
3-Iodobenzo[*b*]thiophene 4{*4*}

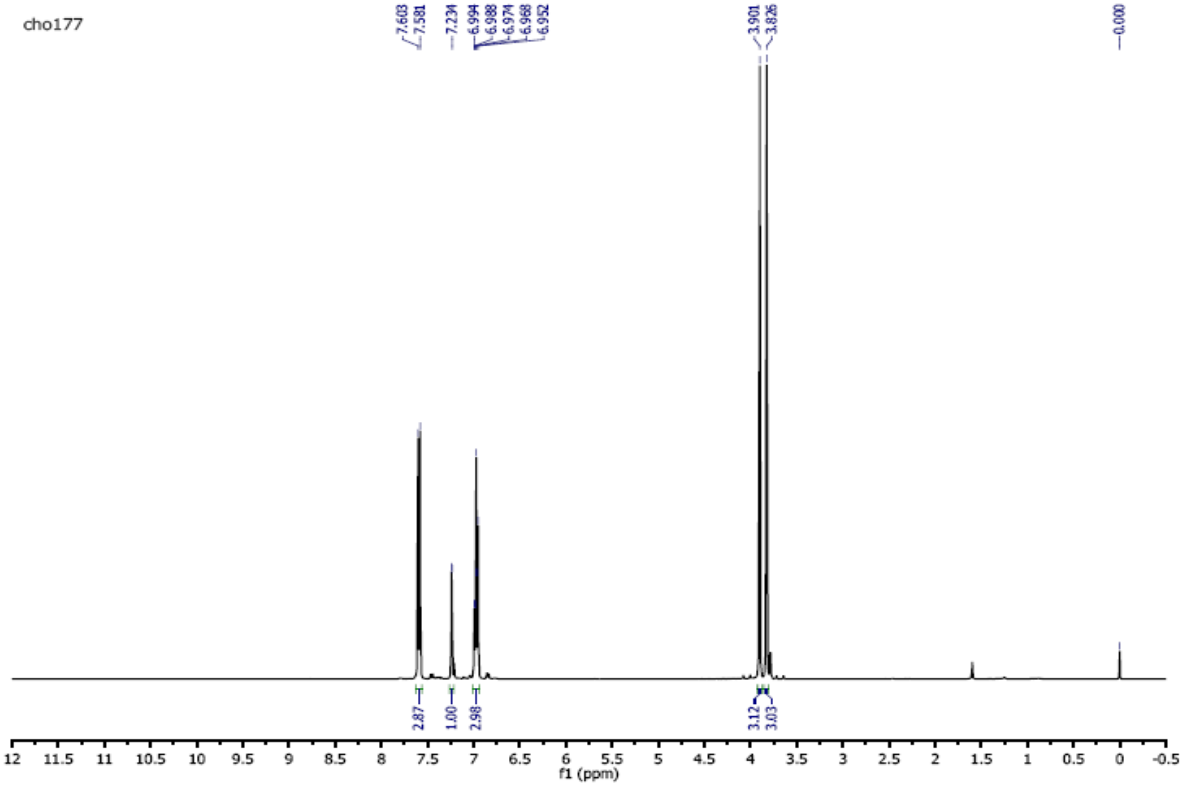


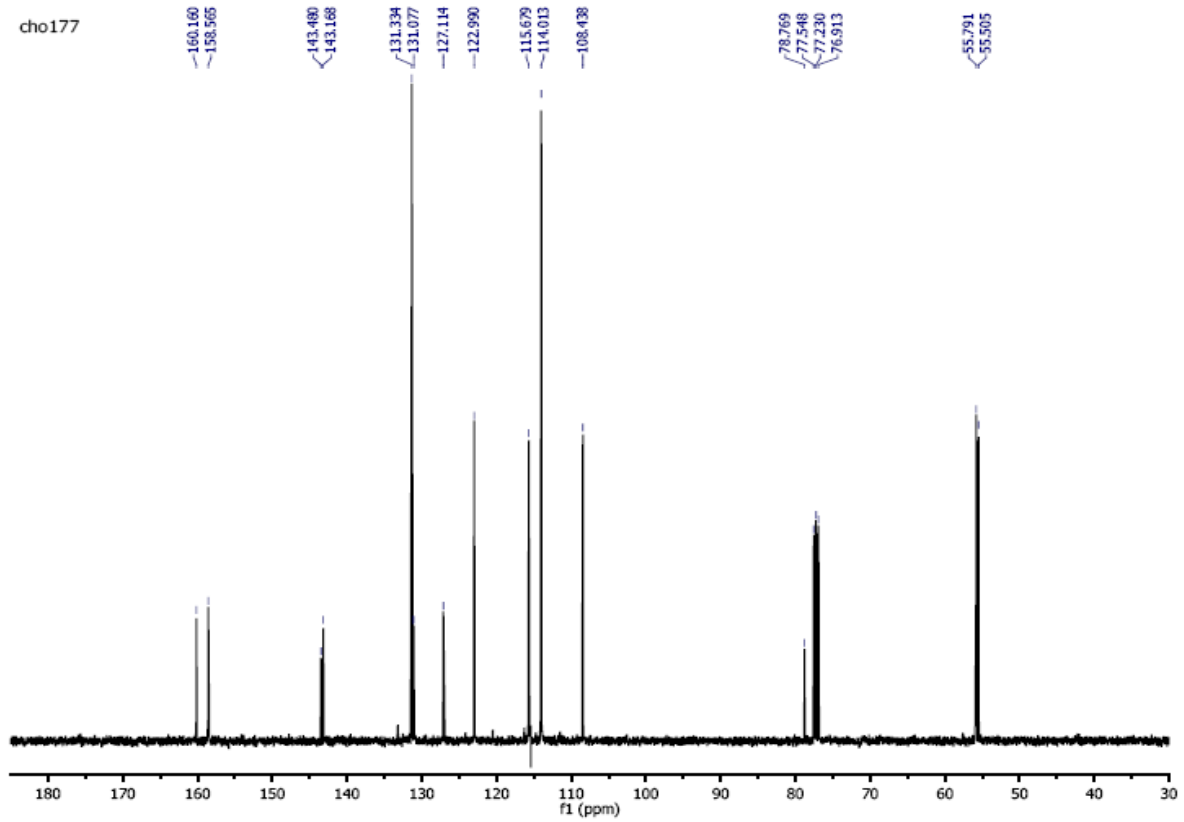




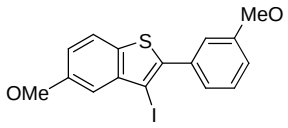
3-Iodobenzo[*b*]thiophene 4{*5*}

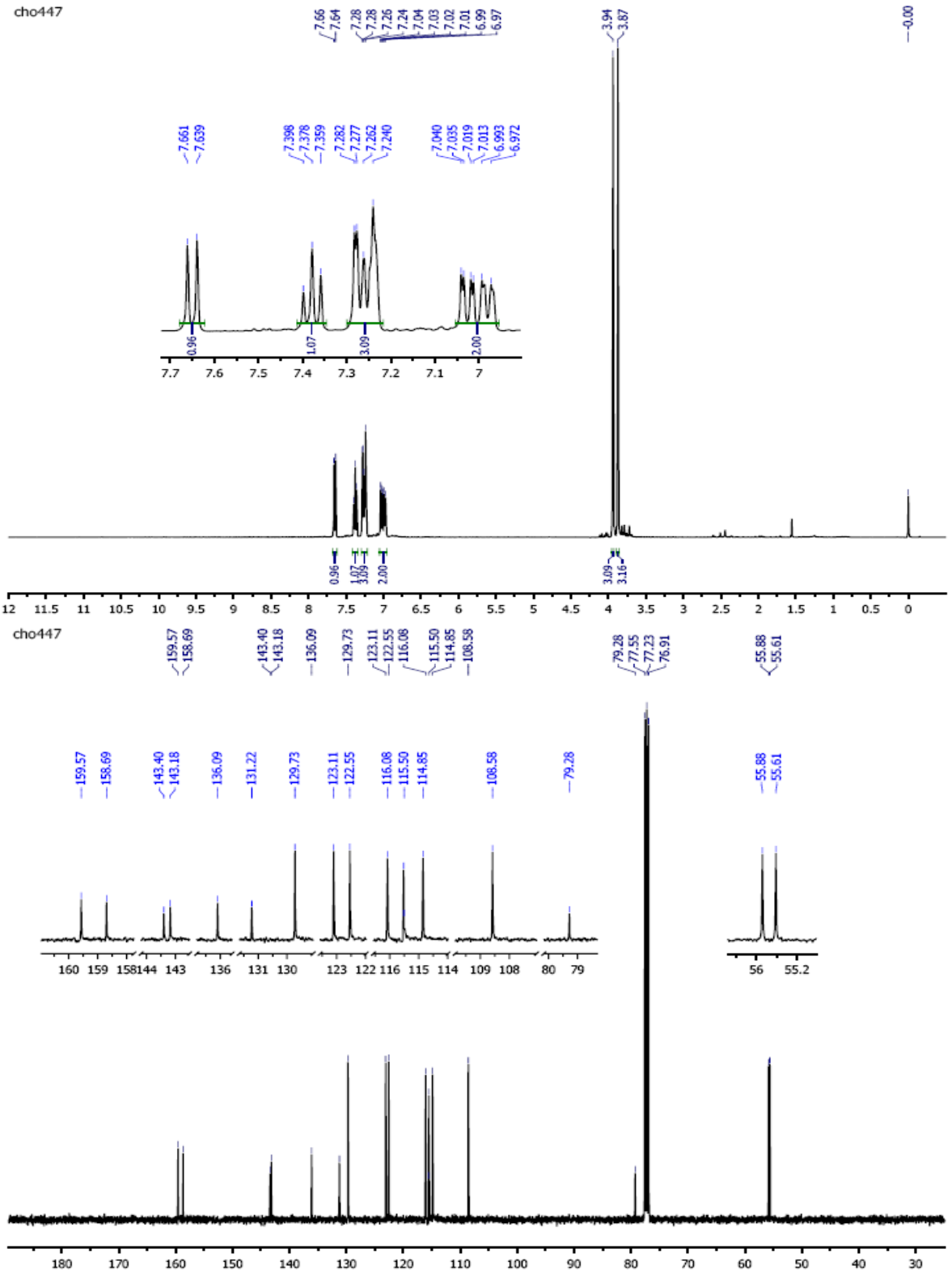




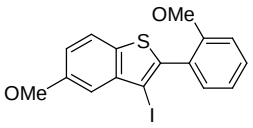


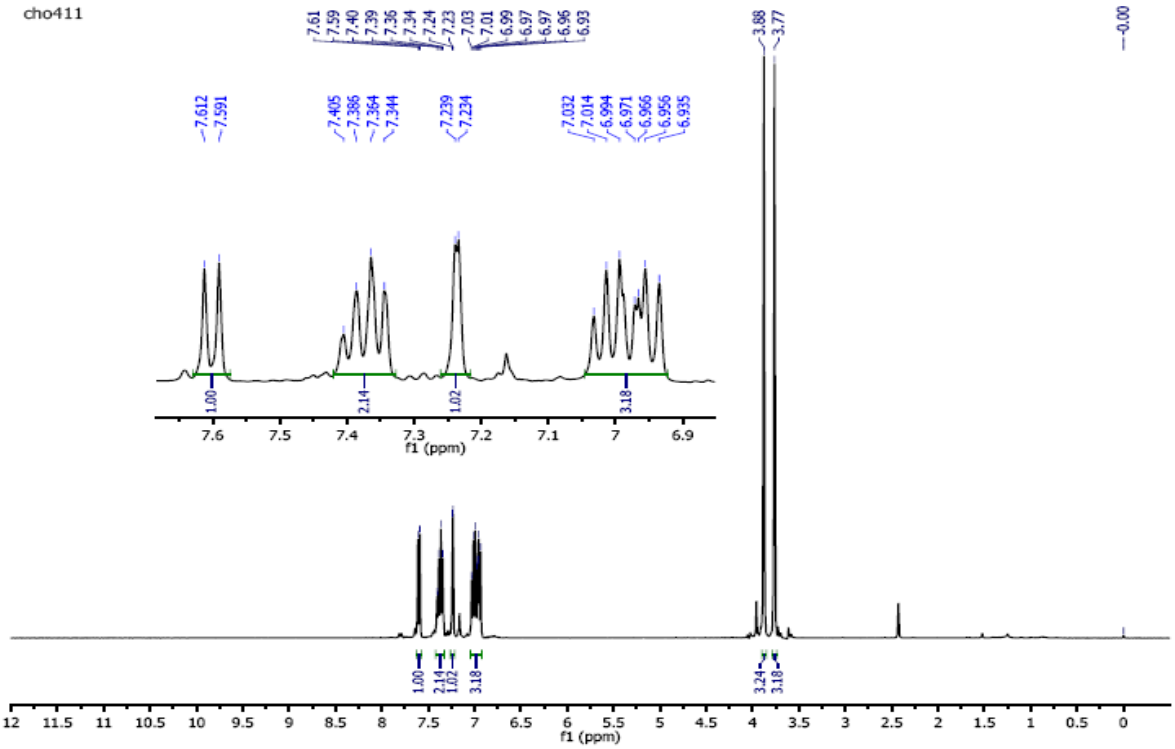
3-Iodobenzo[*b*]thiophene 4{*6*}

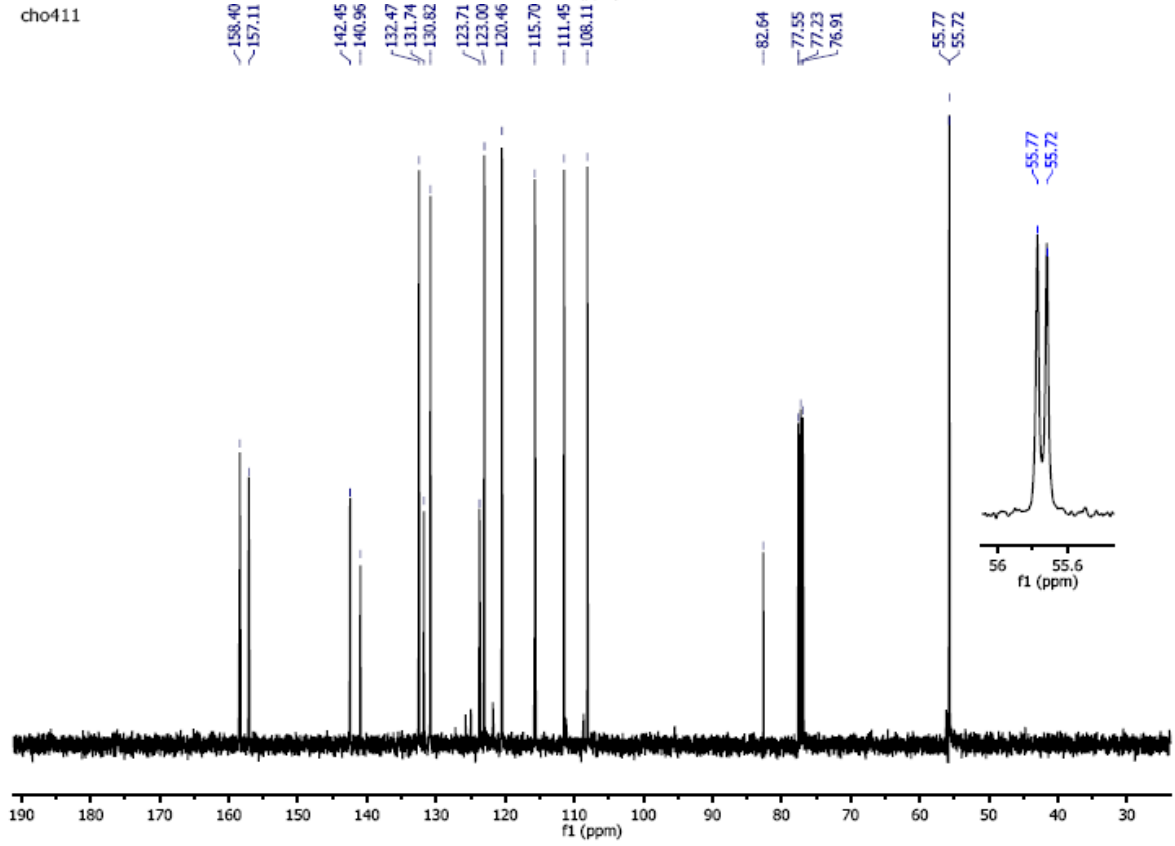




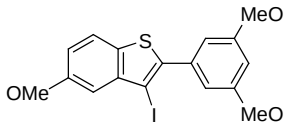
3-Iodobenzo[*b*]thiophene 4{*7*}

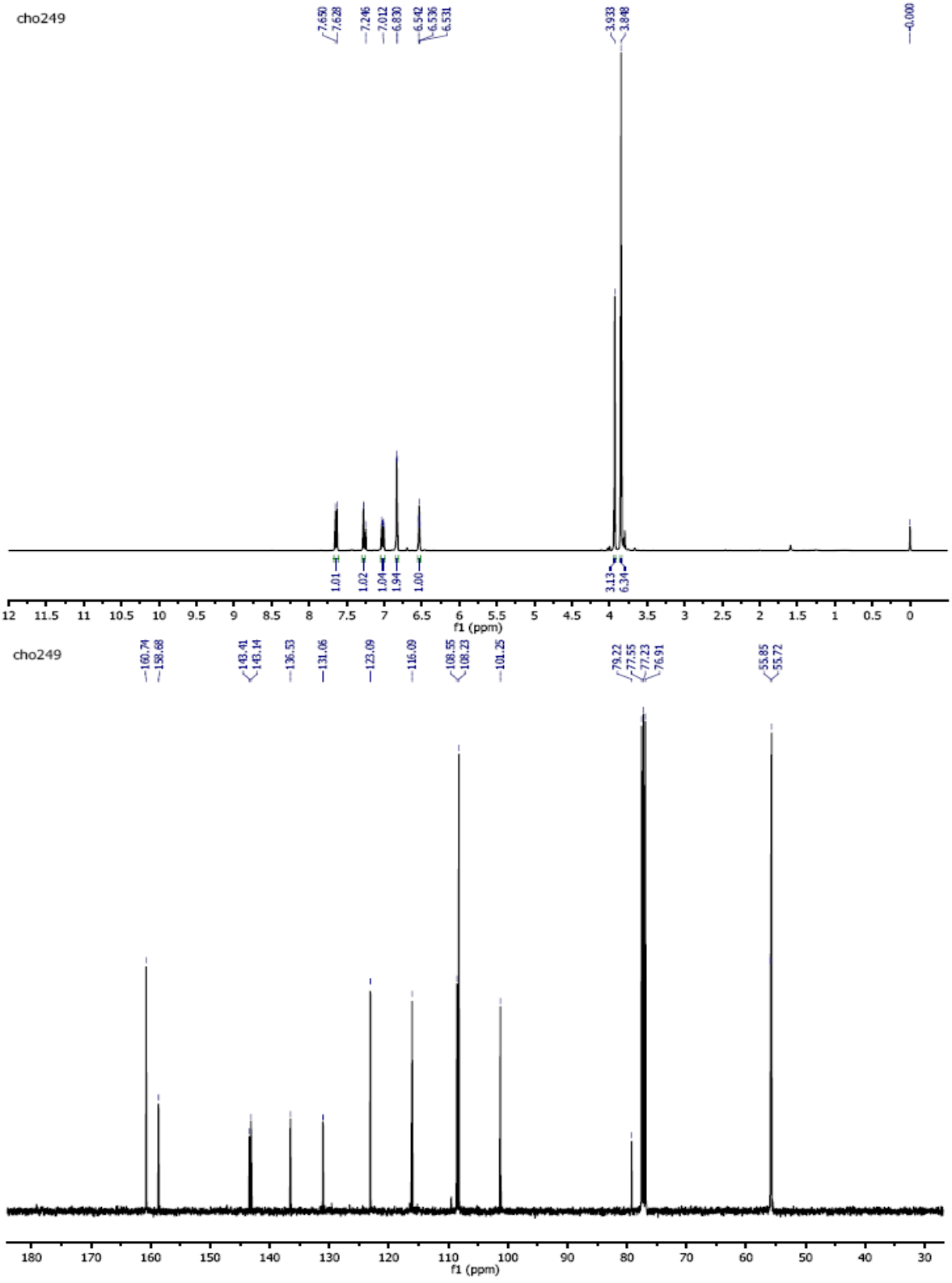




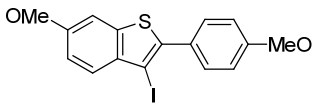


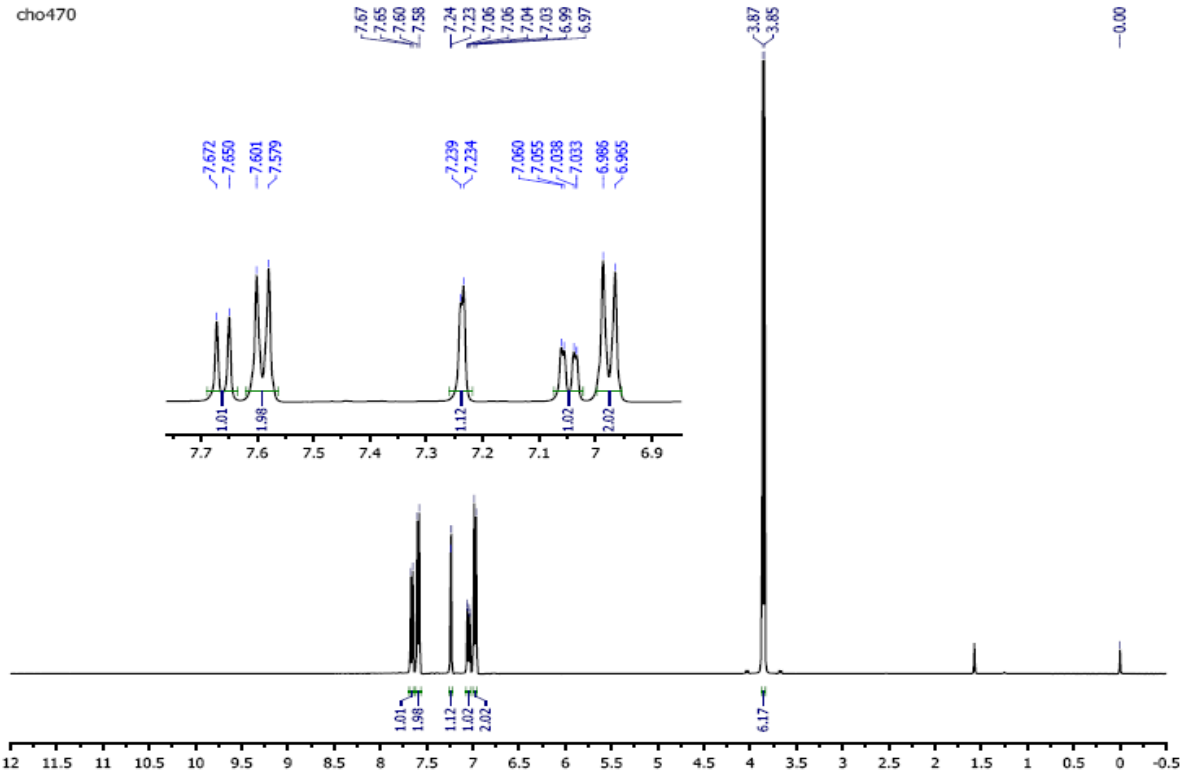
3-Iodobenzo[*b*]thiophene 4{*8*}

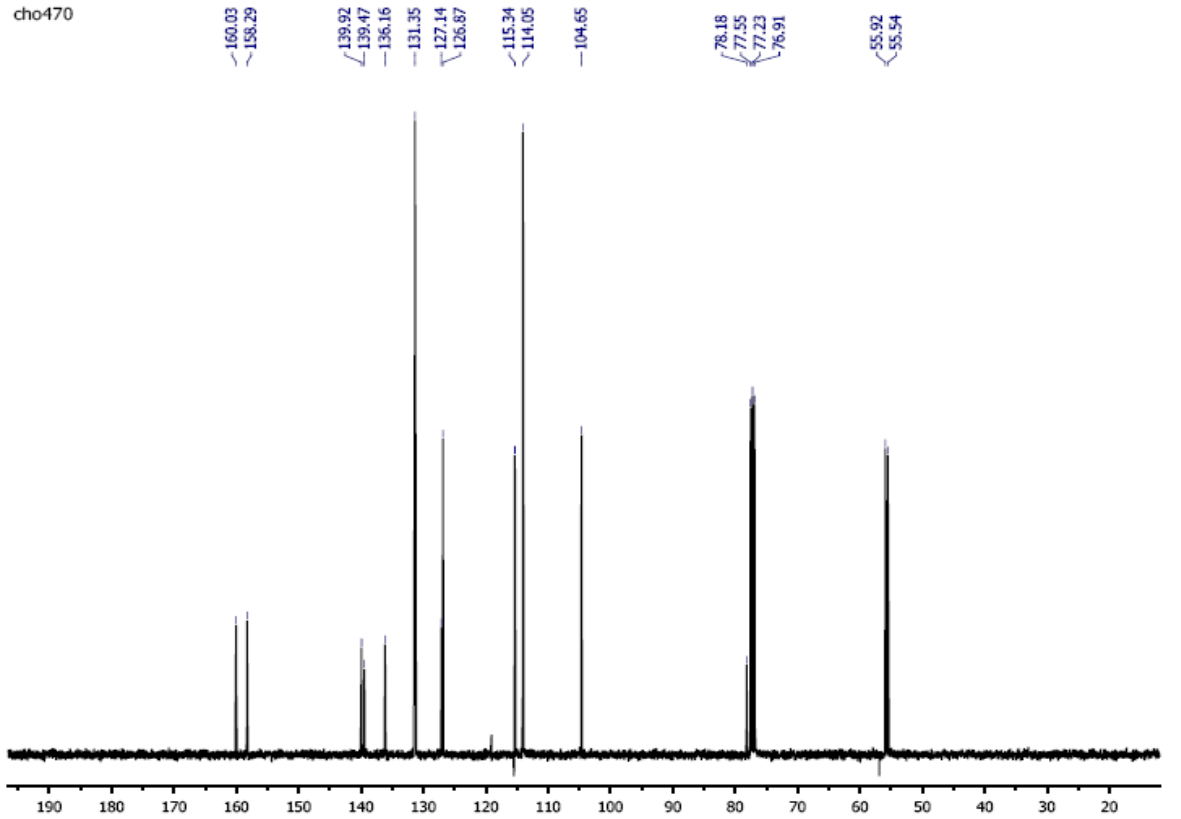




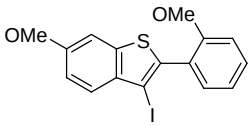
3-Iodobenzo[*b*]thiophene 4{*9*}

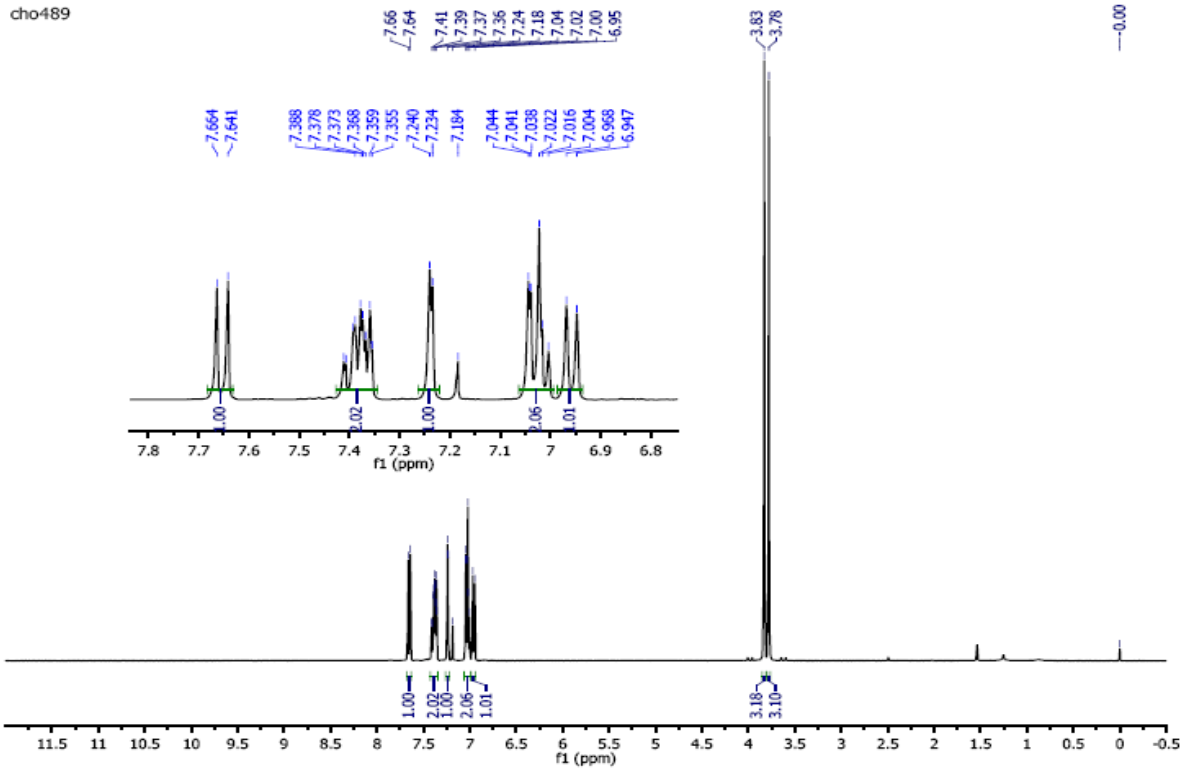


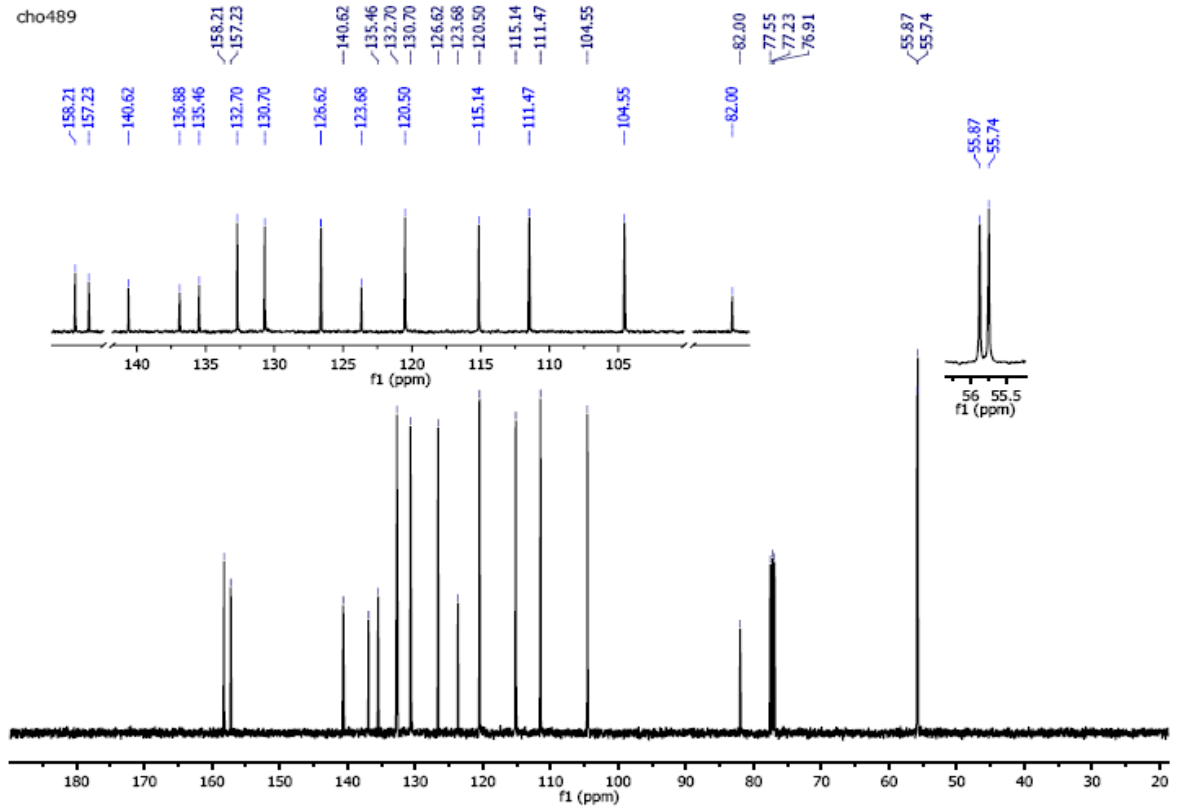




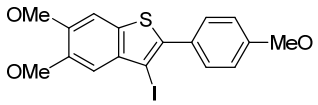
3-Iodobenzo[*b*]thiophene 4{*10*}

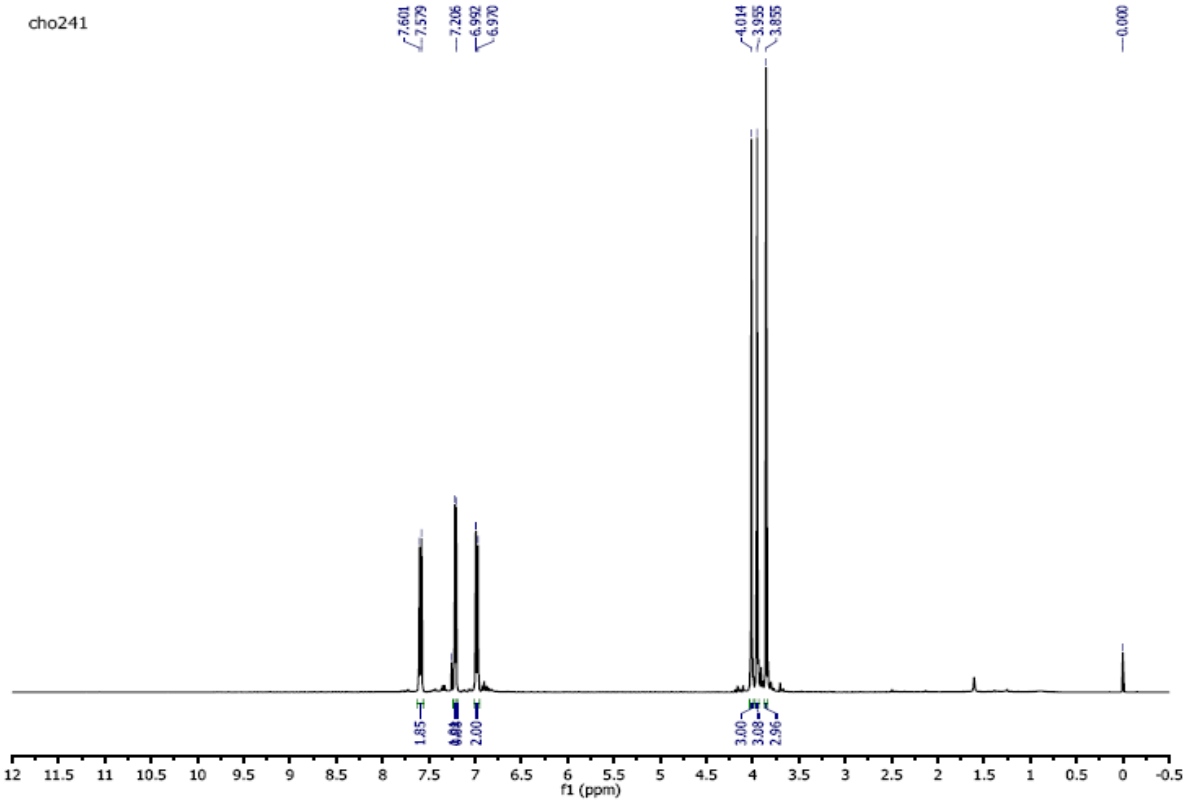


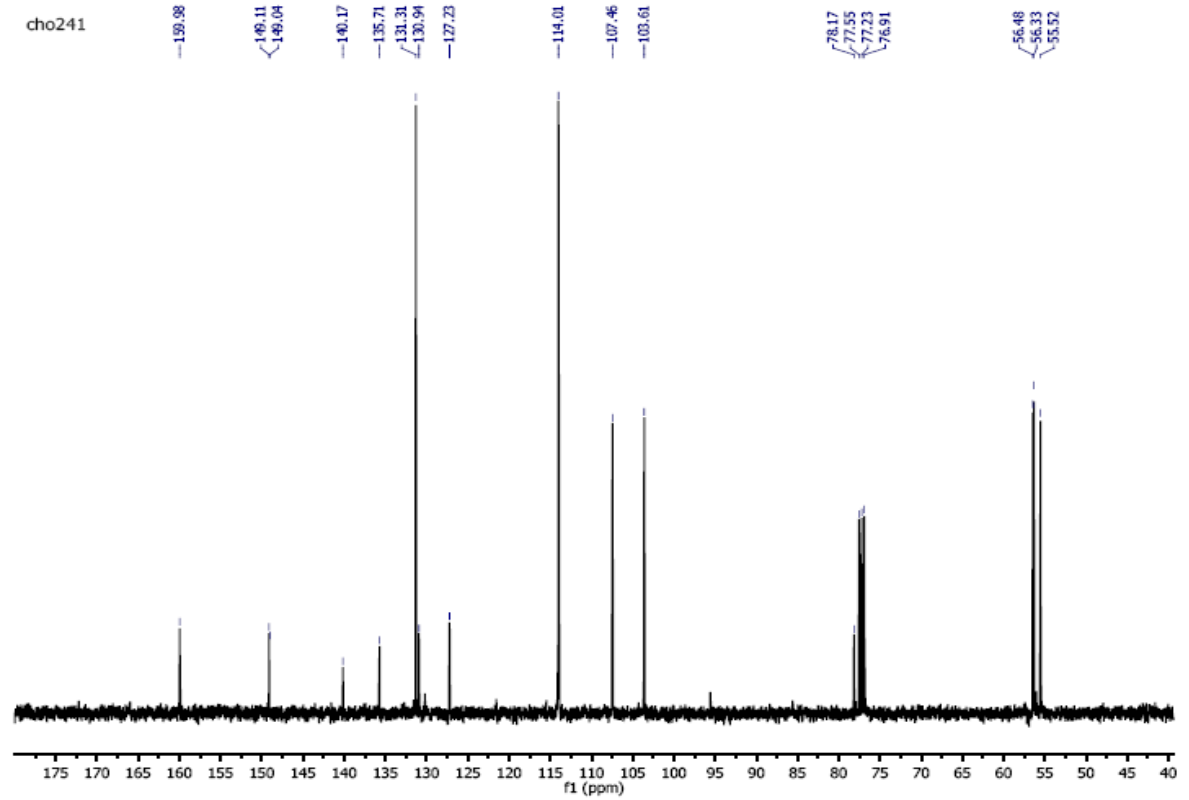




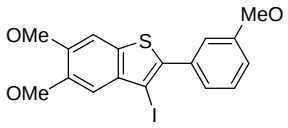
3-Iodobenzo[*b*]thiophene 4{*11*}

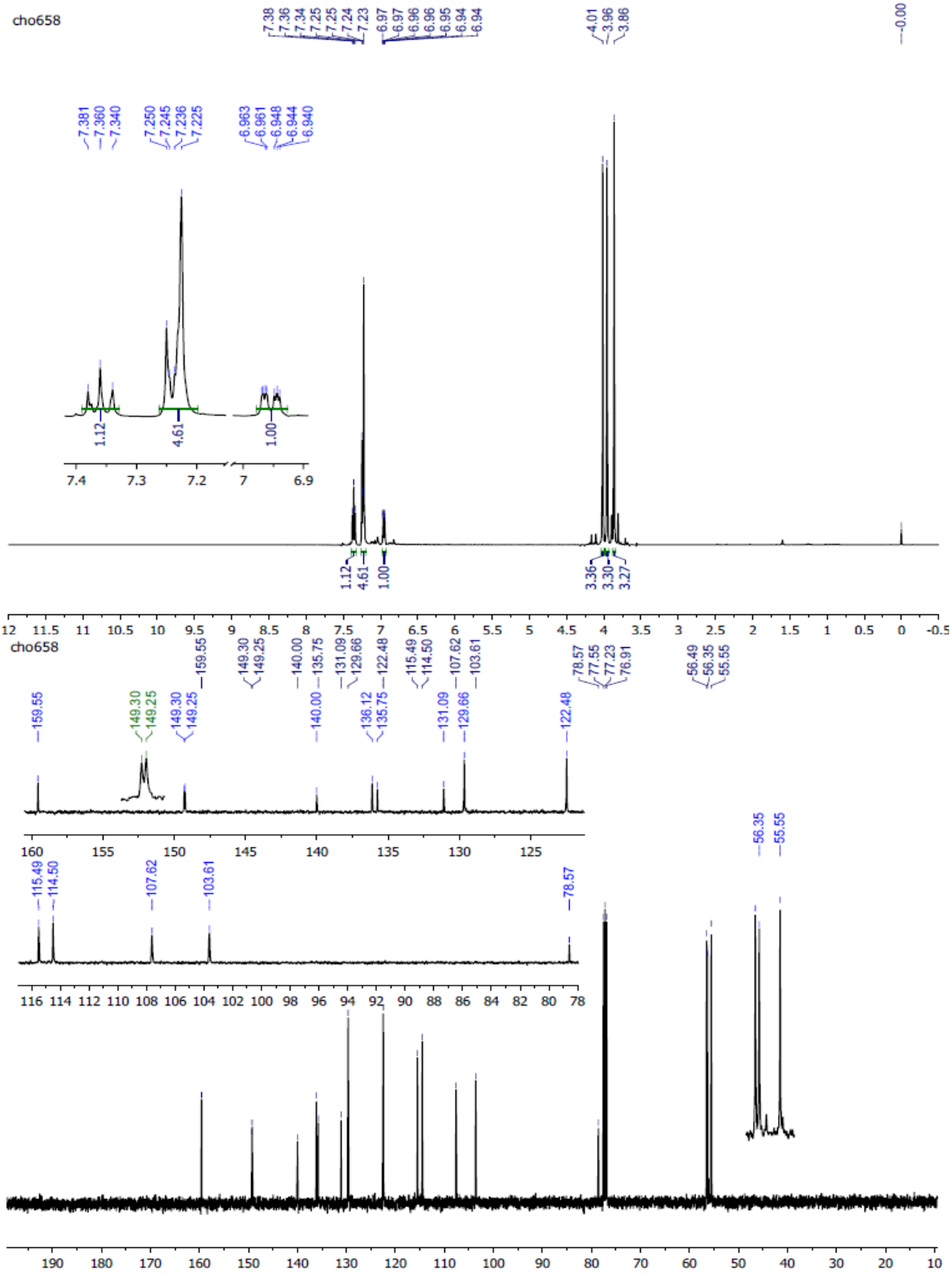




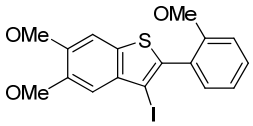


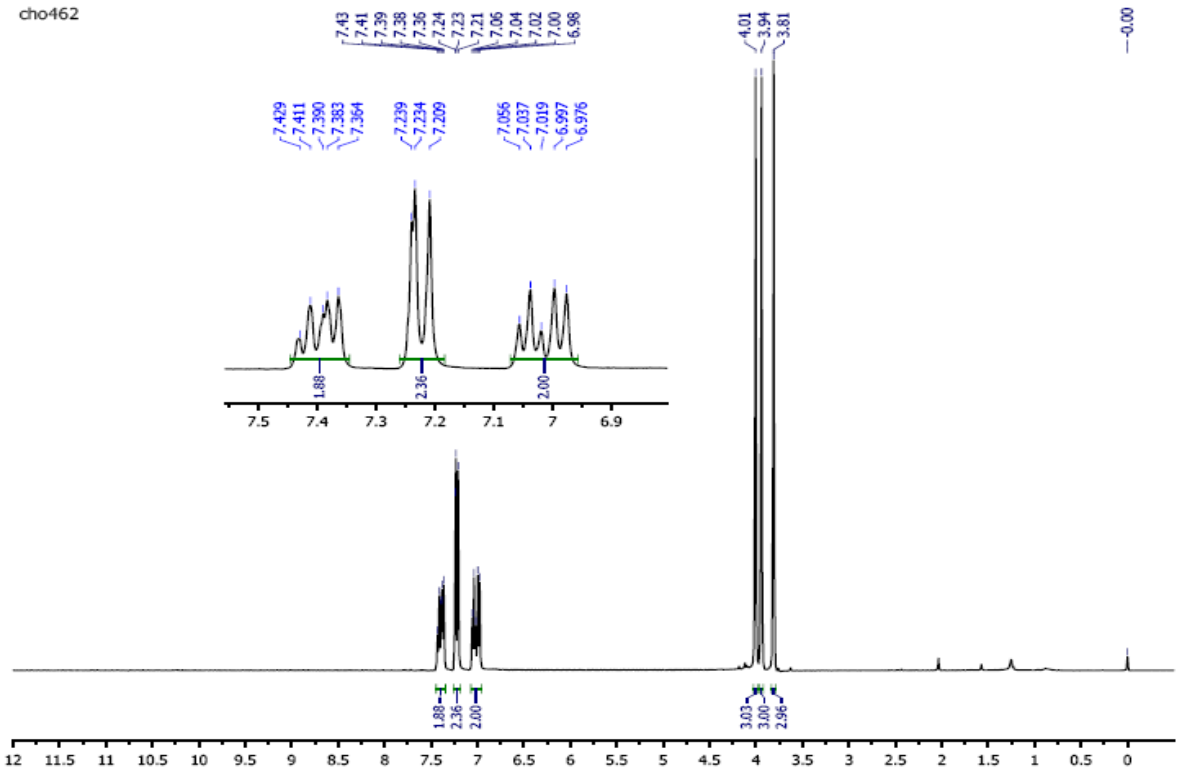
3-Iodobenzo[*b*]thiophene 4{*12*}

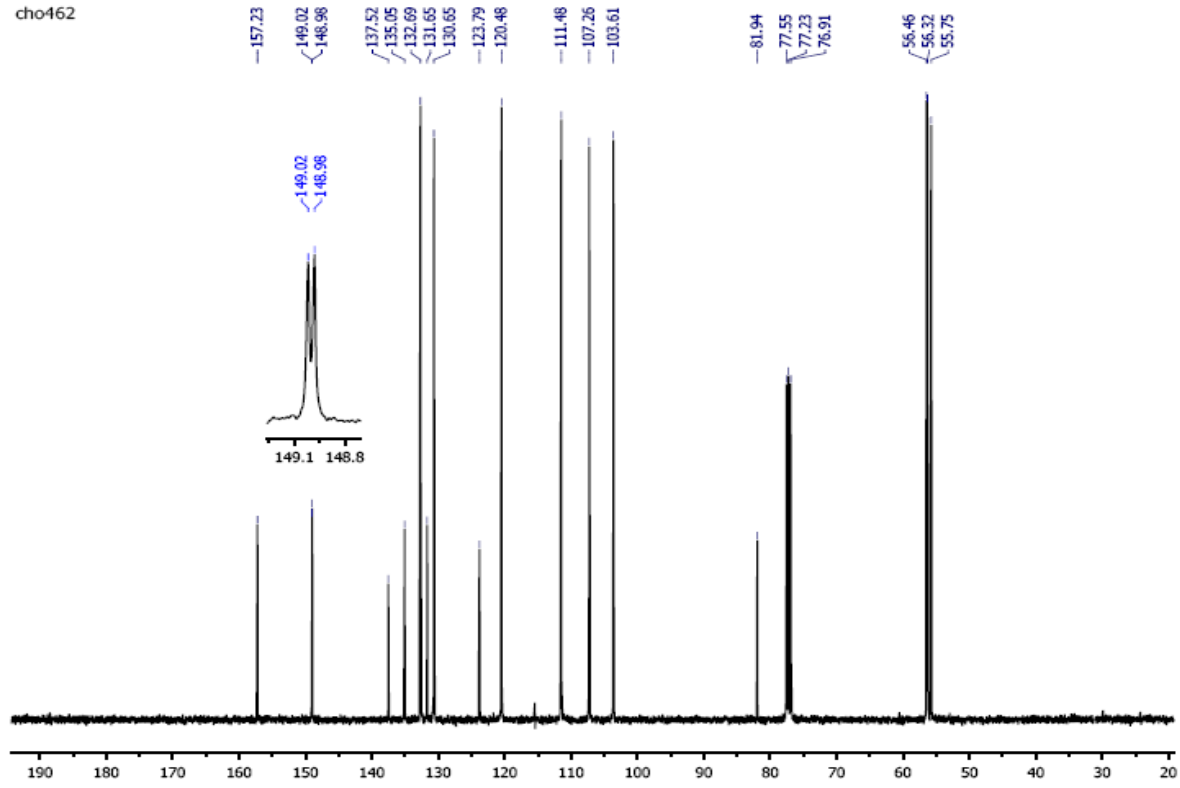




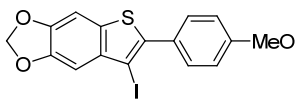
3-Iodobenzo[*b*]thiophene 4{*13*}

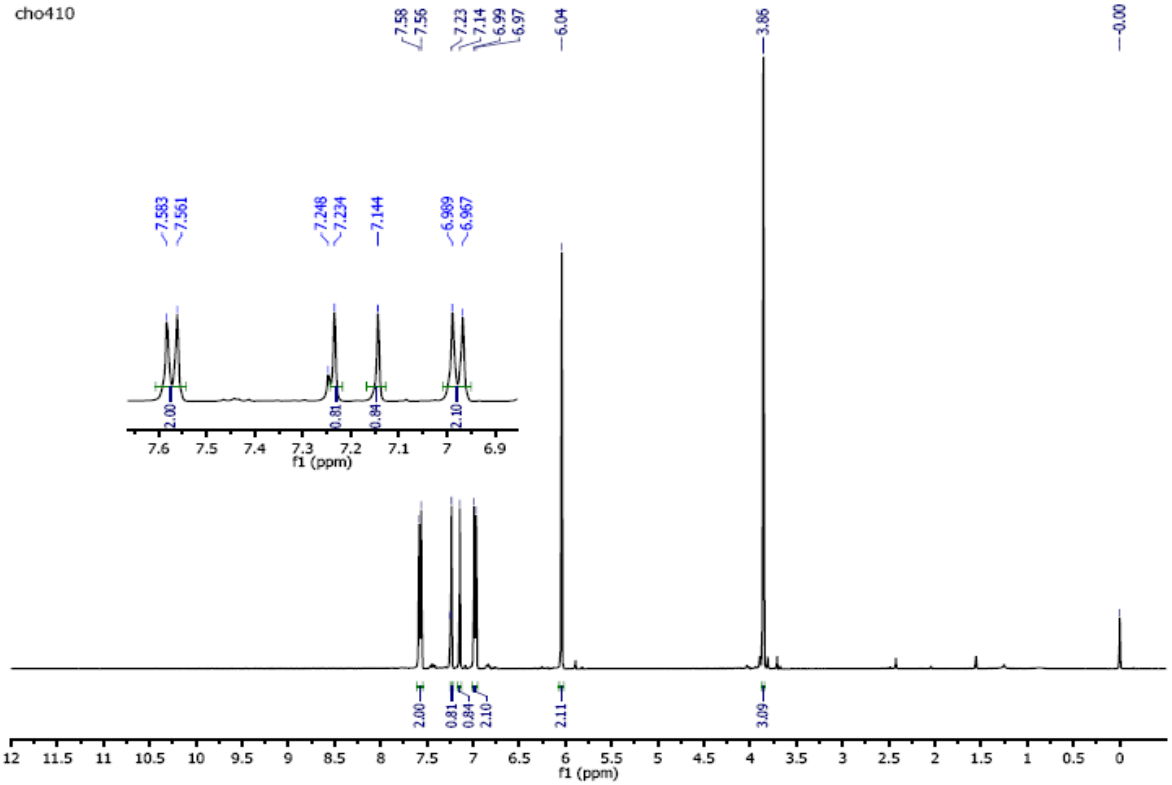


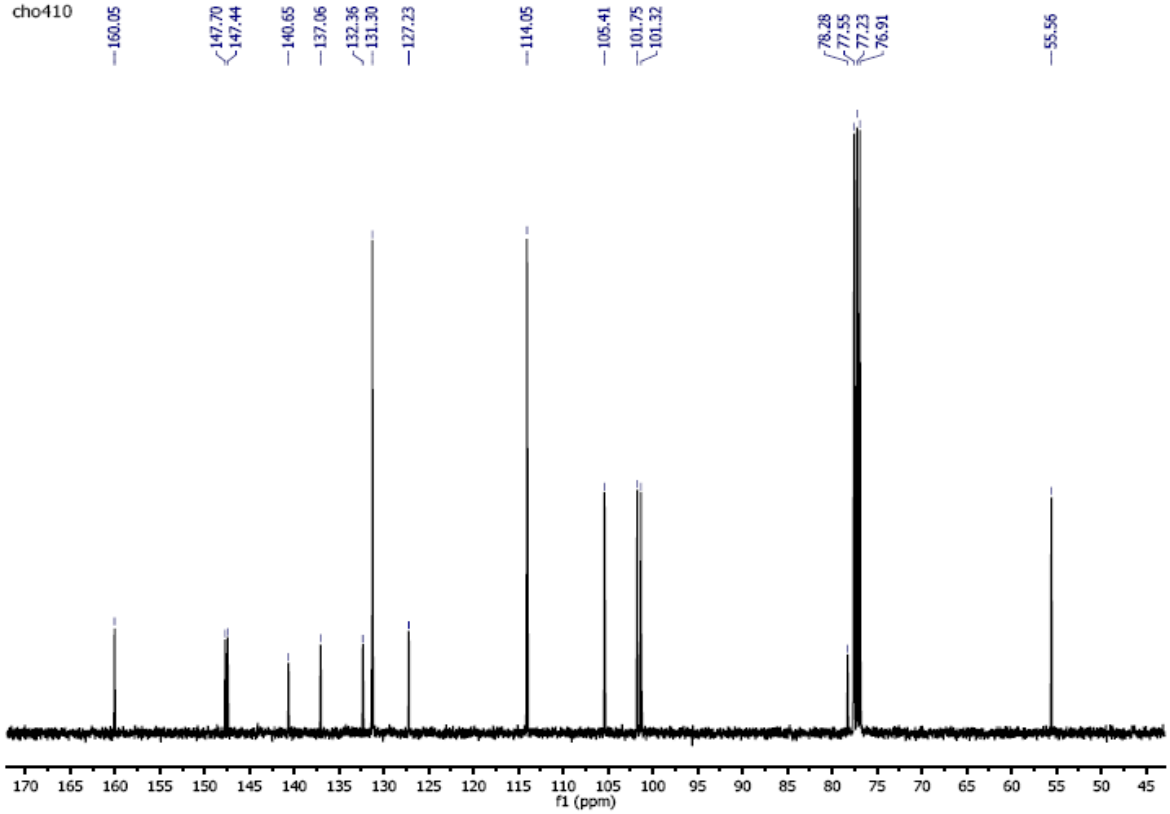




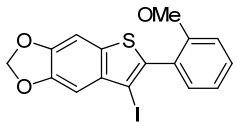
3-Iodobenzo[*b*]thiophene 4{*14*}

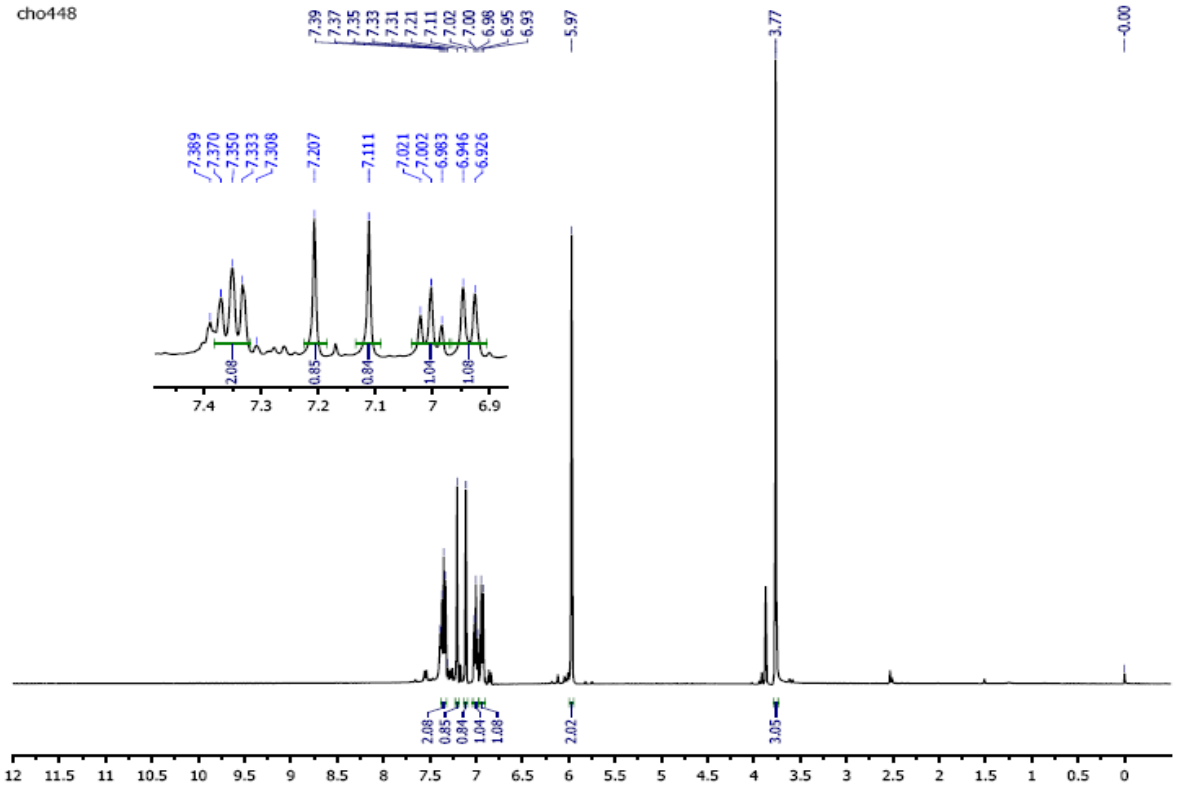


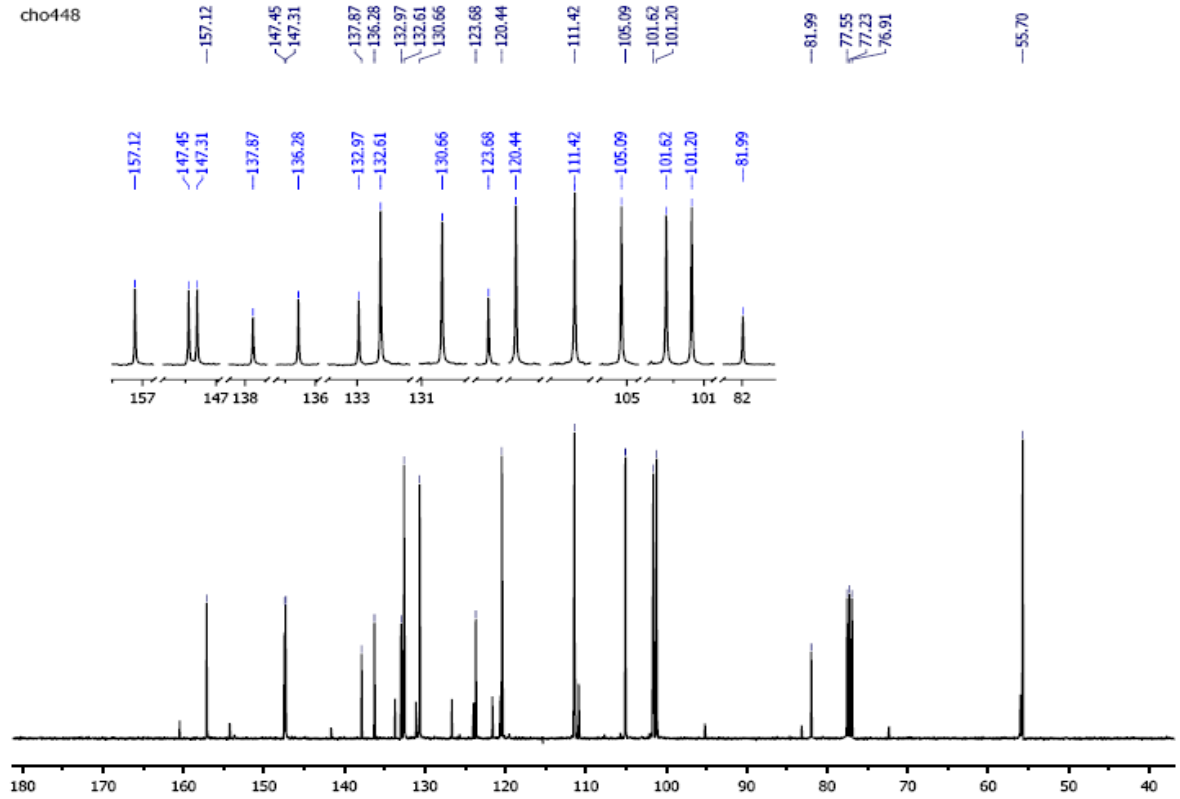




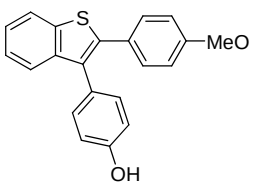
3-Iodobenzo[*b*]thiophene 4{*15*}

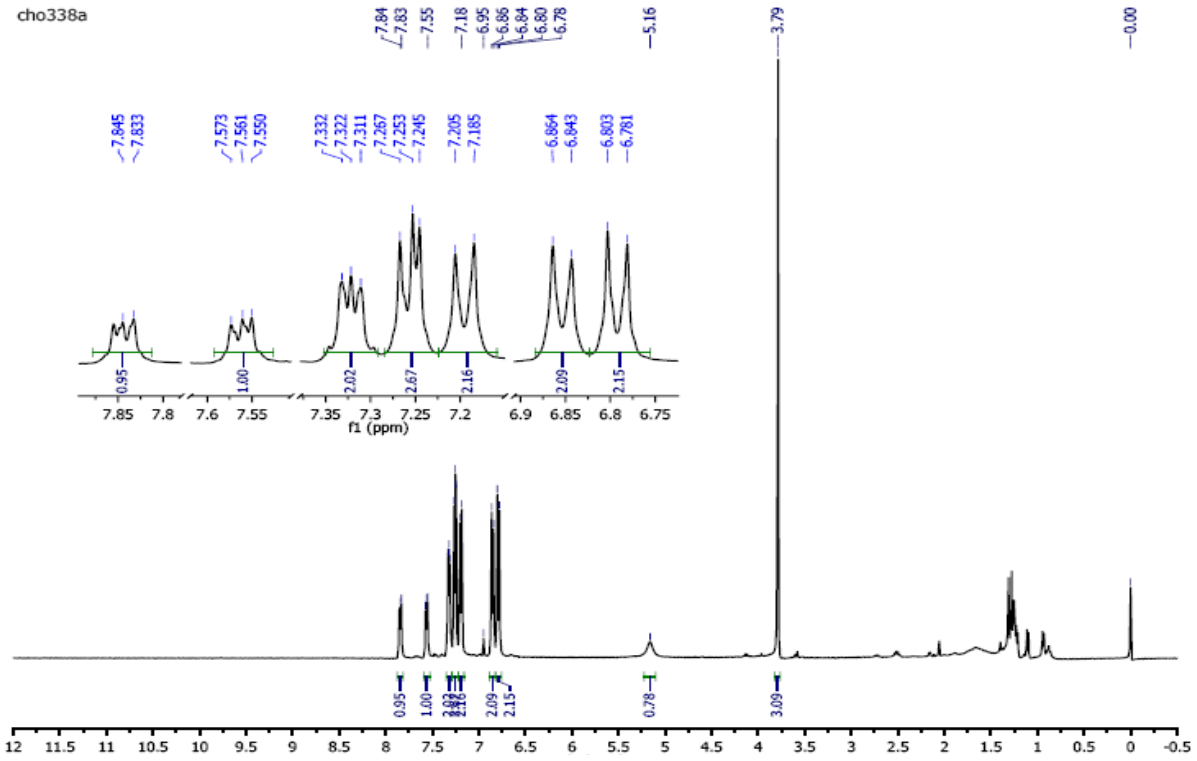


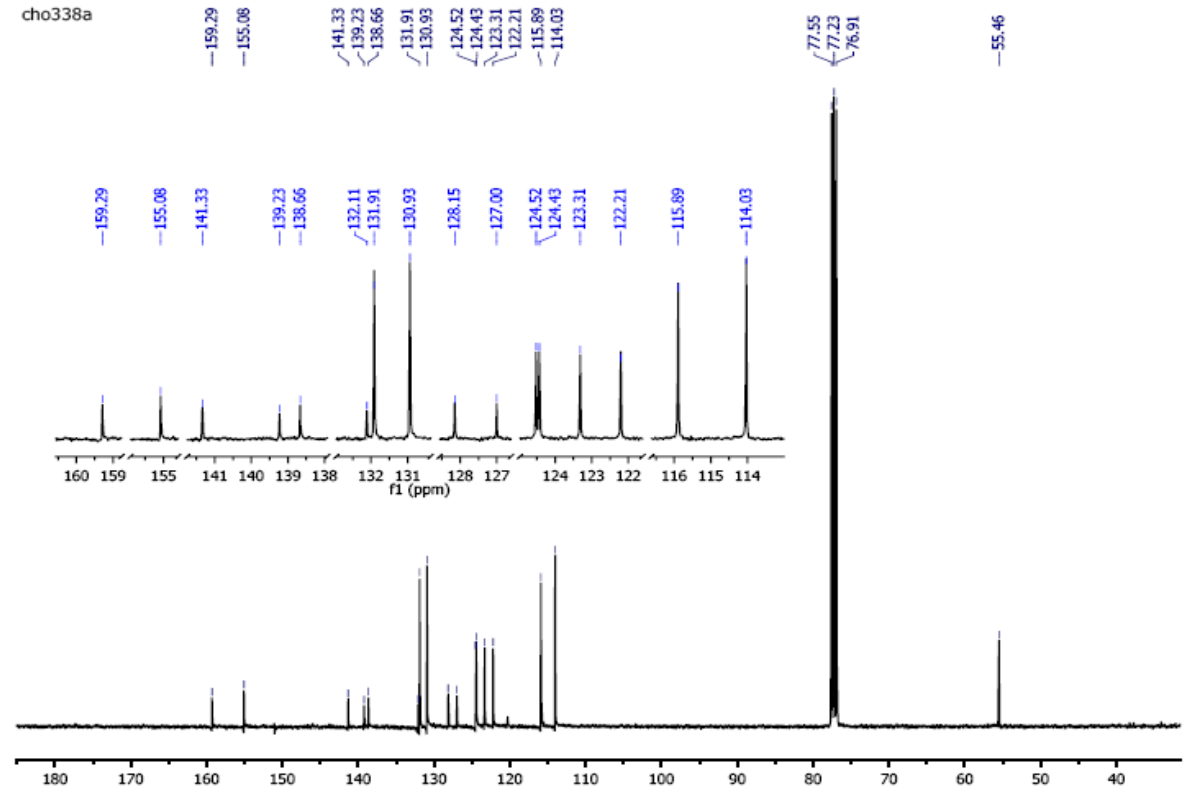




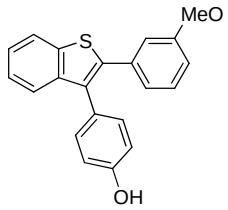
Compound 5{*2*}

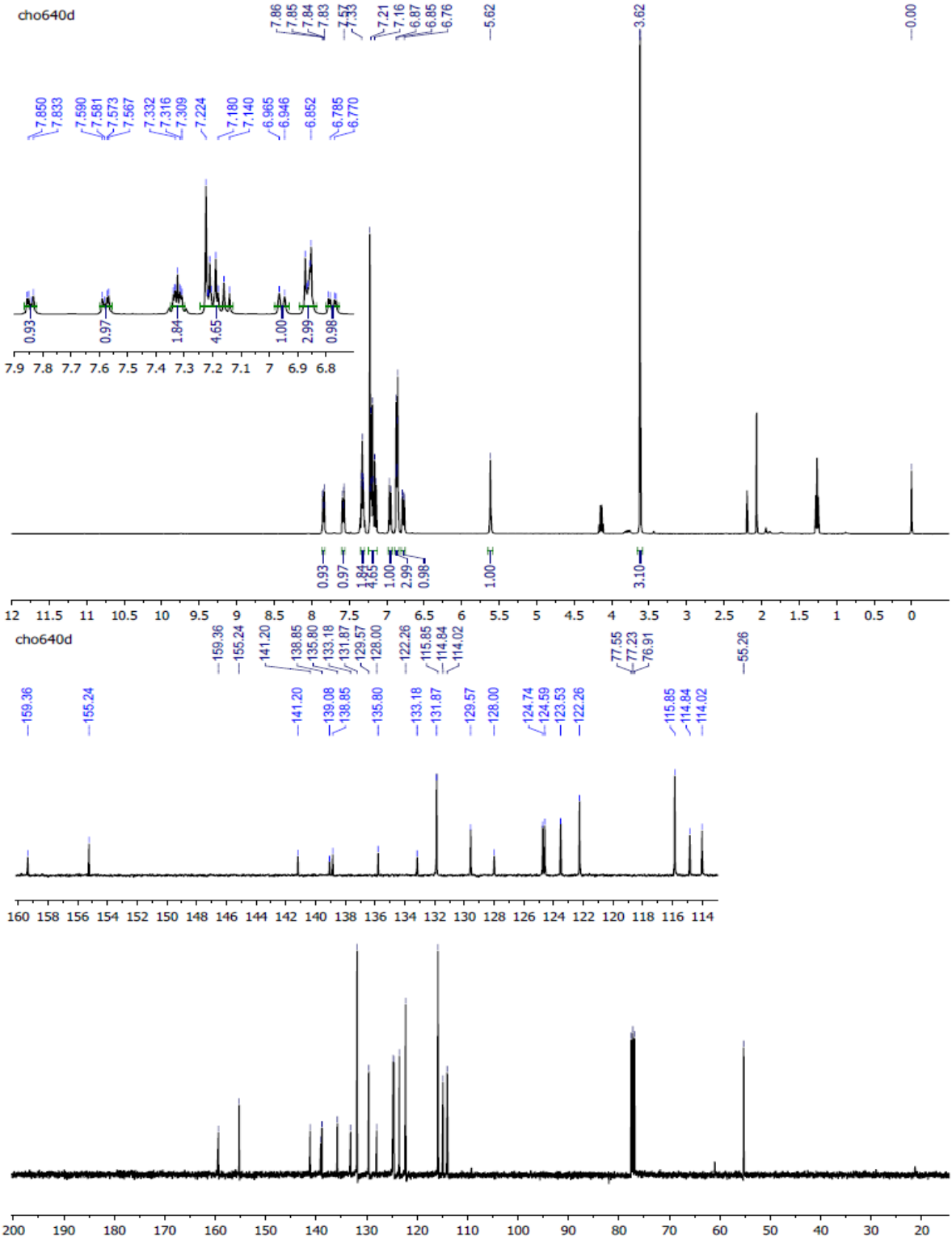

S
MeO
OH


cho338a
7.84
7.83
7.55
7.18
6.95
6.86
6.84
6.80
6.78
5.16
3.79
0.00
7.845
7.833
7.573
7.561
7.550
7.332
7.322
7.311
7.267
7.253
7.245
7.205
7.185
6.864
6.843
6.803
6.781
0.95
1.00
2.02
2.67
2.16
2.09
2.15
7.85 7.8 7.6 7.55 7.35 7.3 7.25 7.2 6.9 6.85 6.8 6.75
f1 (ppm)
0.95
1.00
2.09
2.15
0.78
3.09
12 11.5 11 10.5 10 9.5 9 8.5 8 7.5 7 6.5 6 5.5 5 4.5 4 3.5 3 2.5 2 1.5 1 0.5 0 -0.5

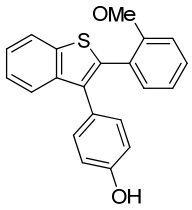

cho338a
159.29
155.08
141.33
139.23
138.66
131.91
130.93
124.52
124.43
123.31
122.21
115.89
114.03
77.55
77.23
76.91
55.46
159.29
155.08
141.33
139.23
138.66
132.11
131.91
130.93
128.15
127.00
124.52
124.43
123.31
122.21
115.89
114.03
160 159 155 141 140 139 138 132 131 128 127 124 123 122 116 115 114
f1 (ppm)
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40

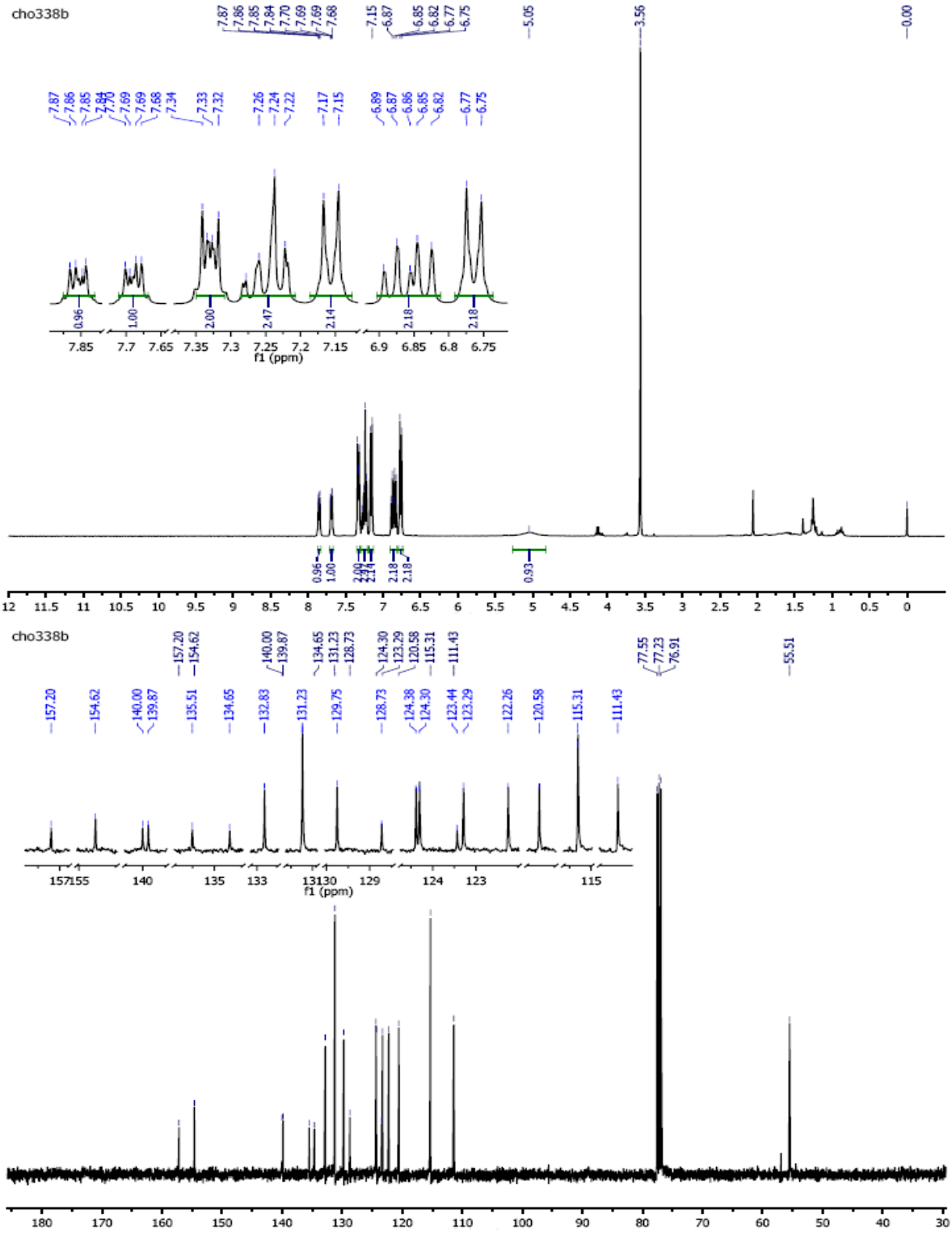
Compound 5{*3*}


MeO
S
OH

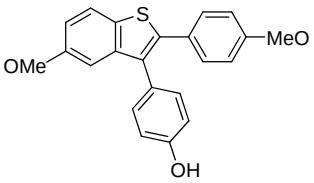

cho640d
7.86
7.85
7.84
7.83
7.57
7.33
7.21
7.16
6.87
6.85
6.76
5.62
3.62
0.00
7.850
7.833
7.590
7.581
7.573
7.567
7.332
7.316
7.309
7.224
7.180
7.140
6.965
6.946
6.852
6.785
6.770
0.93
0.97
1.84
4.65
1.00
2.99
0.98
3.10
cho640d
159.36
155.24
141.20
138.85
135.80
133.18
131.87
129.57
128.00
122.26
115.85
114.84
114.02
77.55
77.23
76.91
55.26
139.08
124.74
124.59
123.53

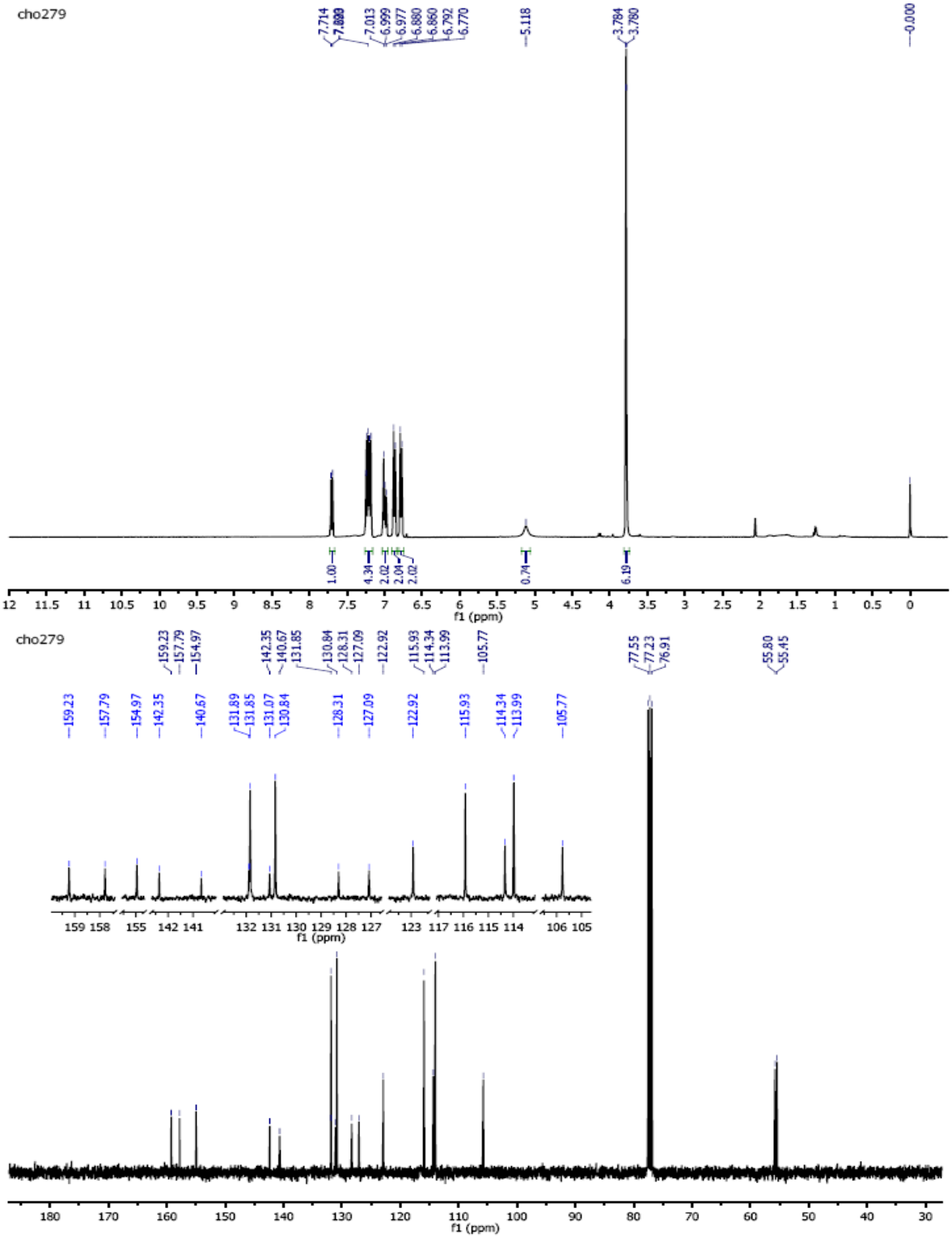
Compound 5{*4*}



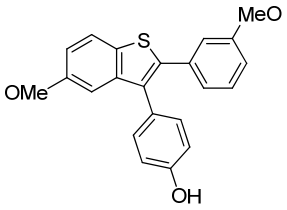


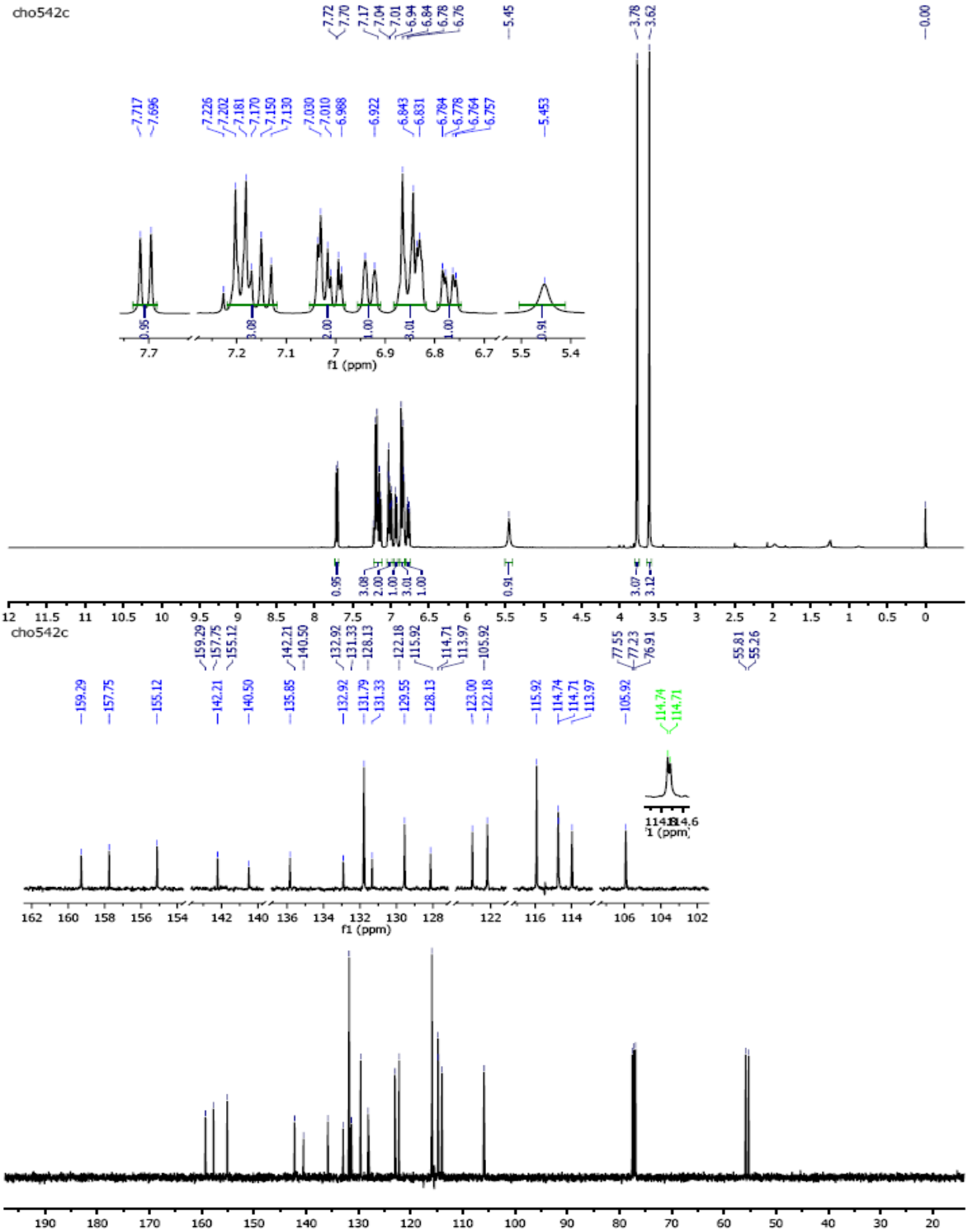
Compound 5{*5*}


S
MeO
OMe
OH

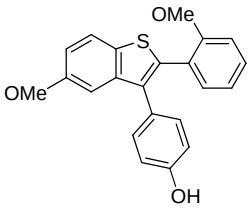

cho279
7.714
7.013
6.999
6.977
6.880
6.860
6.792
6.770
5.118
3.784
3.780
0.000
1.00
4.34
2.02
2.04
2.02
0.74
6.19
f1 (ppm)
cho279
159.23
157.79
154.97
142.35
140.67
131.89
131.85
131.07
130.84
128.31
127.09
122.92
115.93
114.34
113.99
105.77
77.55
77.23
76.91
55.80
55.45
f1 (ppm)

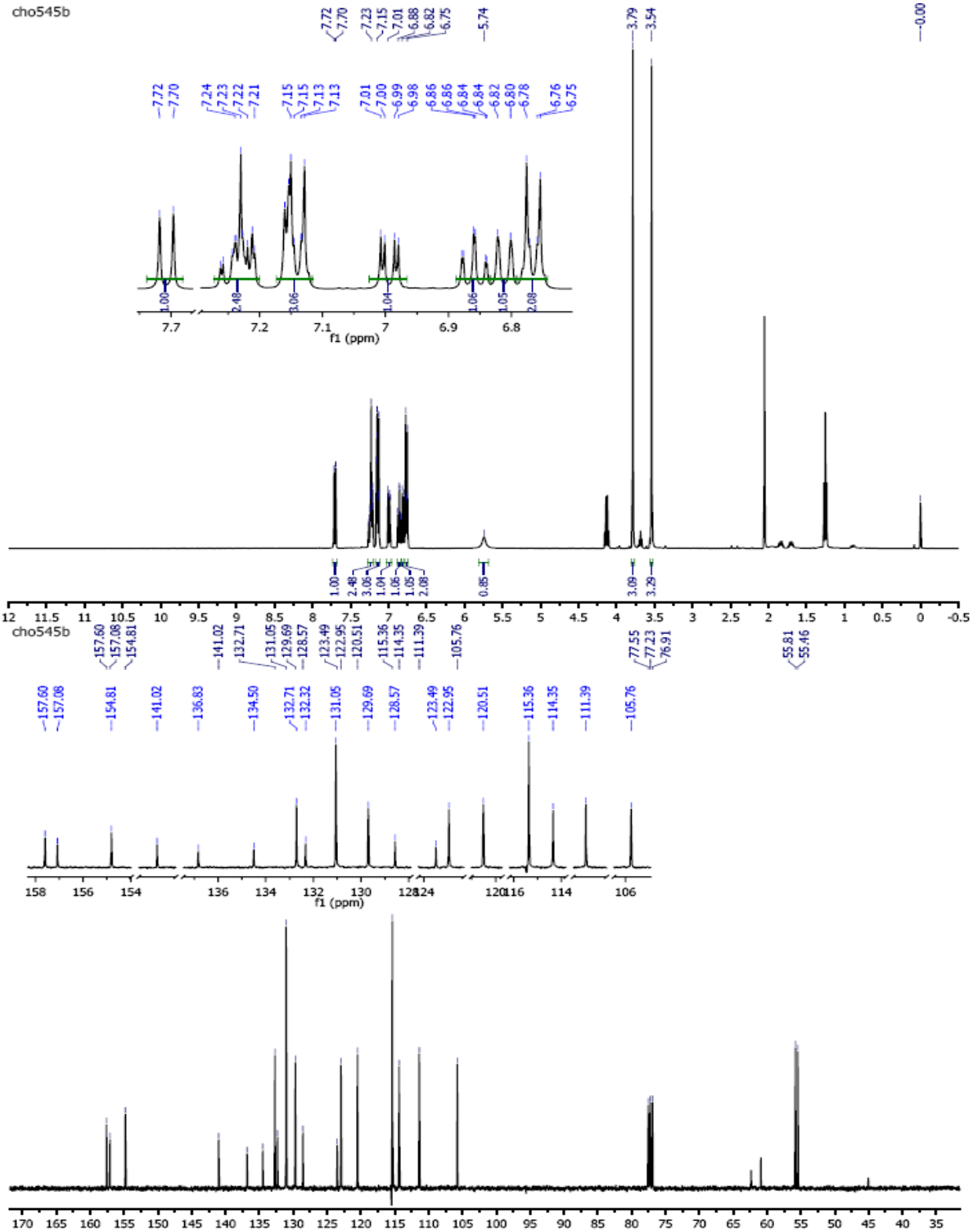
Compound 5{*6*}



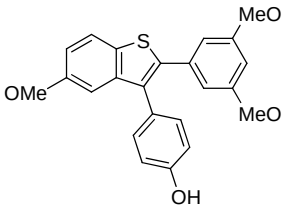


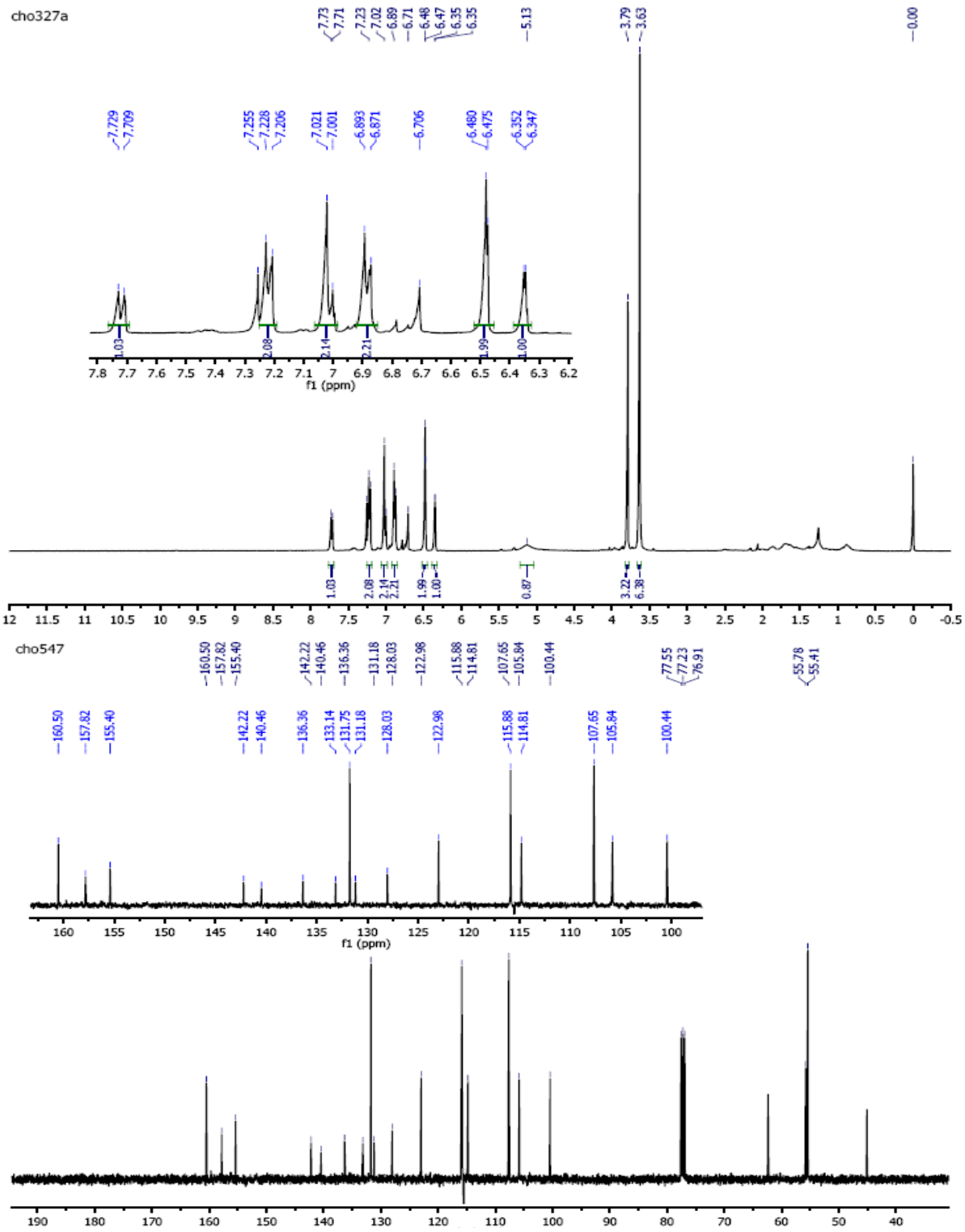
Compound 5{*7*}



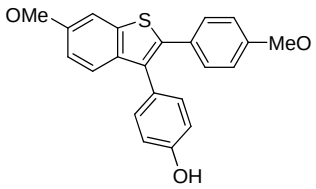


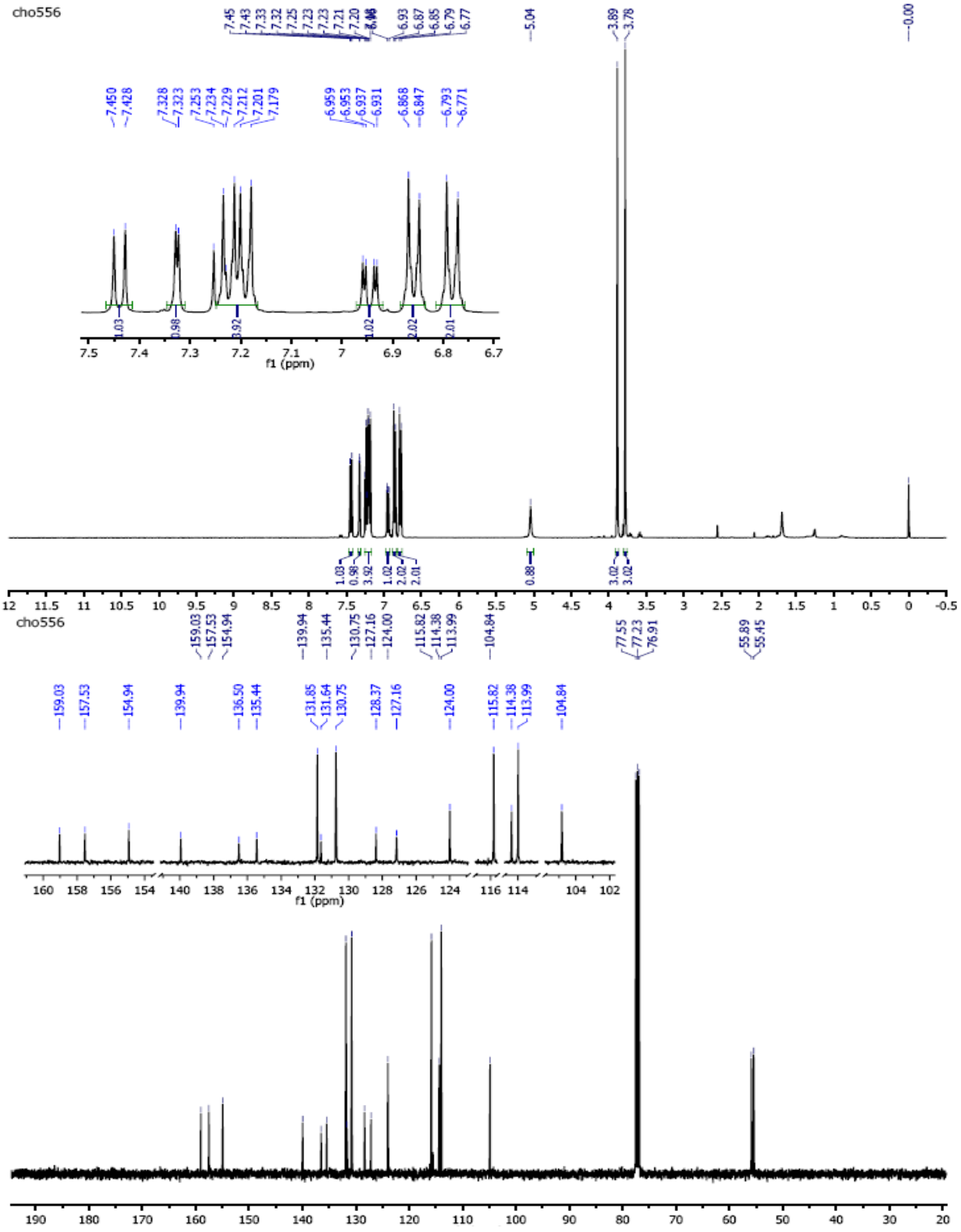
Compound 5{*8*}



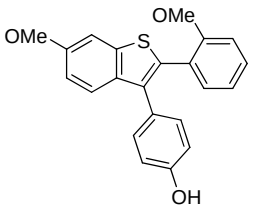


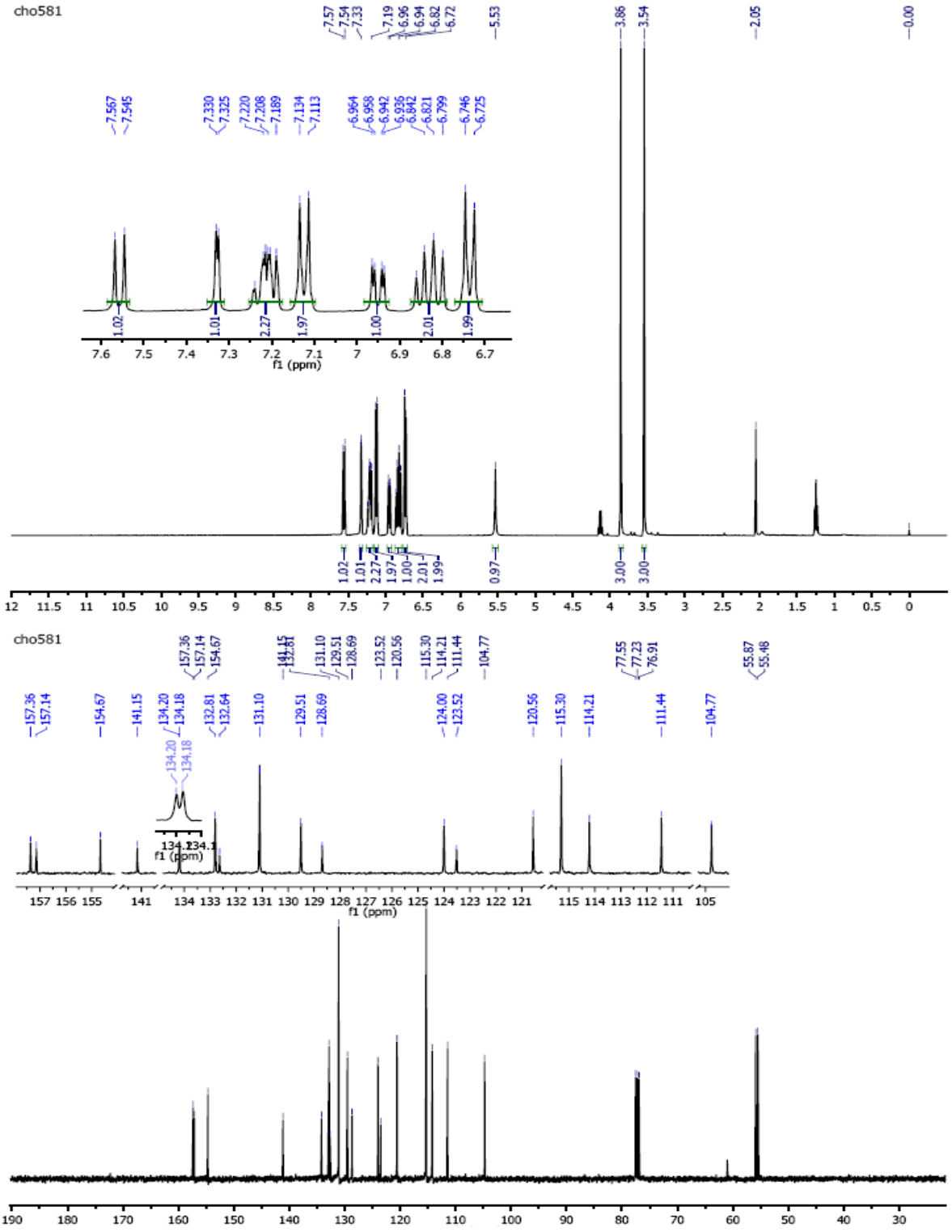
Compound 5{*9*}



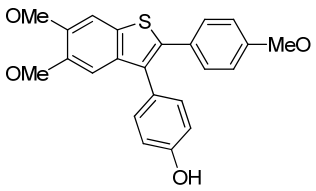


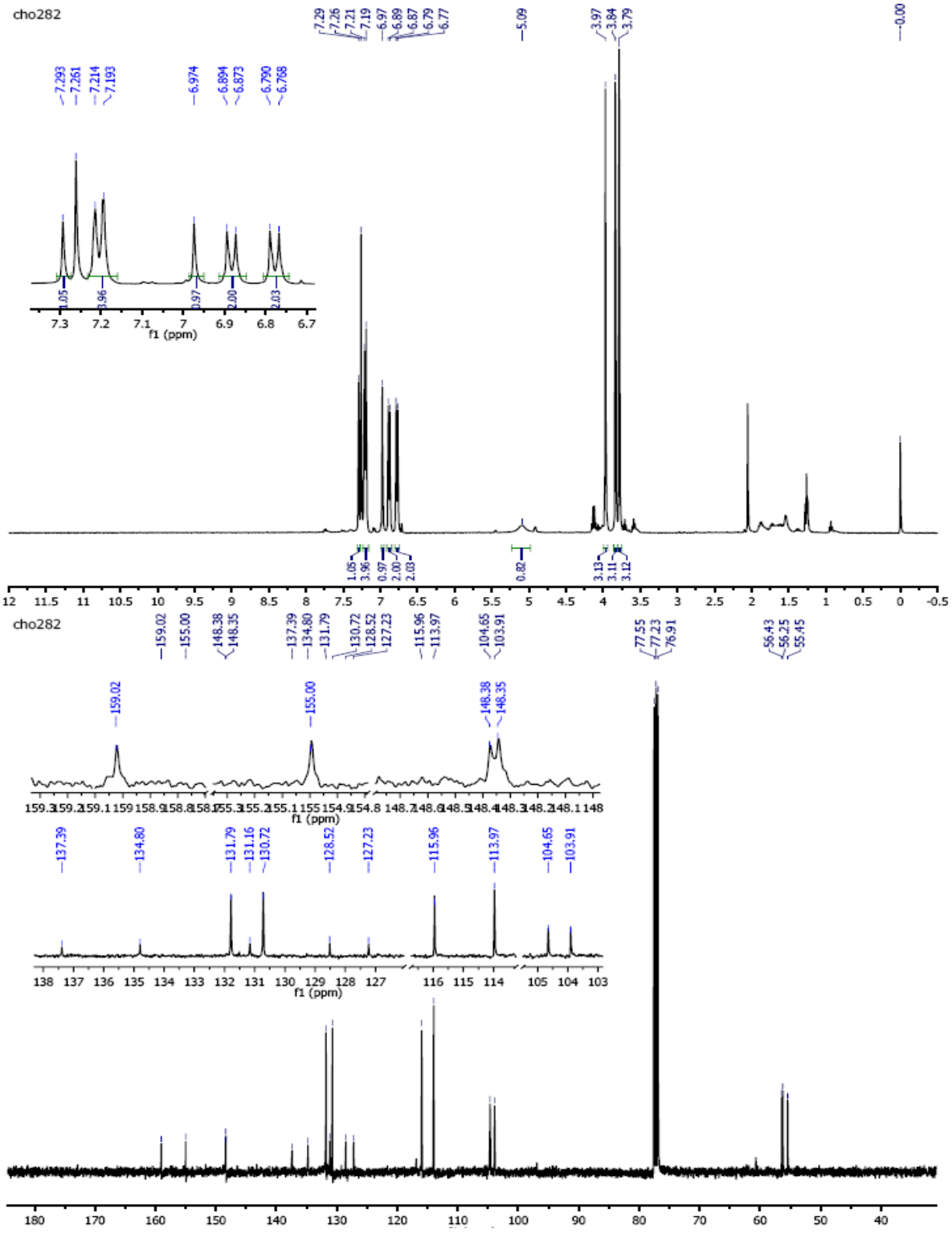
Compound 5{*10*}



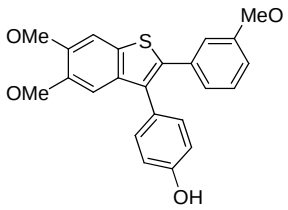


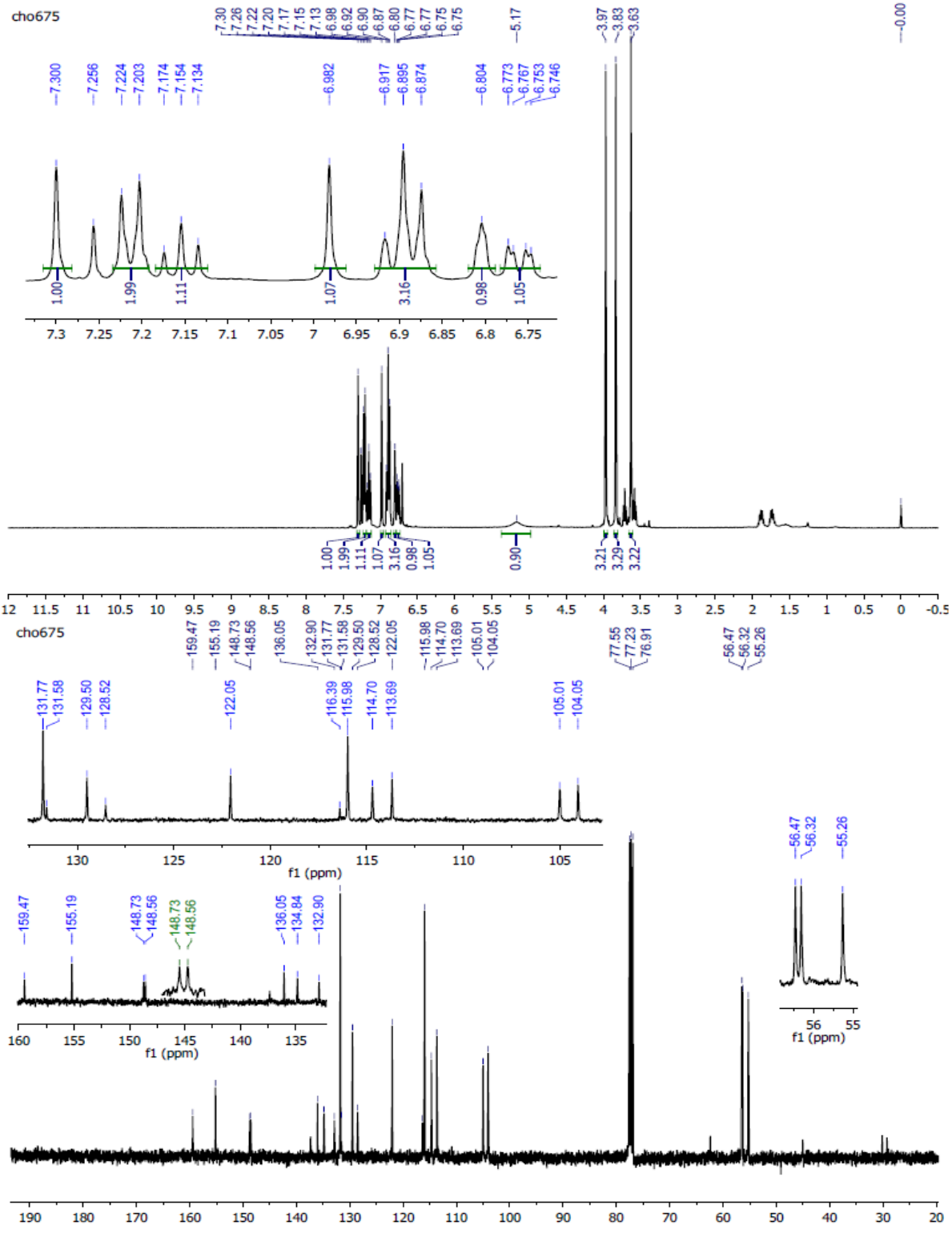
Compound 5{*11*}



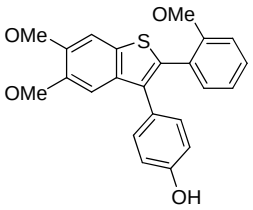


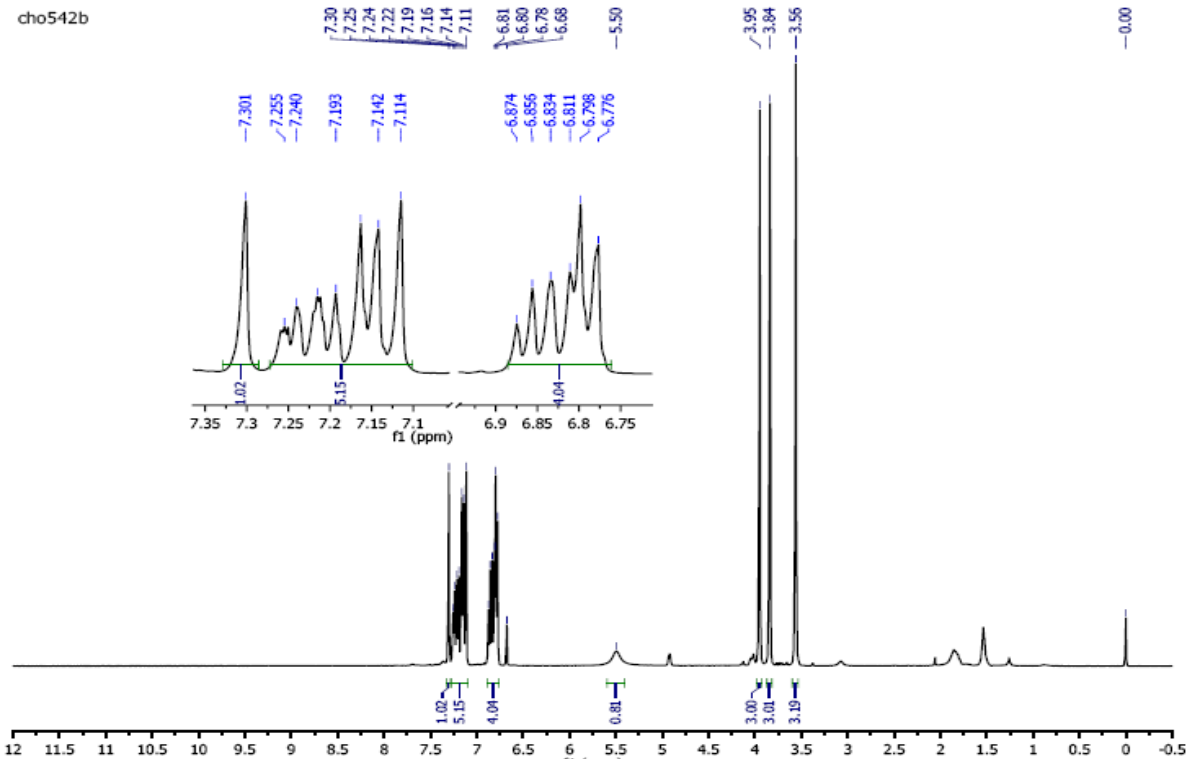
Compound 5{*12*}

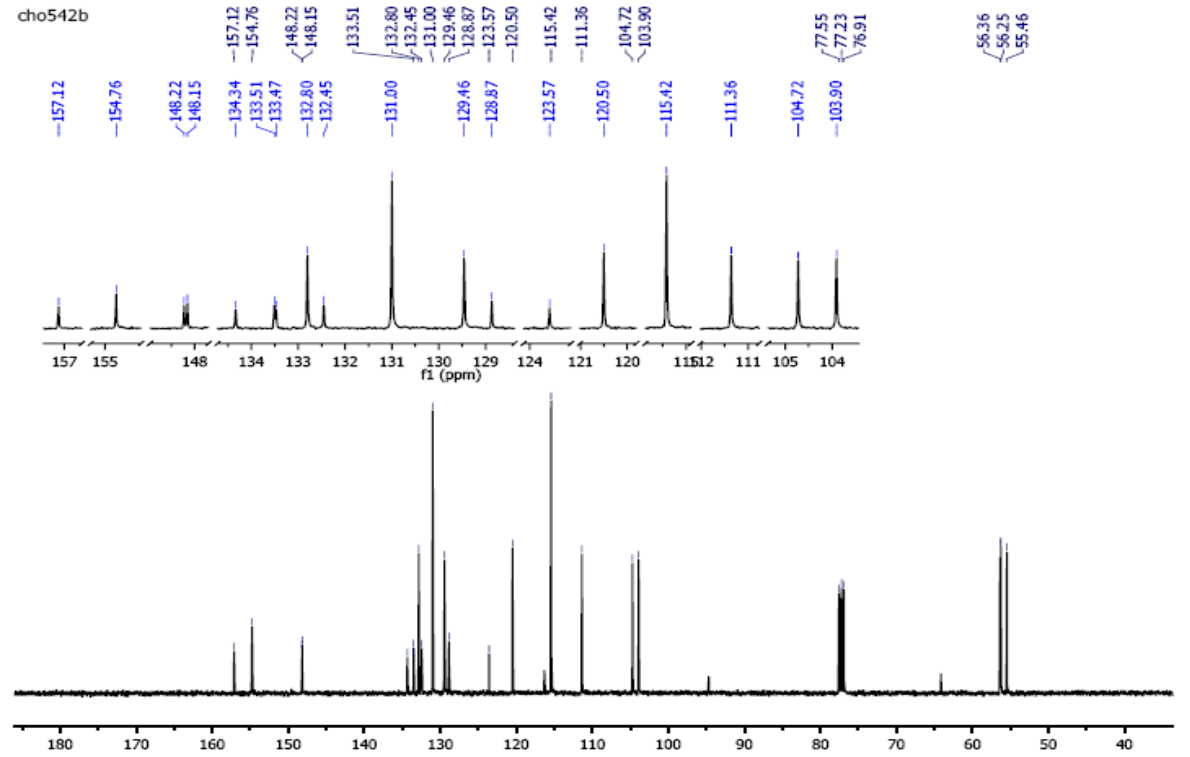




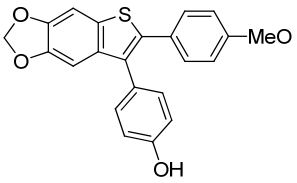
Compound 5{*13*}

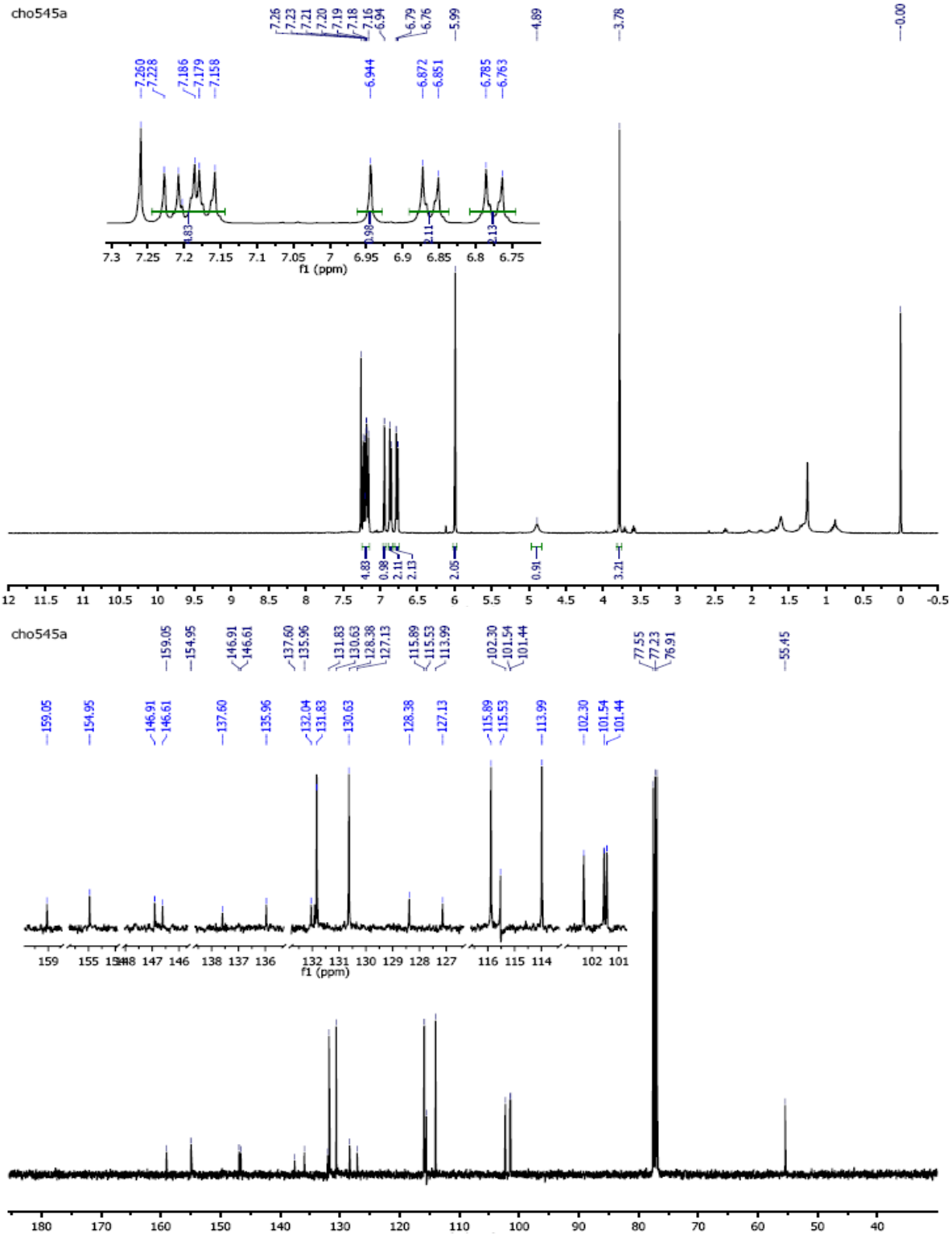




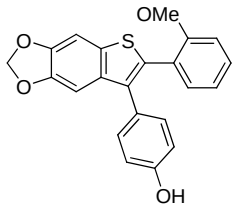


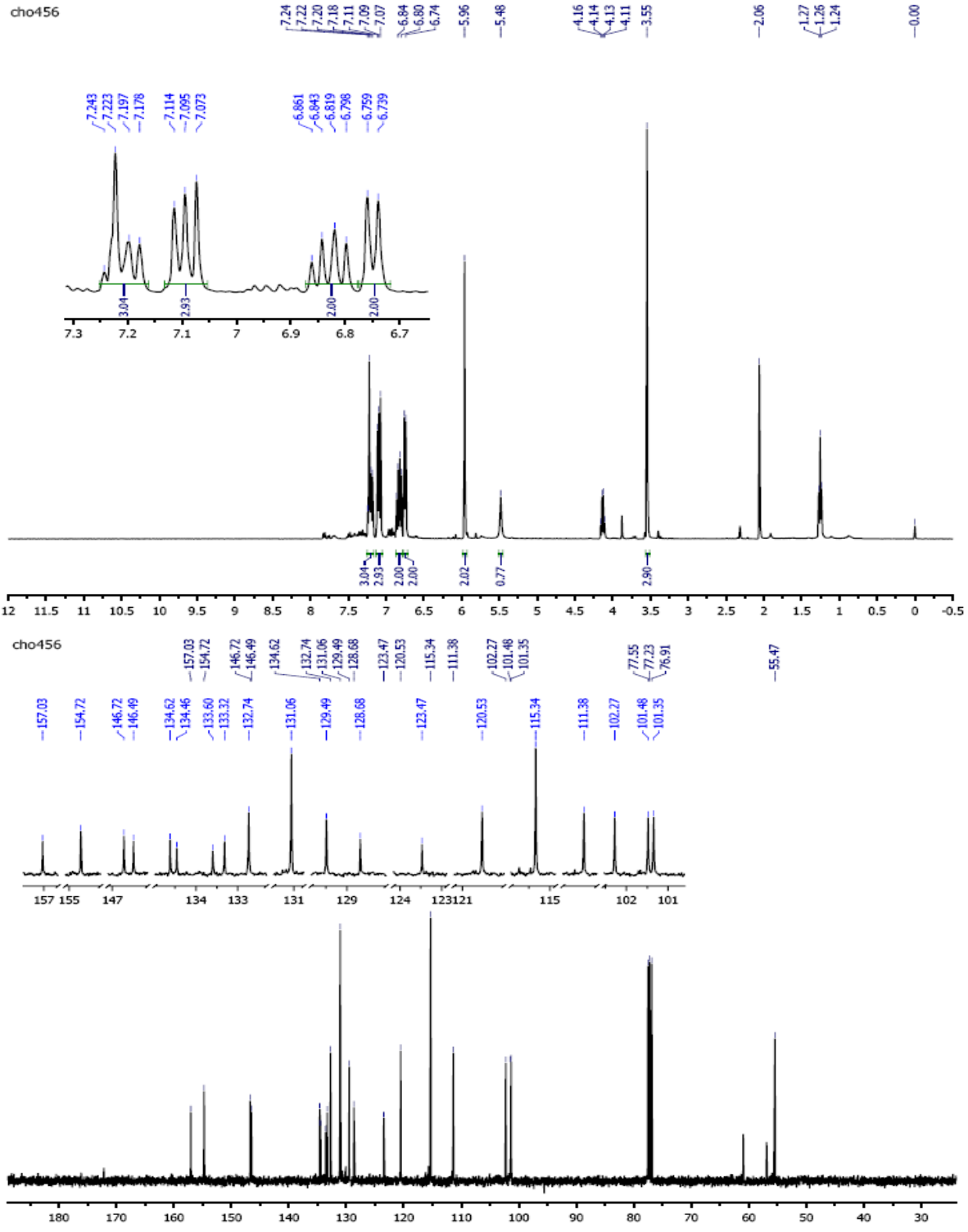
Compound 5{*14*}



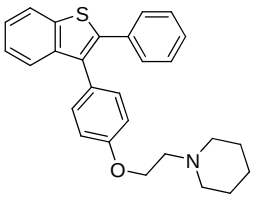


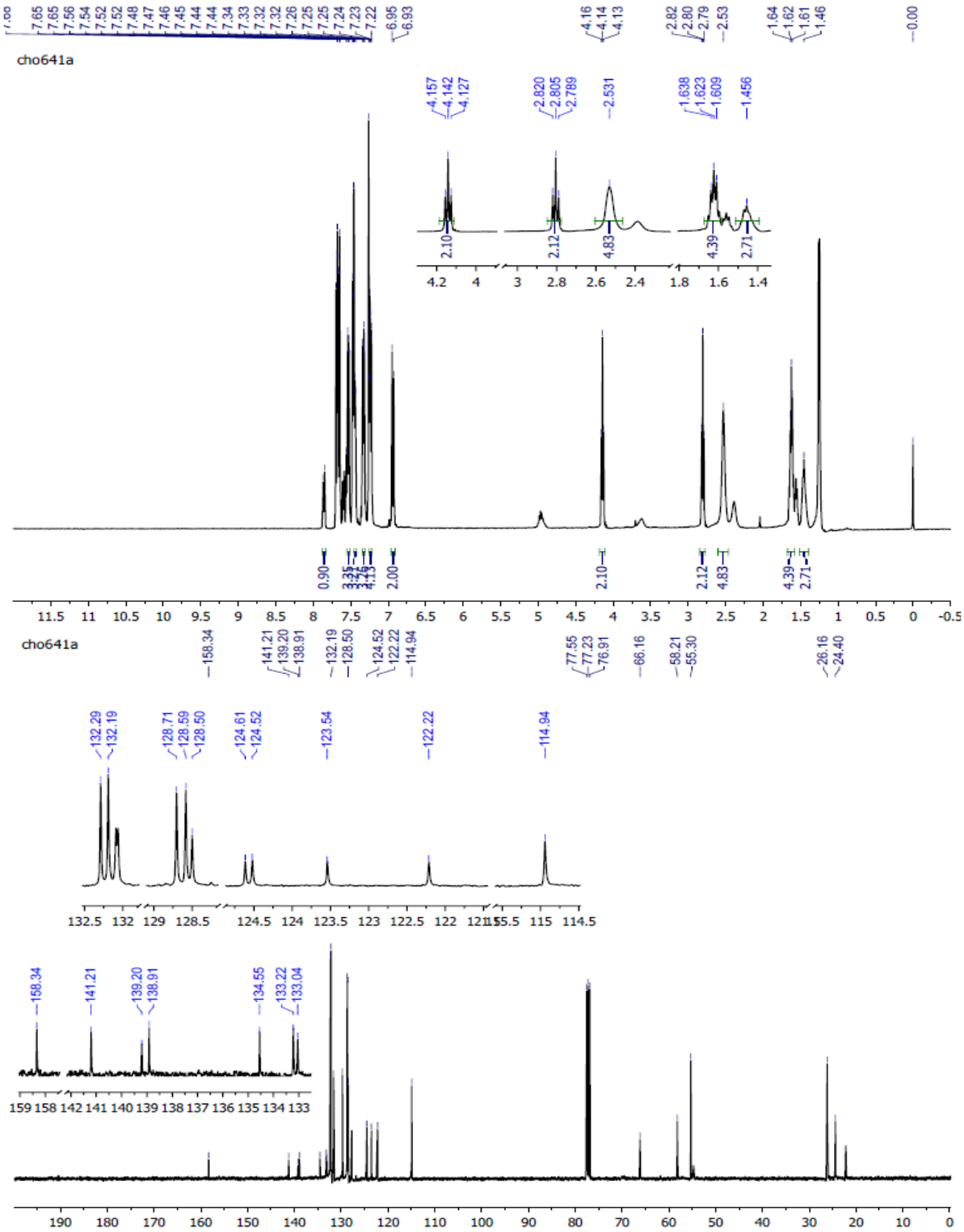
Compound 5{*15*}



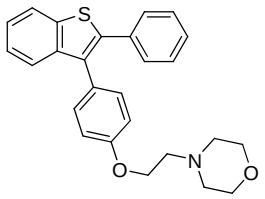


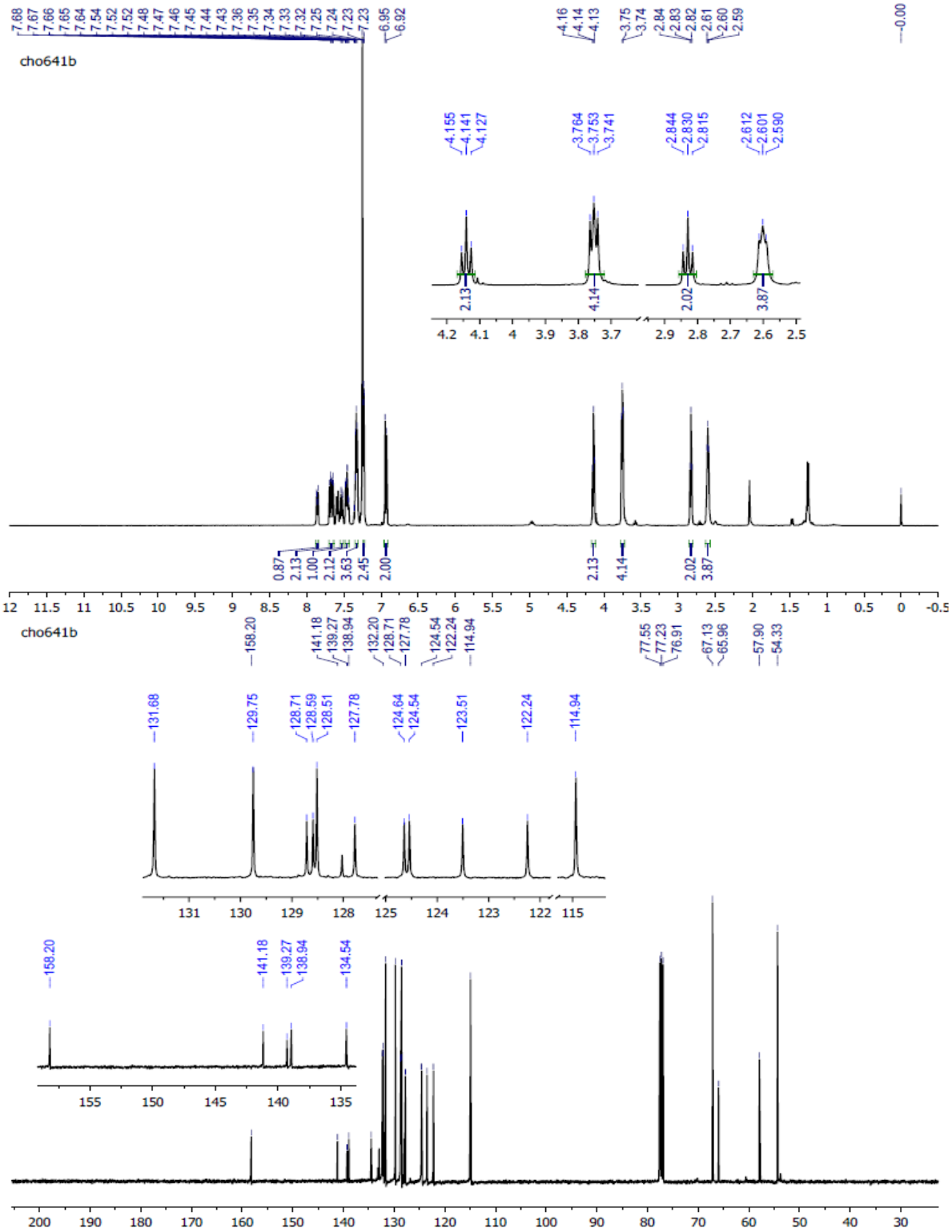
Compound 6{*1*}



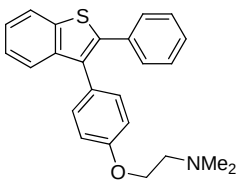


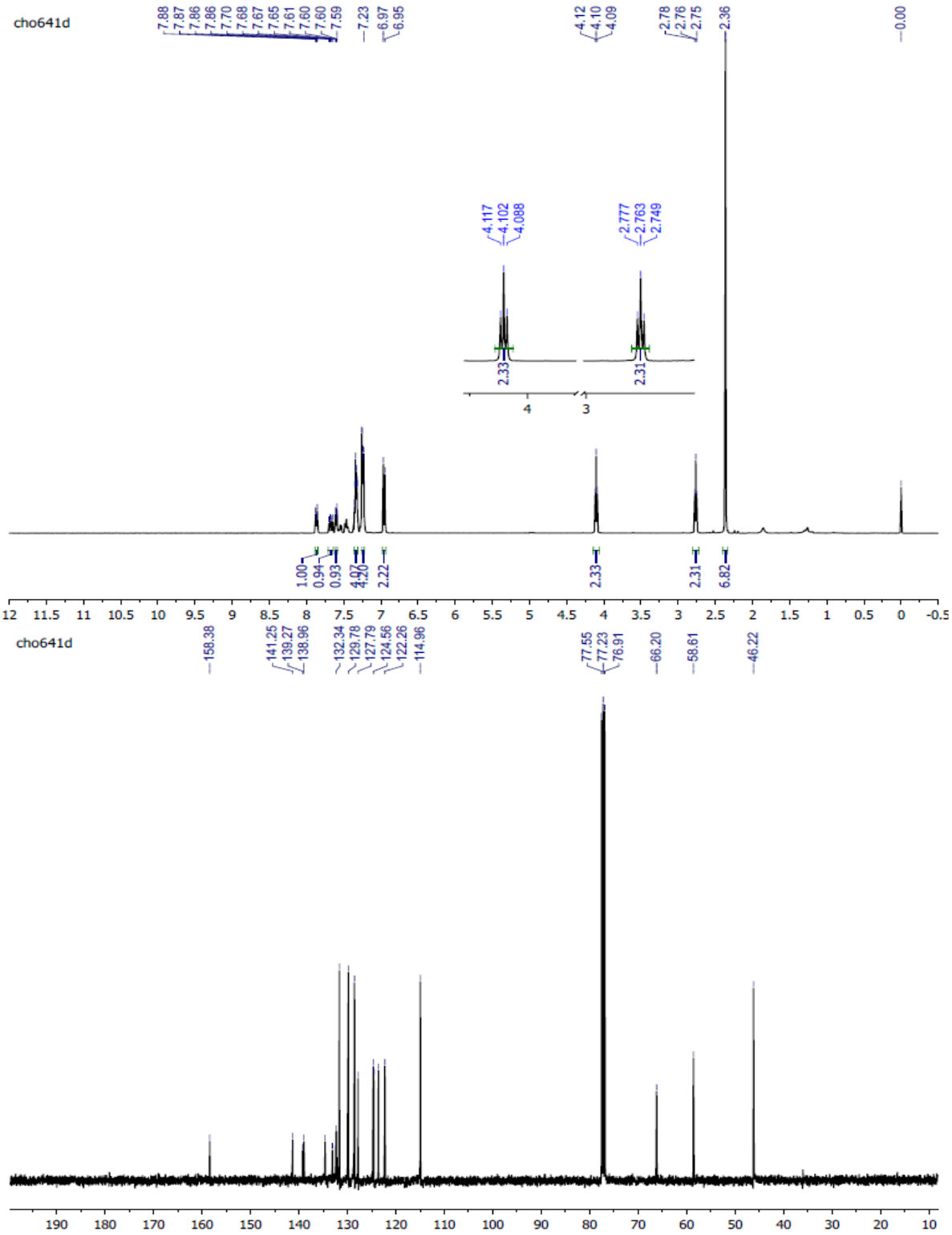
Compound 6{*2*}



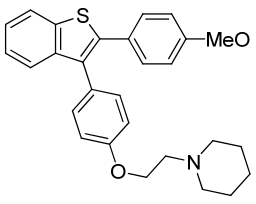


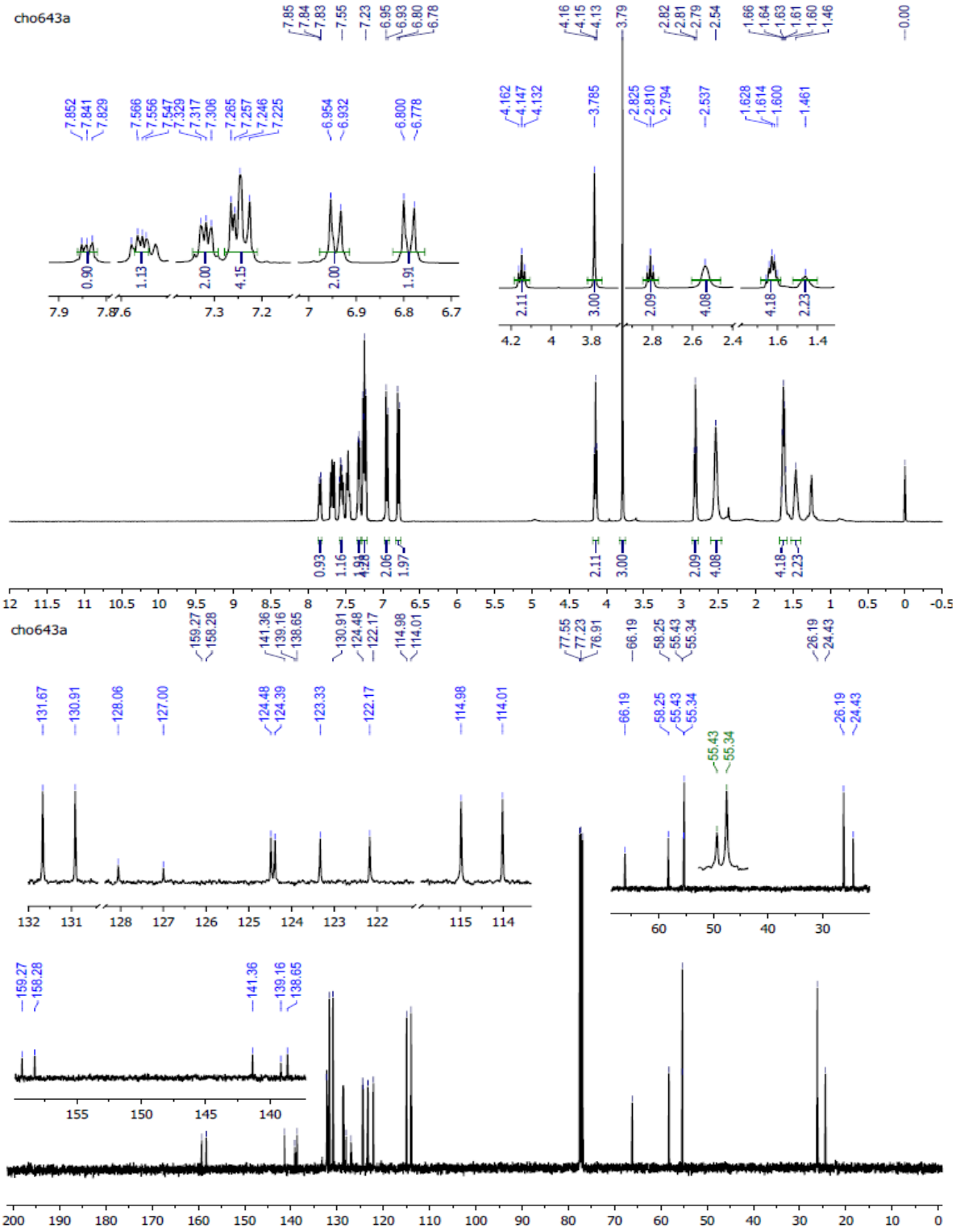
Compound 6{*4*}


S
O
NMe2

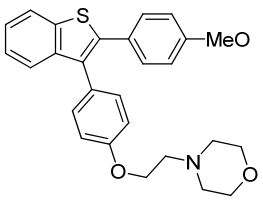

cho641d
7.88
7.87
7.86
7.86
7.70
7.68
7.67
7.65
7.61
7.60
7.60
7.59
7.23
6.97
6.95
4.12
4.10
4.09
2.78
2.76
2.75
2.36
0.00
4.117
4.102
4.088
2.777
2.763
2.749
2.33
2.31
1.00
0.94
0.93
4.07
4.20
2.22
2.33
2.31
6.82
cho641d
158.38
141.25
139.27
138.96
132.34
129.78
127.79
124.56
122.26
114.96
77.55
77.23
76.91
66.20
58.61
46.22

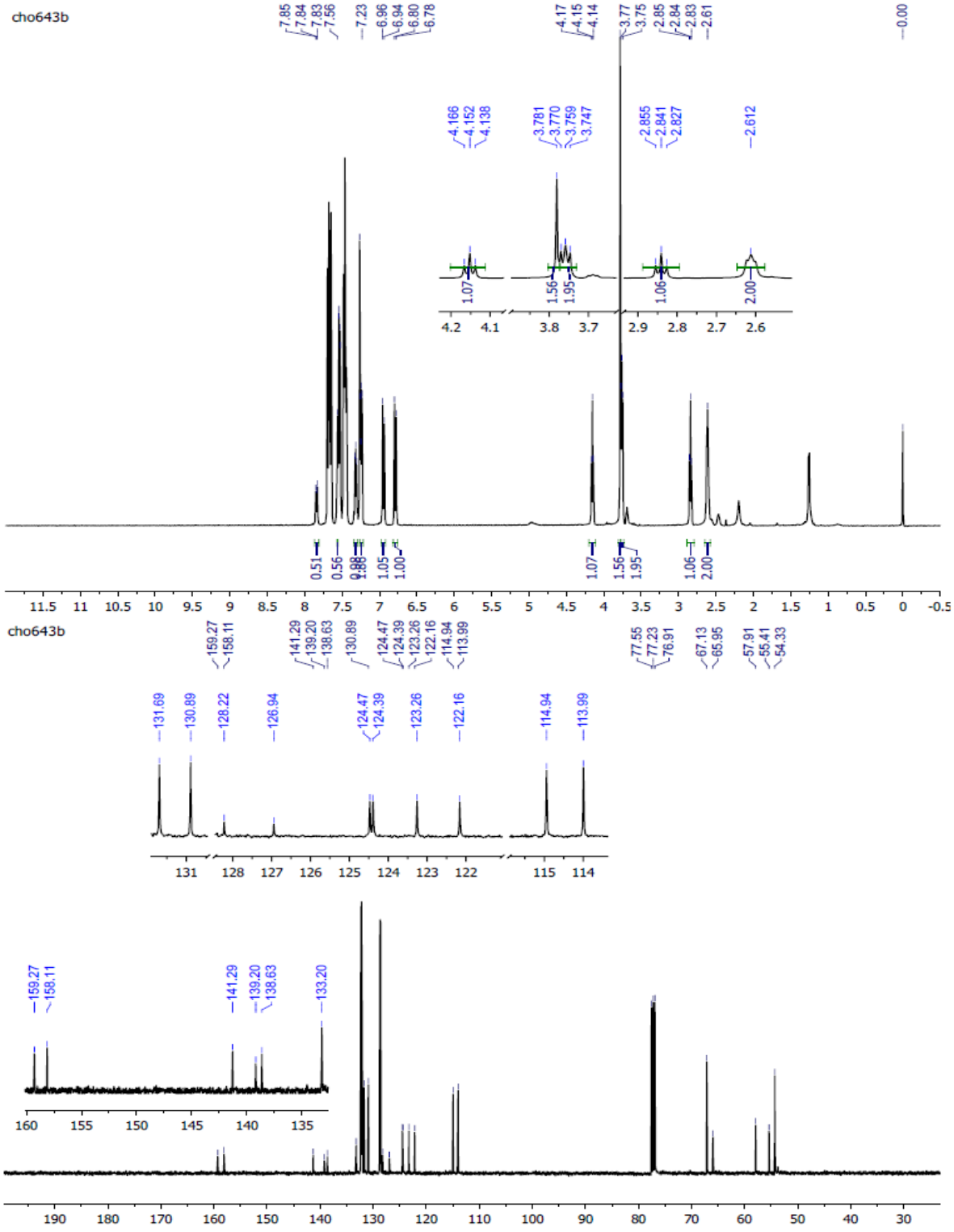
Compound 6{*5*}



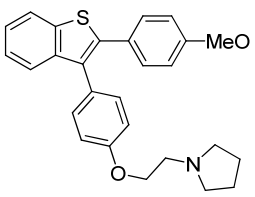


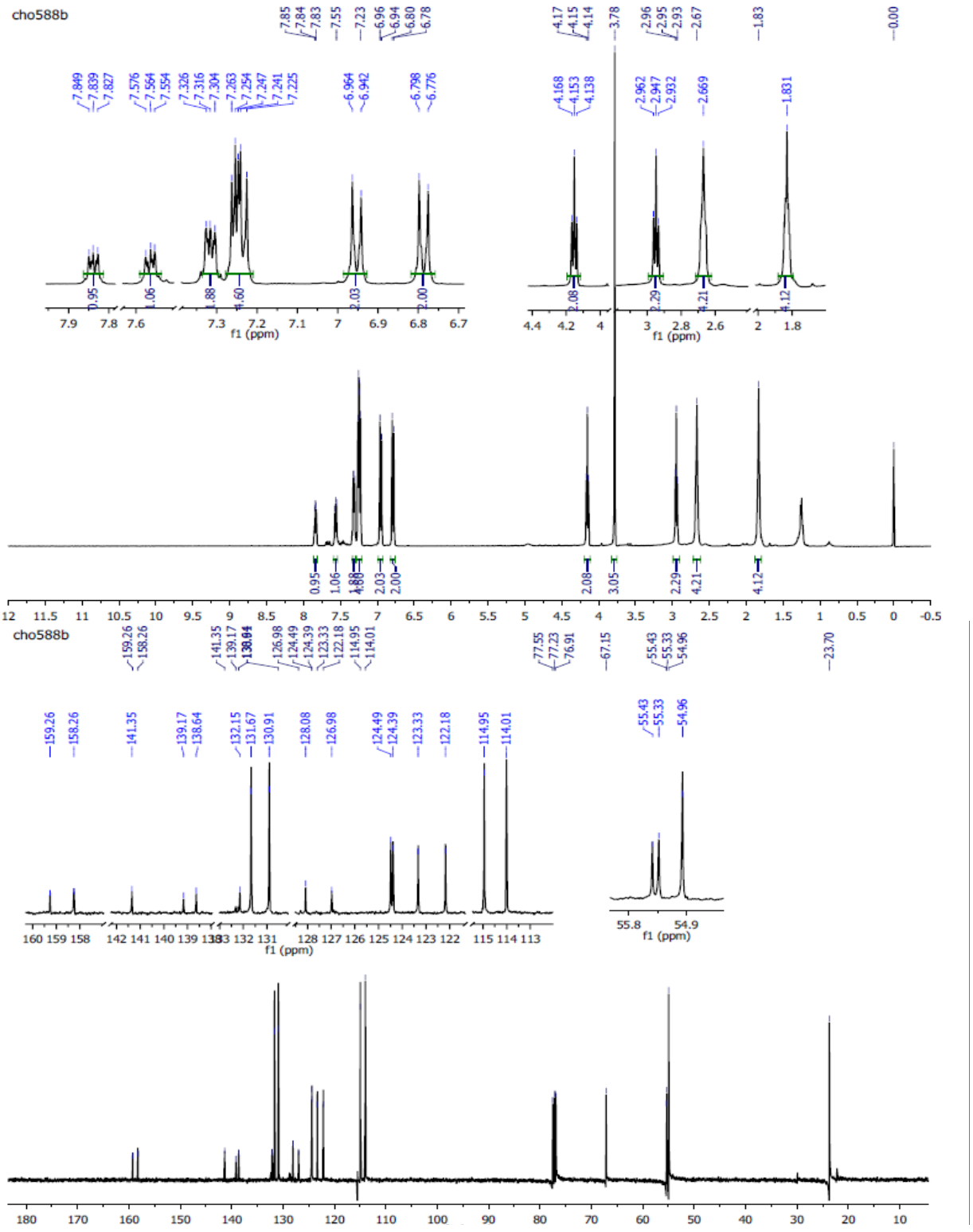
Compound 6{*6*}


S
MeO
O
N
O

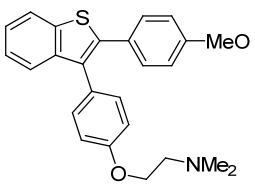

cho643b
7.85
7.84
7.83
7.56
7.23
6.96
6.94
6.80
6.78
4.17
4.15
4.14
3.77
3.75
2.85
2.84
2.83
2.61
0.00
4.166
4.152
4.138
3.781
3.770
3.759
3.747
2.855
2.841
2.827
2.612
1.07
1.56
1.95
1.06
2.00
0.51
0.56
1.05
1.00
cho643b
159.27
158.11
141.29
139.20
138.63
130.89
124.47
124.39
123.26
122.16
114.94
113.99
77.55
77.23
76.91
67.13
65.95
57.91
55.41
54.33
131.69
130.89
128.22
126.94
124.47
124.39
123.26
122.16
114.94
113.99
159.27
158.11
141.29
139.20
138.63
133.20

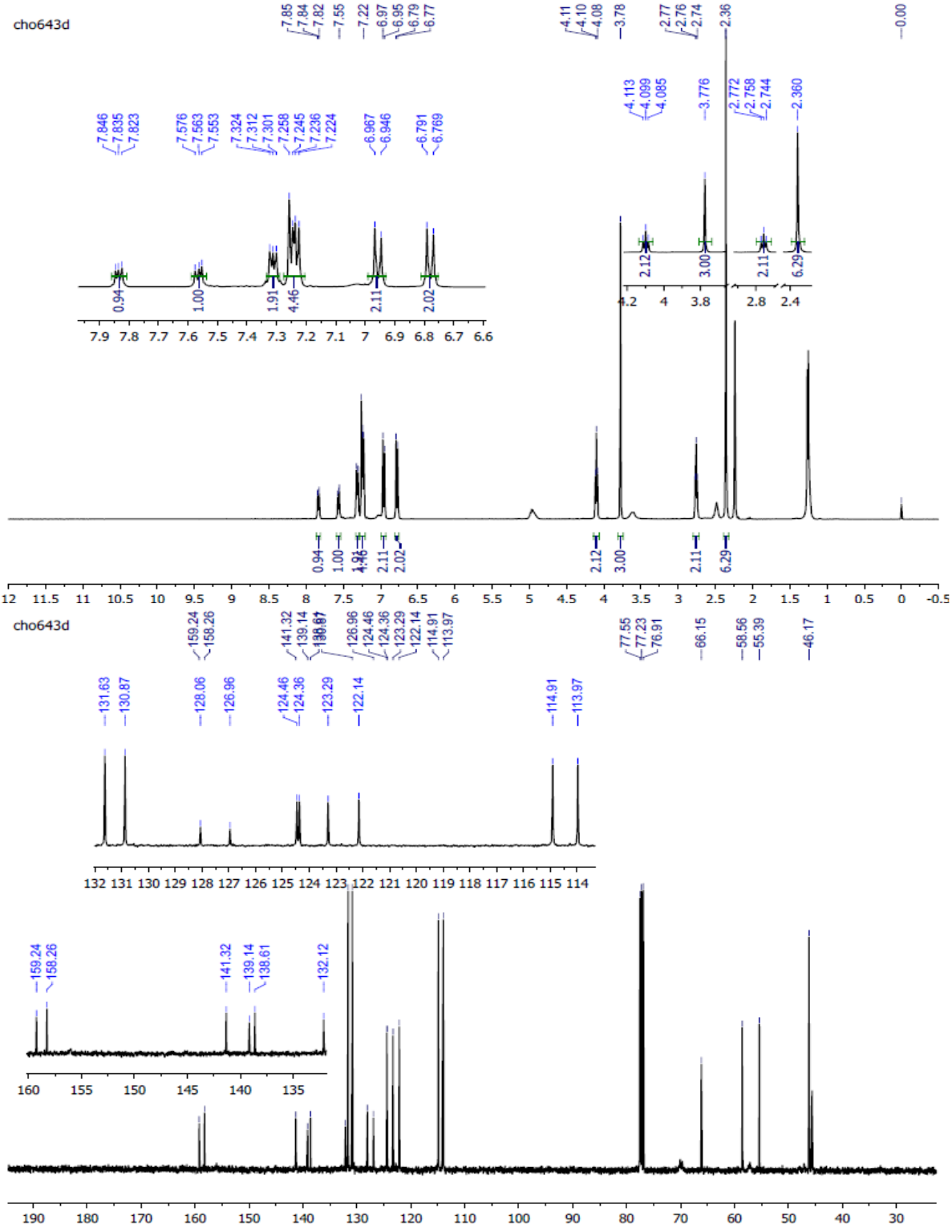
Compound 6{*7*}



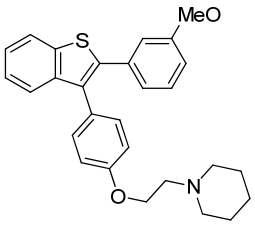


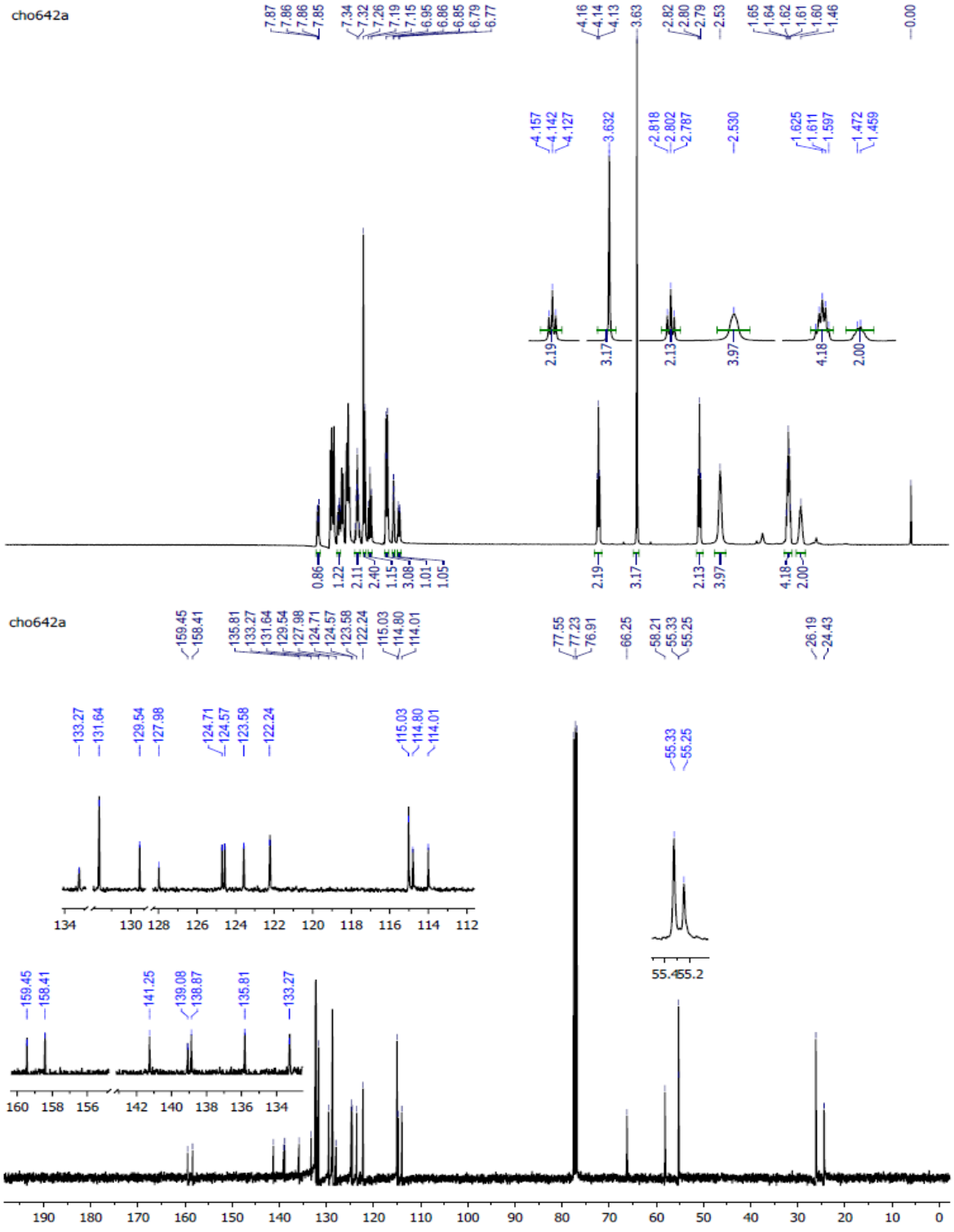
Compound 6{*8*}


S
MeO
O
NMe2

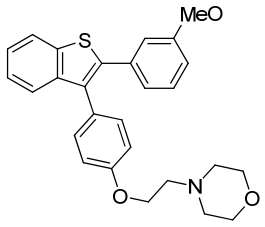

cho643d
7.85
7.84
7.82
7.55
7.22
6.97
6.95
6.79
6.77
4.11
4.10
4.08
3.78
2.77
2.76
2.74
2.36
0.00
7.846
7.835
7.823
7.576
7.563
7.553
7.324
7.312
7.301
7.258
7.245
7.236
7.224
6.967
6.946
6.791
6.769
4.113
4.099
4.085
3.776
2.772
2.758
2.744
2.360
0.94
1.00
1.91
4.46
2.11
2.02
2.12
3.00
2.11
6.29
12 11.5 11 10.5 10 9.5 9 8.5 8 7.5 7 6.5 6 5.5 5 4.5 4 3.5 3 2.5 2 1.5 1 0.5 0 -0.5
cho643d
159.24
158.26
141.32
139.14
138.61
126.96
124.46
124.36
123.29
122.14
114.91
113.97
77.55
77.23
76.91
66.15
58.56
55.39
46.17
131.63
130.87
128.06
126.96
124.46
124.36
123.29
122.14
114.91
113.97
132 131 130 129 128 127 126 125 124 123 122 121 120 119 118 117 116 115 114
159.24
158.26
141.32
139.14
138.61
132.12
160 155 150 145 140 135
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30

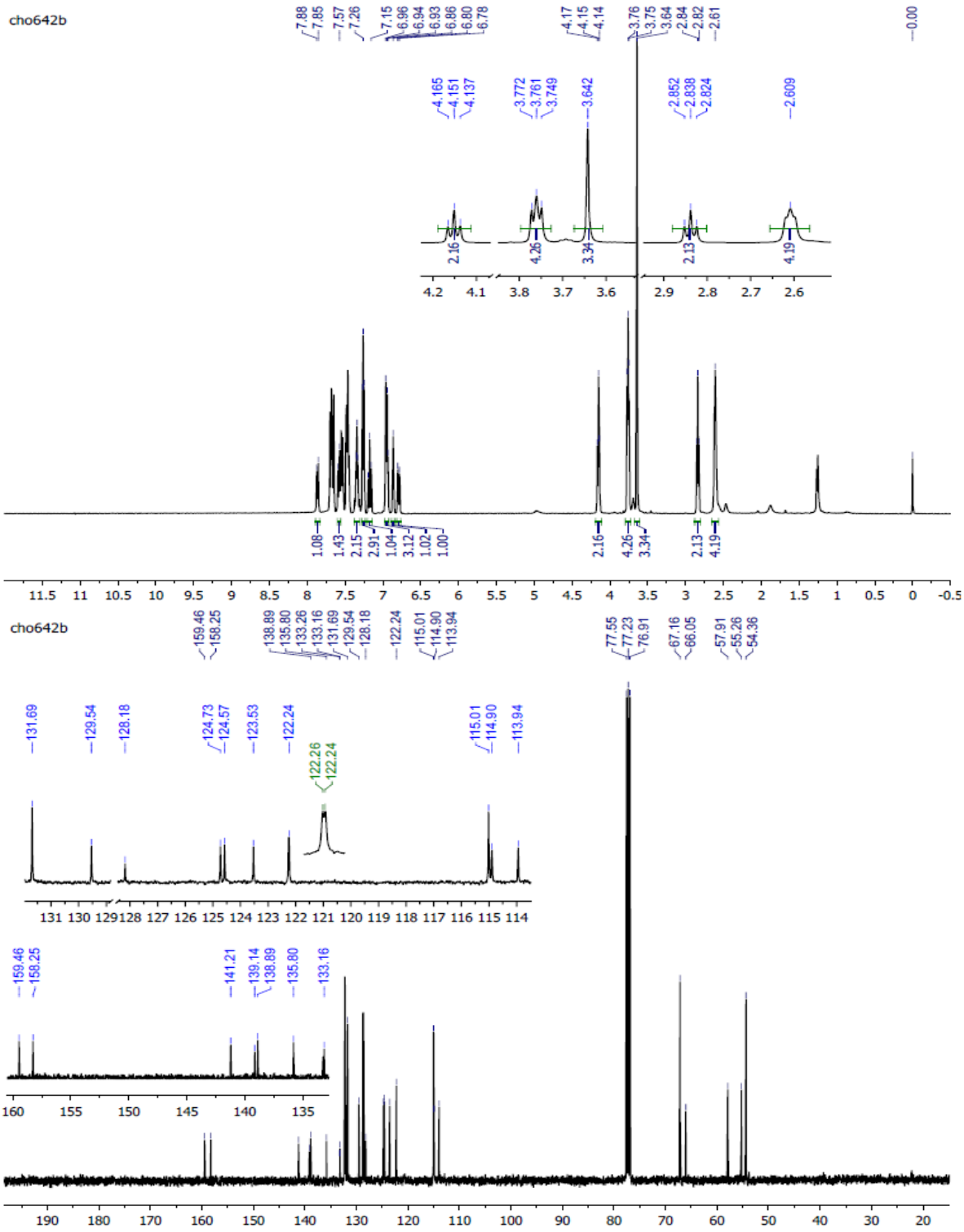
Compound 6{*9*}


MeO
S
O
N

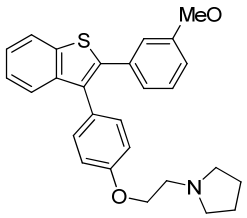

cho642a
7.87
7.86
7.86
7.85
7.34
7.32
7.26
7.19
7.15
6.95
6.86
6.85
6.79
6.77
4.16
4.14
4.13
3.63
2.82
2.80
2.79
2.53
1.65
1.64
1.62
1.61
1.60
1.46
0.00
4.157
4.142
4.127
3.632
2.818
2.802
2.787
2.530
1.625
1.611
1.597
1.472
1.459
2.19
3.17
2.13
3.97
4.18
2.00
0.86
1.22
2.11
2.40
1.15
3.08
1.01
1.05
cho642a
159.45
158.41
135.81
133.27
131.64
129.54
127.98
124.71
124.57
123.58
122.24
115.03
114.80
114.01
77.55
77.23
76.91
66.25
58.21
55.33
55.25
26.19
24.43
55.455.2
160
158
156
142
140
138
136
134
130
128
126
124
122
120
118
116
114
112
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

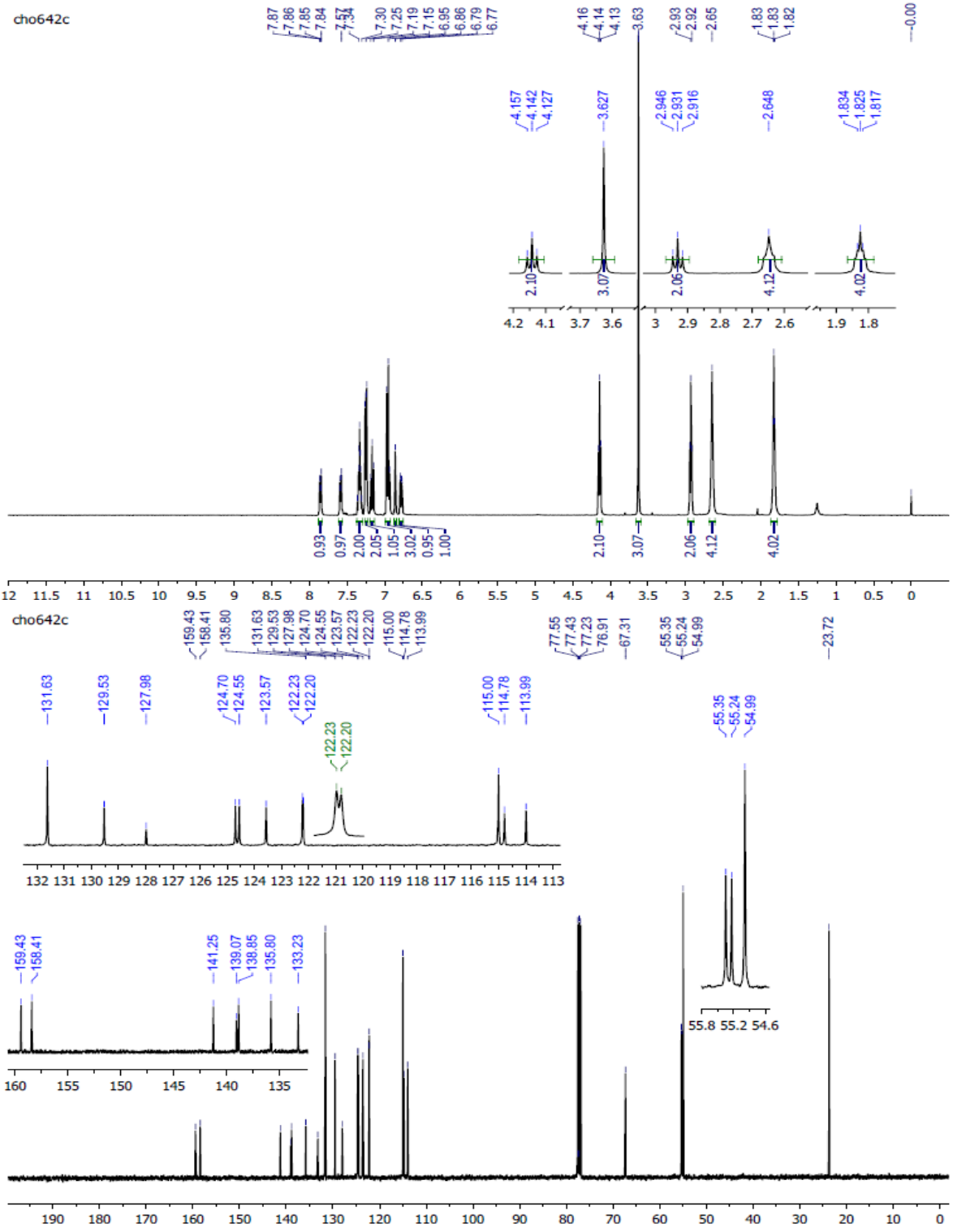
Compound 6{*10*}



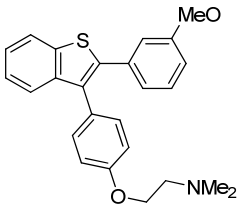


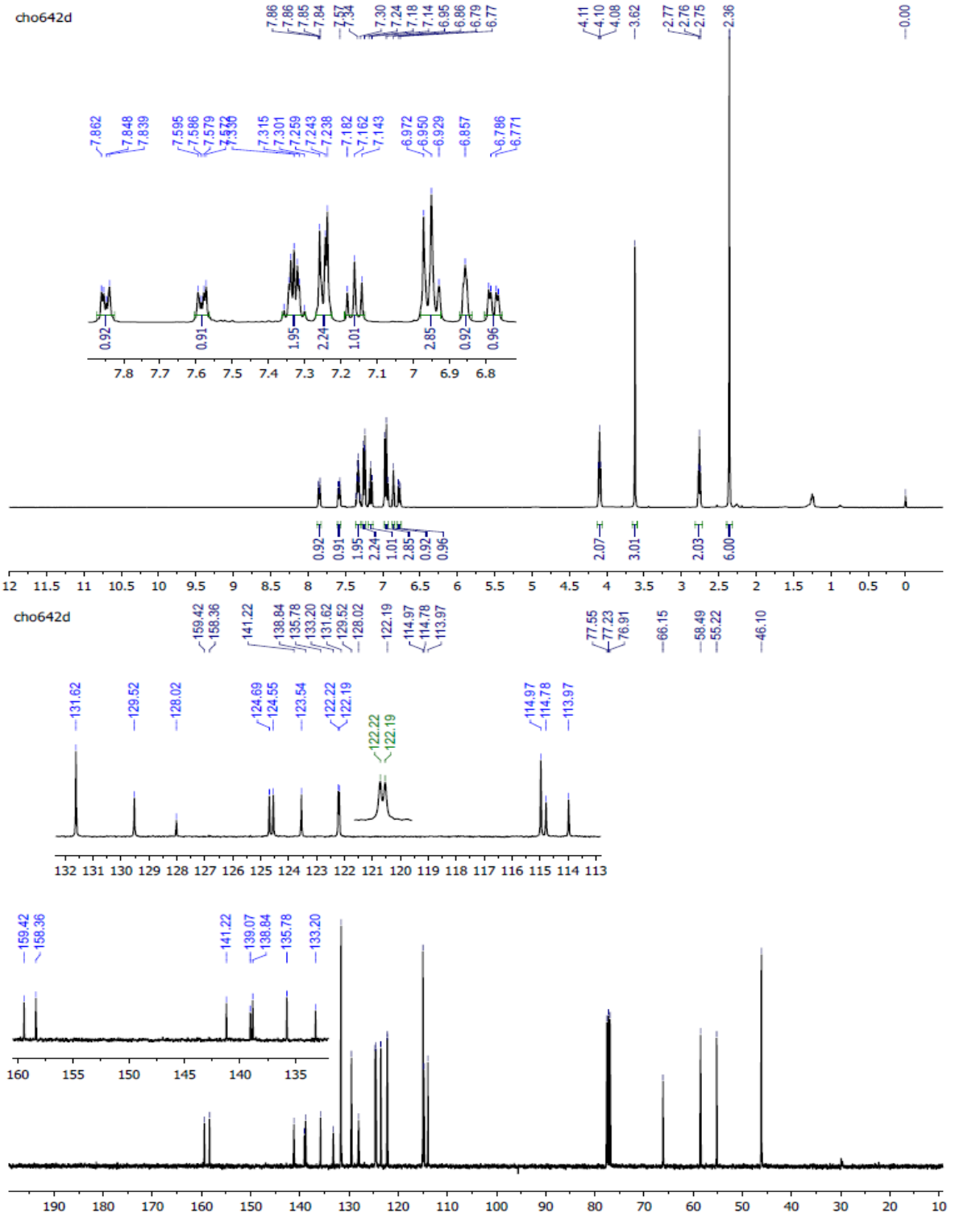
Compound 6{*11*}



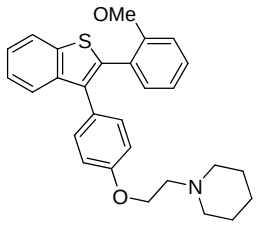


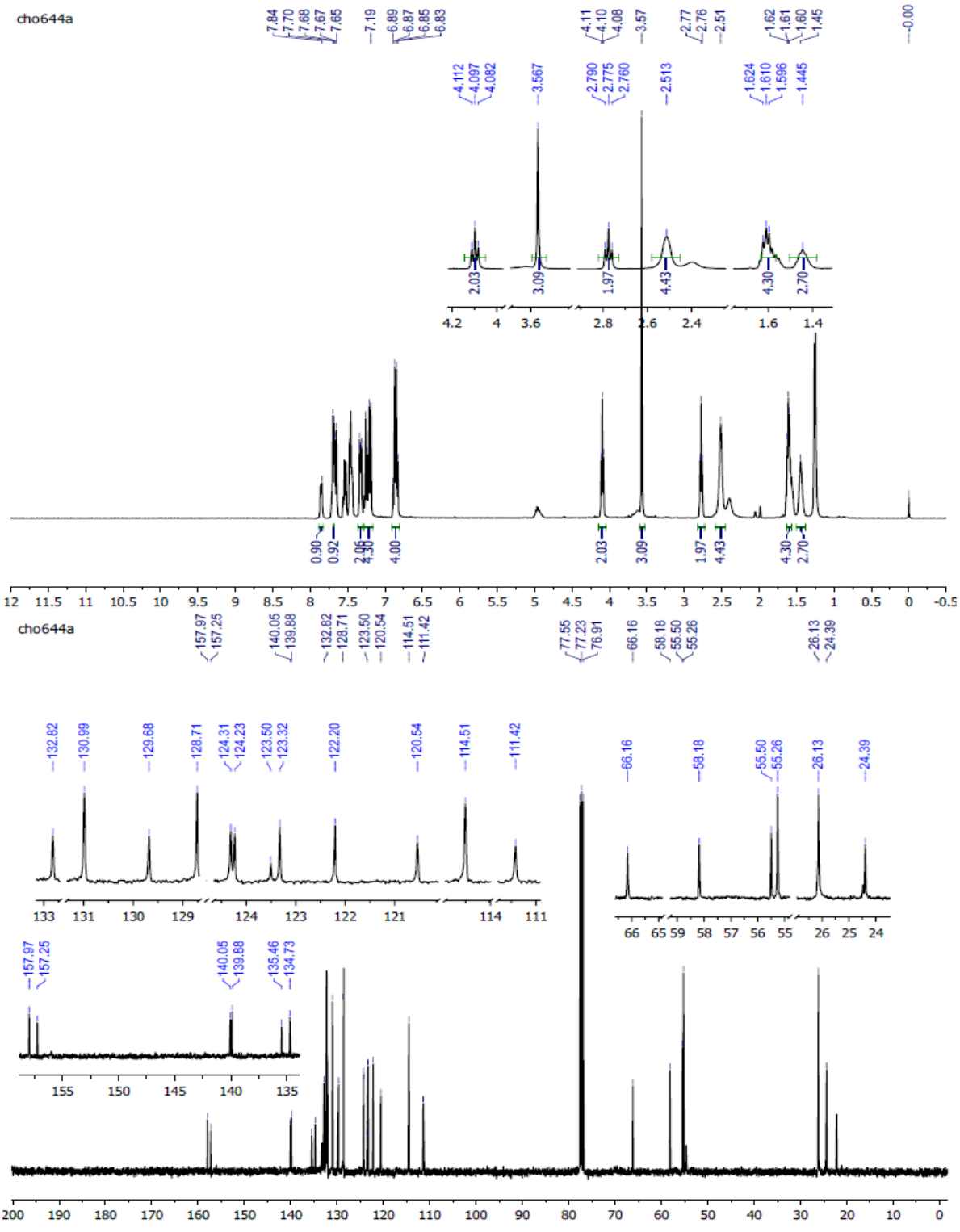
Compound 6{*12*}



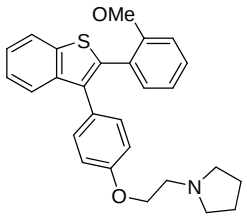


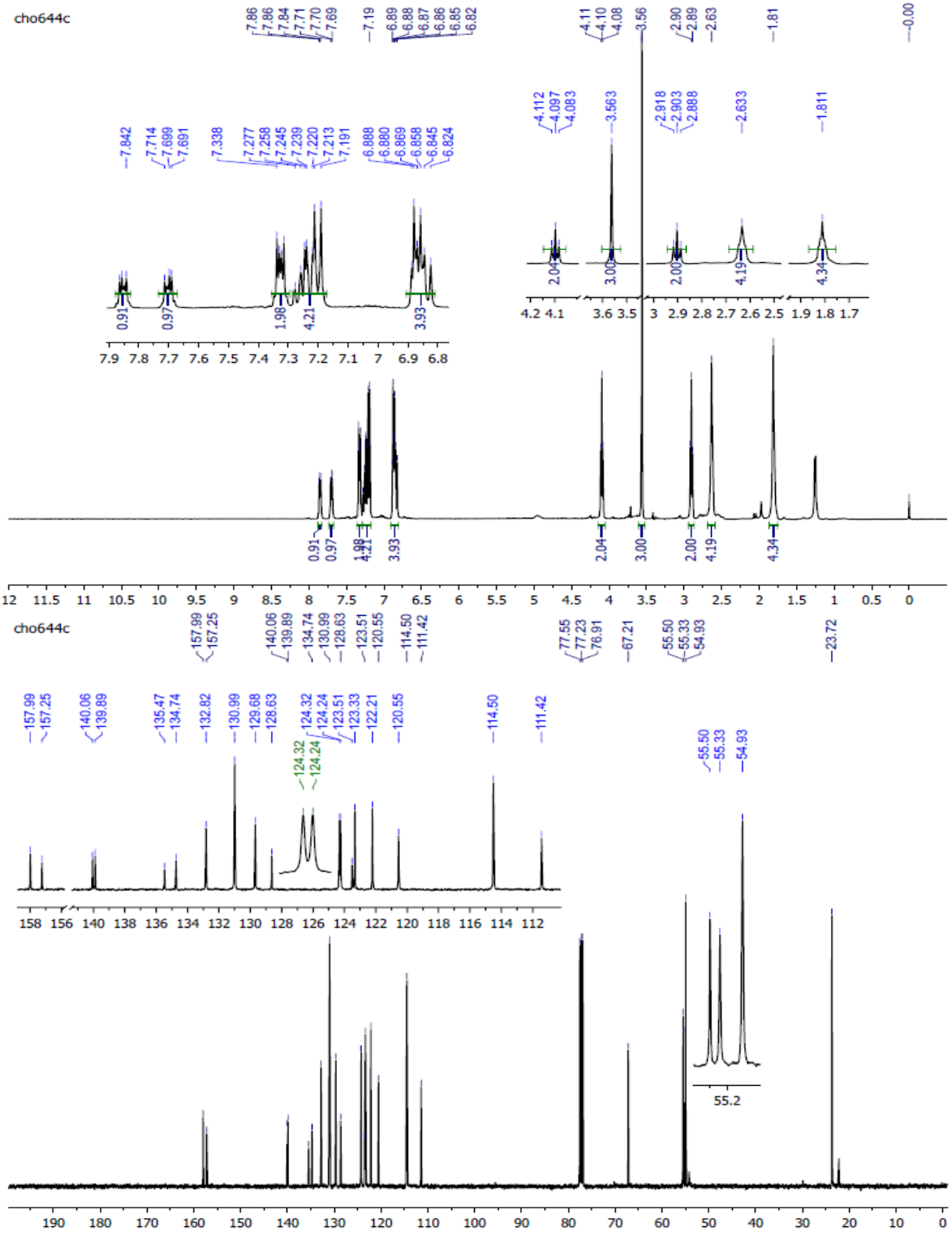
Compound 6{*13*}



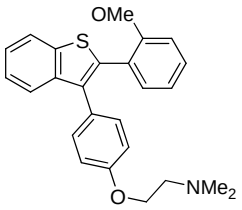


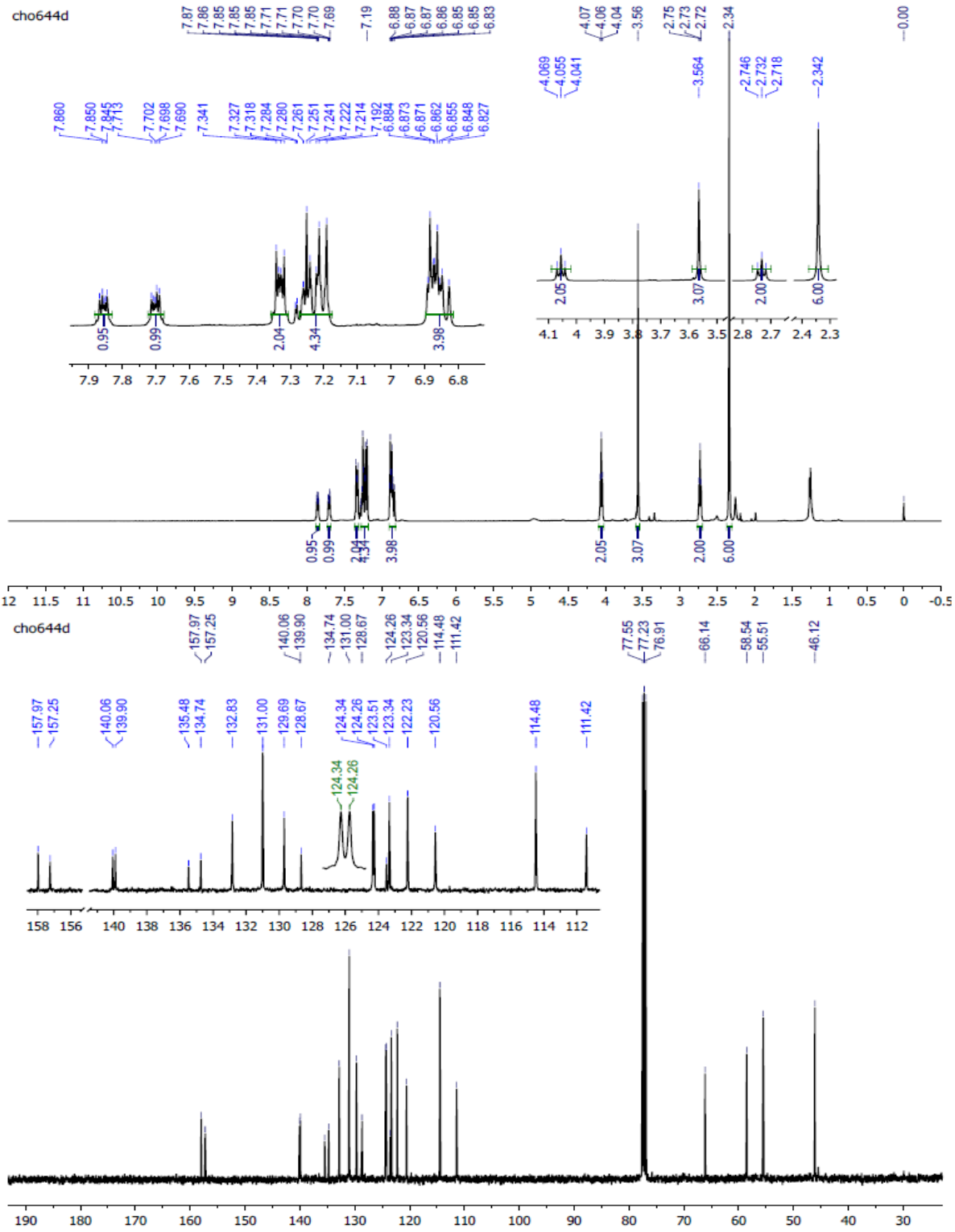
Compound 6{*15*}



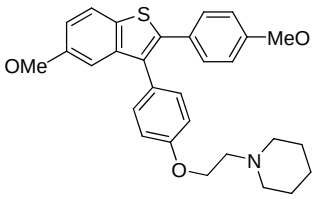


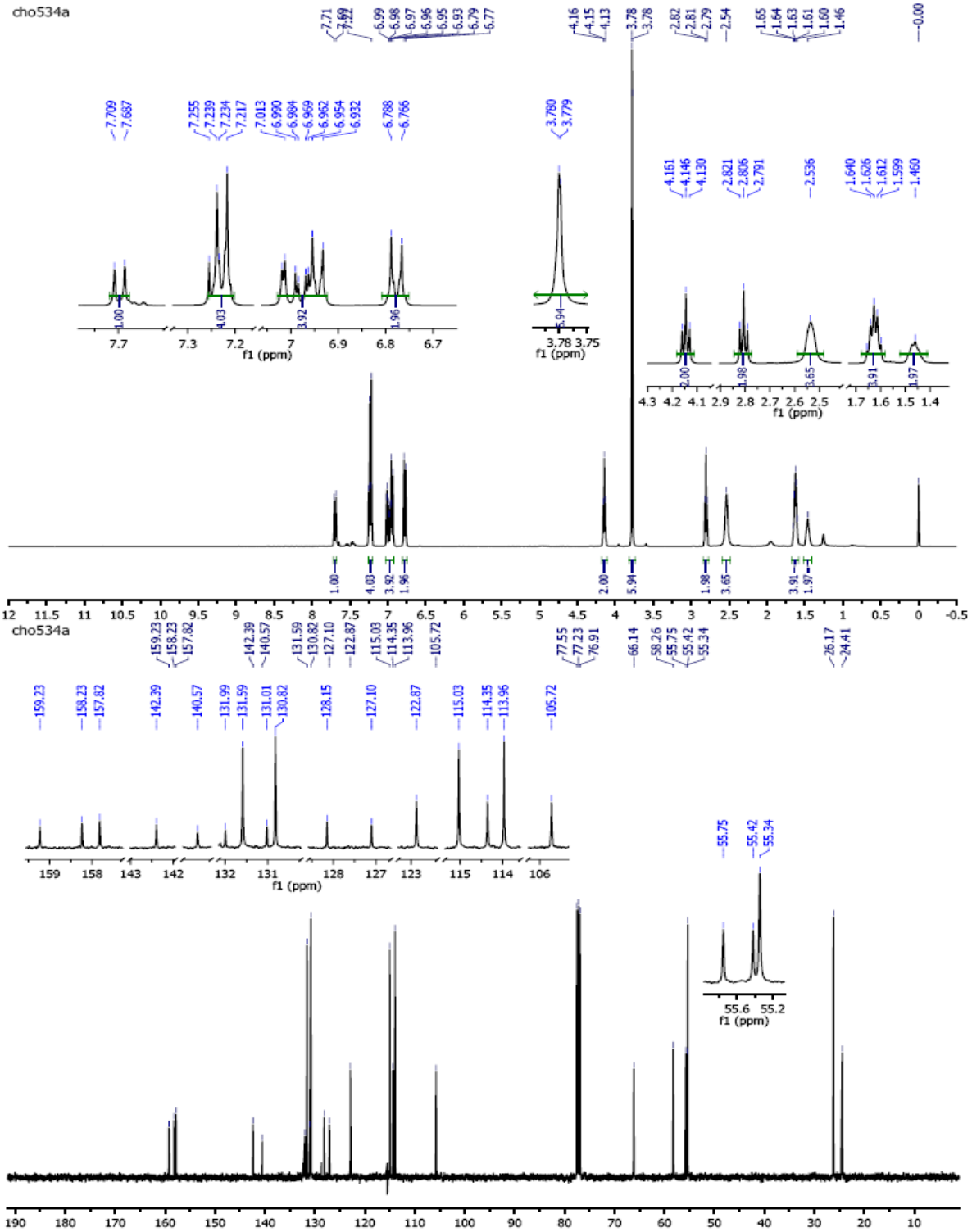
Compound 6{*16*}



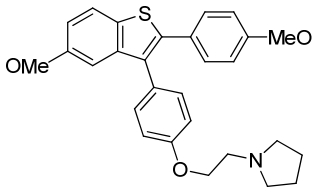


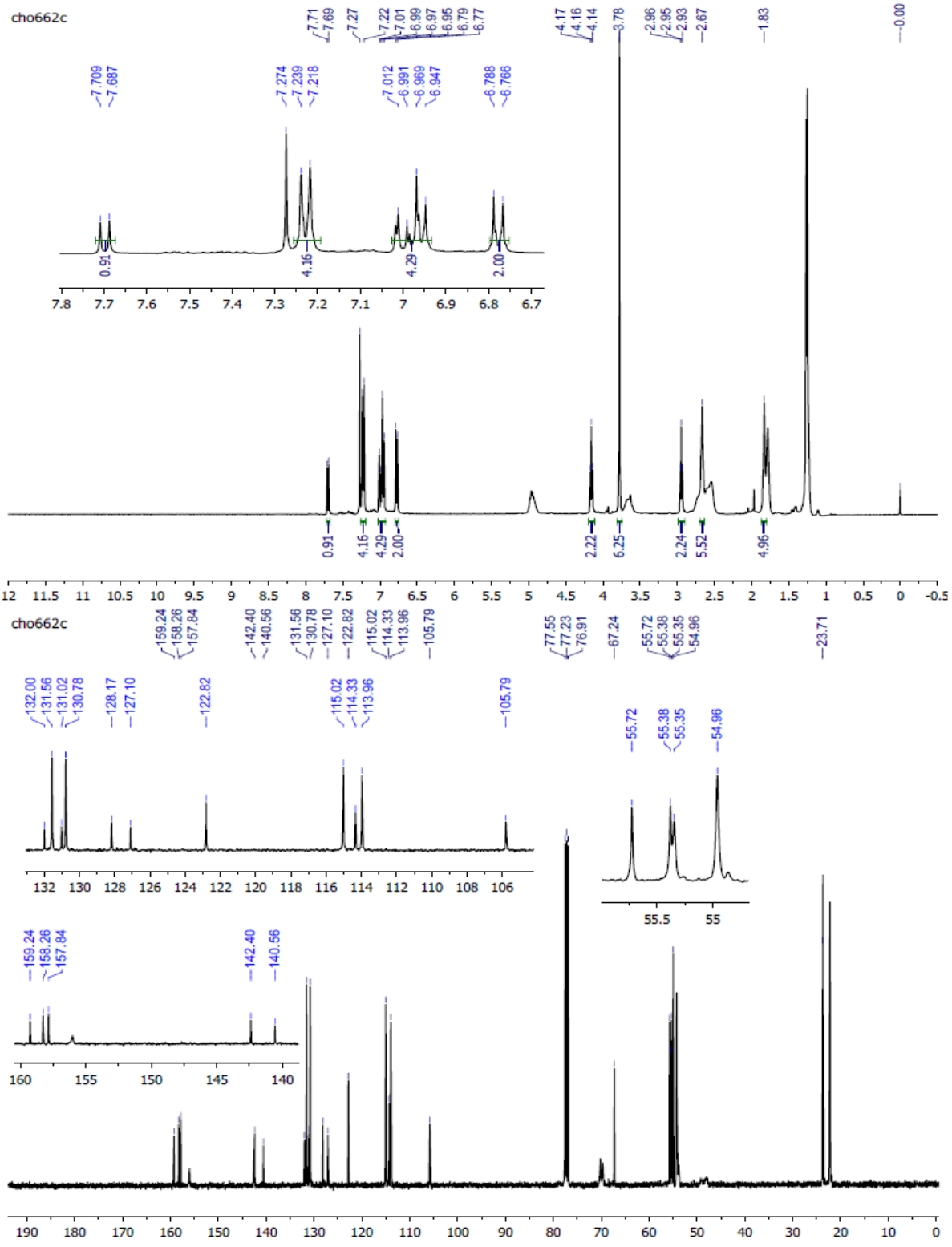
Compound 6{*17*}



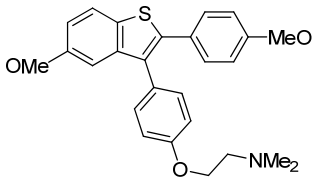


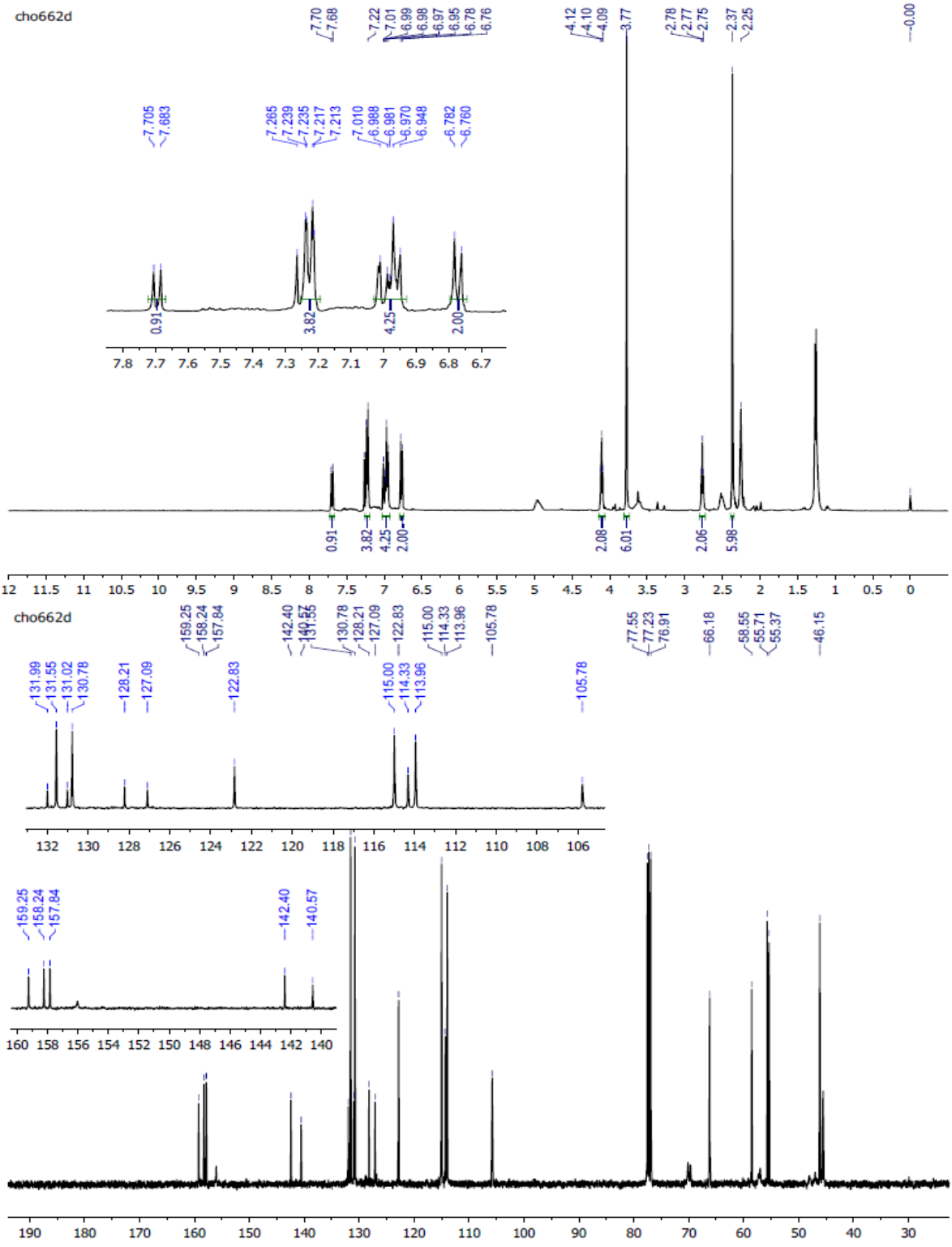
Compound 6{*19*}



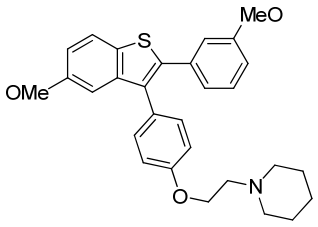


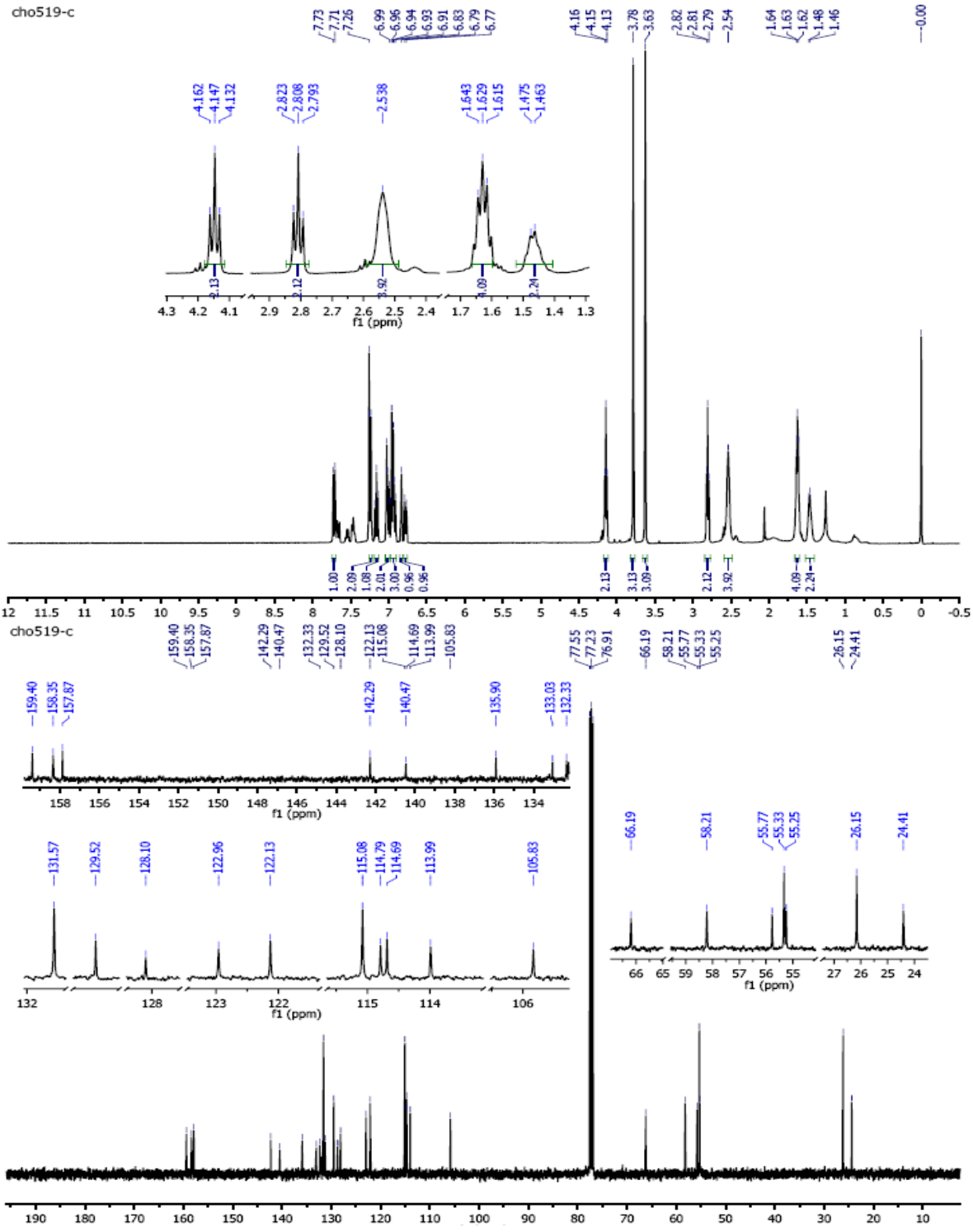
Compound 6{*20*}



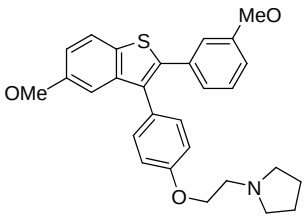


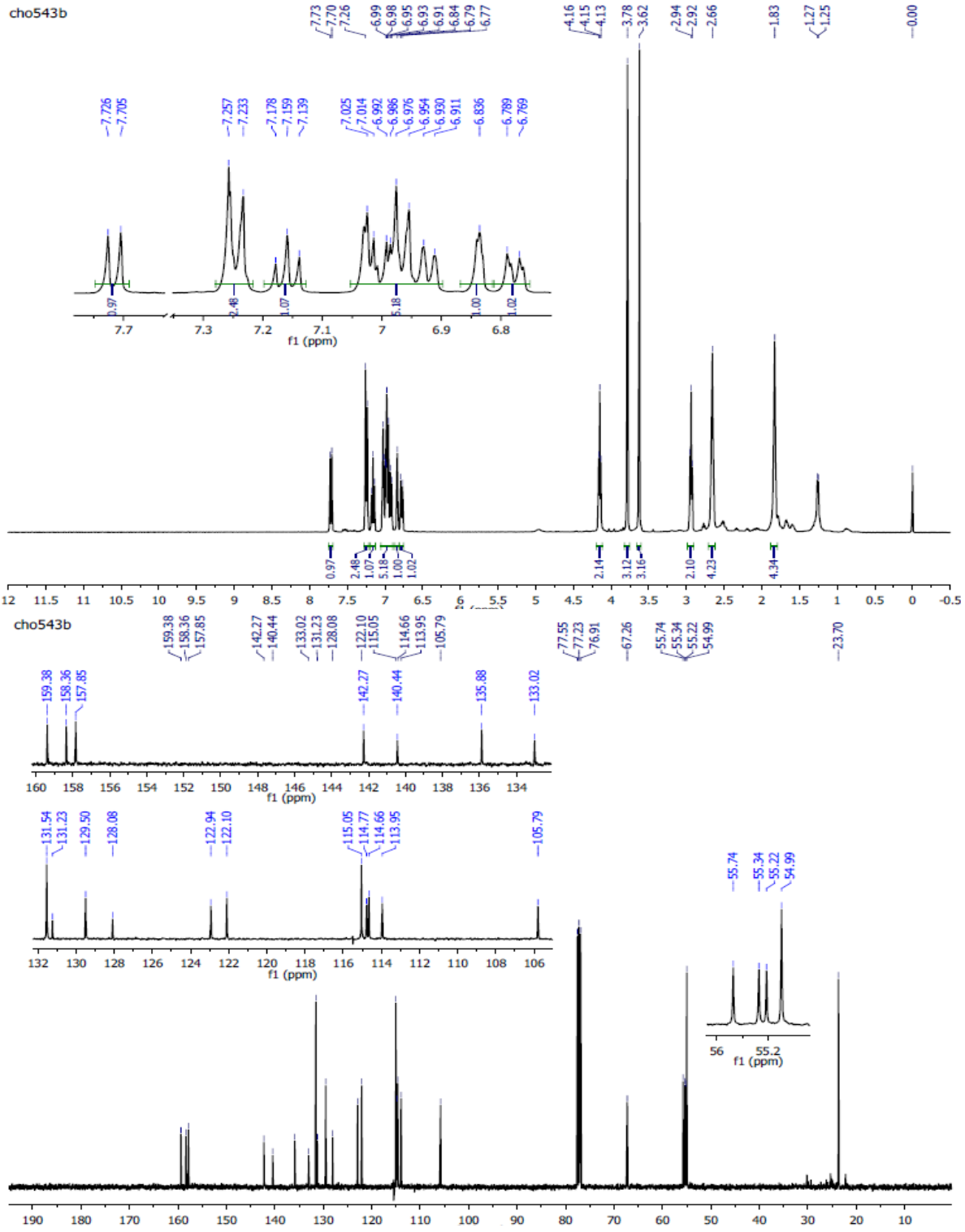
Compound 6{*21*}



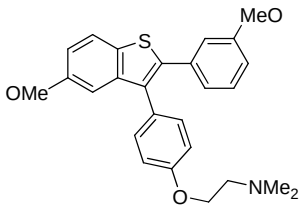


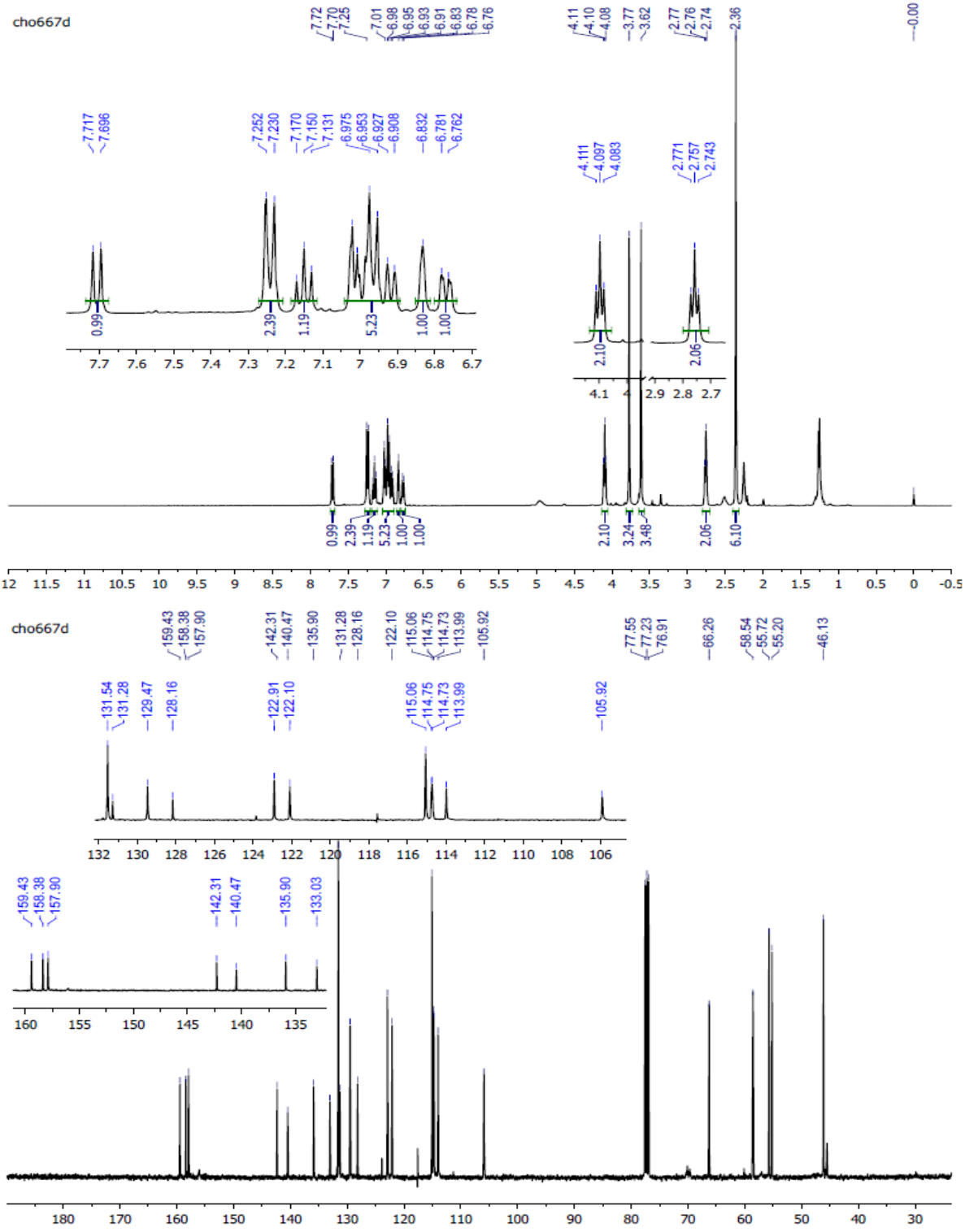
Compound 6{*23*}



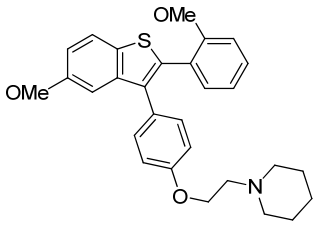


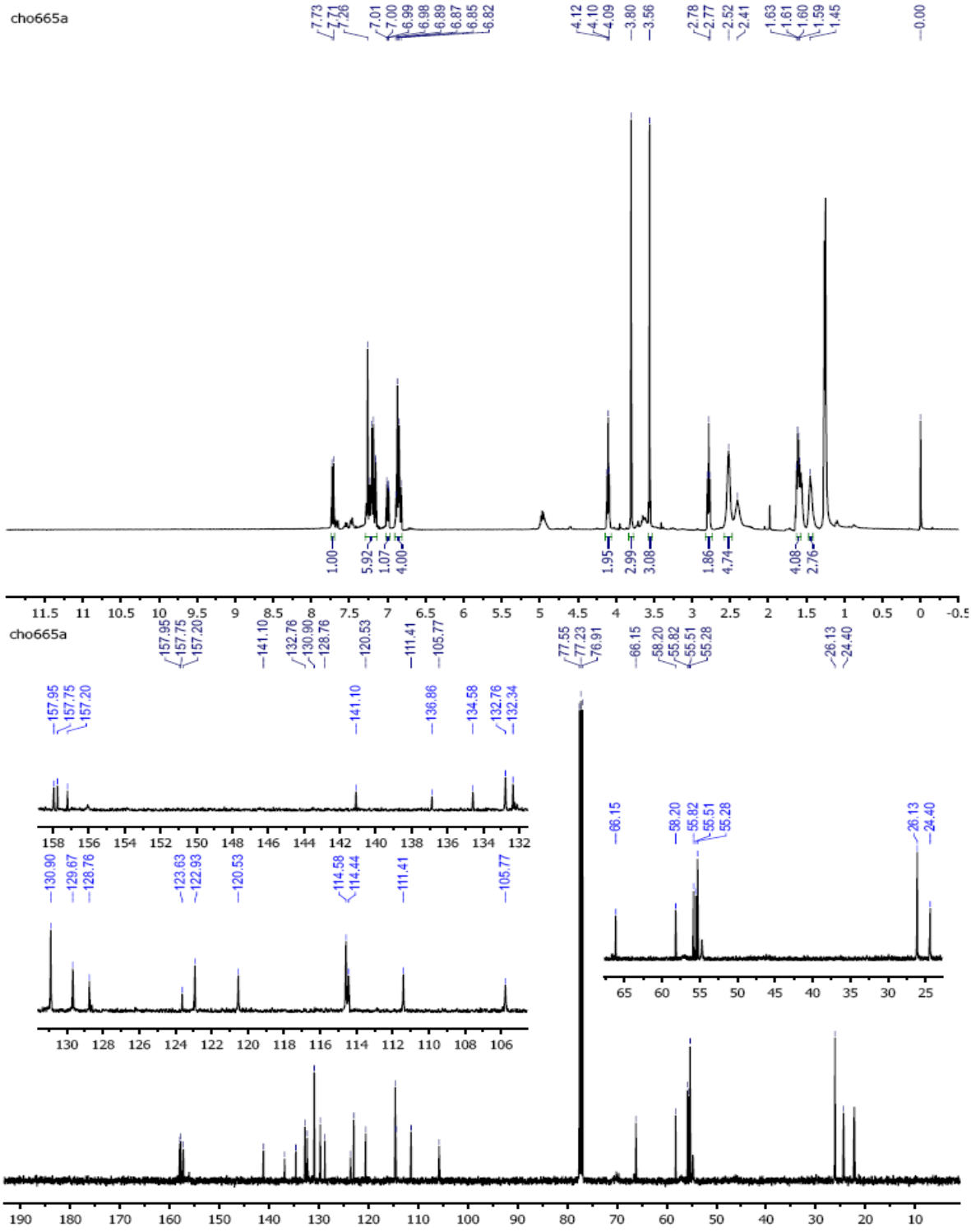
Compound 6{*24*}



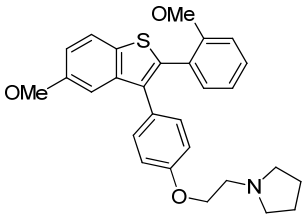


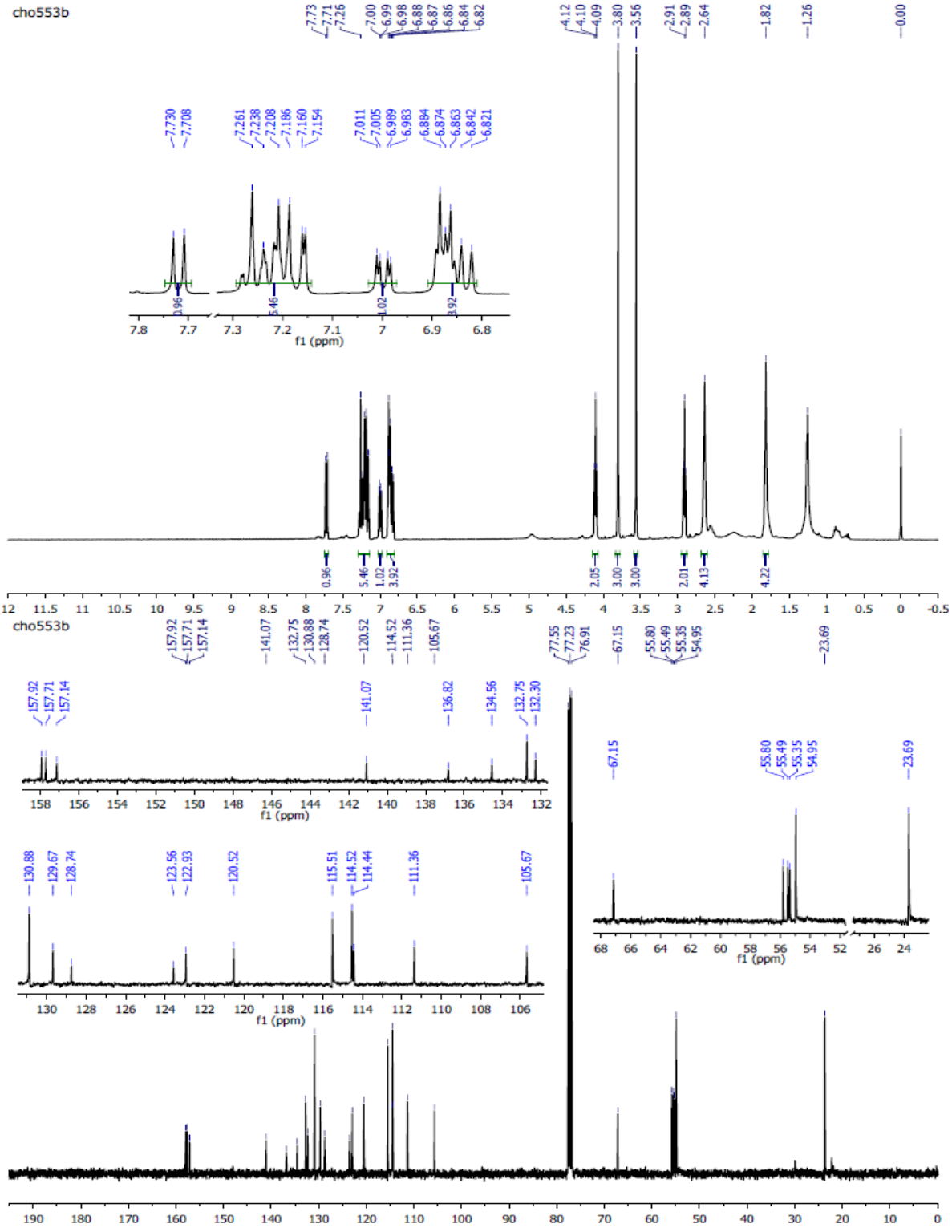
Compound 6{*25*}



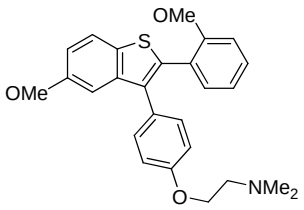


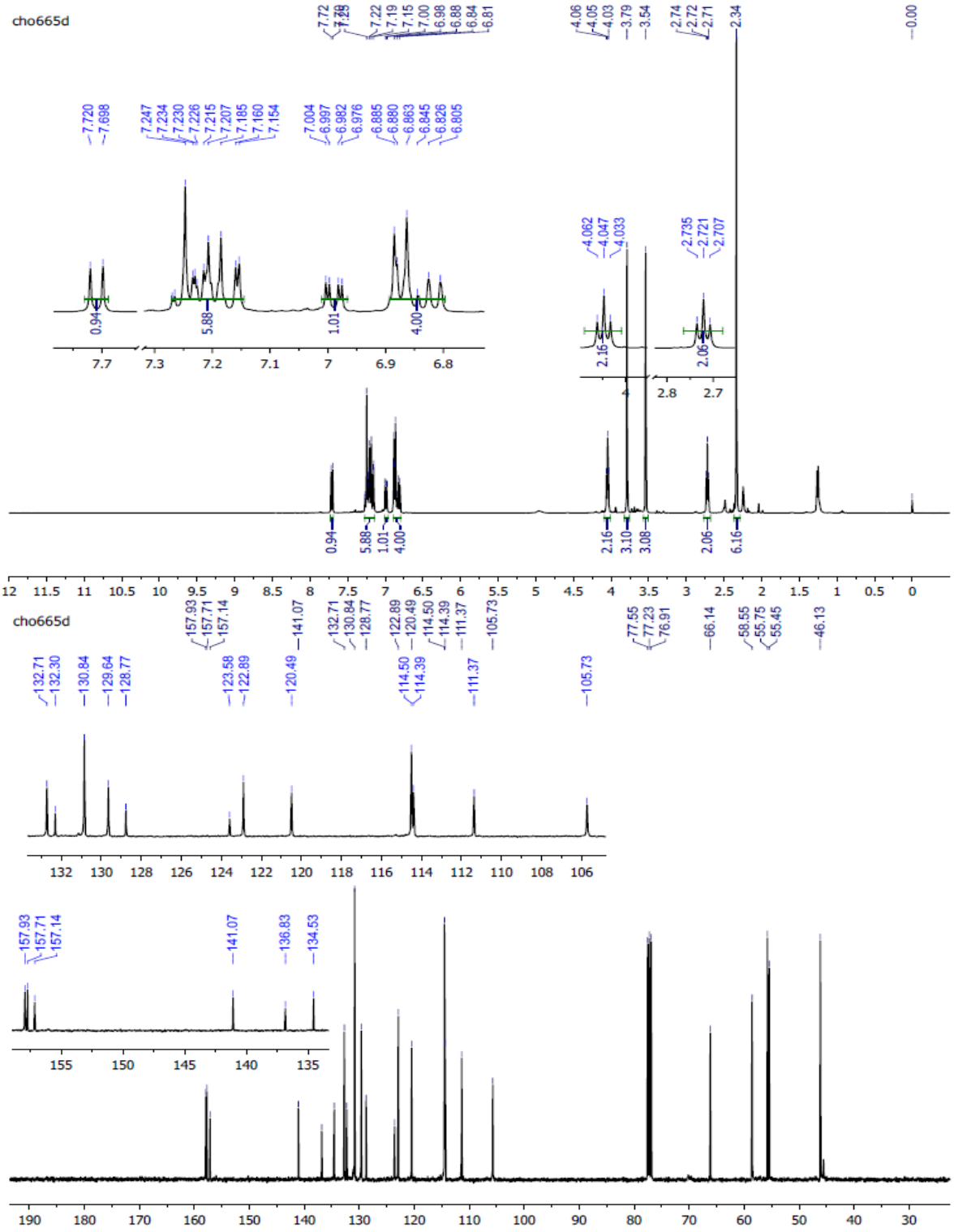
Compound 6{*27*}



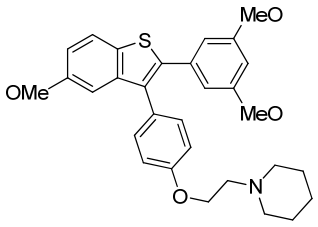


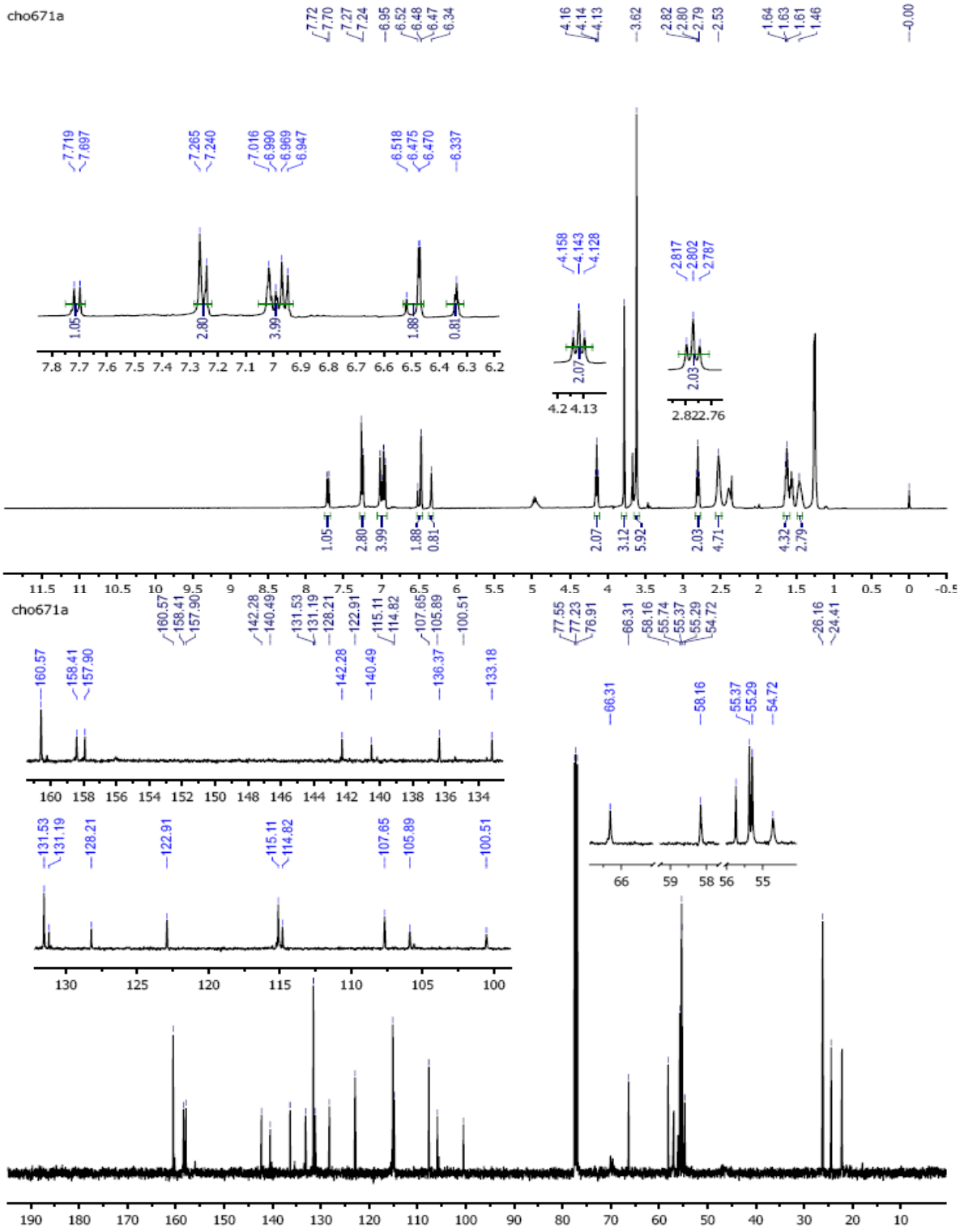
Compound 6{*28*}



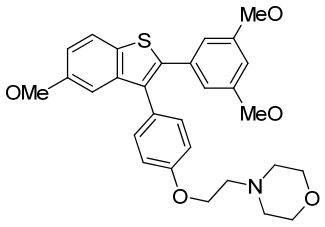


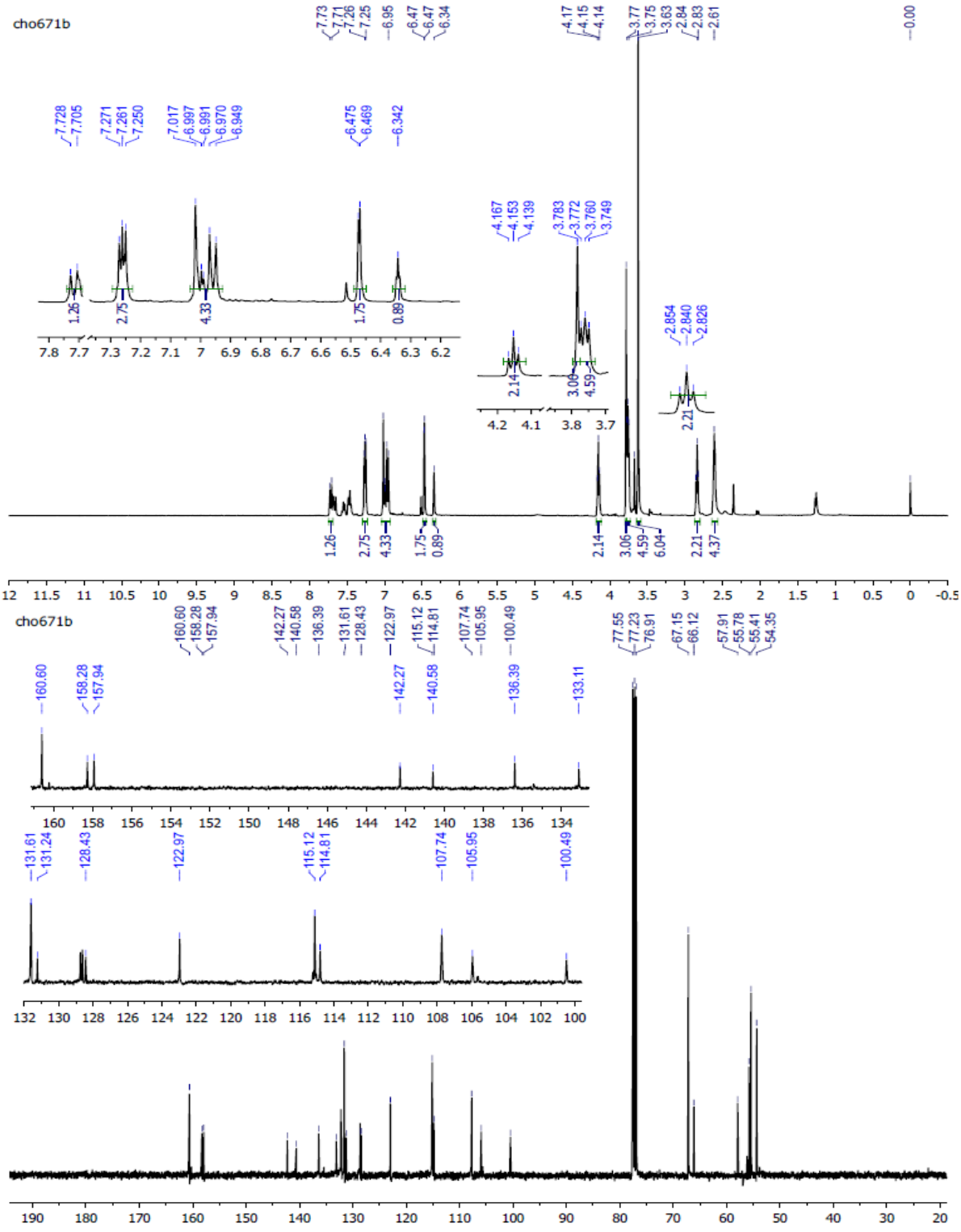
Compound 6{*29*}



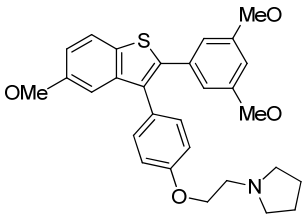


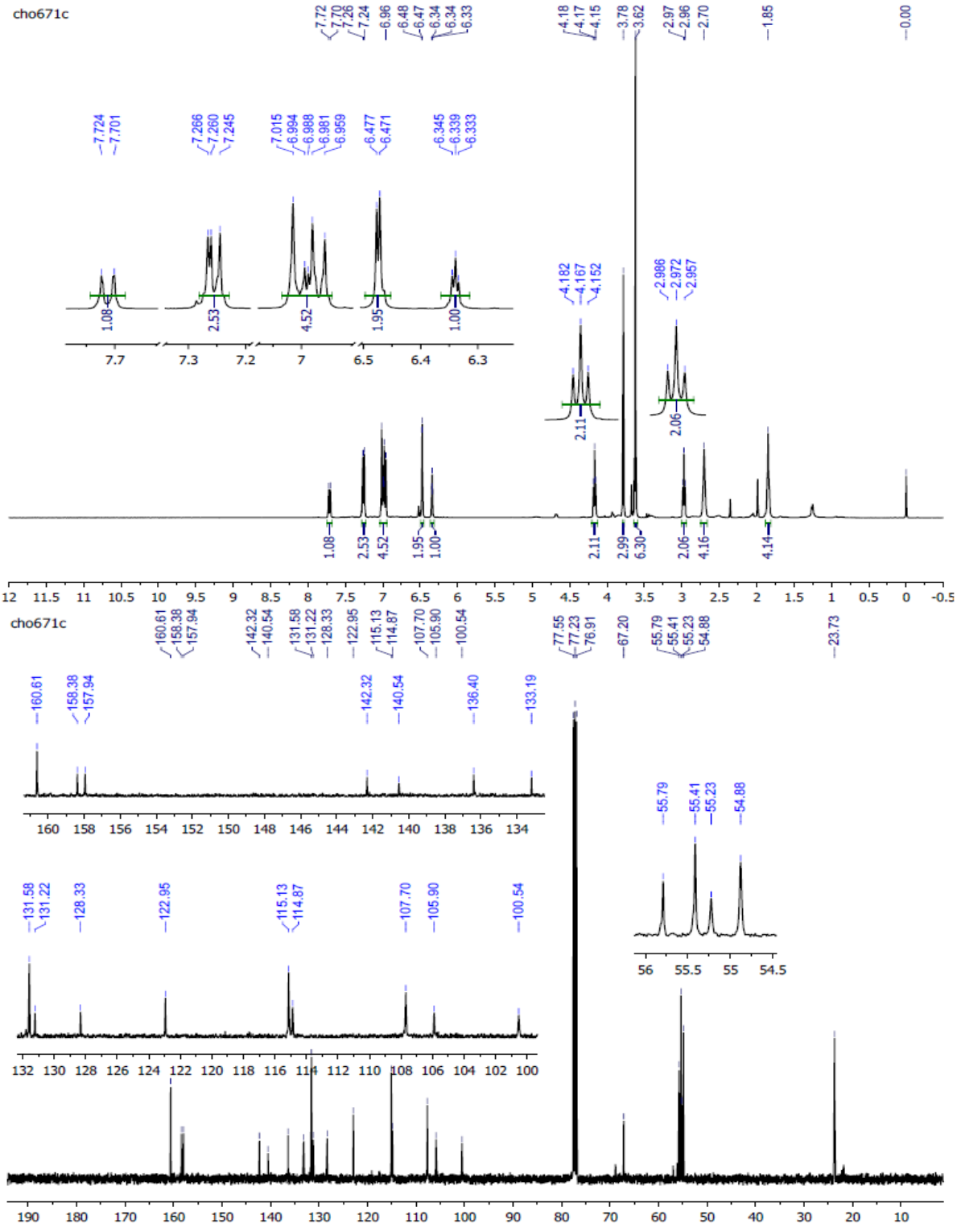
Compound 6{*30*}



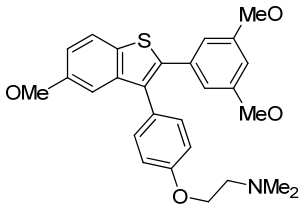


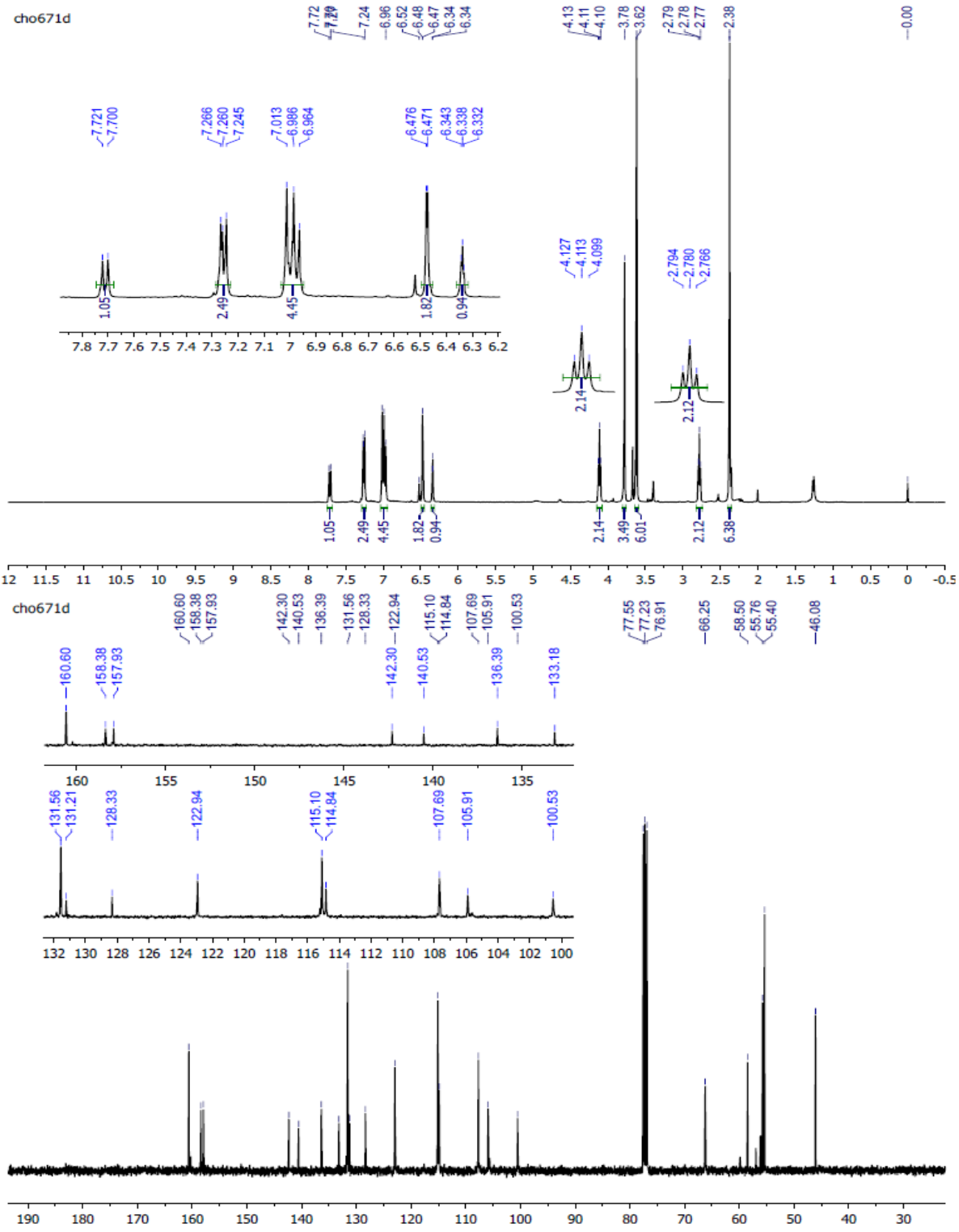
Compound 6{*31*}



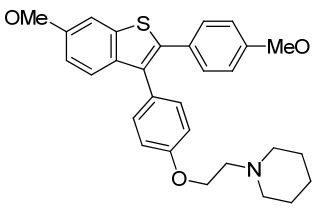


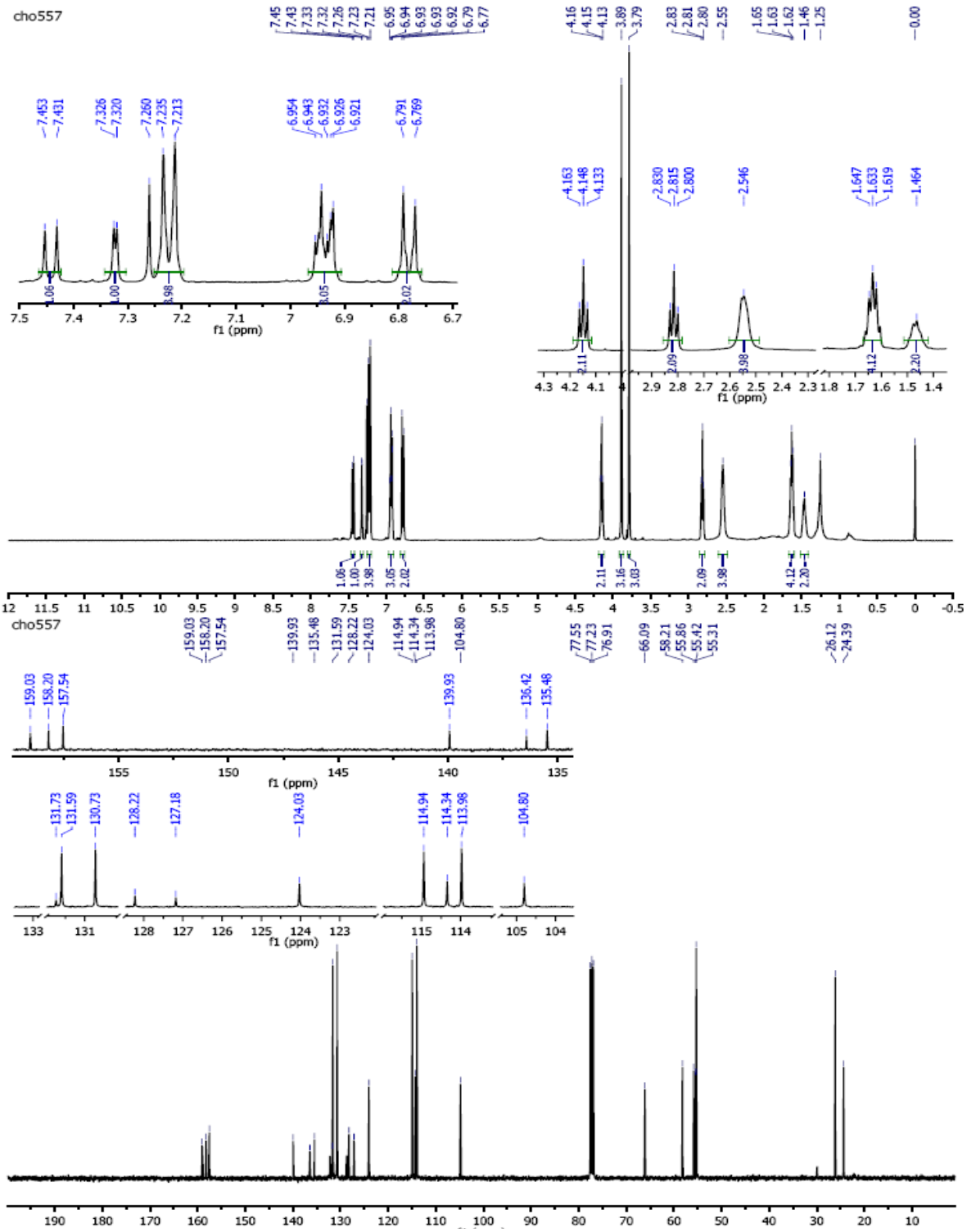
Compound 6{*32*}



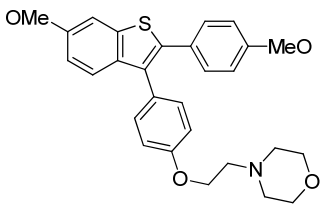


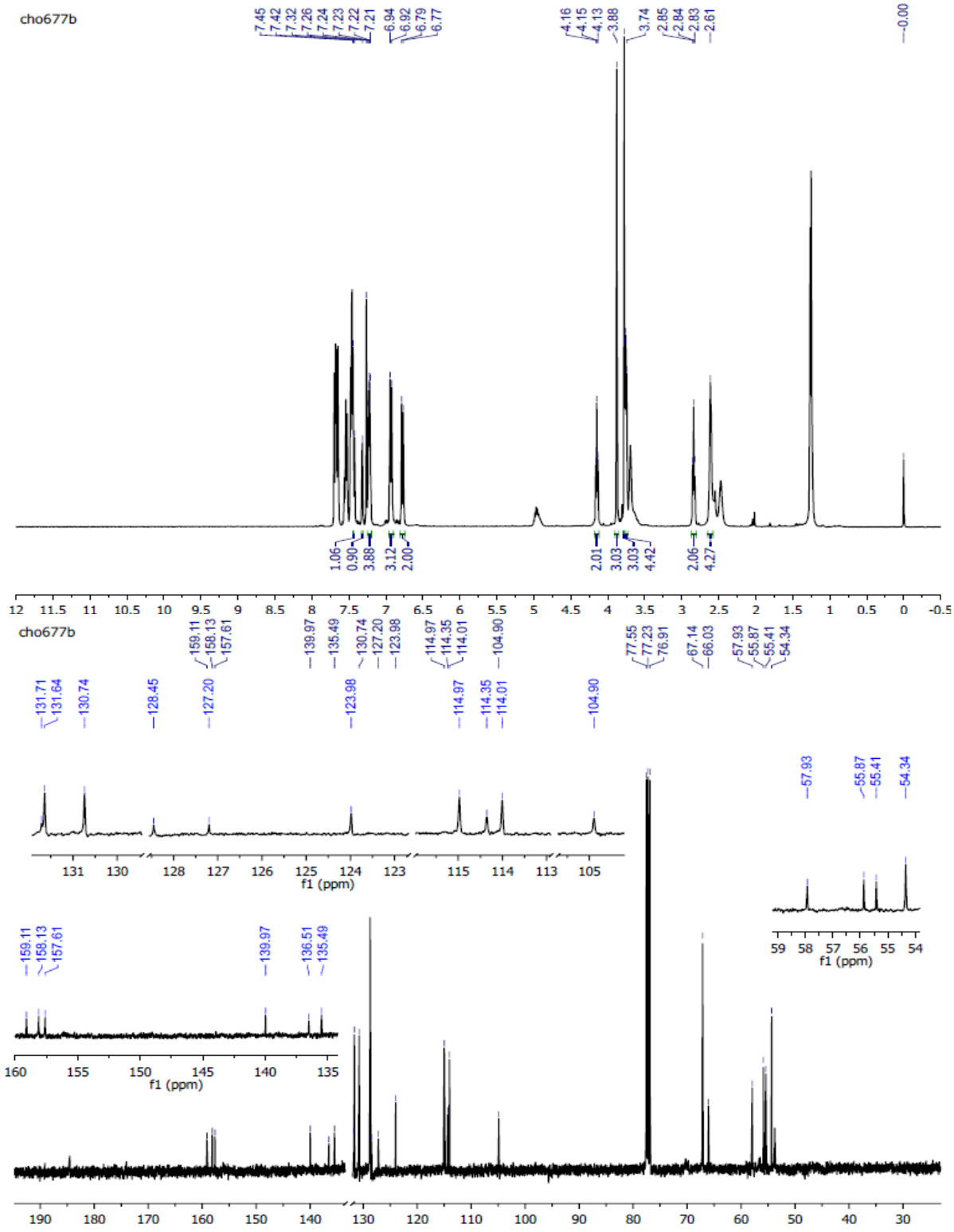
Compound 6{*33*}



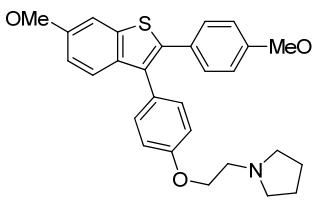


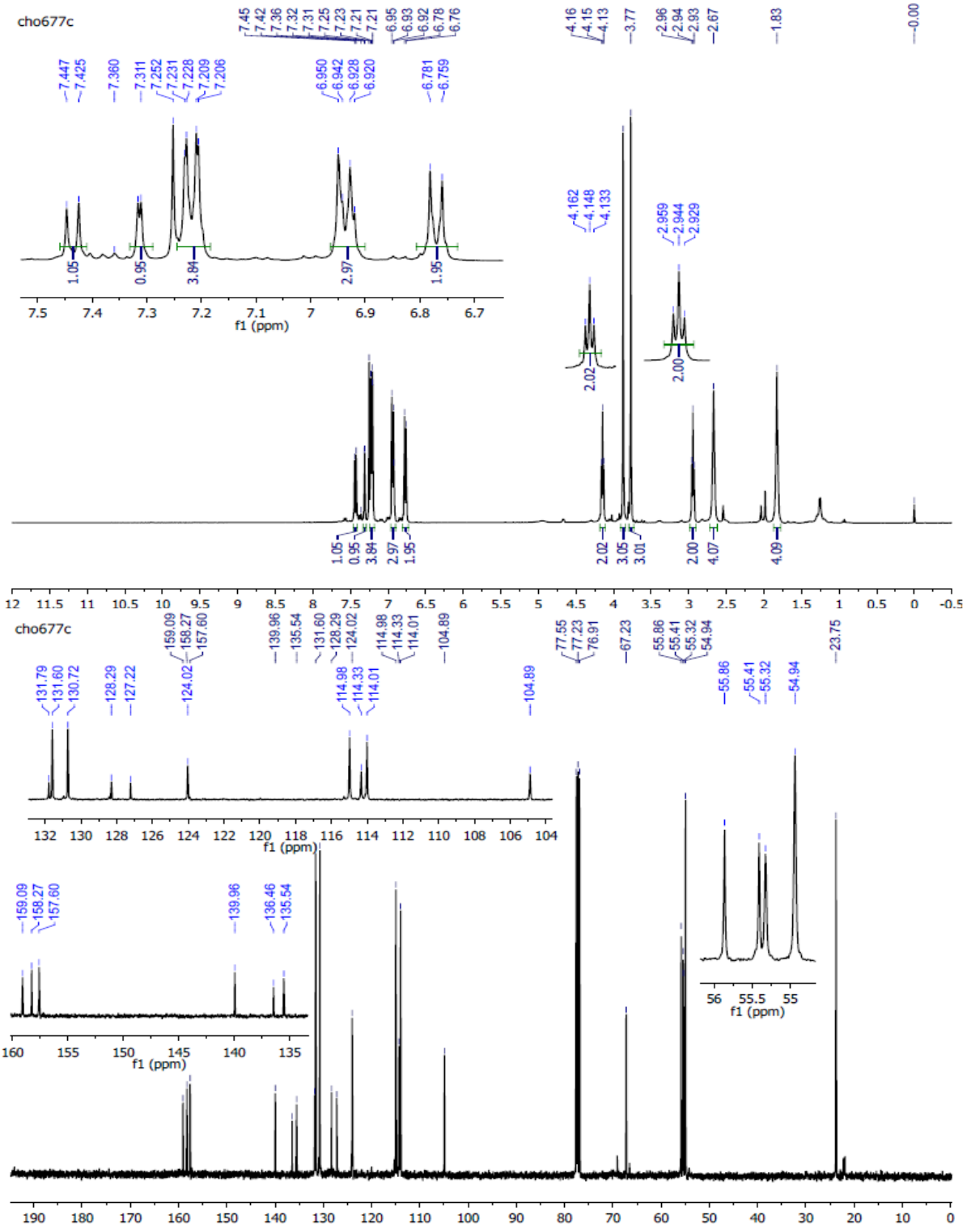
Compound 6{*34*}



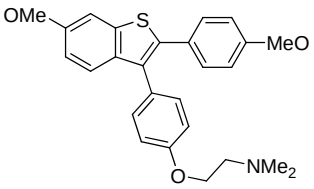


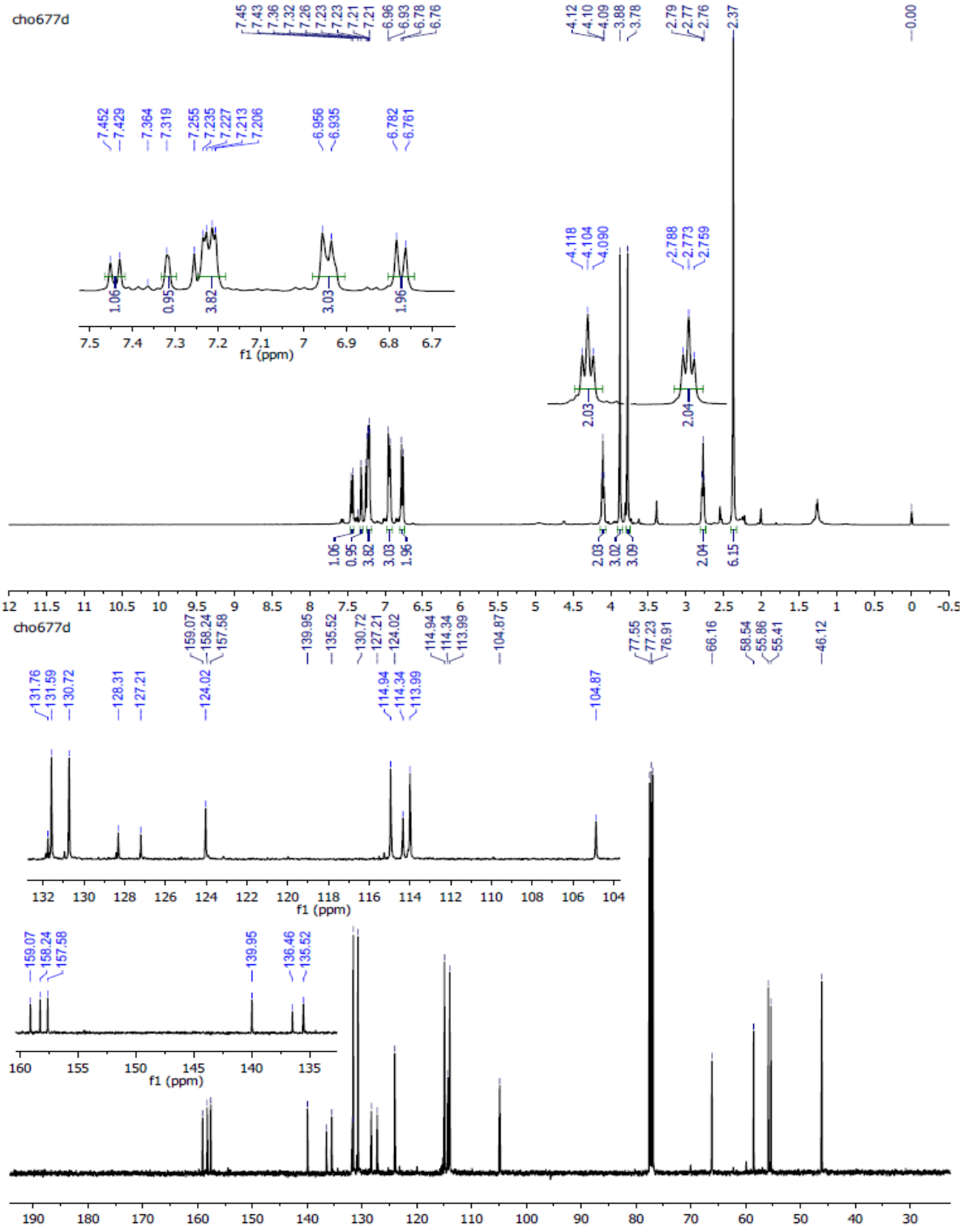
Compound 6{*35*}



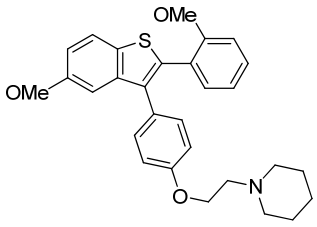


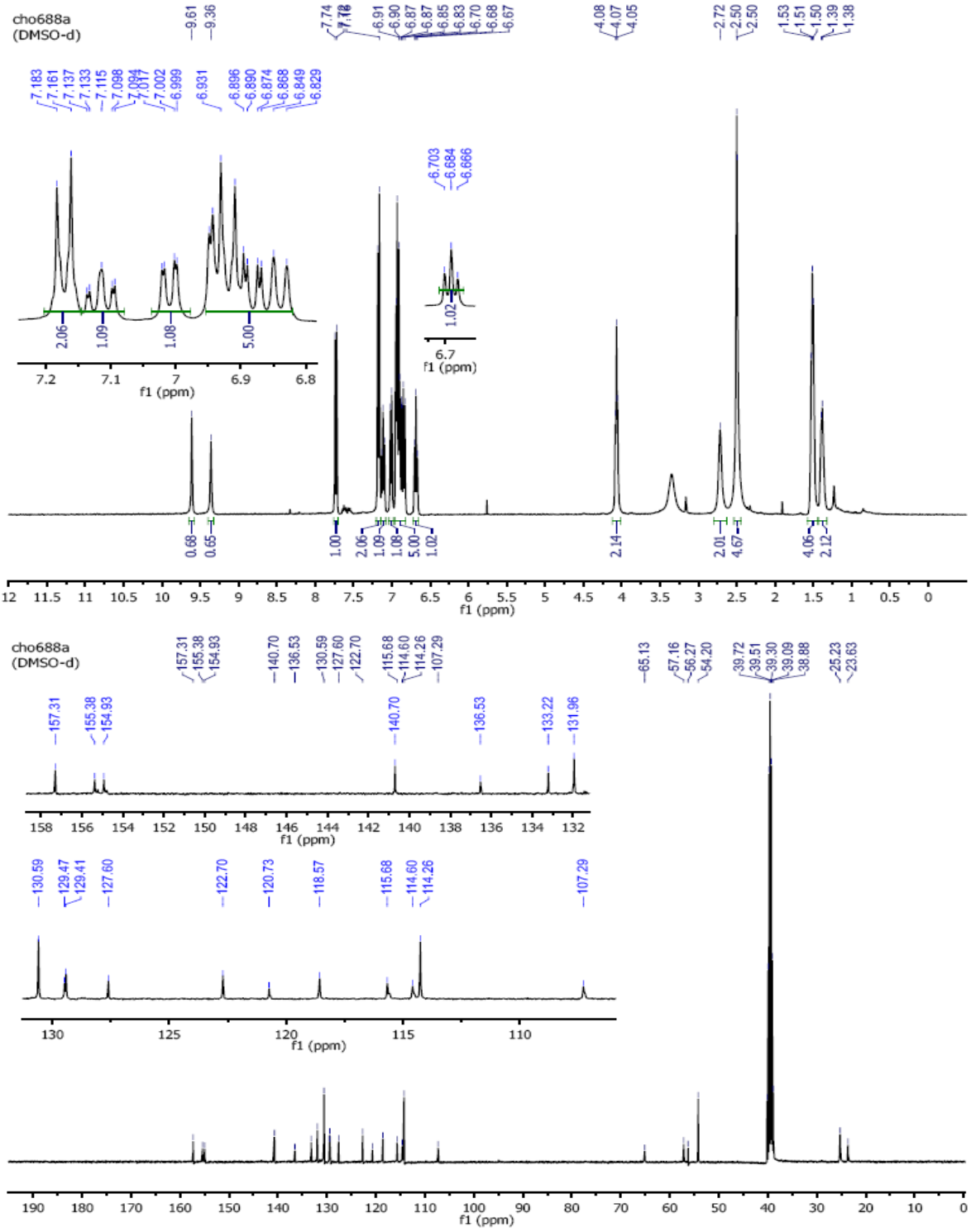
Compound 6{*36*}



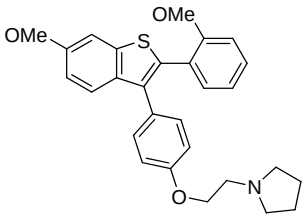


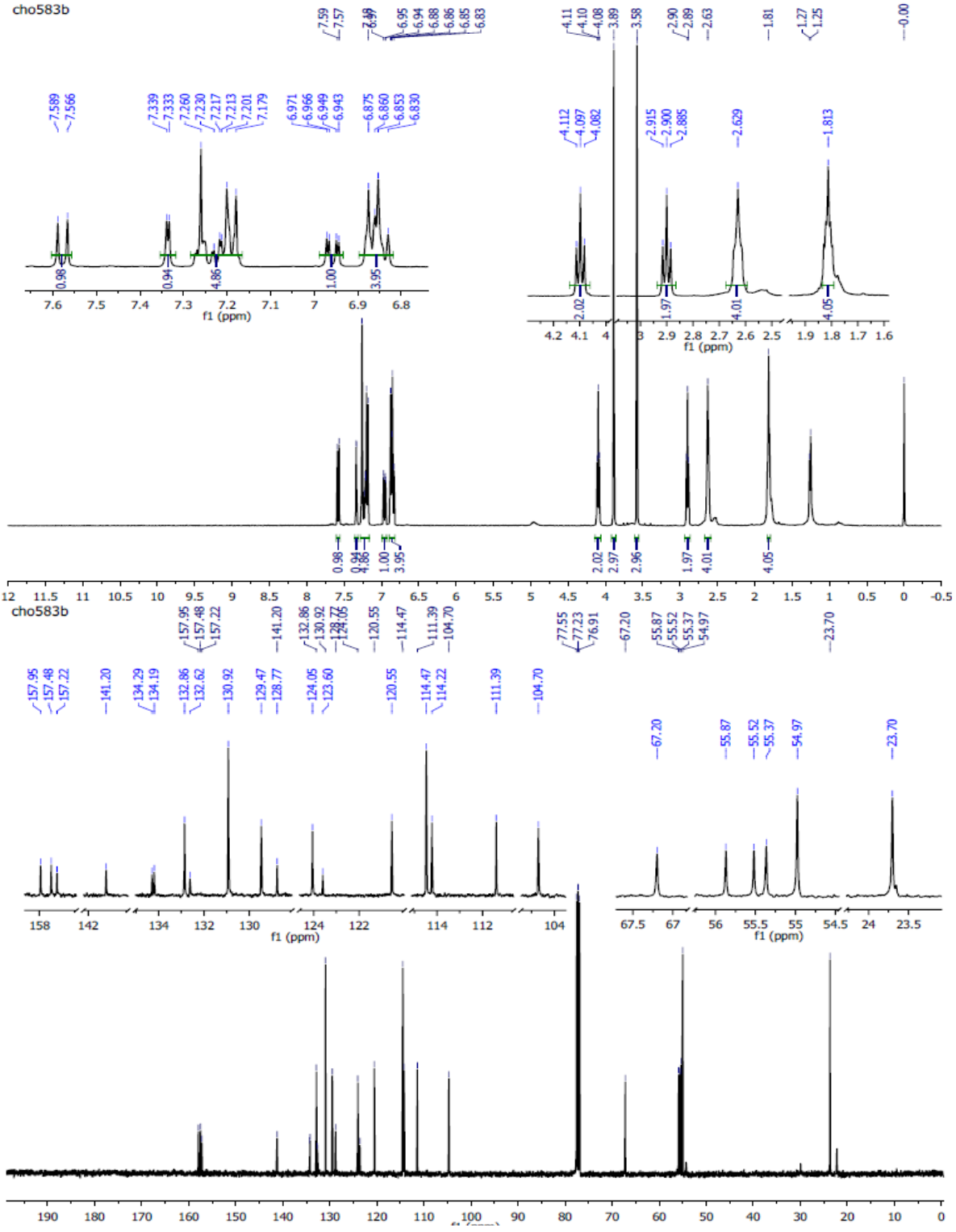
Compound 6{*37*}



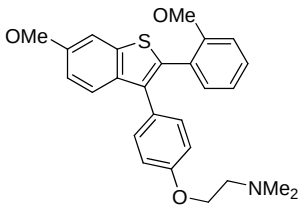


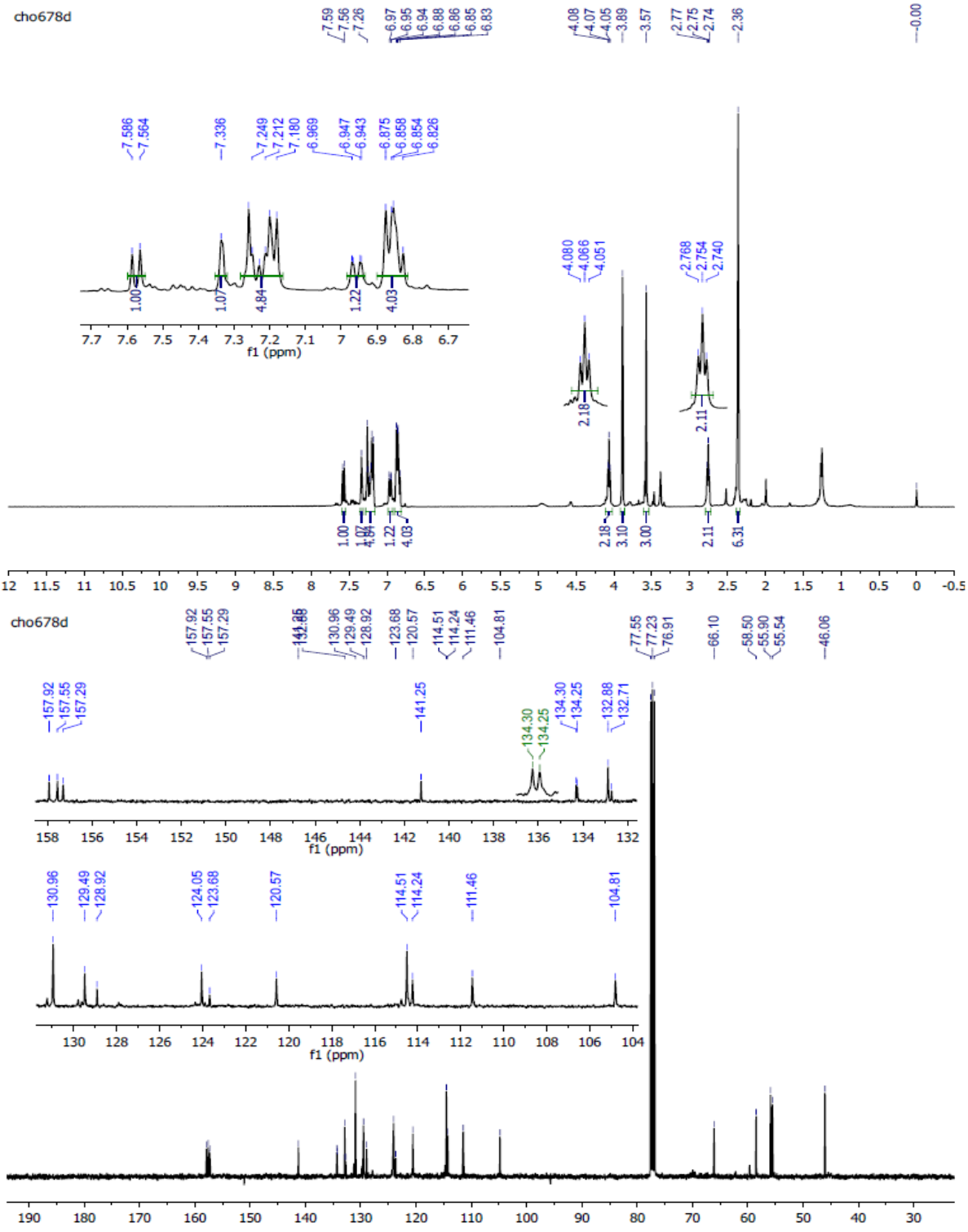
Compound 6{*39*}



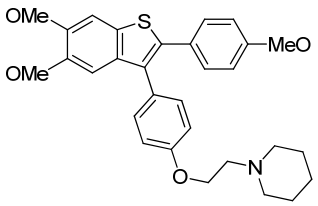


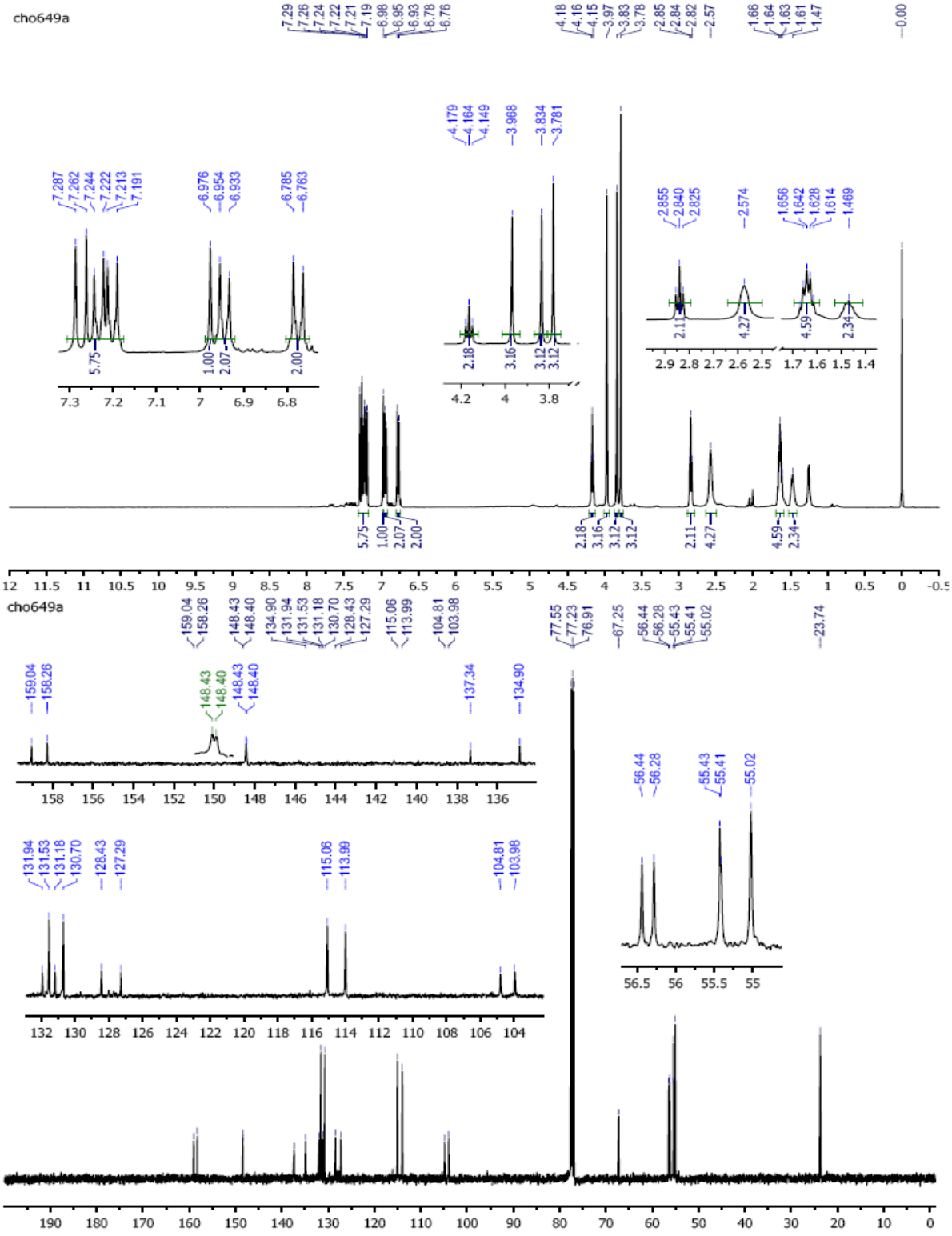
Compound 6{*40*}



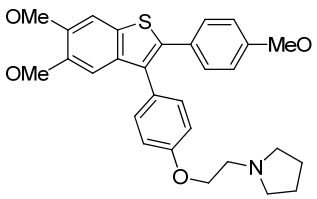


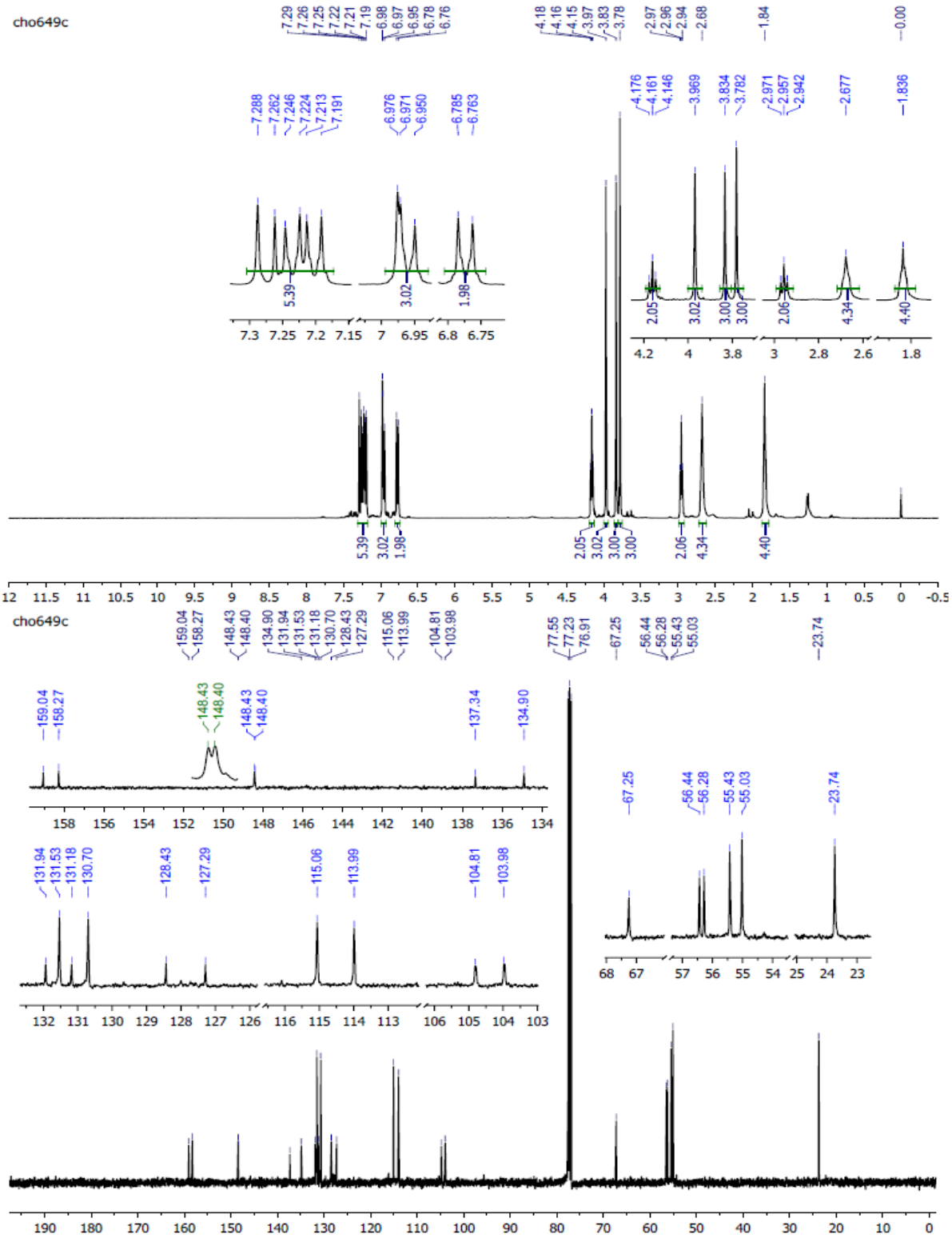
Compound 6{*41*}



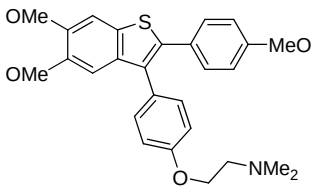


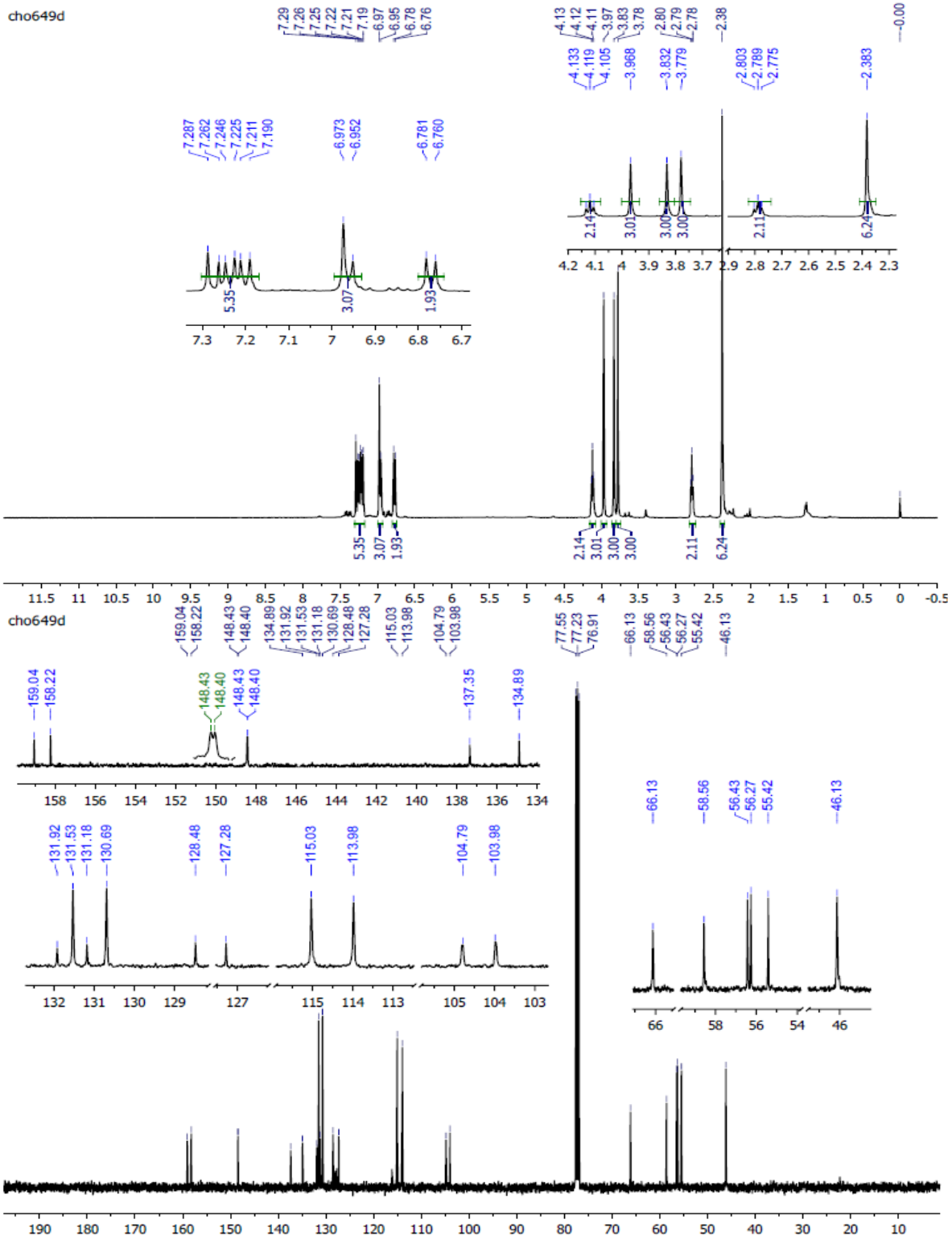
Compound 6{*43*}



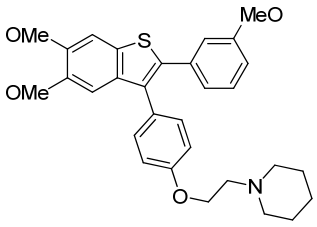


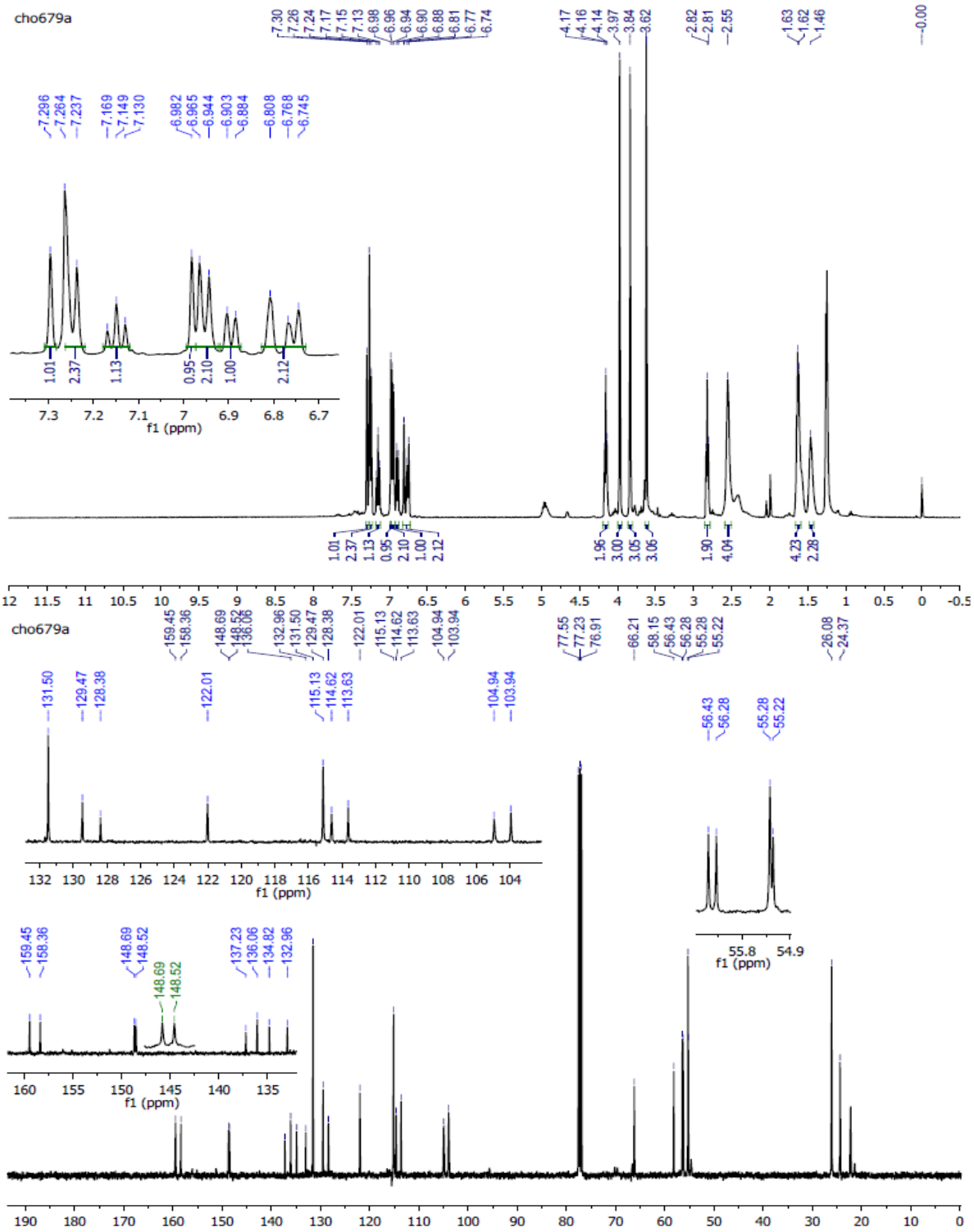
Compound 6{*44*}



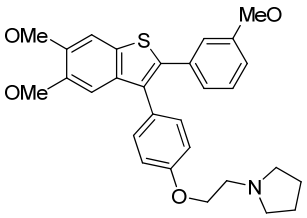


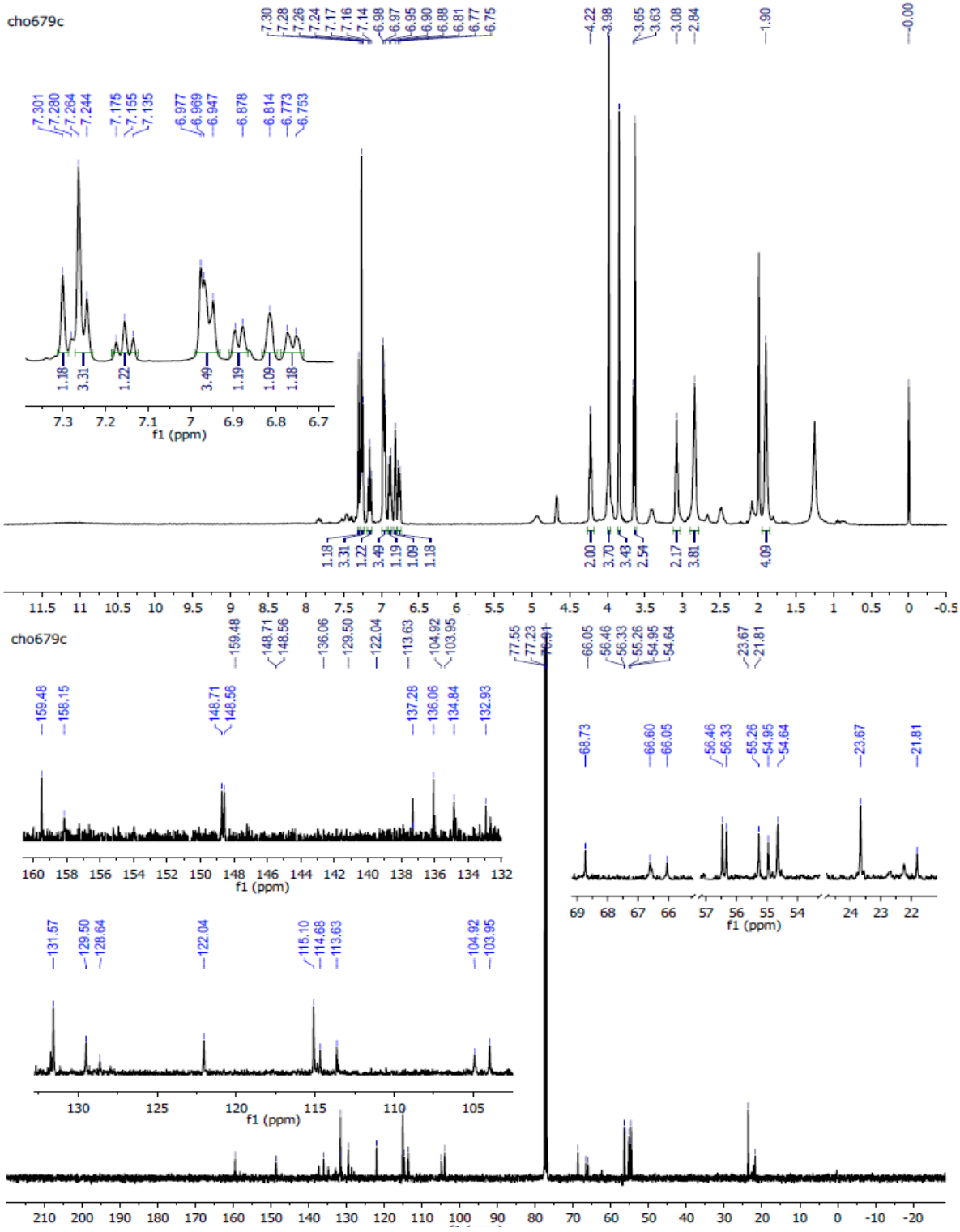
Compound 6{*45*}



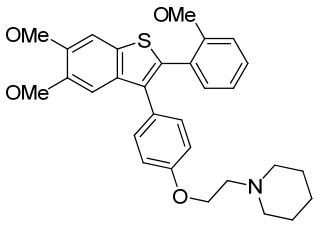


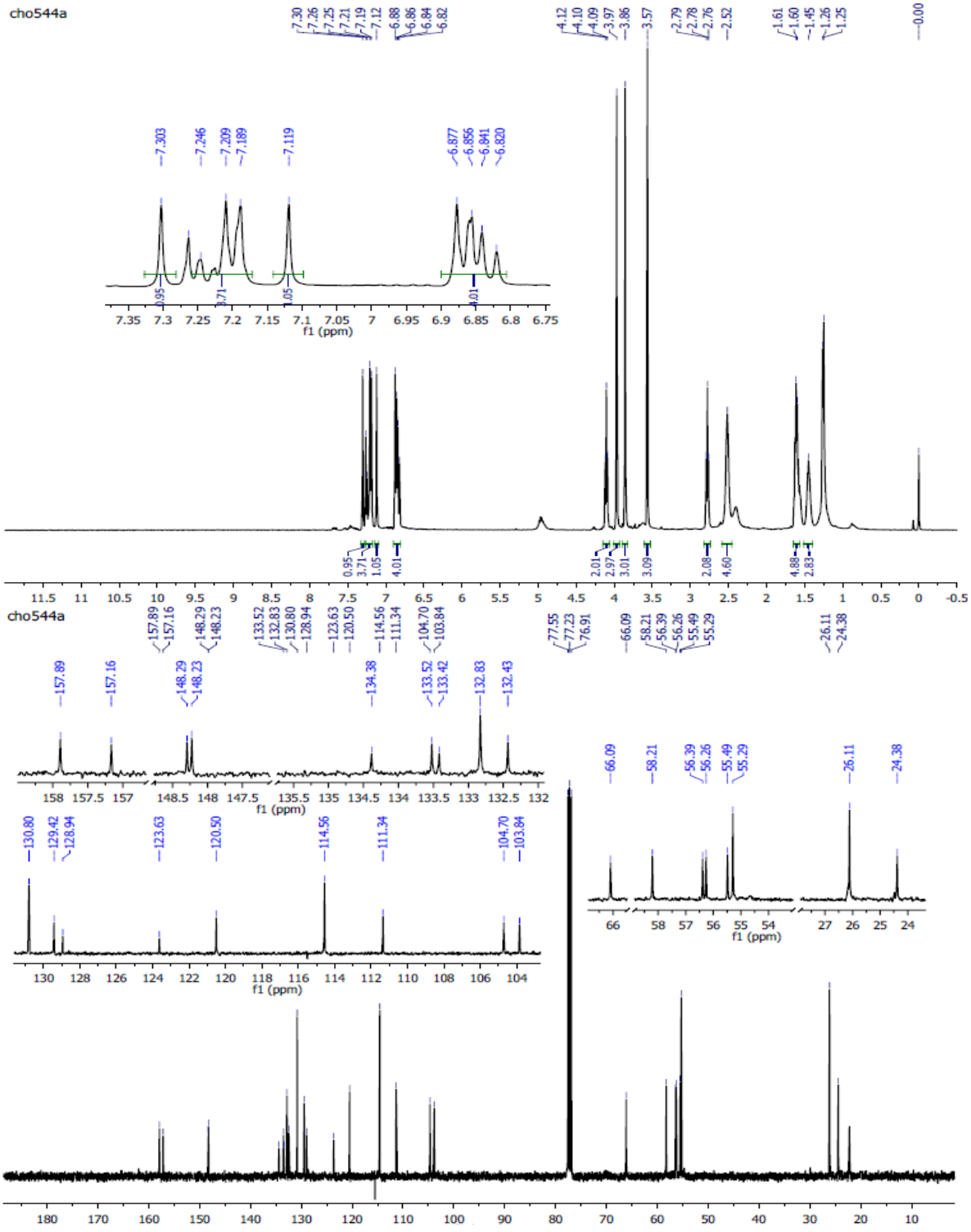
Compound 6{*47*}



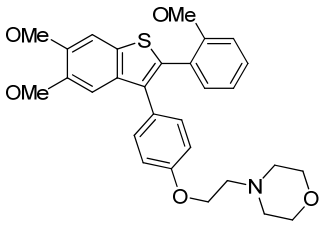


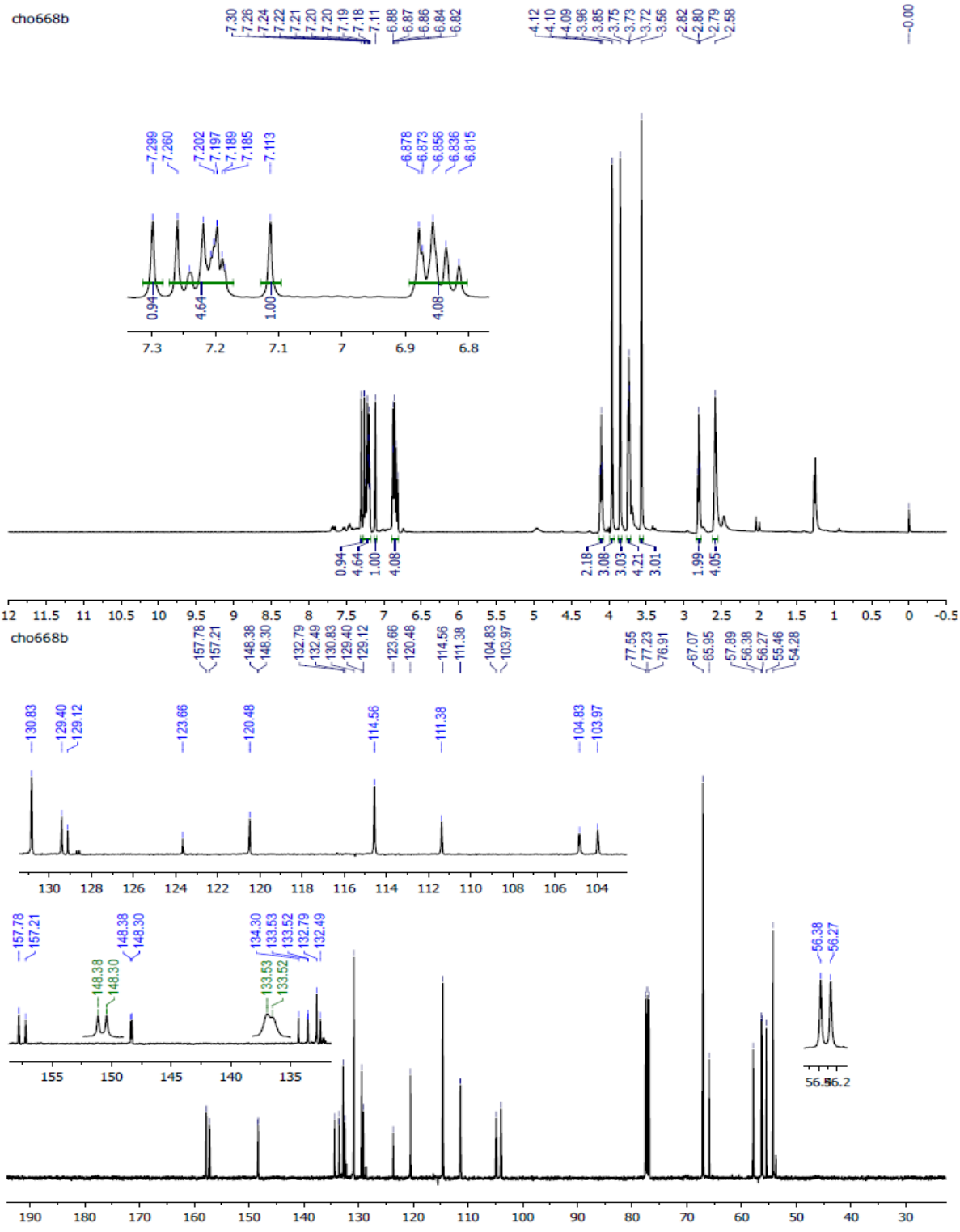
Compound 6{*49*}



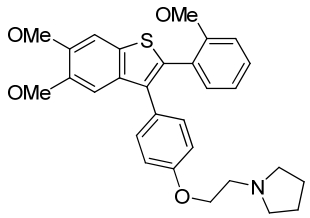


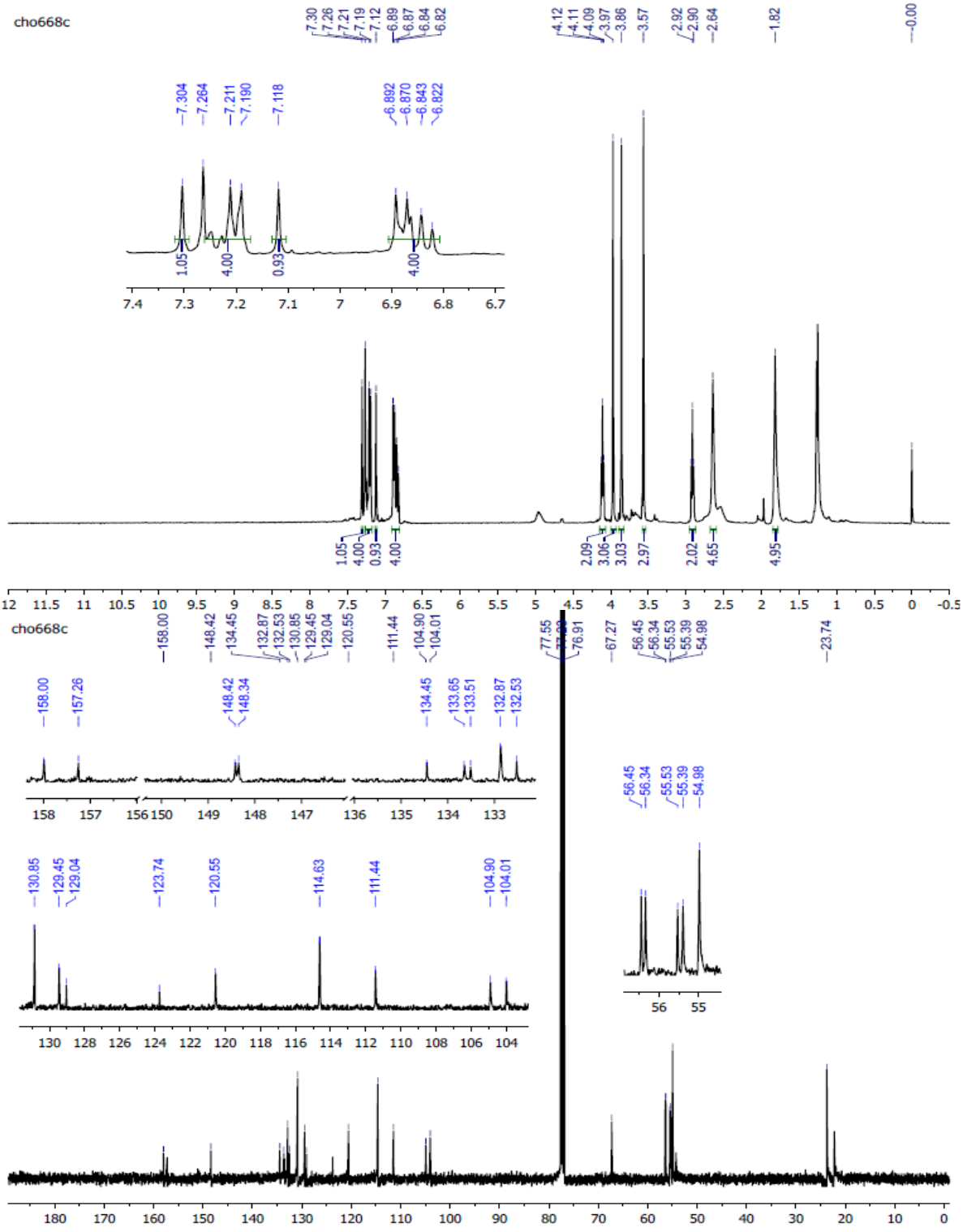
Compound 6{*50*}



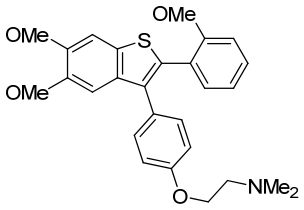


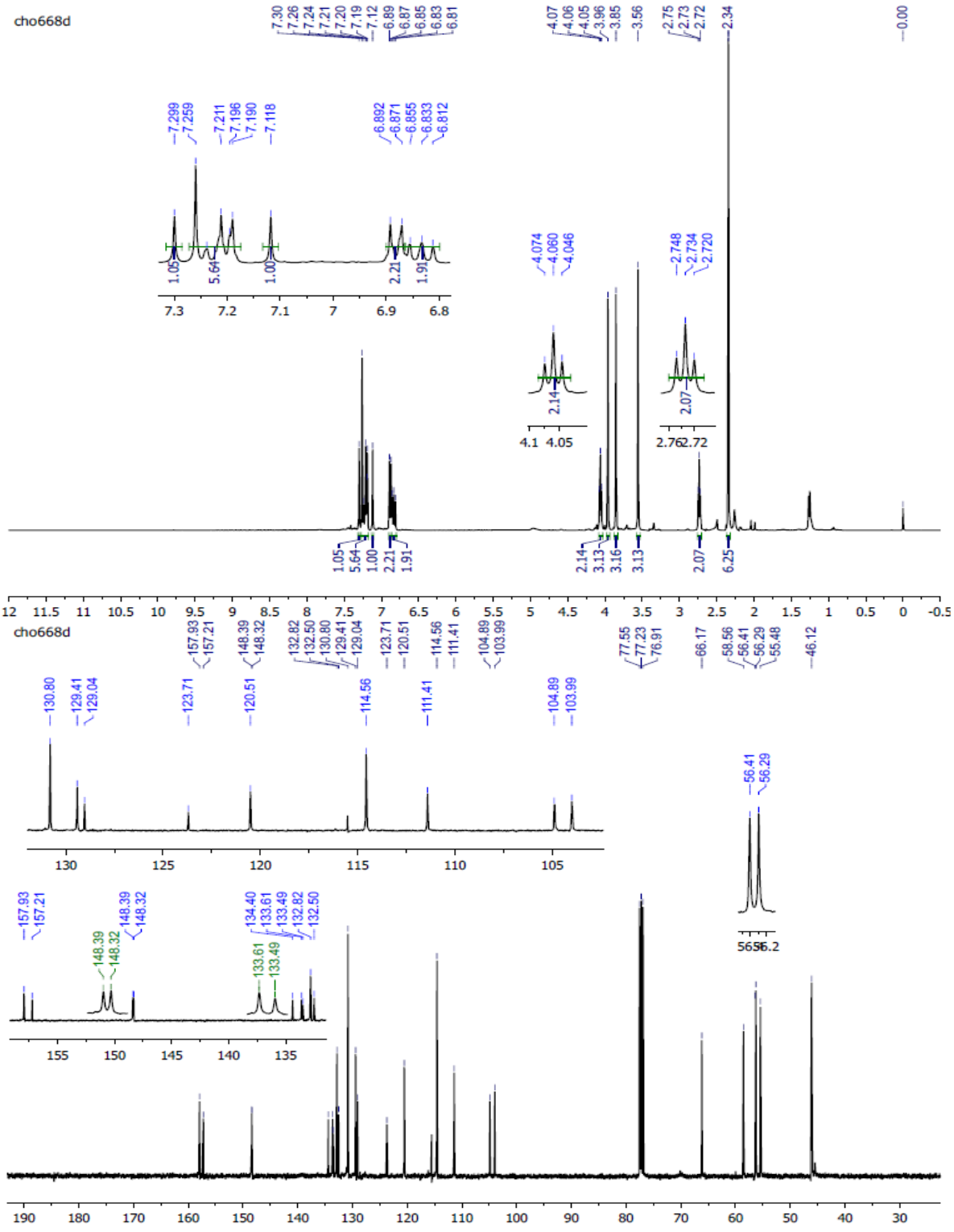
Compound 6{*51*}



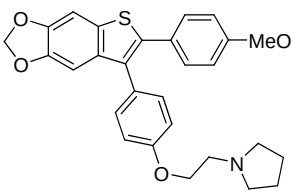


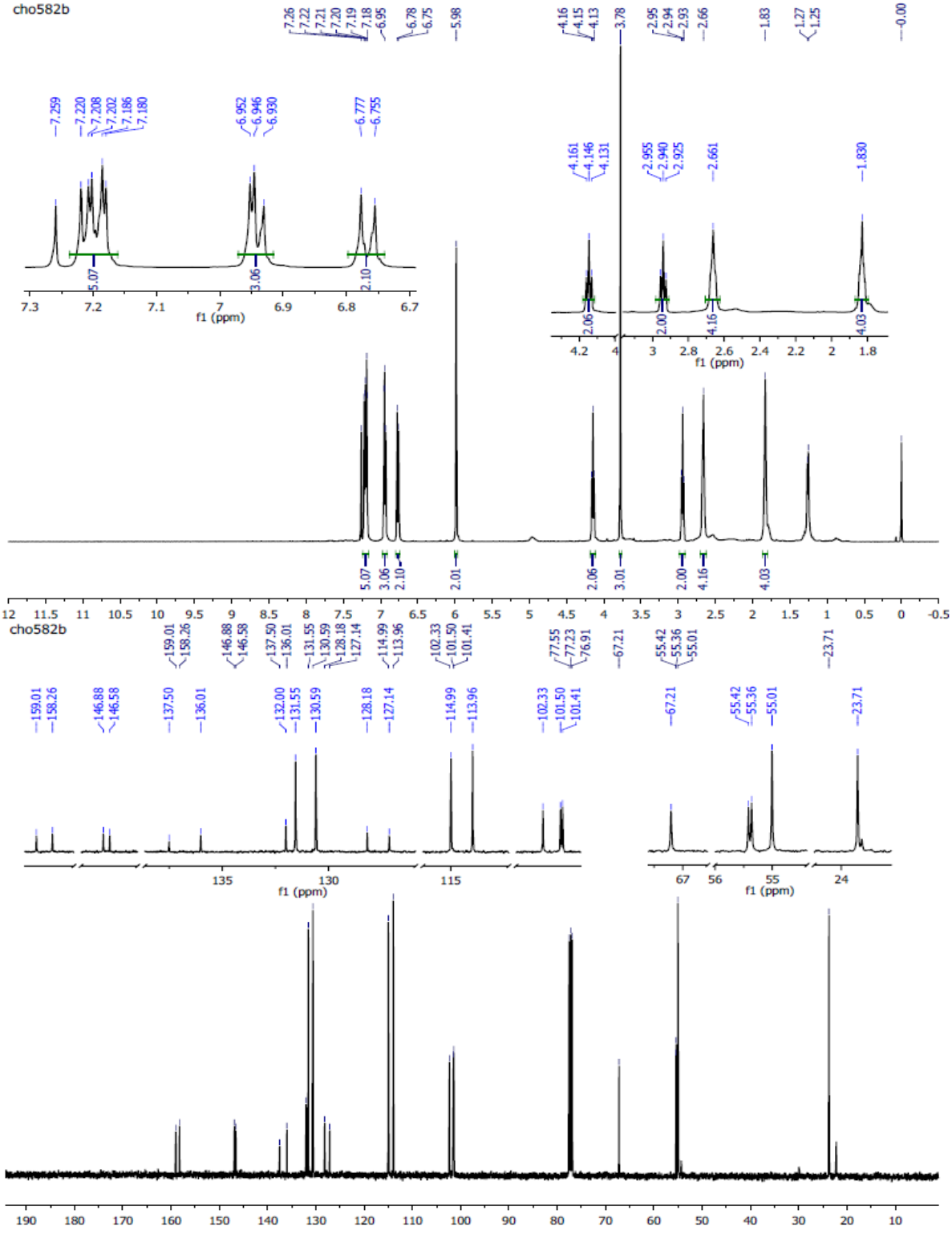
Compound 6{*52*}



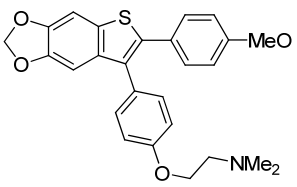


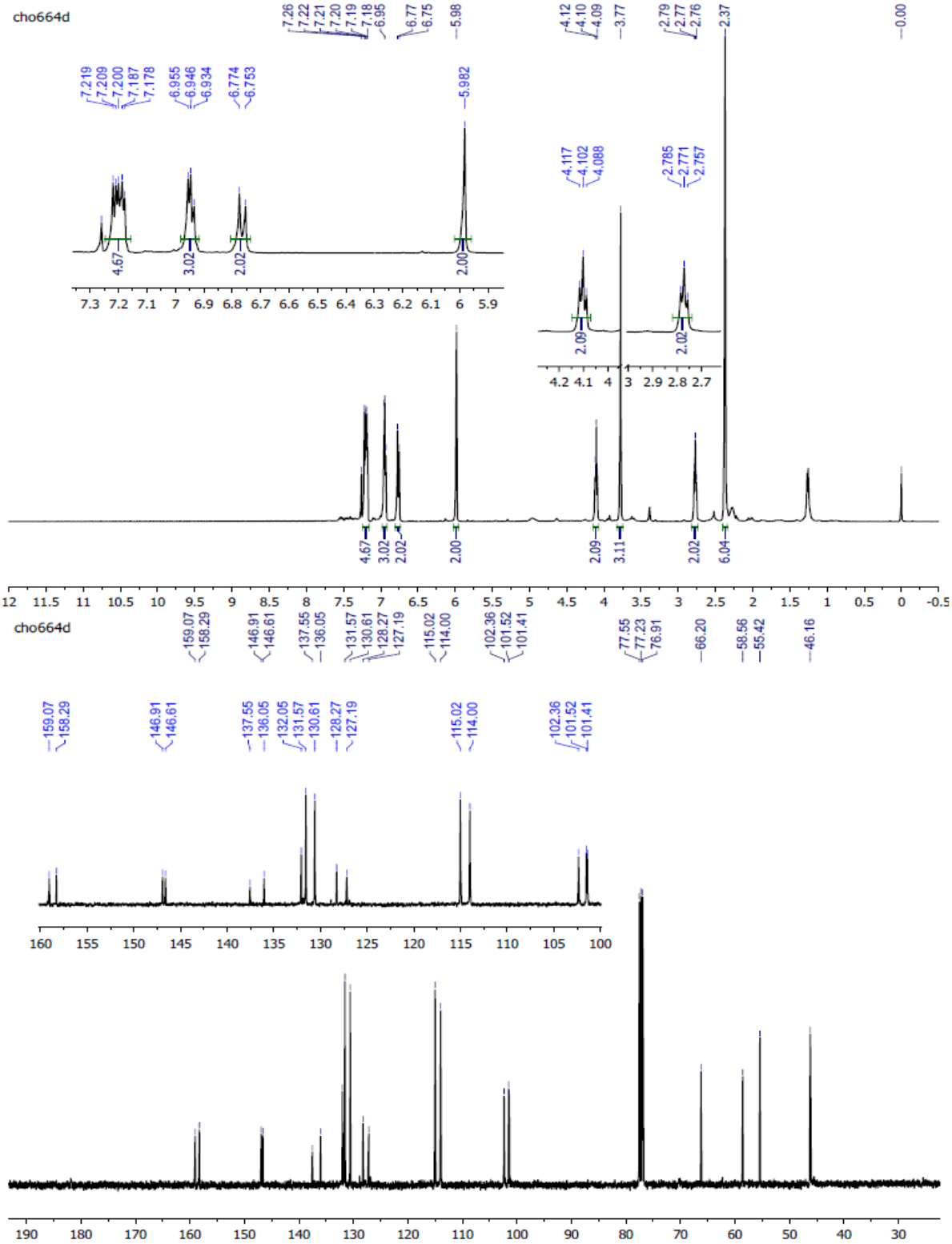
Compound 6{*55*}



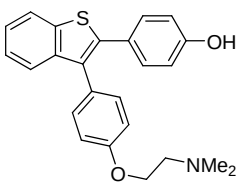


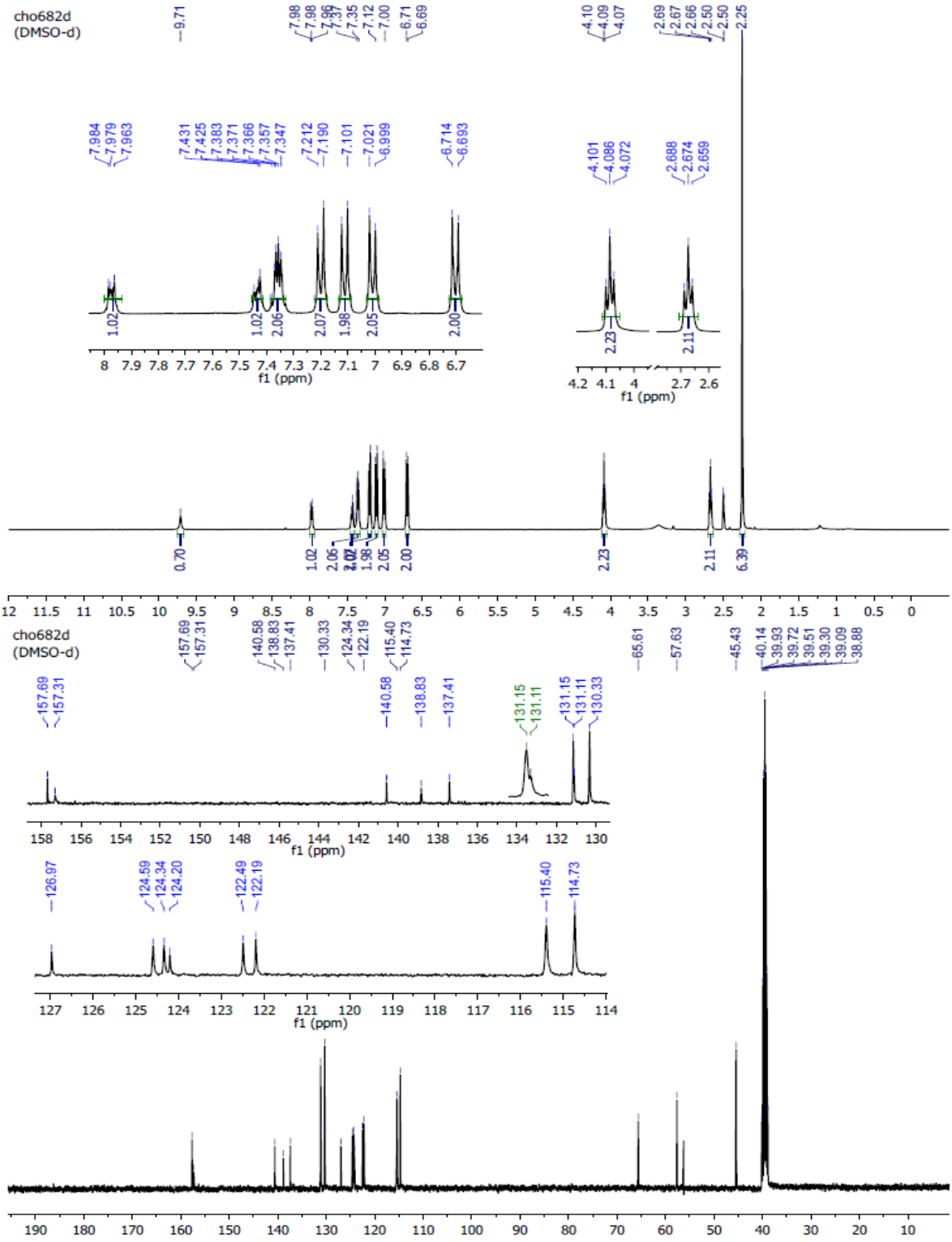
Compound 6{*56*}



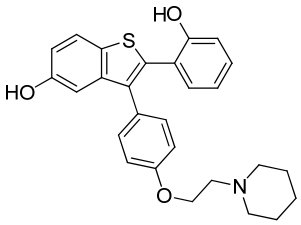


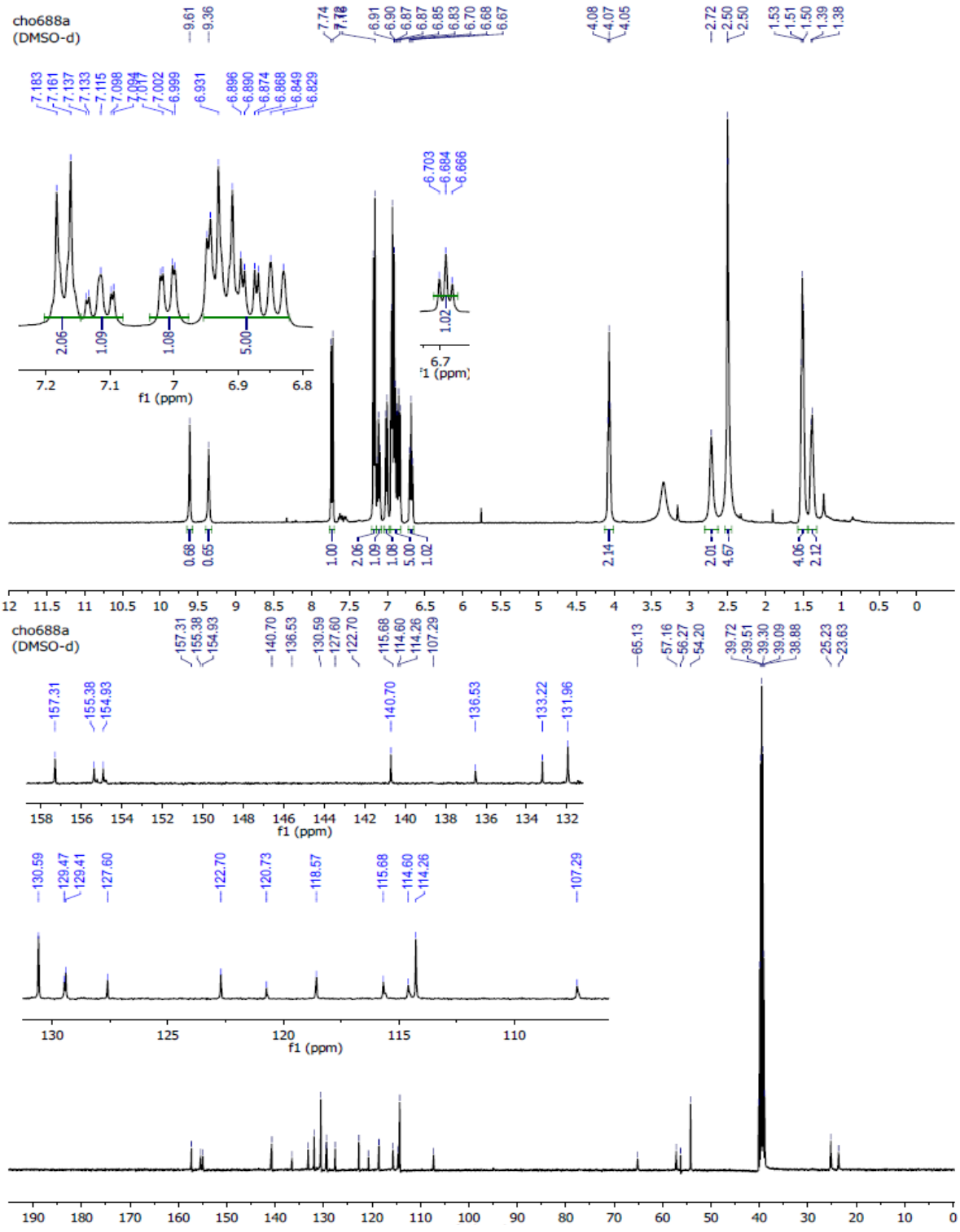
Compound 7{*4*}



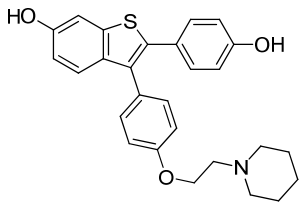


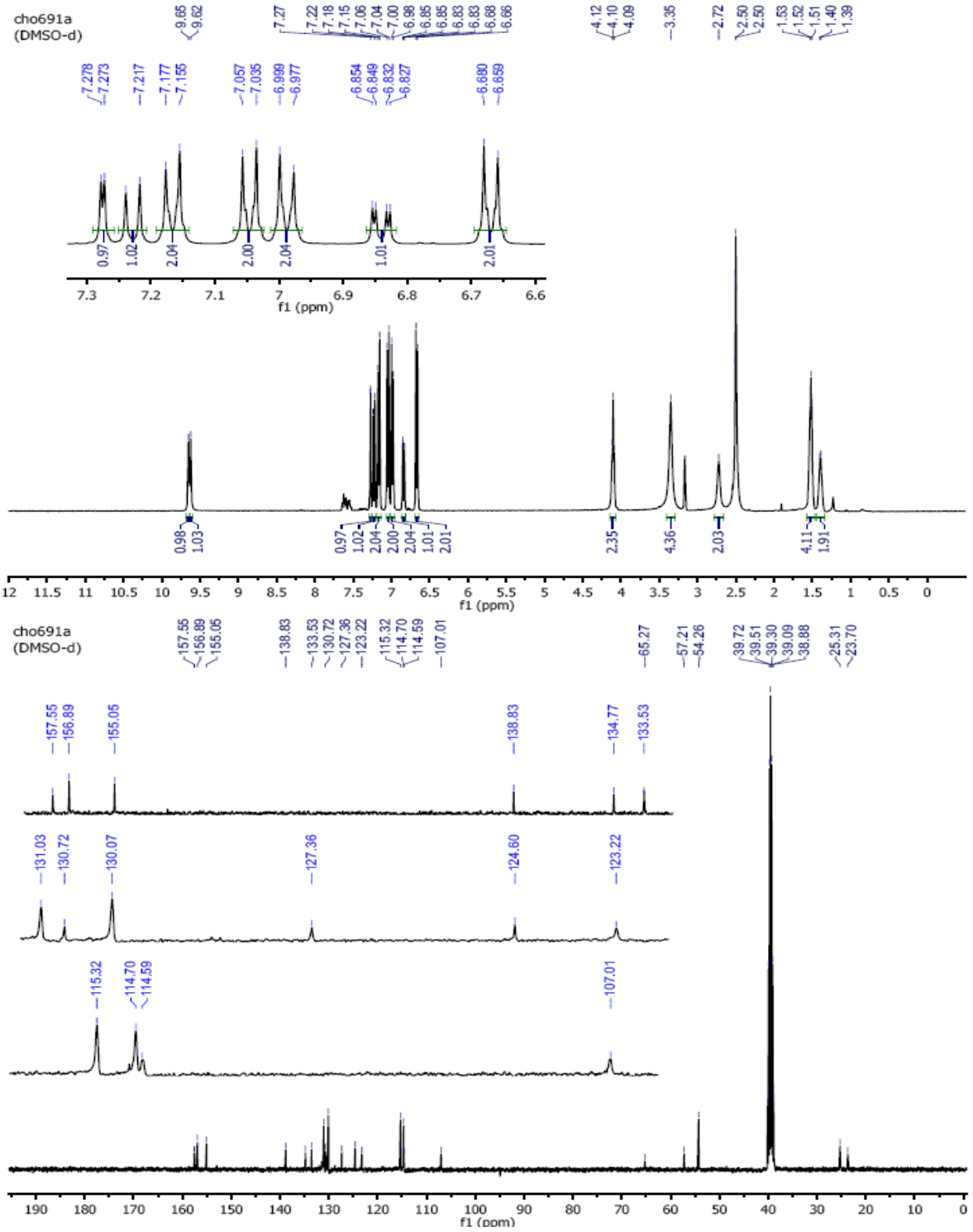
Compound 7{*19*}





Compound 7{*24*}





Compound 7{*27*}