

Supporting Information

A Straightforward Access to Specific Bisindole Systems Related to Caulersin

Fei Hu, Yong-tian Yang, Fei Yu, Mei Xu and Sheng Liu

State Key Laboratory of Discovery and Utilization of Functional Components in Traditional Chinese Medicine,
Natural Products Research Center of Guizhou Province, Guizhou Medical University.

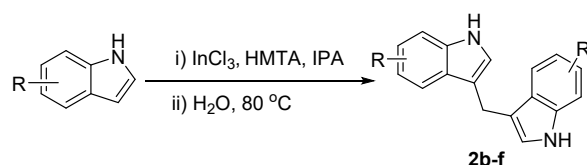
lsheng@126.com

1. Experimental and spectroscopic data for compounds **2**, **1**, **8**, **9**, **11**, **page S2-13**
2. NMR spectra for compounds **2**, **1**, **8**, **9**, **11**, **page S14-73**

Column chromatographic purifications were performed on SDZF silica gel 160. ^1H , ^{13}C and ^{19}F NMR spectra were obtained on a Bruker NMR spectrometer at 600 MHz, 150 MHz and 565 MHz, respectively, referenced internally based on the residual solvent signal. The data reported for the ^1H NMR spectra are as follows: chemical shift (δ , ppm), multiplicity (s, singlet; d, doublet; t, triplet; q, quartet; and m, multiplet), coupling constant in hertz, and number of protons. The data reported for the ^{13}C and ^{19}F spectra are given as chemical shift (δ , ppm). High-resolution mass spectra (HRMS) were obtained on an Agilent mass spectrometer by electrospray ionization-time of flight (ESI-TOF) analysis. Melting points were measured with a melting point instrument without correction. All the chemical reagents and solvents were purchased from commercial sources and used as received.

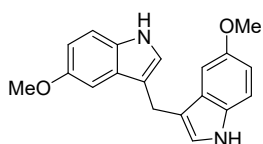
1. Experimental and spectroscopic data for compounds **2**, **1**, **8**, **9**, **11**, page S2-13

1.1 Synthesis of compounds **2b-f**



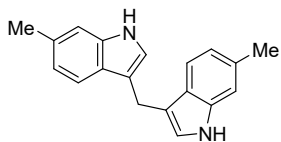
To a solution of indole (5.10 mmol) in 10 mL IPA was added InCl_3 (95 mg, 0.51 mmol) and HMTA (150 mg, 0.51 mmol), then the resulting mixture was stirred at room temperature for 8 h. Water (10 mL) was added to the reaction mixture followed by heating at $80\text{ }^\circ\text{C}$ for 0.5 h. The mixture was extracted with EA three times, the combined organic layers were dried over Na_2SO_4 and concentrated under reduced pressure. The obtained crude products were purified by flash column silica gel chromatography (PE/EA = 10:1) to give compounds **2b-f**.

Bis(5-methoxy-1*H*-indol-3-yl)methane (**2b**)



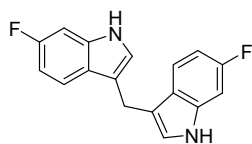
Purification by flash column silica gel chromatography to give **2b** as a white solid (470 mg, yield 45%). $^1\text{H NMR}$ (600 MHz, $\text{DMSO-}d_6$) δ 10.56 (br s, 2H), 7.22 (d, $J = 8.6$ Hz, 2H), 7.09 (d, $J = 2.2$ Hz, 2H), 7.02 (d, $J = 2.4$ Hz, 2H), 6.70 (dd, $J = 2.4, 8.6$ Hz, 2H), 4.06 (s, 2H), 3.71 (s, 6H). The NMR data is consistent with literature values.¹

Bis(6-methyl-1*H*-indol-3-yl)methane (**2c**)



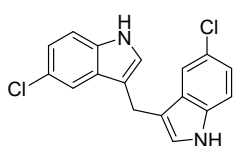
Purification by flash column silica gel chromatography to give **2c** as a white solid (610 mg, yield 58%). $^1\text{H NMR}$ (600 MHz, $\text{DMSO-}d_6$) δ 10.54 (s, 2H), 7.38 (d, $J = 8.0$ Hz, 2H), 7.12 (s, 2H), 7.02 (s, 2H), 6.76 (d, $J = 8.0$ Hz, 2H), 4.08 (s, 2H), 2.37 (s, 6H). The NMR data is consistent with literature values.²

Bis(6-fluoro-1*H*-indol-3-yl)methane (**2d**)



Purification by flash column silica gel chromatography to give **2d** as a white solid (450 mg, yield 35%). $^1\text{H NMR}$ (600 MHz, $\text{DMSO-}d_6$) δ 10.82 (s, 2H), 7.47 (d, $J = 3.0$ Hz, 2H), 7.15 (d, $J = 2.0$ Hz, 2H), 7.12 - 7.07 (m, 2H), 6.78 (s, 2H), 4.26 - 3.88 (m, 2H). The NMR data is consistent with literature values.³

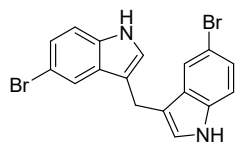
Bis(5-chloro-1*H*-indol-3-yl)methane (**2e**)



Purification by flash column silica gel chromatography to give **2e** as a white solid (600 mg, yield 60%). $^1\text{H NMR}$ (600 MHz, $\text{DMSO-}d_6$) δ 10.98 (s, 2H), 7.52 (d, $J =$

2.0 Hz, 2H), 7.34 (d, $J = 8.6$ Hz, 2H), 7.29 (d, $J = 2.2$ Hz, 2H), 7.03 (dd, $J = 2.1, 8.5$ Hz, 2H), 4.10 (s, 2H). The NMR data is consistent with literature values.³

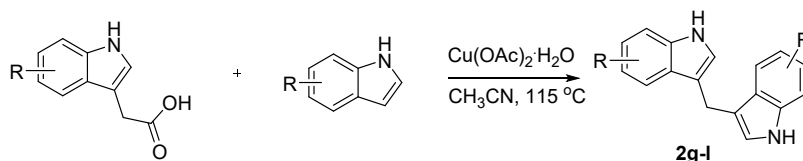
Bis(5-bromo-1*H*-indol-3-yl)methane (2f)



Purification by flash column silica gel chromatography to give **2f** as a white solid (560 mg, yield 55%). ¹H NMR (600 MHz, DMSO-*d*₆) δ 10.75 (br. s., 2H), 7.54 (d, $J = 7.8$ Hz, 2H), 7.33 (d, $J = 8.2$ Hz, 2H), 7.06 - 7.02 (m, 2H), 6.95 - 6.91 (m, 2H),

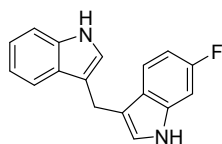
4.15 (s, 2H). The NMR data is consistent with literature values.¹

1.2 Synthesis of compounds 2g-l



To the solution of 2-(1*H*-indol-3-yl)acetic acid (5.71 mmol) in CH₃CN (15 mL) in a 50 mL sealed tube, indole (0.92 g, 6.81 mmol) and Cu(OAc)₂·H₂O (1.14 g, 5.71 mmol) was added. The reaction mixture was stirred at 115 °C for 24 h. The solution was poured into water and extracted with EA three times. The combined organic layers were washed with brine solutions, dried over Na₂SO₄ and evaporated under reduced pressure. The obtained crude products were purified by flash column silica gel chromatography (PE/EA = 10:1) to give compounds **2g-l**.

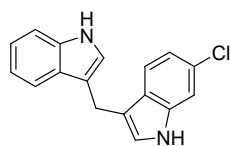
3-((1*H*-indol-3-yl)methyl)-6-fluoro-1*H*-indole (2g)



Purification by flash column silica gel chromatography to give **2g** as a white solid (740 mg, yield 49%). m.p. 120.6-121.7 °C. ¹H NMR (600 MHz, DMSO-*d*₆) δ 10.85 (s, 1H), 10.78 (s, 1H), 7.53 (d, $J = 7.8$ Hz, 2H), 7.34 (d, $J = 8.0$ Hz, 1H), 7.17 (d, $J =$

2.4 Hz, 2H), 7.14 - 7.10 (m, 1H), 7.07 - 7.03 (m, 1H), 6.98 - 6.90 (m, 1H), 6.80 (s, 1H), 4.18 - 4.11 (m, 2H). ¹³C NMR (150 MHz, DMSO-*d*₆) δ 158.8 (d, $J = 232.5$ Hz), 136.4, 136.2 (d, $J = 12.0$ Hz), 127.2 (d, $J = 6.0$ Hz), 124.1 (d, $J = 6.0$ Hz), 123.4 (d, $J = 10.5$ Hz), 122.8 (d, $J = 6.0$ Hz), 120.8 (d, $J = 4.5$ Hz), 119.7 (d, $J = 9.0$ Hz), 118.7 (d, $J = 3.0$ Hz), 118.1 (d, $J = 6.0$ Hz), 114.5 (d, $J = 37.5$ Hz), 114.1 (d, $J = 37.5$ Hz), 111.3 (d, $J = 3.0$ Hz), 106.5 (d, $J = 30.0$ Hz), 97.3 (d, $J = 25.5$ Hz), 20.9 (d, $J = 6.0$ Hz). ¹⁹F NMR (565 MHz, DMSO-*d*₆) δ -122.58. HRMS (ESI-TOF) m/z : [M+Na]⁺ Calcd for C₁₇H₁₃FN₂Na 287.0955; found 287.0949.

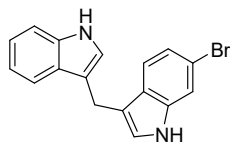
3-((1*H*-indol-3-yl)methyl)-6-chloro-1*H*-indole (2h)



Purification by flash column silica gel chromatography to give **2h** as a white solid (850 mg, yield 53%). ¹H NMR (600 MHz, DMSO-*d*₆) δ 10.97 - 10.86 (m, 1H), 10.80 - 10.70 (m, 1H), 7.57 - 7.46 (m, 2H), 7.42 - 7.35 (m, 1H), 7.36 - 7.30 (m, 1H), 7.23 - 7.17 (m,

1H), 7.18 - 7.12 (m, 1H), 7.10 - 7.01 (m, 1H), 6.97 - 6.89 (m, 2H), 4.18 - 4.09 (m, 2H). The NMR data is consistent with literature values.⁴

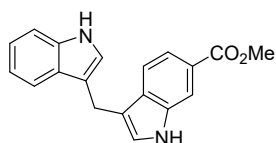
3-((1*H*-indol-3-yl)methyl)-6-bromo-1*H*-indole (**2i**)



Purification by flash column silica gel chromatography to give **2i** as a white solid (650 mg, yield 38%). ¹H NMR (600 MHz, DMSO-*d*₆) δ 10.91 (s, 1H), 10.75 (d, *J* = 11.8 Hz, 1H), 7.61 - 7.40 (m, 3H), 7.33 (d, *J* = 8.0 Hz, 1H), 7.21 - 7.11 (m,

2H), 7.08 - 7.01 (m, 2H), 6.96 - 6.89 (m, 1H), 4.28 - 3.98 (m, 2H). The NMR data is consistent with literature values.⁵

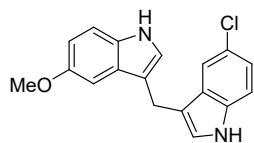
Methyl 3-((1*H*-indol-3-yl)methyl)-1*H*-indole-6-carboxylate (**2j**)



Purification by flash column silica gel chromatography to give **2j** as a white solid (710 mg, yield 43%). ¹H NMR (600 MHz, DMSO-*d*₆) δ 11.23 - 11.19 (m, 1H), 10.81 - 10.75 (m, 1H), 8.06 - 7.98 (m, 1H), 7.64 - 7.62 (m, 1H), 7.59 - 7.56

(m, 1H), 7.53 - 7.50 (m, 1H), 7.44 - 7.41 (m, 1H), 7.35 - 7.31 (m, 1H), 7.17 - 7.15 (m, 1H), 7.06 - 7.02 (m, 1H), 6.94 - 6.90 (m, 1H), 4.23 - 4.10 (m, 2H), 3.90 - 3.77 (m, 3H). The NMR data is consistent with literature values.⁶

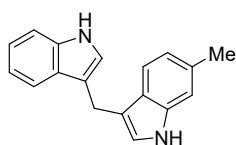
5-chloro-3-((5-methoxy-1*H*-indol-3-yl)methyl)-1*H*-indole (**2k**)



Purification by flash column silica gel chromatography to give **2k** as a white solid (630 mg, yield 57%). m.p. 115.6-116.7 °C. ¹H NMR (600 MHz, DMSO-*d*₆) δ 11.01 - 10.92 (m, 1H), 10.65 - 10.54 (m, 1H), 7.58 - 7.48 (m, 1H), 7.38 - 7.32 (m,

1H), 7.31 - 7.26 (m, 1H), 7.24 - 7.20 (m, 1H), 7.15 - 7.08 (m, 1H), 7.06 - 7.00 (m, 2H), 6.77 - 6.66 (m, 1H), 4.13 - 4.06 (m, 2H), 3.73 - 3.70 (m, 3H). ¹³C NMR (150 MHz, DMSO-*d*₆) δ 152.8, 134.9, 131.6, 128.3, 127.4, 124.7, 123.6, 122.7, 120.7, 118.0, 114.2, 113.6, 112.9, 112.0, 110.8, 100.7, 55.3, 20.7. HRMS (ESI-TOF) *m/z*: [M+Na]⁺ Calcd for C₁₈H₁₅ClN₂ONa 333.0765; found 333.0756.

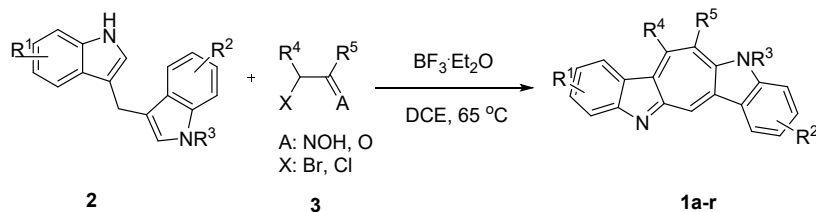
3-((1*H*-indol-3-yl)methyl)-6-methyl-1*H*-indole (**2l**)



Purification by flash column silica gel chromatography to give **2l** as a white solid (920 mg, yield 60%). ¹H NMR (600 MHz, DMSO-*d*₆) δ 10.73 (s, 1H), 10.57 (s., 1H), 7.53 (d, *J* = 8.0 Hz, 1H), 7.41 (d, *J* = 8.0 Hz, 1H), 7.34 (d, *J* = 8.2 Hz, 1H), 7.13

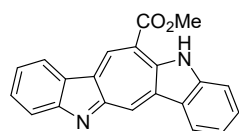
(s, 2H), 7.07 - 7.01 (m, 2H), 6.96 - 6.91 (m, 1H), 6.77 (dd, *J* = 0.8, 8.0 Hz, 1H), 4.12 (s, 2H), 2.37 (s, 3H). The NMR data is consistent with literature values.⁷

1.3 Synthesis of compounds **1a-r**



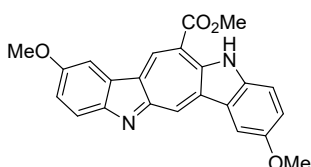
To a solution of DIM **2** (1.22 mmol) in 4 mL DCE was added **3** (1.46 mmol) and $\text{BF}_3 \cdot \text{Et}_2\text{O}$ (231 μL , 1.83 mmol), then the resulting mixture was stirred at 65 °C for 10 h under air. The mixture was cooled to room temperature, then saturated sodium bicarbonate was added, the mixtures were extracted with DCM, the combined organic layers were washed with water, dried over Na_2SO_4 and concentrated under reduced pressure. The obtained crude products were purified by flash column silica gel chromatography (DCM/MeOH = 100:1 to 20:1) to give compounds **1a-r**.

Methyl 11*H*-cyclohepta[1,2-*b*:4,5-*b'*]diindole-12-carboxylate (**1a**)



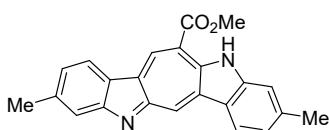
Purification by flash column silica gel chromatography to give **1a** as a red solid (240 mg, yield:60%). m.p. 170.4-171.6 °C. ^1H NMR (600 MHz, $\text{CF}_3\text{CO}_2\text{D}$) δ 10.25 (s, 1H), 9.81 (br. s., 1H), 8.64 (d, $J = 7.6$ Hz, 1H), 8.57 (d, $J = 7.6$ Hz, 1H), 8.09 - 8.07 (m, 1H), 8.05 (d, $J = 7.0$ Hz, 1H), 8.02 (t, $J = 7.2$ Hz, 2H), 7.91 (t, $J = 7.0$ Hz, 1H), 7.81 (t, $J = 7.1$ Hz, 1H), 4.69 (s, 3H). ^{13}C NMR (150 MHz, $\text{CF}_3\text{CO}_2\text{D}$) δ 170.9, 150.0, 144.0, 142.9, 142.4, 137.5, 137.4, 135.4, 134.9, 130.7, 128.9, 128.3, 127.5, 127.4, 125.6, 123.3, 122.8, 118.1, 115.7, 115.3, 56.3. HRMS (ESI-TOF) m/z : $[\text{M}+\text{H}]^+$ Calcd for $\text{C}_{21}\text{H}_{15}\text{N}_2\text{O}_2$ 327.1129; found 327.1128.

Methyl 2,8-dimethoxy-11*H*-cyclohepta[1,2-*b*:4,5-*b'*]diindole-12-carboxylate (**1b**)



Purification by flash column silica gel chromatography to give **1b** as a red solid (195 mg, yield 51%). m.p. 203.8-205.4 °C. ^1H NMR (600 MHz, $\text{DMSO-}d_6 + \text{CF}_3\text{CO}_2\text{D}$) δ 9.04 (br. s., 1H), 8.96 (br. s., 1H), 7.56 (d, $J = 7.6$ Hz, 1H), 7.35 (br. s., 1H), 7.29 - 7.22 (m, 2H), 7.06 (d, $J = 7.2$ Hz, 1H), 6.99 (d, $J = 6.8$ Hz, 1H), 4.06 (br. s., 3H), 3.78 (br. s., 3H), 3.74 (br. s., 3H). ^{13}C NMR (150 MHz, $\text{DMSO-}d_6 + \text{CF}_3\text{CO}_2\text{D}$) δ 172.0, 166.1, 156.4, 156.2, 144.8, 139.4, 135.0, 134.1, 133.0, 131.1, 127.0, 125.9, 125.0, 123.9, 122.4, 120.5, 115.1, 102.4, 55.4, 55.3, 53.6. HRMS (ESI-TOF) m/z Calcd for $\text{C}_{23}\text{H}_{19}\text{N}_2\text{O}_4$ $[\text{M}+\text{H}]^+$: 387.1339; found 387.1329.

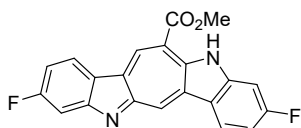
Methyl 3,9-dimethyl-11*H*-cyclohepta[1,2-*b*:4,5-*b'*]diindole-12-carboxylate (**1c**)



Purification by flash column silica gel chromatography to give **1c** as a red solid (233 mg, yield 60%). m.p. 178.7-180.6 °C. ^1H NMR (600 MHz, $\text{DMSO-}d_6$) δ 13.22 (br. s, 1H), 9.46 (br. s, 1H), 9.30 (br. s, 1H), 8.23 (br. s, 2H), 7.61 (br. s, 1H), 7.38 (br. s, 2H), 7.26 (br. s, 1H), 4.19 (s, 3H), 2.48 (br. s, 3H), 2.45 (br. s, 3H). ^{13}C NMR

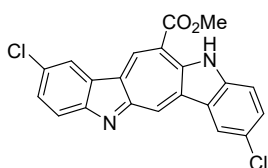
(150 MHz, DMSO-*d*₆) δ 166.5, 145.7, 143.0, 142.7, 141.1, 141.0, 140.9, 133.3, 132.9, 127.0, 126.0, 125.9, 125.8, 123.3, 121.3, 121.1, 121.0, 117.1, 114.2, 112.8, 54.4, 22.5, 22.3. HRMS ESI-TOF) m/z Calcd for C₂₃H₁₉N₂O₂ [M+H]⁺: 355.1442; found 355.1440.

Methyl 3,9-difluoro-11H-cyclohepta[1,2-b:4,5-b']diindole-12-carboxylate (1d)



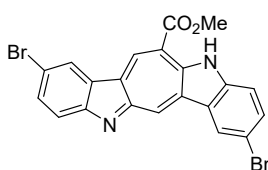
Purification by flash column silica gel chromatography to give **1d** as a red solid (195 mg, yield 50%). m.p. 429.8-431.2 °C. ¹H NMR (600 MHz, DMSO-*d*₆+CF₃CO₂D) δ 9.65 - 9.47 (m, 2H), 8.45 (br. s, 1H), 8.36 (br. s, 1H), 7.59 (d, J = 7.4 Hz, 1H), 7.44 (d, J = 7.2 Hz, 1H), 7.33 (br. s, 2H), 4.13 (br. s, 3H). ¹³C NMR (150 MHz, CF₃CO₂D) δ 168.7, 167.3 (d, J = 40.5 Hz), 165.7 (d, J = 40.5 Hz), 148.5, 143.1, 142.3, 141.9 (d, J = 13.5 Hz), 135.2, 135.0, 129.2, 126.4, 123.5 (d, J = 10.5 Hz), 123.1 (d, J = 10.5 Hz), 122.8, 120.1, 117.1, 115.0 (d, J = 27.0 Hz), 114.4 (d, J = 25.5 Hz), 100.9 (d, J = 27.0 Hz), 99.7 (d, J = 27.0 Hz), 54.4. ¹⁹F NMR (565 MHz, DMSO-*d*₆+CF₃CO₂D) δ -76.03. HRMS (ESI-TOF) m/z Calcd for C₂₁H₁₃F₂N₂O₂ [M+H]⁺: 363.0940; found 363.0937.

Methyl 2,8-dichloro-11H-cyclohepta[1,2-b:4,5-b']diindole-12-carboxylate (1e)



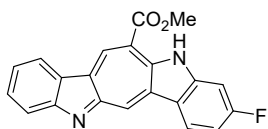
Purification by flash column silica gel chromatography to give **1e** as a red solid (153 mg, yield 40%). m.p. 323.2-324.6 °C. ¹H NMR (600 MHz, CF₃CO₂D) δ 10.65 (s, 1H), 10.24 (s, 1H), 8.88 (s, 1H), 8.84 (s, 1H), 8.33 (d, J = 8.6 Hz, 1H), 8.24 - 8.22 (m, 3H), 4.71 (s, 3H). ¹³C NMR (150 MHz, CF₃CO₂D) δ 168.8, 148.9, 142.5, 139.4, 139.0, 136.5, 134.9, 133.8, 133.6, 132.5, 132.4, 128.3, 128.1, 127.4, 125.0, 121.3, 120.5, 116.8, 115.1, 114.7, 54.4. HRMS (ESI-TOF) m/z : [M+H]⁺ Calcd for C₂₁H₁₃Cl₂N₂O₂ 395.0349; found 395.0341.

Methyl 2,8-dibromo-11H-cyclohepta[1,2-b:4,5-b']diindole-12-carboxylate (1f)



Purification by flash column silica gel chromatography to give **1f** as a red solid (198 mg, yield 55%). m.p. 368.5-369.1 °C. ¹H NMR (600 MHz, DMSO-*d*₆+CF₃CO₂D) δ 9.77 (s, 1H), 9.72 (s, 1H), 8.70 (br. s., 1H), 8.62 (br. s., 1H), 7.91 (d, J = 8.4 Hz, 1H), 7.84 (d, J = 8.0 Hz, 1H), 7.80 (d, J = 8.4 Hz, 1H), 7.73 (d, J = 8.4 Hz, 1H), 4.19 (s, 3H). ¹³C NMR (150 MHz, DMSO-*d*₆+CF₃CO₂D) δ 166.4, 147.1, 141.8, 139.7, 139.6, 135.7, 134.8, 134.4, 133.1, 129.5, 127.3, 126.9, 125.5, 124.6, 124.3, 118.3, 117.2, 116.7, 115.7, 54.1. HRMS (ESI-TOF) m/z : [M+H]⁺ Calcd for C₂₁H₁₃Br₂N₂O₂ 482.9338; found 482.9325.

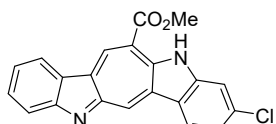
Methyl 9-fluoro-11H-cyclohepta[1,2-b:4,5-b']diindole-12-carboxylate (1g)



Purification by flash column silica gel chromatography to give **1g** as a red solid (227 mg, yield 58%). m.p. 419.7-421.6 °C. ¹H NMR (600 MHz, CF₃CO₂D) δ

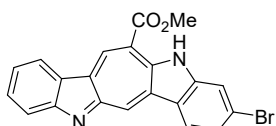
10.39 (s, 1H), 9.89 (s, 1H), 8.62 (d, $J = 8.2$ Hz, 1H), 8.57 (dd, $J = 4.5, 8.7$ Hz, 1H), 8.03 - 7.96 (m, 2H), 7.81 (t, $J = 7.0$ Hz, 1H), 7.74 (d, $J = 6.6$ Hz, 1H), 7.54 - 7.42 (m, 1H), 4.43 (s, 3H). ^{13}C NMR (150 MHz, $\text{CF}_3\text{CO}_2\text{D}$) δ 168.6, 167.1 (d, $J = 255.0$ Hz), 148.4, 142.2, 141.6 (d, $J = 13.5$ Hz), 140.9, 135.2, 134.7, 132.8, 129.0, 126.4, 126.0, 125.2, 123.2 (d, $J = 12.0$ Hz), 120.7, 119.8, 116.0, 114.0 (d, $J = 24.0$ Hz), 113.1, 100.7 (d, $J = 27.0$ Hz), 54.1. ^{19}F NMR (565 MHz, $\text{CF}_3\text{CO}_2\text{D}$) δ -77.61. HRMS (ESI-TOF) m/z : $[\text{M}+\text{H}]^+$ Calcd for $\text{C}_{21}\text{H}_{14}\text{F}_1\text{N}_2\text{O}_2$: 345.1034; found 345.1027.

Methyl 9-chloro-11H-cyclohepta[1,2-b:4,5-b']diindole-12-carboxylate (1h)



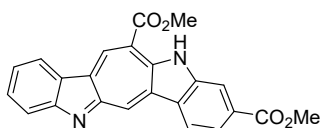
Purification by flash column silica gel chromatography to give **1h** as a red solid (230 mg, yield 60%). m.p. 313.0-315.0 °C. ^1H NMR (600 MHz, $\text{CF}_3\text{CO}_2\text{D}$) δ 10.44 (s, 1H), 9.93 (s, 1H), 8.66 (d, $J = 8.2$ Hz, 1H), 8.50 (d, $J = 8.4$ Hz, 1H), 8.04 (d, $J = 9.4$ Hz, 3H), 7.85 (t, $J = 7.0$ Hz, 1H), 7.72 (d, $J = 8.2$ Hz, 1H), 4.46 (s, 3H). ^{13}C NMR (150 MHz, $\text{CF}_3\text{CO}_2\text{D}$) δ 169.6, 149.6, 143.5, 142.4, 142.0, 141.3, 136.8, 135.7, 134.3, 130.7, 128.0, 127.5, 127.2, 126.6, 123.4, 123.2, 122.0, 118.0, 114.8, 114.5, 55.3. HRMS (ESI-TOF) m/z : $[\text{M}+\text{H}]^+$ Calcd for $\text{C}_{21}\text{H}_{14}\text{ClN}_2\text{O}_2$: 361.0738, found:361.0729.

Methyl 9-bromo-11H-cyclohepta[1,2-b:4,5-b']diindole-12-carboxylate (1i)



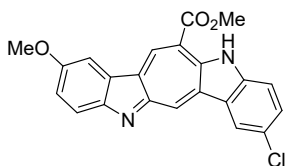
Purification by flash column silica gel chromatography to give **1i** as a red solid (190 mg, yield 50%). m.p. 301.7-303.5 °C. ^1H NMR (600 MHz, $\text{CF}_3\text{CO}_2\text{D}$) δ 10.54 (br. s., 1H), 10.04 (br. s., 1H), 8.80 (d, $J = 8.2$ Hz, 1H), 8.53 (d, $J = 7.4$ Hz, 1H), 8.33 (br. s., 1H), 8.23 - 8.17 (m, 2H), 8.04 - 8.01 (m, 1H), 7.97 (d, $J = 7.4$ Hz, 1H), 4.65 (s, 3H). ^{13}C NMR (150 MHz, $\text{CF}_3\text{CO}_2\text{D}$) δ 168.6, 148.0, 142.2, 141.1, 140.4, 135.9, 135.3, 133.5, 128.8, 128.1, 127.3, 126.9, 125.6, 124.8, 123.5, 121.6, 121.3, 116.6, 116.3, 113.7, 54.2. HRMS (ESI-TOF) m/z : $[\text{M}+\text{H}]^+$ Calcd for $\text{C}_{21}\text{H}_{14}\text{BrN}_2\text{O}_2$:405.0233, found:405.0219.

Dimethyl 11H-cyclohepta[1,2-b:4,5-b']diindole-9,12-dicarboxylate (1j)



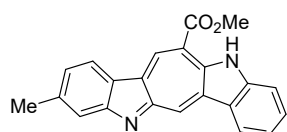
Purification by flash column silica gel chromatography to give **1j** as a red solid (240 mg, yield 63%). m.p. 371.8-372.1 °C. ^1H NMR (600 MHz, $\text{CF}_3\text{CO}_2\text{D}$) δ 11.68 (d, $J = 4.4$ Hz, 1H), 11.23 (d, $J = 4.2$ Hz, 1H), 9.94 (d, $J = 12.8$ Hz, 3H), 9.74 - 9.64 (m, 1H), 9.30 (d, $J = 7.0$ Hz, 2H), 9.13 (d, $J = 6.4$ Hz, 1H), 5.84 - 5.74 (m, 3H), 5.55 - 5.45 (m, 3H). ^{13}C NMR (150 MHz, $\text{CF}_3\text{CO}_2\text{D}$) δ 170.2, 169.2, 149.6, 142.6, 142.2, 140.5, 137.3, 134.3, 133.5, 130.3, 129.5, 128.5, 127.3, 126.5, 122.4, 121.9, 117.7, 114.4, 55.2, 54.3. HRMS (ESI-TOF) m/z : $[\text{M}+\text{H}]^+$ Calcd for $\text{C}_{23}\text{H}_{17}\text{N}_2\text{O}_4$ 385.1183; found 385.1172.

Methyl 8-chloro-2-methoxy-11H-cyclohepta[1,2-b:4,5-b']diindole-12-carboxylate (1k)



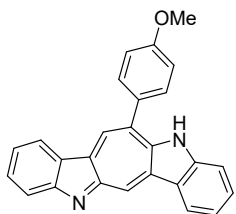
Purification by flash column silica gel chromatography to give **1k** as a dark red solid (215 mg, yield 57%). m.p. 334.9-336.1 °C. ¹H NMR (600 MHz, CF₃CO₂D) δ 10.90 (s, 1H), 10.40 (s, 1H), 9.08 (s, 1H), 8.72 (s, 1H), 8.60 (d, *J* = 9.0 Hz, 1H), 8.56 (d, *J* = 8.6 Hz, 1H), 8.49 (d, *J* = 8.6 Hz, 1H), 8.37 (d, *J* = 9.0 Hz, 1H), 5.11 (s, 3H), 4.87 (s, 3H). ¹³C NMR (150 MHz, CF₃CO₂D) δ 169.0, 158.3, 148.7, 142.2, 138.9, 137.4, 136.5, 133.7, 133.6, 132.4, 128.8, 128.1, 125.4, 124.9, 121.4, 116.6, 115.2, 115.1, 103.0, 56.7, 54.7. HRMS (ESI-TOF) *m/z*: [M+H]⁺ Calcd for C₂₂H₁₆ClN₂O₃ 391.0844; found 391.0832.

Methyl 3-methyl-11H-cyclohepta[1,2-b:4,5-b']diindole-12-carboxylate (**1l**)



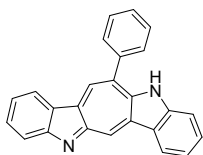
Purification by flash column silica gel chromatography to give **1l** (Containing 10% **1l'**) as a red solid (165 mg, yield 42%). m.p. 295.1-296.3 °C. Selected NMR signals for compound **1l**. ¹H NMR (600 MHz, CF₃CO₂D) δ 10.38 (s, 1H), 9.86 (br. s., 1H), 8.70 (d, *J* = 8.0 Hz, 1H), 8.51 (d, *J* = 8.0 Hz, 1H), 8.11 (d, *J* = 7.2 Hz, 1H), 8.09 (br. s., 1H), 7.94 (br. s., 1H), 7.89 (br. s., 1H), 7.72 (br. s., 1H), 4.59 (s, 3H), 2.82 (s, 3H). ¹³C NMR (150 MHz, CF₃CO₂D) δ 168.8, 147.8, 146.2, 142.0, 140.8, 140.7, 135.4, 134.9, 132.5, 128.3, 127.0, 126.1, 125.8, 125.1, 121.1, 120.9, 120.6, 115.9, 115.7, 115.2, 114.0, 113.3, 113.1, 54.2, 20.9. HRMS (ESI-TOF) *m/z*: [M+H]⁺ Calcd for C₂₂H₁₇N₂O₂ 341.1285; found 341.1280.

12-(4-methoxyphenyl)-11H-cyclohepta[1,2-b:4,5-b']diindole (**1o**)



Purification by flash column silica gel chromatography to give **1o** as a yellow solid (245 mg, yield 52%). m.p. 190.5-191.0 °C. ¹H NMR (600 MHz, DMSO-*d*₆+CF₃CO₂D) δ 9.60 (s, 1 H), 9.08 (s, 1H), 8.43 (t, *J* = 7.6 Hz, 2H), 7.71 (s, 1H), 7.62 (dd, *J* = 8.5, 15.8 Hz, 4H), 7.56 - 7.53 (m, 1H), 7.49 (s, 1H), 7.29 - 7.25 (m, 1H), 7.19 (d, *J* = 8.4 Hz, 2H), 3.89 (s, 3H). ¹³C NMR (150 MHz, DMSO-*d*₆+CF₃CO₂D) δ 160.6, 147.2, 141.1, 140.7, 140.5, 134.7, 134.5, 131.6, 131.3, 131.2, 131.0, 130.0, 125.8, 124.9, 124.5, 123.4, 122.6, 122.0, 121.6, 115.1, 113.8, 112.9, 55.2. HRMS (ESI-TOF) *m/z*: [M+H]⁺ Calcd for C₂₆H₁₉N₂O:375.1492, found:375.1487.

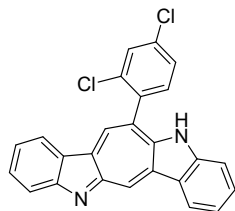
12-phenyl-11H-cyclohepta[1,2-b:4,5-b']diindole (**1p**)



Purification by flash column silica gel chromatography to give **1p** as a yellow solid (160 mg, yield 38%). m.p. 233.6-234.1 °C. ¹H NMR (600 MHz, DMSO-*d*₆+CF₃CO₂D) δ 9.88 (br. s, 1H), 9.34 (br. s, 1H), 8.75 - 8.54 (m, 2H), 7.82 (d, *J* = 6.8 Hz, 2H), 7.77 (s, 3H), 7.74 - 7.66 (m, 4H), 7.60 (br. s, 1H), 7.41 (br. s, 1H). ¹³C NMR (150 MHz, DMSO-*d*₆+CF₃CO₂D) δ 147.3, 141.2,

141.0, 140.8, 138.9, 135.1, 134.9, 132.1, 131.5, 130.2, 130.1, 129.8, 129.7, 126.7, 125.3, 124.7, 123.7, 122.9, 122.6, 122.1, 114.1, 113.2. HRMS (ESI-TOF) m/z : $[M+H]^+$ Calcd for $C_{25}H_{17}N_2$:345.1386, found:345.1381.

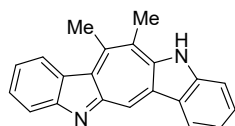
12-(2,4-dichlorophenyl)-11*H*-cyclohepta[1,2-*b*:4,5-*b'*]diindole (**1q**)



Purification by flash column silica gel chromatography to give **1q** as a red solid (162 mg, yield 32%). m.p. 170.4-171.6 °C. 1H NMR (600 MHz, $DMSO-d_6 + CF_3CO_2D$) δ 9.77 (d, $J = 2.4$ Hz, 1H), 9.19 (d, $J = 3.4$ Hz, 1H), 8.45 (d, $J = 7.0$ Hz, 1H), 8.39 (br. s, 1H), 7.75 - 7.68 (m, 2H), 7.65 (br. s, 2H), 7.63 - 7.54 (m, 3H), 7.47 (d, $J = 4.0$

Hz, 1H), 7.34 (t, $J = 7.1$ Hz, 1H). ^{13}C NMR (150 MHz, $DMSO-d_6 + CF_3CO_2D$) δ 147.3, 141.2, 141.1, 140.9, 136.0, 135.8, 134.8, 134.4, 132.9, 132.1, 131.5, 131.4, 130.2, 130.0, 129.9, 128.4, 126.8, 125.1, 124.5, 123.6, 123.0, 121.7, 121.6, 113.4, 113.0. HRMS (ESI-TOF) m/z : $[M+H]^+$ Calcd for $C_{25}H_{15}Cl_2N_2$ 413.0607; found 413.0594.

12,13-dimethyl-11*H*-cyclohepta[1,2-*b*:4,5-*b'*]diindole (**1r**)

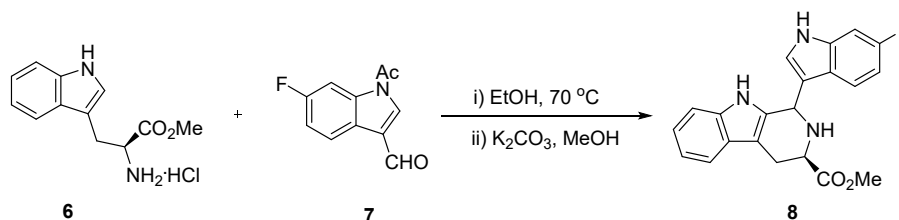


Purification by flash column silica gel chromatography to give **1r** as a red solid (152 mg, yield 42%). m.p. 303.9-304.5 °C. 1H NMR (600 MHz, $DMSO-d_6$) δ 12.70 (br. s., 1H), 9.19 (s, 1H), 8.36 (d, $J = 8.4$ Hz, 1H), 8.25 (d, $J = 7.8$ Hz, 1H), 7.73 - 7.69

(m, 1H), 7.69 - 7.63 (m, 2H), 7.61 (d, $J = 7.8$ Hz, 1H), 7.49 (t, $J = 7.4$ Hz, 1H), 7.40 - 7.33 (m, 1H), 3.09 (s, 3H), 2.77 (s, 3H). ^{13}C NMR (150 MHz, $DMSO-d_6$) δ 149.2, 146.4, 140.4, 140.2, 139.5, 131.1, 130.7, 130.0, 129.5, 129.4, 126.1, 123.9, 123.6, 123.2, 123.0, 122.3, 121.3, 112.8, 112.7, 25.1, 20.5. HRMS (ESI-TOF) m/z : $[M+H]^+$ Calcd for $C_{21}H_{17}N_2$:297.1387, found:297.1379.

1.4 Alternative synthesis of **1g**

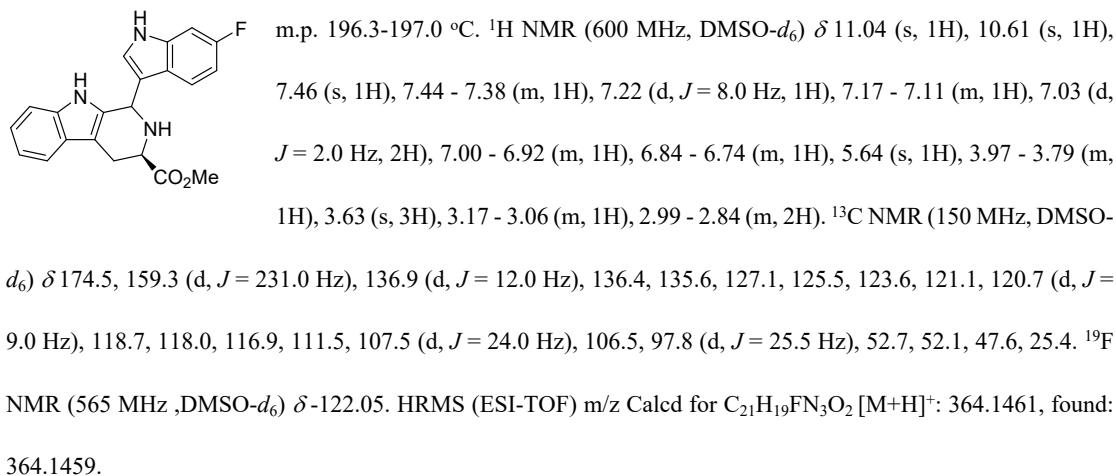
1.4.1 Synthesis of **8**



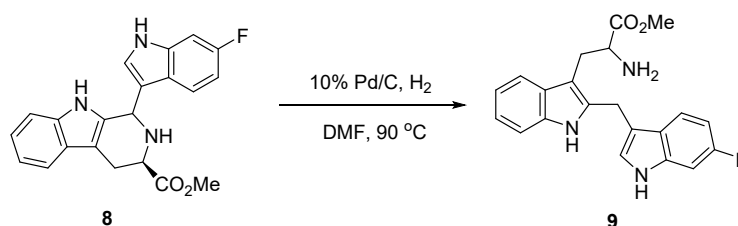
To a solution of compound **7** (1.0 g, 4.88 mmol) was dissolved in 5 mL of EtOH, and compound **6** (1.49 g, 5.87 mmol) was added with stirring. The mixture was refluxed at 70 °C for 12 h. After the reaction was completed as monitored by TLC, the mixture was concentrated under reduced pressure. Then the crude product was dissolved in 10 mL of MeOH, and potassium carbonate (2.69 g, 19.5 mmol) was slowly added with stirring at room temperature. The mixture was stirred at room temperature for 10 min. After the reaction was complete, the reaction mixture was diluted with EA three times and washed with saturated brine solution. The organic phase was dried over anhydrous

sodium sulfate and concentrated under reduced pressure to obtain a crude product. The crude product was purified by flash column chromatography (DCM/MeOH = 100:1 to 50:1) to give **8** as a white solid (1.53 g, yield 86%).

Methyl (3*R*)-1-(6-fluoro-1*H*-indol-3-yl)-2,3,4,9-tetrahydro-1*H*-pyrido[3,4-*b*]indole-3-carboxylate (8**)**

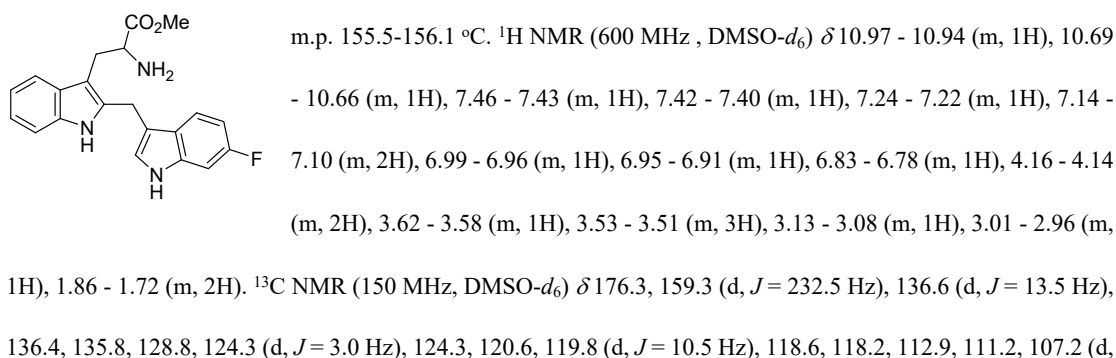


1.4.2 Synthesis of **9**



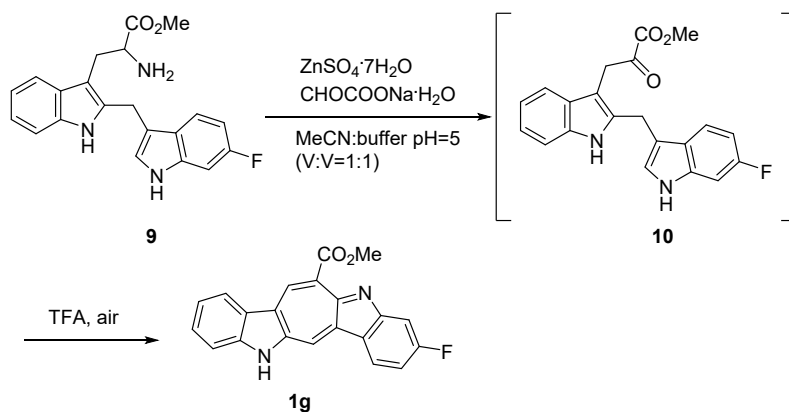
Compound **8** (1.0 g, 2.75 mmol) was dissolved in 12.0 mL of DMF, 10% Pd/C (100 mg) was added, and the mixture was stirred under a hydrogen atmosphere at 90 °C for 12 h. The mixture was filtered through Celite. The filtrate was diluted with ethyl acetate, washed three times with 10.0 mL of water, then washed with saturated brine. The organic phase was dried over anhydrous sodium sulfate and concentrated under reduced pressure to give a crude product. The crude product was purified by flash column chromatography (DCM/MeOH = 200:1) to obtain compound **9** as a white solid (690 mg, yield 69%).

Methyl 2-amino-3-(2-((6-fluoro-1*H*-indol-3-yl)methyl)-1*H*-indol-3-yl)propanoate (9**)**



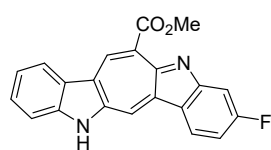
$J = 24.0$ Hz), 106.5, 97.8 (d, $J = 25.5$ Hz), 56.0, 51.8, 30.7, 22.3. ^{19}F NMR (565 MHz, $\text{DMSO-}d_6$) δ -122.29. HRMS (ESI-TOF) m/z Calcd for $\text{C}_{21}\text{H}_{21}\text{FN}_3\text{O}_2$ $[\text{M}+\text{H}]^+$: 366.1618, found: 366.1615.

1.4.3 Synthesis of **1g**



To a solution of compound **9** (323 mg, 0.88 mmol) in 8 mL of MeCN and 8 mL of buffer (pH = 5, containing 1.3 g sodium acetate and 0.24 mL acetic acid) were added $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ (254 mg, 0.88 mmol), $\text{CHOCOONa} \cdot \text{H}_2\text{O}$ (340 mg, 3.54 mmol). The resulting mixture was stirred at room temperature for 4 h, then water was added to the reaction, the mixture was extracted with ethyl acetate, the combined organic layers were dried over Na_2SO_4 and concentrated under reduced pressure. Then, compound **10** was dissolved in 3.0 mL of TFA at room temperature and reacted for 2 h. The mixture was quenched with water, extracted three times with DCM, dried over Na_2SO_4 , and concentrated under reduced pressure. The crude product was purified by column chromatography (DCM/MeOH = 30:1 to 20:1) to give **1g** as a red solid (119 mg, yield 39%).

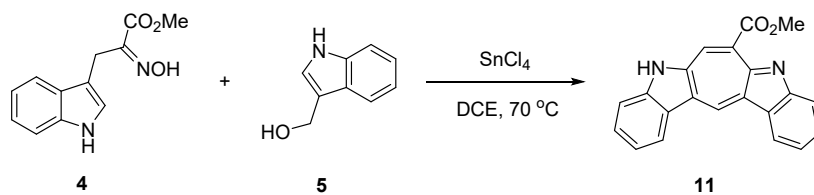
Methyl 9-fluoro-5H-cyclohepta[1,2-b:4,5-b']diindole-12-carboxylate (**1g**)



m.p. 179.5-181.7 °C. ^1H NMR (600 MHz, $\text{CF}_3\text{CO}_2\text{D}$) δ 10.75 (s, 1H), 10.24 (s, 1H), 9.00 (d, $J = 8.1$ Hz, 1H), 8.95 (dd, $J = 4.5, 8.5$ Hz, 1H), 8.41 - 8.35 (m, 2H), 8.20 (t, $J = 7.3$ Hz, 1H), 8.12 (d, $J = 7.9$ Hz, 1H), 7.87 (t, $J = 8.6$ Hz, 1H), 4.83 (s, 3H). ^{13}C

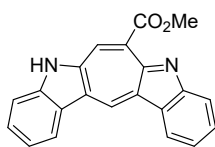
NMR (150 MHz, $\text{CF}_3\text{CO}_2\text{D}$) δ 169.0, 167.5 (d, $J = 253.5$ Hz), 148.8, 142.6, 142.0 (d, $J = 12.0$ Hz), 141.3, 135.6, 135.1, 133.2, 129.4, 126.8, 126.4, 125.6, 123.6 (d, $J = 10.5$ Hz), 121.1, 120.2, 116.4, 114.4 (d, $J = 25.5$ Hz), 113.5, 101.1 (d, $J = 27.0$ Hz), 54.6 (d, $J = 36.0$ Hz). ^{19}F NMR (565 MHz, $\text{CF}_3\text{CO}_2\text{D}$) δ -77.42. HRMS (ESI-TOF) m/z Calcd for $\text{C}_{21}\text{H}_{14}\text{FN}_2\text{O}_2$ $[\text{M}+\text{H}]^+$: 345.1039, found: 345.1017.

1.5 Synthesis of compound **11**



Compound **4** (500 mg, 2.16 mmol) and compound **5** (508 mg, 3.45 mmol) were dissolved in DCE (20 mL). SnCl₄ (201 μL, 1.72 mmol) was added dropwise to the mixture at 0°C. The resulting solution was heated to 70 °C under air and stirred for 3 h. The mixture was quenched with saturated aqueous sodium bicarbonate, then extracted with DCM. The combined organic layers were dried over anhydrous sodium sulfate, filtered and concentrated under reduced pressure. The crude product was purified by column chromatography (DCM/MeOH = 50:1) to give **11a** as a red solid (290 mg, yield 41%).

Methyl 5H-cyclohepta[1,2-b:5,4-b']diindole-7-carboxylate (11)



m.p. 172.5-173.2 °C. ¹H NMR (600 MHz, CF₃CO₂D) δ 10.41 (s, 1H), 9.97 (s, 1H), 8.65 (dd, *J* = 7.9, 18.6 Hz, 2H), 8.11 (d, *J* = 8.2 Hz, 1H), 8.08 - 8.03 (m, 3H), 7.86 (td, *J* = 7.4, 19.6 Hz, 2H), 4.51 (s, 3H). ¹³C NMR (150 MHz, CF₃CO₂D) δ 168.8, 147.8,

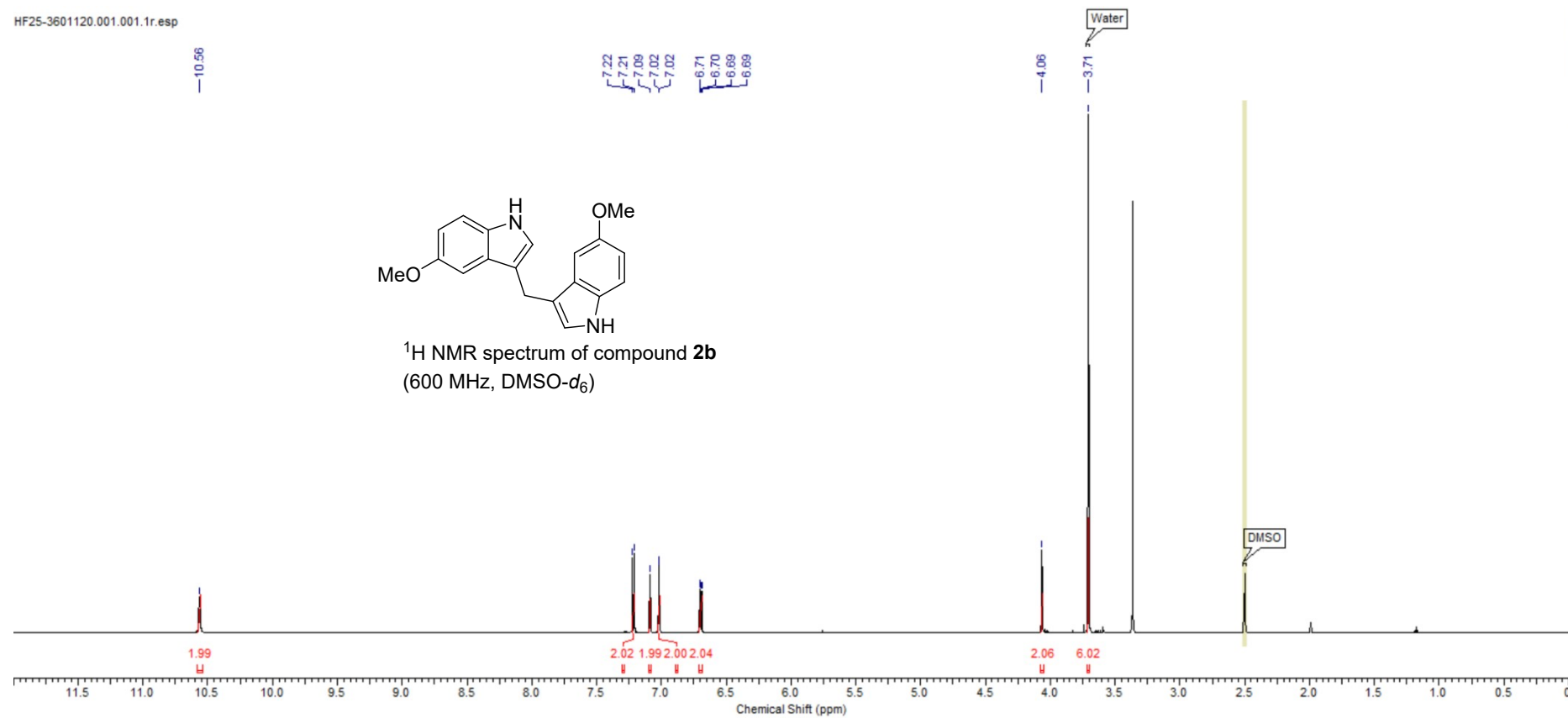
141.9, 140.8, 140.3, 135.4, 133.2, 132.6, 128.5, 126.8, 126.2, 125.3, 125.2, 123.5, 121.2, 120.6, 116.0, 113.5, 113.2, 54.1. HRMS (ESI-TOF) *m/z*: [M+H]⁺ Calcd for C₂₁H₁₅N₂O₂ 327.1128; found 327.1123.

References:

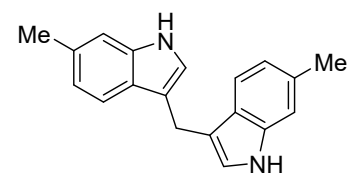
- (1) Pradhan P K, Dey S, Giri V S, Jaisankar P. InCl₃-HMTA as a methylene donor: one-pot synthesis of diindolylmethane (DIM) and its derivatives. *Synthesis*, 2005, 2005(11): 1779–1782.
- (2) Sun C, Zou X, Li F. Direct Use of Methanol as an Alternative to Formaldehyde for the Synthesis of 3, 3'-Bisindolylmethanes (3, 3'-BIMs). *Chemistry-A European Journal*, 2013, 19(42):14030-14033.
- (3) Pradhan M, Mandal A, Tiwari P, Borthakur I, Borpuzari M P, Kundu S. Hydricity Modulated Methylation of Indoles and Nitriles Using Methanol: Selective Synthesis of C3-Methylated Indoles, Bisindolylmethanes, and α -Methylated Nitriles. *Advanced Synthesis & Catalysis*, 2026, 368(3): e70224.
- (4) Li D, Wu T, Liang K, Xia C. Curtius-like rearrangement of an iron–nitrenoid complex and application in biomimetic synthesis of bisindolylmethanes. *Organic Letters*, 2016, 18(9): 2228–2231.
- (5) Pillaiyar T, Uzair M, Ullah S, Schnakenburg G, Müller C E. Decarboxylative Coupling Reaction of 2-(1H-Indol-3-yl) acetic Acids with Indole, Azaindole, Benzimidazole and Indazole Derivatives. *Advanced Synthesis & Catalysis*, 2019, 361(18): 4286–4293.
- (6) Cui X, Chen C, Xie M, Zhao T, Yi J, Sun W, Xiong Z, Hu J, Wong W-L, Wu J-Q. One-pot sequential synthesis of unsymmetrical diarylmethanes using methylene chloride as a C1-synthon. *Organic & Biomolecular Chemistry*, 2024, 22(39): 7965–7970.
- (7) Liu D, Zhang H P, Qian J C, Wang Y, Ren S J, Tan R X. Enzymatic synthesis of health-beneficial oligoindoles using peroxidase. *Green Chemistry*, 2025, 27(24): 7319–7328.

2. NMR spectra for compounds 2, 1, 8, 9, 11: page S14-73

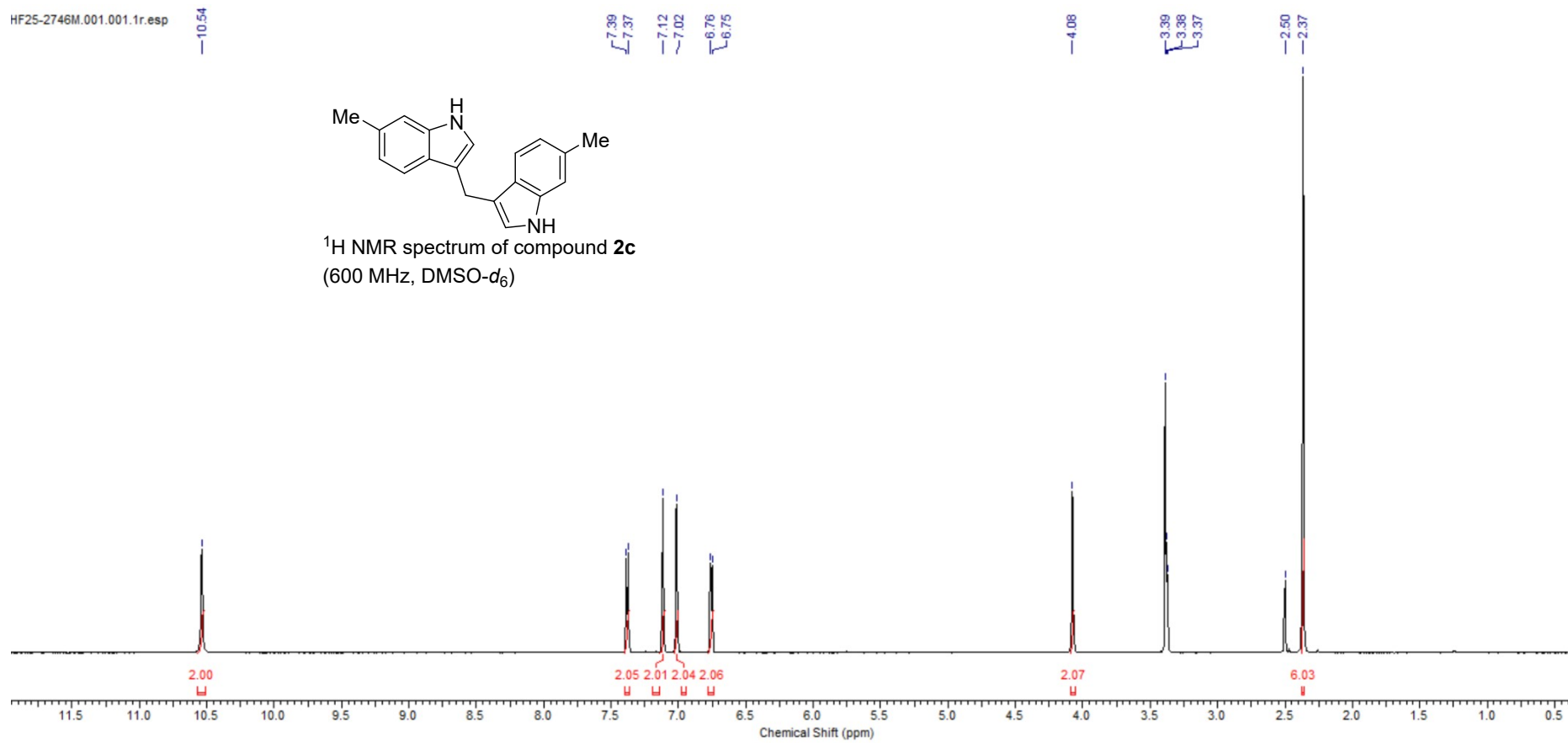
HF25-3601120.001.001.1r.esp



HF25-2746M.001.001.1r.esp



¹H NMR spectrum of compound **2c**
(600 MHz, DMSO-*d*₆)



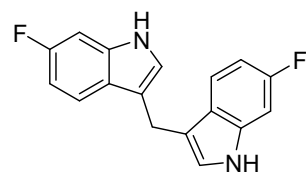
fF25-2826F.001.001.1r.esp

—10.82

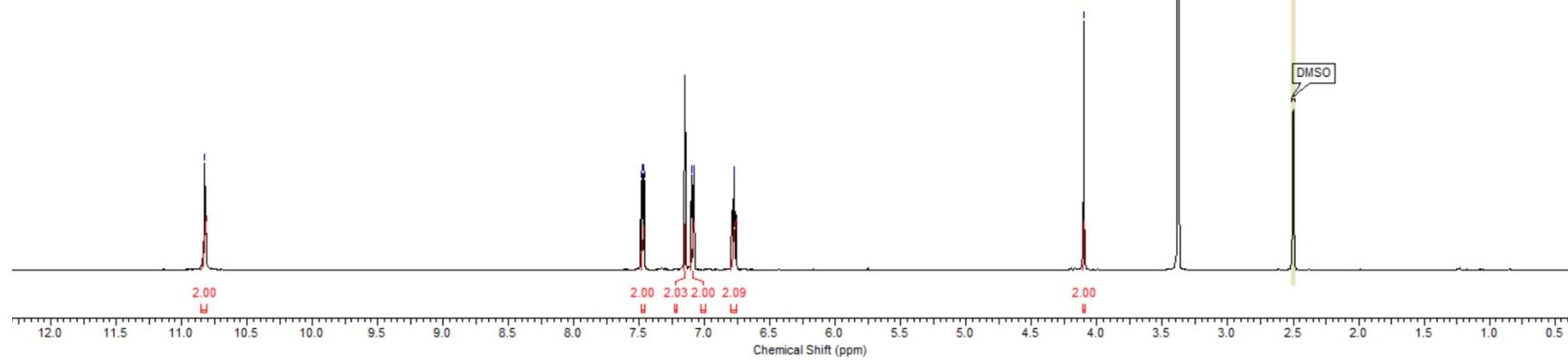
7.49
7.48
7.47
7.46
7.15
7.10
7.10
7.09
7.08
6.77

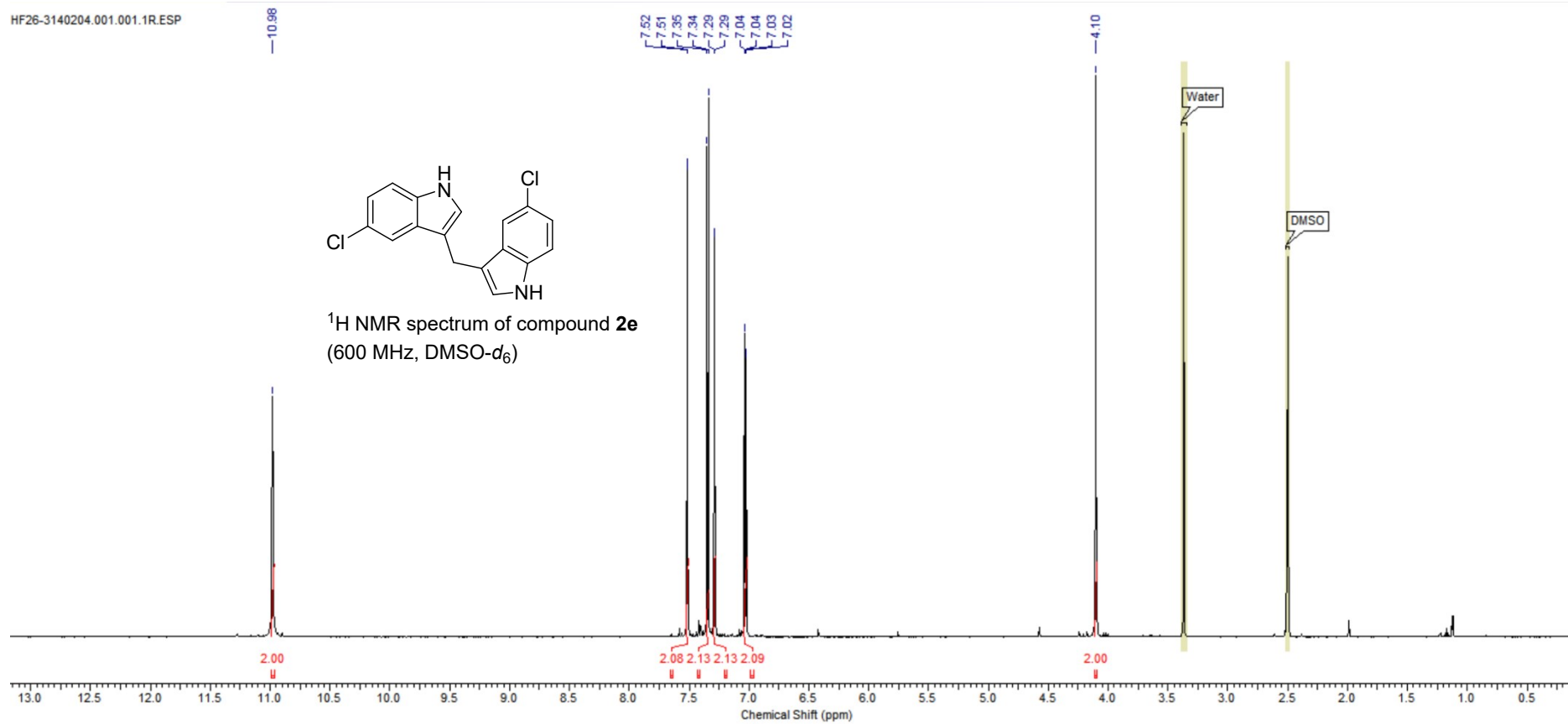
—4.10

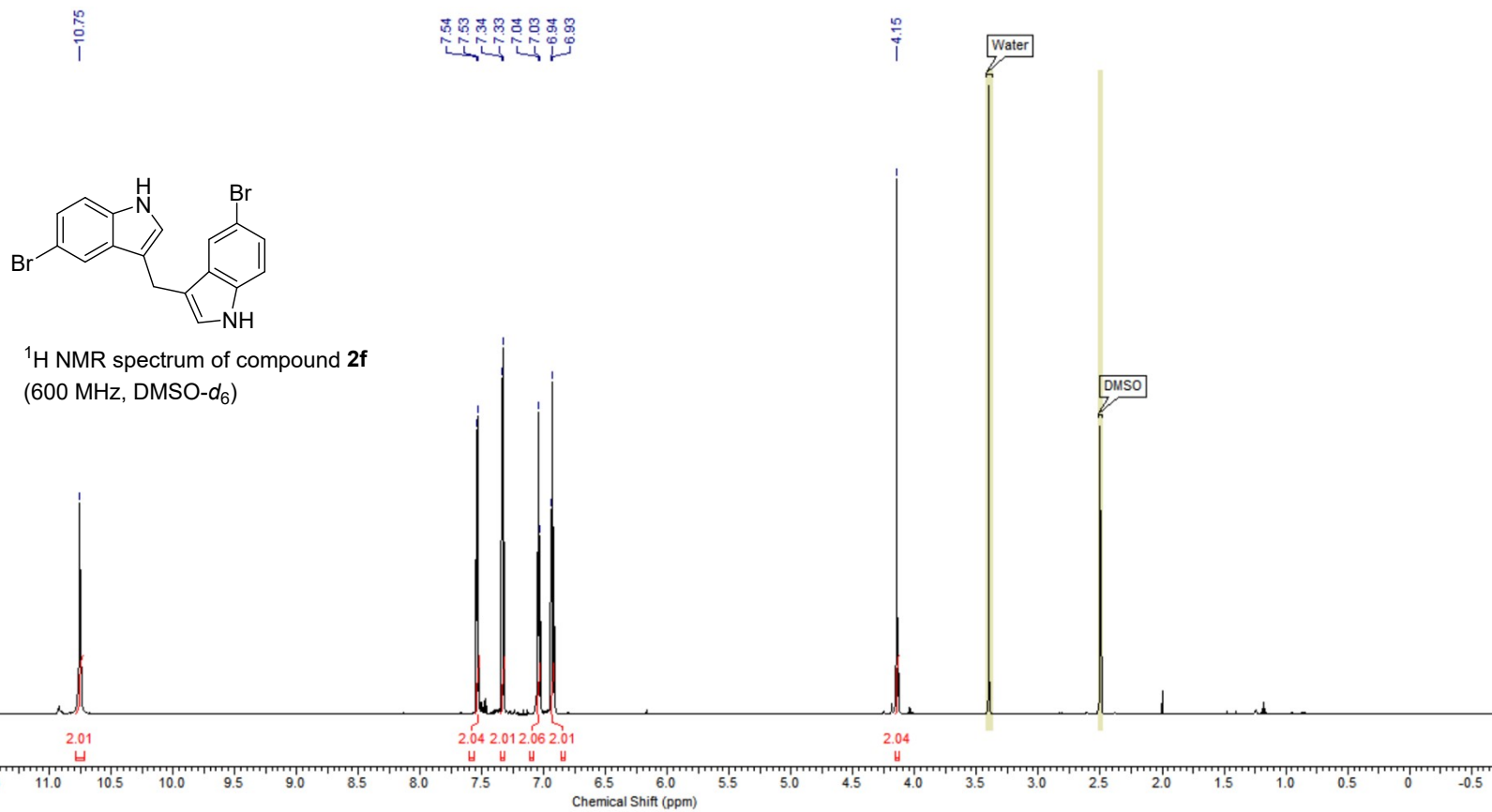
—3.38

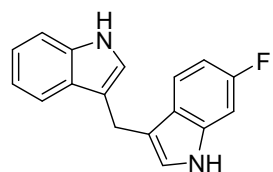


¹H NMR spectrum of compound **2d**
(600 MHz, DMSO-*d*₆)

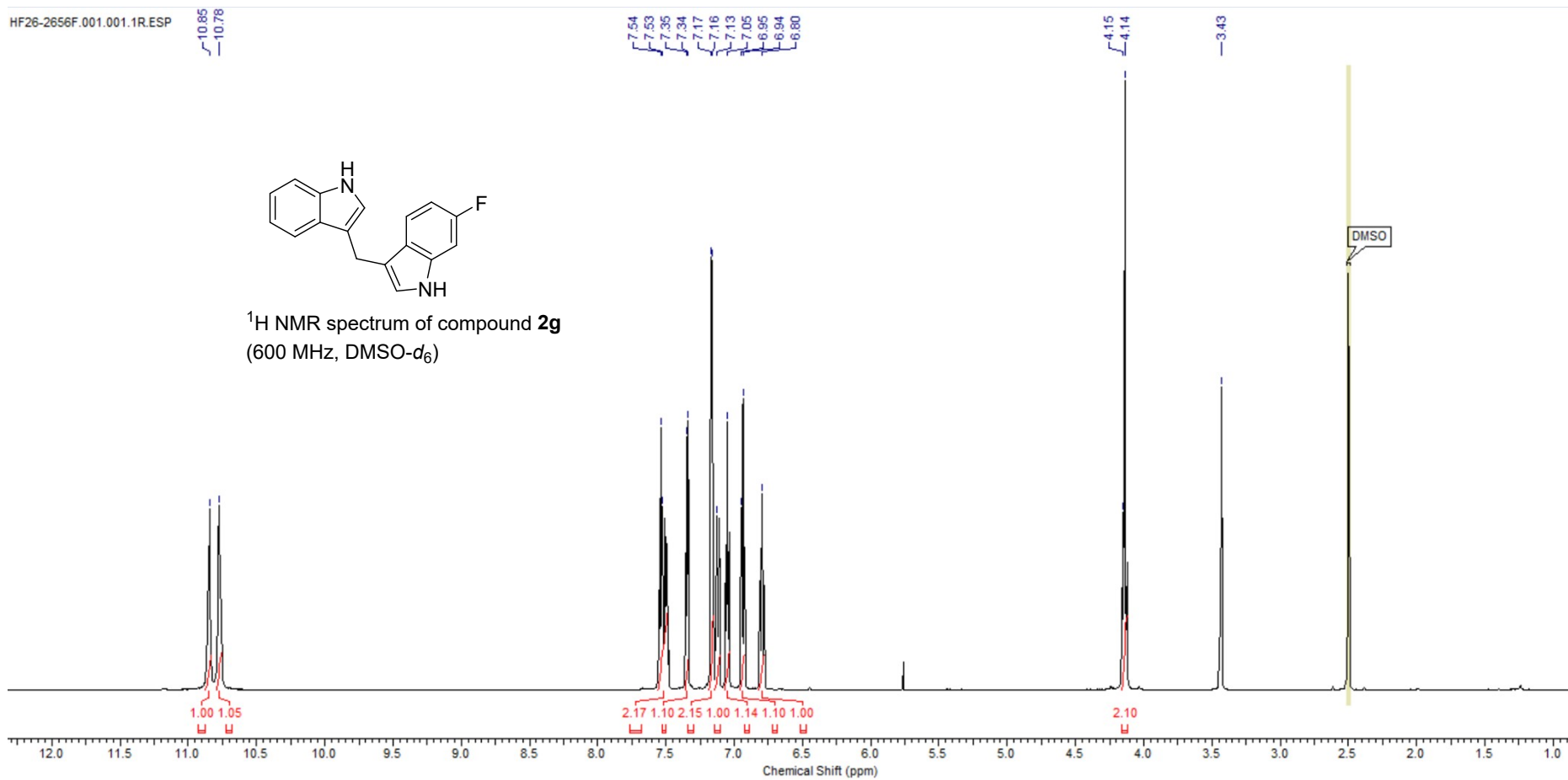








¹H NMR spectrum of compound **2g**
(600 MHz, DMSO-*d*₆)



4F26-2656F.002.001.1R.ESP

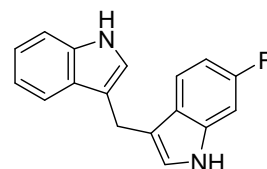
159.58
158.03

136.43
136.27
136.19
127.19
124.10
123.36
122.83
120.81
120.78
119.66
119.60
118.69
118.10
114.51
114.24
113.99
111.36
111.34
106.58
106.47
106.43

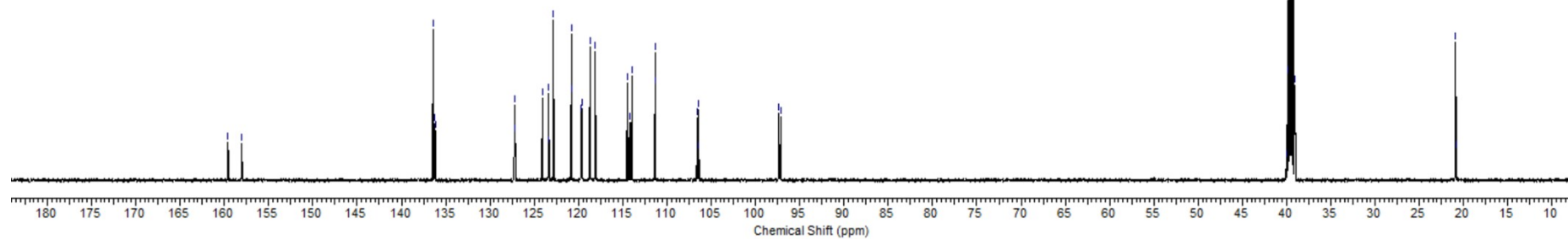
97.35
97.18

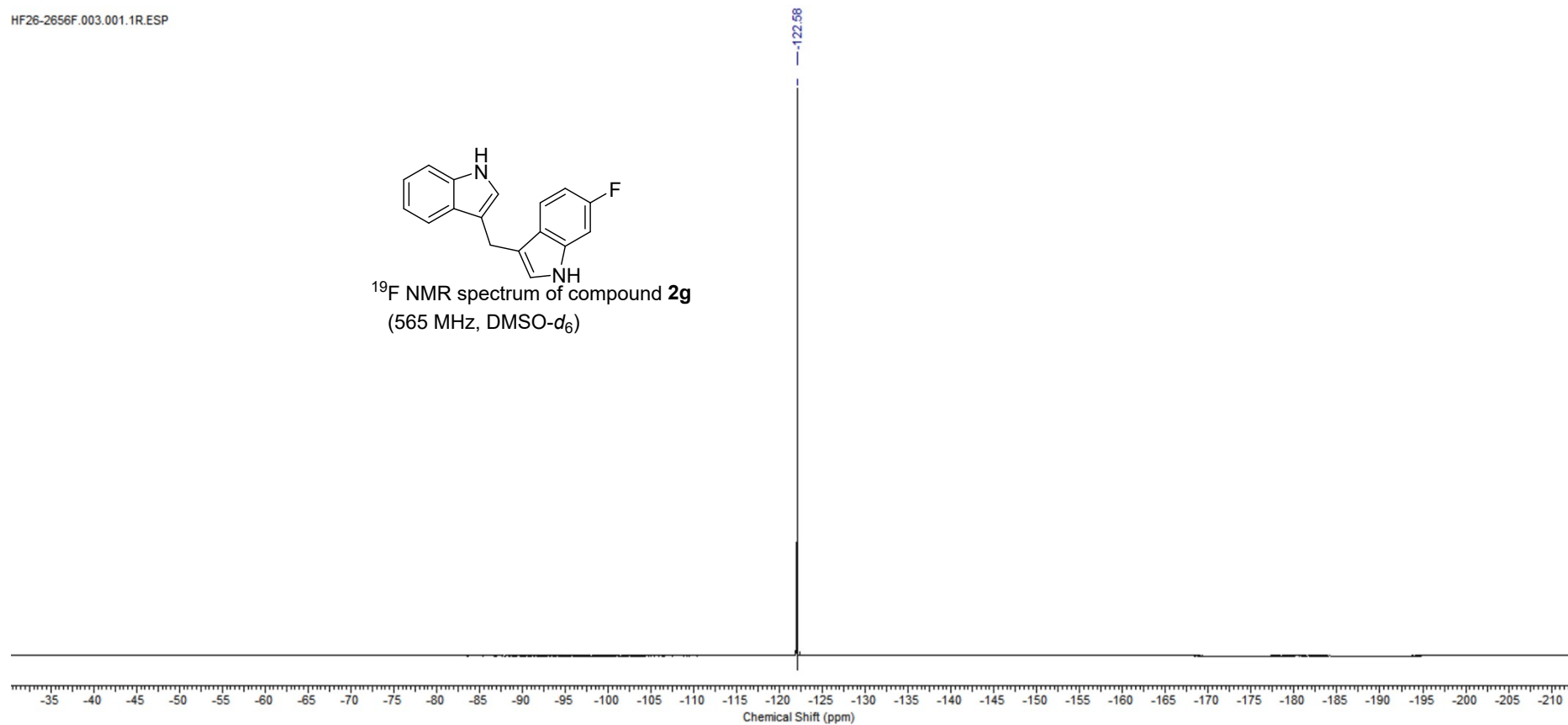
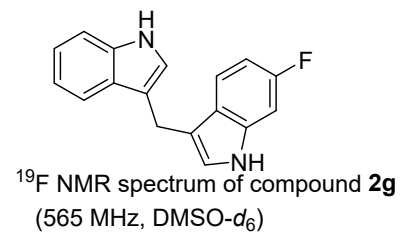
40.04
39.93
39.79
39.65
39.51
39.37
39.23
39.09

20.91
20.87



¹³C NMR spectrum of compound **2g**
(150 MHz, DMSO-*d*₆)

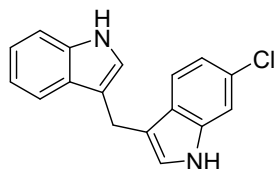




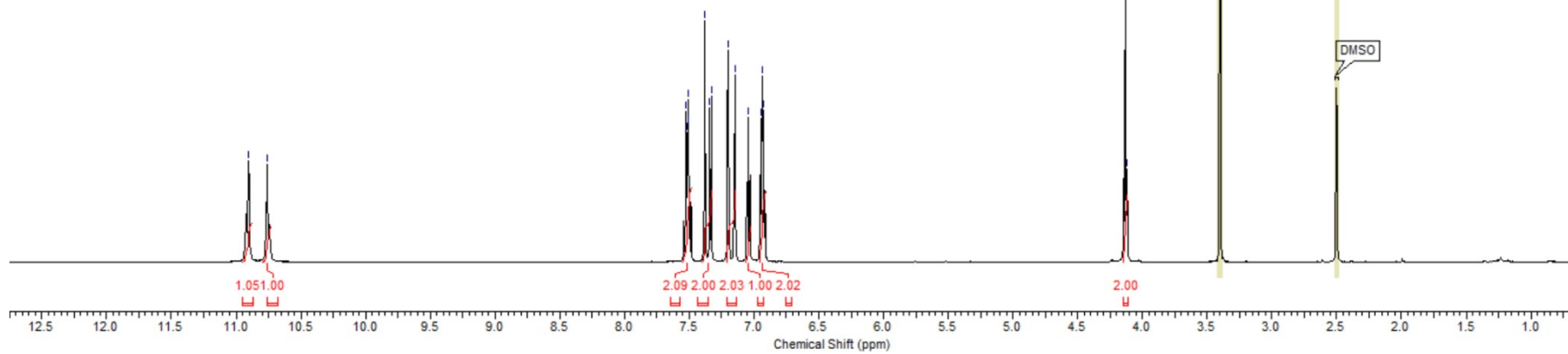
10.90
10.76

7.52
7.51
7.50
7.38
7.34
7.33
7.20
7.15
7.04
6.96
6.94
6.93

4.13
4.12



¹H NMR spectrum of compound **2h**
(600 MHz, DMSO-*d*₆)

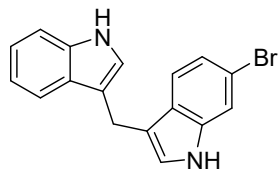


HF25-3251031.001.001.1R.ES

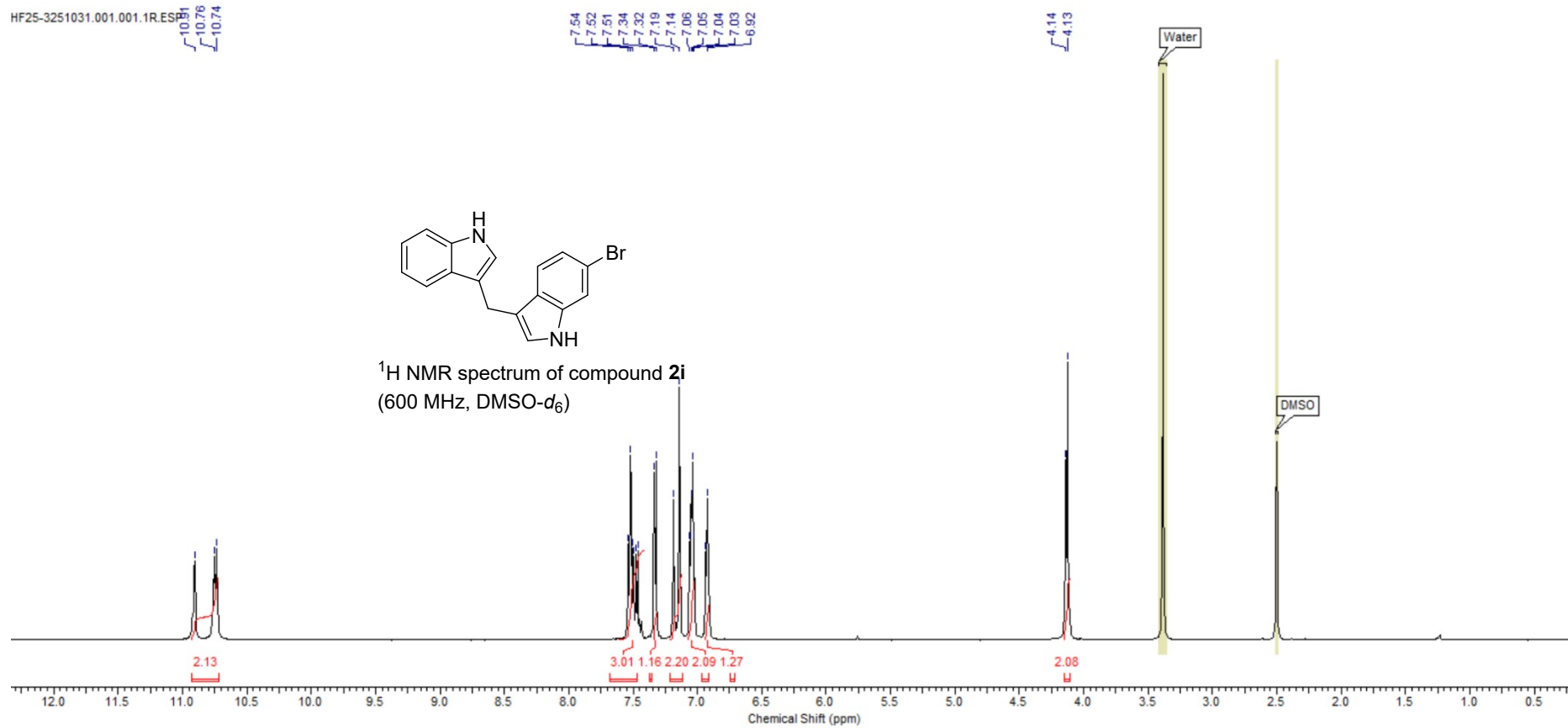
10.81
10.76
10.74

7.54
7.52
7.51
7.34
7.32
7.19
7.14
7.06
7.05
7.04
7.03
6.92

4.14
4.13



¹H NMR spectrum of compound **2i**
(600 MHz, DMSO-d₆)



HF26-3040312.001.001.1R.ESP

— 11.21

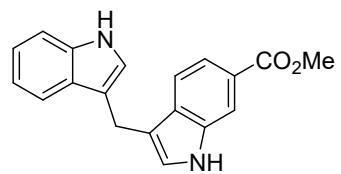
— 10.78

8.03
7.63
7.62
7.58
7.52
7.51
7.43
7.34
7.32
7.16
7.04
7.03
6.94
6.92

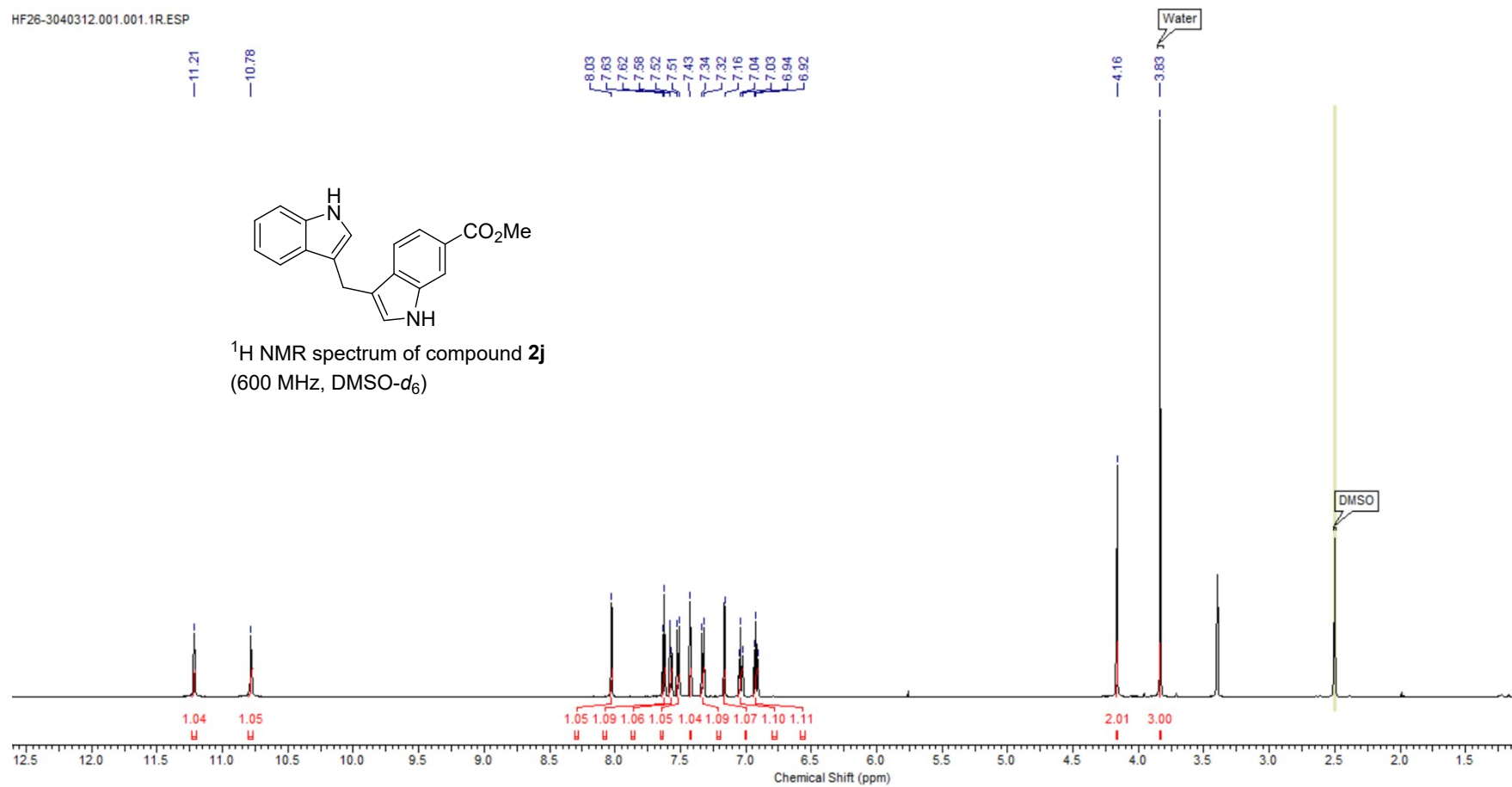
— 4.16

Water

— 3.83



¹H NMR spectrum of compound **2j**
(600 MHz, DMSO-*d*₆)



HF26-3100312.001.001.1r.esp

10.97
10.60

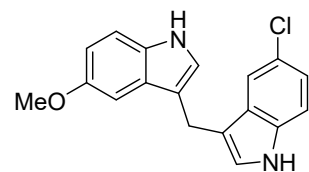
7.54
7.53
7.34
7.33
7.27
7.26
7.22
7.20
7.03
7.02
7.00
6.70
6.68

4.10
4.08

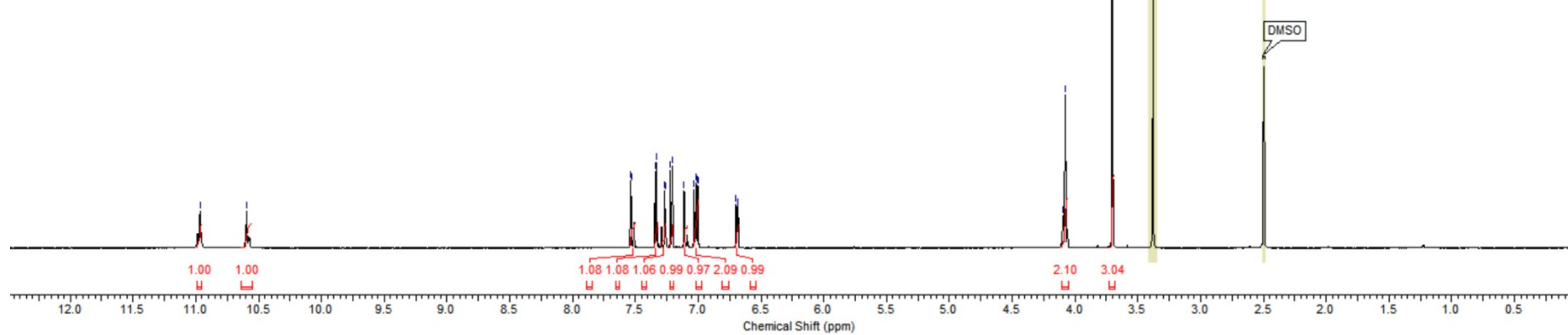
3.70

Water

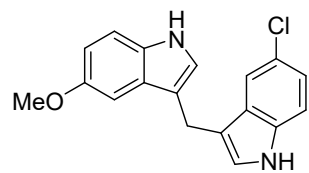
DMSO



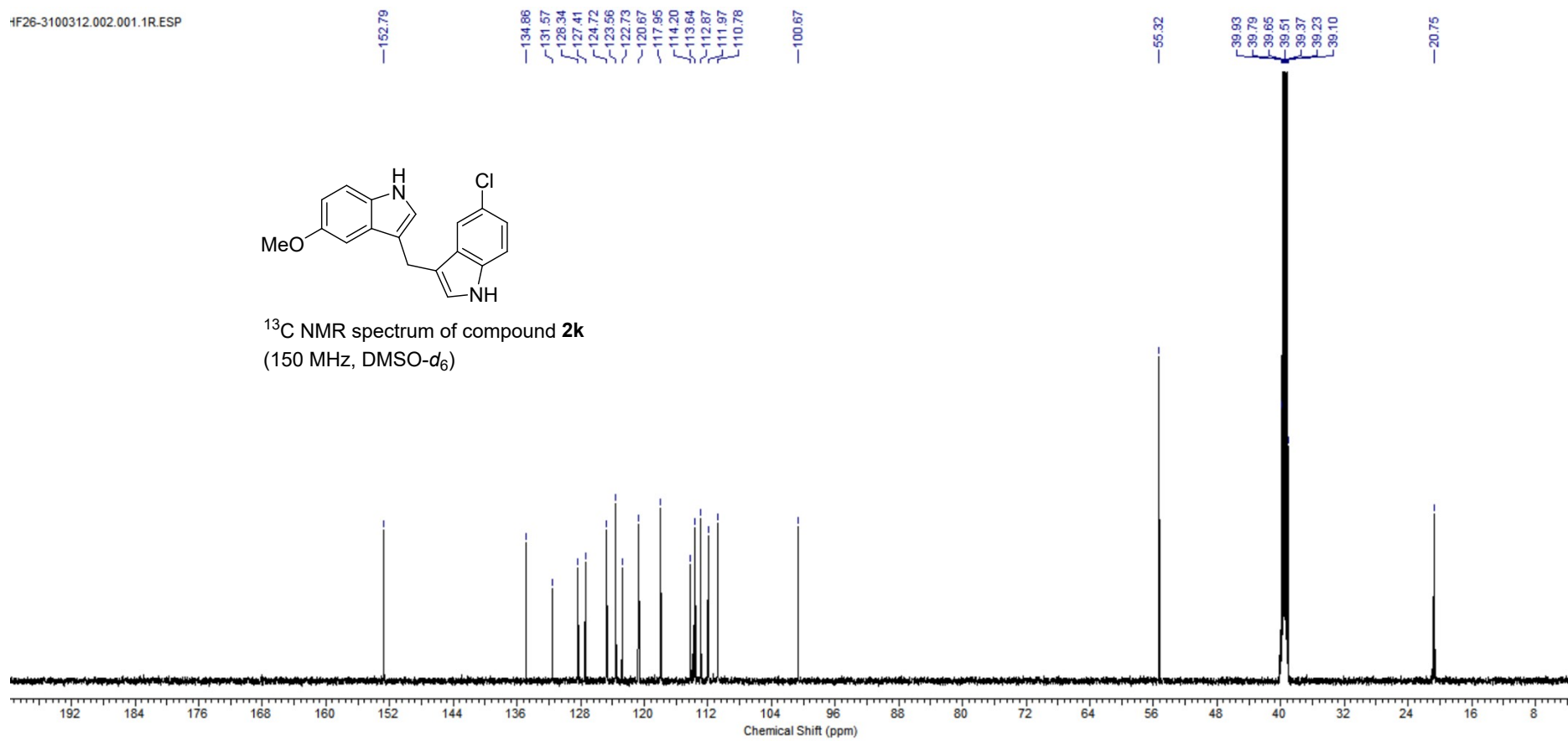
¹H NMR spectrum of compound **2k**
(600 MHz, DMSO-*d*₆)

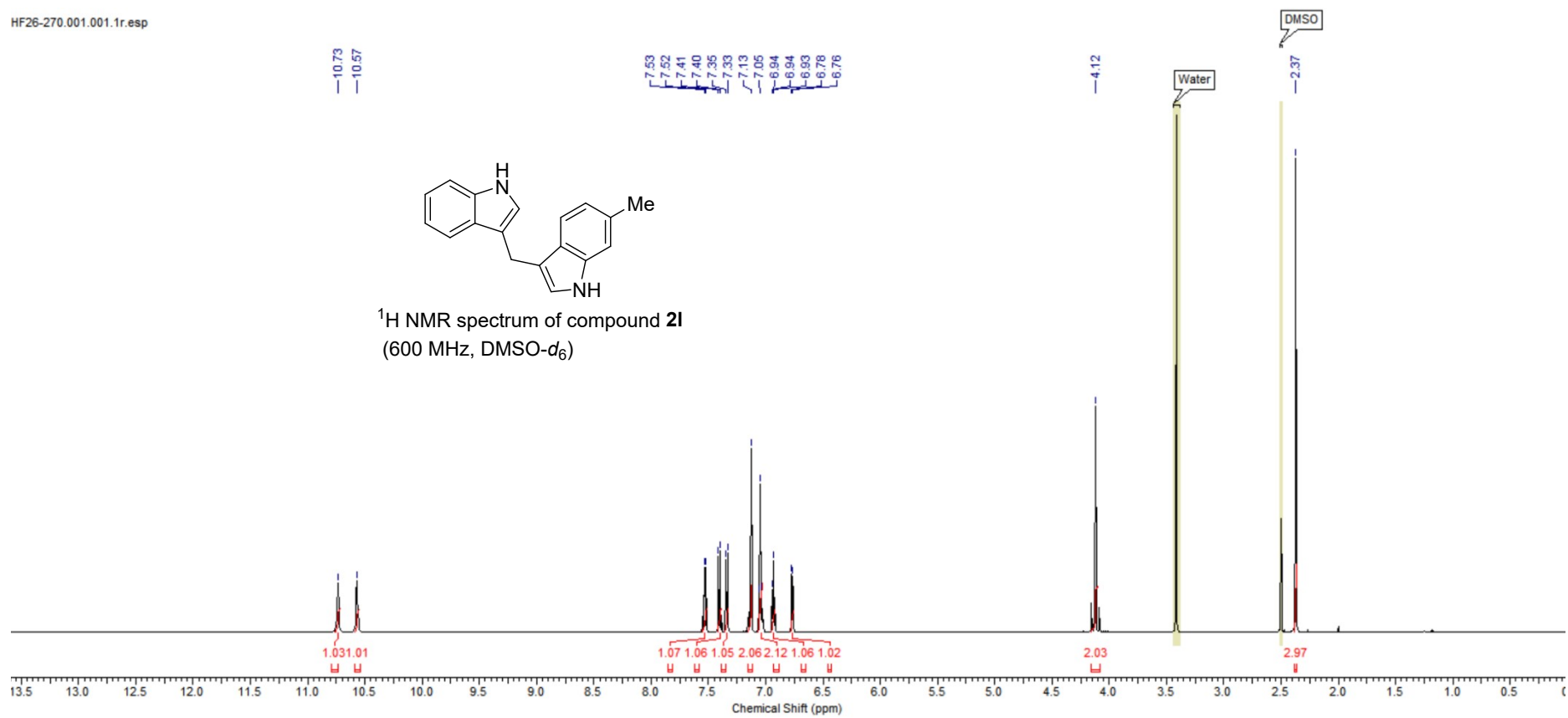


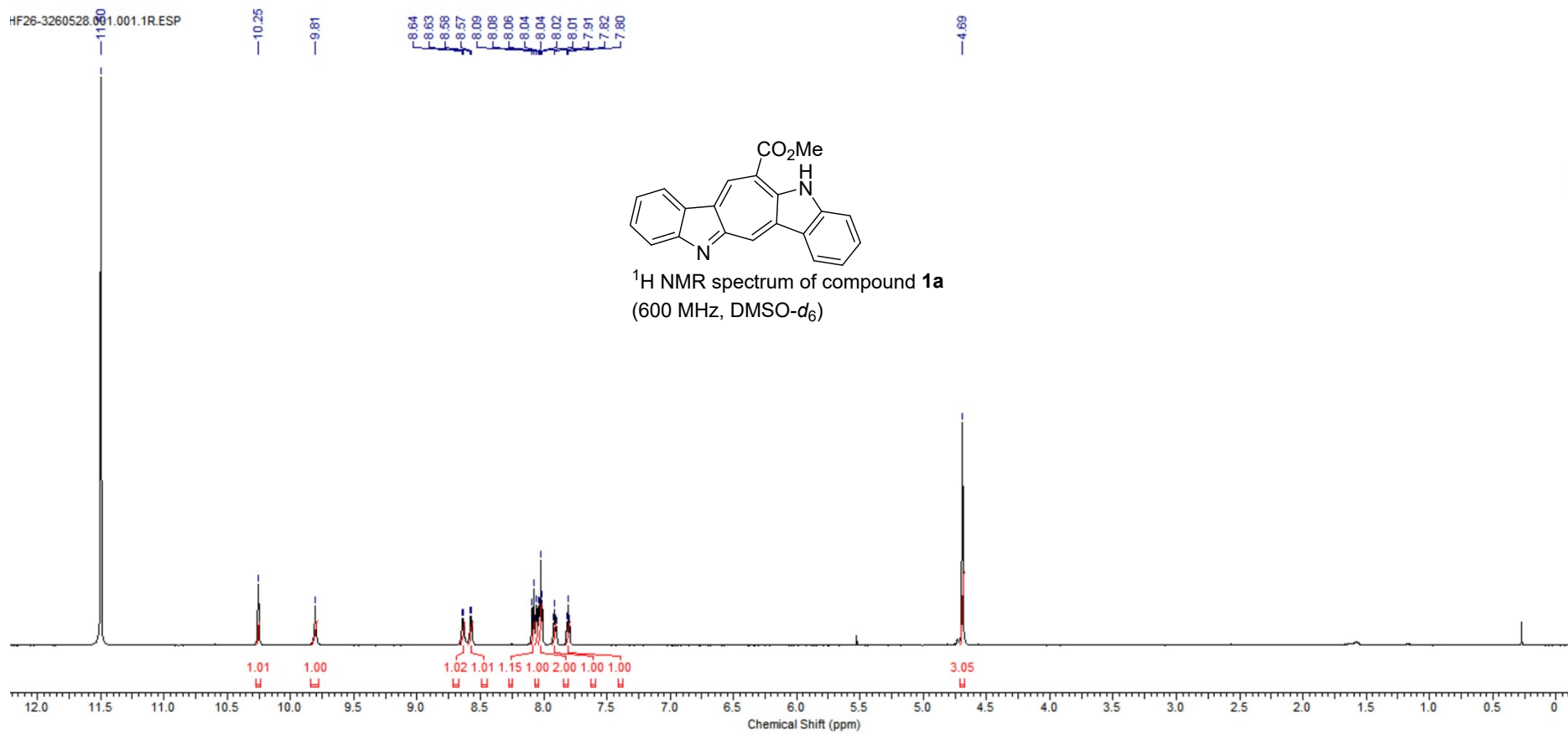
4F26-3100312.002.001.1R.ESP



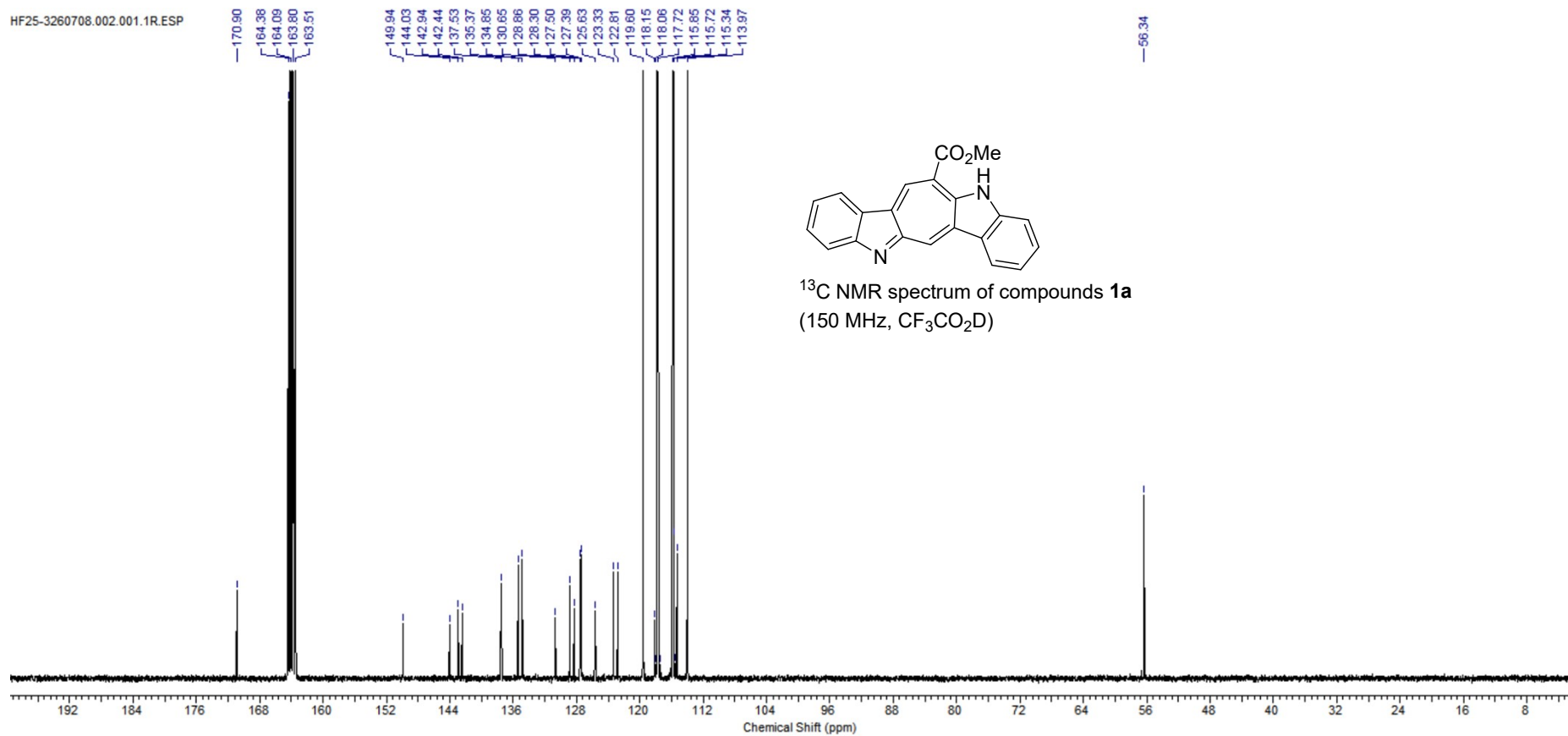
^{13}C NMR spectrum of compound **2k**
(150 MHz, $\text{DMSO-}d_6$)



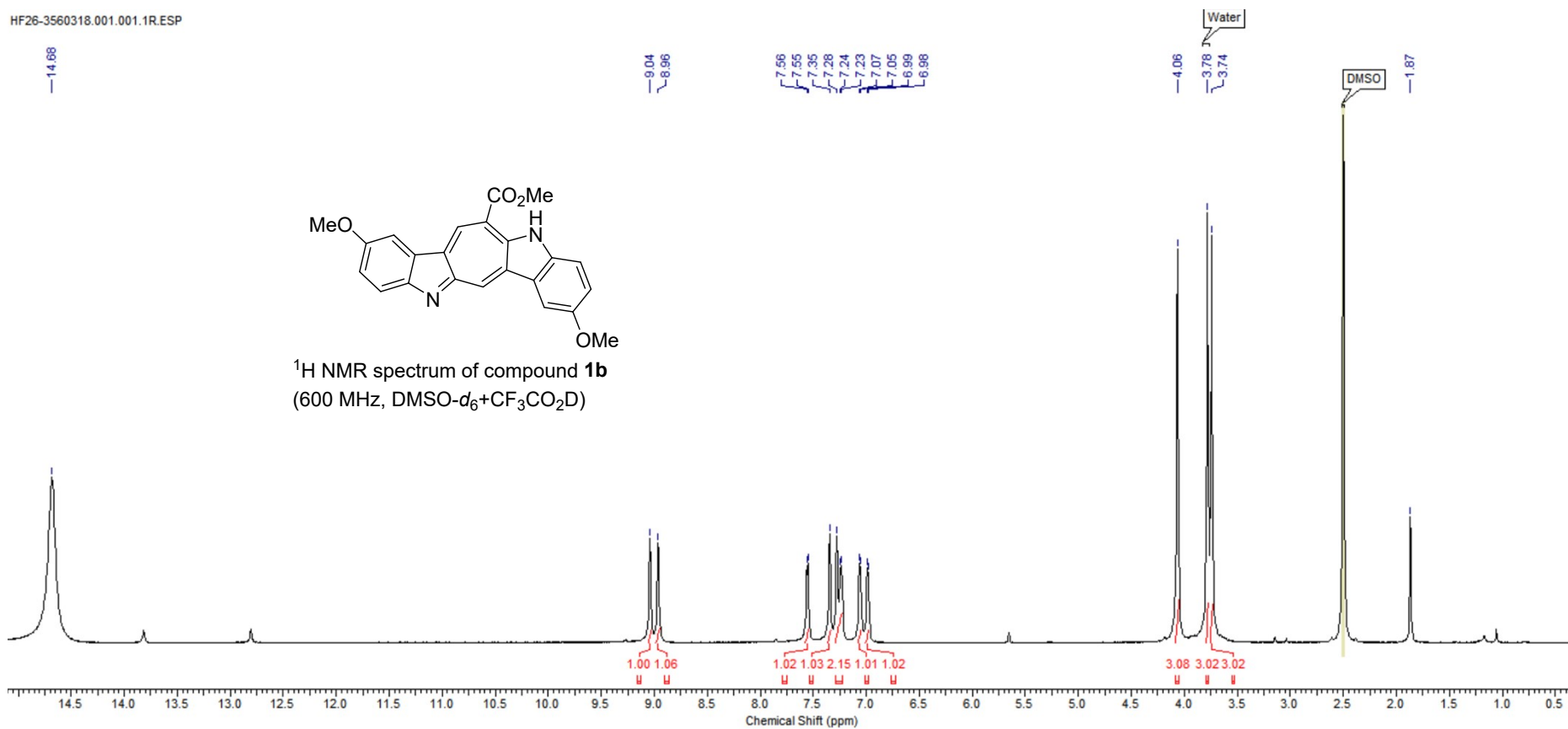


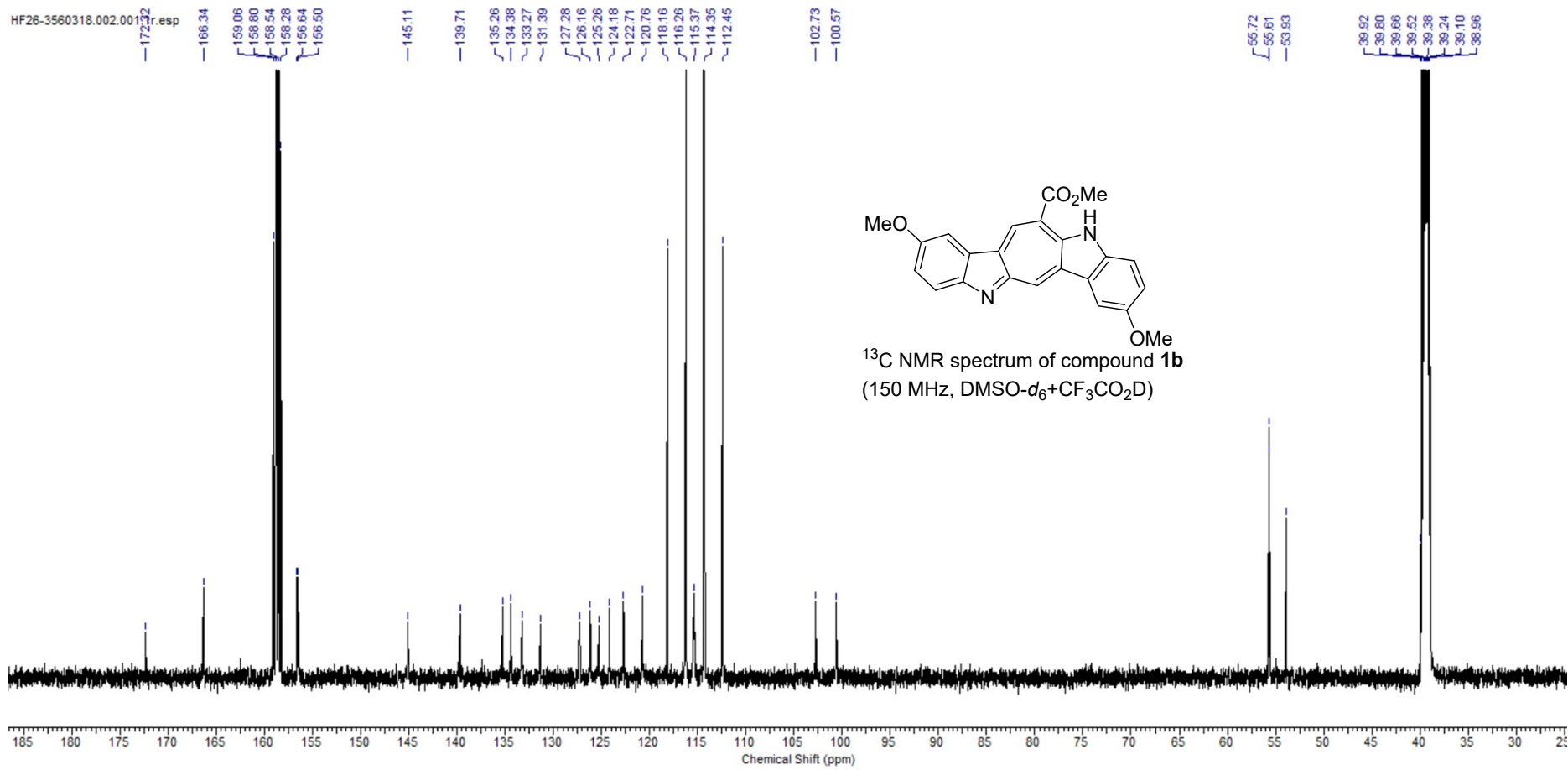


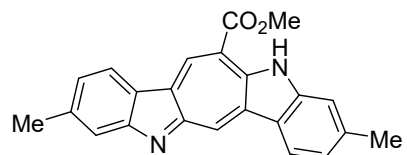
HF25-3260708.002.001.1R.ESP



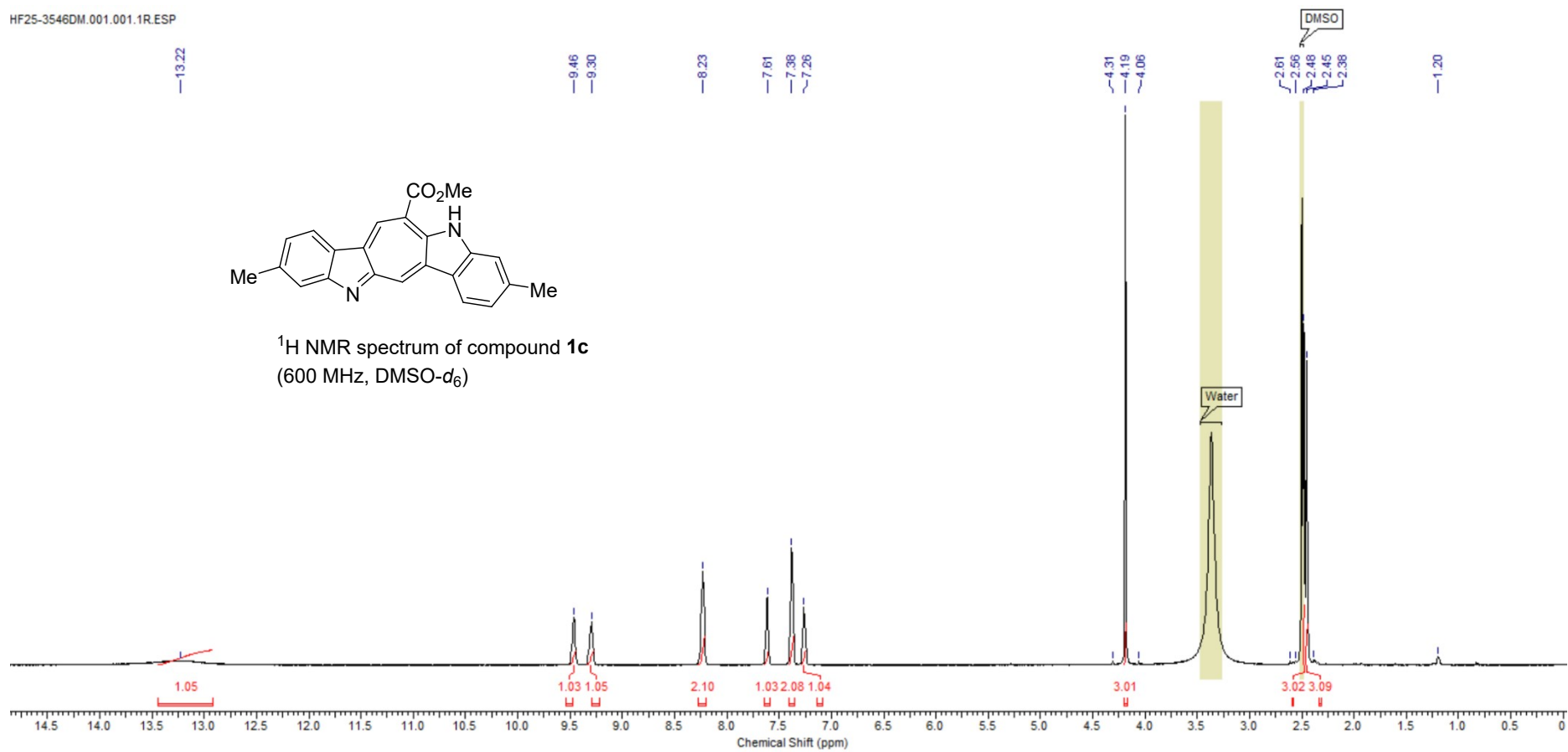
HF26-3560318.001.001.1R.ESP





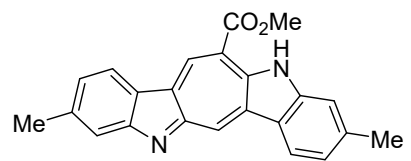


¹H NMR spectrum of compound **1c**
(600 MHz, DMSO-*d*₆)

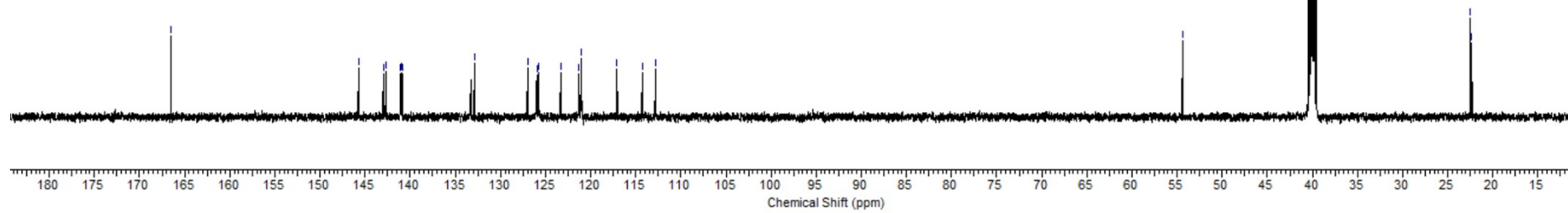


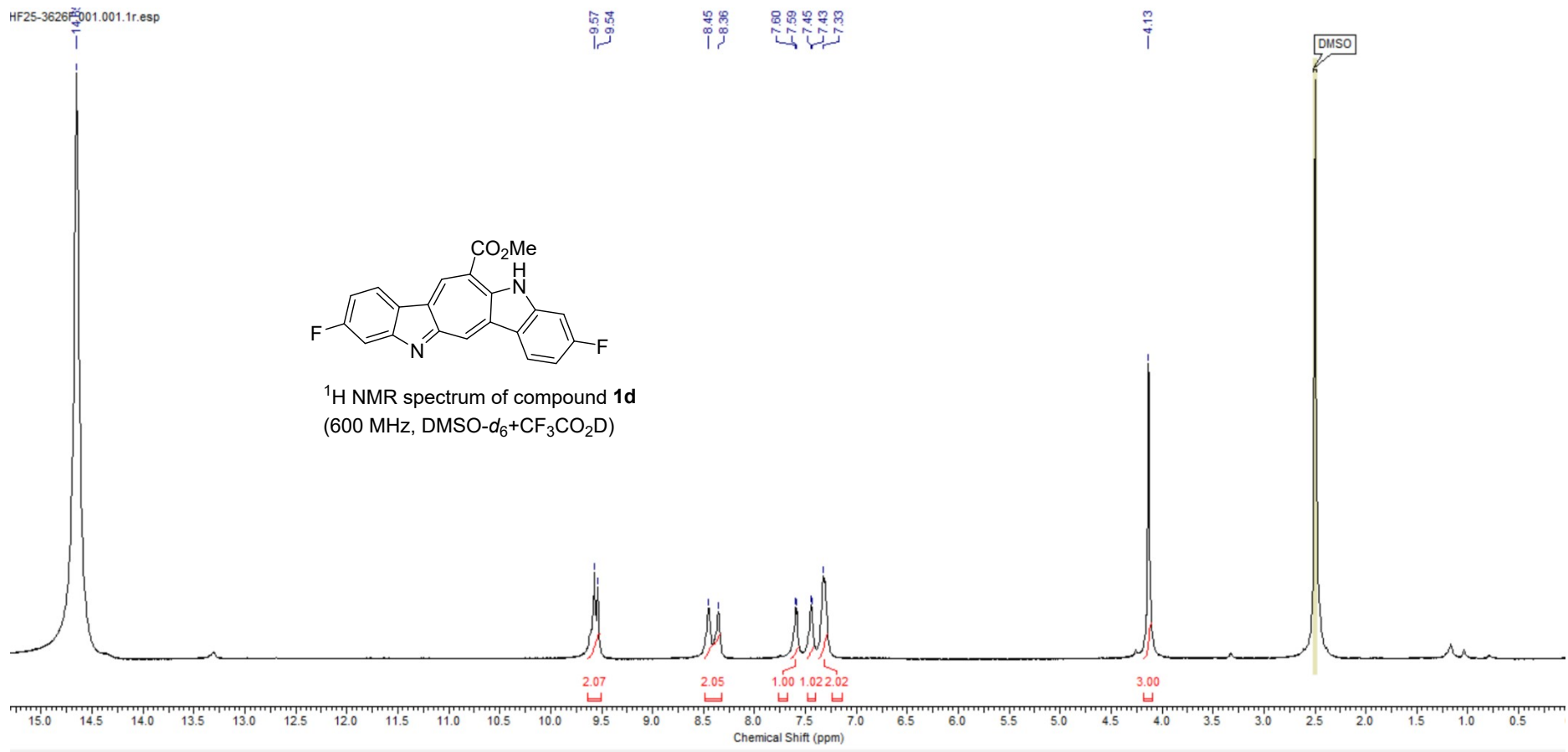
HF25-3546DM.002.001.1R.16680

166.80
145.71 142.98 142.73 141.08 140.99 140.89
132.86
126.98 125.88 125.78 123.31 121.26 121.10
117.07 114.23 112.84
54.40
40.38 40.24 40.10 39.97 39.83 39.69 39.55
22.51 22.33

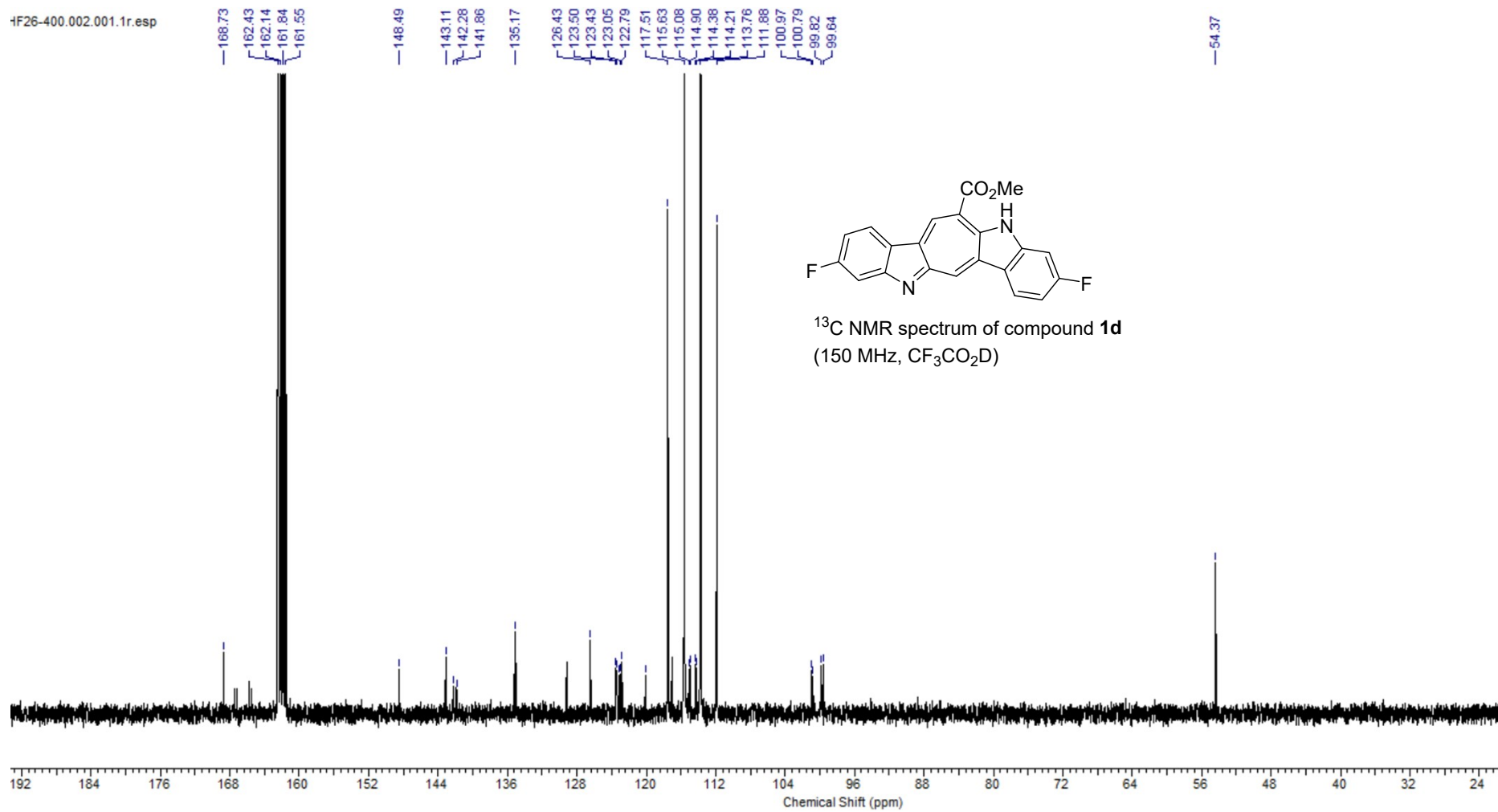


^{13}C NMR spectrum of compound **1c**
(150 MHz, $\text{DMSO-}d_6$)

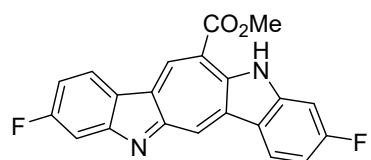




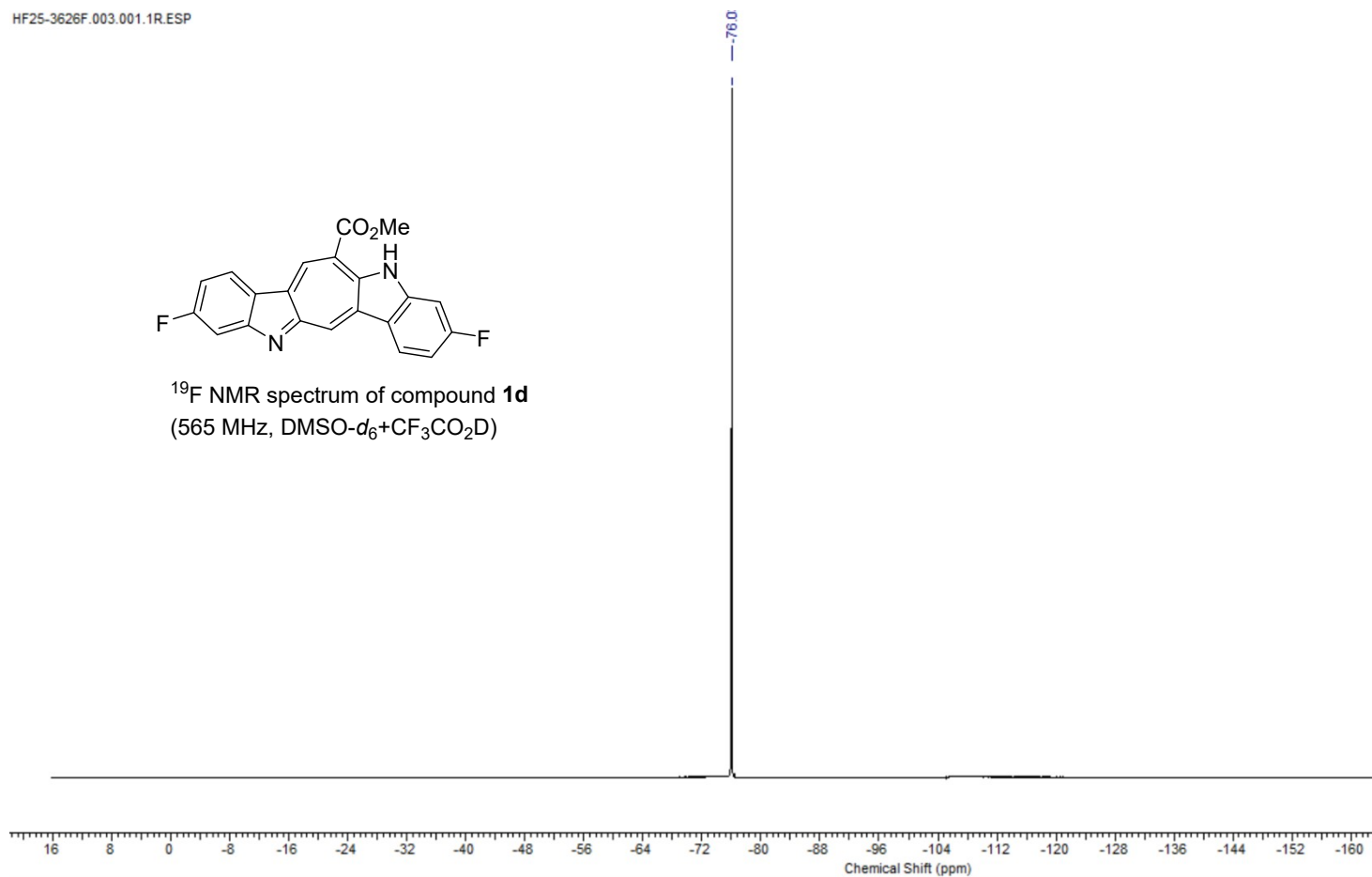
4F26-400.002.001.1r.esp



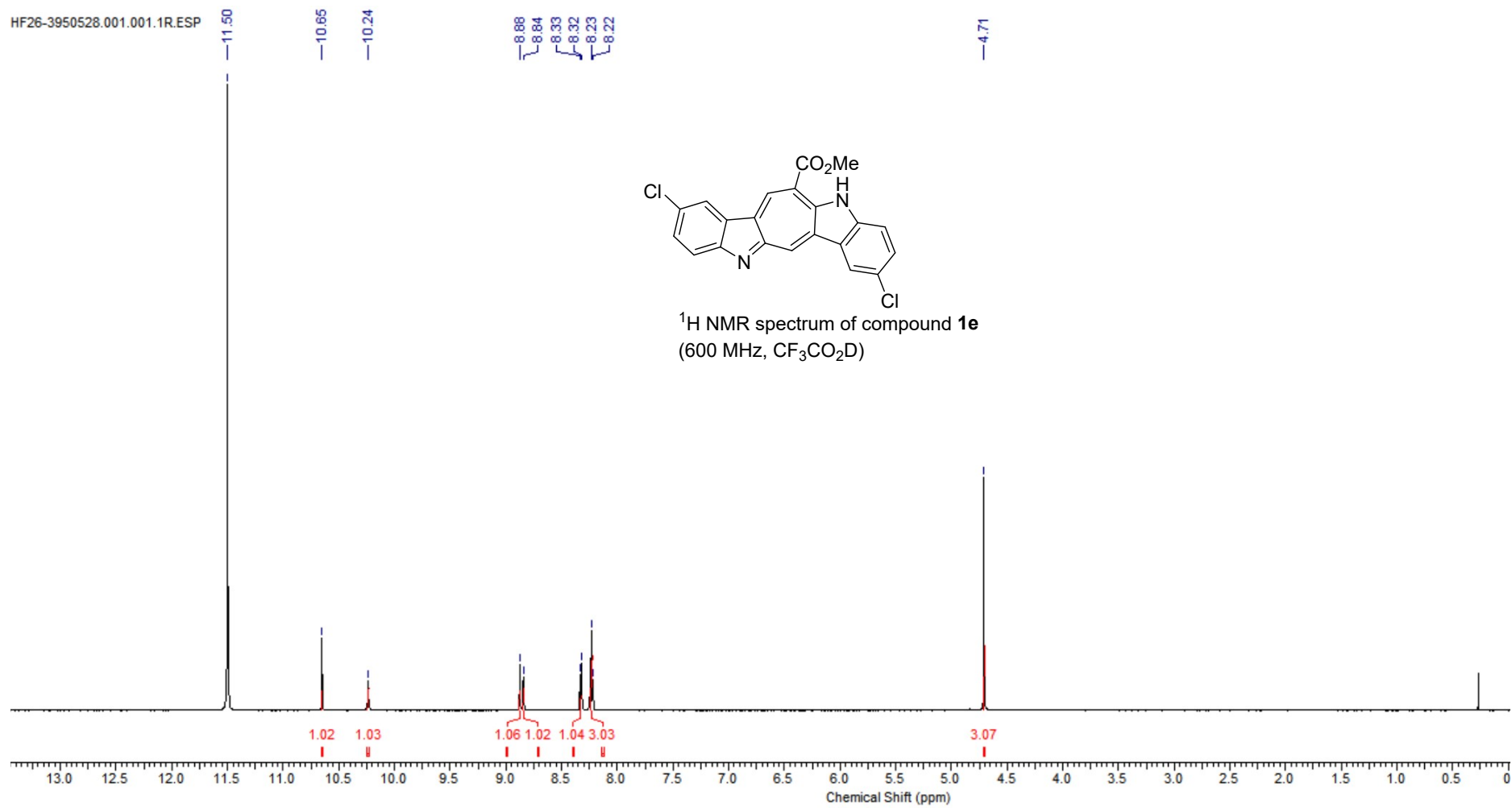
HF25-3626F.003.001.1R.ESP



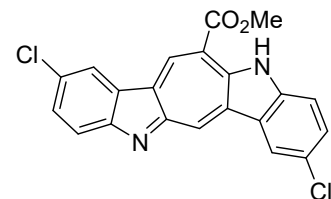
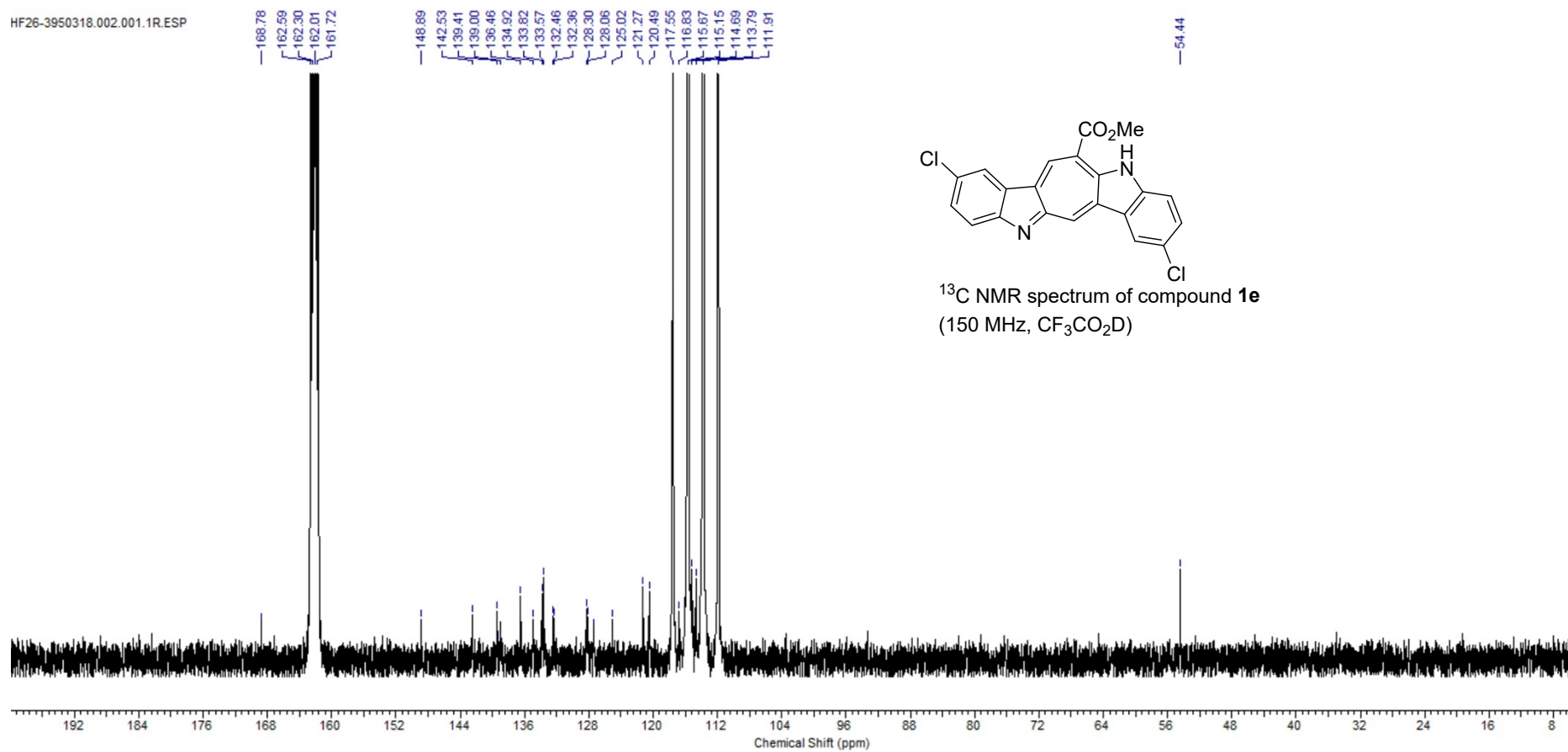
¹⁹F NMR spectrum of compound **1d**
(565 MHz, DMSO-*d*₆+CF₃CO₂D)



HF26-3950528.001.001.1R.ESP

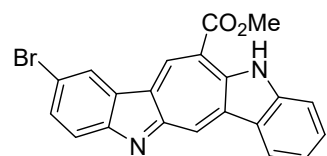


HF26-3950318.002.001.1R.ESP

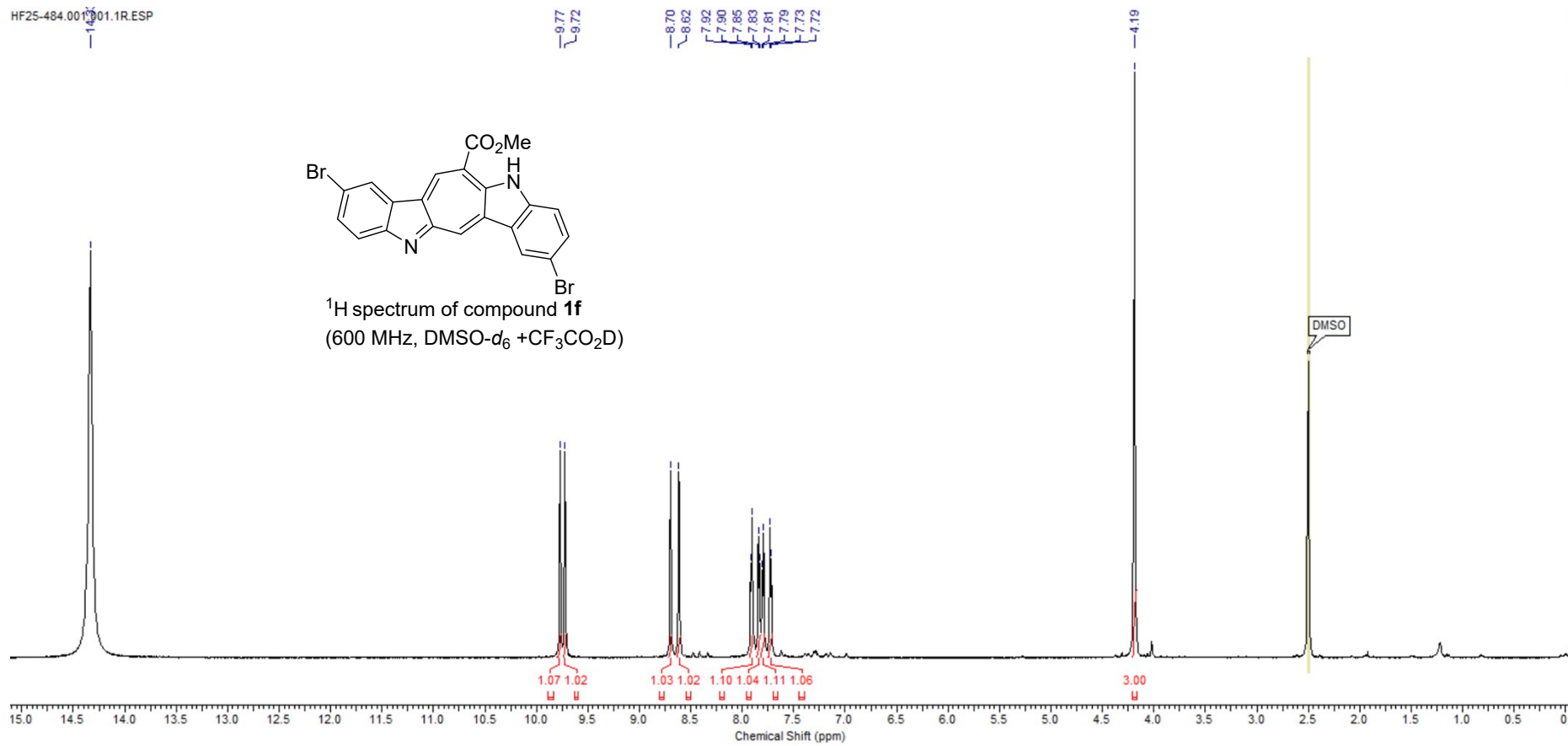


¹³C NMR spectrum of compound **1e**
(150 MHz, CF₃CO₂D)

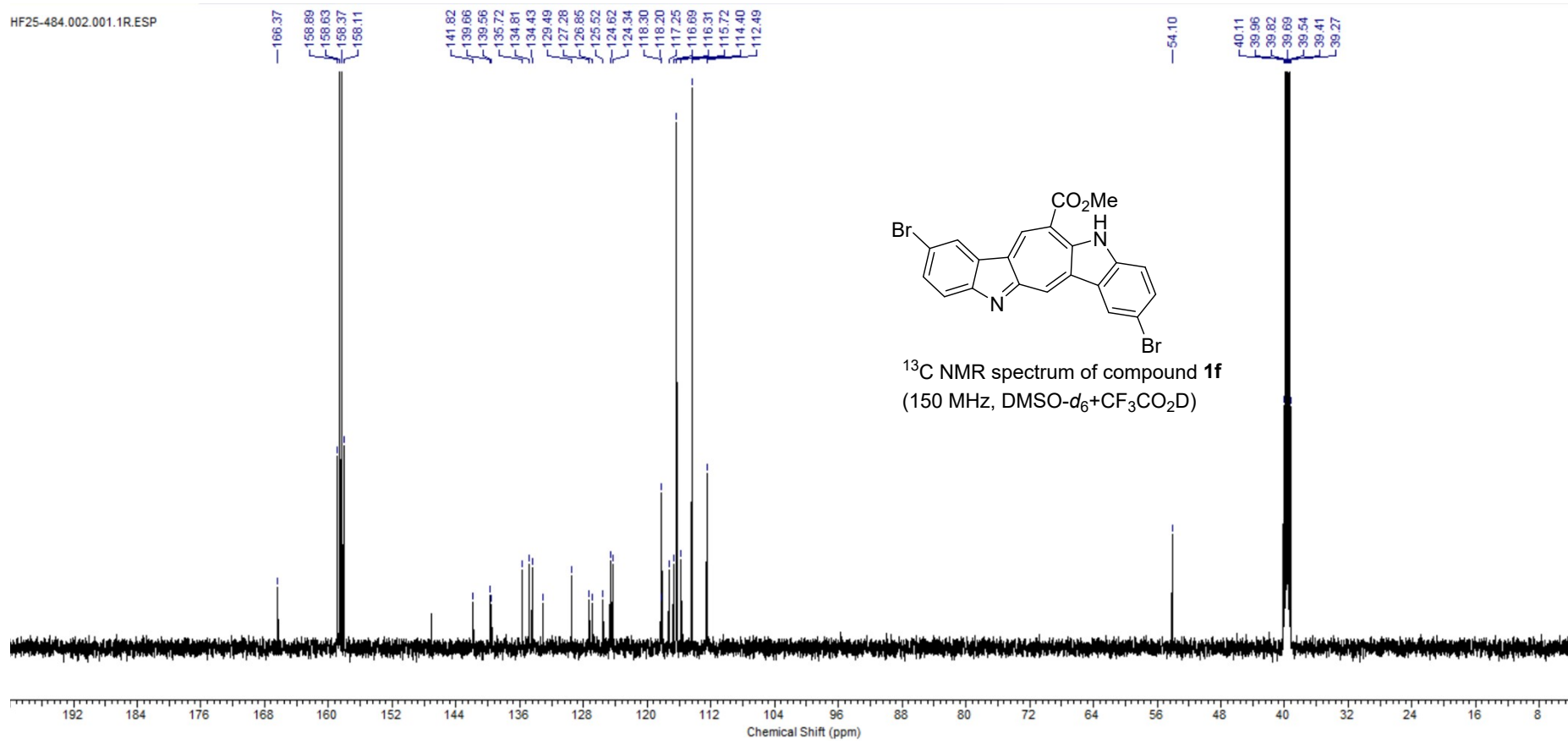
HF25-484.001.001.1R.ESP



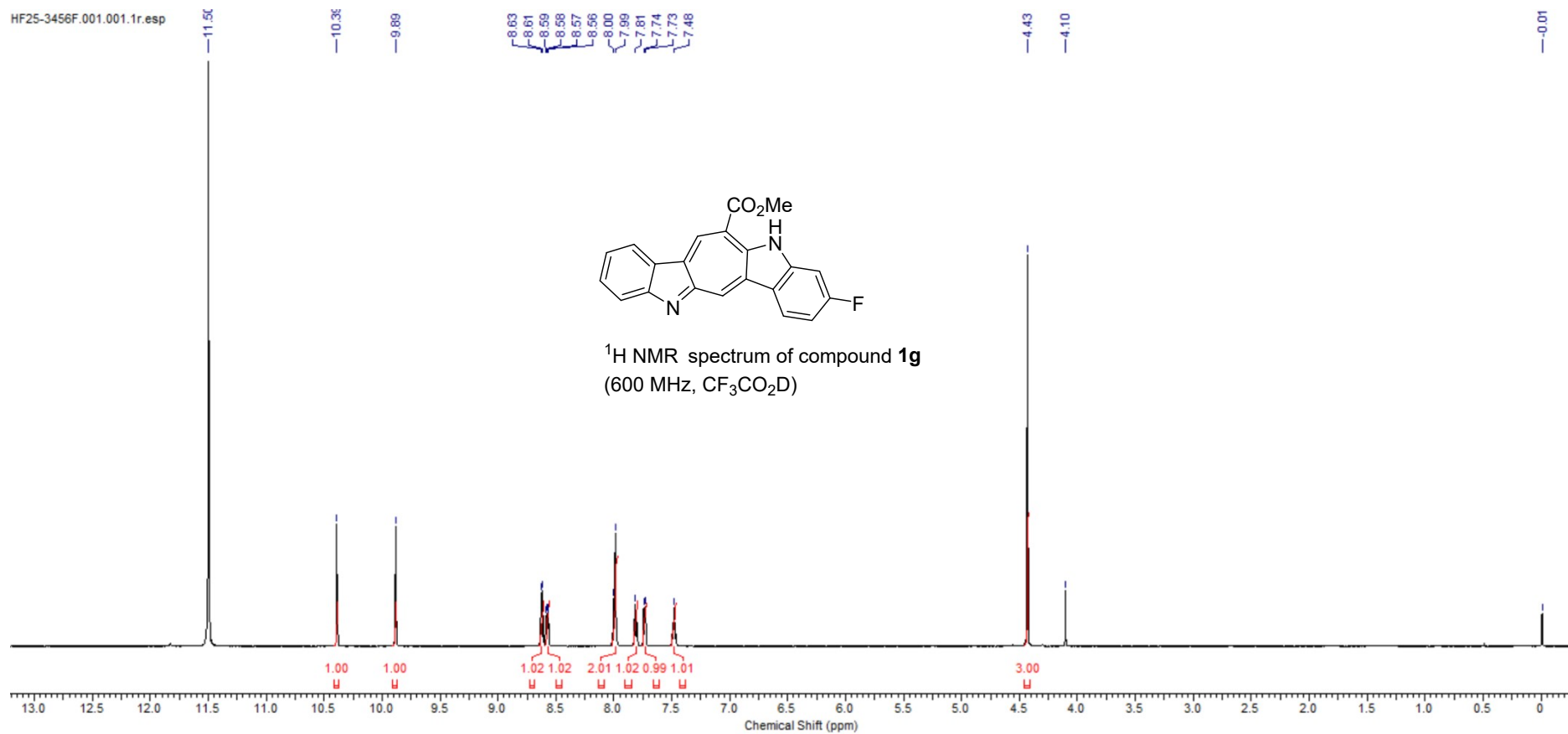
¹H spectrum of compound **1f**
(600 MHz, DMSO-*d*₆ +CF₃CO₂D)



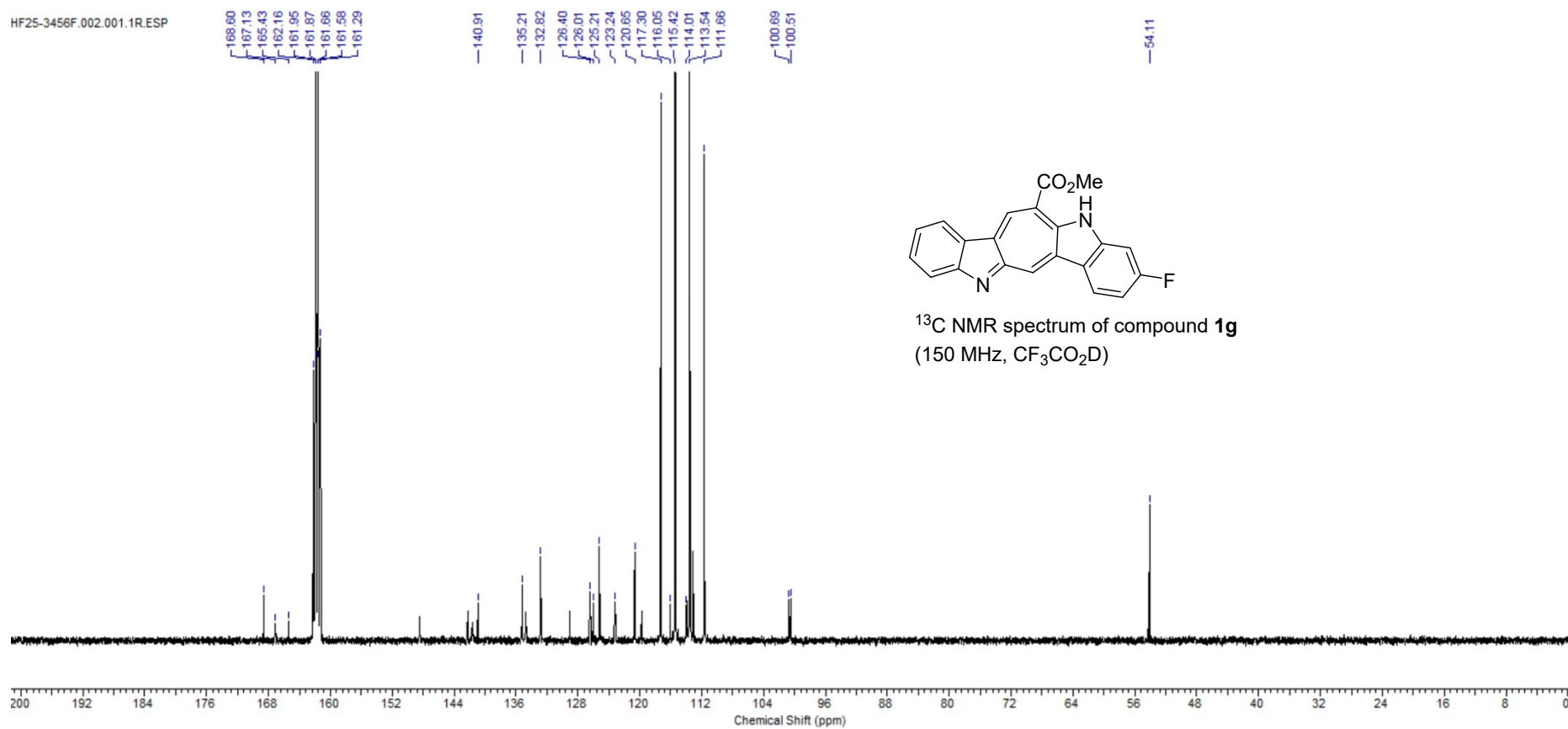
HF25-484.002.001.1R.ESP



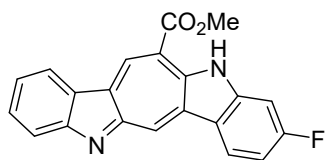
HF25-3456F.001.001.1r.esp



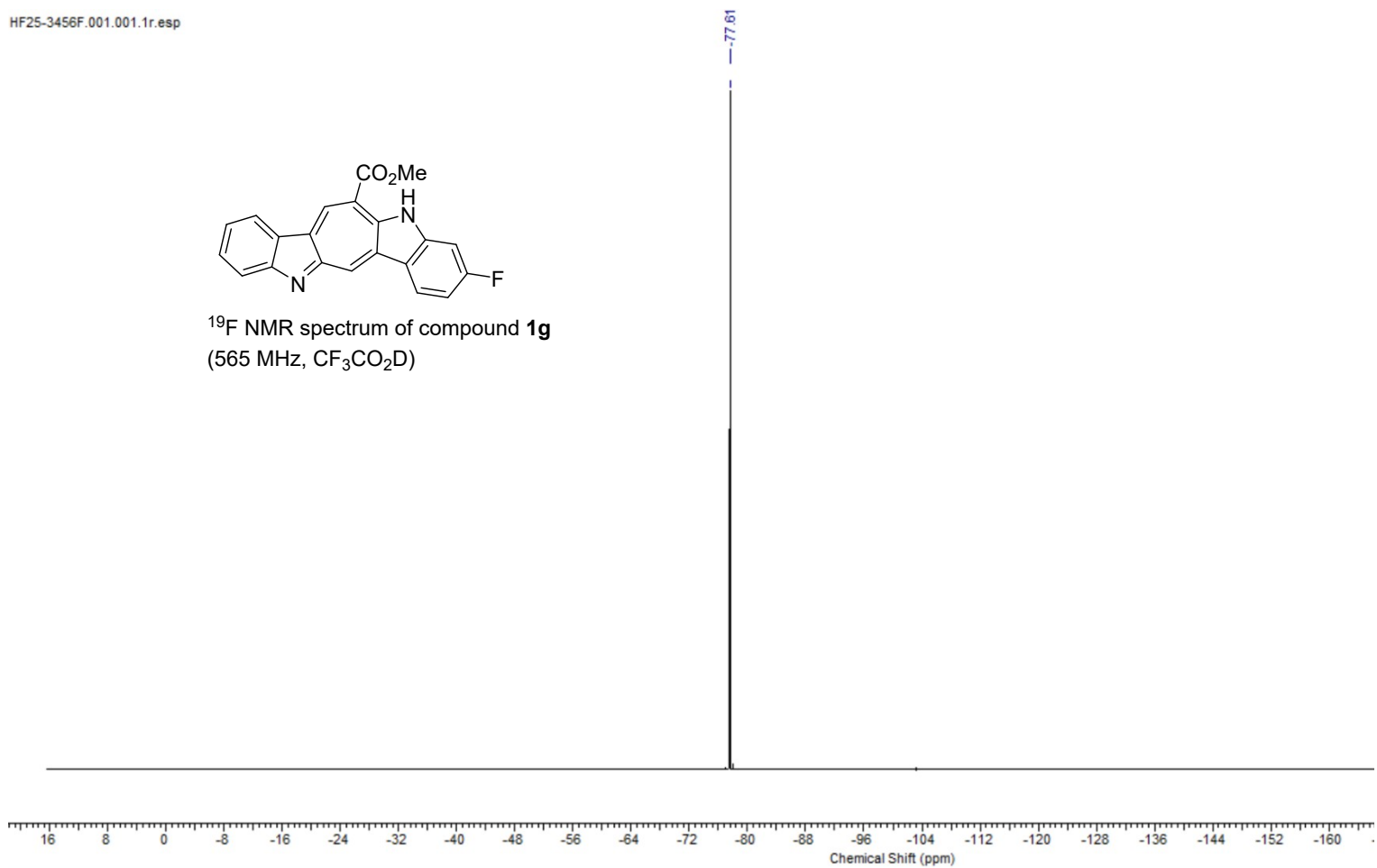
HF25-3456F.002.001.1R.ESP

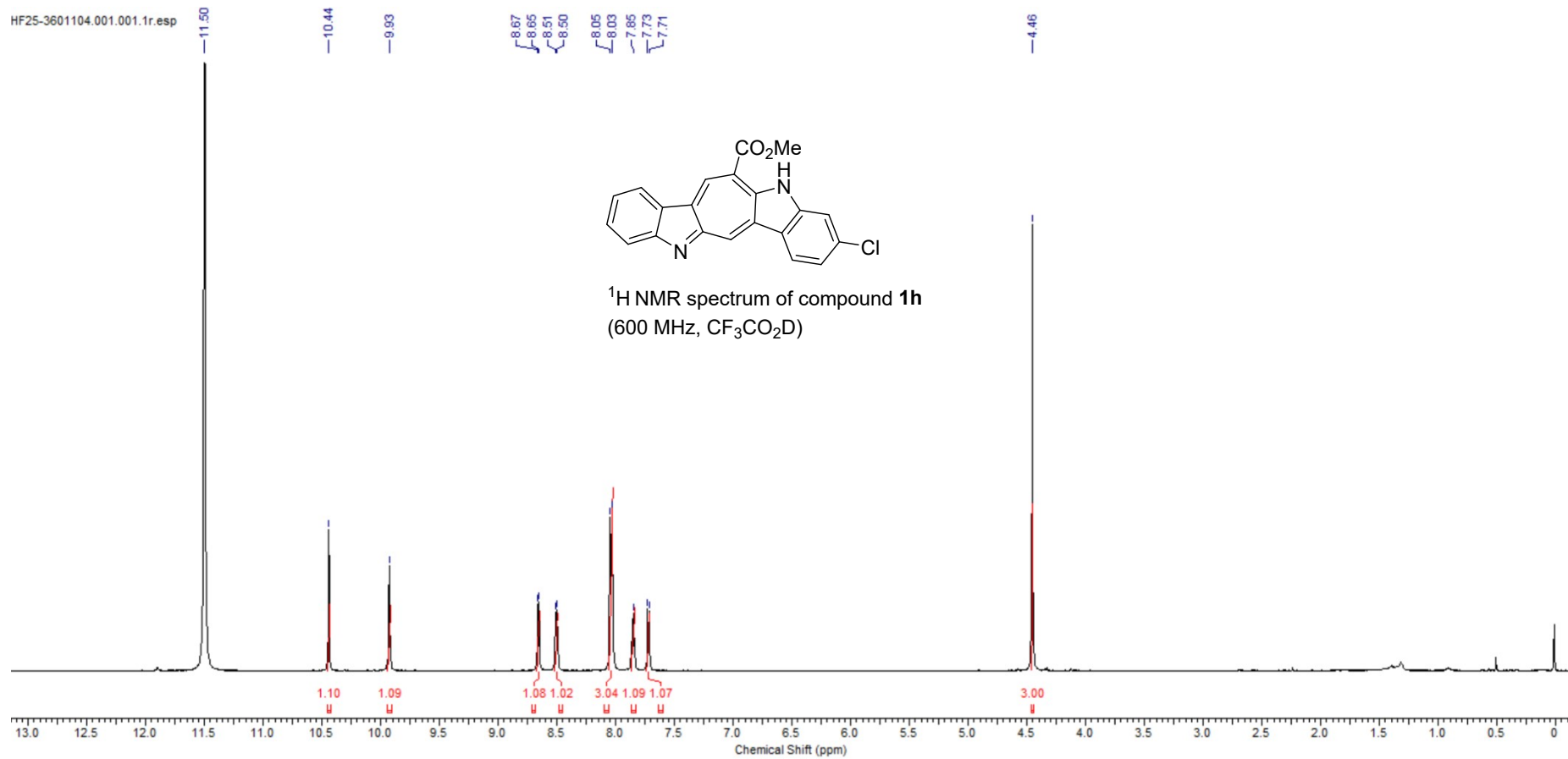


HF25-3456F.001.001.1r.esp

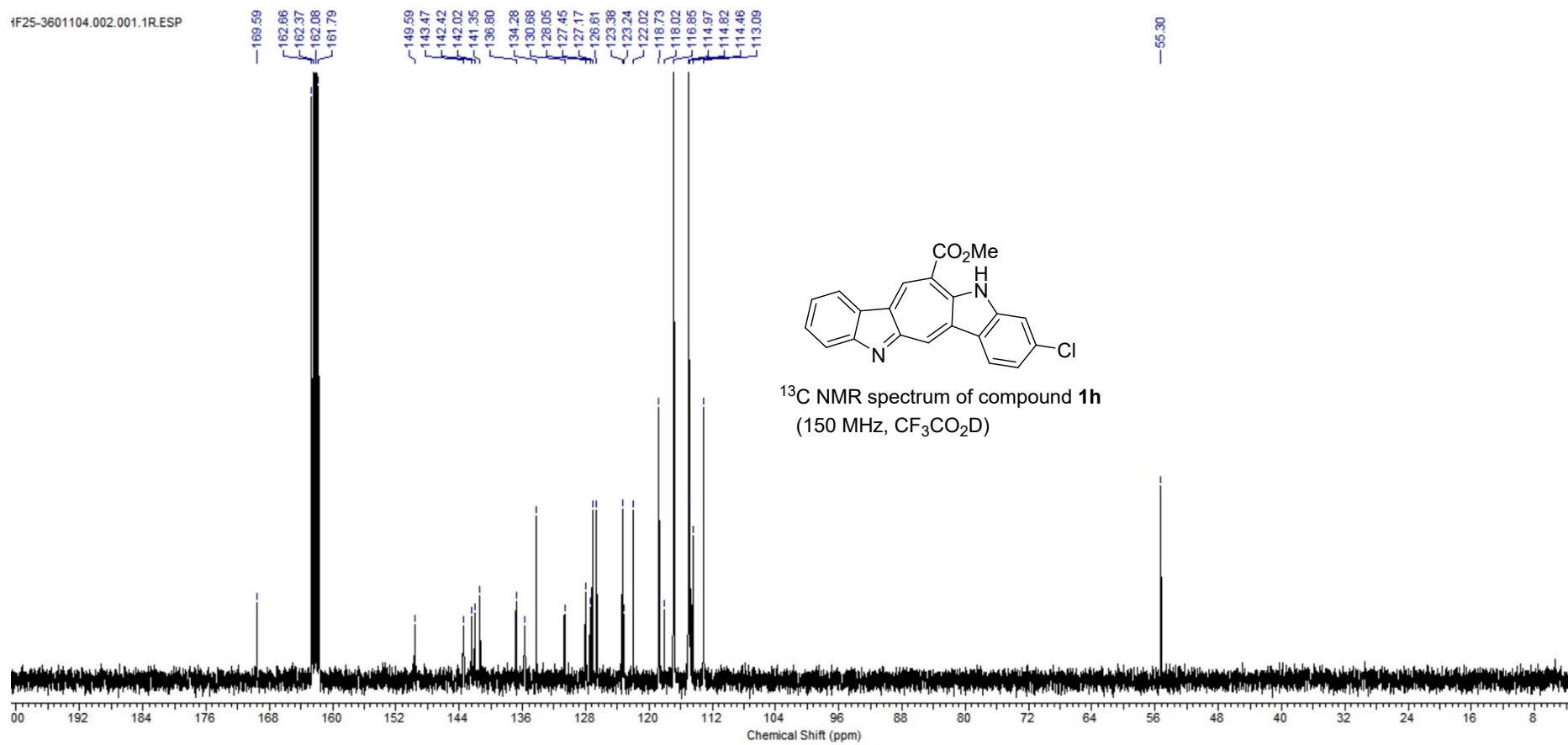


¹⁹F NMR spectrum of compound **1g**
(565 MHz, CF₃CO₂D)

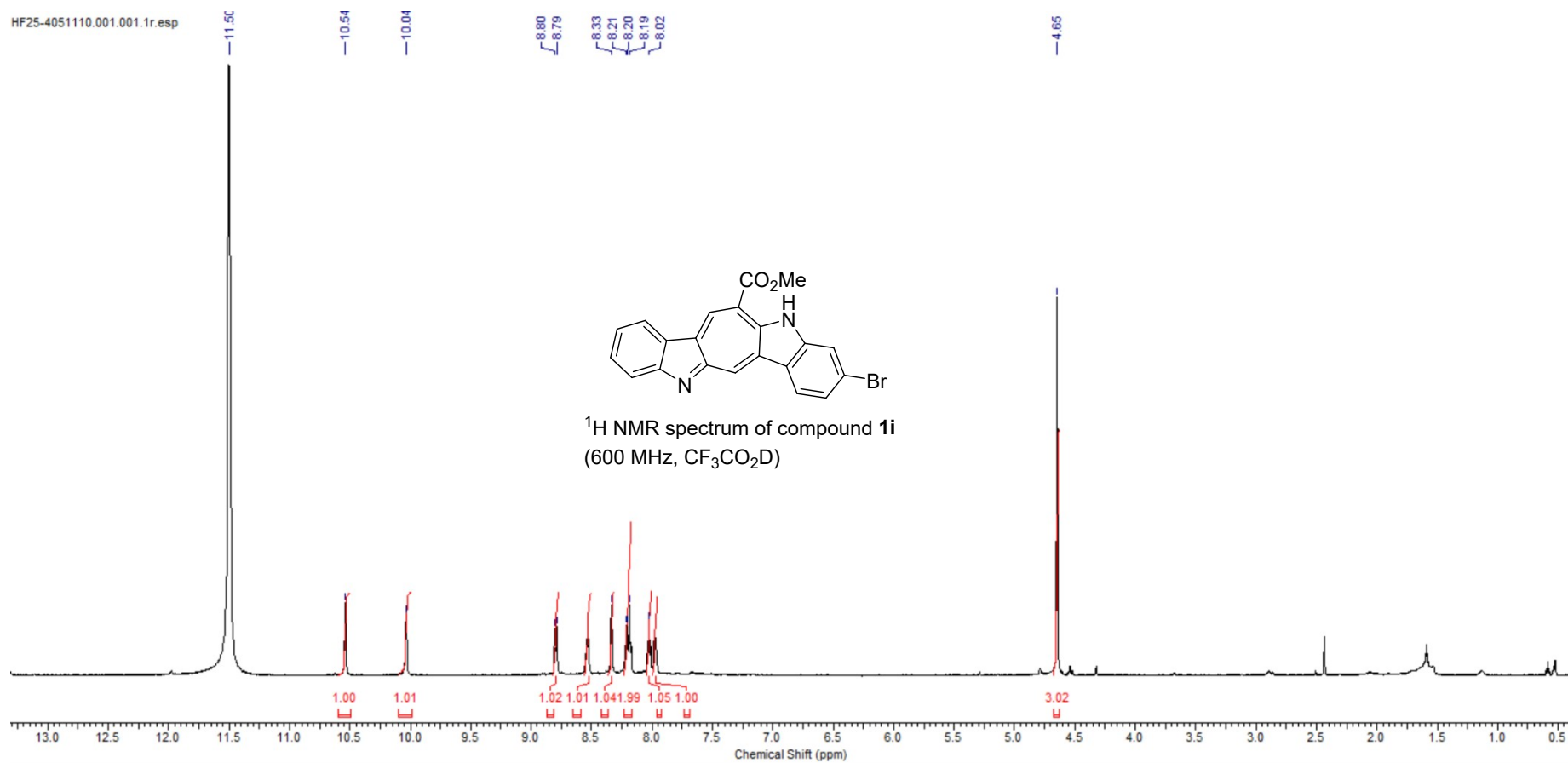




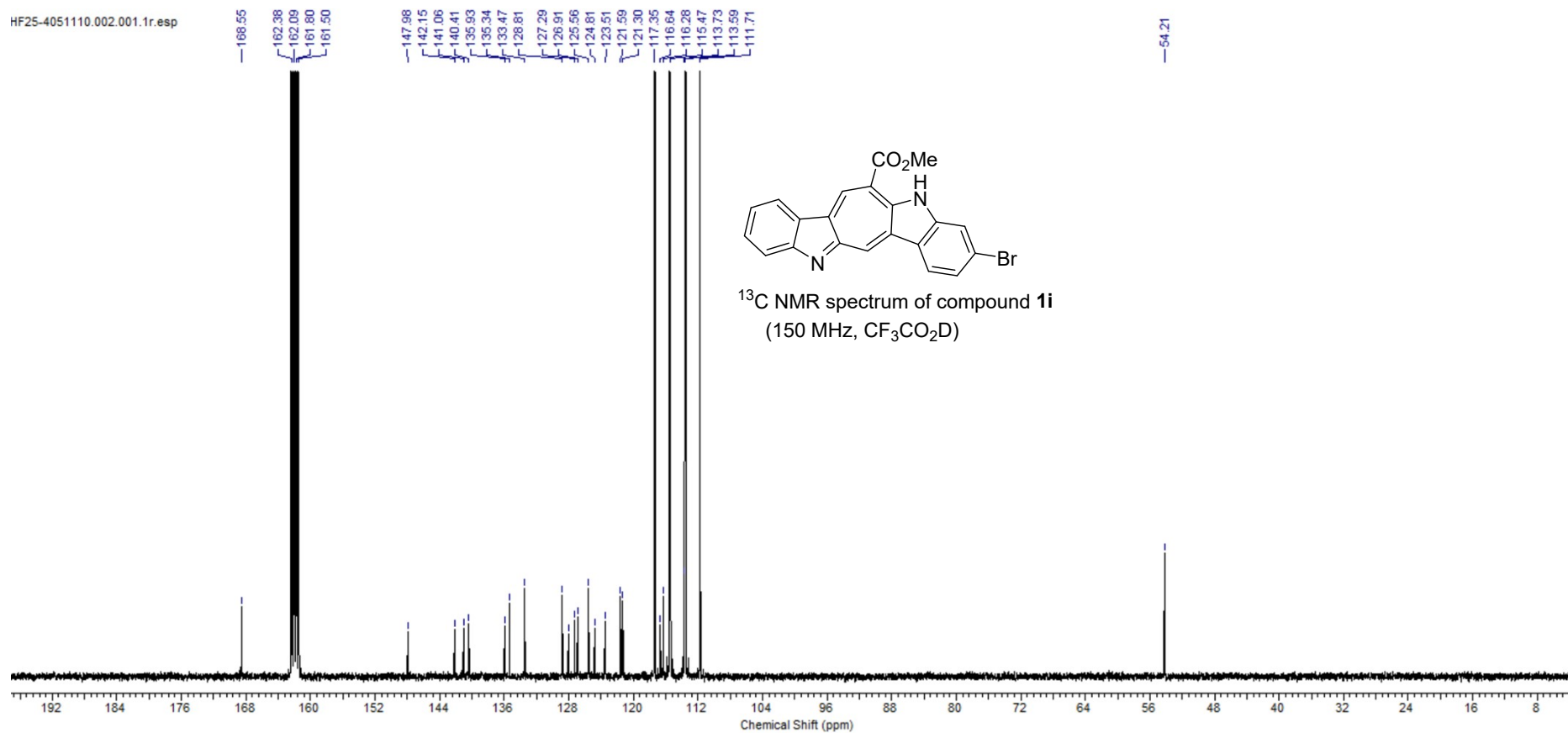
1F25-3601104.002.001.1R.ESP

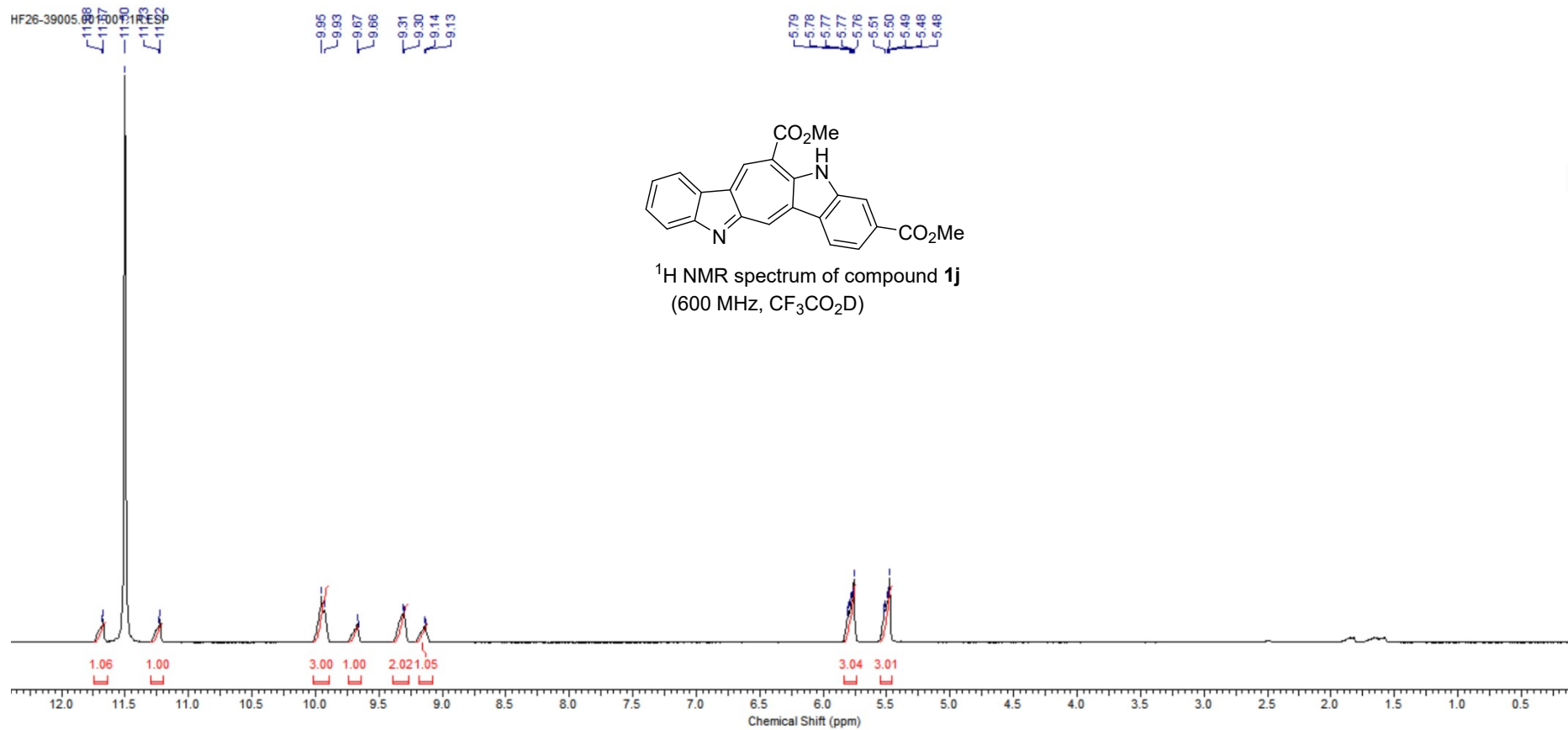


HF25-4051110.001.001.1r.esp

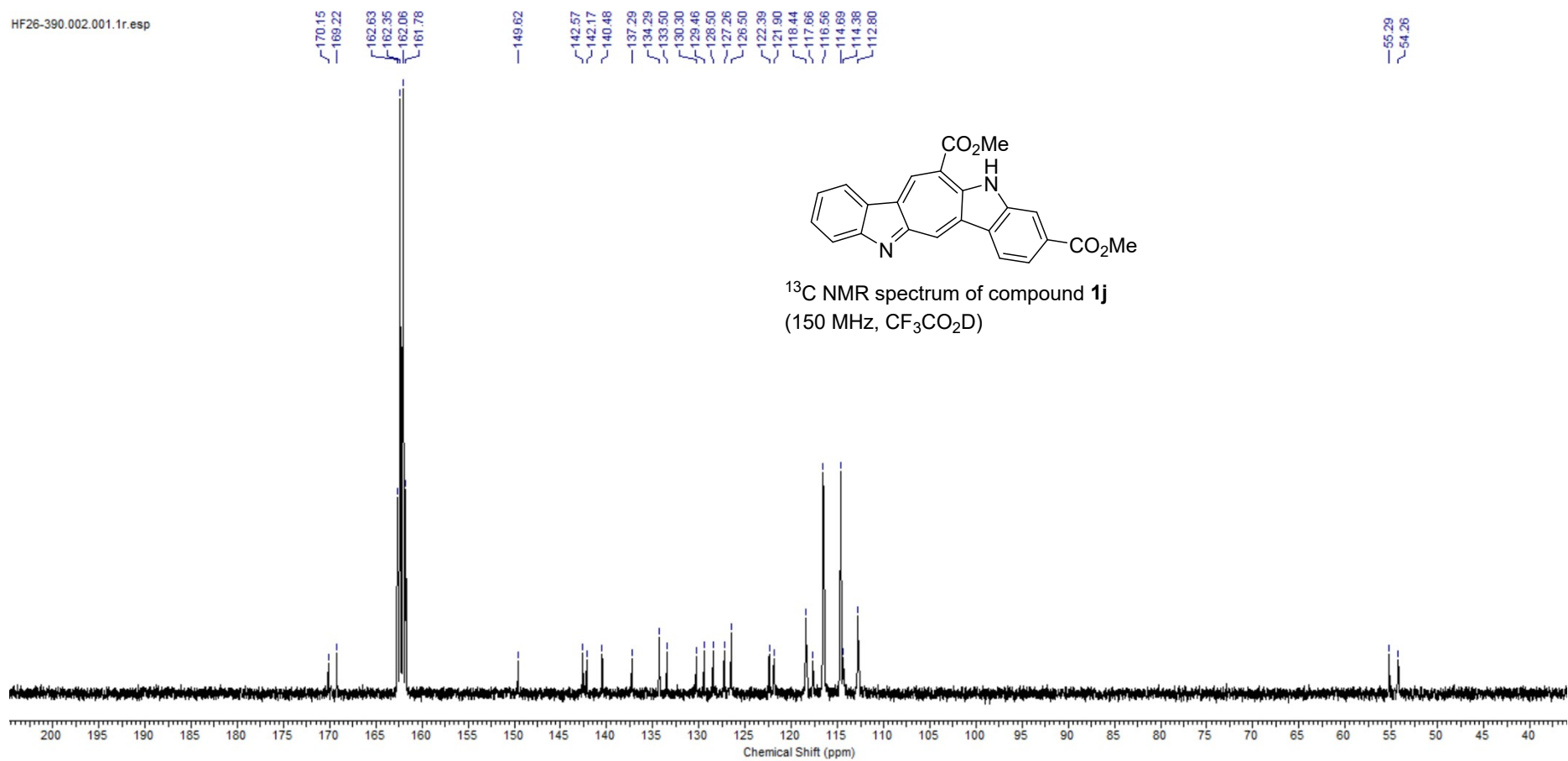


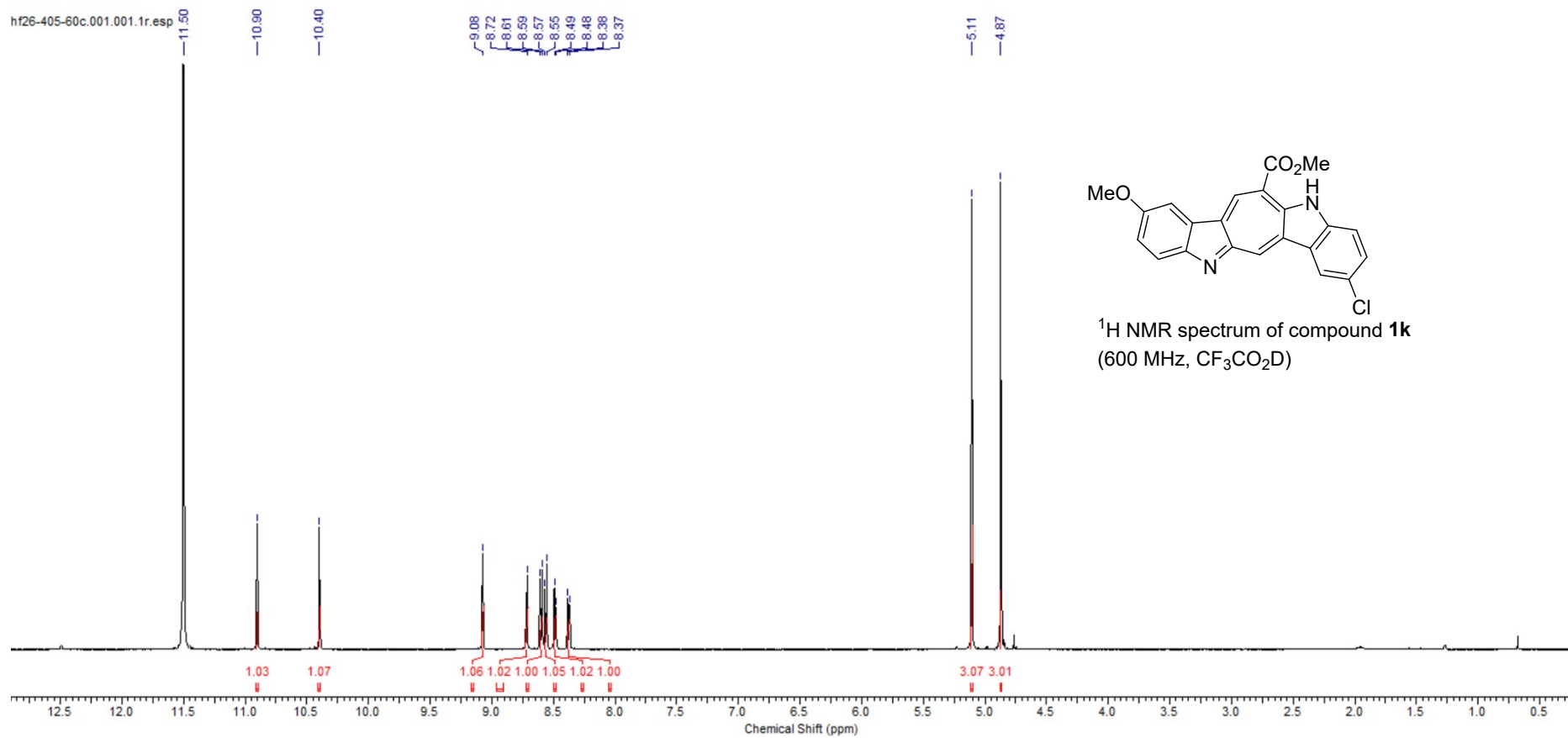
HF25-4051110.002.001.1r.esp



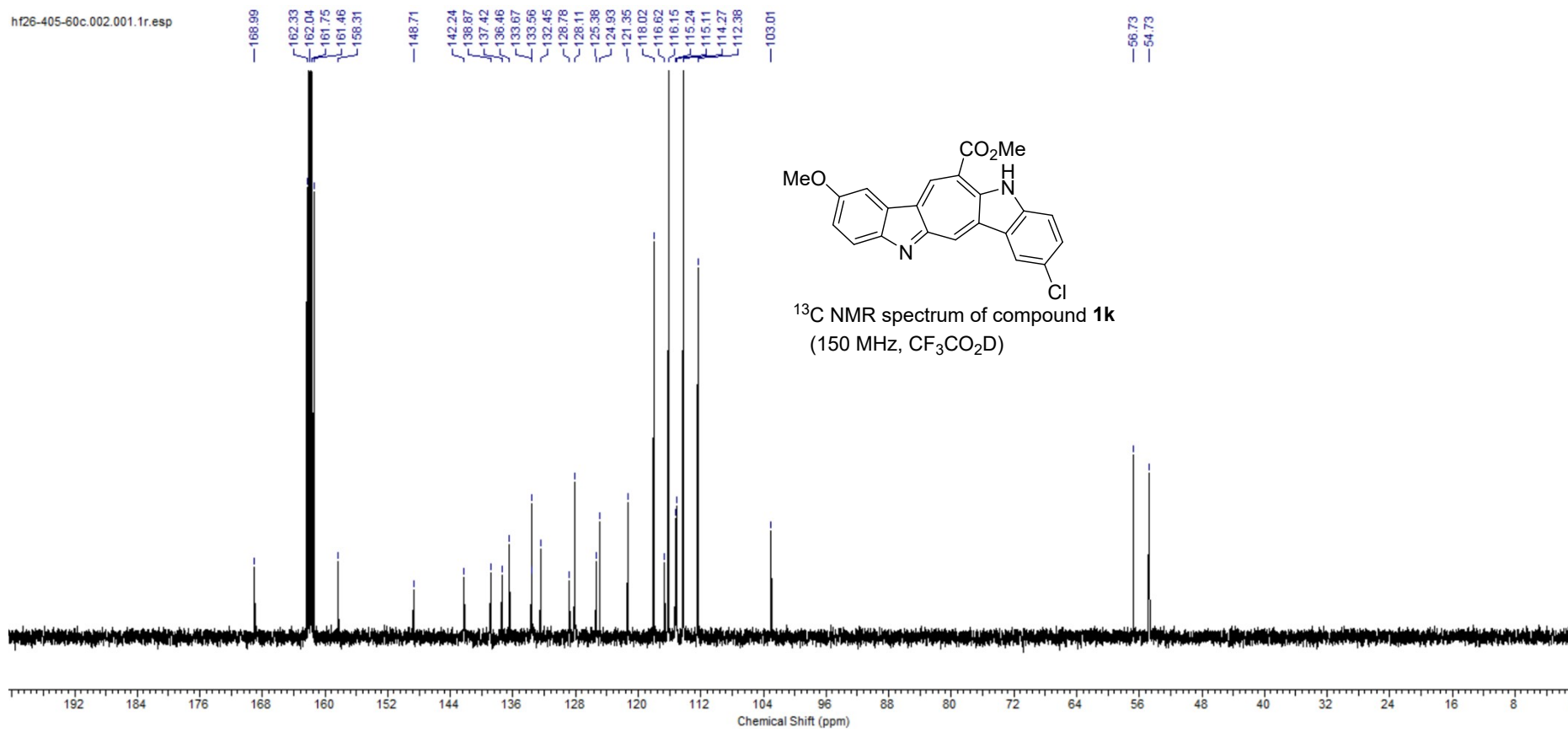


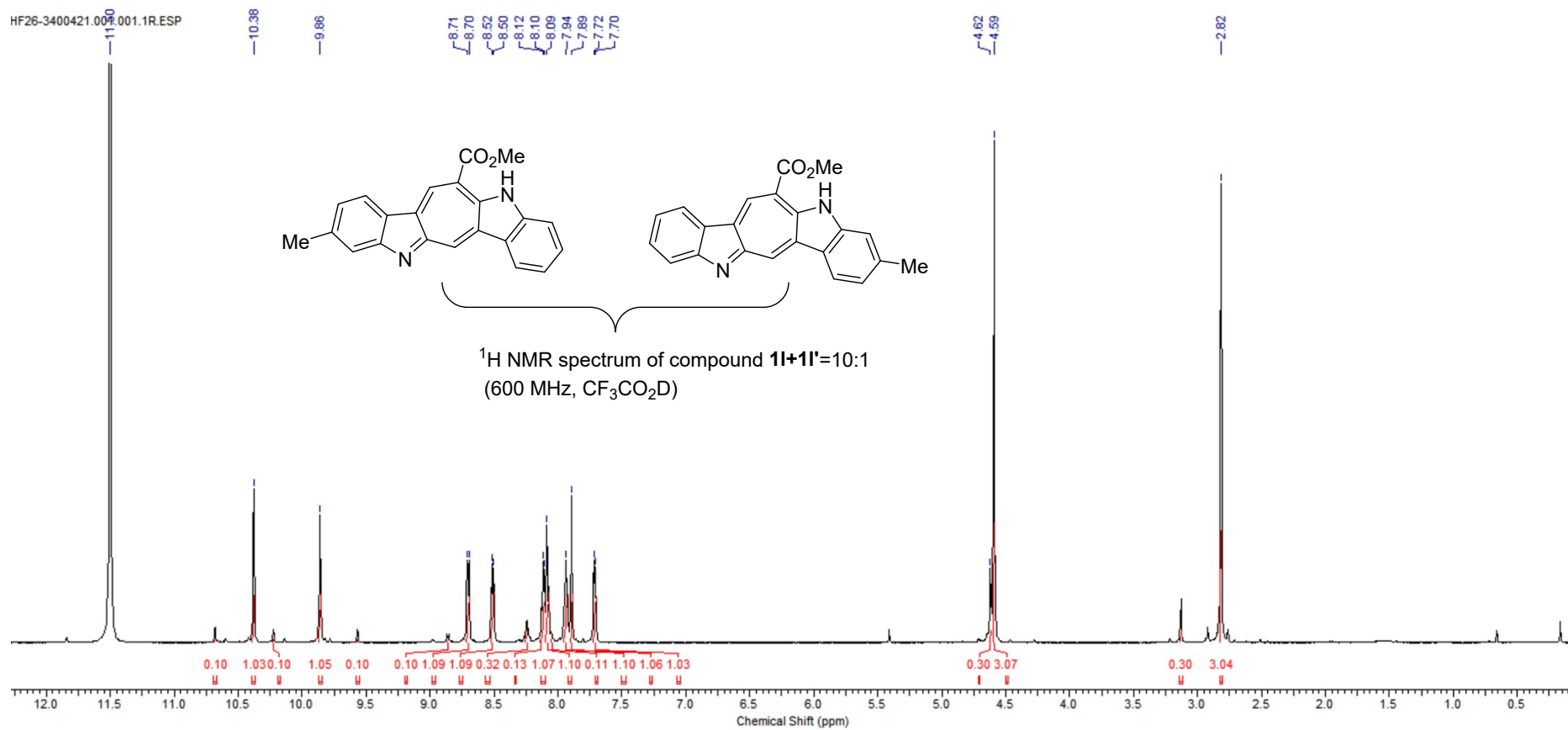
HF26-390.002.001.1r.esp



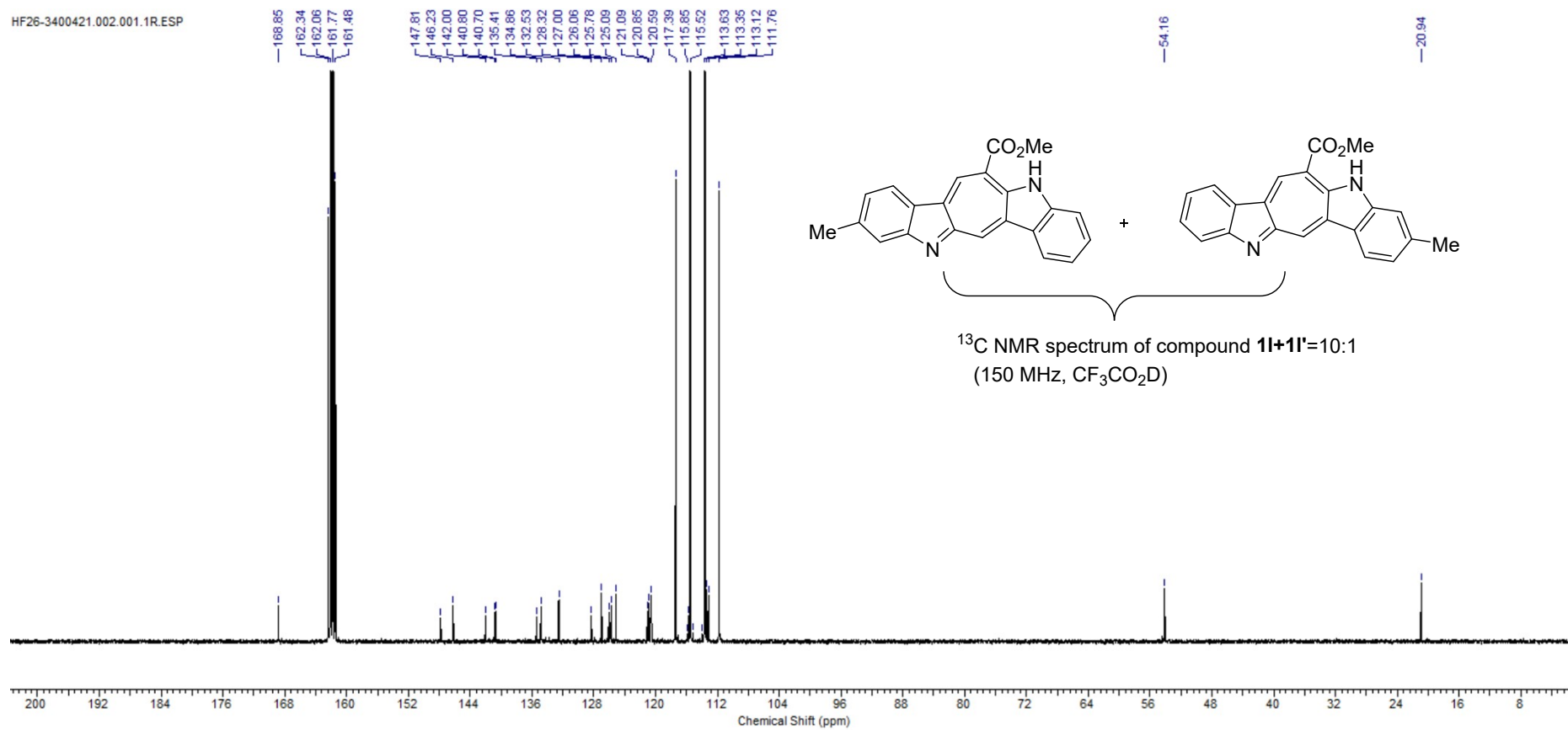


hf26-405-60c.002.001.1r.esp

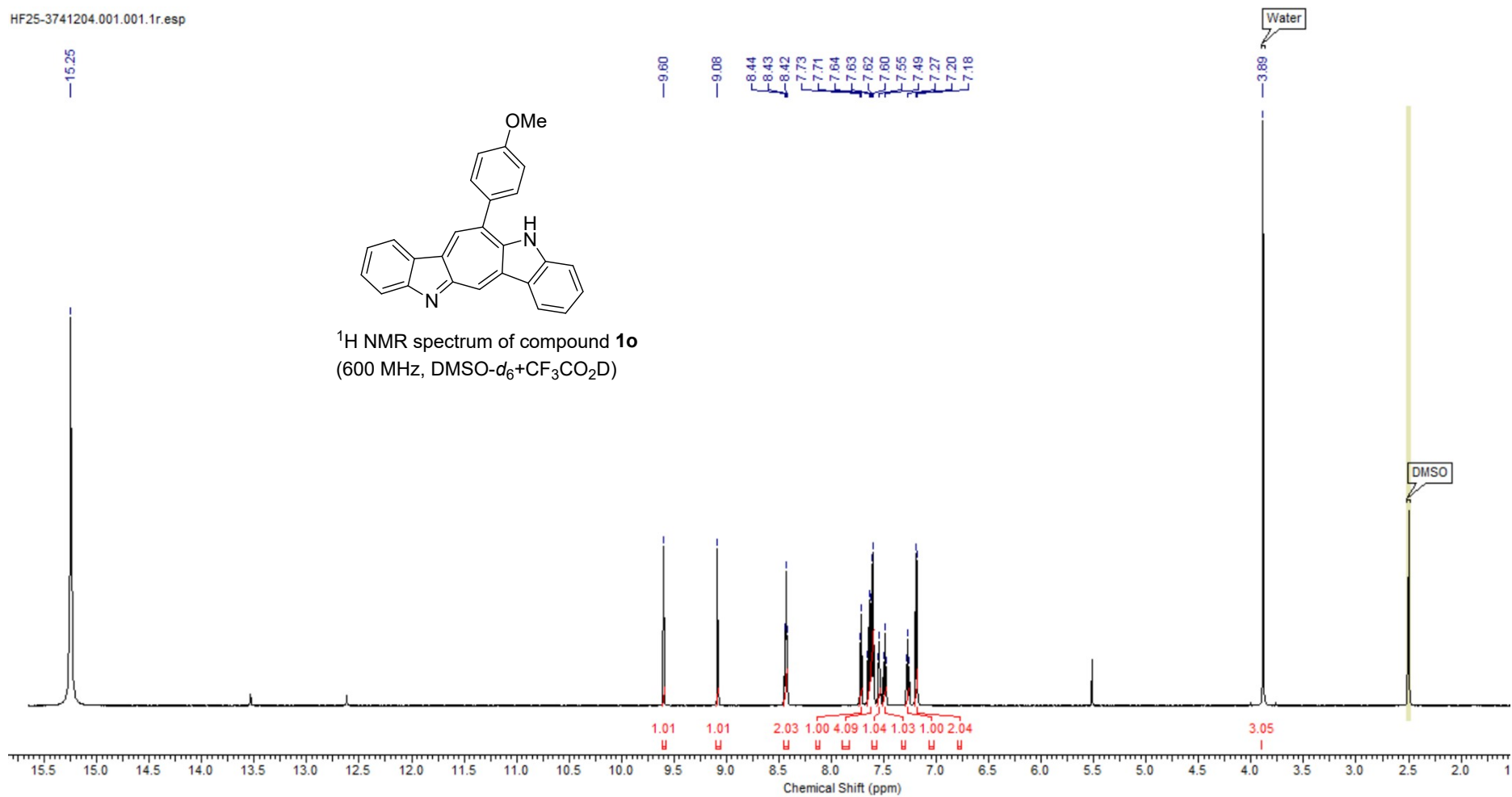




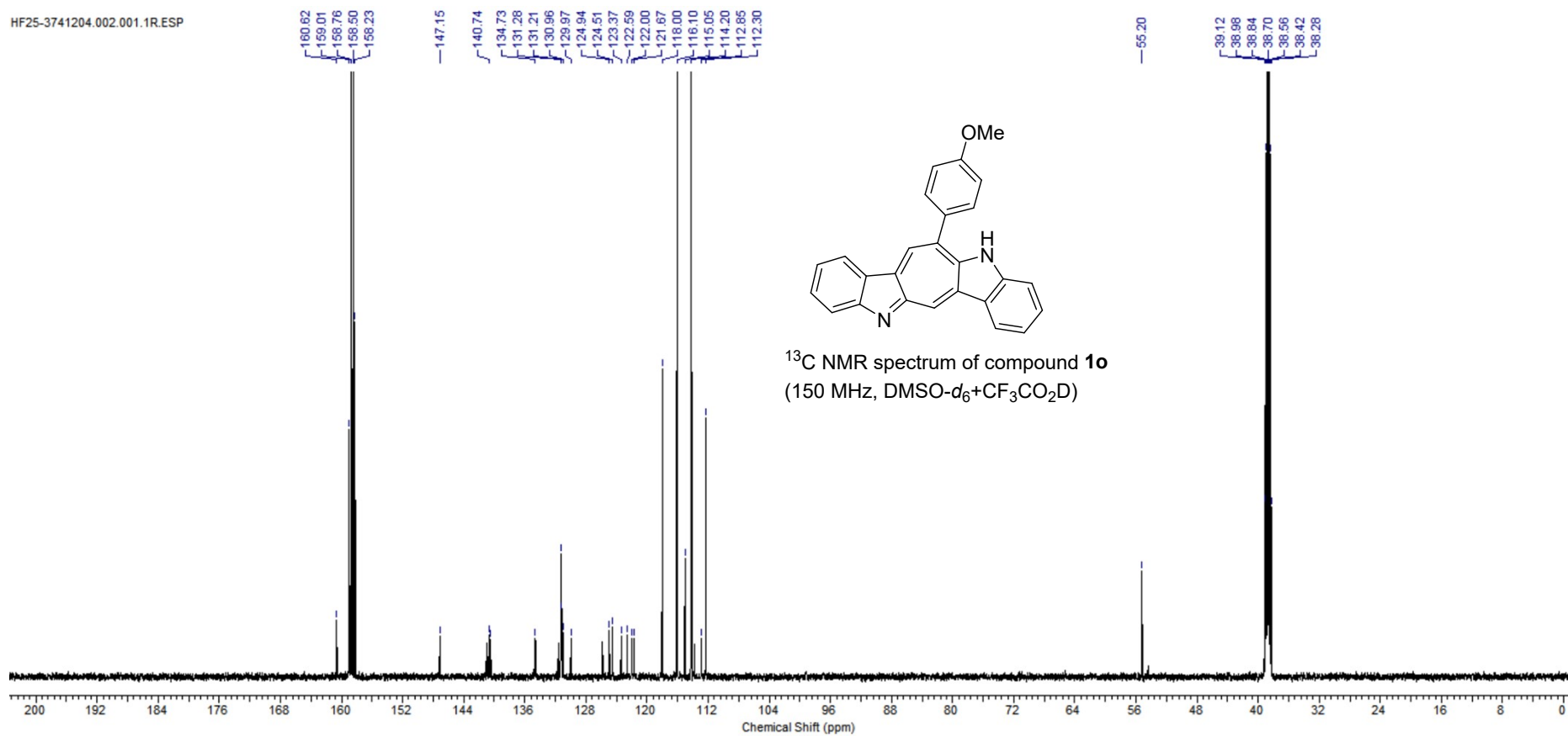
HF26-3400421.002.001.1R.ESP



HF25-3741204.001.001.1r.esp



HF25-3741204.002.001.1R.ESP



HF25-3461125-001.001.1r.esp

14.93

9.88

9.34

8.67

8.63

7.82

7.81

7.77

7.75

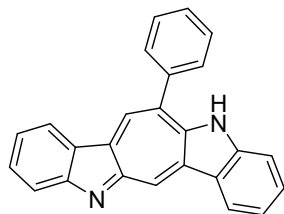
7.72

7.71

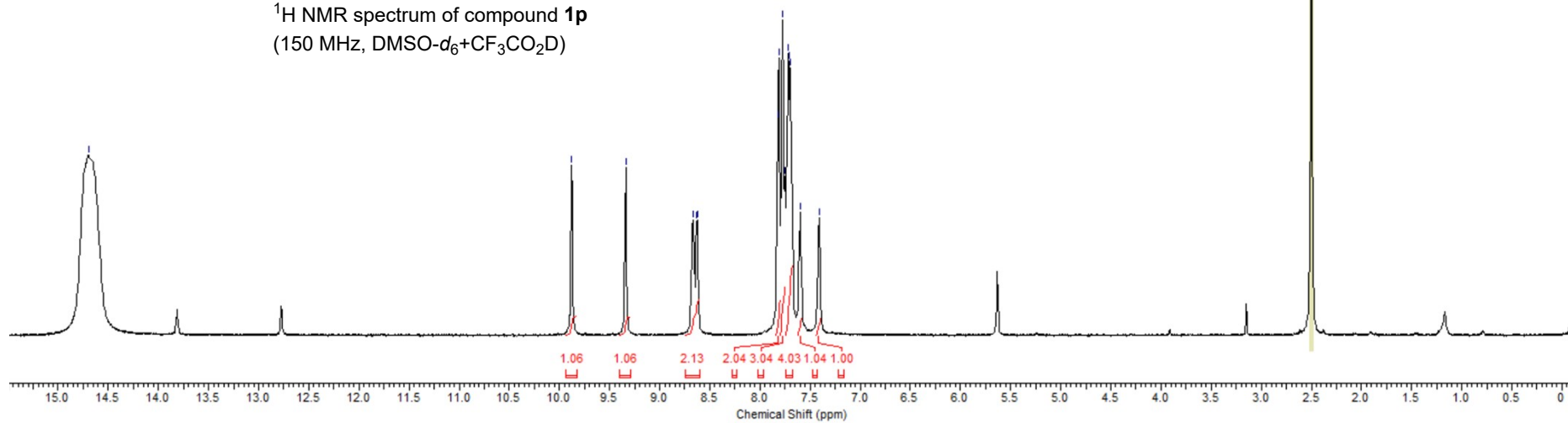
7.60

7.41

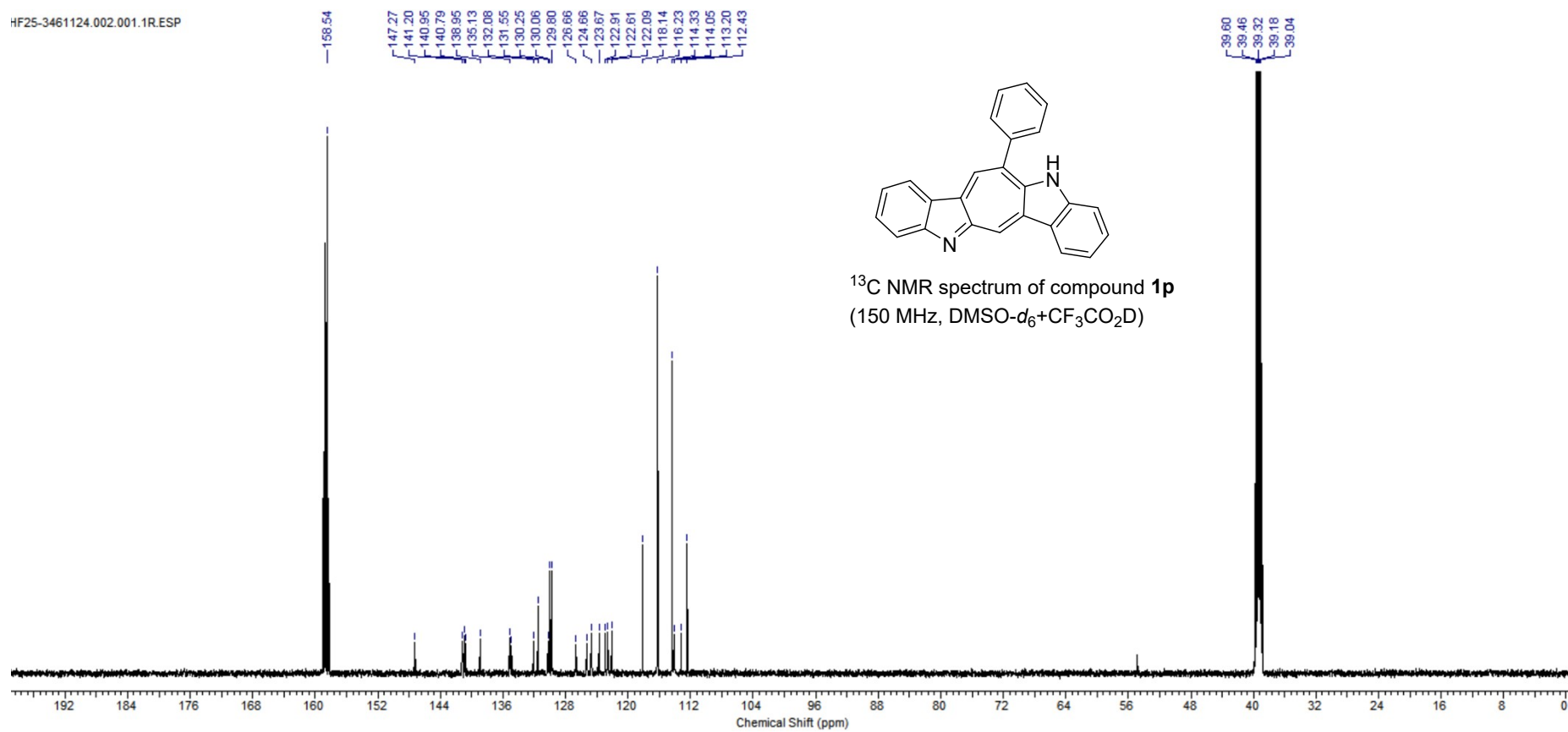
DMSO



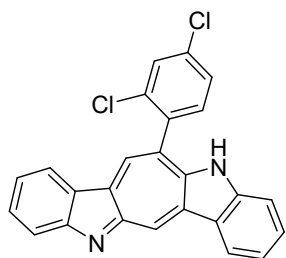
¹H NMR spectrum of compound **1p**
(150 MHz, DMSO-*d*₆+CF₃CO₂D)



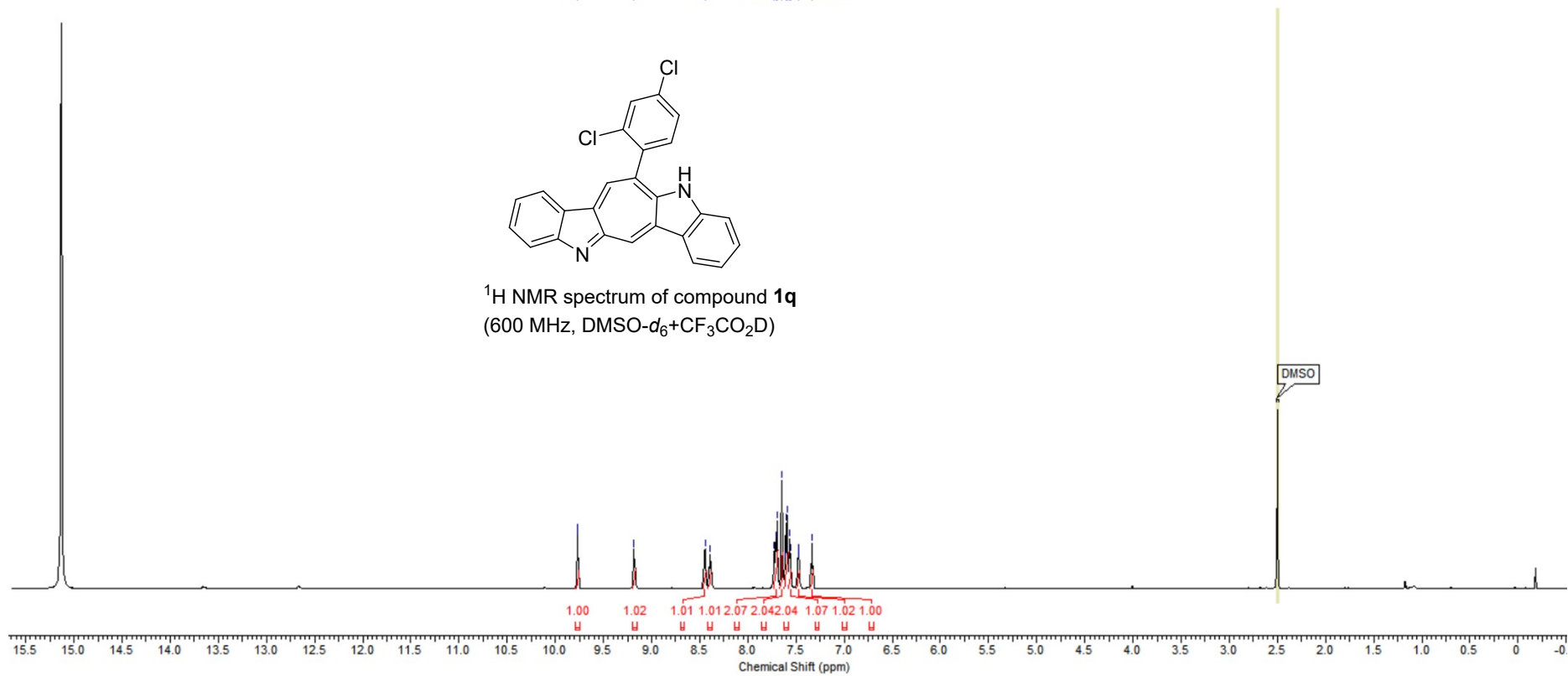
HF25-3461124.002.001.1R.ESP



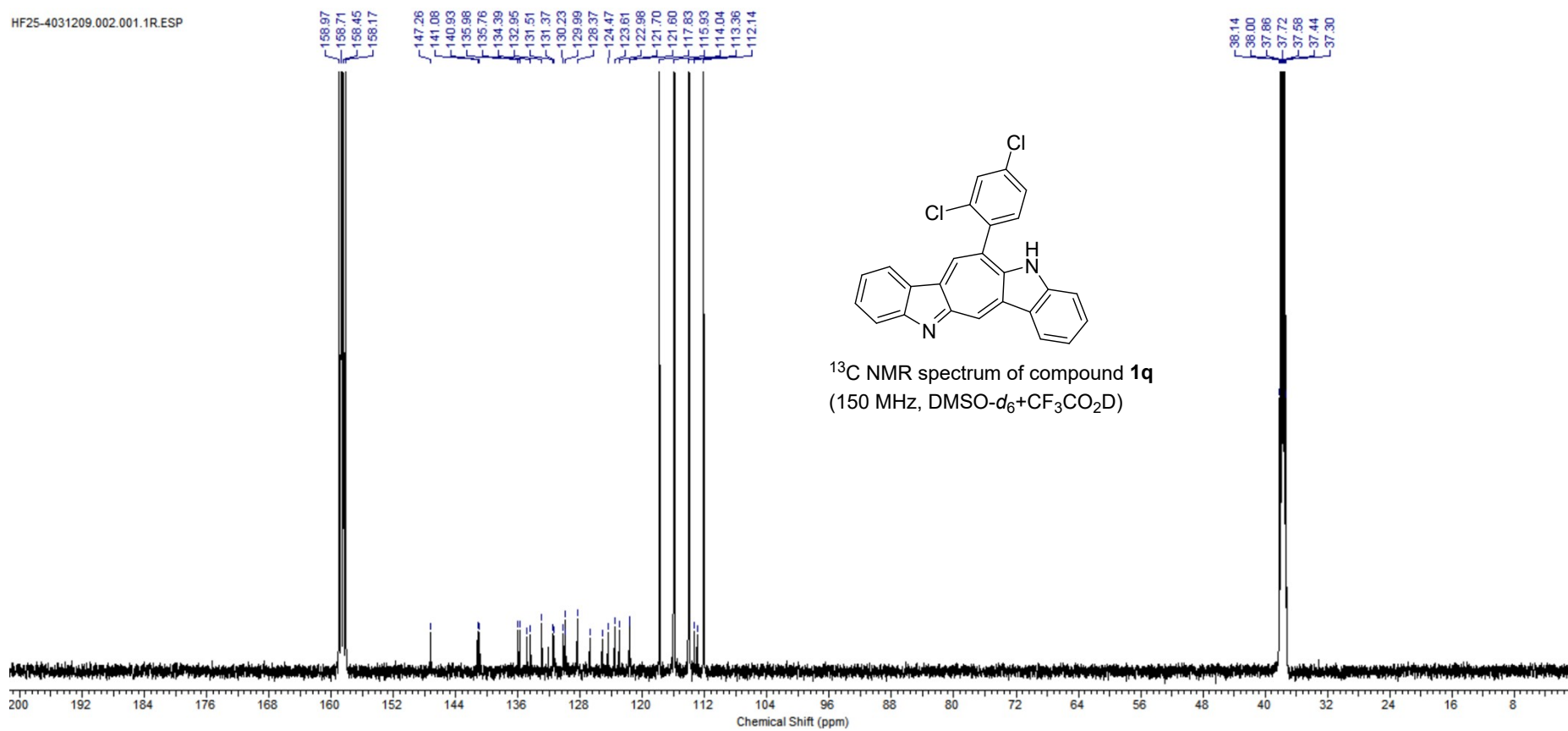
9.77
9.77
9.19
9.18
8.45
7.73
7.71
7.70
7.65
7.61
7.59
7.57
7.56
7.48
7.33



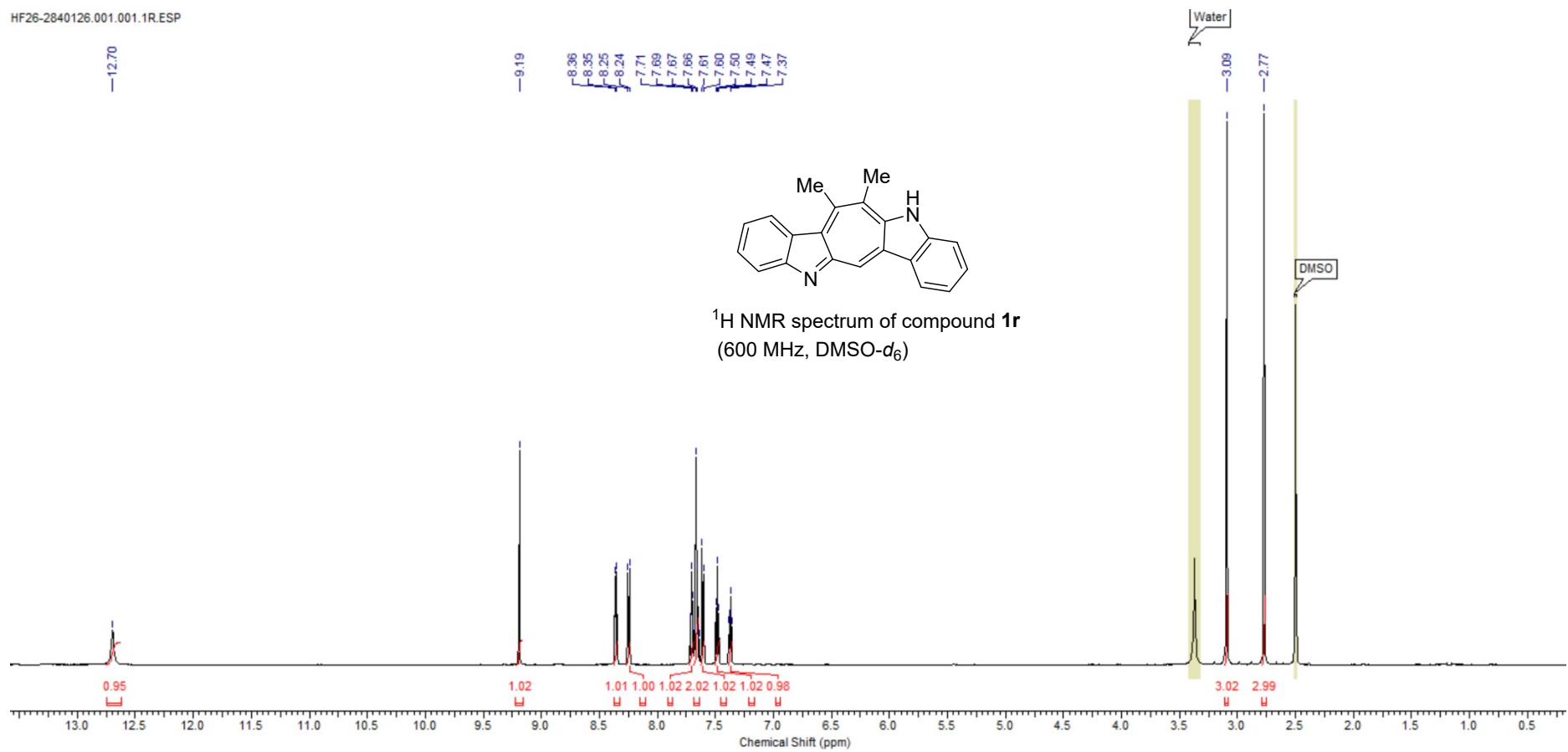
¹H NMR spectrum of compound **1q**
(600 MHz, DMSO-*d*₆+CF₃CO₂D)



HF25-4031209.002.001.1R.ESP



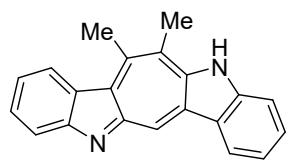
HF26-2840126.001.001.1R.ESP



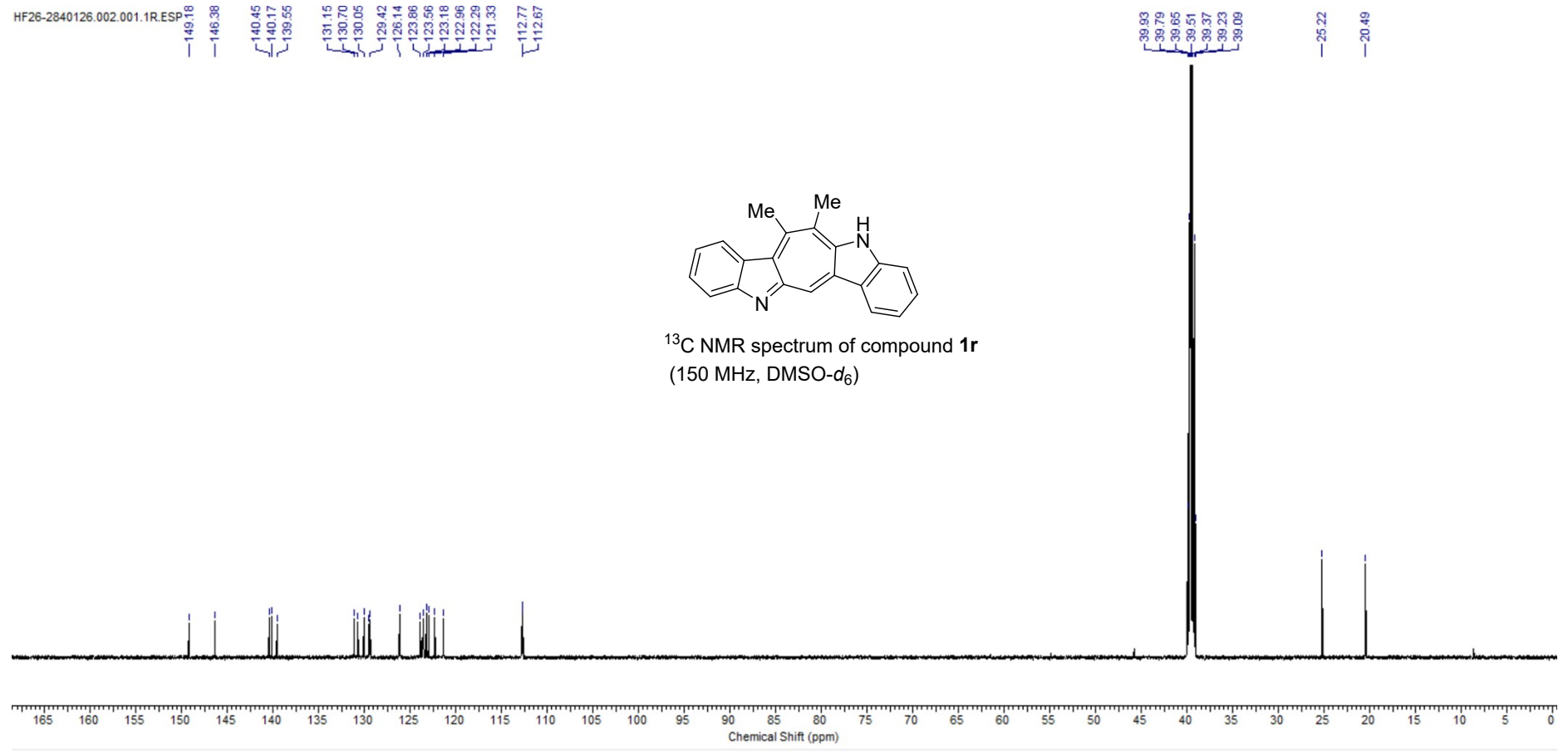
HF26-2840126.002.001.1R.ESP

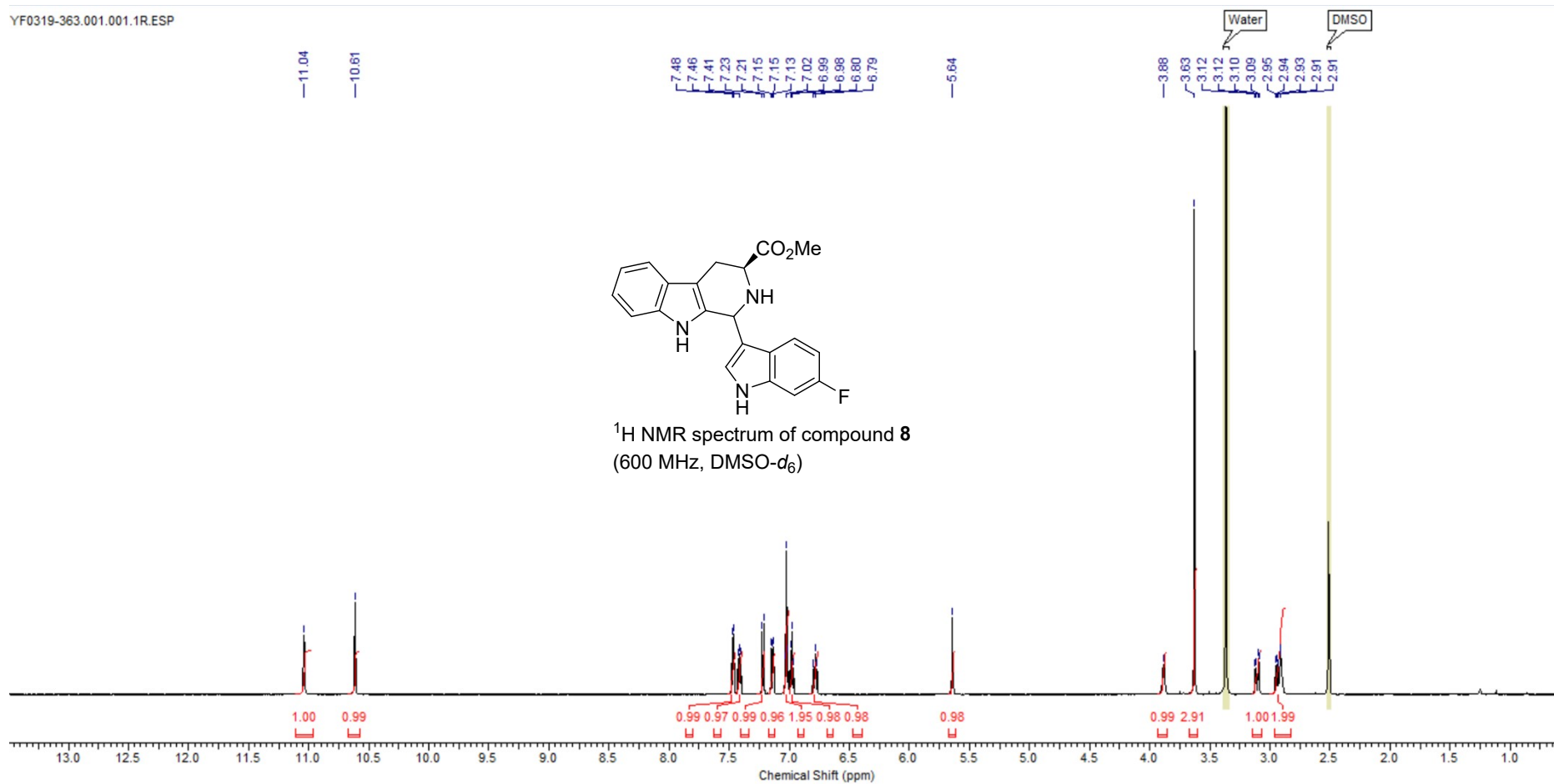
149.18
146.38
140.45
140.17
139.55
131.15
130.70
130.05
129.42
126.14
123.66
123.56
123.18
122.96
122.29
121.33
112.77
112.67

39.93
39.79
39.65
39.51
39.37
39.23
39.09
25.22
20.49

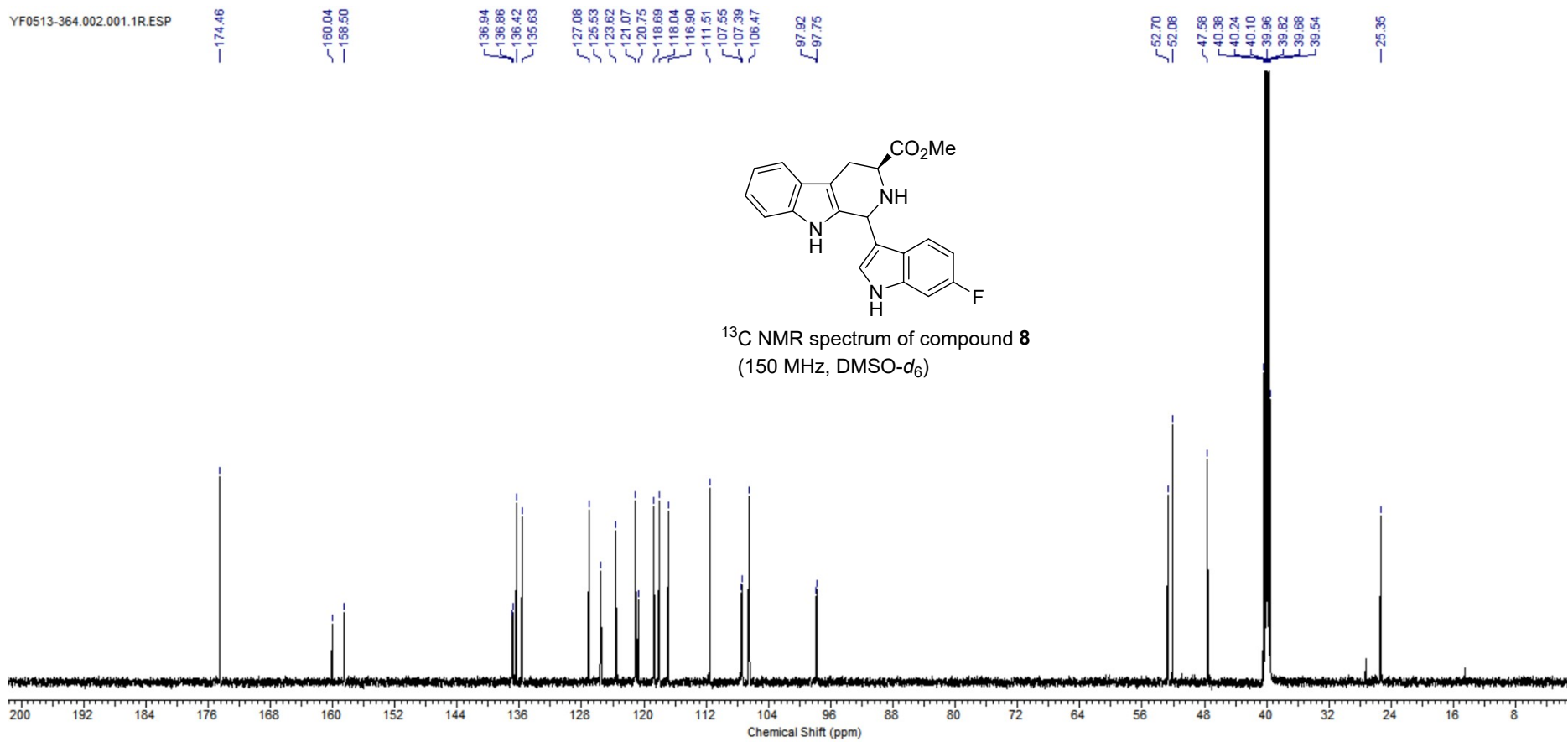


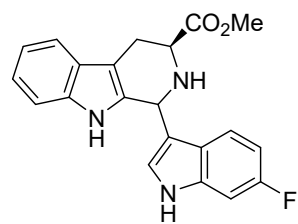
¹³C NMR spectrum of compound **1r**
(150 MHz, DMSO-d₆)



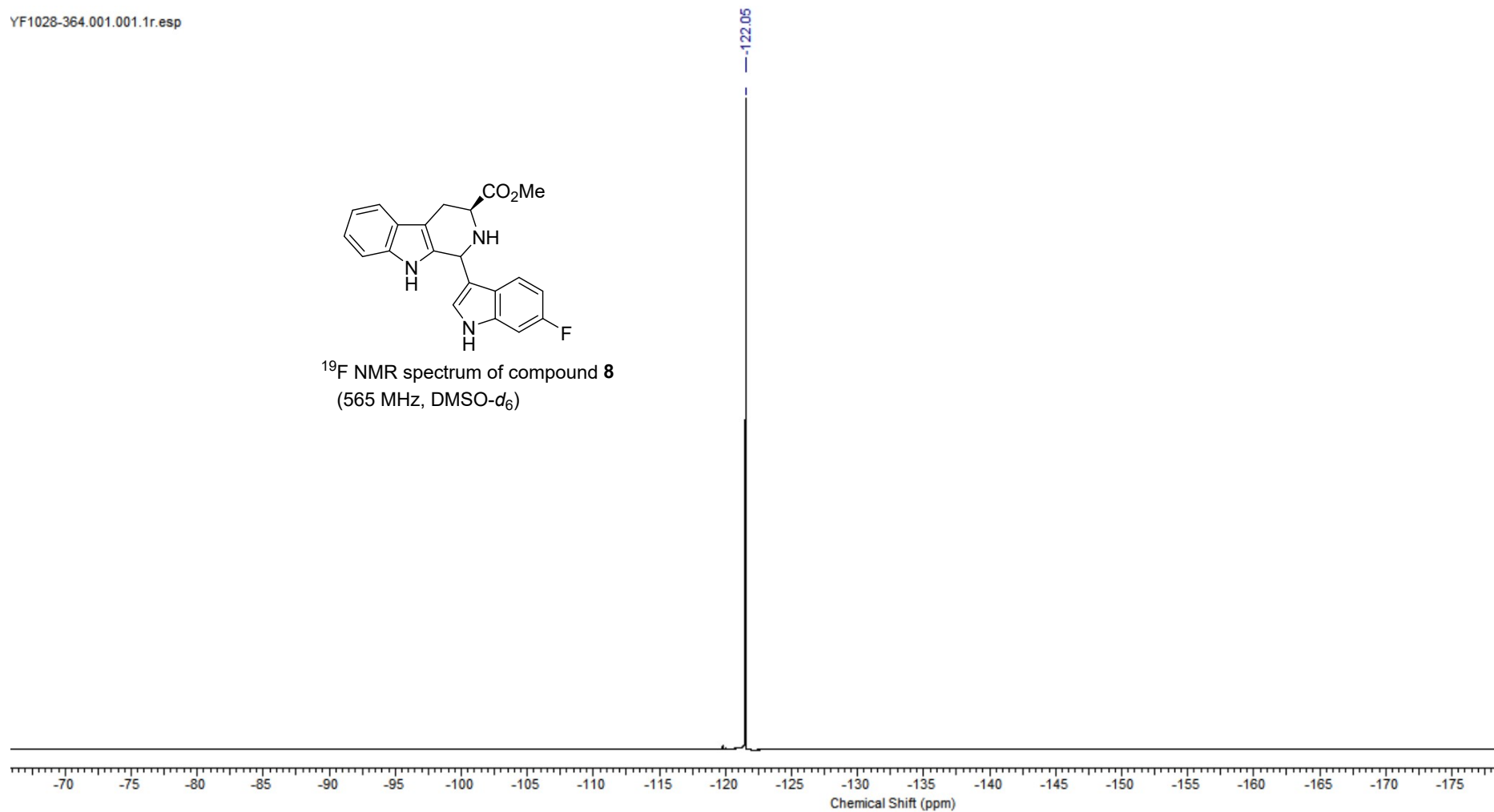


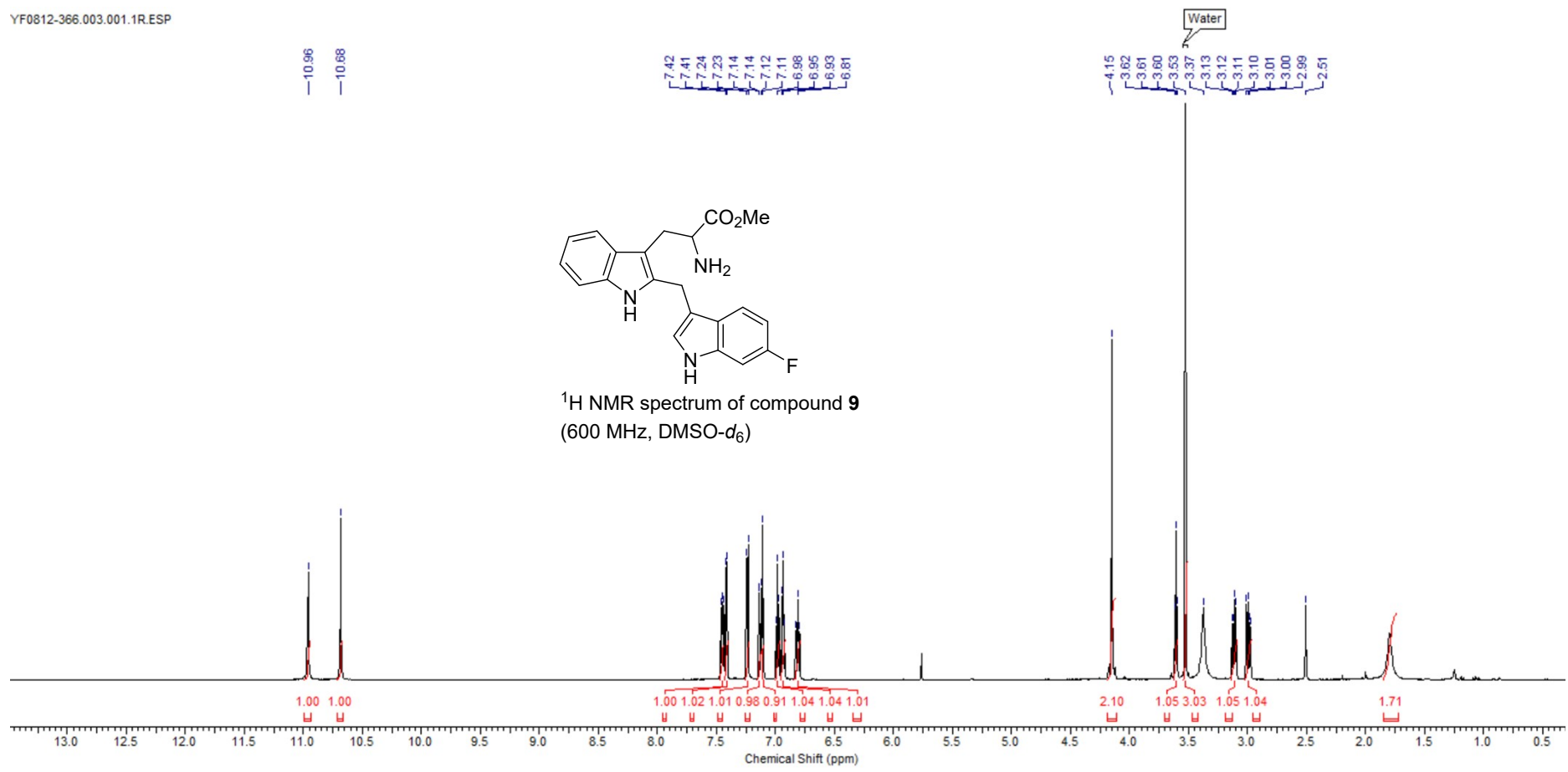
YF0513-364.002.001.1R.ESP



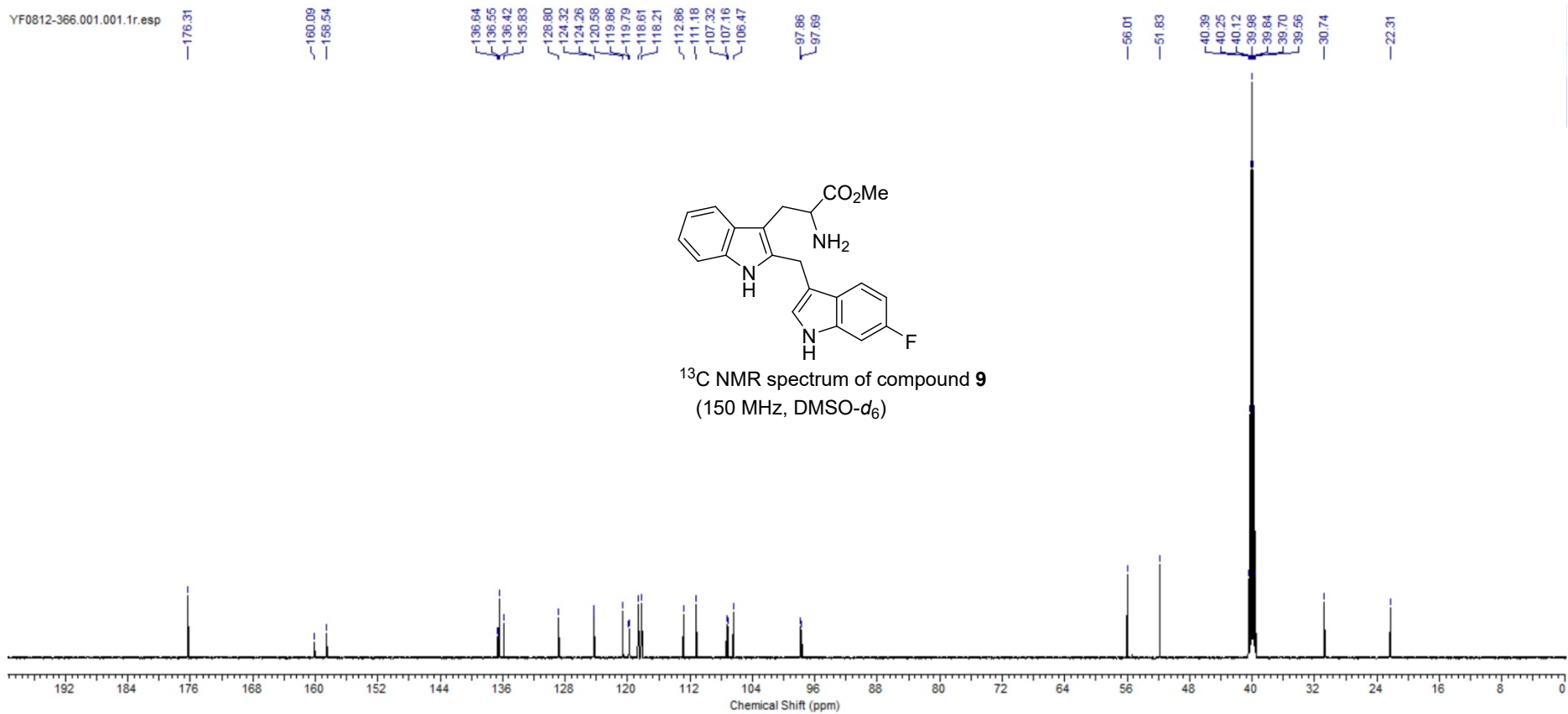


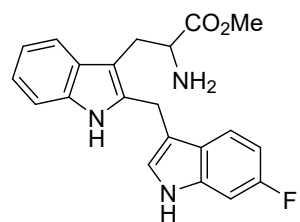
¹⁹F NMR spectrum of compound **8**
(565 MHz, DMSO-*d*₆)





YF0812-366.001.001.1r.esp

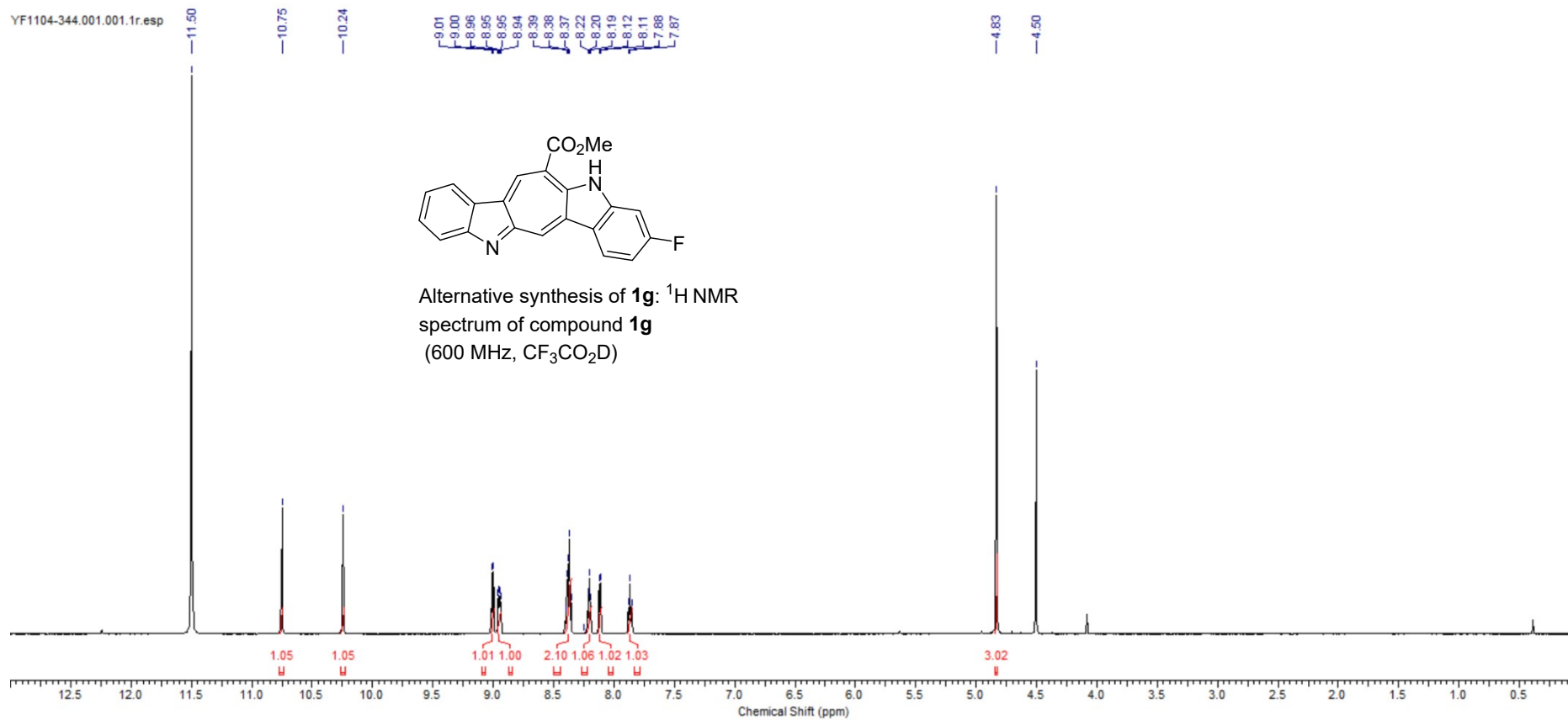




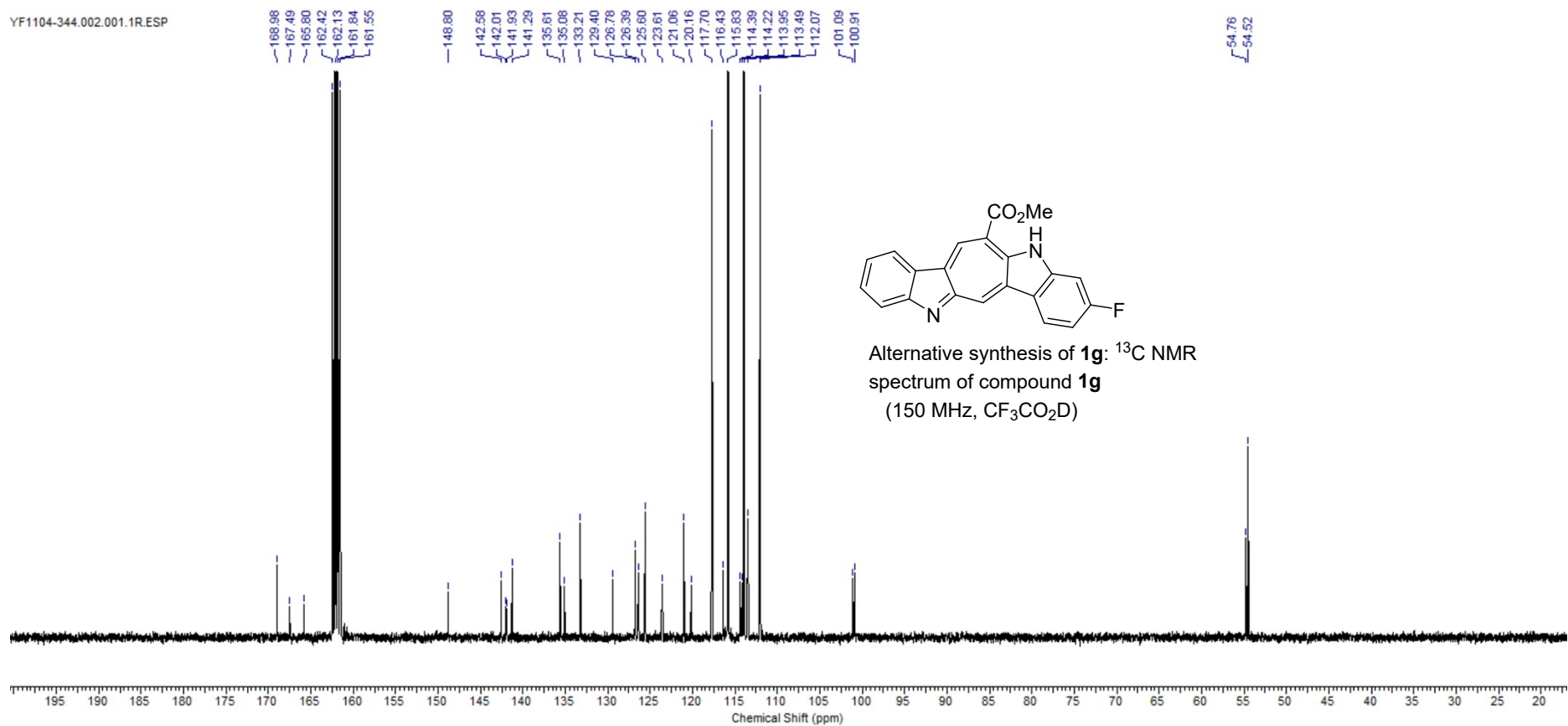
¹⁹F NMR spectrum of compound **9**
(565 MHz, DMSO-*d*₆)

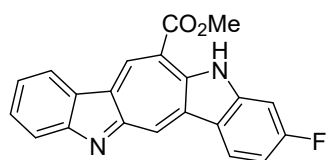


YF1104-344.001.001.1r.esp

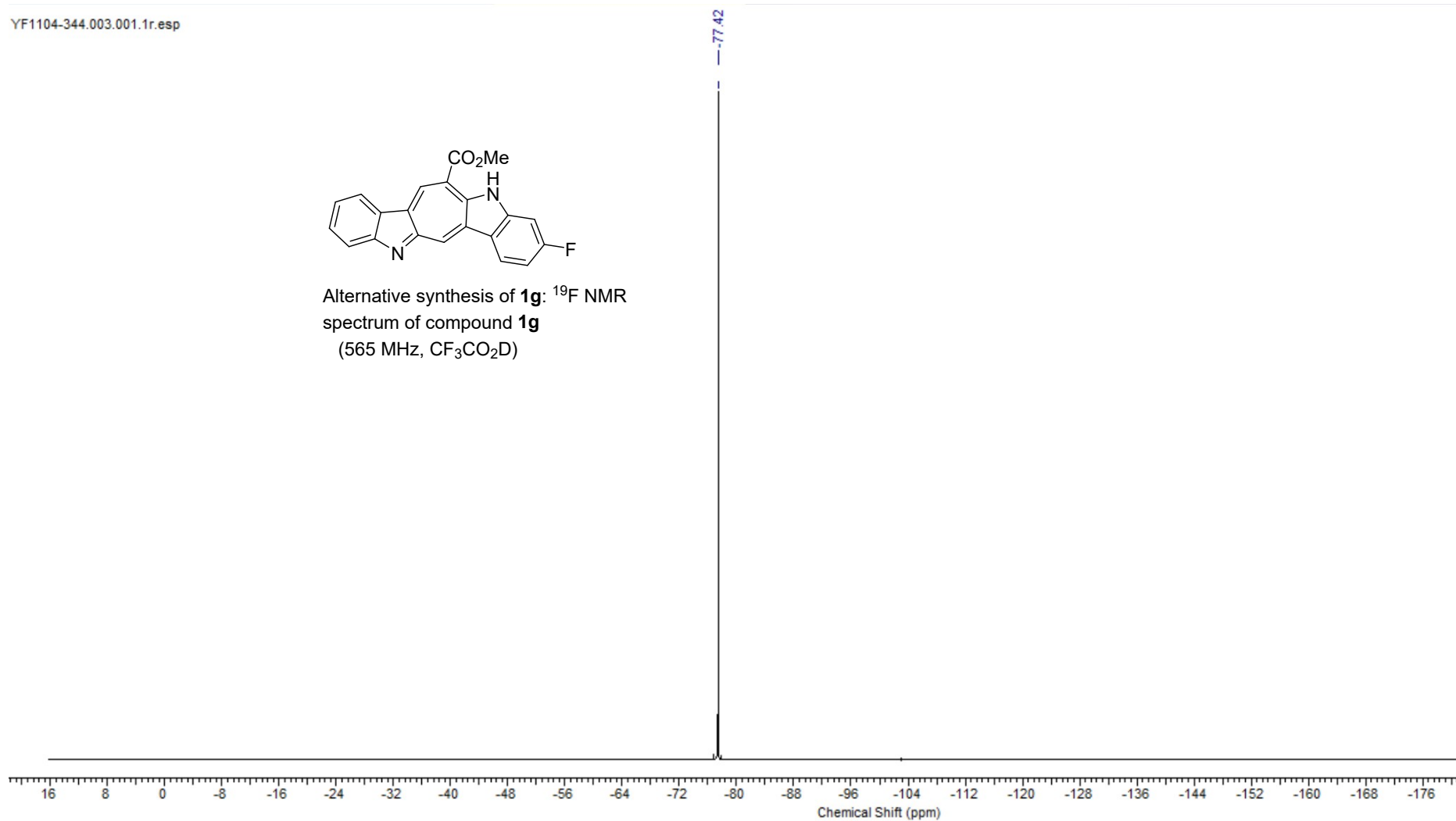


YF1104-344.002.001.1R.ESP

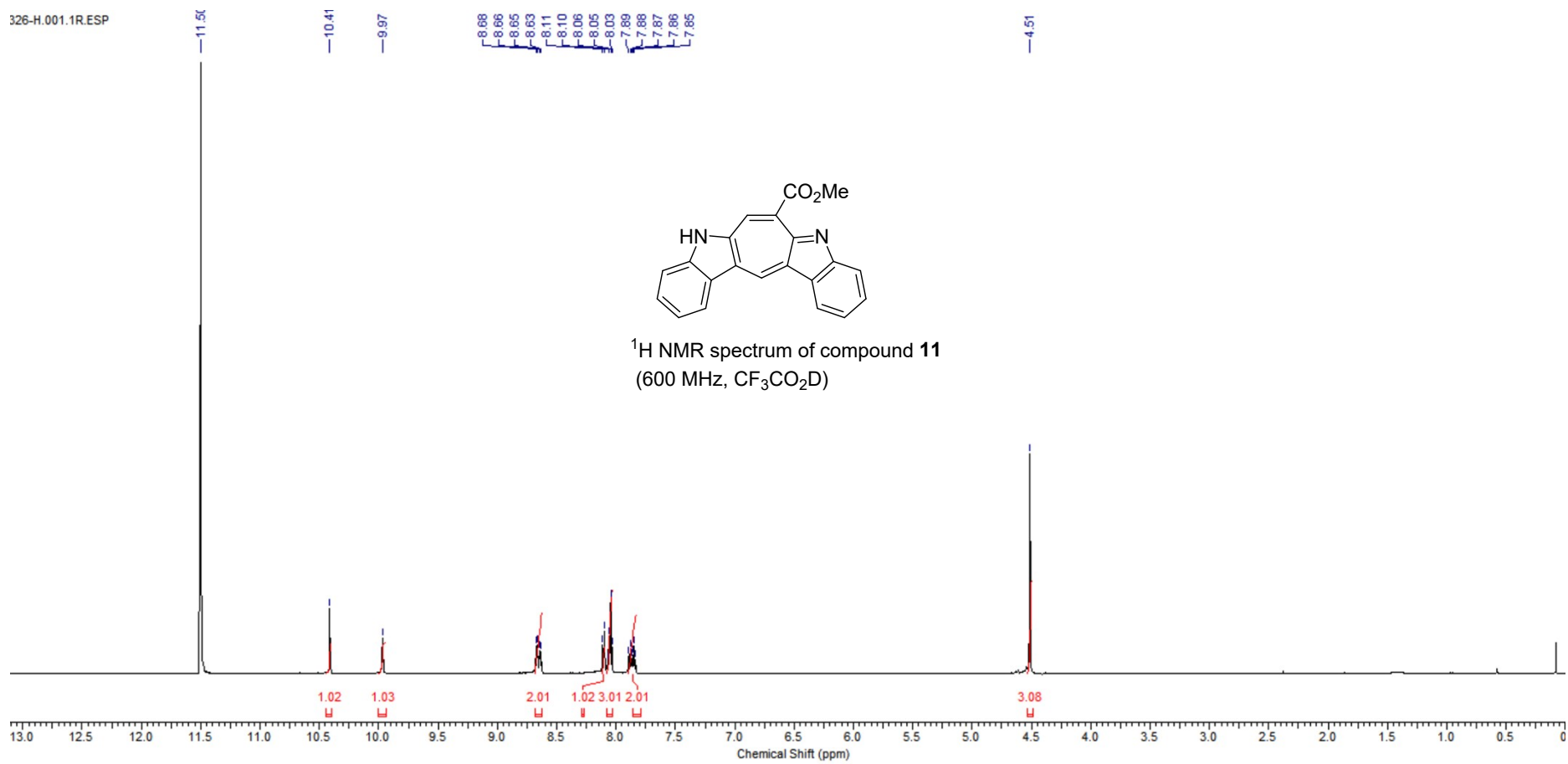




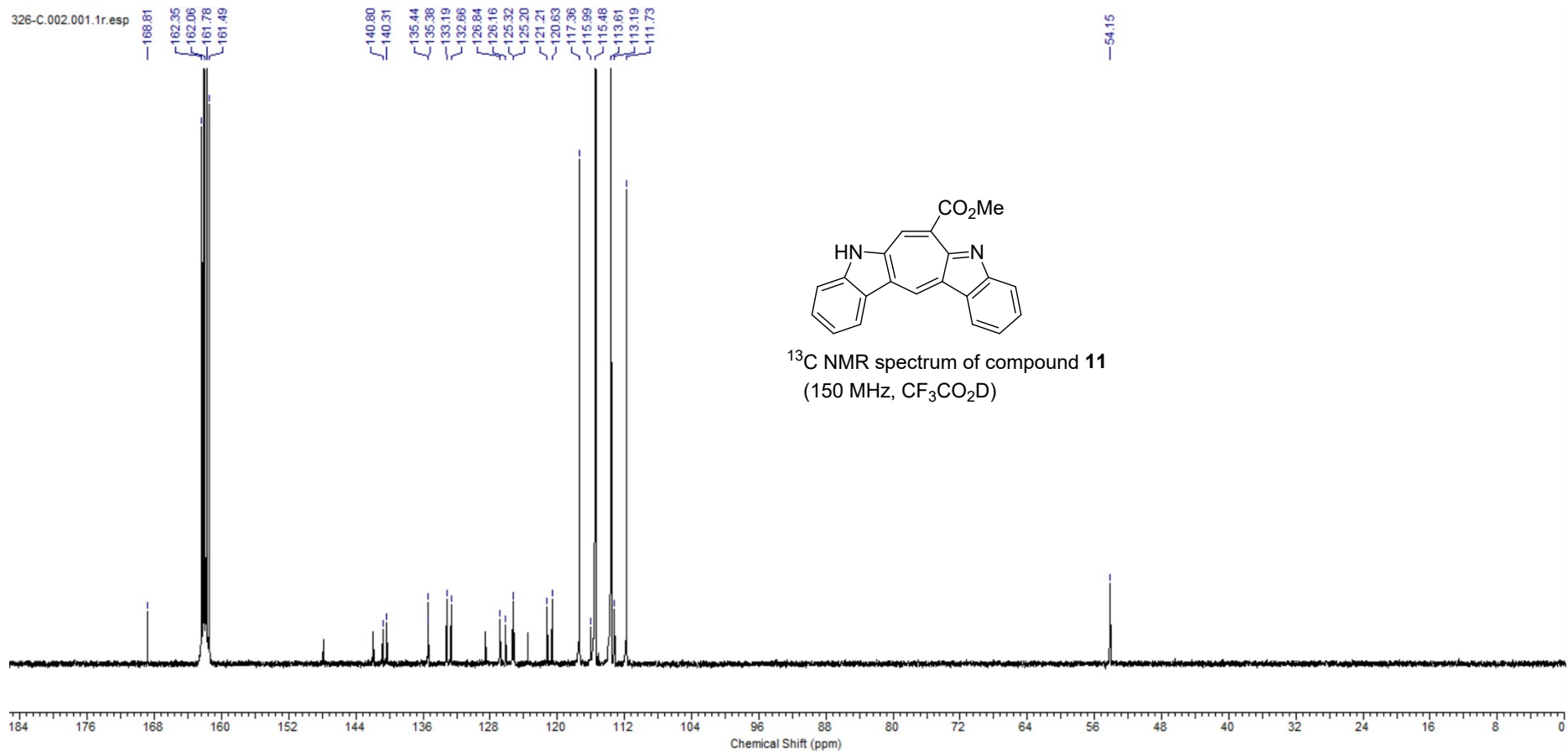
Alternative synthesis of **1g**: ^{19}F NMR
spectrum of compound **1g**
(565 MHz, $\text{CF}_3\text{CO}_2\text{D}$)



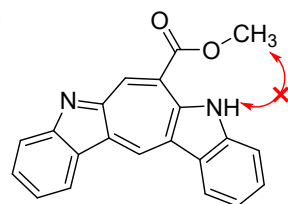
326-H.001.1R.ESP



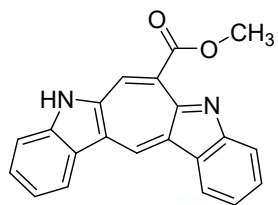
326-C.002.001.1r.esp



YYT-0331-326. 2. ser



Not detected



NOESY spectrum of compound 11
(DMSO- d_6)

