Study of aza- and diaza-cyclotribenzylidenes conformations

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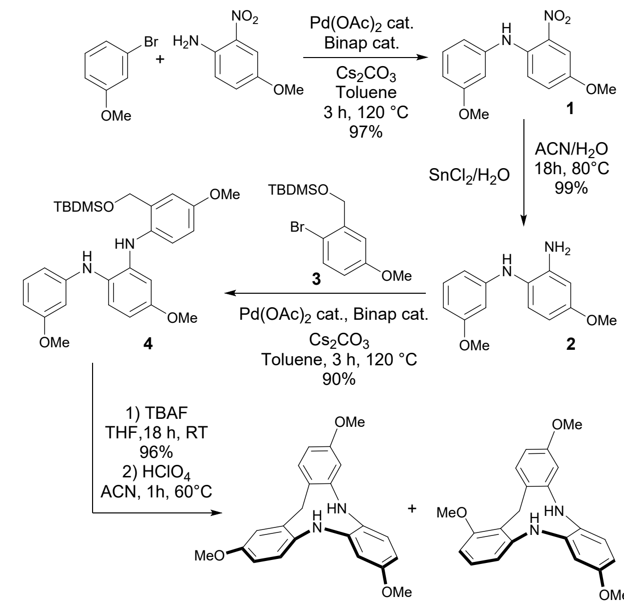
1 General

All reagents and solvents were obtained from commercial suppliers and were used without further purification. NMR spectra were recorded either at 400 MHz or 600 MHz (Bruker Neo 400 MHz or Bruker NEO 600 MHz) for ^{1}H NMR and at 100 or 150 MHz for ^{13}C NMR with chemical shift (δ) given in parts per million (ppm) relative to TMS as internal standard and recorded at 295K. The following abbreviations are used to describe peak splitting patterns when appropriate: br=broad, s=singlet, d=doublet, t=triplet, q=quartet, m=multiplet, dd=doublet of doublet, dt=doublet of triplet. Coupling constants J are reported in hertz units (Hz). Chromatography was carried out on a column using silica gel 60 Merck (0.063-0.200 mm) as the stationary phase. Melting points were measured on a Stuart Automatic Melting Point SMP-50 apparatus. High resolution mass spectra (HRMS) were obtained by Atmospheric Solids Analysis Probe (HRMS-ASAP) on a WATERS H-ClassXevo G2-XS QTof, or by ElectroSpray (HRMS-ESI) on a Bruker maXis mass spectrometer.
[(2-Bromo-5-methoxyphenyl)methoxy](tert-butyl)dimethylsilane **3**[1] and 2,7,12-trimethoxy-10,15-dihydro-*5H*-tribenzo[b,e,h]azonine **CTB-1NH** [2] were synthesized according to the literature.
Full characterization of **CTB-2NH**, **6**, **CTB-1NMe**, **CTB-1NBn**, **CTB-1NAc, CTB-2NAc and CTB-2NMe** have been done using ^{1}H, ^{13}C and 2D NMR spectra. All spectra were recorded after equilibration, unless otherwise stated. The method used to determine the composition of the mixtures is based on the sum of integrals.

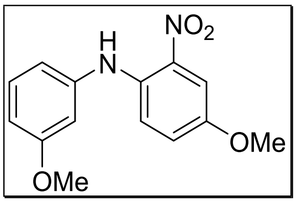
2 Synthesis

2.1 Diaza-cyclotriveratrylene:

A Buchwald Hartwig cross-coupling (BHC) was realized between 3-bromoanisole and 2-nitro-4-methoxyaniline, leading to **1** with 97% yield. Reduction of the nitro group afforded **2** with a quantitative yield. Then, compound **3** was prepared from 2-bromo-5-methoxybenzaldehyde, following the experimental procedures described in the literature.[1] The BHC realized between **3** and **2** afforded the trimer **4** with 90% yield. Deprotection of the benzylic alcohol, followed by intramolecular S_EAr cyclization, afforded the expected **CTB-2NH** with 53% yield. Interestingly, compound **6**, obtained from the cyclization on the *ortho* position of the methoxy group, has also been isolated from this last reaction with 11% yield. The obtention of this type of secondary product is rare, but also observed in similar cyclizations reported by Martinez *et al.*[3] or Brotin *et al.*[4] Overall, **CTB-2NH** has been obtained in 5 steps from 3-bromo-anisole with 44% overall yield.



4-Methoxy-*N*-(3-methoxyphenyl)-2-nitroaniline 1



In a round bottom flask placed under nitrogen atmosphere, 3-bromoanisole (1.5 g, 8.02 mmol), 4-methoxy-2-nitroaniline (1.35 g, 8.02 mmol), palladium acetate (179.6 mg, 0.80 mmol), 2,2′-bis(diphenylphosphino)-1,1′-binaphthyl (999 mg, 1.6 mmol) and cesium carbonate (7.84 g, 24.06 mmol) in 40 mL of anhydrous toluene was heated to reflux for 3 h. The solution was filtrated through a pad of SiO_2 using ethyl acetate as eluent and concentrated under vacuum. The crude mixture was purified using silica chromatography using cyclohexane/Et_2O as the eluent, affording the expected product as a dark red powder. (2.13 g, 97%).

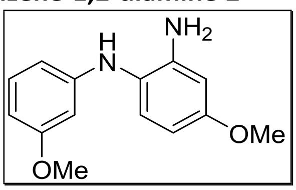
^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.29 (s, 1H), 7.62 (d, *J* = 3.0 Hz, 1H), 7.31 – 7.28 (m, 2H), 7.07 (dd, *J* = 9.4, 3.0 Hz, 1H), 6.83 (m, 1H), 6.77 (m, 1H), 6.72 (m, 1H), 3.82 (s, 3H), 3.81 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 160.8, 151.4, 140.7, 137.7, 133.2, 130.5, 126.2, 118.5, 115.6, 110.4, 109.1, 107.0, 56.0, 55.5.

Melting point 83-85 °C

HRMS-ESI calculated for $C_{14}H_{15}N_2O_4$ $[M+H]^+$ 275.1032, found 275.1032.

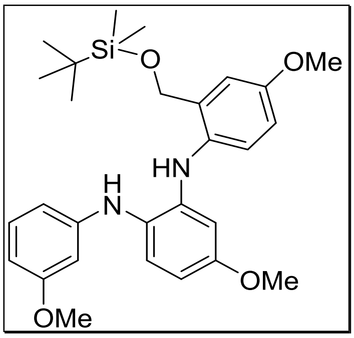
4-Methoxy-*N1*-(3-methoxyphenyl)benzene-1,2-diamine 2



4-Methoxy-*N*-(3-methoxyphenyl)-2-nitroaniline (2 g, 7.3 mmol) and tin(II) chloride (16.4 g, 73 mmol) were dissolved in 40 mL of a 1/1 mixture acetonitrile/water and the solution was stirred overnight at 80 °C. A saturated solution of potassium carbonate and a 2 M solution of sodium tartrate were added, the solution was stirred for 2 h, extracted with ethyl acetate, washed with brine, dried over $MgSO_4$, filtered and concentrated under vacuum. The product was obtained without purification as a brown powder (1.77 g, 99%).

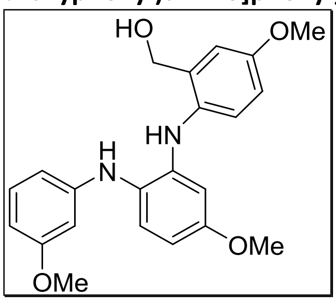
^{1}H NMR (600 MHz, $CDCl_3$): δ = 7.08 (t, *J* = 8.1 Hz, 1H), 7.01 (d, *J* = 8.5 Hz, 1H), 6.37 – 6.29 (m, 3H), 6.27 -6.23 (m, 1H), 6.18 (m, 1H), 5.02 (s, 1H), 3.78 (s, 3H), 3.74 (s, 3H).
^{13}C NMR (151 MHz, $CDCl_3$): δ = 161.0, 158.9, 148.4, 145.0, 130.2, 128.9, 120.6, 107.0, 104.2, 103.8, 101.4, 100.1, 55.5, 55.2.
Melting point 116-118 °C
HRMS-ESI calculated for $C_{14}H_{17}N_2O_2$ $[M+H]^+$ 245.1290, found 245.1284.

***N2*-(2-{[(*tert*-Butyldimethylsilyl)oxy]methyl}-4-methoxyphenyl)-4-methoxy-*N1*-(3-methoxyphenyl) benzene-1,2-diamine 4**



In a round bottom flask placed under nitrogen atmosphere, [(2-bromo-5-methoxyphenyl)methoxy](tert-butyl)dimethylsilane (2.53 g, 7.65 mmol), 4-methoxy-*N1*-(3-methoxyphenyl)benzene-1,2-diamine (1.7 g, 6.96 mmol), palladium acetate (156 mg, 0.70 mmol), 2,2′-bis(diphenylphosphino)-1,1′-binaphthyl (867 mg, 1.39 mmol) and cesium carbonate (6.80 g, 20.8 mmol) in 35 ml of anhydrous toluene were heated to reflux for 3 h. The solution was filtrated through a pad of SiO_2 using ethyl acetate as eluent and concentrated under vacuum. The crude mixture was purified using silica chromatography using cyclohexane/Et_2O as the eluent, affording the expected product as a brown oil. (3.1 g, 90%).
^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.19 (d, *J* = 8.7 Hz, 1H), 7.11-7.05 (m, 2H), 6.94 (d, *J* = 3.0 Hz, 1H), 6.78 (dd, *J* = 8.7, 3.0 Hz, 1H), 6.44 (d, *J* = 2.8 Hz, 1H), 6.36 – 6.29 (m, 4H), 6.25 (m, 1H), 5.05 (s, 1H), 4.58 (s, 2H), 3.80 (s, 3H), 3.73 (s, 3H), 3.71 (s, 3H), 0.84 (s, 9H), -0.01 (s, 6H).
^{13}C NMR (100 MHz, $CDCl_3$): δ = 160.9, 158.5, 155.9, 148.3, 143.5, 135.9, 133.1, 130.1, 127.8, 124.1, 122.2, 113.8, 113.3, 107.7, 104.3, 103.8, 100.7, 100.0, 63.2, 55.6, 55.4, 55.2, 26.0 (3C), 18.4, -5.2 (2C).
HRMS-ESI calculated for $C_{28}H_{38}N_2O_4SiNa$ $[M+Na]^+$ 517.2499, found 517.2498.

[5-Methoxy-2-({5-methoxy-2-[(3-methoxyphenyl)amino]phenyl}amino)phenyl]methanol 5

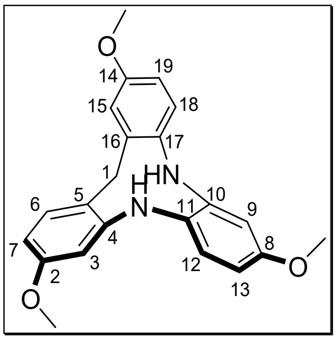


Tetrabutylammonium fluoride (1M in THF, 7.2 mL, 7.2 mmol) was added at 0 °C to a solution of *N2*-(2-{[(*tert*-butyldimethylsilyl)oxy]methyl}-4-methoxyphenyl)-4-methoxy-*N1*-(3-methoxyphenyl)benzene-1,2-diamine (1.79 g, 3.62 mmol) in THF (30 mL) and the mixture was stirred for 18 h at room temperature. The solution was quenched with saturated aqueous solution of $NaHCO_3$, extracted with ethyl acetate, washed with brine, dried over $MgSO_4$, filtered and concentrated under vacuum. Purification over silica gel (cyclohexane/Et_2O 5/5) afforded the product as a light-yellow oil (1.03 g, 96%).

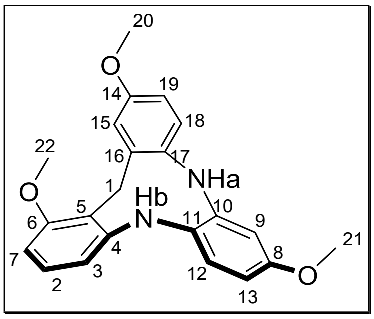
^{1}H NMR (600 MHz, $CDCl_3$): δ = 7.23 (d, *J* = 8.6 Hz, 1H), 7.11 – 7.06 (m, 2H), 6.87 (d, *J* = 3.0 Hz, 1H), 6.82 (dd, *J* = 8.6, 3.0 Hz, 1H), 6.46-6.41 (m, 2H), 6.36 – 6.33 (m, 2H), 6.32- 6.30 (m, 1H), 6.24-6.23 (m, 1H), 5.16 (s, 1H), 4.51 (s, 2H), 3.79 (s, 3H), 3.73 (s, 3H), 3.72 (s, 3H).
^{13}C NMR (151 MHz, $CDCl_3$): δ = 161.0, 158.9, 156.1, 148.4, 143.8, 135.2, 133.7, 130.2, 128.7, 124.5, 121.4, 114.9, 114.1, 107.2, 104.1, 103.7, 100.2, 100.0, 63.6, 55.7, 55.5, 55.3.
HRMS-ESI calculated for $C_{22}H_{24}N_2O_4Na$ $[M+Na]^+$ 403.1634, found 403.1629.

CTB-2NH and 1,8,13-Trimethoxy-10,15-dihydro-*5H*-tribenzo[*b,e,h*][1,4]diazonine 6

Perchloric acid (70% in water, 0.17 mL, 1.99 mmol) was added dropwise at 0 °C to a solution of [5-methoxy-2-({5-methoxy-2-[(3-methoxyphenyl)amino]phenyl}amino)phenyl]methanol (758 mg, 1.99 mmol) in acetonitrile (400 mL) and the solution was heated for 1 h at 60 °C. The reaction was quenched with water and the organic solvent was removed under vacuum. The aqueous layer was extracted two times with ethyl acetate. The organic layers were washed with brine, dried over $MgSO_4$, filtered and concentrated under vacuum. Purification over silica gel (cyclohexane/Et_2O 9/1 to 8/2) afforded **6** as a black powder (78 mg, 11%) and **CTB-2NH** as a white powder (383 mg, 53%).



CTB-2NH:
^{1}H NMR (600 MHz, $CDCl_3$): δ = 6.96 (d, *J* = 6.3 Hz, 1H, H6), 6.95 (d, *J* = 6.3 Hz, 1H, H18), 6.86 (d, *J* = 8.6 Hz, 1H, H12), 6.66 (dd, *J* = 8.5, 3.0 Hz, 1H, H19), 6.55 (d, *J* = 3.0 Hz, 1H, H15), 6.41 (dd, *J* = 8.3, 2.6 Hz, 1H, H7), 6.38 (dd, *J* = 8.6, 2.8 Hz, 1H, H13), 6.35 (d, *J* = 2.6 Hz, 1H, H9), 6.31 (d, *J* = 2.9 Hz, 1H, H3), 5.35 (s, 1H, NH), 4.96 (s, 1H, NH), 3.76 (s, 3H, OMe), 3.73 (s, 3H, OMe), 3.73 (s, 3H, OMe), 3.63 (s, 2H, H1).
^{13}C NMR (151 MHz, $CDCl_3$): δ = 159.1 (C2), 157.9 (C8), 156.2 (C14), 145.4 (C4), 142.8 (C10), 136.6 (C17), 136.1 (C16), 132.5 (C6), 128.4 (C12), 126.5 (C11), 124.5 (C18), 122.3 (C5), 116.7 (C15), 111.6 (C19), 107.2 (C7), 106.6 (C13), 106.1 (C9), 106.0 (C3), 55.5 (2C, OMe), 55.3 (OMe), 34.9 (C1).
Melting point 166-168 °C
HRMS-ESI calculated for $C_{22}H_{23}N_2O_3$ $[M+H]^+$ 363.1709, found 363.1700.

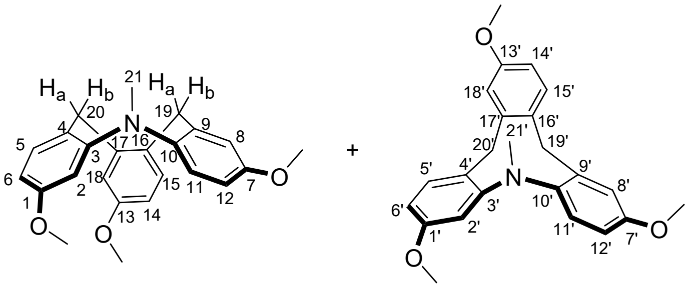


1,8,13-Trimethoxy-10,15-dihydro-*5H*-tribenzo[*b,e,h*][1,4]diazonine 6:
^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.02 (t, *J* = 8.1 Hz, 1H, H2), 6.98 (d, *J* = 9.1 Hz, 1H, H18), 6.84 (d, *J* = 8.6 Hz, 1H, H12), 6.67 – 6.63 (m, 2H, H15, H19), 6.43 (s, 1H, H3), 6.41 (s, 1H, H7), 6.38 (dd, *J* = 8.6, 2.9 Hz,

1H, H13), 6.31 (d, *J* = 2.8 Hz, 1H, H9), 5.38 (s, 1H, NHb), 4.97 (s, 1H, NHa), 3.78 (s, 2H, H1), 3.75 (s, 3H, H22), 3.74 (s, 3H, H20), 3.71 (s, 3H, H21).
^{13}C NMR (101 MHz, $CDCl_3$) δ = 158.9 (C6), 157. 7 (C8), 156.5 (C3), 145.2 (C4), 142.7 (C10), 137.3 (C6), 137.2 (C7), 127.4 (C2), 127.2 (C11), 127.1 (C12), 125.3 (C18), 117.6 (C15), 117.5 (C13), 113.0 (C3), 111.3 (C19), 107.3 (C13), 106.7 (C9), 103.5 (C7), 55.8 (C22), 55.5 (2C : C20, C21), 27.0 (C1).
Melting point: 108-110°C
HMRS: calculated for $C_{22}H_{22}N_2O_3$ [M]° 362.1630, found 362.1613

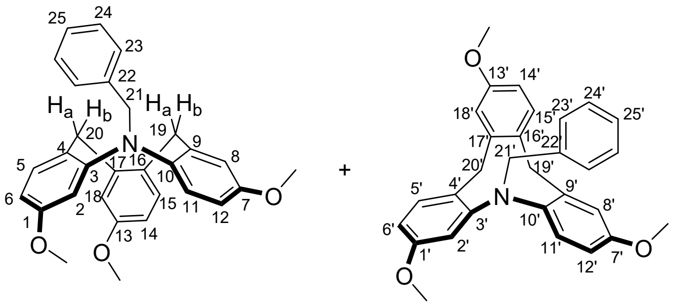
2.2 Substituted aza- cyclotriveratrylene:

CTB-1NMe



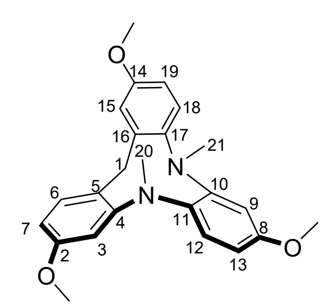
In a round bottom flask placed under nitrogen atmosphere at 0°C, sodium hydride 60% (28 mg, 0.73 mmol) was added to a solution of 2,7,12-trimethoxy-10,15-dihydro-*5H*-tribenzo[*b,e,h*]azonine (240 mg, 0.67 mmol) in 1 mL of anhydrous DMF over 10 minutes. The solution was stirred at 0°C for 20 minutes, and methyl iodide (102 µL, 1.66 mmol) was adiided. The solution was allowed to reach room temperature and was stirred for 48 hours. The reaction was quenched with water, extracted with ethyl acetate, dried over $MgSO_4$, filtered and concentrated under vacuum. Purification over silica gel (cyclohexane/Et_2O 95/5) afforded both saddle and crown conformers as a white powder (149 mg, 60%).
^{1}H NMR (600 MHz, $CDCl_3$) : δ = 7.54 (d, *J* = 8.8 Hz, 0.3 H, H11), 7.31 (d, *J* = 8.5 Hz, 0.3H, H5), 7.25 (d, *J* = 8.4 Hz, 0.3H, H15), 7.17 (d, *J* = 2.6 Hz, 0.3H, H2), 7.04 (d, *J* = 8.3 Hz, 1H,H15'), 6.97 (d, *J* = 8.7 Hz, 1H, H11'), 6.95 (d, *J* = 8.3 Hz, 1H, H5'), 6.89 (d, *J* = 3.1 Hz, 0.3H, H8), 6.86 (d, *J* = 2.7 Hz, 0.3H, H18), 6.77 (dd, *J* = 8.7, 3.0 Hz, 1H, H12'), 6.71 (dd, *J* = 8.8, 3.1 Hz, 0.3H, H12), 6.68 (d, *J* = 3.1 Hz, 1H, H8'), 6.66 (dd, *J* = 8.5, 2.6 Hz, 0.3H, H6), 6.64-6.62 (m, 1.3H, H14 et H14'), 6.59 (d, *J* = 2.8 Hz, 1H, H18'), 6.53 (d, *J* = 2.5 Hz, 1H, H2'), 6.35 (dd, *J* = 8.3, 2.6 Hz, 1H, H6'), 5.27 (d, *J* = 12.4 Hz, 0.3H,$H20_b$), 5.24 (d, *J* = 12.4 Hz, 0.3H, $H19_a$), 3.97 (s, 2H, H19'), 3.78 (s, 3H, OMe $_{saddle}$), 3.76 (s, 0.9H, OMe $_{crown}$), 3.75-3.74 (m, 3.9H, OMe $_{saddle}$ +OMe $_{crown}$), 3.74 (s, 3H, OMe $_{saddle}$), 3.73 (s, 0.9H, OMe $_{crown}$), 3.43-3.42 (m, 2.60H, $H19_b$, $H20_a$, H20'), 3.17 (s, 0.9H, H21), 3.15 (s, 3H, H21').
^{13}C NMR (151 MHz, $CDCl_3$) : δ = 159.2 (C1'), 159.1(C1), 158.2 (C13), 157.8 (C13'), 157.5 (C7), 157.1 (C7'), 152.6 (C3), 149.7 (C3'), 144.0 (C10), 142.7 (C9), 142.3 (C10'), 141.8 (C17), 141.0 (C17'), 137.9 (C9'), 133.1 (C4), 132.9 (C5'), 132.5 (C16), 131.0 (C16'), 130.9 (C15), 130.8 (C15', C5), 127.6 (C11), 126.6 (C11'), 123.1 (C4'), 116.7 (C18'), 116.0 (C8'), 115.4 (C18), 115.1 (C8), 113.4 (C12'), 112.8 (C12), 112.7 (C2), 111.9 (C14), 111.5 (C6), 110.9 (C14'), 104.3 (C6'), 103.7 (C2'), 55.5 (OMe $_{saddle}$), 55.5 (OMe $_{crown}$), 55.5 (OMe $_{crown}$), 55.3 (OMe $_{crown}$ + OMe $_{saddle}$), 55.3 (OMe $_{saddle}$), 46.4 (C21), 42.8 (C21'), 37.8 (C19'), 37.5 (C20'), 35.5 (C20), 35.4 (C19).
HRMS-ESI calculated for $C_{24}H_{26}NO_3$ $[M+H]^+$ 376.1913, found 376.1909.
R_f (cyclohexane/ Et_2O 8/2): for saddle compound Rf = 0.40; for crown compound Rf = 0.33

CTB-1NBn



In a round bottom flask placed under nitrogen atmosphere at 0°C, sodium hydride 60% (28 mg, 0.69 mmol) was added to a solution of 2,7,12-trimethoxy-10,15-dihydro-*5H*-tribenzo[*b,e,h*]azonine (100 mg, 0.28 mmol) in 1 mL of anhydrous DMF over 10 minutes. The solution was stirred at 0°C for 20 minutes, and benzyl bromide (99 µL, 0.83 mmol) was added. The solution was allowed to reach room temperature and was stirred for 48 hours. The reaction was quenched with water, extracted with ethyl acetate, dried over $MgSO_4$, filtered and concentrated under vacuum. Purification over silica gel (petroleum ether/Et_2O 95/5) afforded both saddle and crown conformers as a white oil (105 mg, 84%).
^{1}H NMR (600 MHz, $CDCl_3$) δ = 7.61 (d, *J* = 8.8 Hz, 1H, H11), 7.31 (d, *J* = 6.9 Hz, 2H, H23), 7.26 – 7.24 (m, 4H, H24, H5, H2), 7.21 (dd, *J* = 6.1, 3.8 Hz, 1H, H25), 7.18 (d, *J* = 8.5 Hz, 1H, H15), 7.13 – 7.10 (m, 3H, H24', H25'), 7.00 (d, *J* = 8.4 Hz, 1H, H15'), 6.98 (d, *J* = 4.2 Hz, 1H, H5'), 6.96 (d, *J* = 4.6 Hz, 1H, H11'), 6.87 – 6.83 (m, 2H, H23'), 6.81 (d, *J* = 2.7 Hz, 1H, H18), 6.79 (d, *J* = 3.0 Hz, 1H, H8), 6.73 – 6.73 – 6.72 (m, 1H, H12), 6.71 – 6.70 (m, 1H, H12'), 6.69 – 6.67 (m, 2H, H8', H14'), 6.64 (dd, *J* = 8.5, 2.6 Hz, 1H, H6), 6.61– 6.59 (m, 2H, H14, H18'), 6.47 (d, *J* = 2.5 Hz, 1H, H2'), 6.38 (dd, *J* = 8.3, 2.5 Hz, 1H, H6'), 5.09 (d, *J* = 12.6 Hz, 1H, $H20_b$), 5.07 (d, *J* = 12.6 Hz, 1H, $H19_a$), 4.66 (s, 2H, H21'), 4.56 (s, 2H, H21), 3.95 (s, 2H, H19'), 3.77 (s, 3H, OMe), 3.76 (s, 3H, OMe), 3.75 (s, 3H, OMe), 3.73 (s, 3H, OMe), 3.71 (s, 3H, OMe), 3.64 (s, 3H, OMe), 3.53 (s, 2H, H20'), 3.26 (d, *J* = 12.6 Hz, 1H, $H20_a$), 3.21 (d, *J* = 12.6 Hz, 1H, $H19_b$).
^{13}C NMR (151 MHz, $CDCl_3$) δ 159.0 (C1), 158.9 (C1'), 158.2 (C13), 157.8 (C13'), 157.5 (C7), 156.9 (C7'), 151.4 (C3), 149.0 (C3'), 143.2 (C9), 142.5 (C10), 141.8 (C17), 141.6 (C10'), 140.2 (C17'), 138.7 (C22), 138.5 (C9'), 138.4 (C22'), 133.5 (C4), 132.5 (C16), 132.3 (C5'), 131.0 (C15'), 131.0 (C16'), 130.8 (C15), 130.7 (C5), 129.9 (2C,C23), 128.3 (2C, C24'), 128.2 (C11), 128.2 (2C, C24), 127.6 (2C, C23'), 127.2 (C25), 126.9 (C11'), 126.7 (C25'), 125.0 (C4'), 116.6 (C18'), 116.1 (C8'), 115.4 (C18), 114.9 (C8), 113.4 (C2), 113.0 (C12'), 112.7 (C12), 111.8 (C14), 111.5 (C6), 111.2 (C14'), 106.0 (C2'), 105.9 (C6'), 63.2 (C21), 58.9 (C21'), 55.5 (OMe), 55.5 (OMe), 55.4 (OMe), 55.3 (OMe), 55.3 (OMe), 55.2 (OMe), 38.5 (C19'), 37.7 (C20'), 35.6 (C20), 35.4 (C19).
HRMS-ESI calculated for $C_{30}H_{30}N_2O_3$ $[M+H]^+$ 452.2226, found 452.2227.
R_f (petroleum ether/ Et_2O 8/2): for saddle compound Rf = 0.33; for crown compound, Rf =0.18

CTB-2NMe



In a round bottom flask placed under nitrogen atmosphere at 0°C, sodium hydride 60% (48 mg, 1.21 mmol) was added to a solution of **CTB-2NH** (100 mg, 0.28 mmol) in 1 mL of anhydrous DMF over 10 minutes. The solution was stirred at 0°C for 20 minutes, and methyl iodide (139 µL, 2.21 mmol) was added. The solution was allowed to reach room temperature and was stirred for 48 hours. The reaction was quenched with water, extracted with ethyl acetate, dried over $MgSO_4$, filtered and concentrated under vacuum. Purification over silica gel (cyclohexane/Et_2O 95/5) afforded **CTB-2NMe** as a brown powder (75 mg, 69%).

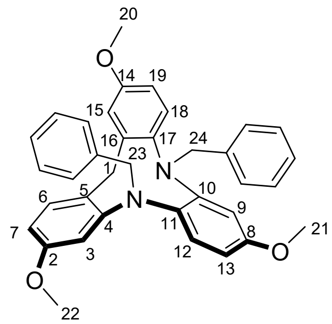
^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.02 (d, *J* = 8.7 Hz, 1H, H6), 6.98 (d, *J* = 8.2 Hz, 1H, H6), 6.74 (d, *J* = 8.5 Hz, 1H, H12), 6.64 (dd, *J* = 8.7, 3.0 Hz, 1H, H19), 6.53 (d, *J* = 2.6 Hz, 1H, H3), 6.46 (d, *J* = 2.7 Hz, 1H, H9), 6.38 (dd, *J* = 8.2, 2.6 Hz, 1H, H15), 6.29 (d, *J* = 3.1 Hz, 1H, H7), 6.25 (dd, *J* = 8.6, 2.8 Hz, 1H, H16), 3.77 (s, 6H, -OMe), 3.66 (s, 3H, -OMe), 3.45 (s, 2H, H1), 3.36 (s, 3H, H21), 2.55 (s, 3H, H20).

^{13}C NMR (101 MHz, $CDCl_3$) δ = 159.2 (C2), 158.6 (C8), 155.5 (C14), 150.3 (C4), 146.2 (C10), 142.1 (C17), 136.4 (C16), 130.8 (C12), 130.5 (2C, C6, C11), 127.8 (C5), 123.0 (C18), 115.1 (C15), 111.3 (C19), 105.6 (C3), 105.2 (C7), 103.2 (C13), 101.6 (C9), 55.5 (OMe), 55.4 (OMe), 55.3 (OMe), 44.1 (C21), 41.2 (C20), 35.8 (C1).

Melting point: 115-117 °C

HMRS-ESI: calculated for $C_{24}H_{26}N_2O_3$ [M]° 390.1943, found 390.1952

CTB-2NBn



In a round bottom flask placed under nitrogen atmosphere at 0°C, sodium hydride 60% (48 mg, 1.21 mmol) was added to a solution of **CTB-2NH** (100 mg, 0.28 mmol) in 1 mL of anhydrous DMF. The solution was stirred at 0 °C for 20 minutes, and benzyl bromide (162 µL, 2.21 mmol) was added. The solution was allowed to reach room temperature and was stirred for 36 hours. The reaction was quenched with water and extracted with ethyl acetate. The organic layer was dried over $MgSO_4$, filtered and concentrated under vacuum. Purification over silica gel (cyclohexane/ethyl acetate 95/5) afforded **CTB-2NBn** as a white powder (83 mg, 56%).

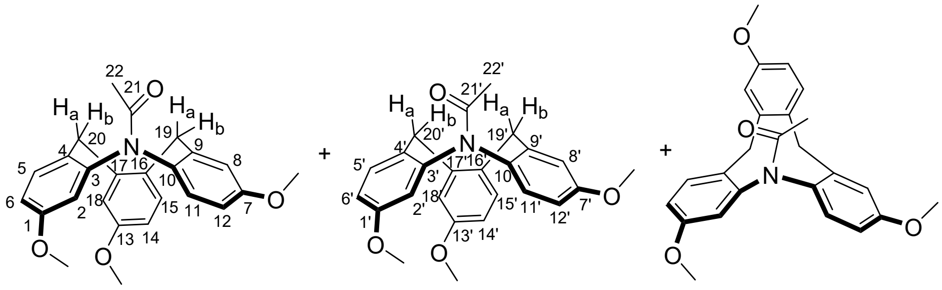
^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.26 – 7.04 (m, 8H, HBz), 7.00 (d, *J* = 8.1 Hz, 1H, H6), 6.91 (d, *J* = 8.8 Hz, 1H, H18), 6.80 (d, *J* = 8.6 Hz, 1H, H12), 6.61 (dd, *J* = 8.8, 3.1 Hz, 1H, H19), 6.57 – 6.51 (m, 2H, HBz), 6.45 (d, *J* = 3.0 Hz, 1H, H15), 6.42 (d, *J* = 2.5 Hz, 1H, H3), 6.39 (dd, *J* = 8.1, 2.5 Hz, 1H, H7), 6.34 (d, *J* = 2.8 Hz, 1H, H9), 6.30 (dd, *J* = 8.6, 2.8 Hz, 1H, H13), 4.91 (s, 2H, H24), 4.33 (s, 2H, H23), 3.72 (s, 3H, H21), 3.65 (s, 3H, H22), 3.63 (s, 2H, H1), 3.60 (s, 3H, H20).

^{13}C NMR (101 MHz, $CDCl_3$) δ = 158.8 (C2), 158.1 (C8), 155.5 (C14), 149.2 (C4), 145.3 (C10), 142.2 (C17), 139.0 (CBn), 137.7 (CBn), 134.7 (C16), 131.4 (C11), 130.9 (C6), 130.5 (C12), 128.7 (2C, CBn), 128.6 (2C, CBn), 128.0 (2C, CBn), 126.8 (CBn), 126.7 (CBn), 126.5 (2C, CBn), 126.4 (C5), 122.9 (C18), 116.2 (C15), 111.7 (C19), 106.4 (C3), 105.7 (C7), 105.4 (C13), 104.2 (C9), 60.0 (C24), 58.9 (C23), 55.5 (C21), 55.3 (C22), 55.2 (C20), 36.5 (C1).

Melting point: 70-72°C

HMRS: calculated for $C_{36}H_{34}N_2O_3$ [M]° 542.2569, found 542.2573

CTB-1NAc



In a round bottom flask placed under nitrogen atmosphere at 0 °C, sodium hydride 60% (50 mg, 0.623 mmol) was added to a solution of **CTB-1NH** (300 mg, 0.831 mmol) in 30 mL of anhydrous THF. The solution was stirred at 0 °C for 20 minutes, and acetyl chloride (195 µL, 2.741 mmol) was added. The solution was allowed to reach room temperature and was stirred for 48 hours. The reaction was quenched with saturated solution of $NaHCO_3$, extracted with ethyl acetate, dried over $MgSO_4$, filtered and concentrated under vacuum. Purification over silica gel (cyclohexane/ethyl acetate 7/3), the crown conformer **CTB-1NAc** was obtained as a mixture of two rotamers as a colorless oil. (291 mg, 86%).

The sample is composed of two conformers, crown and saddle, each presenting two rotamers. These four compounds cannot be separated. The crown rotamers were characterized and assigned by 1D and 2D NMR, but the signals from saddle rotamers couldn't be assigned properly.

<u>NMR of the saddle conformers:</u>

^{1}H NMR (400 MHz, CDCl$_3$) δ = 7.23 – 7.16 (m, 2H), 7.11 (dd, *J* = 8.4, 2.7 Hz, 2H), 6.92 (d, *J* = 8.4 Hz, 1H), 6.87 (d, *J* = 8.4 Hz, 1H), 6.85 – 6.73 (m, 7H), 6.72 – 6.60 (m, 3H), 6.53 (d, *J* = 2.9 Hz, 1H), 6.45 (d, *J* = 2.9 Hz, 1H), 4.36 – 4.15 (m, 4H), 3.88 – 3.73 (m, 2H), 3.83 (s, 3H), 3.80 (s, 3H), 3.79 (s, 3H), 3.76 (s, 3H), 3.69 (s, 6H), 3.49 – 3.39 (m, 2H), 1.11 (s, 3H), 1.08 (s, 3H).

<u>NMR of the crown conformer:</u>

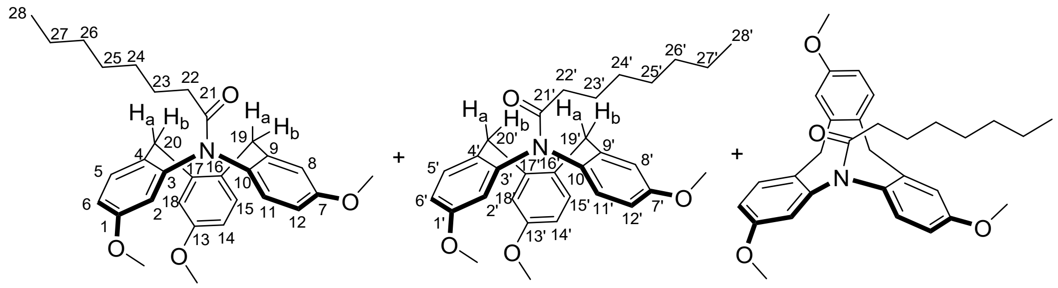
^{1}H NMR (400 MHz, CDCl$_3$) δ = 7.43 (d, *J* = 8.6 Hz, 1H, H5), 7.40 (d, *J* = 8.6 Hz, 1H, H5'), 7.34 (d, *J* = 8.6 Hz, 1H, H11), 7.31 – 7.23 (m, 3H, H15, H11', H15'), 6.99 (d, *J* = 3.0 Hz, 1H, H8), 6.97 (d, *J* = 3.0 Hz, 1H, H8'), 6.94 (d, *J* = 2.7 Hz, 1H, H2), 6.91 – 6.85 (m, 3H, H18, H18', H2'), 6.83 (dd, *J* = 8.5, 2.7 Hz, 1H, H6), 6.79 (dd, *J* = 8.5, 2.7 Hz, 1H, H6'), 6.76 – 6.70 (m, 2H, H12, H12'), 6.70 – 6.59 (m, 2H, H14, H14'), 4.56 (d, *J* = 13.1 Hz, 2H, H20b, H19a), 4.52 (d, *J* = 13.5 Hz, 2H, H20b', H19a'), 3.79 (s, 3H,-OMe), 3.77 (s, 3H,-OMe), 3.76 (s, 3H,-OMe), 3.75 – 3.73 (m, 9H,-OMe), 3.60 (d, *J* = 13.2 Hz, 2H, H20a, H19b), 3.59 (d, *J* = 13.2 Hz, 2H, H20a', H19b'), 2.11 (s, 3H, H22), 2.10 (s, 3H, H22').

<u>NMR of the mix of conformers</u>

^{13}C NMR (151 MHz, CDCl3) δ = 171.9 (C21), 171.7 (C21'), 170.4 (Csaddle), 159.7 (C7), 159.5 (C7'), 159.4 (C1), 159.3 (C1'), 159.1 (Csaddle), 159.0 (Csaddle), 158.6 (C13), 158.5 (C13'), 158.3 (Csaddle), 158.2 (Csaddle), 143.1 (Csaddle), 142.7 (C3), 142.1 (C9), 141.9 (2C, C3', C9'), 141.1 (C17), 140.4 (Csaddle), 139.9 (C17'), 139.4 (Csaddle), 139.2 (Csaddle), 139.1 (Csaddle), 137.9 (Csaddle), 135.2 (Csaddle), 134.5 (C10), 133.5 (C10'), 132.2 (C4), 132.0 (C4'), 131.9 (C5), 131.8 (Csaddle), 131.7 (Csaddle), 131.6 (Csaddle), 131.4 (2C, C5', C16), 131.1 (C15), 131.1 (Csaddle), 130.9 (C15'), 130.8 (Csaddle), 130.2 (2C, C16', C11), 130.1 (2Csaddle), 129.9 (Csaddle), 129.6 (C11'), 129.2 (Csaddle), 128.6 (Csaddle), 116.5 (Csaddle), 116.4 (C8), 116.4 (Csaddle), 116.1 (C8'), 115.7 (Csaddle), 115.4 (Csaddle), 115.3 (C18), 115.3 (C18'), 115.0 (C2), 114.9 (Csaddle), 114.5 (C2'), 114.4 (Csaddle), 114.4 (C6), 114.2 (C6'), 113.3 (Csaddle), 113.0 (C12), 113.0 (C12'), 112.9 (Csaddle), 112.8 (Csaddle), 112.7 (Csaddle), 112.5 (C14), 112.4 (C14'), 112.1 (Csaddle), 111.5 (Csaddle), 55.6 (C, -OMe), 55.6 (Csaddle), 55.6 (C, -OMe), 55.5 (2C, -OMe), 55.5 (Csaddle), 55.4 (Csaddle), 55.4 (C, -OMe), 55.3 (C, -OMe), 40.6 (Csaddle), 40.4 (Csaddle), 36.6 (2Csaddle), 35.5 (2C, C20, C19), 35.4 (2C, C20', C19'), 29.8 (Csaddle), 22.4 (2C, C22, C22'), 21.2 (Csaddle), 21.1 (Csaddle).

HMRS: calculated for $C_{25}H_{26}NO_4$ $[M+H]^+$ 404.1862, found 404.1866

<u>CTB-1NCOC8</u>



In a round bottom flask placed under nitrogen atmosphere at 0 °C, sodium hydride 60% (17 mg, 0.42 mmol) was added to a solution of 2,7,12-trimethoxy-10,15-dihydro-*5H*-tribenzo[*b,e,h*]azonine (100 mg, 0.28 mmol) in 10.6 mL of anhydrous THF over 10 minutes. The solution was stirred at 0°C for 20 minutes, and octanoyl chloride (70 µL, 0.42 mmol) was added. The solution was allowed to reach room temperature and was stirred for 48 hours. The reaction was quenched with water, extracted with ethyl acetate, dried over $MgSO_4$, filtered and concentrated under vacuum. Purification over silica gel (Cyclohexane/Et_2O 8/2 to 6/4) afforded both saddle and crown conformers as a white oil (100 mg, 76%).

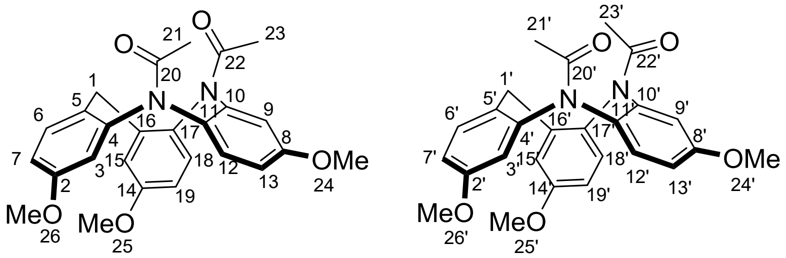
This sample is composed of two conformers, crown and saddle, each presenting two rotamers. These four compounds cannot be separated. The two crown isomers were characterized and assigned by 1D and 2D NMR, but the signals from the saddle compounds could not be assigned properly.

^{1}H NMR (600 MHz, $CDCl_3$) δ = 7.42 (d, *J* = 8.6 Hz, 1H, H5), 7.37 (d, *J* = 8.5 Hz, 1H, H5’), 7.31 (d, *J* = 8.7 Hz, 1H, H11), 7.28 (d, *J* = 8.5 Hz, 1H, H15), 7.27 – 7.25 (m, 1H, H15’), 7.22 (d, *J* = 8.7 Hz, 1H, H11’), 7.19 (d, *J* = 8.4 Hz, 0.4H, 2H_{saddle}), 7.11 – 7.08 (m, 0.4H, 2H_{saddle}), 6.99 (d, *J* = 2.9 Hz, 1H, H8), 6.96 (d, *J* = 2.9 Hz, 1H, H8’), 6.92 (d, *J* = 2.6 Hz, 1H, H2), 6.91 (s, 0.2H, 1H_{saddle}), 6.88 (d, *J* = 2.7 Hz, 1H, H18), 6.86 (d, *J* = 2.7 Hz, 1H, H18’),, H_{saddle} 6.84 – 6.81 (m, 2.4H, H6, H2’, 2H_{saddle}), 6.80 (dd, *J* = 8.4, 2.7 Hz, 0.2H, H_{saddle}), 6.77 (dd, *J* = 8.5, 2.7 Hz, 1.4H, H6’, 2H_{saddle}), 6.75 (d, *J* = 2.6 Hz, 0.2H, H_{saddle}), 6.73 (dd, *J* = 8.7, 3.0 Hz, 1H, H12), 6.71 (dd, *J* = 8.7, 2.9 Hz, 1.2H, H12’, H_{saddle}), 6.68 (d, *J* = 3.3 Hz, 0.2H, H_{saddle}), 6.68 – 6.65 (m, 2,2H, H14, H14’), 6.64 – 6.60 (m, 0.4H, 2H_{saddle}), 6.53 (d, *J* = 2.7 Hz, 0.2H, H_{saddle}), 6.44 (d, *J* = 2.7 Hz, 0.2H, H_{saddle}), 4.56 (d, *J* = 13.4 Hz, 2H, H20$_b$, H20’$_b$), 4.49 (d, *J* = 13.4 Hz, 1H, H19$_a$), 4.48 (d, *J* = 13.4 Hz, 1H, H19’$_a$), 4.35 – 4.13 (m, 0.8H, 4H_{saddle}), 3.91 – 3.84 (m, 0.4H, 2H_{saddle}), 3.83 (s, 0.6H, 3H_{saddle}), 3.80 (s, 0.6H, 3H_{saddle}), 3.79 (s, 0.6H, 3H_{saddle}), 3.79 (s, 3.8H, OMe, 4H_{saddle}), 3.77 (s, 3H, OMe), 3.76 (s, 3H, OMe), 3.74 (s, 3H, OMe), 3.74 (s, 3H, OMe), 3.73 (s, H, OMe), 3.69 (s, 0.6H, 3H_{saddle}), 3.68 (s, 0.6H, 3H_{saddle}), 3.57 (d, *J* = 13.4 Hz, 4H, H20$_a$, H19$_b$, H20’$_a$, H19’$_b$), 3.46 – 3.35 (m, 0.4H, 2H_{saddle}), 2.34 (t, *J* = 7.5 Hz, 0.8H, 4H_{saddle}), 2.31 – 2.24 (m, *J* = 13.8, 7.4 Hz, 4H, H22, H22’), 1.86 – 1.76 (m, 0.6H, 3H_{saddle}), 1.76 – 1.66 (m, 4H, H23, H23’), 1.36 – 1.20 (m, 18H, H24, H25, H26, H27, H24’, H25’, H26’, H27’, 10 H_{saddle}), 0.92 – 0.79 (m, 8H, H28, H28’, 10H_{saddle}), 0.64 – 0.47 (m, 0.4H, 2H_{saddle}).

^{13}C NMR (151 MHz, $CDCl_3$) δ 174.4 (C21), 174.2 (C21’), 172.9 (C_{saddle}), 172.9 (C_{saddle}), 159.7 (C7), 159.3 (C7)’, 159.3 (C1), 159.2 (C1’), 159.0 (C_{saddle}), 158.9 (C_{saddle}), 158.6 (C13), 158.6 (C_{saddle}), 158.4 (C13’), 158.3 (C_{saddle}), 158.2 (C_{saddle}), 158.0 (C_{saddle}), 142.6 (C_{saddle}), 142.3 (C3), 142.2 (C9), 142.2 (C3’), 142.0 (C9’), 141.2 (C17), 140.8 (C_{saddle}), 139.9 (C17’), 139.6 (C_{saddle}), 139.4(C_{saddle}), 139.0 (C_{saddle}), 138.2 (C_{saddle}), 134.7 (C_{saddle}), 133.9 (C10), 133.8 (C10’), 132.3 (C4), 132. 2 (C4’), 131.8 (C5), 131.7 (C_{saddle}), 131.6 (C_{saddle}), 131.5 (C16), 131.4 (C_{saddle}), 131.3 (C5’), 131.1 (C15), 130.9 (C15’), 130.6 (C_{saddle}), 130.4 (C11), 130.3 (C_{saddle}), 130.2 (C16’), 130.2 (C_{saddle}), 130.1 (C_{saddle}), 129.7 (C11’), 129.2 (C_{saddle}), 128.8 (C_{saddle}), 116.5 (C_{saddle}), 116.4 (C_{saddle}), 116.4 (C8), 116.1 (C8’), 115.6 (C_{saddle}), 115.4 (C_{saddle}), 115.3 (C2), 115.3 (C18), 115.2 (C18’), 114.9 (C_{saddle}), 114.6 (C2’), 114.5 (C_{saddle}) , 114.3 (C6), 114.0 (C6’), 113.1 (C_{saddle}), 112.9 (C12), 112.9 (C12’), 112.7 (C_{saddle}), 112.7 (C_{saddle}), 112.5 (C14), 112.3 (C14’), 112.1 (C_{saddle}), 111.2 (C_{saddle}), 55.6 (OMe), 55.6 (OMe_{saddle}), 55.6 (OMe), 55.5 (OMe_{saddle}), 55.5 (OMe), 55.5 (OMe), 55.4 (OMe_{saddle}), 55.4 (OMe), 55.4 (OMe), 55.3 (OMe_{saddle}), 55.2 (OMe_{saddle}), 40.7 (C_{saddle}), 40.4 (C_{saddle}), 36.7 (C_{saddle}), 36.6 (C_{saddle}), 35.6 (C20), 35.6 (C19), 35.4 (2C, C19’, C20’), 33.9 (C22), 33.9 (C22’), 33.3 ($C_{saddle\ CH2}$), 33.3 ($C_{saddle\ CH2}$), 31.9 ($C_{saddle\ CH2}$), 31.9 ($C_{saddle\ CH2}$), 31.8 (2C, CH_2), 30.5 ($C_{saddle\ CH2}$), 29.9 ($C_{saddle\ CH2}$), 29.6 (2C, CH_2), 29.5 ($C_{saddle\ CH2}$), 29.4 ($C_{saddle\ CH2}$), 29.3 ($C_{saddle\ CH2}$), 29.2 (2C, CH_2), 27.0 ($C_{saddle\ CH2}$), 25.3 (C23), 25.3(C23’), 25.0 ($C_{saddle\ CH2}$), 24.9 ($C_{saddle\ CH2}$), 22.7 (2C, CH_2), 22.7 ($C_{saddle\ CH2}$), 14.2 (2C, C_{saddle}), 14.2 (C28), 14.2 (C28’).

HRMS-ESI calculated for $C_{31}H_{38}NO_4$ $[M+H]^+$ 488.2801 found 488.2802
R_f (cyclohexane/ Et_2O 5/5): for saddle compound Rf = 0.15; for crown compound Rf = 0.1

1,1'-(2,7,12-Trimethoxy-*5H*-tribenzo[*b,e,h*][1,4]diazonine-5,10(*15H*)-diyl)bis(ethan-1-one) CTB-2NAc

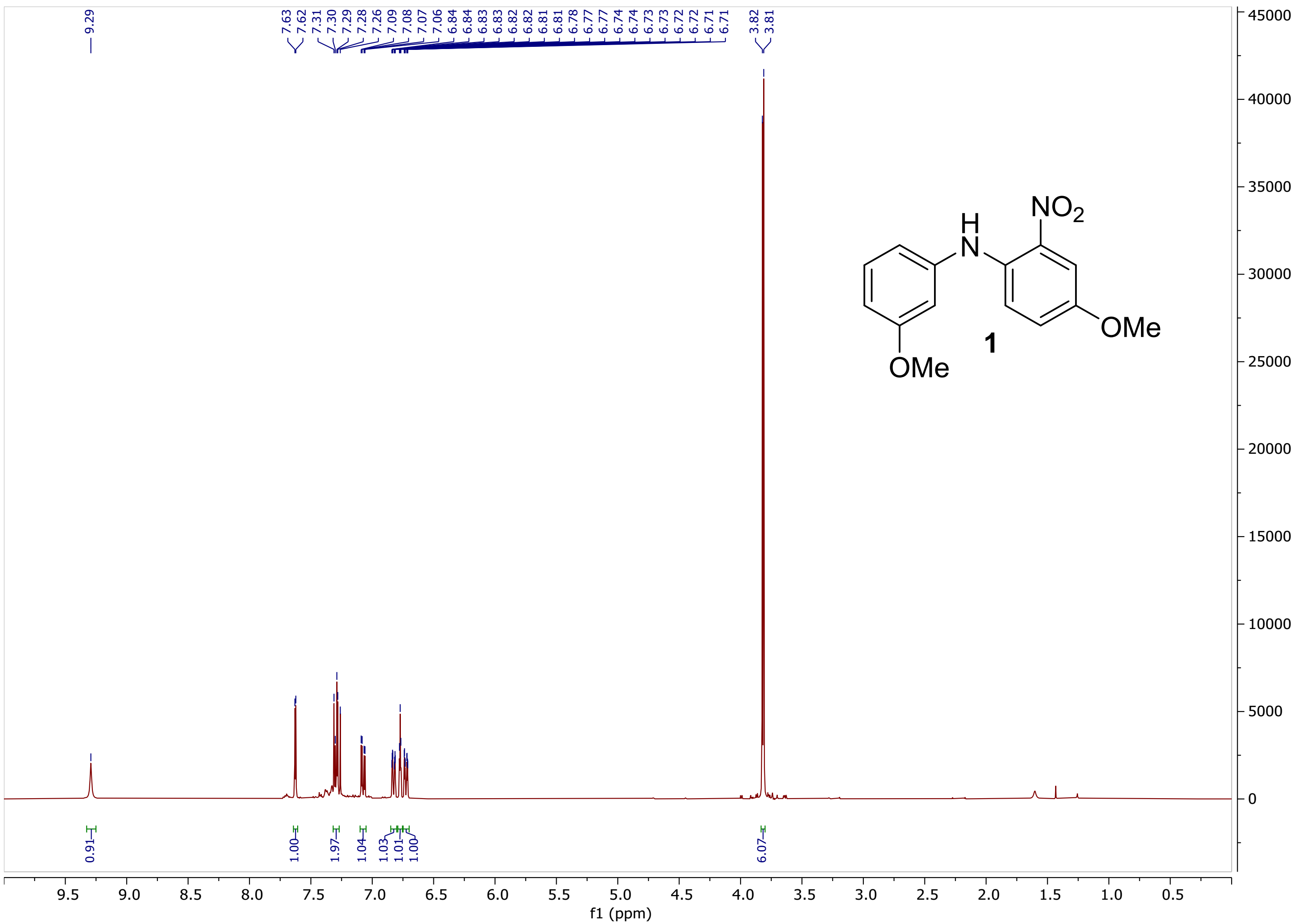


In a round bottom flask placed under nitrogen atmosphere at 0°C, sodium hydride 60% (0.12 g, 3.09 mmol) was added to a solution of **CTB-2NH** (0.16 g, 0.44 mmol) in anhydrous DMF (1.5 mL). The solution was stirred at 0°C for 20 minutes, and acetyl chloride (315 µL, 4.42 mmol) was added. The solution was allowed to reach room temperature and was stirred for 48 hours. The reaction was quenched with water, extracted three times with ethyl acetate. The organic layers were dried over $MgSO_4$, filtered and concentrated under vacuum. Purification over silica gel (cyclohexane/ethyl acetate 25/75) afforded the crown conformer of CTB-2NH as a mixture of two rotamers as a colorless oil (0.07 g, 53%).
^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.48 – 7.43 (m, 2H, H12, H12'), 7.42 (d, *J* = 9.3 Hz, 1H, H6'), 7.36 (d, *J* = 9.3 Hz, 1H, H6), 7.24 (d, *J* = 8.9 Hz, 1H, H18), 7.18 (d, *J* = 8.7 Hz, 1H, H18'), 7.05 (d, *J* = 2.9 Hz, 1H, H9'), 7.02 (d, *J* = 2.9 Hz, 1H, H9), 6.98 (d, *J* = 2.9 Hz, 1H, H15), 6.98 – 6.94 (m, 2H, H15', H13'), 6.92 (dd, *J* = 8.8, 2.9 Hz, 1H, H13), 6.86 – 6.82 (m, 2H, H3', H7'), 6.80 – 6.76 (m, 2H, H3, H7), 6.72 (m, 2H, H19, H19'), 4.54 (d, *J* = 12.8 Hz, 2H, H1, H1'), 3.81 (s, 6H, H24, H24'), 3.79 (s, 3H, H25), 3.75 (s, 3H, H25'), 3.75 (s, 3H, H26'), 3.72 (s, 3H, H26), 3.53 (d, *J* = 12.9 Hz, 2H, H1,H1'), 2.21 (s, 3H, $COCH_3$), 2.20 (s, 3H, $COCH_3$), 1.97 (s, 3H, $COCH_3$), 1.95 (s, 3H, $COCH_3$).
^{13}C NMR (101 MHz, $CDCl_3$) δ = 173. 6 ($\underline{C}OCH_3$), 173.3 ($\underline{C}OCH_3$), 172.6 ($\underline{C}OCH_3$), 172.3 ($\underline{C}OCH_3$), 160.4 (C8), 160.2 (C8'), 156.0 (C14), 159.5(C14' and C2), 159.4 (C2'), 142.7 (C10'), 142.7 (C10), 142.1 (C16), 142.0 (C4'), 141.9 (C4), 141.4 (C16), 134.2 (C11), 133.8 (C11'), 133.7 (C17), 133.3 (C17'), 132.1 (C5'), 132.1 (C12'), 131.5 (C6'), 131.5 (C5), 131.4 (C12), 130.7 (C6), 130.1 (C18), 129.7 (C18'), 116.6 (C9), 116.5 (C9'), 115.7 (C15), 115.4 (C15'), 115.1 (C13), 115.0 (C7'), 114.9 (C3'), 114.6 (C13'), 114.5 (C3'), 114.2 (C3), 113.4 (C19), 113.2 (C19), 55.8 (C24'), 55.8 (C24), 55.6 (C25, C25'), 55.5 (C26'), 55.4 (C26), 33.8 (C1'), 33.7 (C1), 22.9 ($CO\underline{C}H_3$), 22.8 ($CO\underline{C}H_3$), 22.7 ($CO\underline{C}H_3$), 22.6 ($CO\underline{C}H_3$).
Melting point: 123-125 °C
HRMS-ESI: calculated for $C_{26}H_{27}N_2O_5$ $[M+H]^+$ 447.1920, found 447.1920

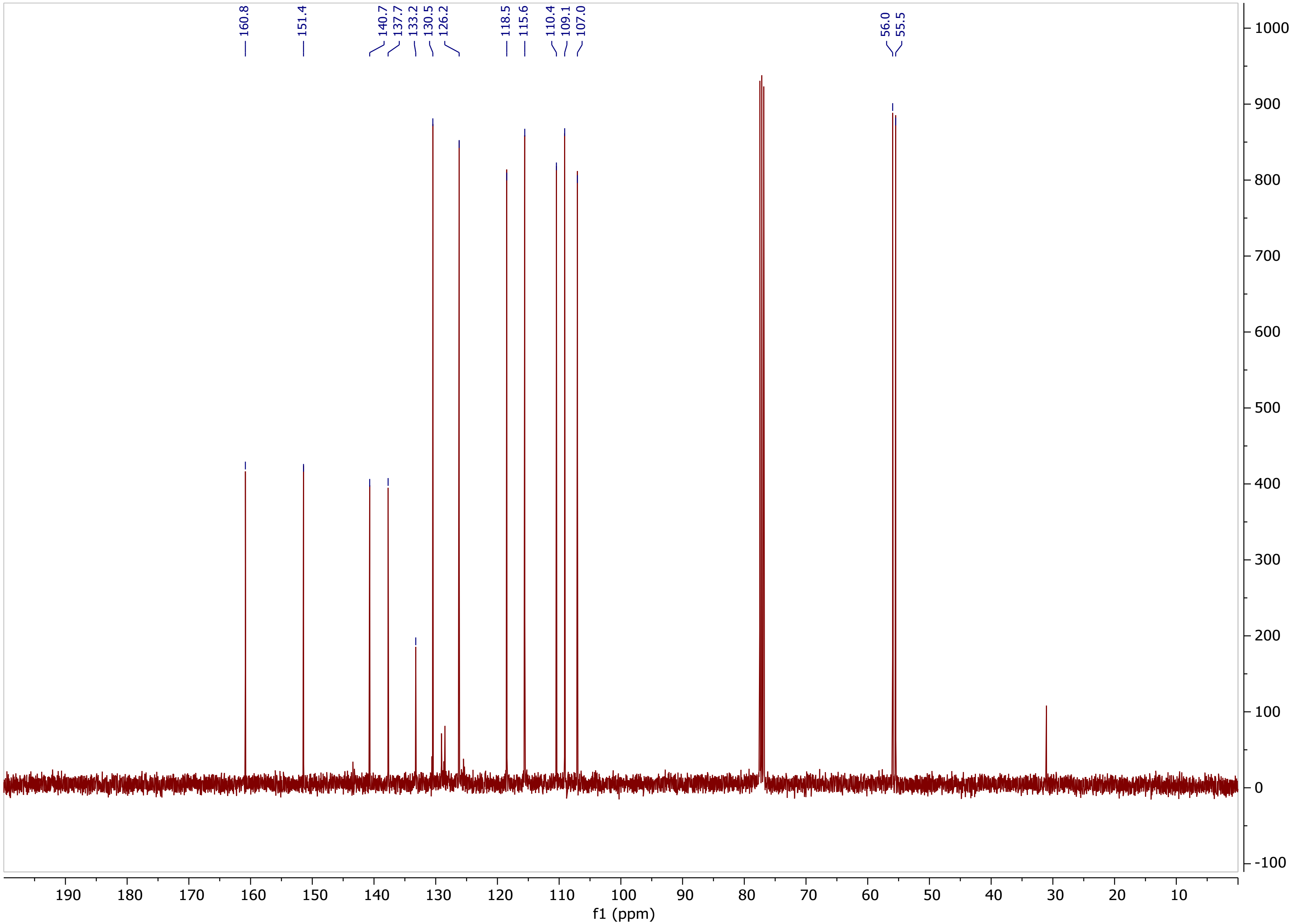
3 NMR Spectra

3.1 4-Methoxy-*N*-(3-methoxyphenyl)-2-nitroaniline 1

^{1}H NMR

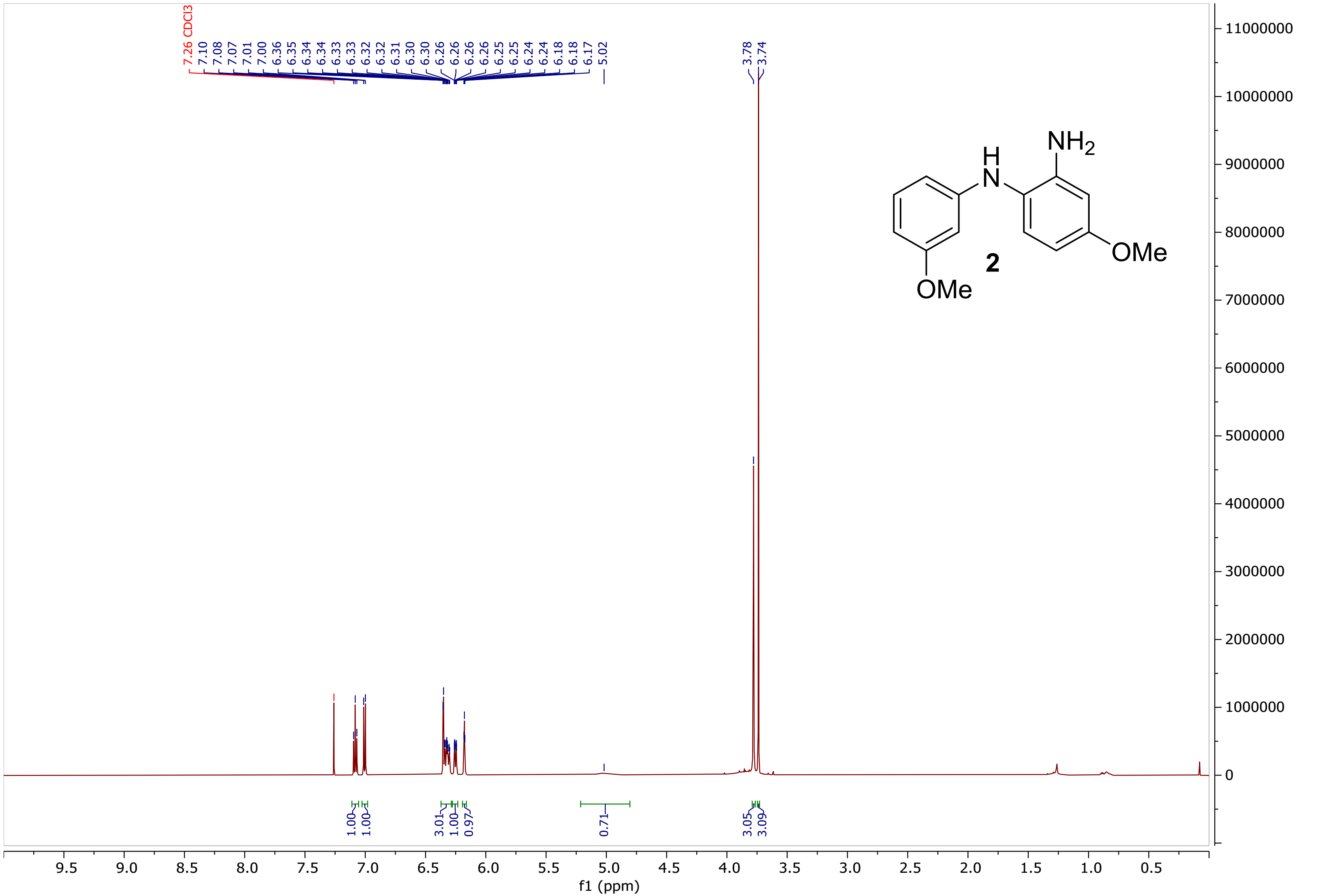


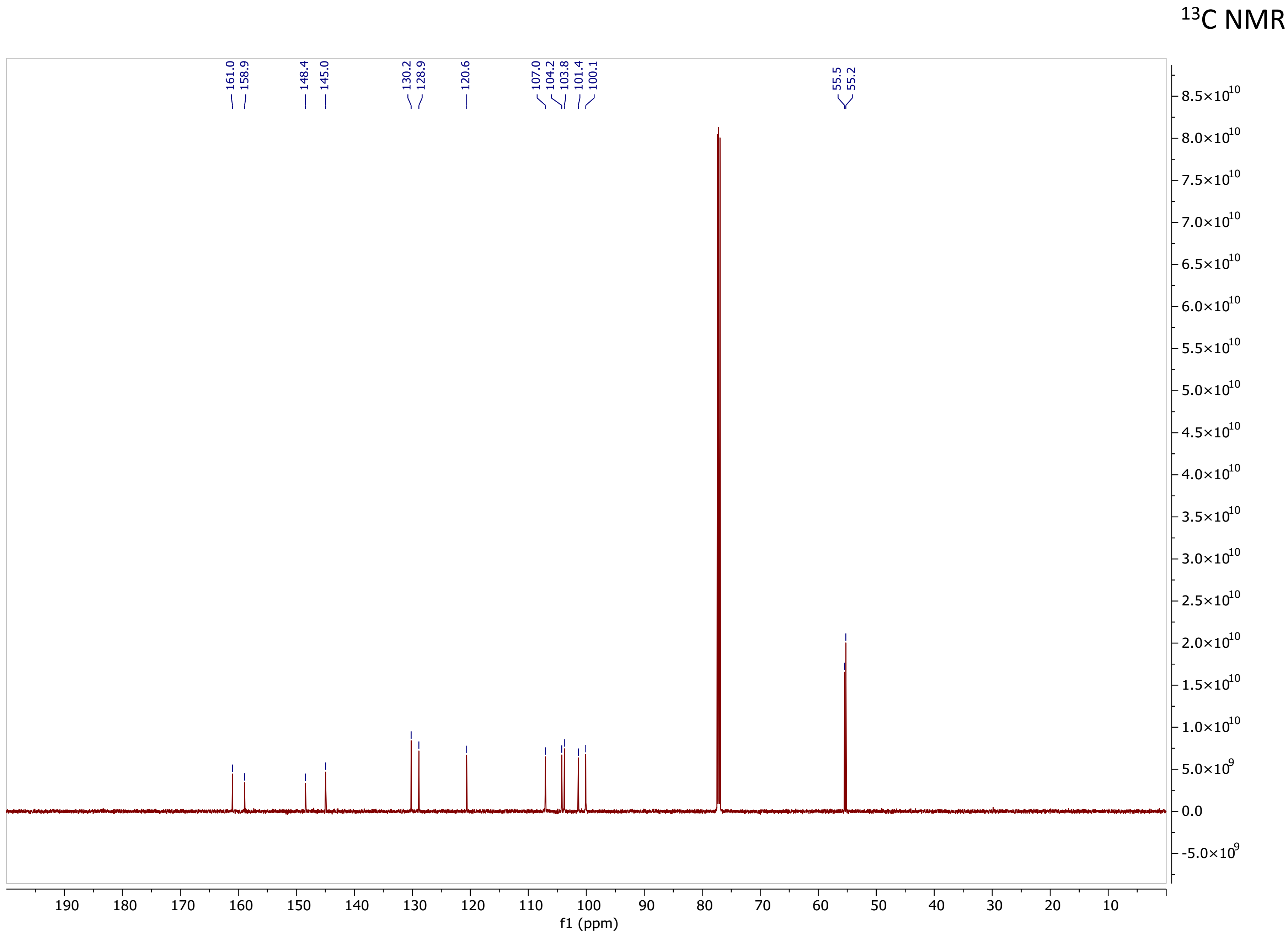
^{13}C NMR



160.8
151.4
140.7
137.7
133.2
130.5
126.2
118.5
115.6
110.4
109.1
107.0
56.0
55.5
f1 (ppm)

3.2 4-Methoxy-*N1*-(3-methoxyphenyl)benzene-1,2-diamine 2

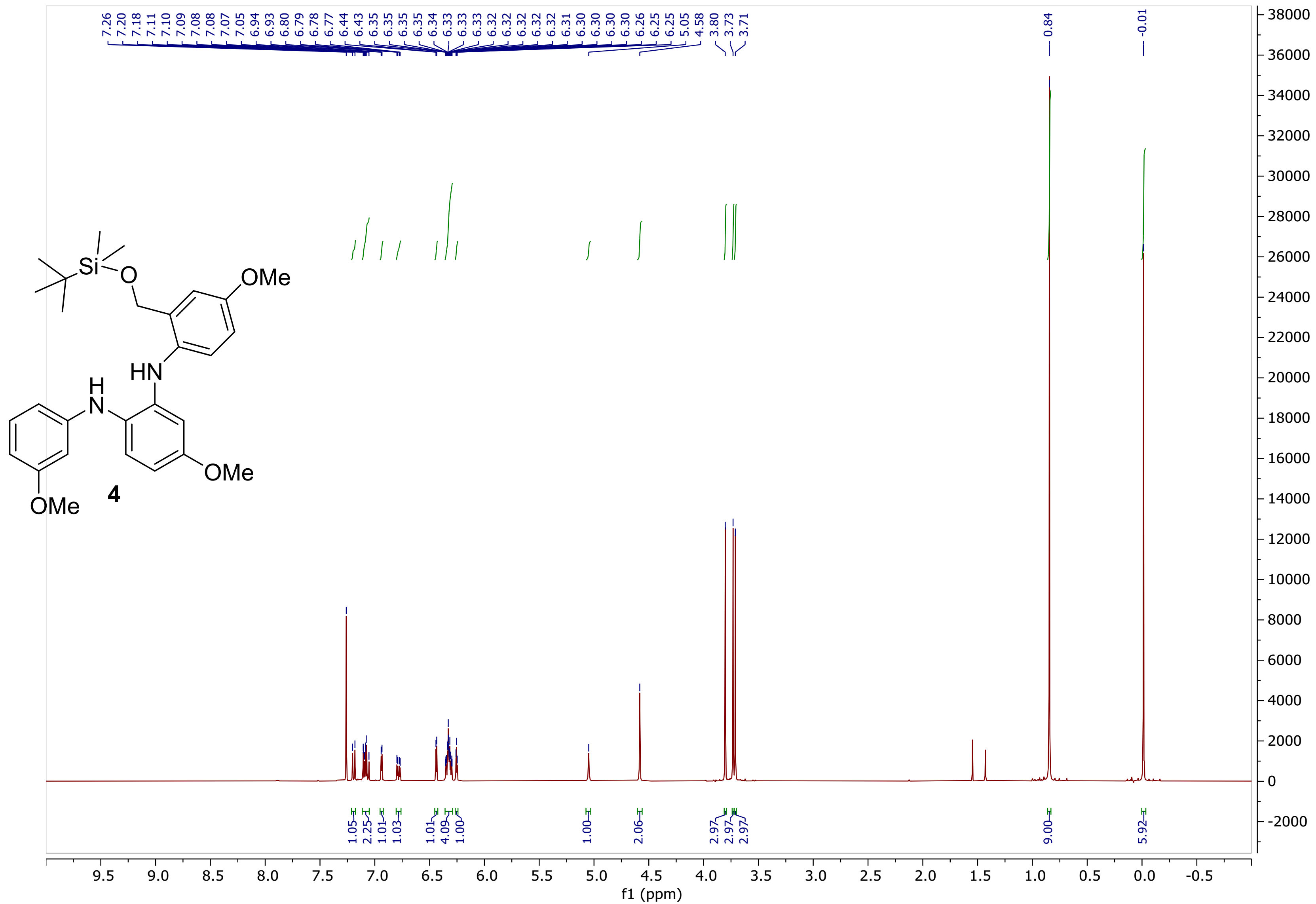




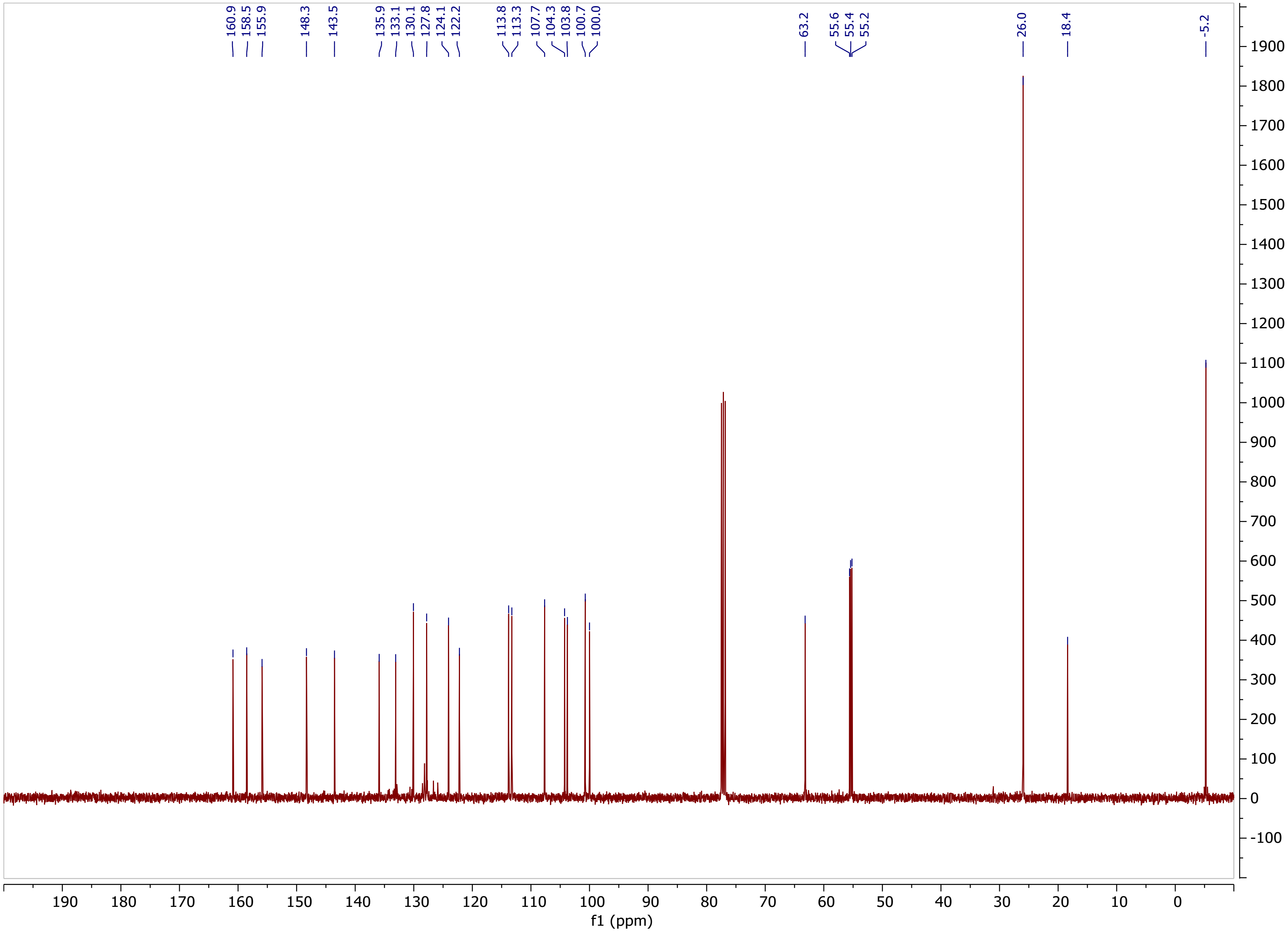
^{13}C NMR
161.0
158.9
148.4
145.0
130.2
128.9
120.6
107.0
104.2
103.8
101.4
100.1
55.5
55.2
f1 (ppm)

3.3 ***N2*-(2-{[(*tert*-Butyldimethylsilyl)oxy]methyl}-4-methoxyphenyl)-4-methoxy-*N1*-(3-methoxyphenyl)benzene-1,2-diamine 4**

^{1}H NMR



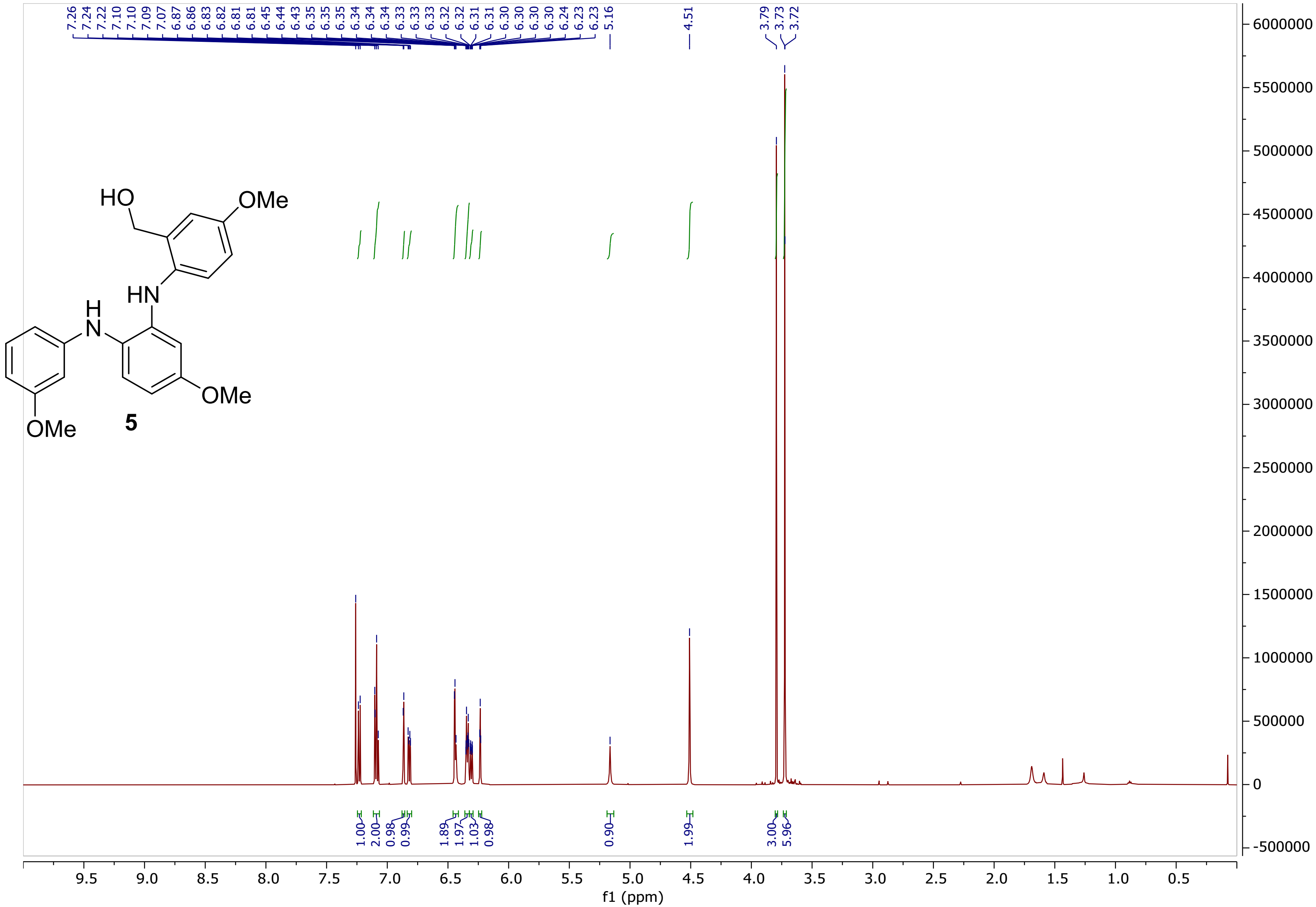
^{13}C NMR

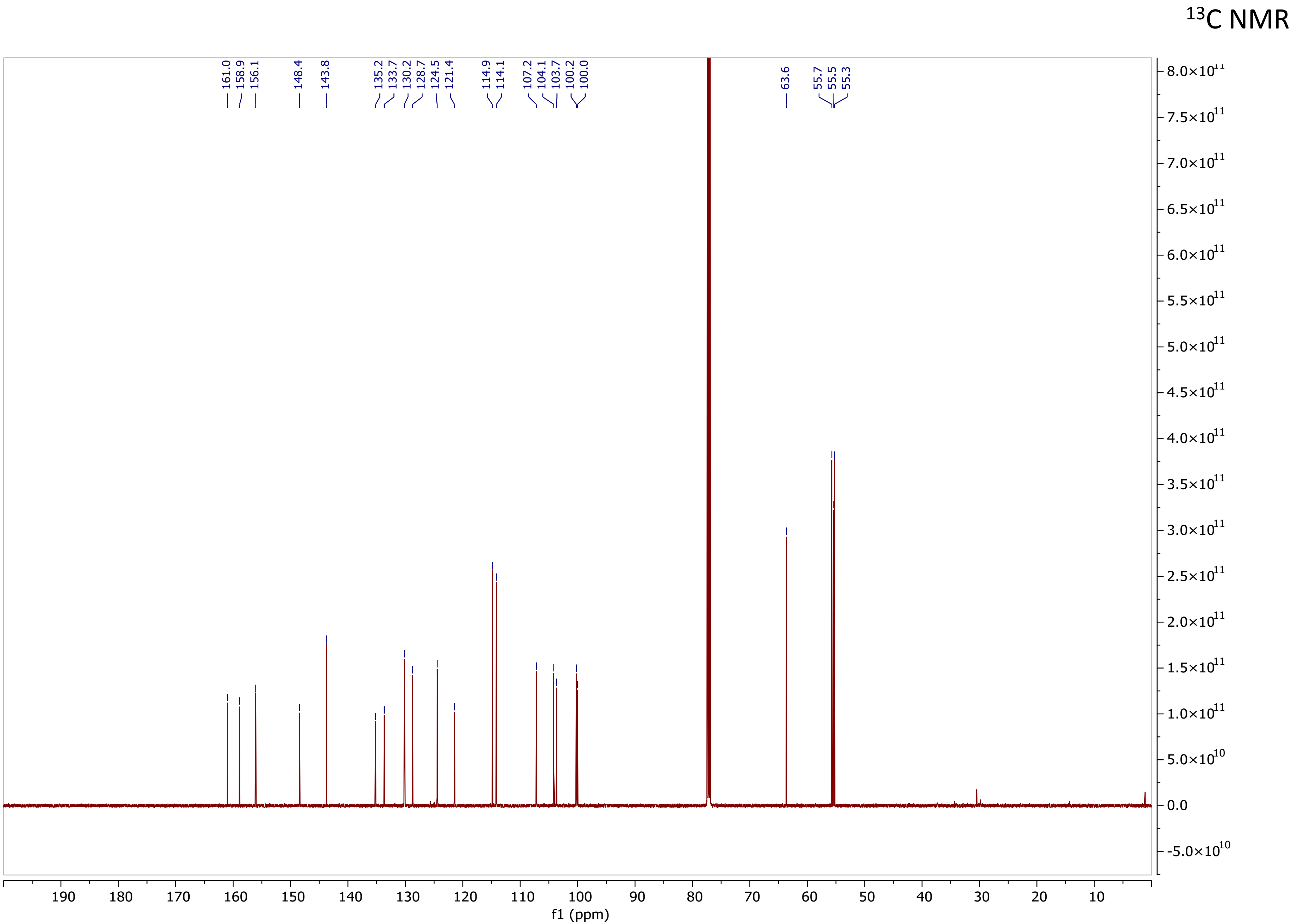


160.9
158.5
155.9
148.3
143.5
135.9
133.1
130.1
127.8
124.1
122.2
113.8
113.3
107.7
104.3
103.8
100.7
100.0
63.2
55.6
55.4
55.2
26.0
18.4
-5.2
f1 (ppm)

3.4 [5-Methoxy-2-({5-methoxy-2-[(3-methoxyphenyl)amino]phenyl}amino)phenyl]methanol 5

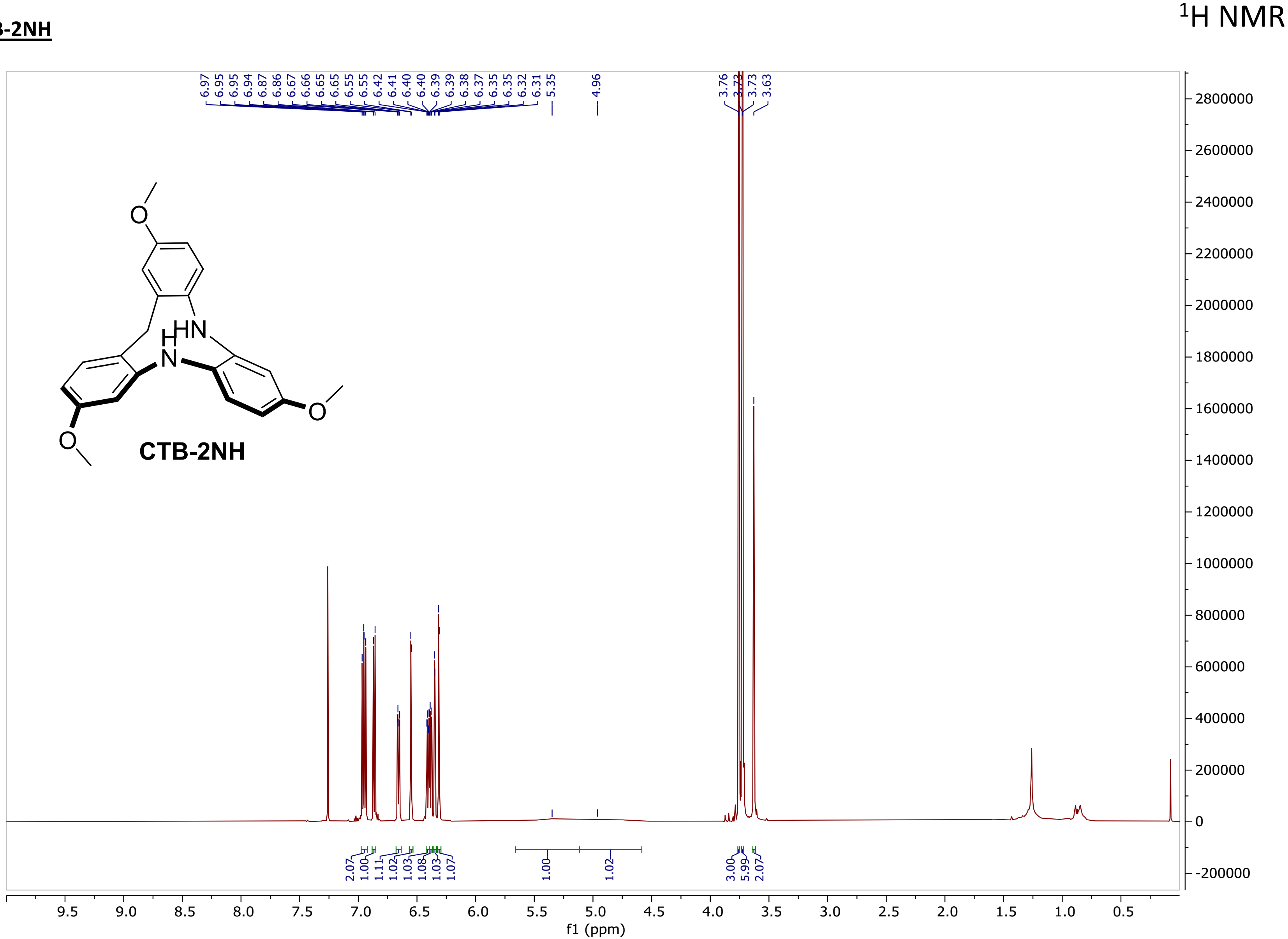
^1H NMR





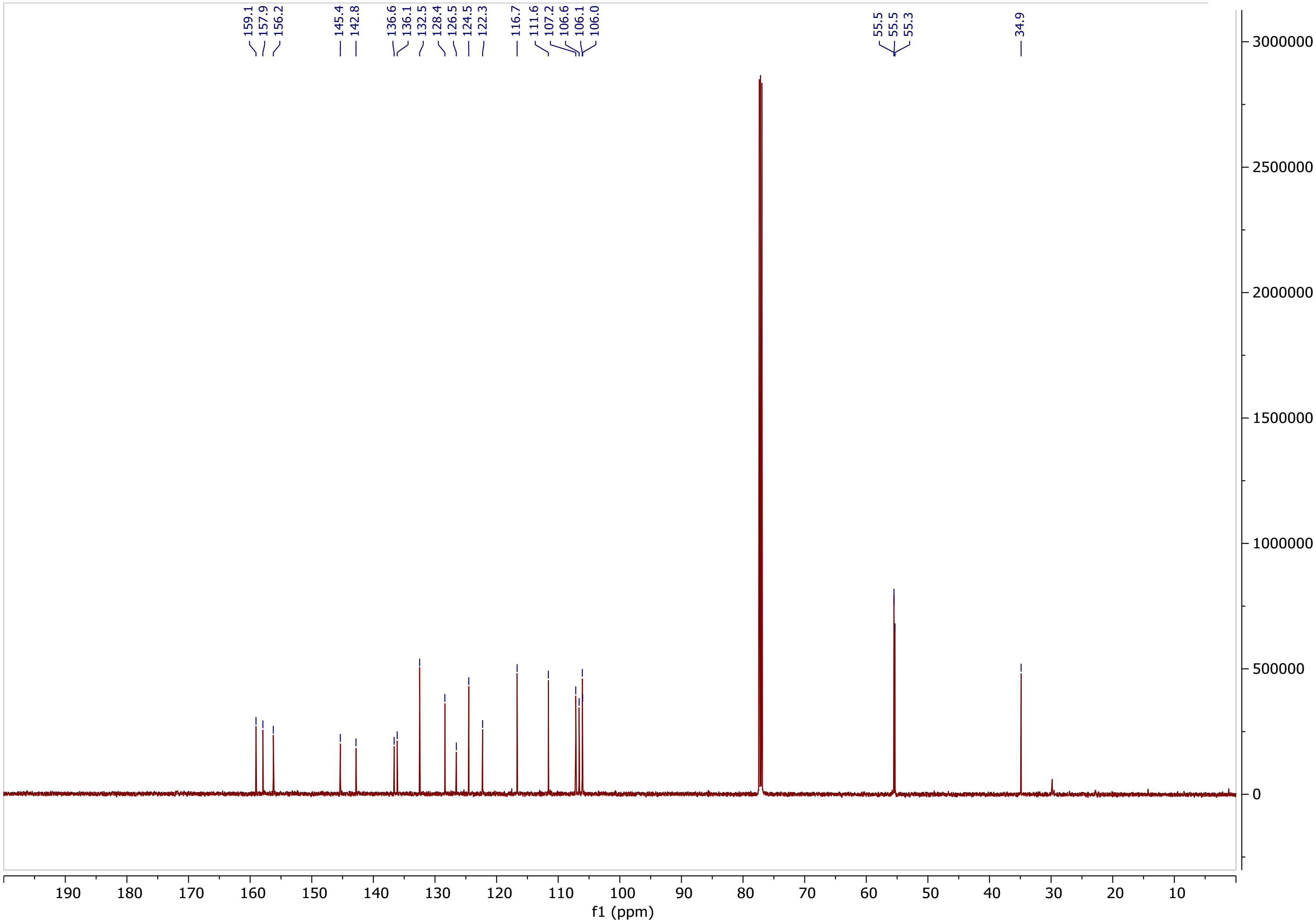
13C NMR
161.0
158.9
156.1
148.4
143.8
135.2
133.7
130.2
128.7
124.5
121.4
114.9
114.1
107.2
104.1
103.7
100.2
100.0
63.6
55.7
55.5
55.3
f1 (ppm)

3.5 CTB-2NH



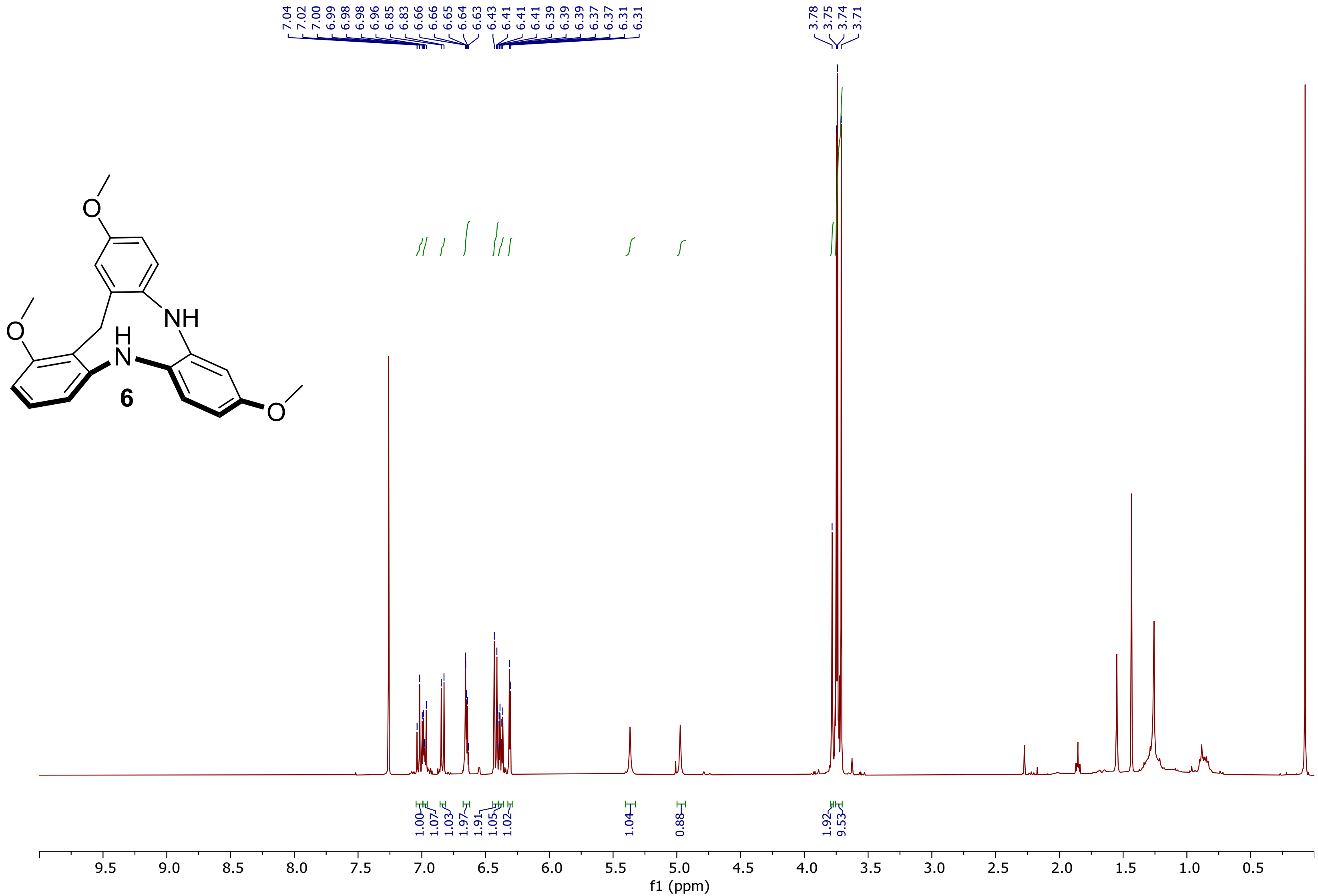
¹H NMR
6.97
6.95
6.95
6.94
6.87
6.86
6.67
6.66
6.65
6.65
6.55
6.55
6.42
6.41
6.40
6.40
6.39
6.39
6.38
6.37
6.35
6.35
6.32
6.31
5.35
4.96
3.76
3.72
3.73
3.63
HN
H
N
O
O
O
CTB-2NH
2.07
1.00
1.11
1.02
1.03
1.08
1.03
1.07
1.00
1.02
3.00
5.99
2.07
f1 (ppm)

^{13}C NMR

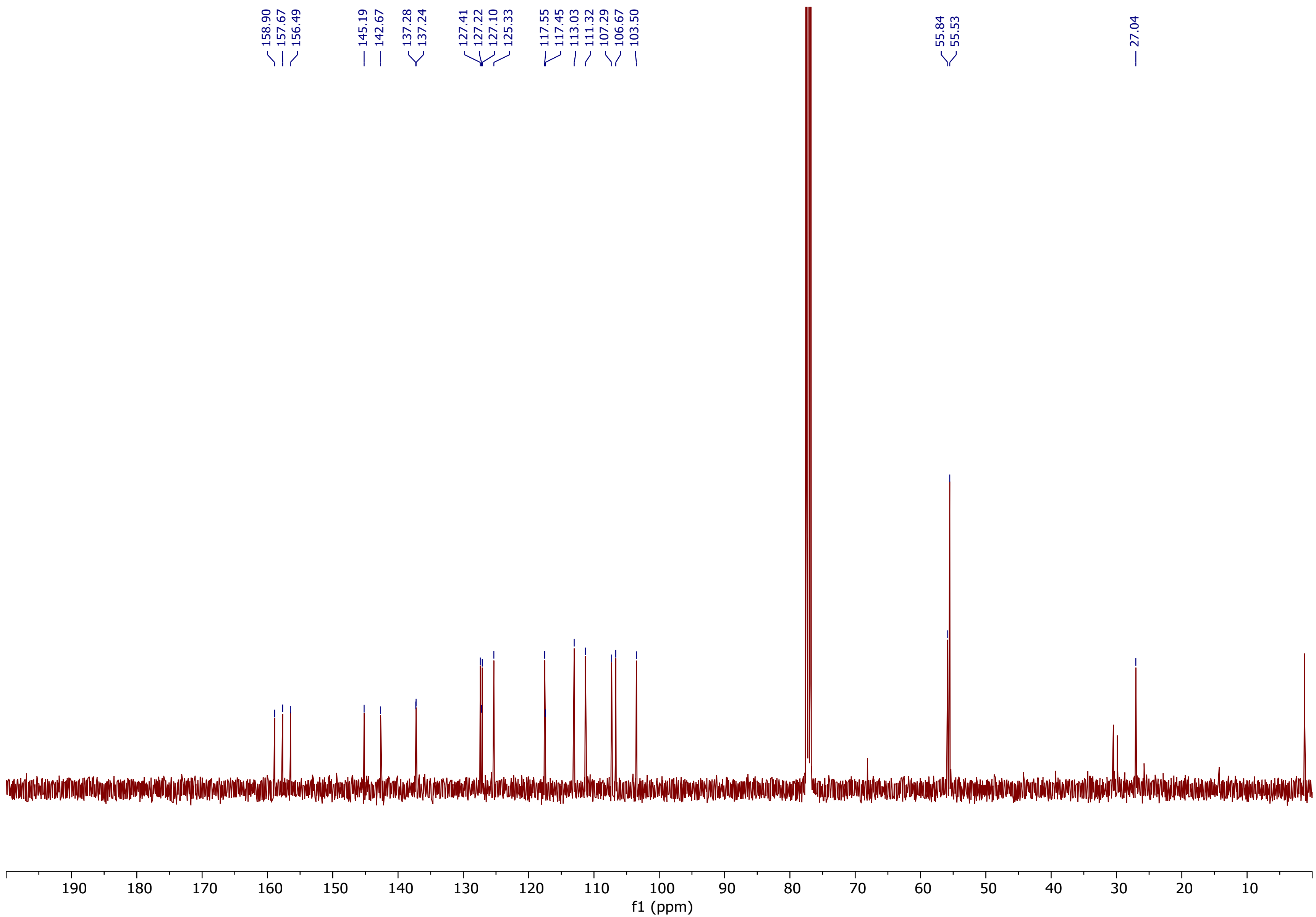

159.1
157.9
156.2
145.4
142.8
136.6
136.1
132.5
128.4
126.5
124.5
122.3
116.7
111.6
107.2
106.6
106.1
106.0
55.5
55.5
55.3
34.9
3000000
2500000
2000000
1500000
1000000
500000
0
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

3.6 1,8,13-Trimethoxy-10,15-dihydro-*5H*-tribenzo[*b,e,h*][1,4]diazonine 6

^{1}H NMR

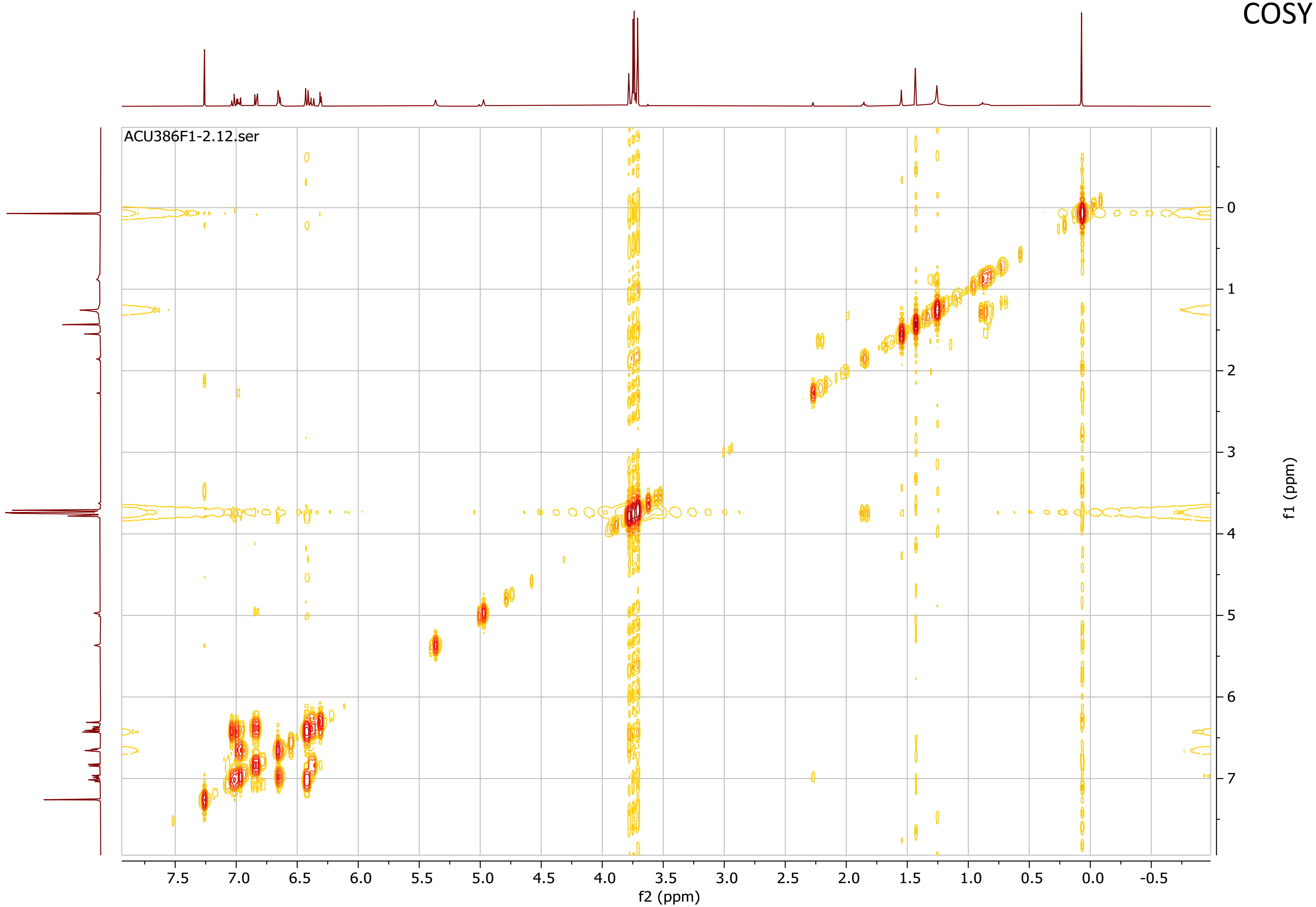


^{13}C NMR

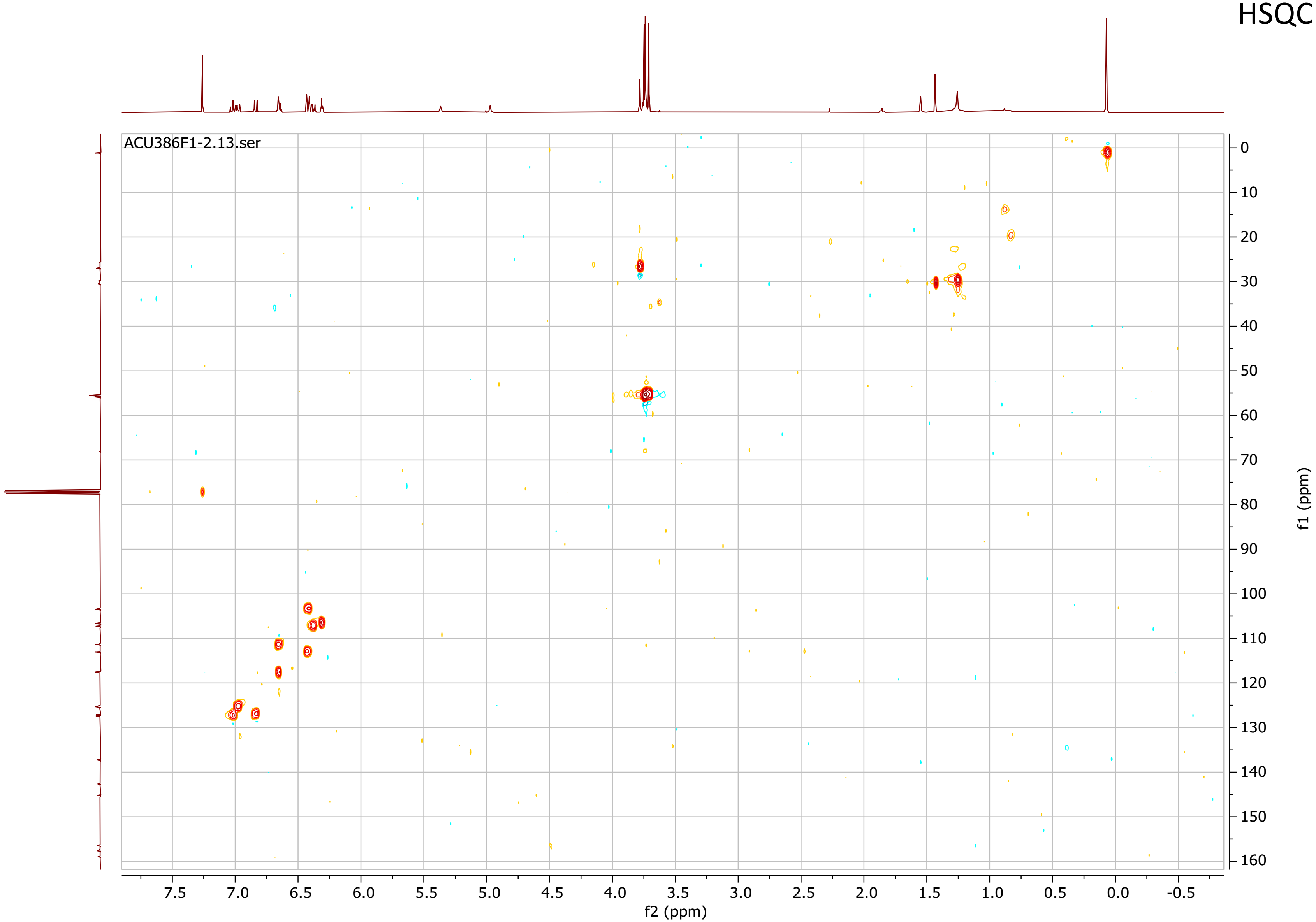

158.90
157.67
156.49
145.19
142.67
137.28
137.24
127.41
127.22
127.10
125.33
117.55
117.45
113.03
111.32
107.29
106.67
103.50
55.84
55.53
27.04
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

1

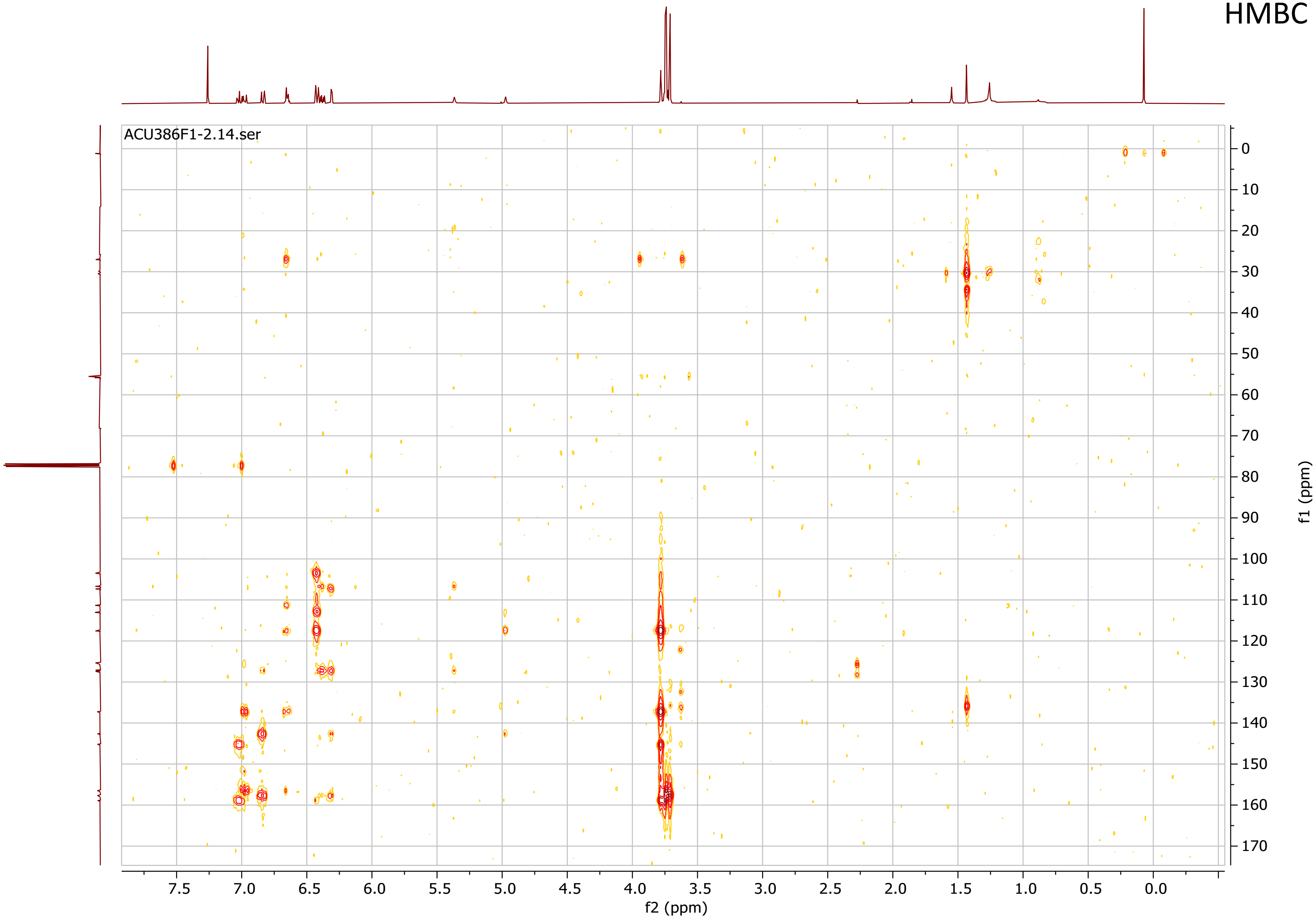
COSY HH


ACU386F1-2.12.ser
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f2 (ppm)
0
1
2
3
4
5
6
7
f1 (ppm)

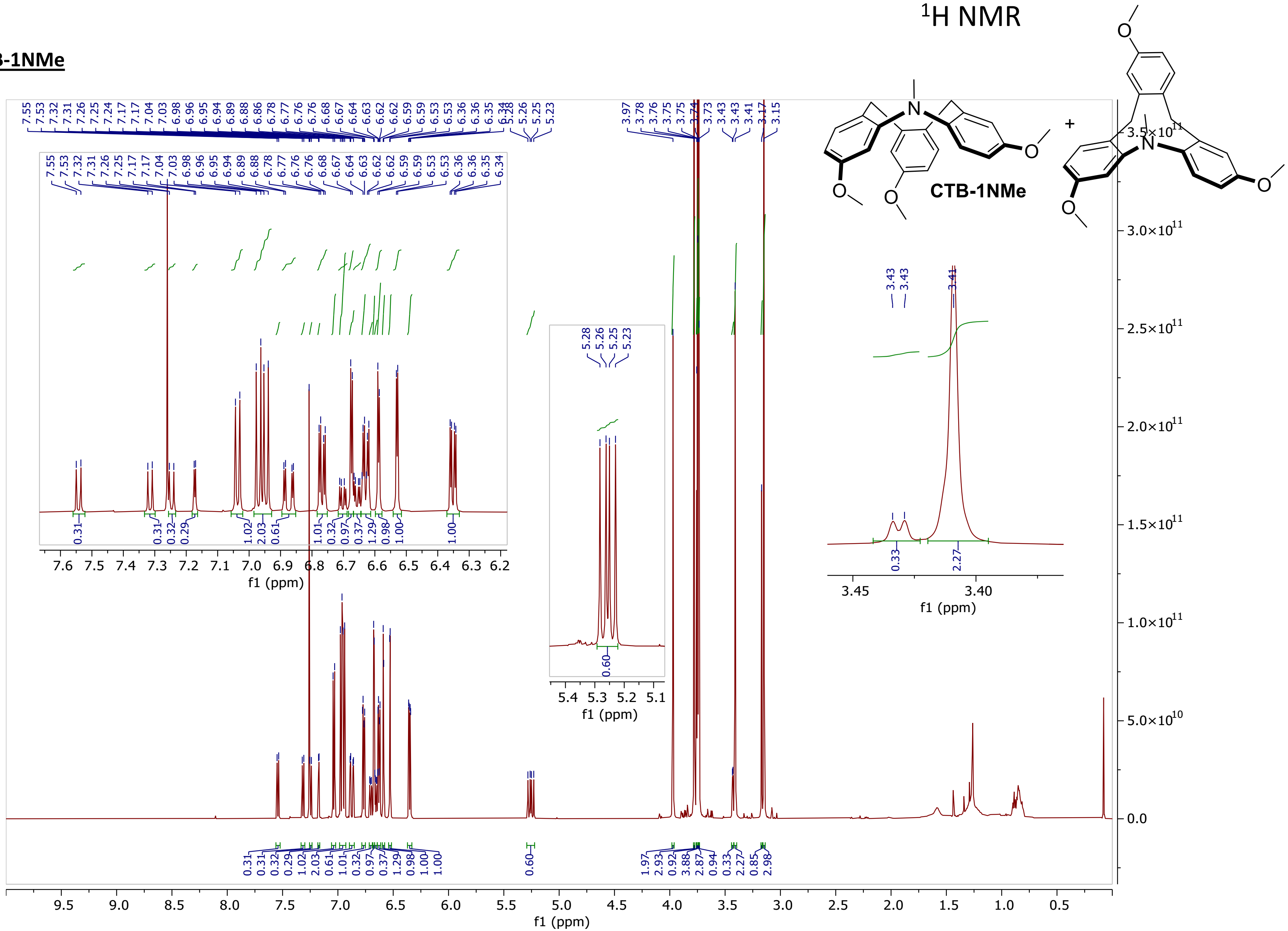
HSQC

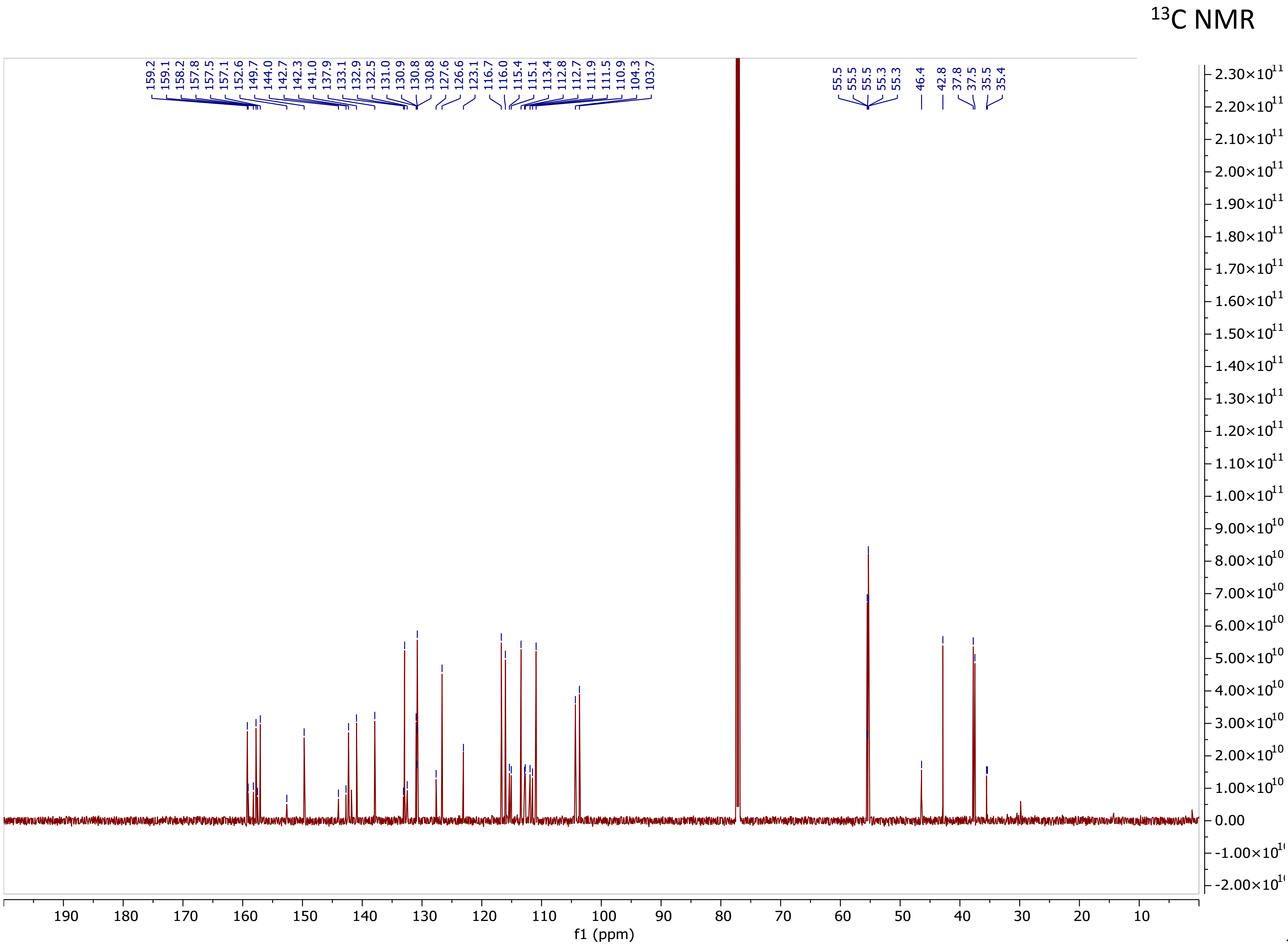

ACU386F1-2.13.ser
7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f2 (ppm)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160
f1 (ppm)

HMBC



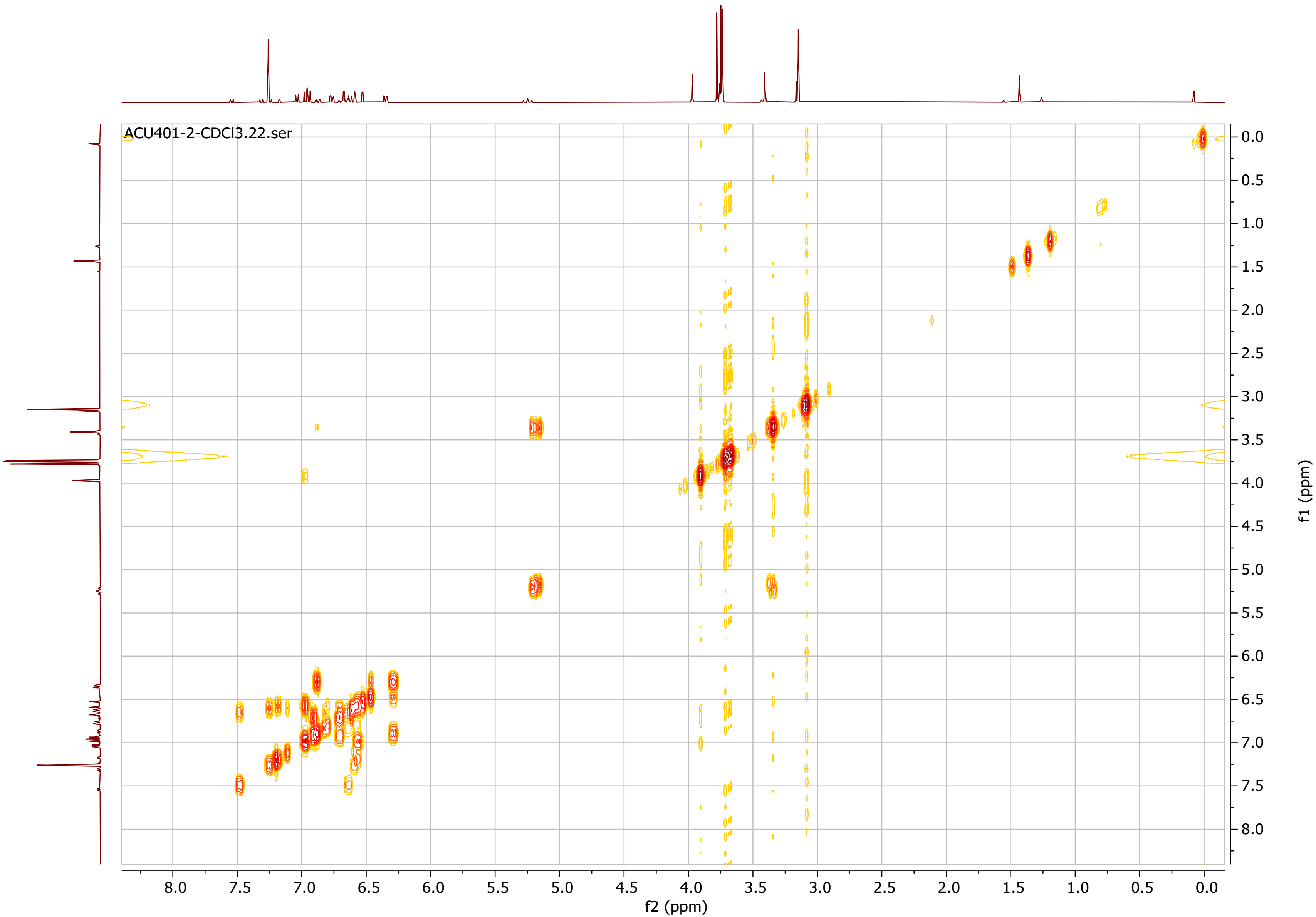
3.7 CTB-1NMe





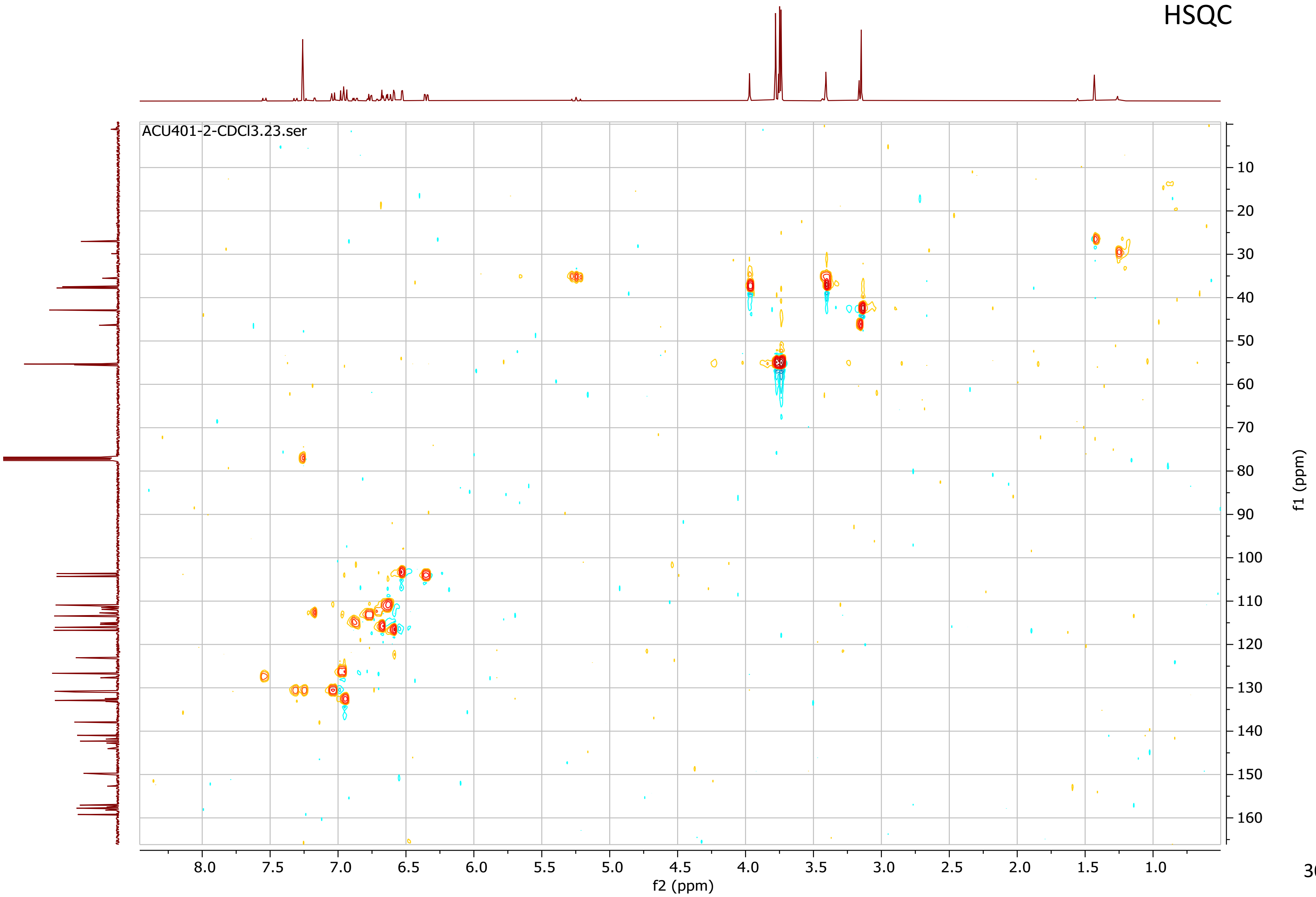
13C NMR
159.2
159.1
158.2
157.8
157.5
157.1
152.6
149.7
144.0
142.7
142.3
141.0
137.9
133.1
132.9
132.5
131.0
130.9
130.8
130.8
127.6
126.6
123.1
116.7
116.0
115.4
115.1
113.4
112.8
112.7
111.9
111.5
110.9
104.3
103.7
55.5
55.5
55.5
55.3
55.3
46.4
42.8
37.8
37.5
35.5
35.4
f1 (ppm)

COSY HH



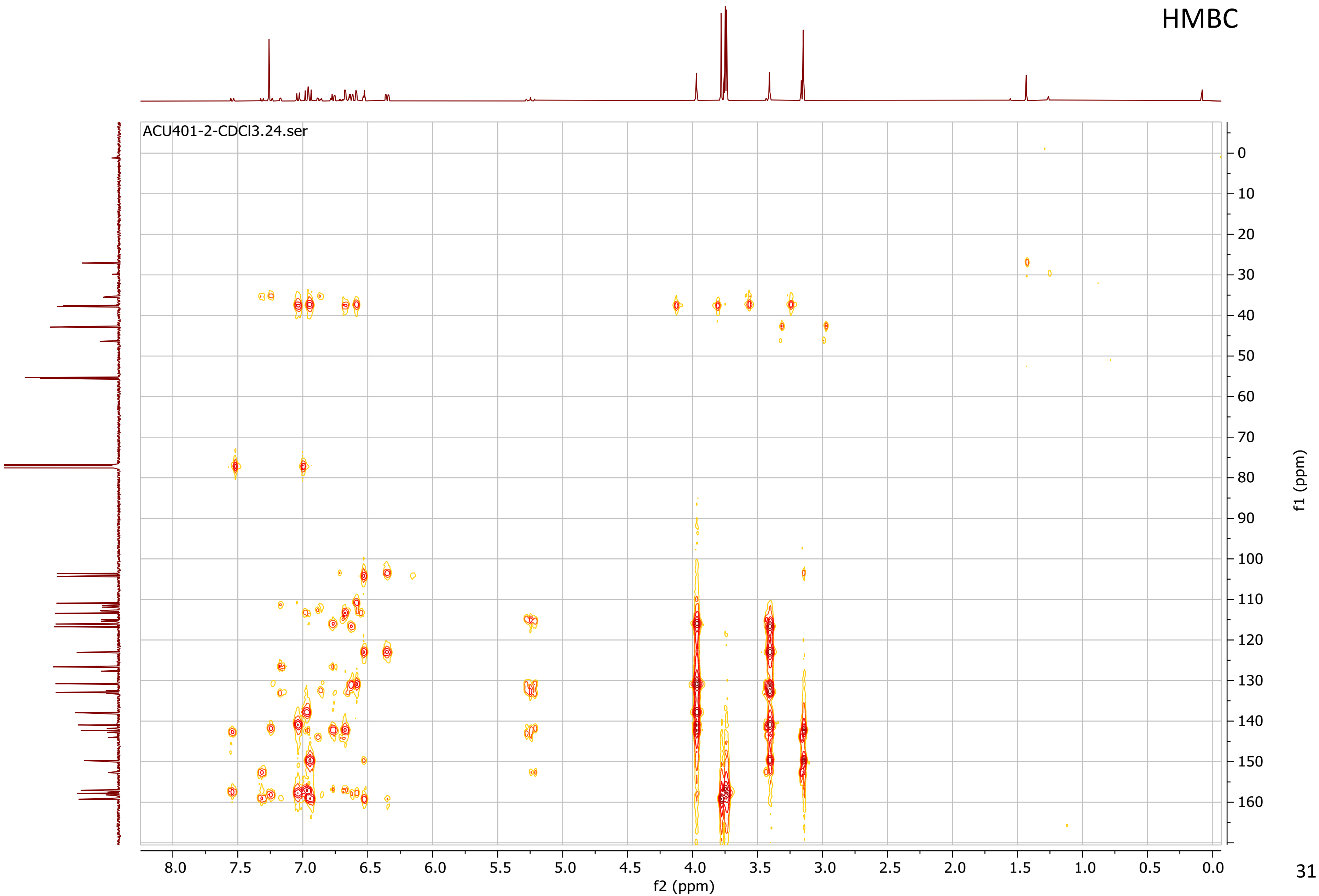
ACU401-2-CDCl3.22.ser
f2 (ppm)
f1 (ppm)
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0

HSQC

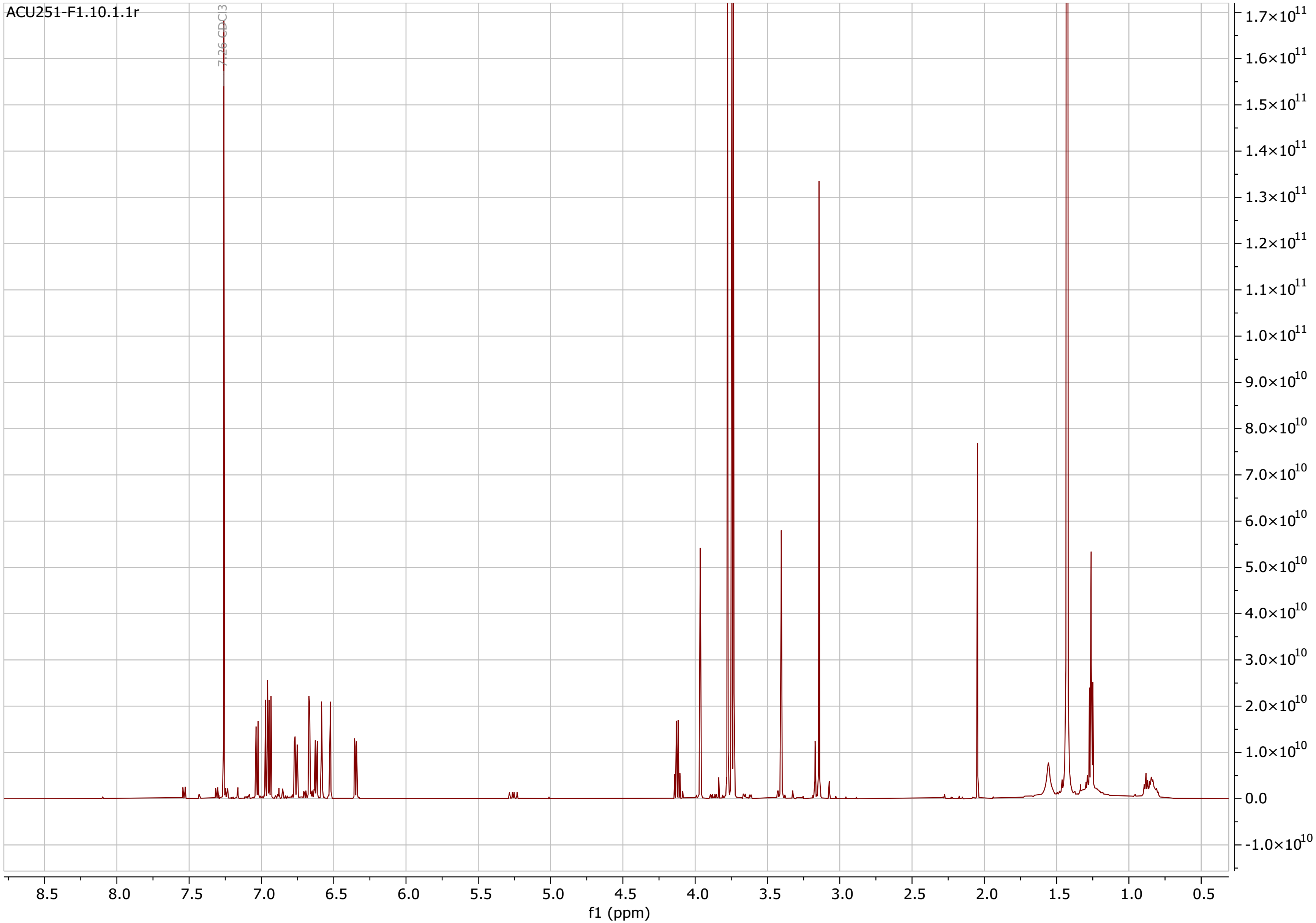


ACU401-2-CDCl3.23.ser
f2 (ppm)
f1 (ppm)
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160

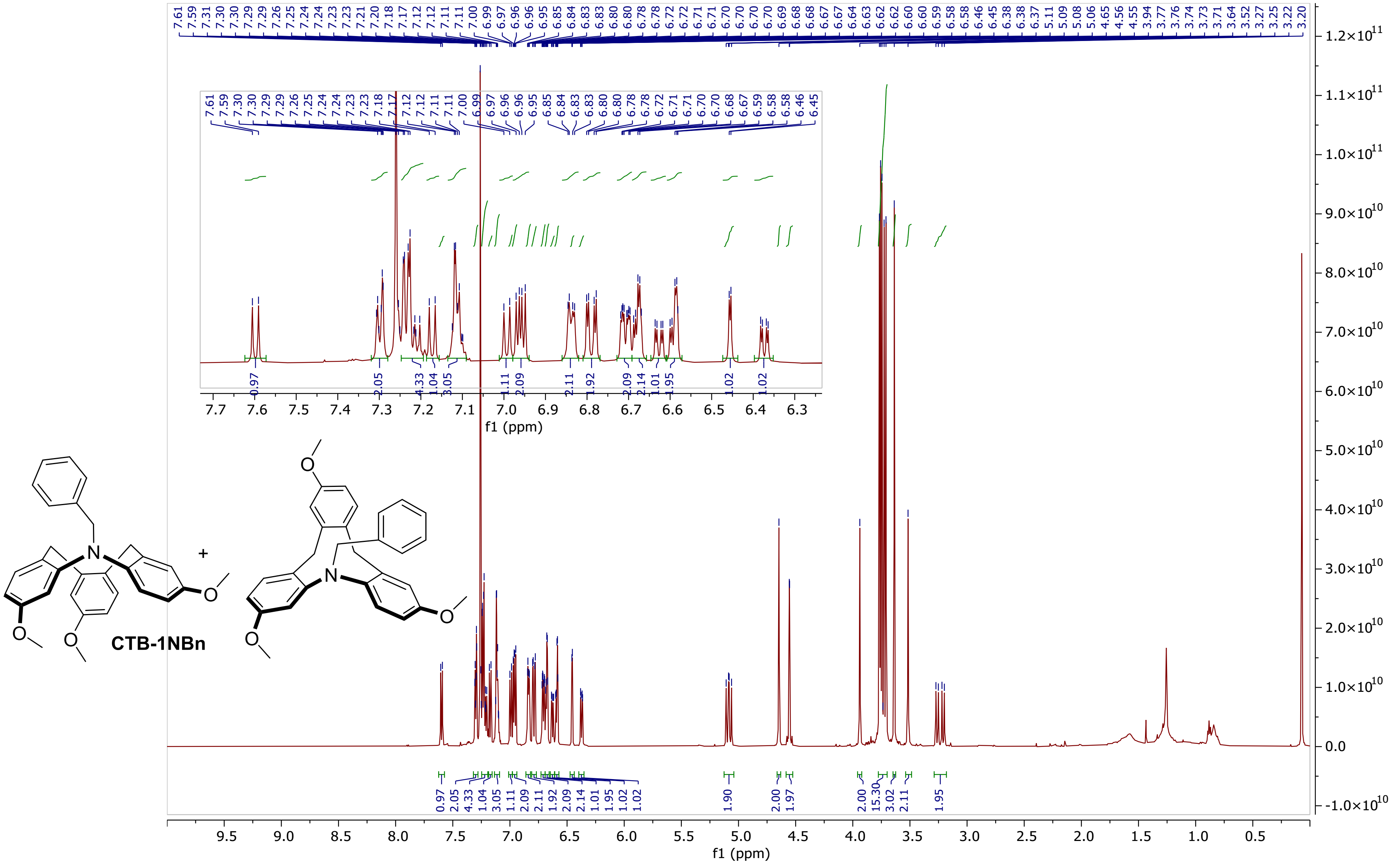
HMBC

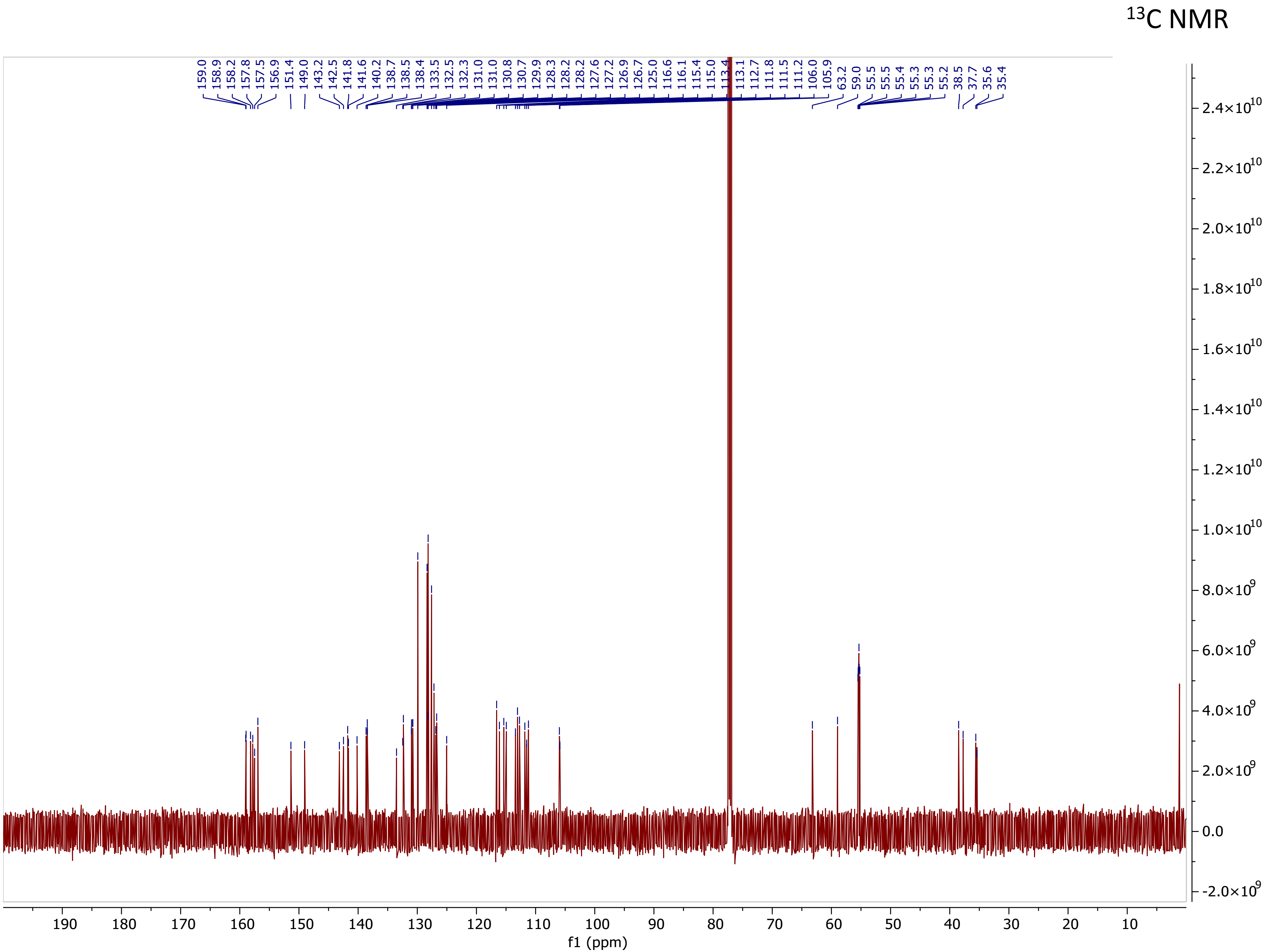


^{1}H NMR t_0 spectrum



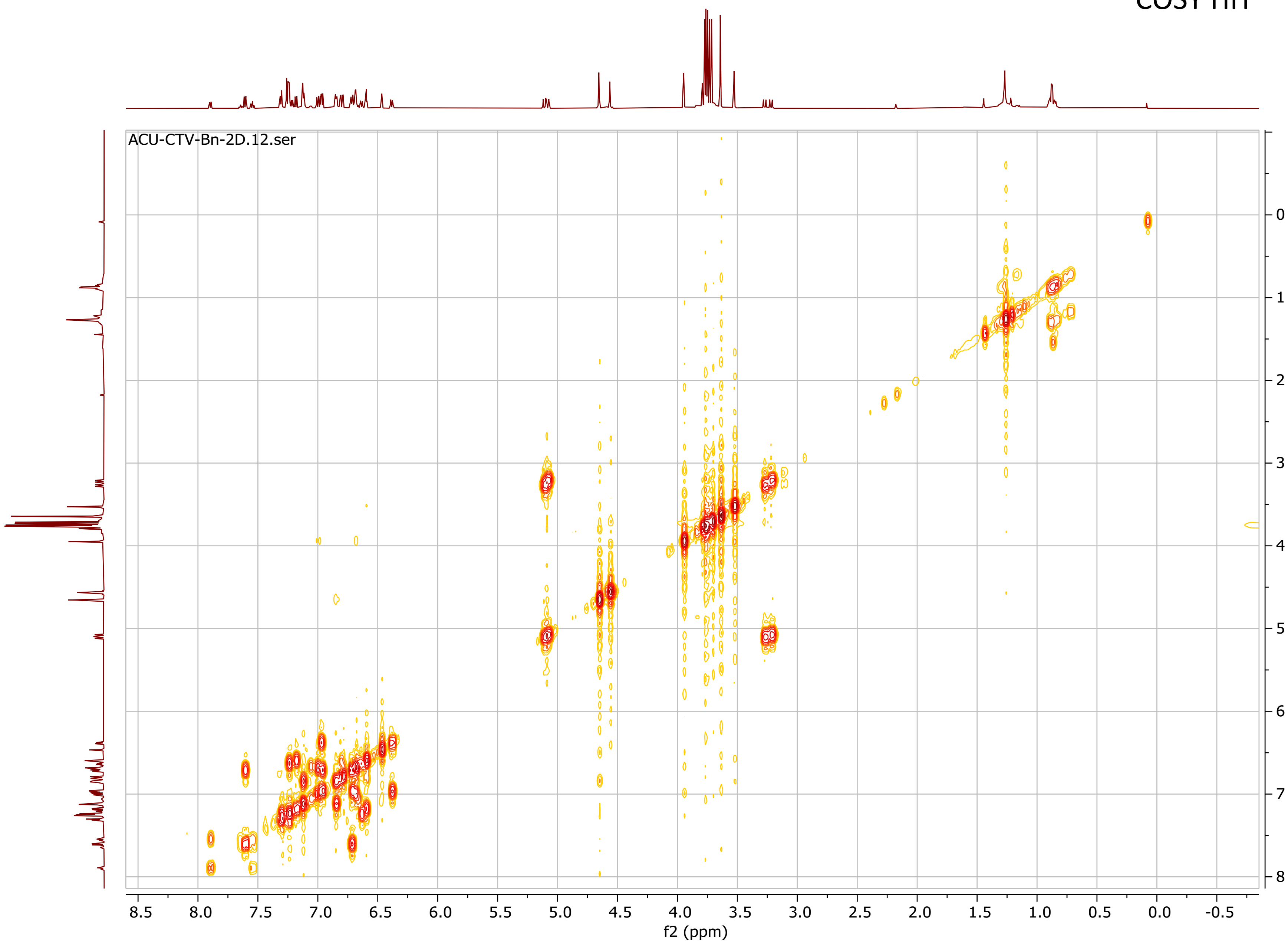
3.8 CTB-1NBn



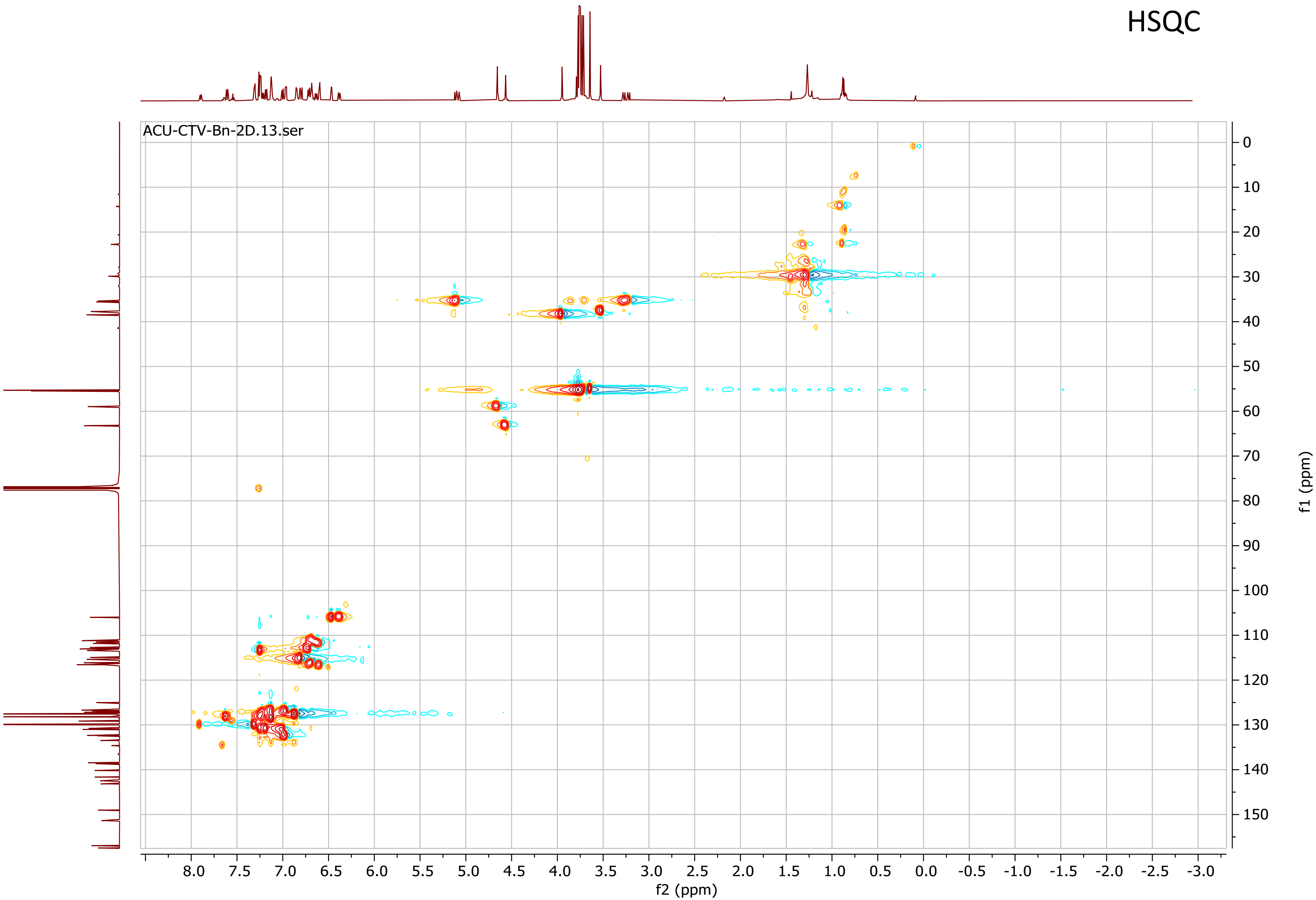


¹³C NMR
159.0
158.9
158.2
157.8
157.5
156.9
151.4
149.0
143.2
142.5
141.8
141.6
140.2
138.7
138.5
138.4
133.5
132.5
132.3
131.0
131.0
130.8
130.7
129.9
128.3
128.2
128.2
127.6
127.2
126.9
126.7
125.0
116.6
116.1
115.4
115.0
113.4
113.1
112.7
111.8
111.5
111.2
106.0
105.9
63.2
59.0
55.5
55.5
55.4
55.3
55.3
55.2
38.5
37.7
35.6
35.4
f1 (ppm)

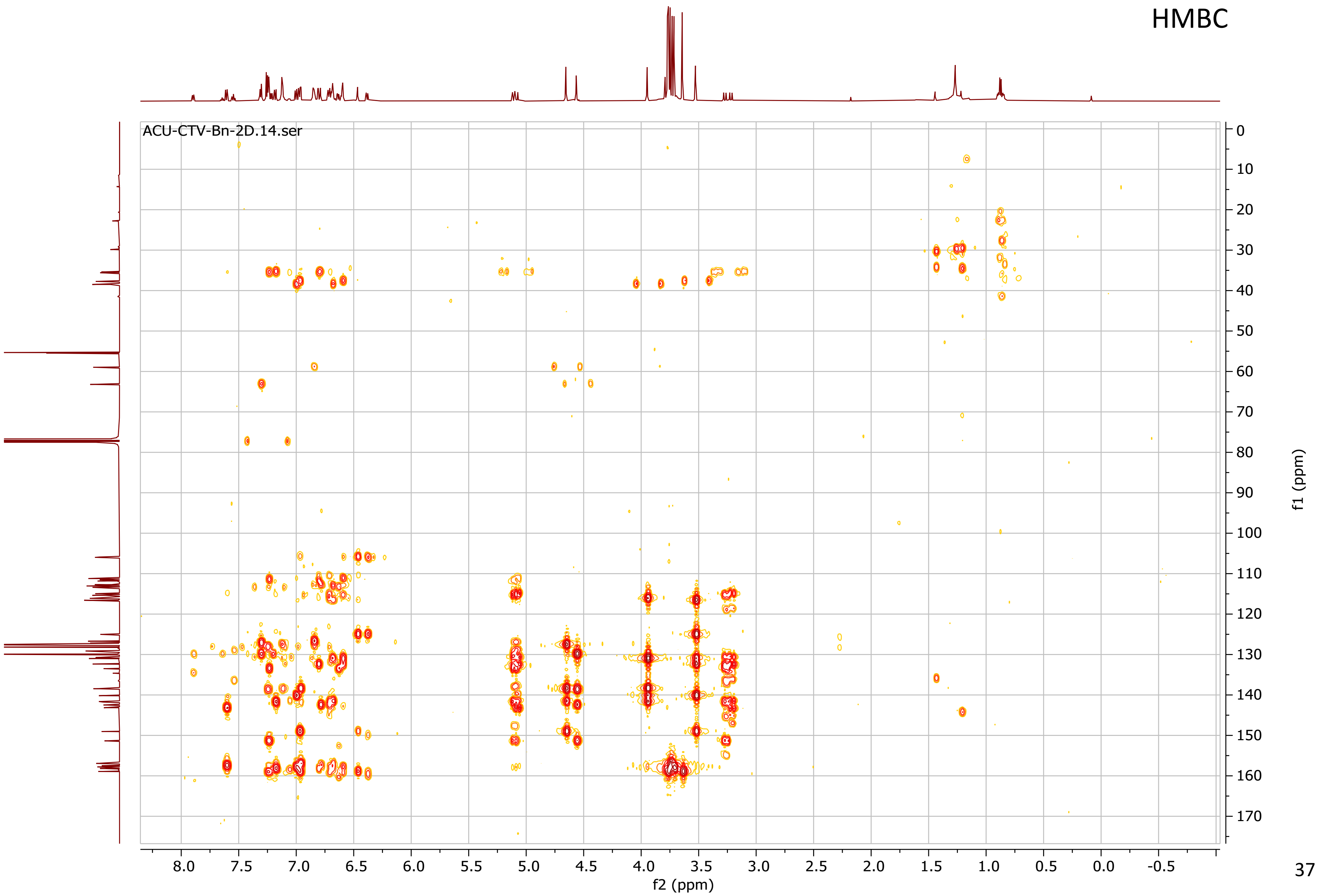
COSY HH


ACU-CTV-Bn-2D.12.ser
f2 (ppm)
f1 (ppm)
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
0
1
2
3
4
5
6
7
8

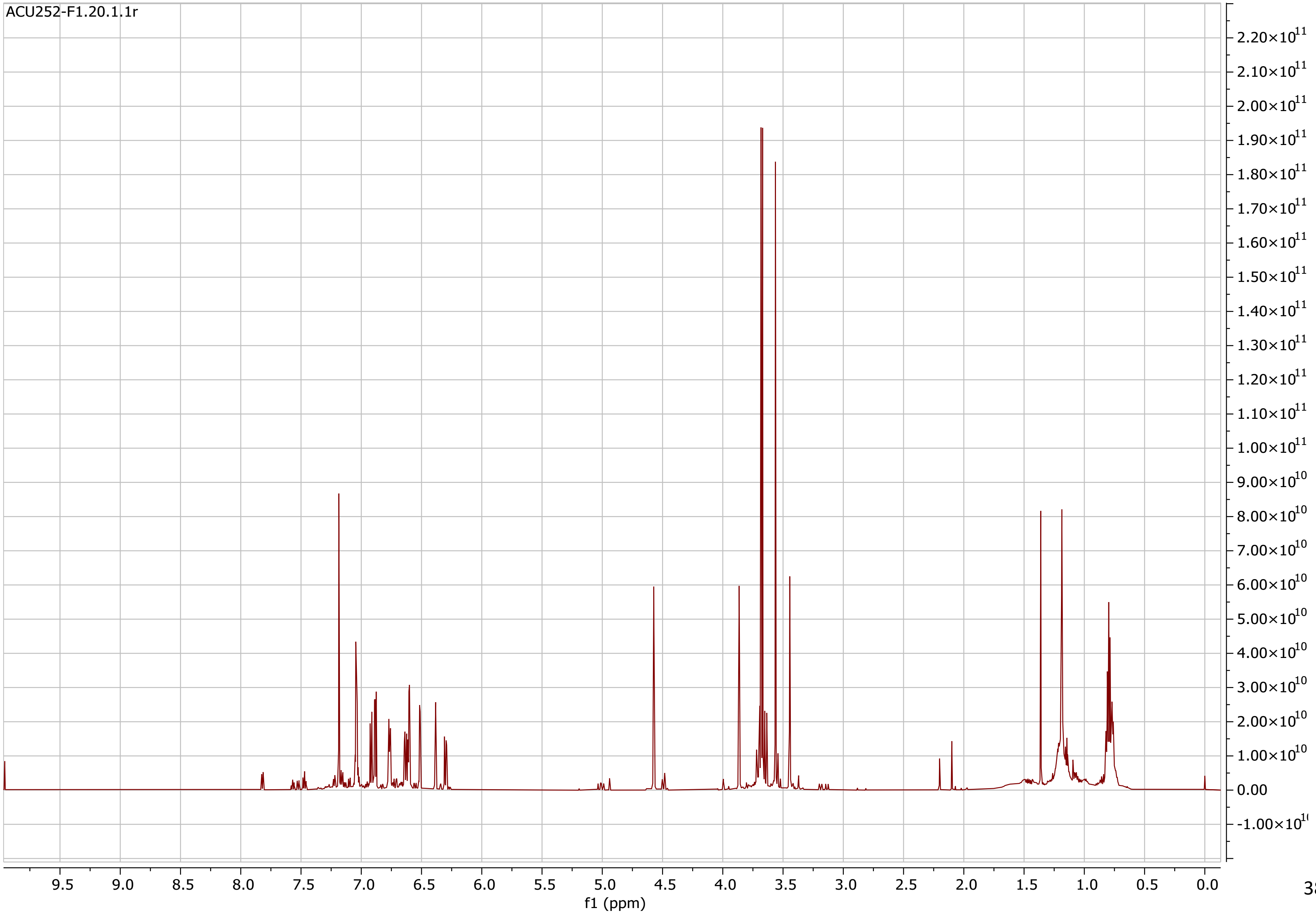
HSQC



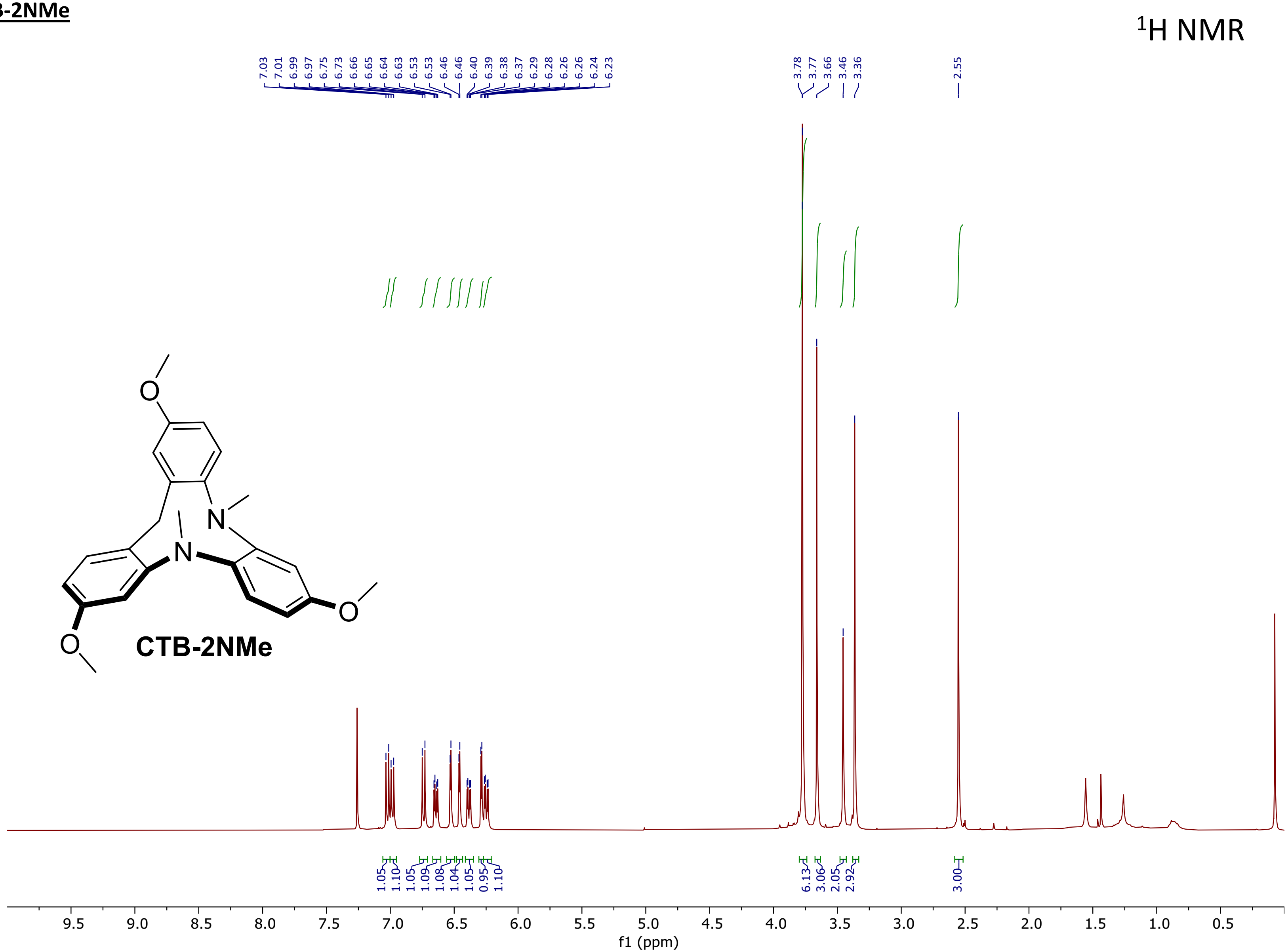
HMBC



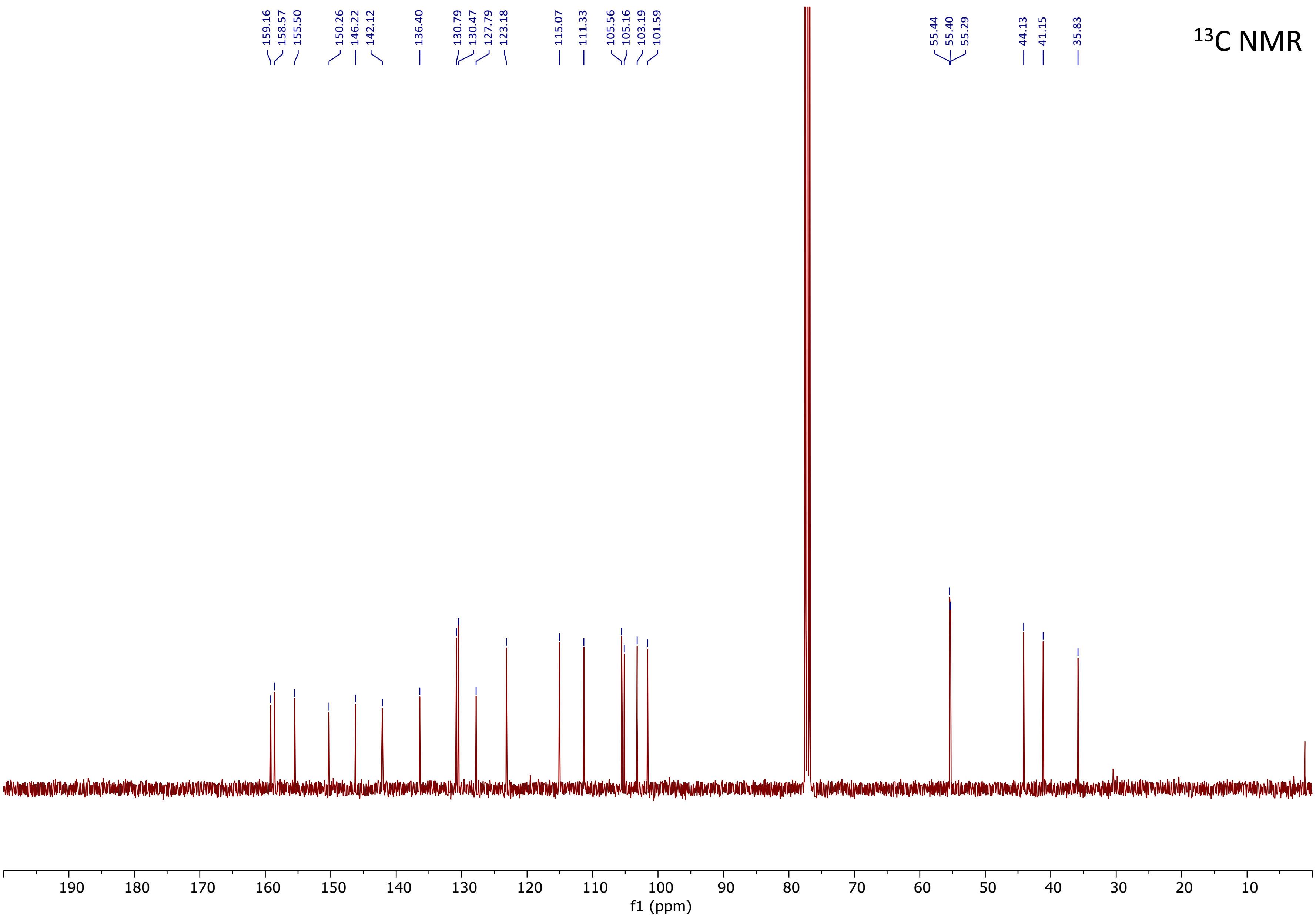
^{1}H NMR t_0 spectrum



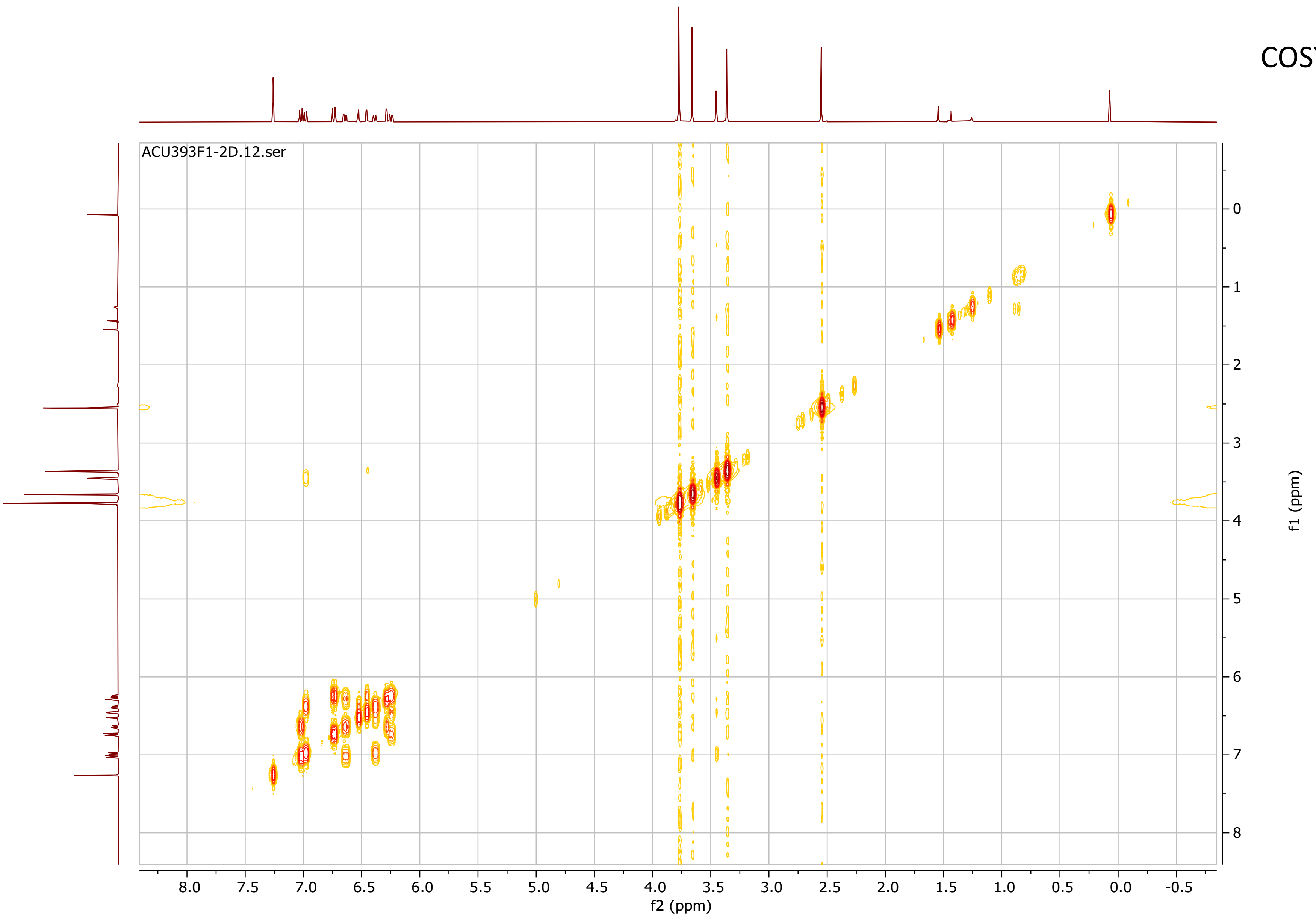
3.9 CTB-2NMe

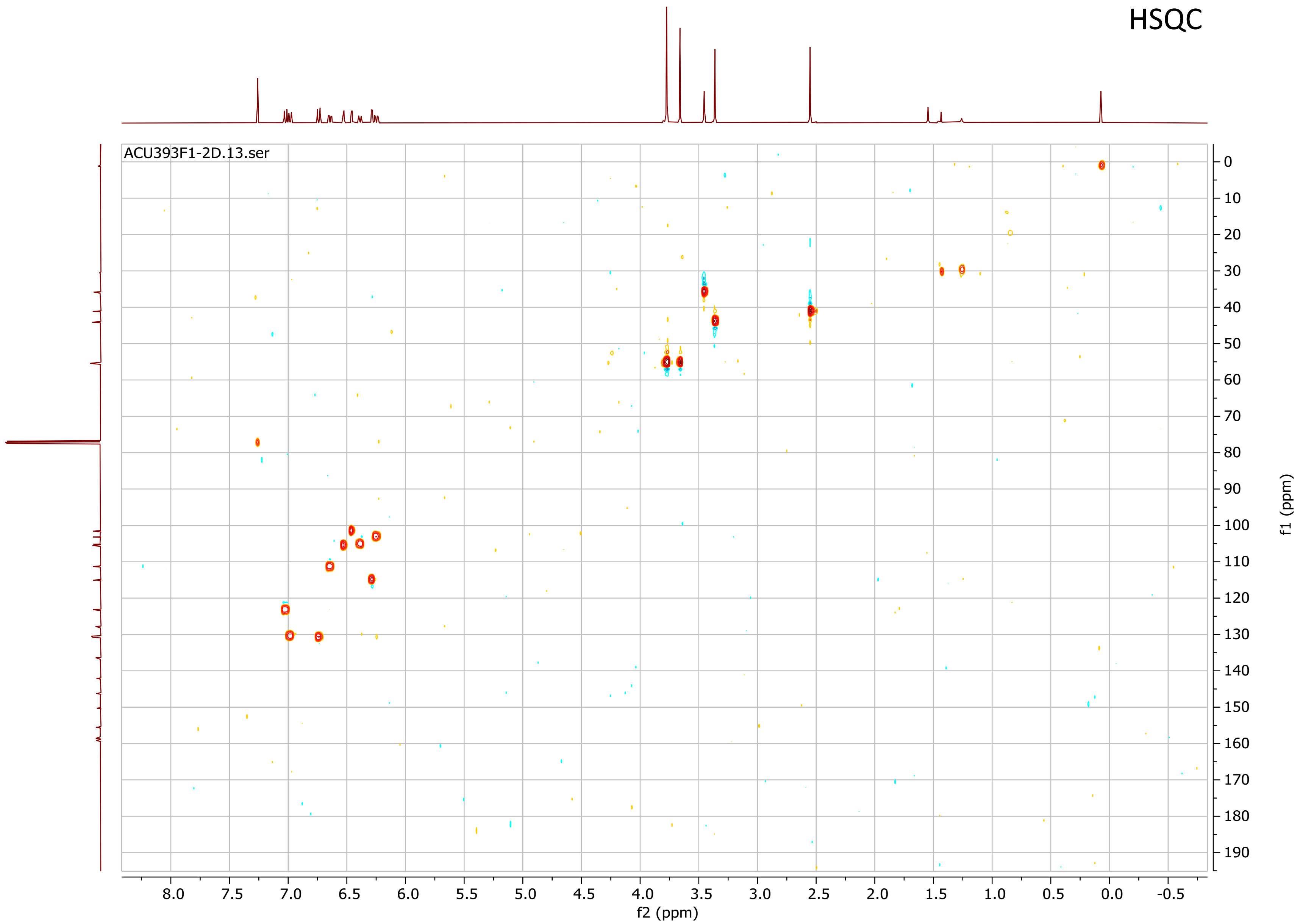


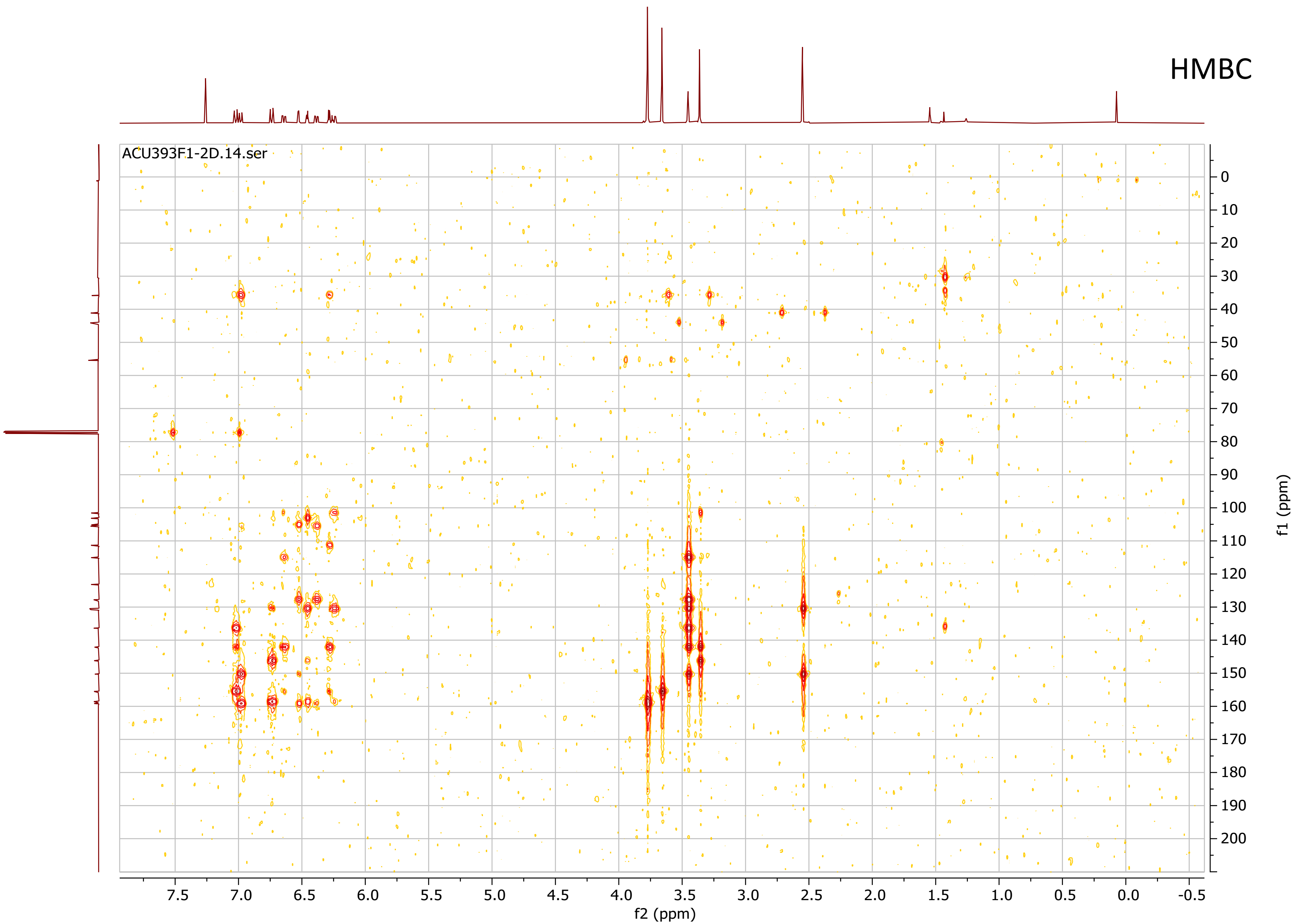
¹H NMR
7.03 7.01 6.99 6.97 6.75 6.73 6.66 6.65 6.64 6.63 6.53 6.53 6.46 6.46 6.40 6.39 6.38 6.37 6.29 6.28 6.26 6.24 6.23
3.78 3.77 3.66 3.46 3.36
2.55
O
N
N
O
O
CTB-2NMe
1.05 1.10 1.05 1.09 1.08 1.04 1.05 0.95 1.10
6.13 3.06 2.05 2.92
3.00
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)


159.16
158.57
155.50
150.26
146.22
142.12
136.40
130.79
130.47
127.79
123.18
115.07
111.33
105.56
105.16
103.19
101.59
55.44
55.40
55.29
44.13
41.15
35.83
^{13}C NMR
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

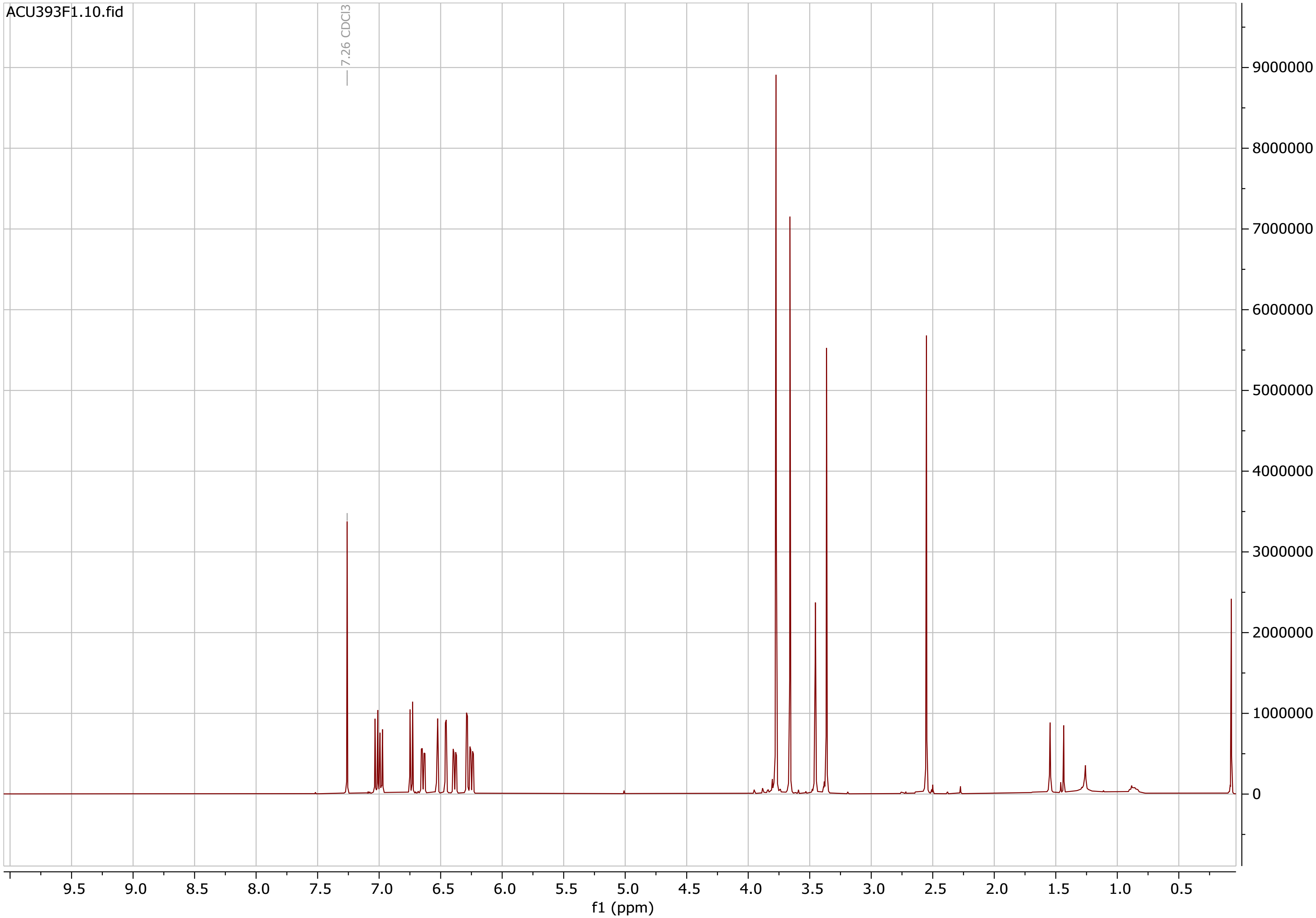
COSY HH


ACU393F1-2D.12.ser
f2 (ppm)
f1 (ppm)
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
0
1
2
3
4
5
6
7
8


HSQC
ACU393F1-2D.13.ser
f2 (ppm)
f1 (ppm)

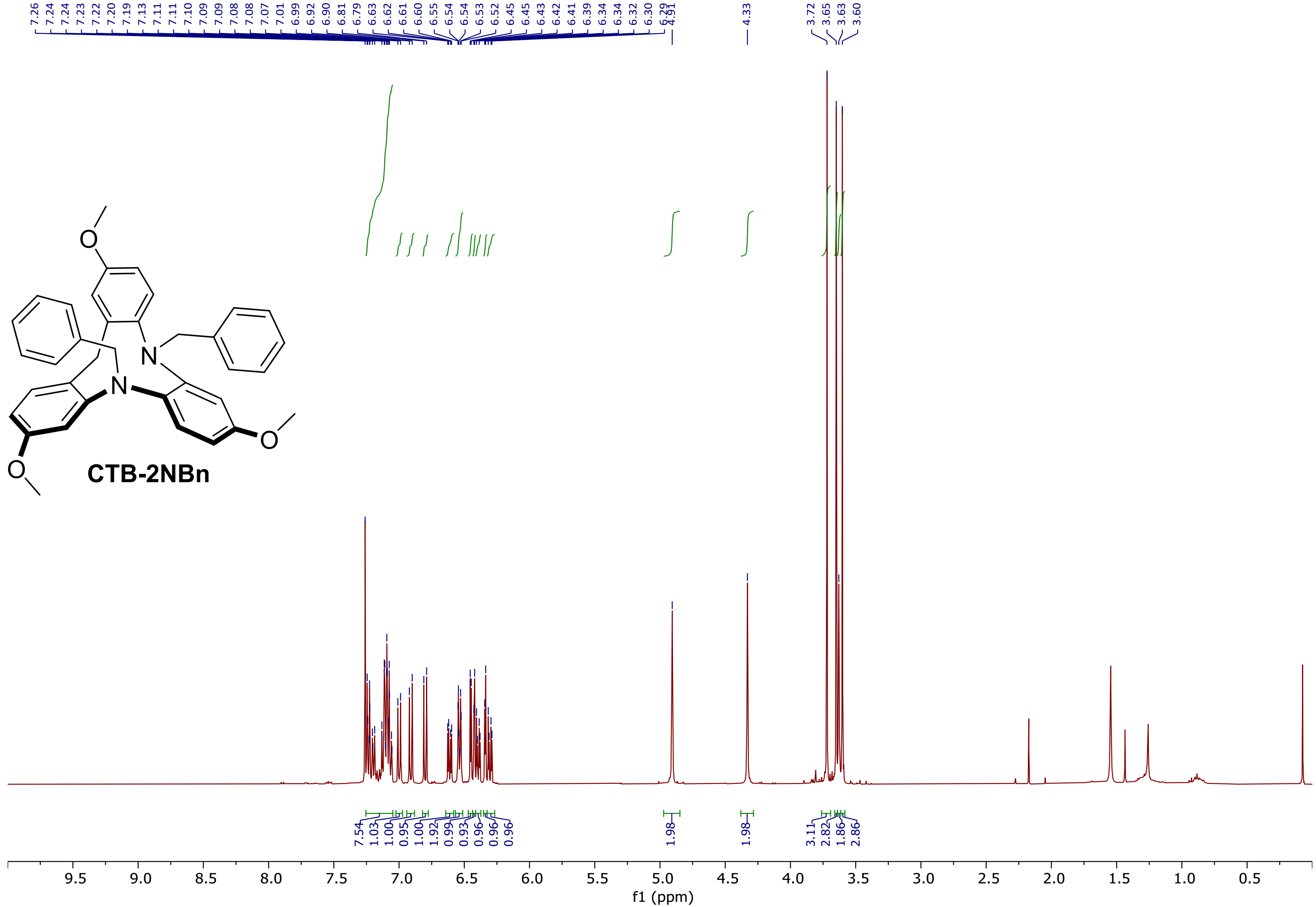

HMBC
ACU393F1-2D.14.ser
f2 (ppm)
f1 (ppm)

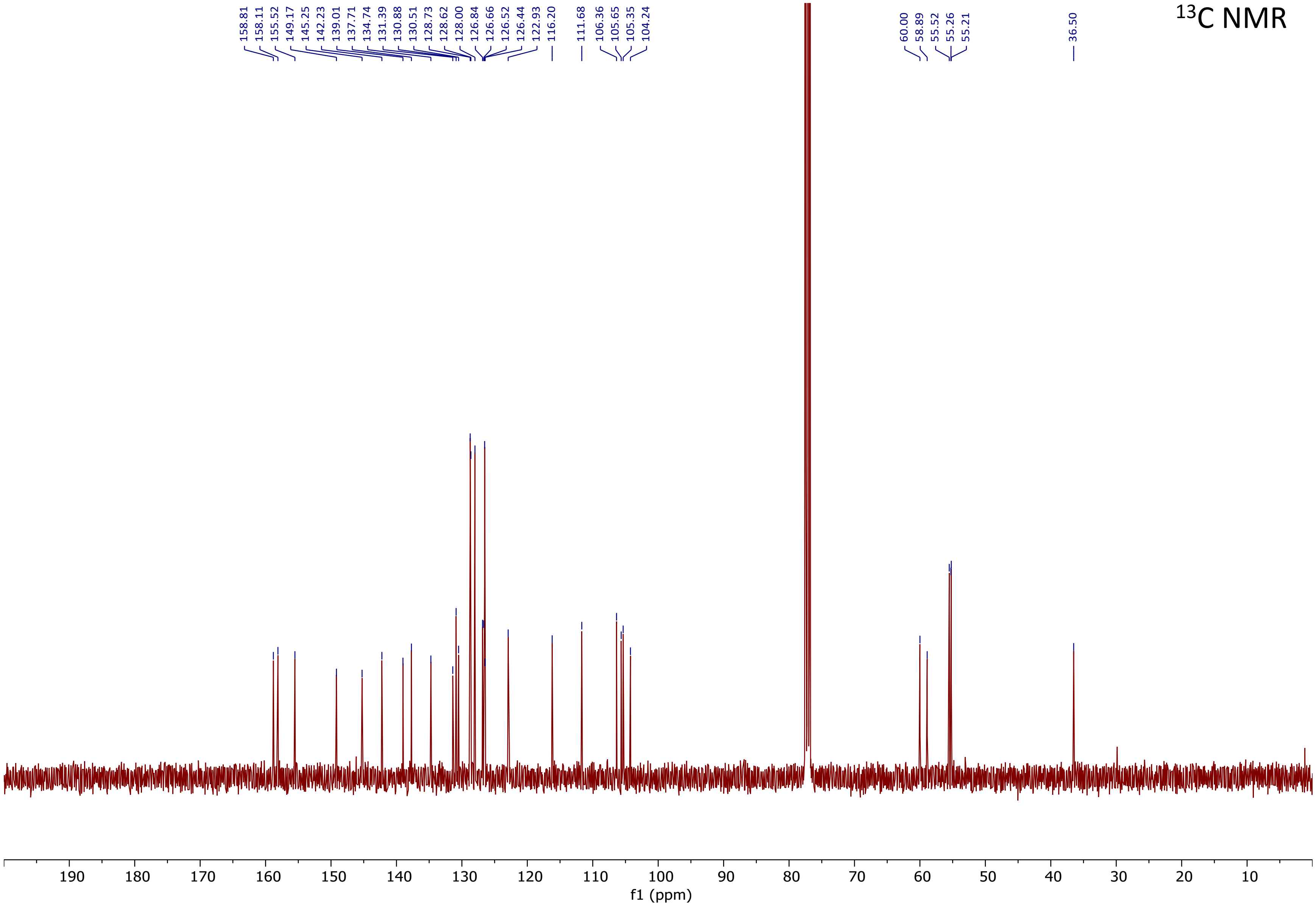
^1H NMR t_0 spectrum



3.10 CTB-2NBn

^{1}H NMR





13C NMR
158.81
158.11
155.52
149.17
145.25
142.23
139.01
137.71
134.74
131.39
130.88
130.51
128.73
128.62
128.00
126.84
126.66
126.52
126.44
122.93
116.20
111.68
106.36
105.65
105.35
104.24
60.00
58.89
55.52
55.26
55.21
36.50
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

COSY HH

ACU397-2D-2.12.ser
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
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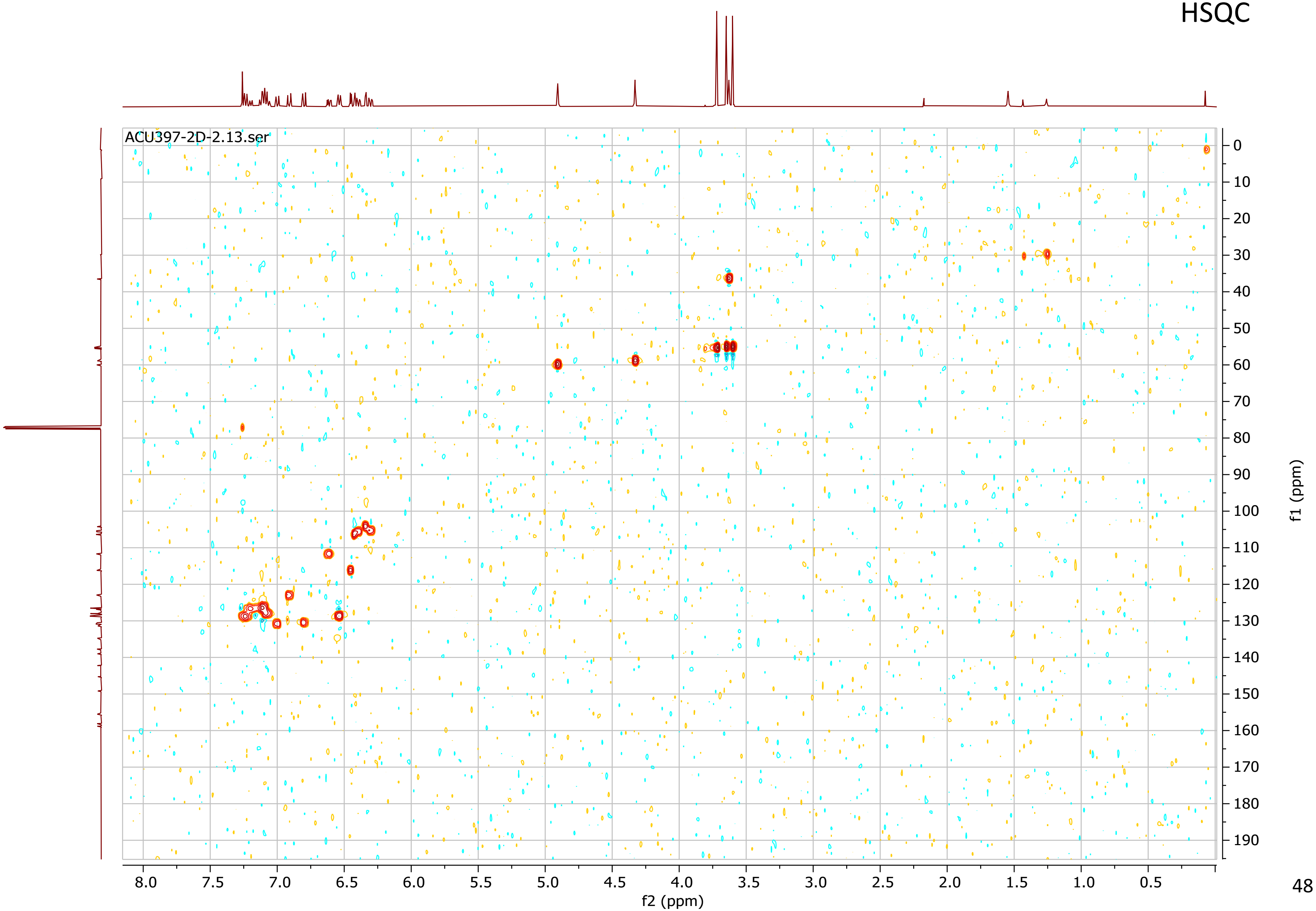
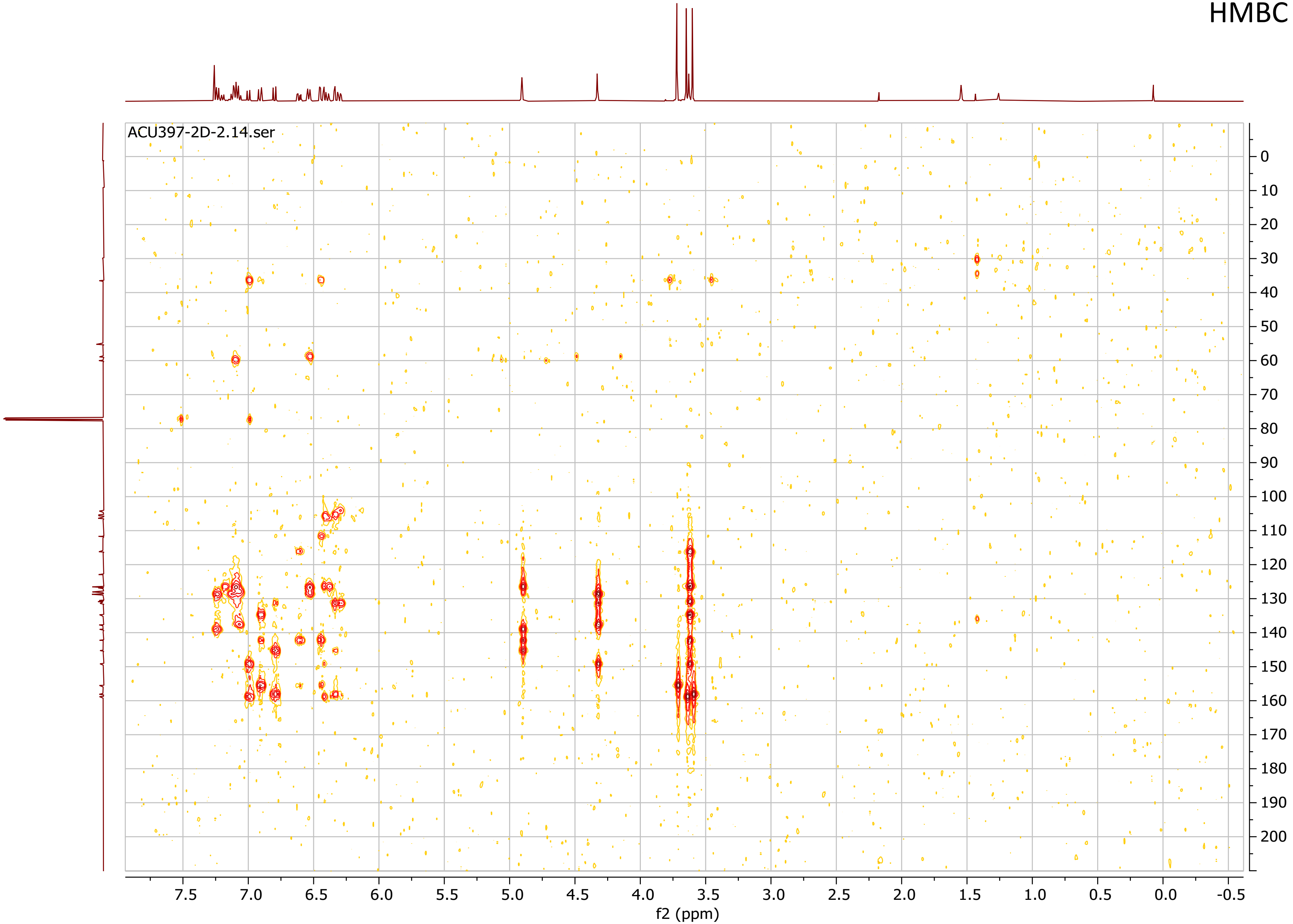
3.0
2.5
2.0
1.5
1.0
0.5
f2 (ppm)
f1 (ppm)

HSQC



HMBC



ACU397-2D-2.14.ser
f2 (ppm)
f1 (ppm)
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6.5
6.0
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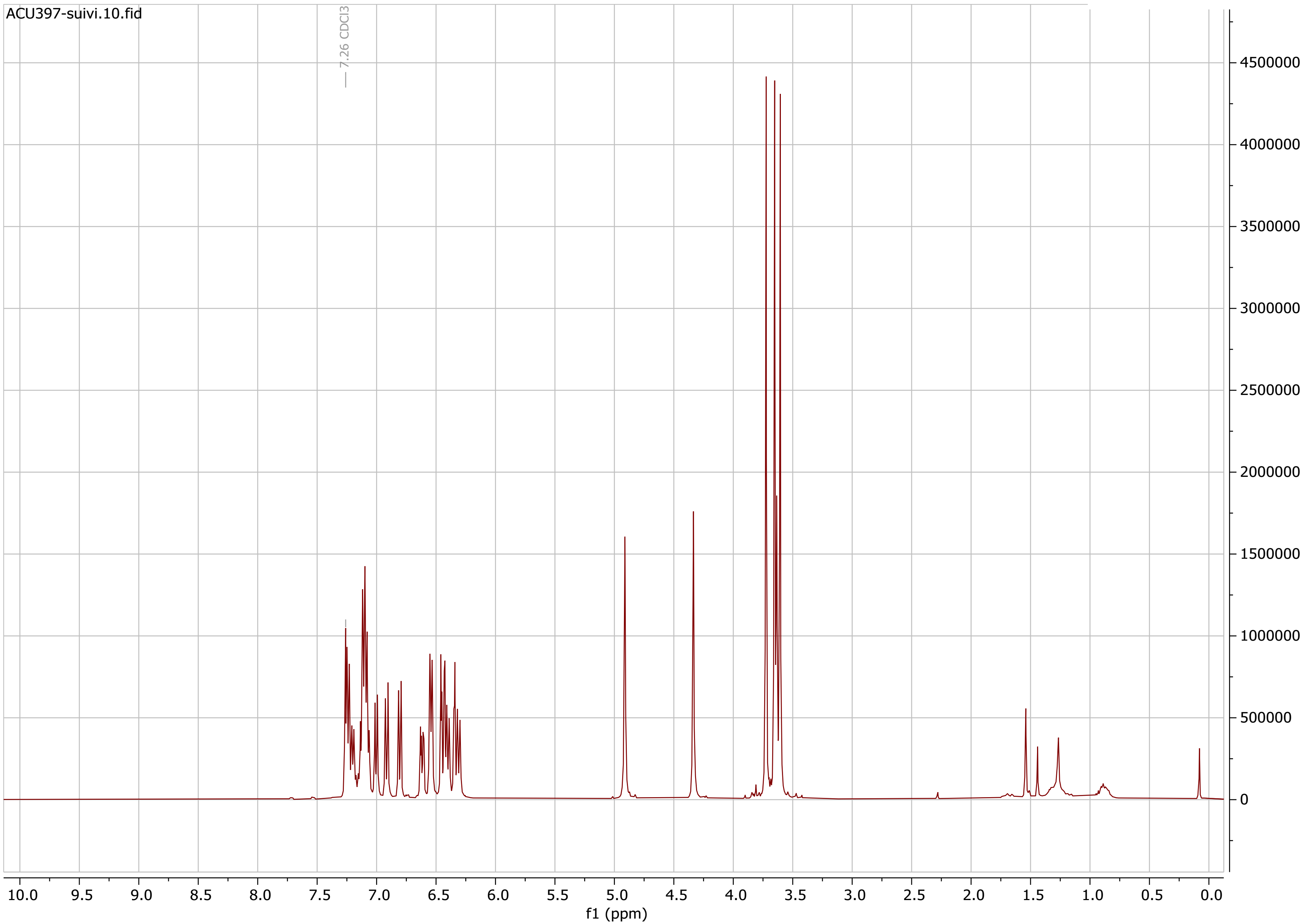
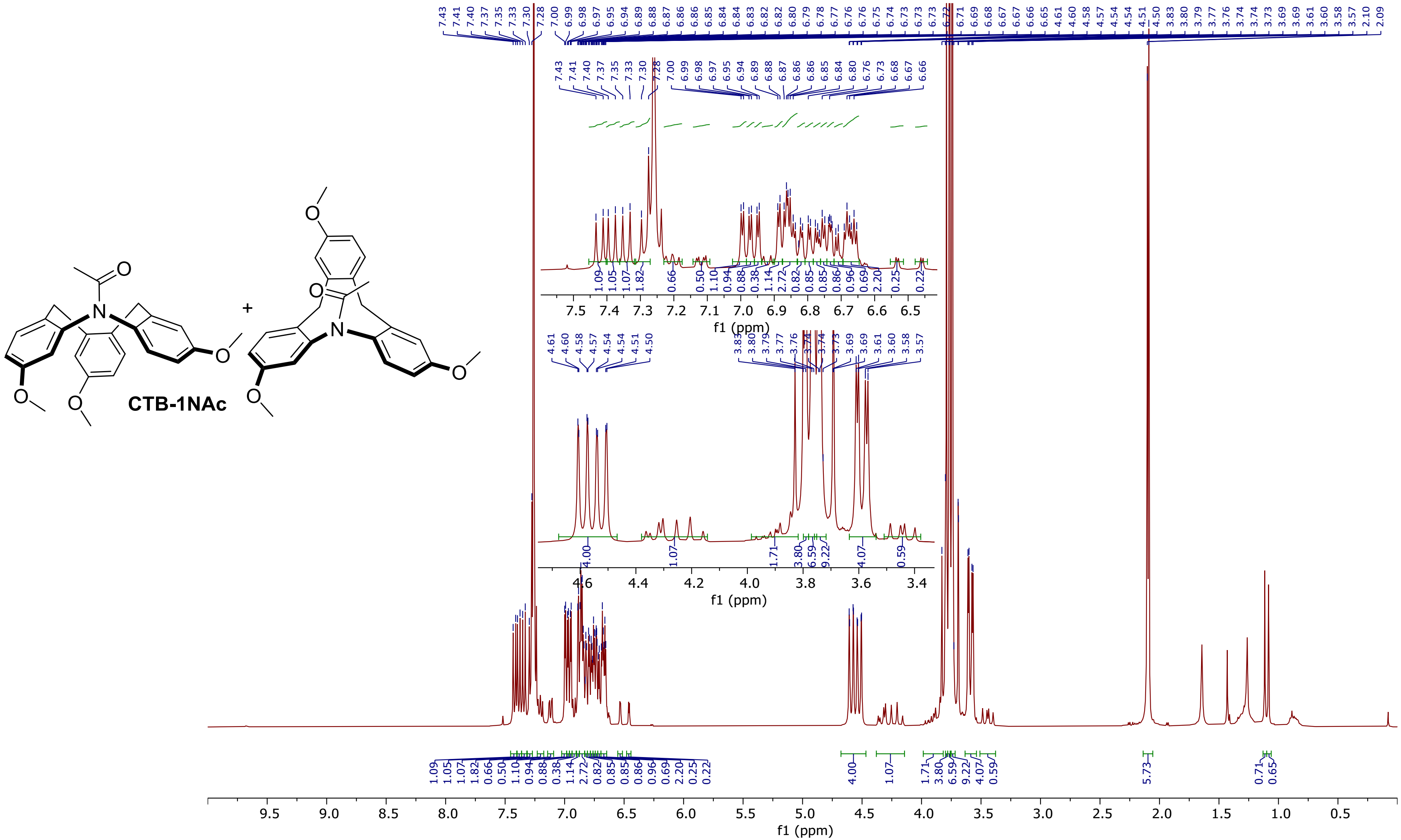
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200

^{1}H NMR t_0 spectrum

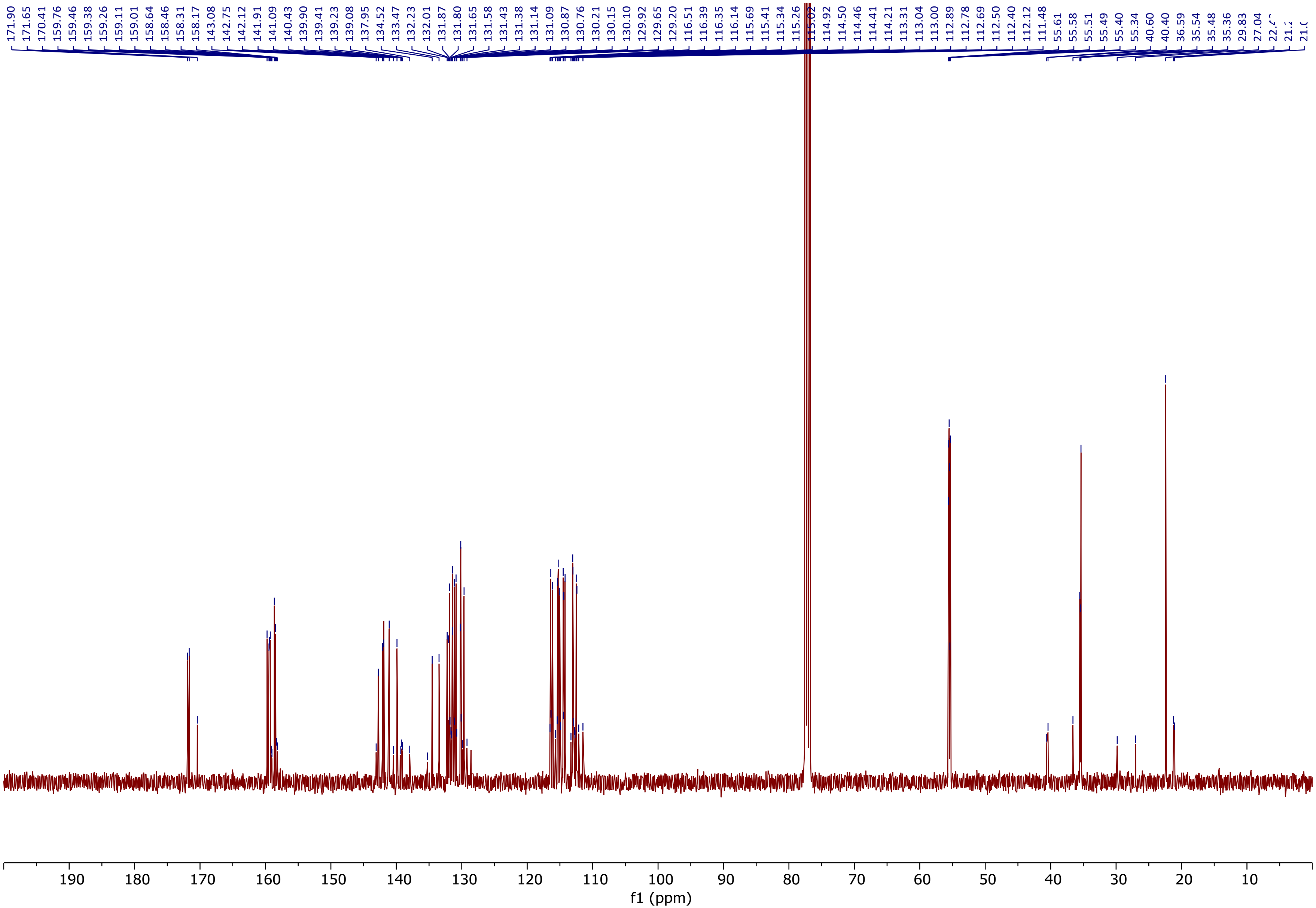


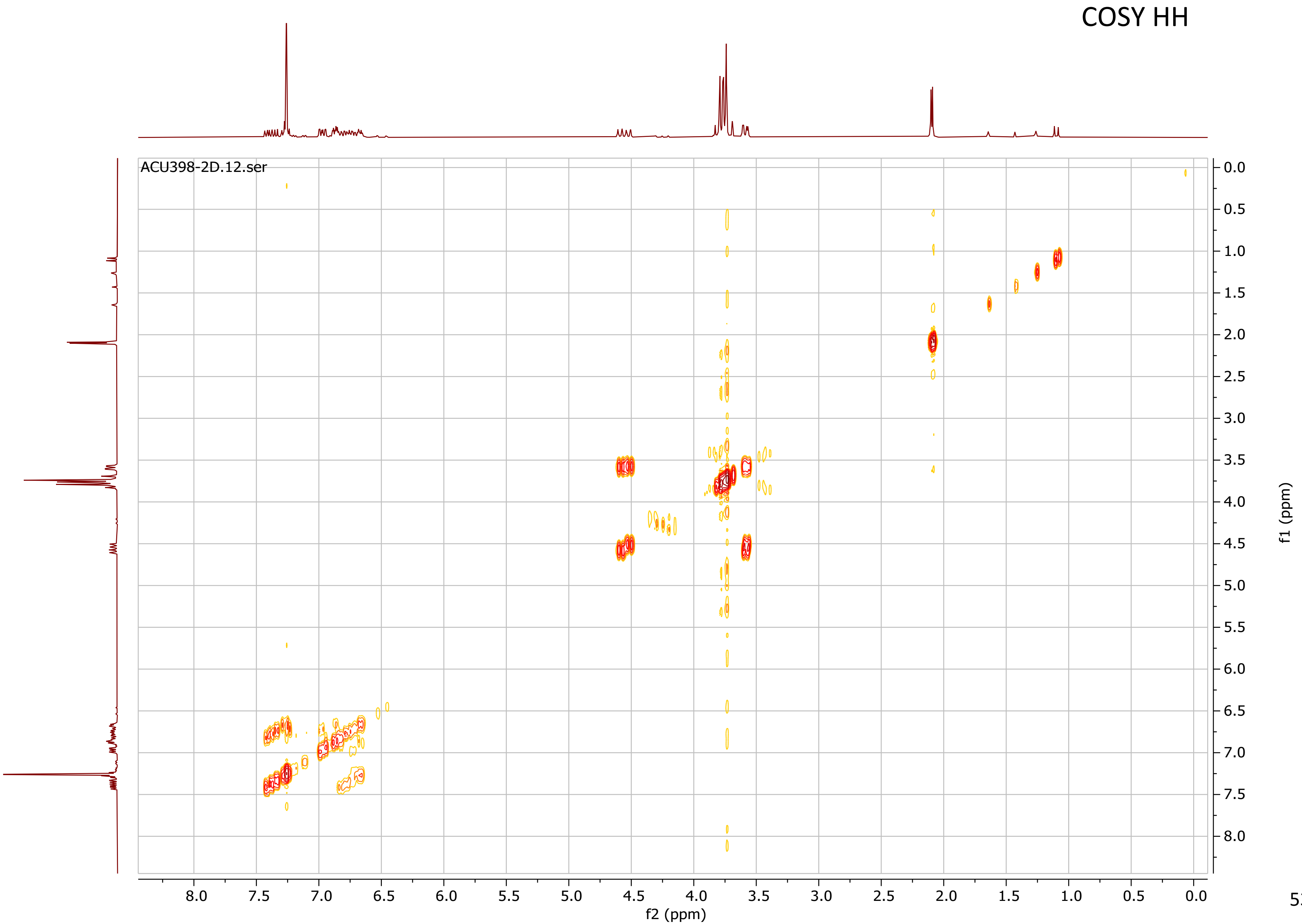
3.11 CTB-1NAc

^{1}H NMR

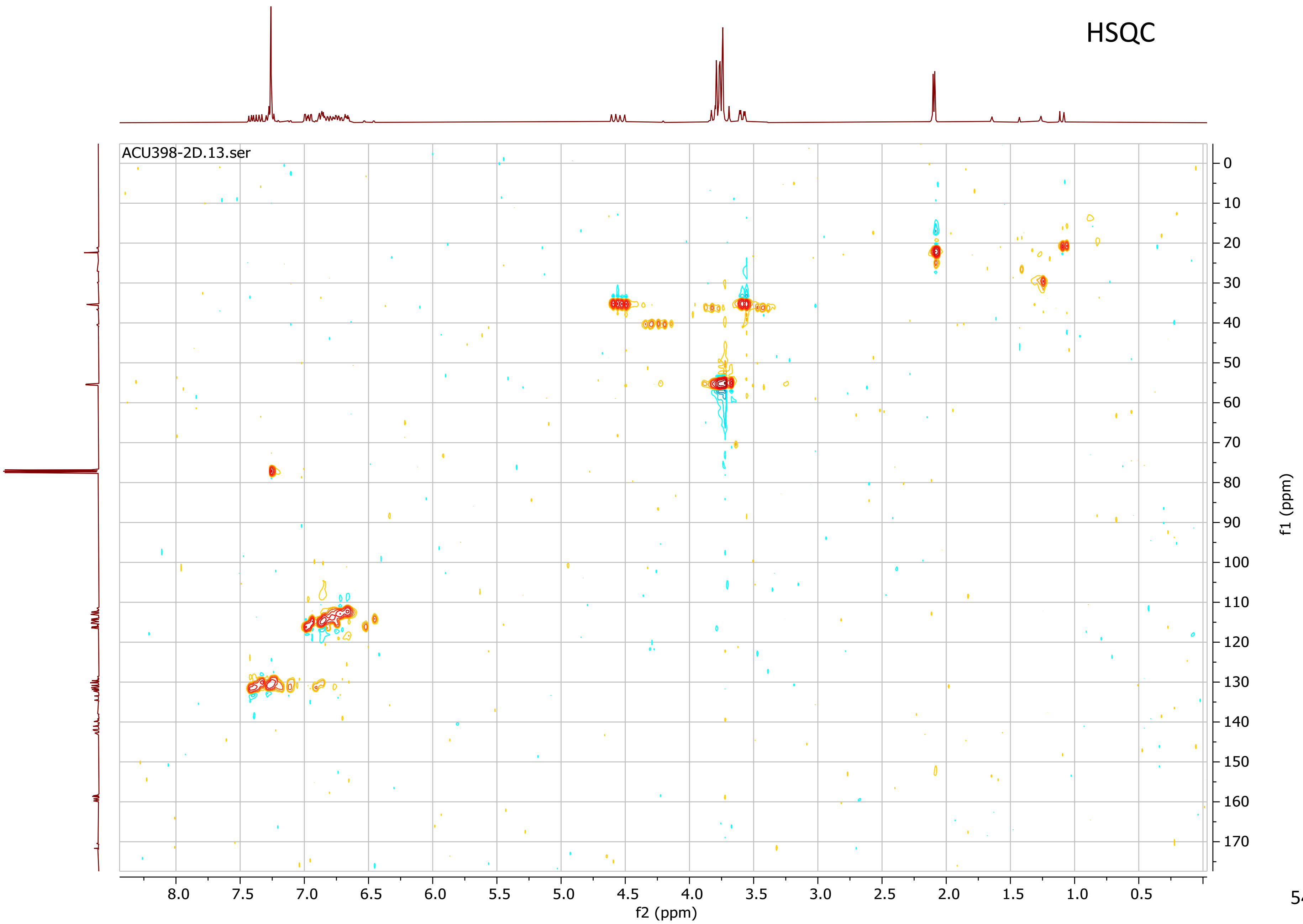


^{13}C NMR


171.90
171.65
170.41
159.76
159.46
159.38
159.26
159.11
159.01
158.64
158.46
158.31
158.17
143.08
142.75
142.12
141.91
141.09
140.43
139.90
139.41
139.23
139.08
137.95
134.52
133.47
132.23
132.01
131.87
131.80
131.65
131.58
131.43
131.38
131.14
131.09
130.87
130.76
130.21
130.15
130.10
129.92
129.65
129.20
116.51
116.39
116.35
116.14
115.69
115.41
115.34
115.26
115.02
114.92
114.50
114.46
114.41
114.21
113.31
113.04
113.00
112.89
112.78
112.69
112.50
112.40
112.12
111.48
55.61
55.58
55.51
55.49
55.40
55.34
40.60
40.40
36.59
35.54
35.48
35.36
29.83
27.04
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)


COSY HH
ACU398-2D.12.ser
f2 (ppm)
f1 (ppm)

HSQC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f2 (ppm)
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60
70
80
90
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130
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150
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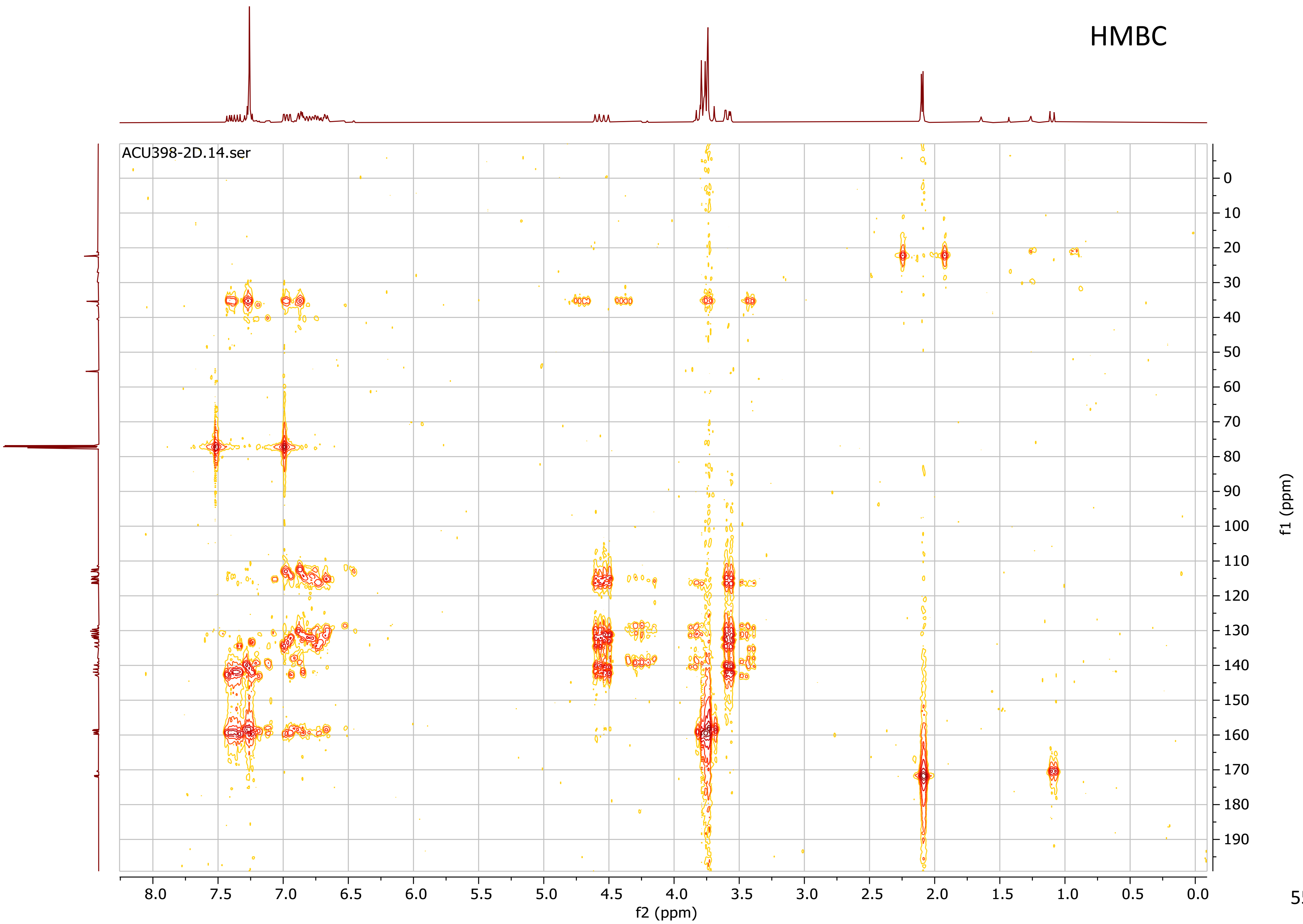
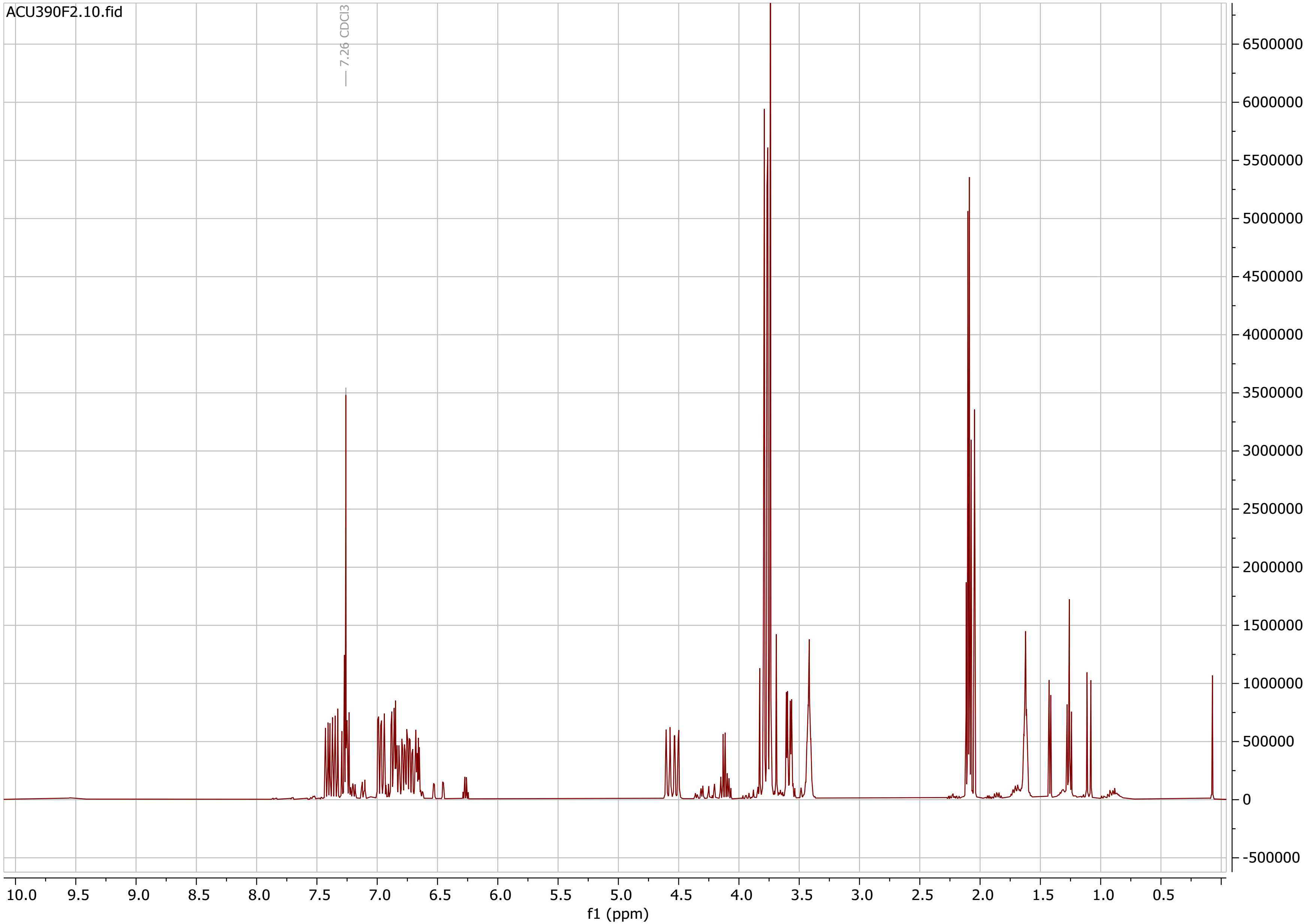
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5

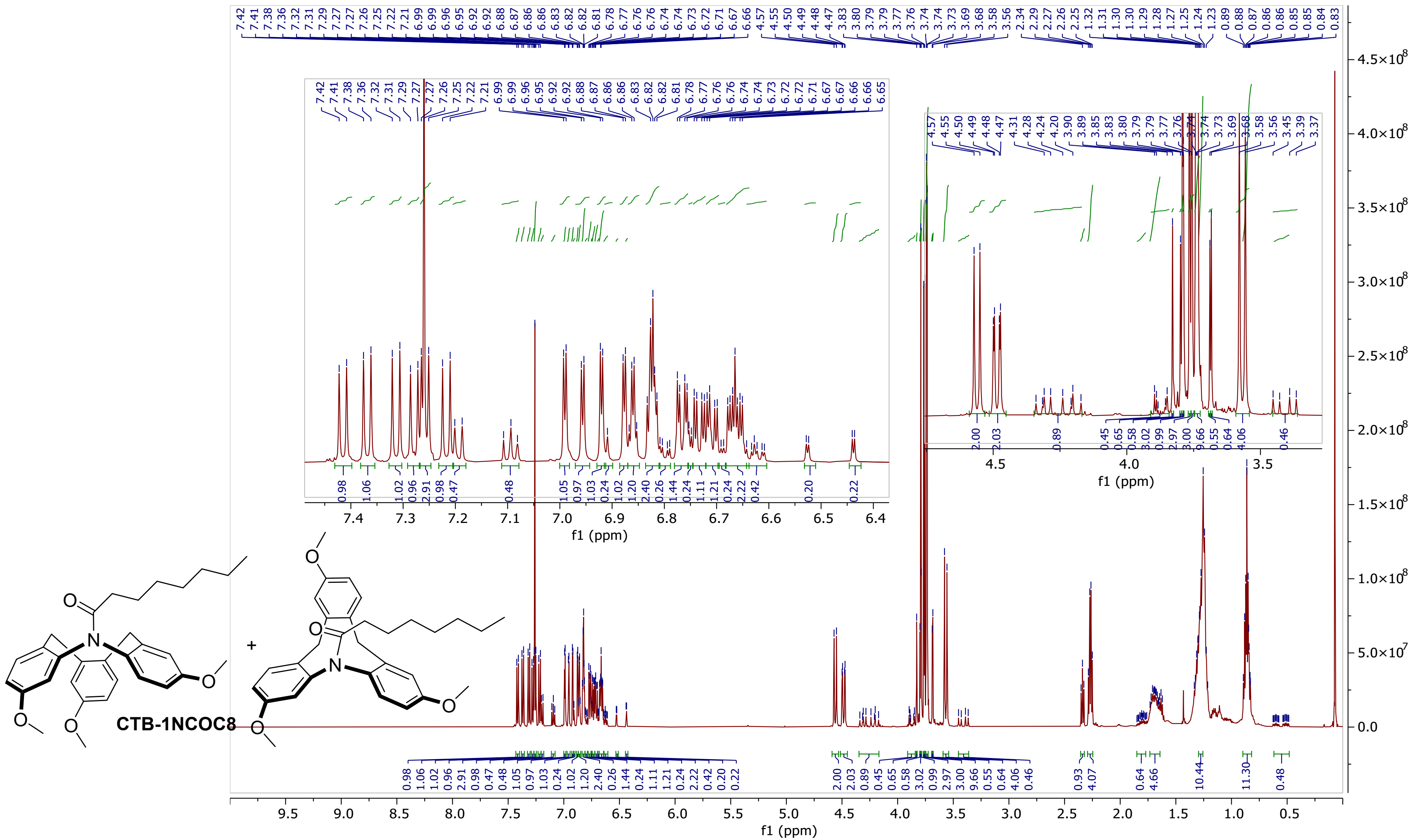

HMBC
ACU398-2D.14.ser
f2 (ppm)
f1 (ppm)

^{1}H NMR t_0 spectrum

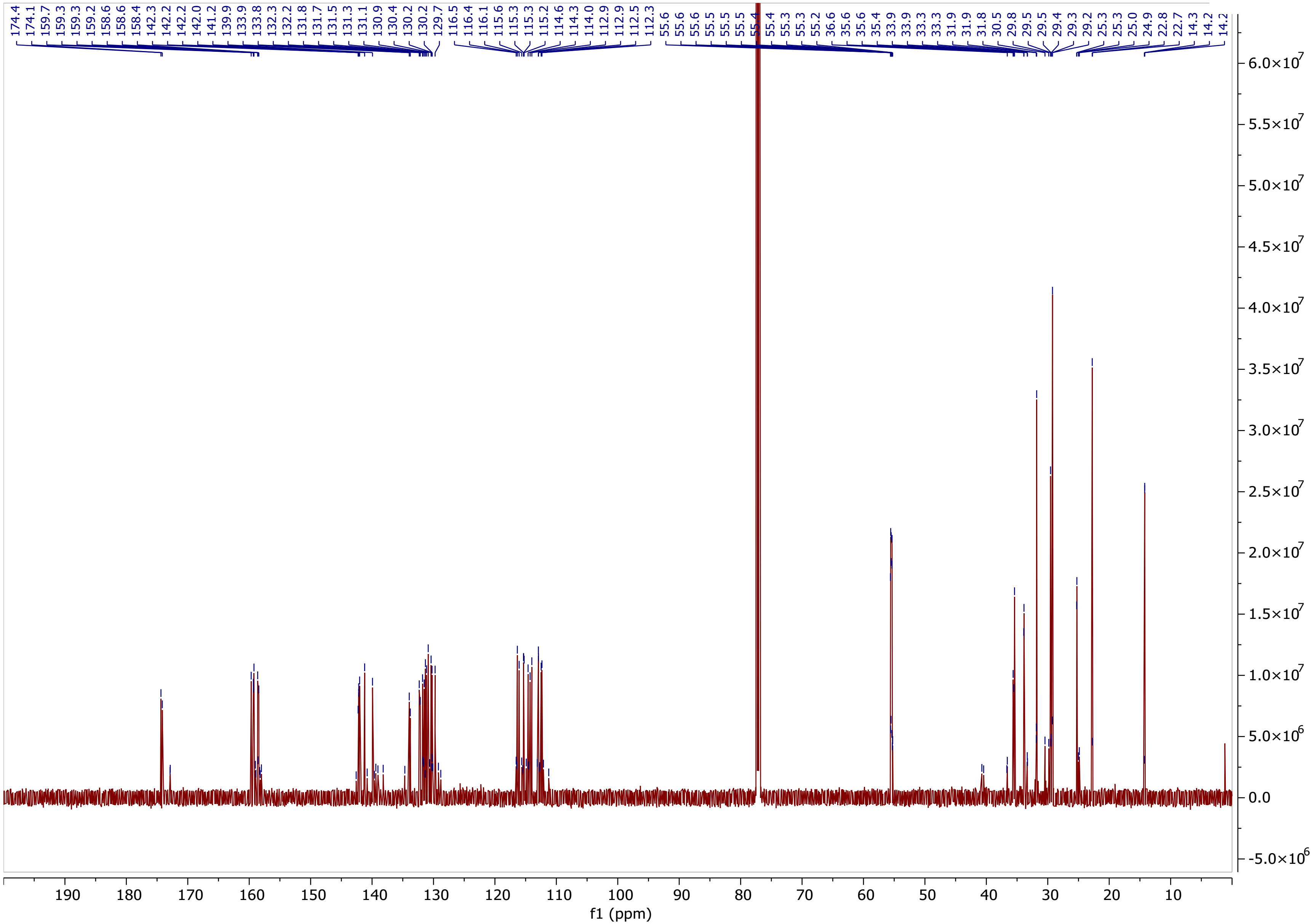


3.12 CTB-1NCOC8

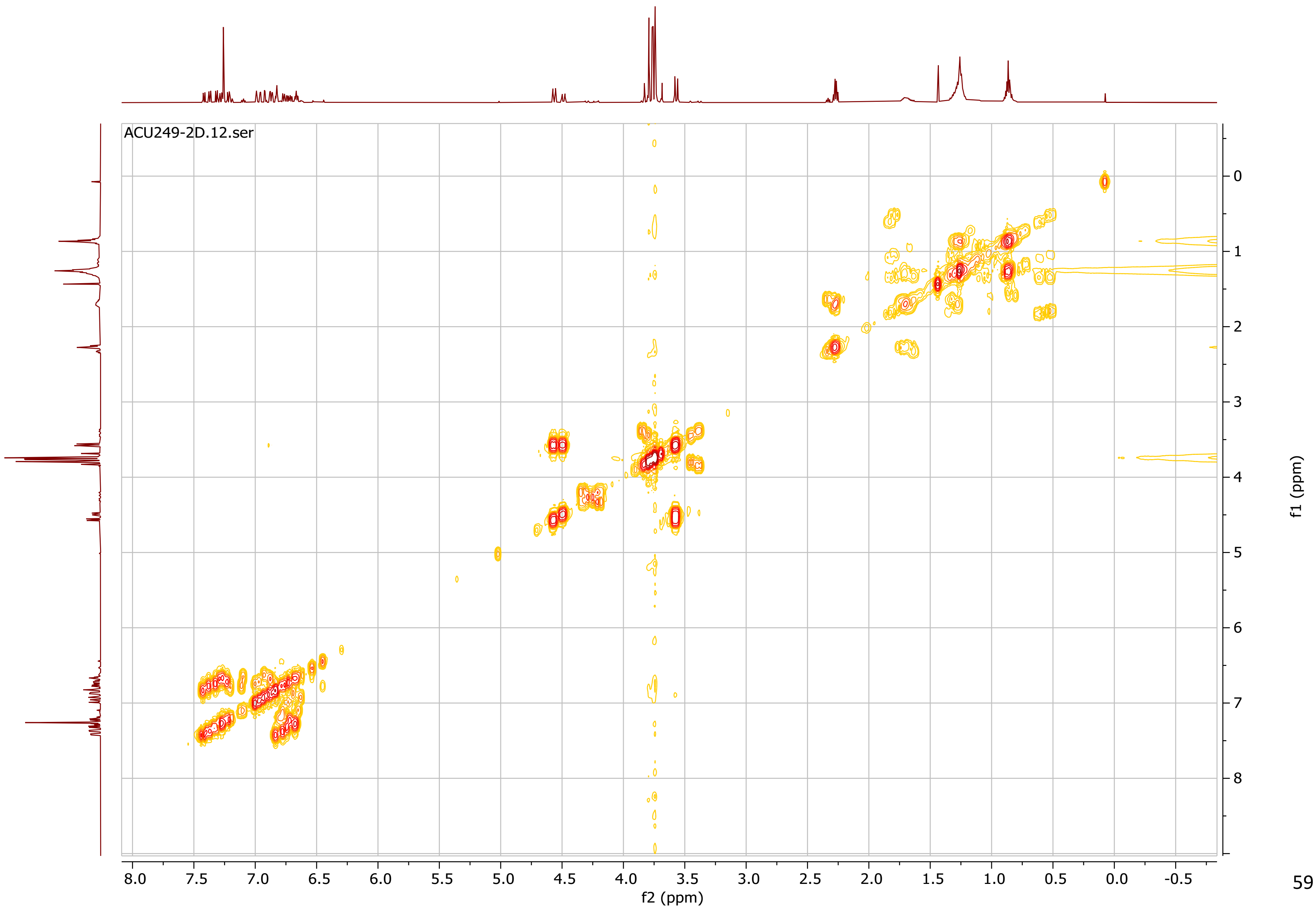
^{1}H NMR



^{13}C NMR



COSY HH


ACU249-2D.12.ser
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f1 (ppm)
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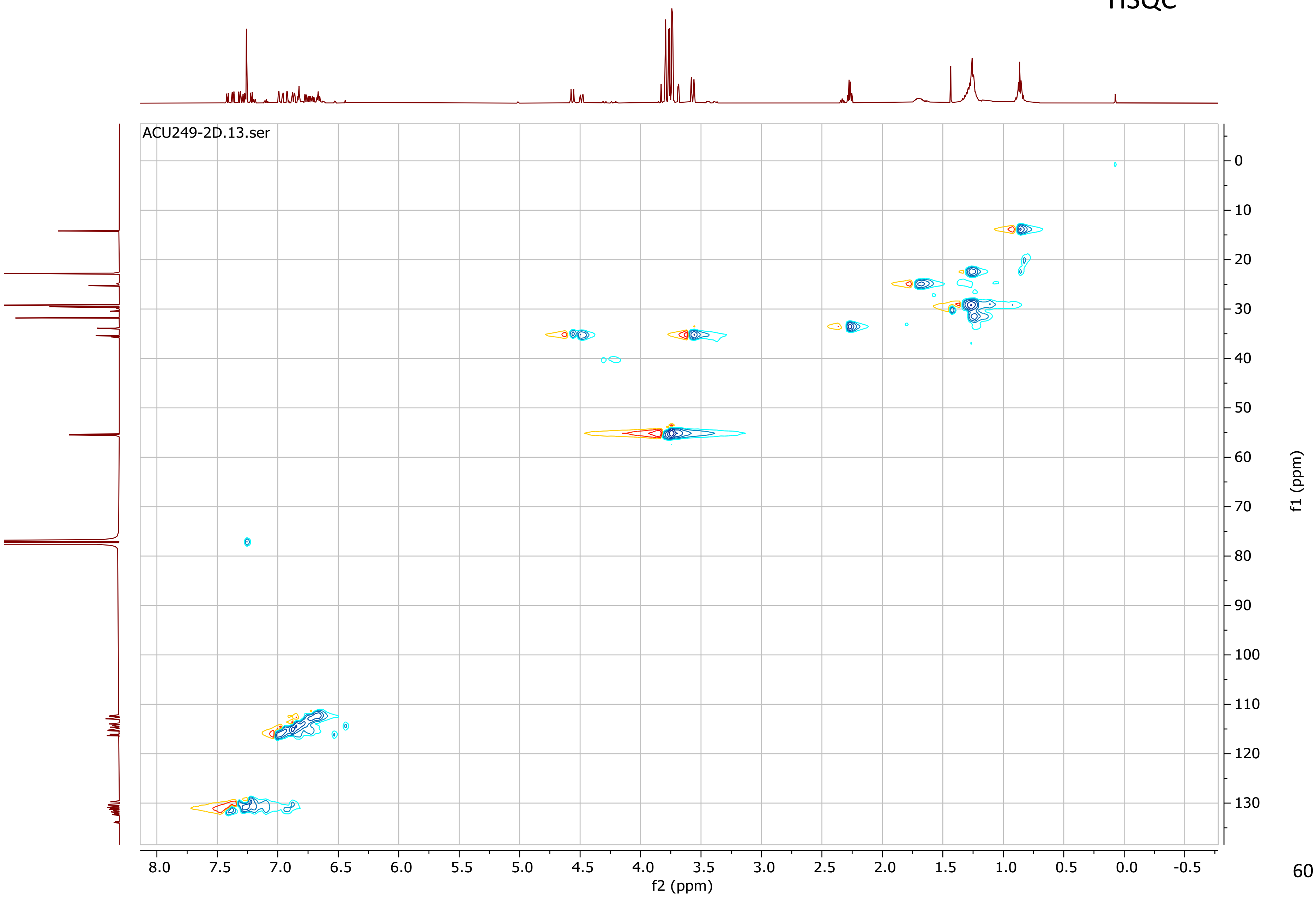
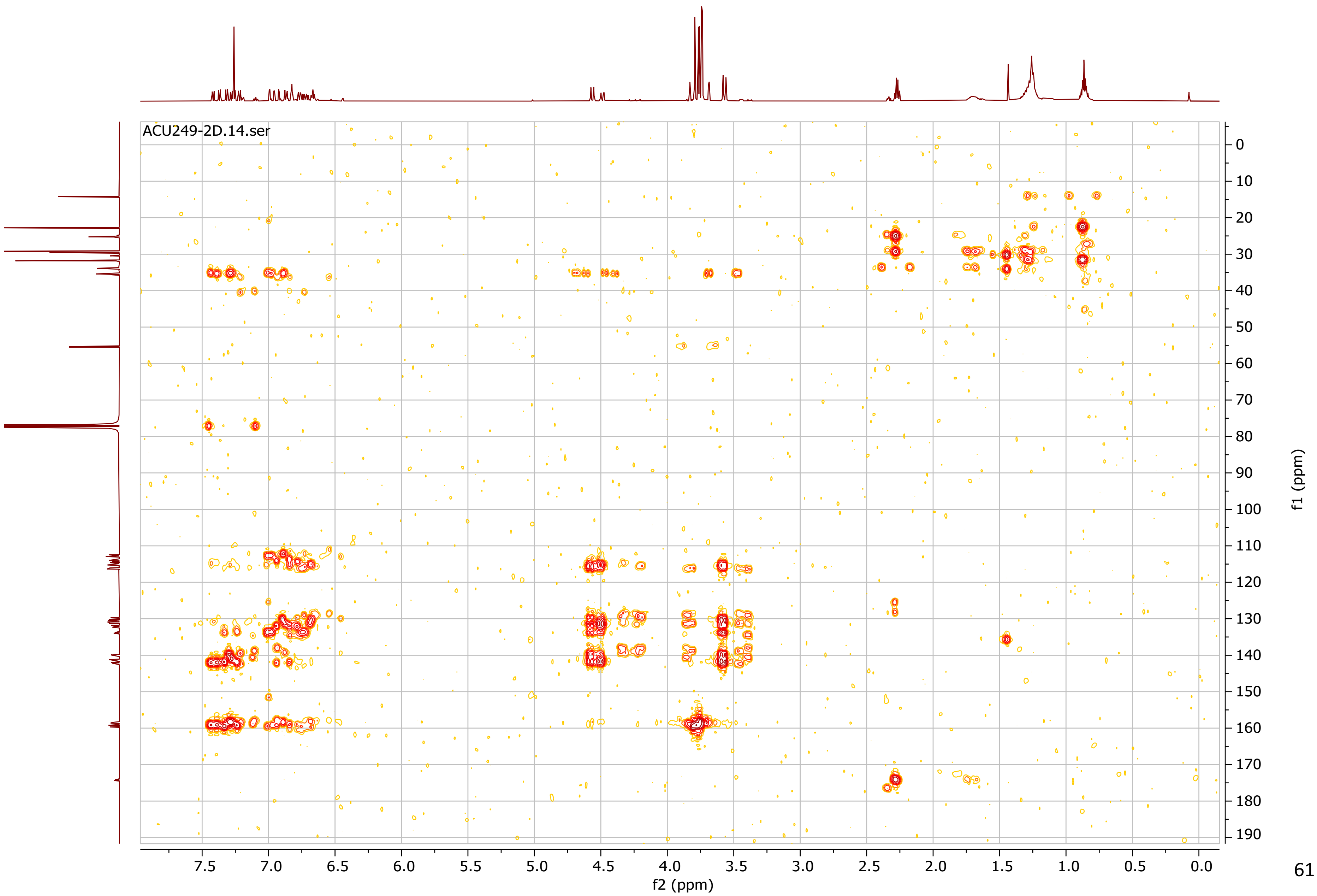
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
0
1
2
3
4
5
6
7
8

HSQC

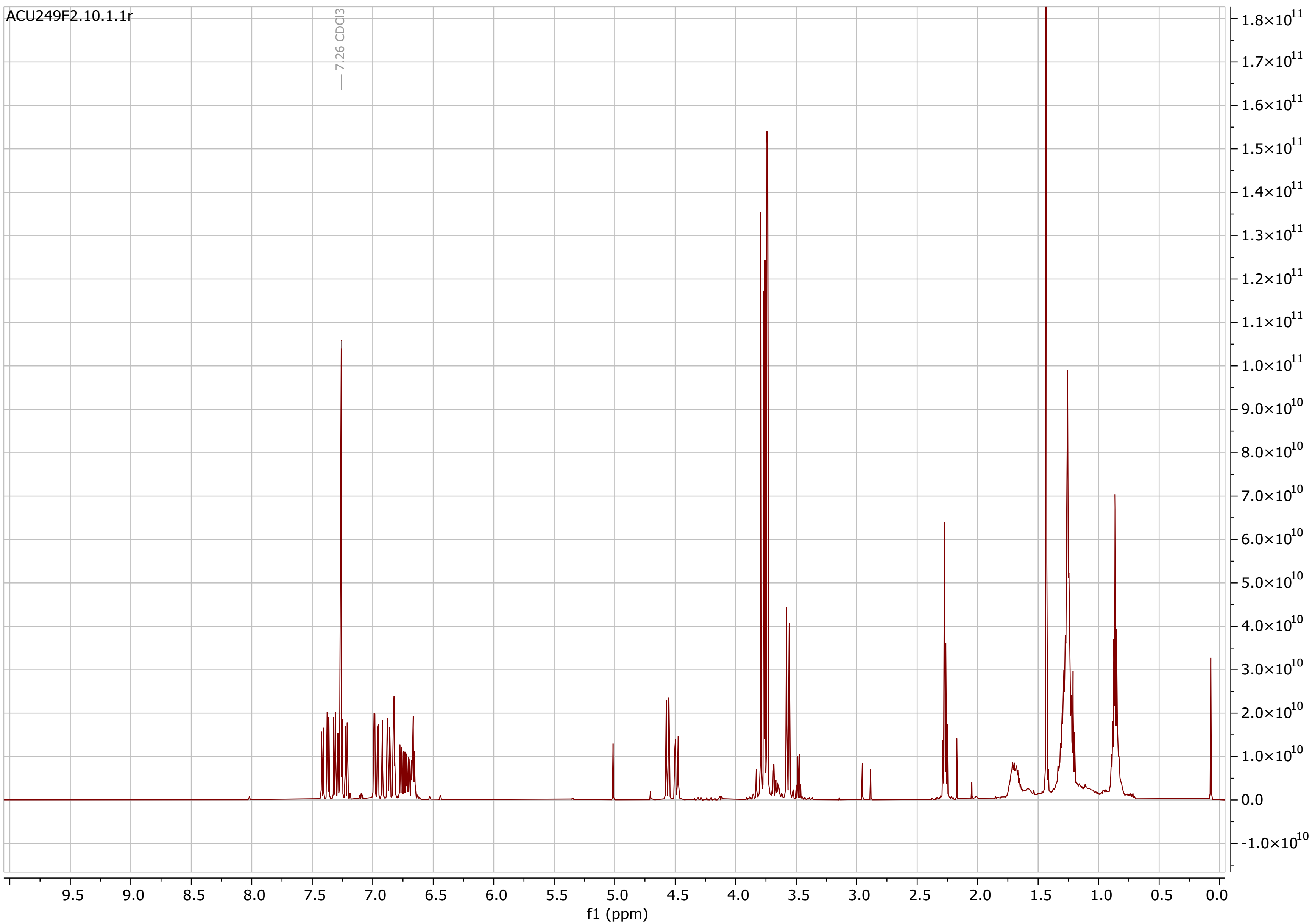


HMBC



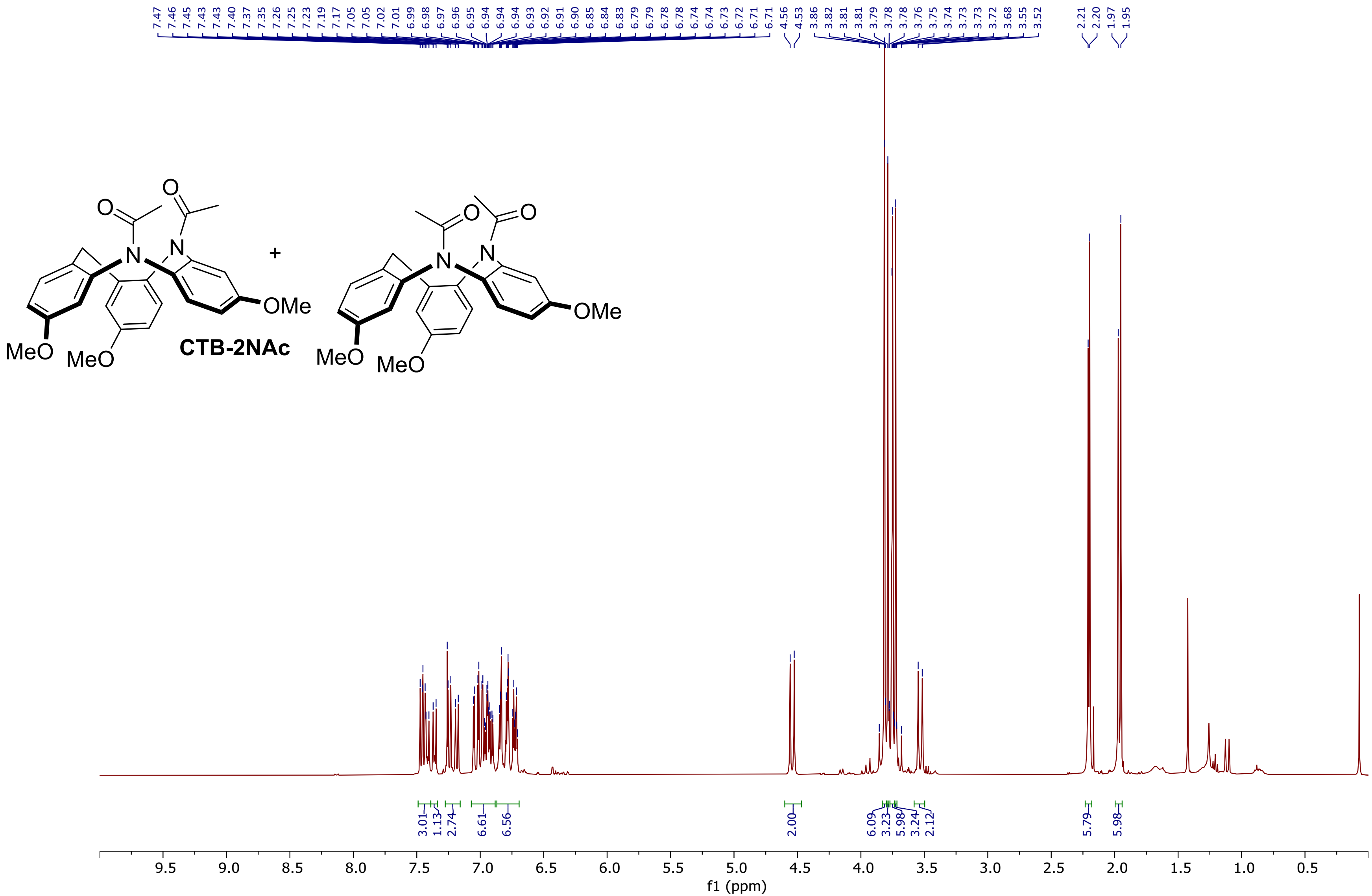
ACU249-2D.14.ser
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f2 (ppm)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
f1 (ppm)

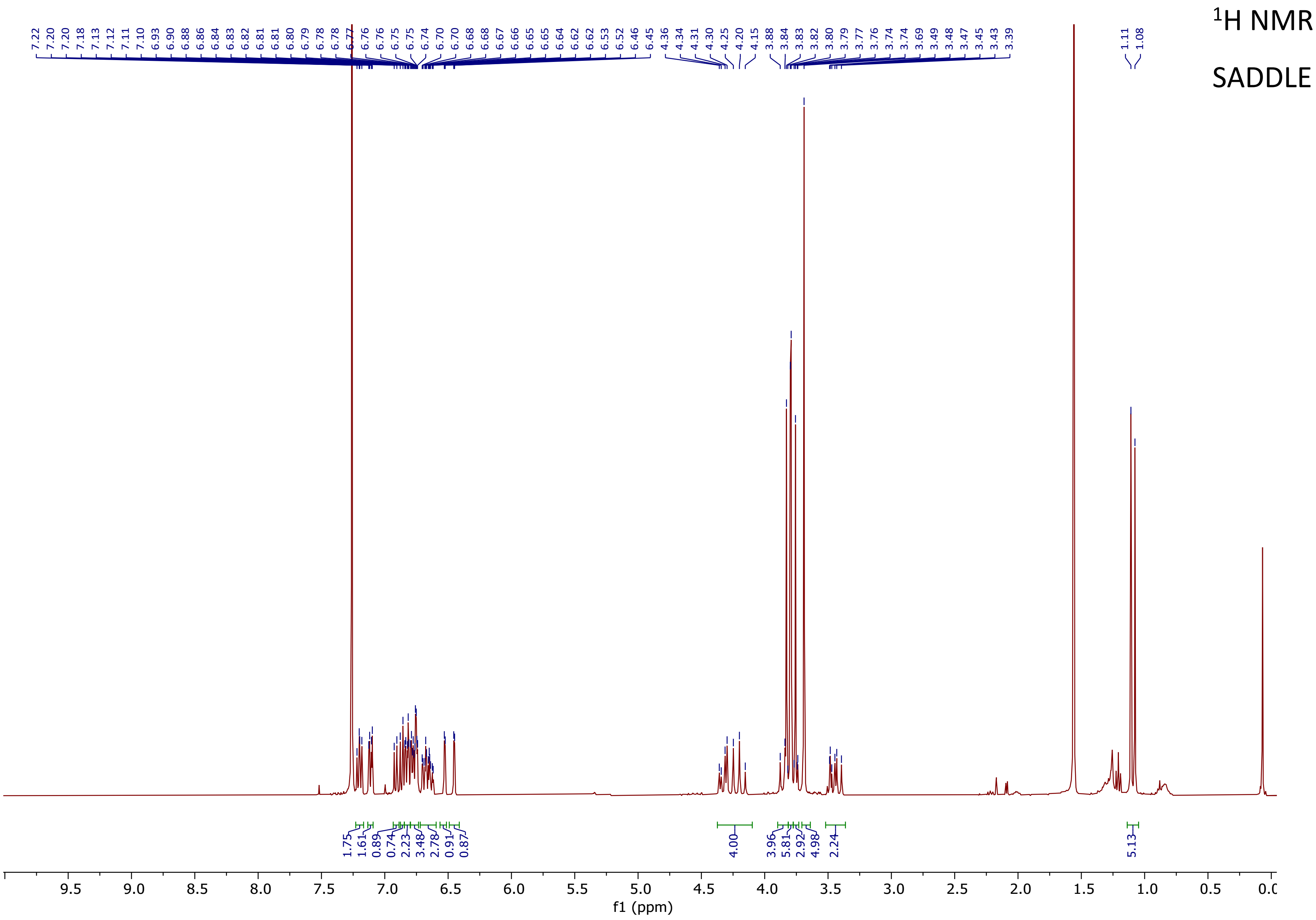
^1H NMR t_0 spectrum



^{1}H NMR

3.13 CTB-2NAc

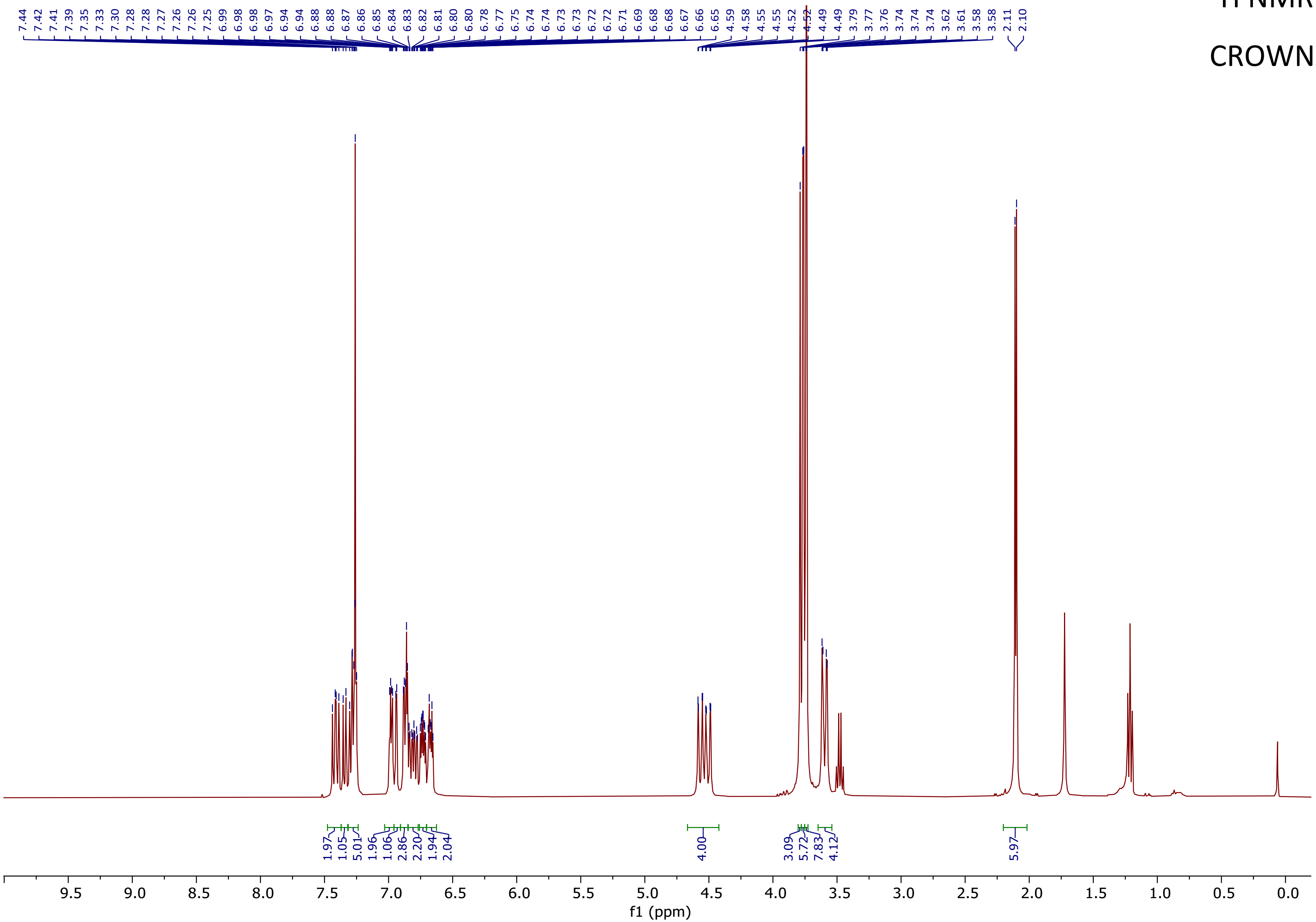




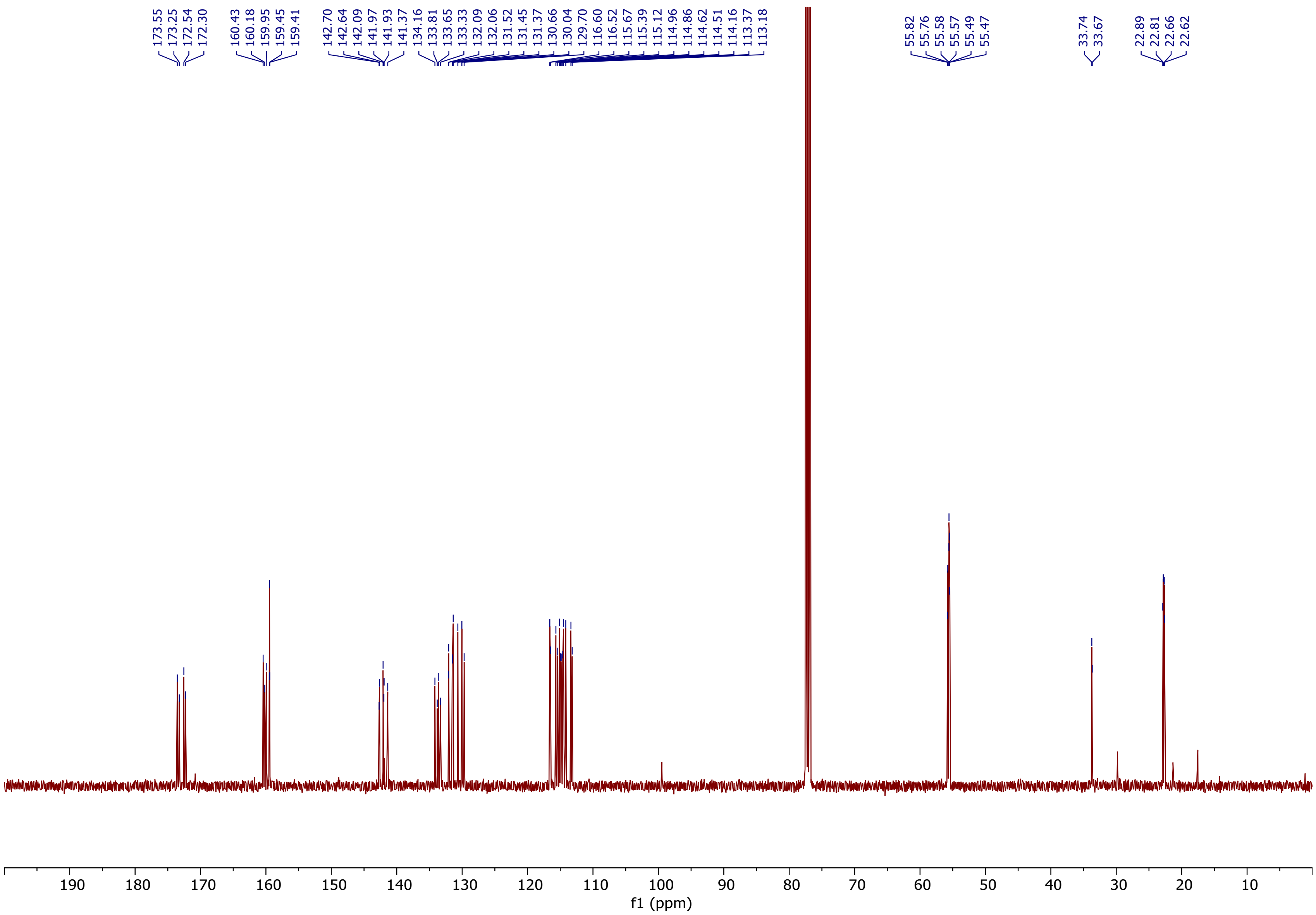
1H NMR
SADDLE
f1 (ppm)

^{1}H NMR

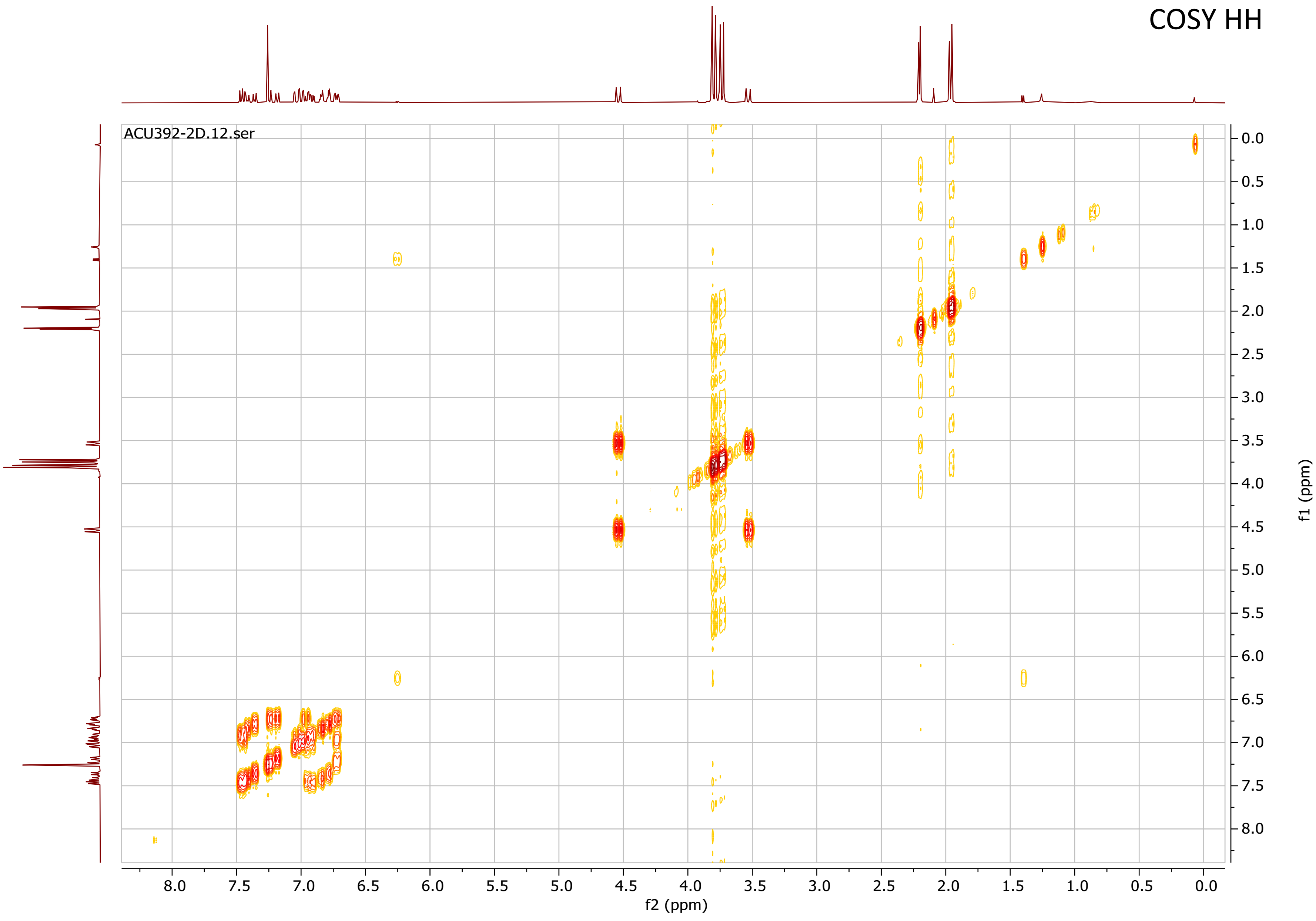
CROWN



^{13}C NMR



173.55
173.25
172.54
172.30
160.43
160.18
159.95
159.45
159.41
142.70
142.64
142.09
141.97
141.93
141.37
134.16
133.81
133.65
133.33
132.09
132.06
131.52
131.45
131.37
130.66
130.04
129.70
116.60
116.52
115.67
115.39
115.12
114.96
114.86
114.62
114.51
114.16
113.37
113.18
55.82
55.76
55.58
55.57
55.49
55.47
33.74
33.67
22.89
22.81
22.66
22.62
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)


COSY HH
ACU392-2D.12.ser
f2 (ppm)
f1 (ppm)
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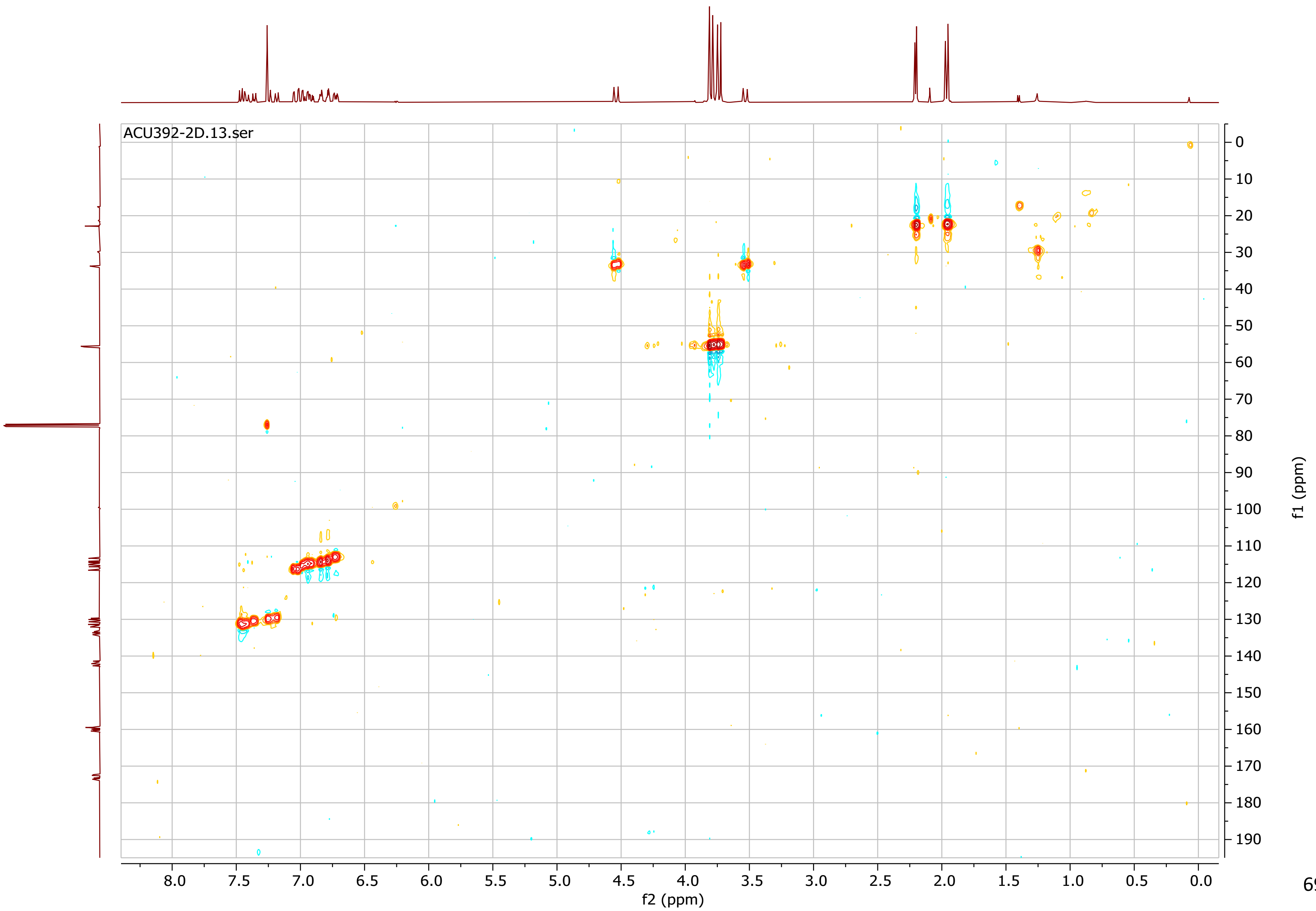
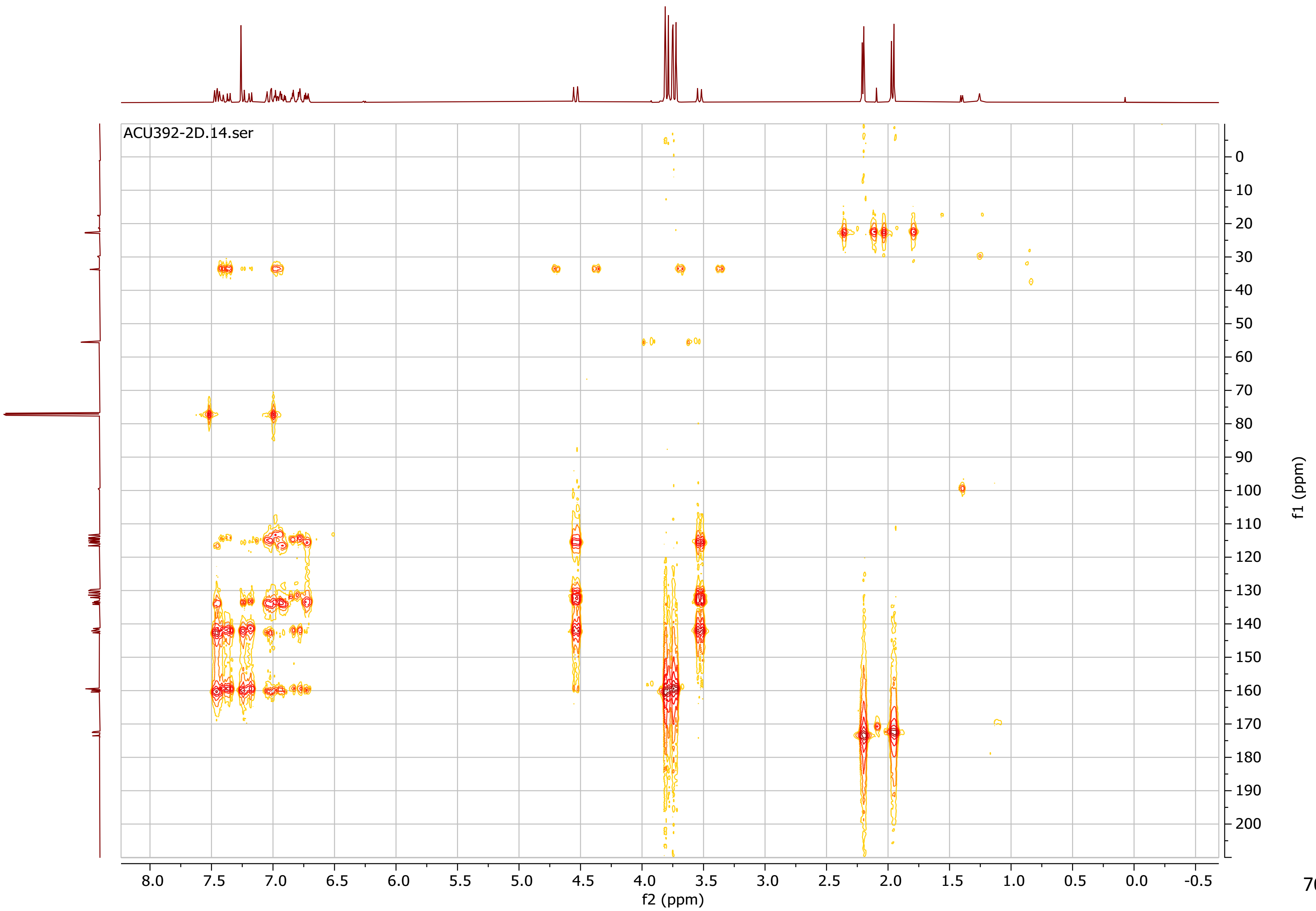
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0

HSQC



HMBC


ACU392-2D.14.ser
f2 (ppm)
f1 (ppm)
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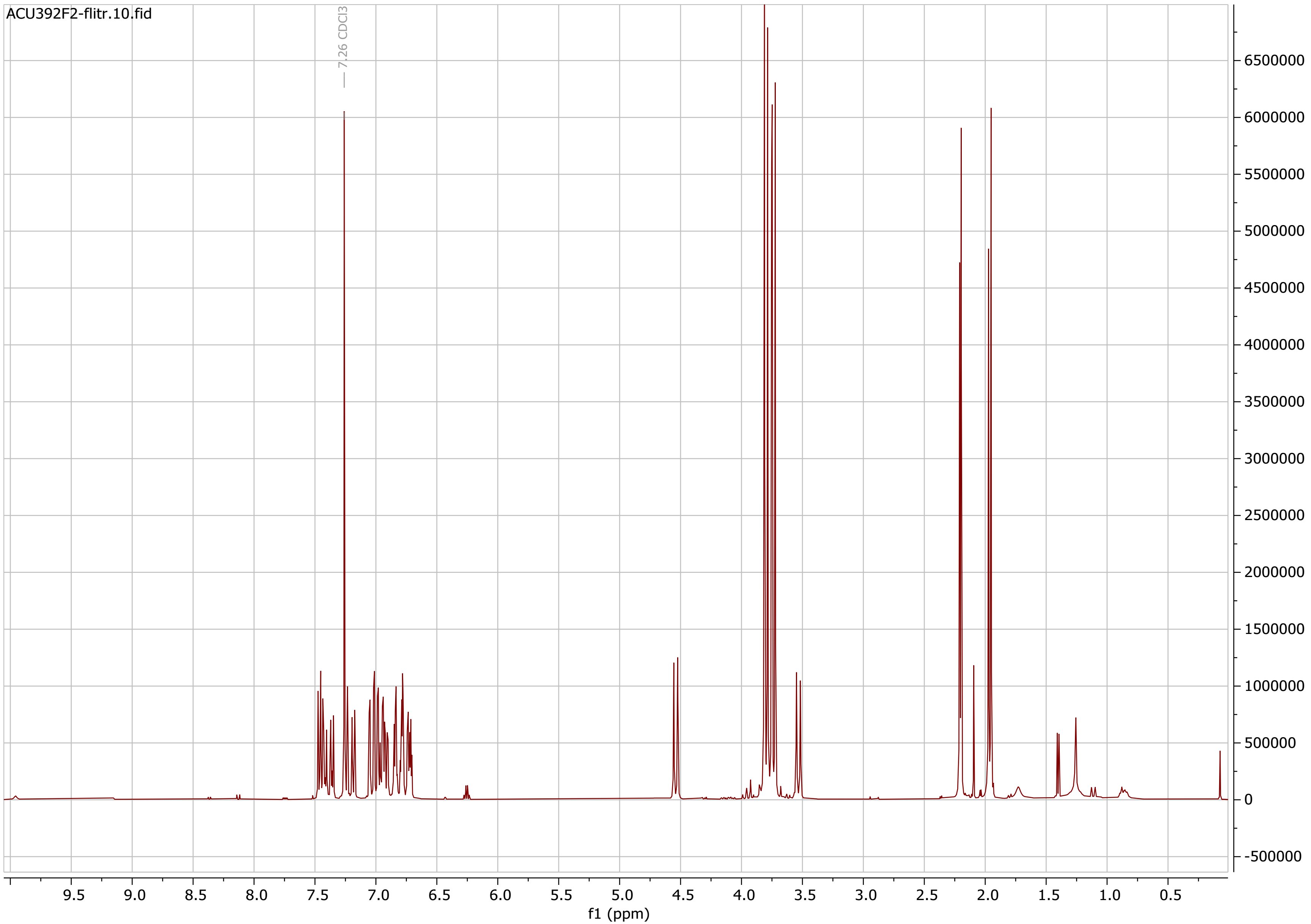
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200

^{1}H NMR t_0 spectrum



4 NMR studies

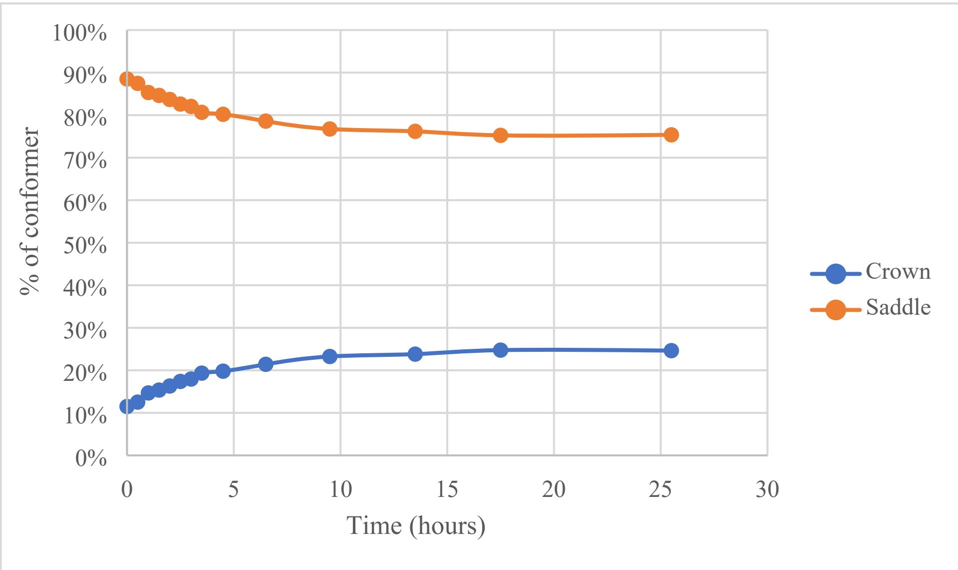
Procedure for CTB-1NMe and CTB-1NBn

The saddle conformer of each compound has been purified and solubilized in $CDCl_3$ (C = 10 mg/0.5 mL). A ^{1}H NMR spectra was recorded over 80 (CTB-1NMe) and 95 hours (CTB-1NBn). The ratio of crown/saddle conformers was extracted from these spectra, and reported in a graph.

CTB-1NMe

Time (h)	Ratio	
	Saddle	Crown
0	89%	11%
0.5	87%	13%
1	85%	15%
1.5	85%	15%
2	84%	16%
2.5	83%	17%
3	82%	18%
3.5	81%	19%
4.5	80%	20%
6.5	79%	21%
9.5	77%	23%
13.5	76%	24%
17.5	75%	25%
25.5	75%	25%
28.5	75%	25%
32.5	75%	25%
56.5	75%	25%
80.5	75%	25%

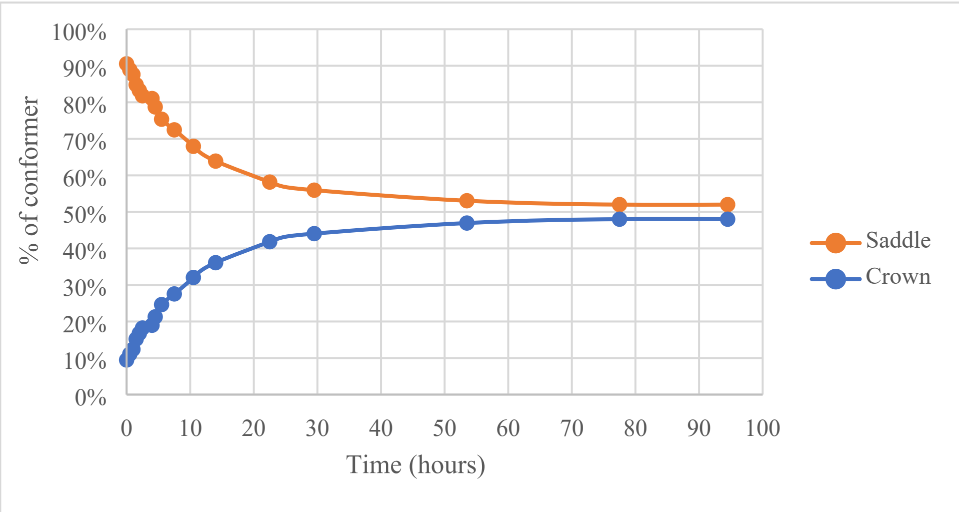
The percentages of the saddle and crown conformers were determined by integrating the crown signal at 7.54 (d, *J* = 8.8 Hz, H11) ppm and and the saddle signal at 6.77 (dd, *J* = 8.7, 3.0 Hz, H12’) ppm.



CTB-1NBn

Time (h)	Ratio	
	Saddle	Crown
0	91%	9%
0.5	89%	11%
1	88%	12%
1.5	85%	15%
2	83%	17%
2.5	82%	18%
4	81%	19%
4.5	79%	21%
5.5	75%	25%
7.5	72%	28%
10.5	68%	32%
14	64%	36%
22.5	58%	42%
29.5	56%	44%
53.5	53%	46%
77.5	52%	48%
94.5	52%	48%

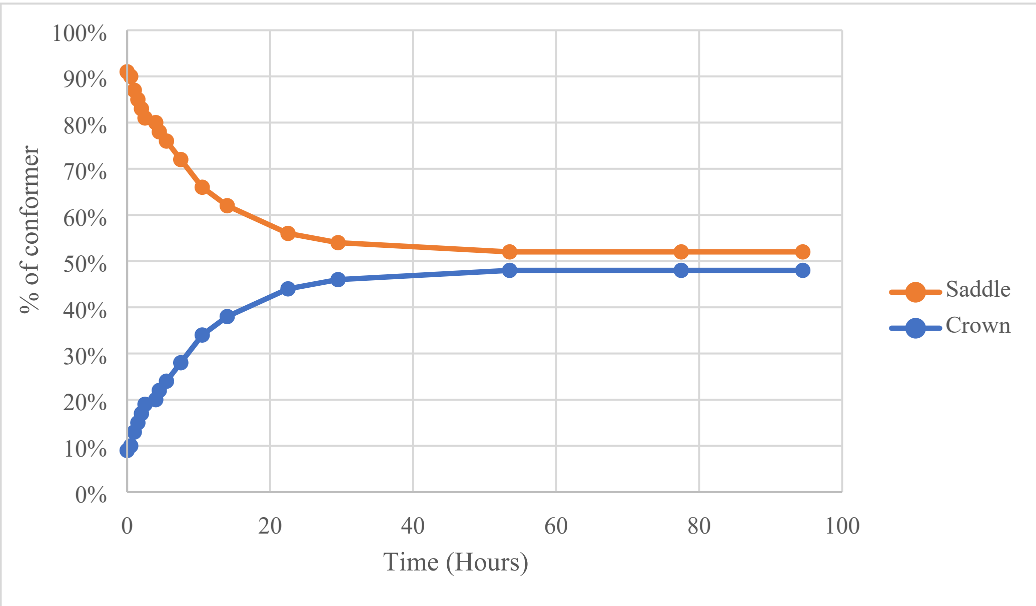
The percentages of the saddle and crown conformers were determined by integrating the crown signal at 5.09 (d, *J* = 12.6 Hz, $H20_b$) ppm and and the saddle signal at 3.95 (s, H19') ppm.



Time (h)	Ratio	
	Saddle	Crown
0	91%	9%
0.5	90%	10%
1	87%	13%
1.5	85%	15%
2	83%	17%
2.5	81%	19%

4	80%	20%
4.5	78%	22%
5.5	76%	24%
7.5	72%	28%
10.5	66%	34%
14	62%	38%
22.5	56%	44%
29.5	54%	46%
53.5	52%	48%
77.5	52%	48%
94.5	52%	48%

The percentages of the saddle and crown conformers were determined by integrating the crown signal at 5.09 (d, *J* = 12.6 Hz, $H20_b$) ppm and and the saddle signal at 3.95 (s, H19') ppm, using the residual non-deuterated $CHCl_3$ signal as an internal reference.



Procedure for CTB-1NAc and CTB-1NCOC8

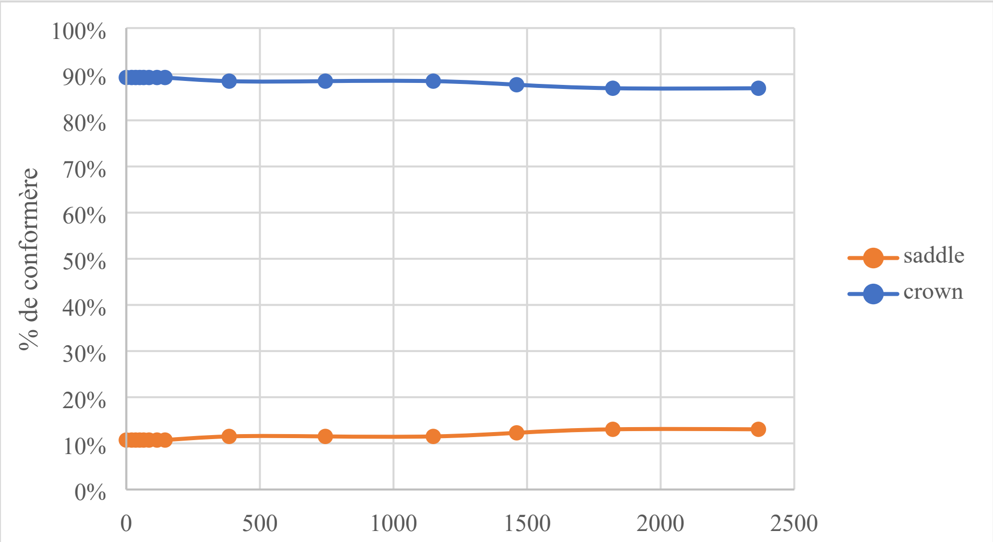
The crown conformer of each compound has been purified and solubilized in $CDCl_3$ (C = 10 mg/0.5 mL). A ^{1}H NMR spectra was recorded over 39.4 hours (**CTB-1NAc**) and 366 hours (**CTB-1NCO8**). The ratio of crown/saddle conformers was extracted from these spectra, and reported in a graph.

CTB-1NAc

Time (h)	Ratio	
	Saddle	Crown
0.0	11%	89%
0.3	11%	89%
0.6	11%	89%
0.8	11%	89%
1.1	11%	89%
1.4	11%	89%
1.9	11%	89%
2.4	11%	89%

6.4	12%	88%
12.4	12%	88%
19.2	12%	88%
24.4	12%	88%
30.4	13%	87%
39.4	13%	87%

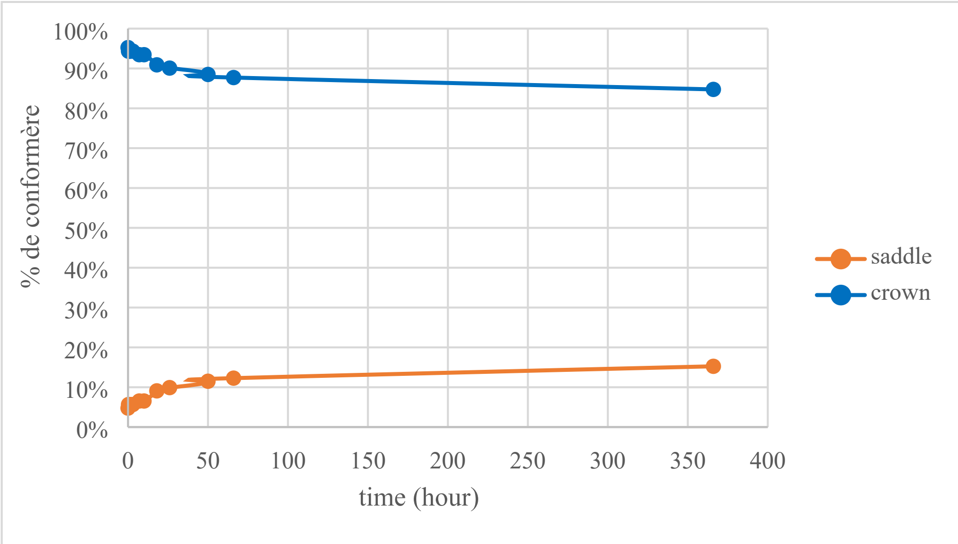
The percentages of the saddle and crown conformers were determined by integrating the crown signal 7.43 (d, J = 8.6 Hz, H5) ppm and and the saddle signal at 6.46 (d, J = 2.9 Hz) ppm.



CTB-1NCOC8

Time (h)	Ratio	
	Saddle	Crown
0	5%	95%
0.3	6%	94%
0.7	6%	94%
1.3	6%	94%
3	6%	94%
7	7%	93%
10	7%	93%
18	9%	91%
26	10%	90%
50	12%	88%
66	12%	88%
366	15%	85%

The percentages of the saddle and crown conformers were determined by integrating the crown signal 7.42 (d, J = 8.6 Hz, H5) ppm and and the saddle signal at 6.53 (d, J = 2.7 Hz) ppm.


100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% de conformère
0
50
100
150
200
250
300
350
400
time (hour)
saddle
crown

5 Barrier interconversion

The conformer interconversion was studied by [1]H NMR, by acquiring NMR spectra at regular time intervals from an initially enriched solution.

The interconversion equilibrium is defined by the following equation:

$$\text{saddle} \underset{k_{-1}}{\overset{k}{\rightleftharpoons}} \text{crown}$$

$Keq = k/k_{-1} = [crown]_{eq}/[saddle]_{eq}$

Progress table:

	saddle	crown
t0	a	b
t	a-x	b+x

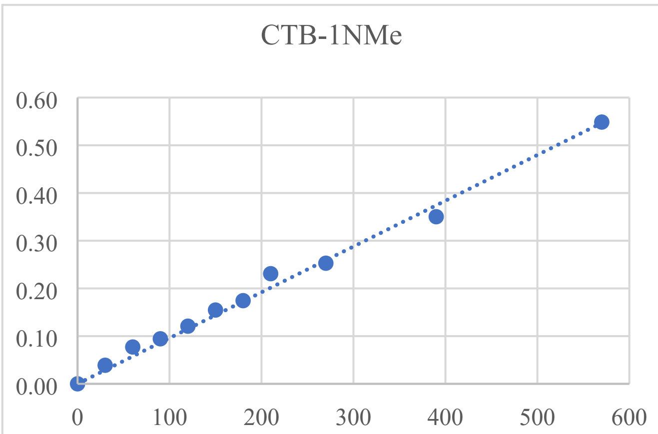
$$kt = \frac{-1}{1+\frac{1}{keq}} ln\left(\frac{1-x(1+\frac{1}{keq})}{a-\frac{b}{keq}}\right)$$

Then, the inversion energy is defined by $\Delta G = RT\ ln\frac{kbT}{hk}$

CTB-1NMe:

Keq = 0.329; a = 0.89; b = 0.11

t(min)	% saddle	x	kt
0	0.89	0.00	0.00
30	0.87	0.02	0.04
60	0.85	0.04	0.08
90	0.85	0.04	0.09
120	0.84	0.05	0.12
150	0.83	0.06	0.15
180	0.82	0.07	0.17
210	0.81	0.08	0.23
270	0.80	0.09	0.25
390	0.79	0.10	0.35
570	0.77	0.12	0.55

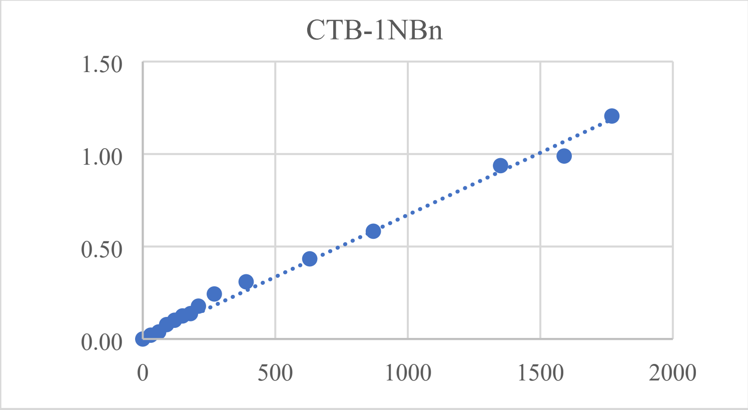


$\Delta G = RTln\ (K_BT/\ hk) = 88540.96$ J/mol

CTB-1NBn

Keq = 0.884; a = 0.91; b = 0.09

t (min)	% saddle	x	kt
0	0,905	0,00	0,00
30	0,889	0,02	0,02
60	0,876	0,03	0,04
90	0,848	0,06	0,08
120	0,832	0,07	0,10
150	0,818	0,09	0,12
180	0,810	0,10	0,14
210	0,787	0,12	0,18
270	0,754	0,15	0,24
390	0,725	0,18	0,31
630	0,679	0,23	0,43
870	0,639	0,27	0,58
1350	0,582	0,32	0,94
1590	0,576	0,33	0,99
1770	0,559	0,35	1,21

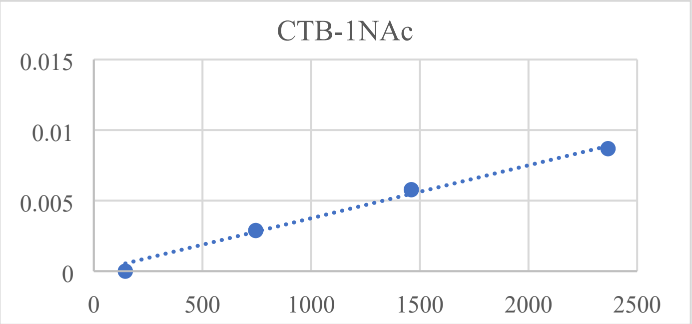


$\Delta G = RT\ln(K_BT/hk) = 89409.83$ J/mol

CTB-1NAc

Keq = 0.15; a = 0.892; b = 0.107

t (min)	% crown	x	kt
0	0,893	0	0
145	0,893	0	0
745	0,885	0,008	0,0029
1461	0,877	0,016	0,0058
2366	0,870	0,023	0,0087

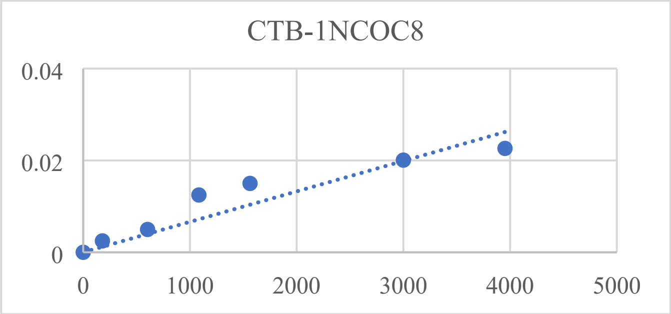


$\Delta G = RT\ln(K_BT/hk) = 101991.25$ J/mol

$CTB-1NCOC_8$

Keq = 0.15; a = 0.892; b = 0.107

t (min)	% crown	x	kt
0	0,952	0,000	0
180	0,943	0,009	0,0024805
603	0,935	0,018	0,00496777
1084	0,909	0,043	0,01247631
1563	0,901	0,051	0,01499684
3000	0,885	0,067	0,0200684
3952	0,877	0,075	0,02262078



$\Delta G = RT\ln (K_BT/ hk) = 100628.03$ J/mol

6 Crystallographic data

6.1 X-ray structure analysis

Single crystals of compounds **CTB-1NMe**, **CTB-1NAc**, and **CTB-2NMe** suitable for X-ray crystallographic analysis were obtained by slow evaporation from diethyl ether.

Diffraction data for **CTB-1NMe** and **CTB-1NAc** were collected at 132 K using a DualFlex Rigaku Oxford diffractometer equipped with a Hybrid Pixel Array detector. Data for **CTB-1NMe** were collected using Cu-Kα radiation, whereas data for **CTB-1NAc** were collected using Mo-Kα radiation generated by a PhotonJet micro-focus sealed X-ray tube. Diffraction data for **CTB-2NMe** were collected at 150 K on a Bruker D8 diffractometer using Mo-Kα radiation generated by a MicroSource type IµS (λ = 0.71073 Å) and a PHOTON100 detector.

The crystal structures were solved using the SHELXT dual-space algorithm and refined by full-matrix least-squares refinement on F^2 using SHELXL-97. All non-hydrogen atoms were refined anisotropically, and hydrogen atoms were placed in calculated positions and refined using a riding model.

Crystallographic data have been deposited at the Cambridge Crystallographic Data Centre (CCDC) under deposition number CCDC 2521660-2521661-2521662. Copies of these data can be obtained free of charge from the CCDC, 12 Union Road, Cambridge CB2 1EZ, UK (tel: +44-1223-336408; e-mail: deposit@ccdc.cam.ac.uk; https://www.ccdc.cam.ac.uk)

6.2 Superimposition of structures

The superposition was performed systematically by aligning the two most coplanar rings, positioning the substituted methoxy group on the left and the para-substituted ring on the right.

A. Crystal structure of unmethylated analogue CTB-1NH (Triclinic P-1 with four **CTB - 1NH** molecules per crystal lattice). The pink and cyan molecules are those present in the asymmetric unit, while the green and yellow molecules are their symmetry-related counterparts generated by the center of symmetry. All four molecules adopt saddle conformations. Moreover, the superposition of the molecules shows that the pink and yellow molecules correspond to one enantiomeric form (first saddle enantiomer), whereas the green and cyan molecules represent the second saddle enantiomer.

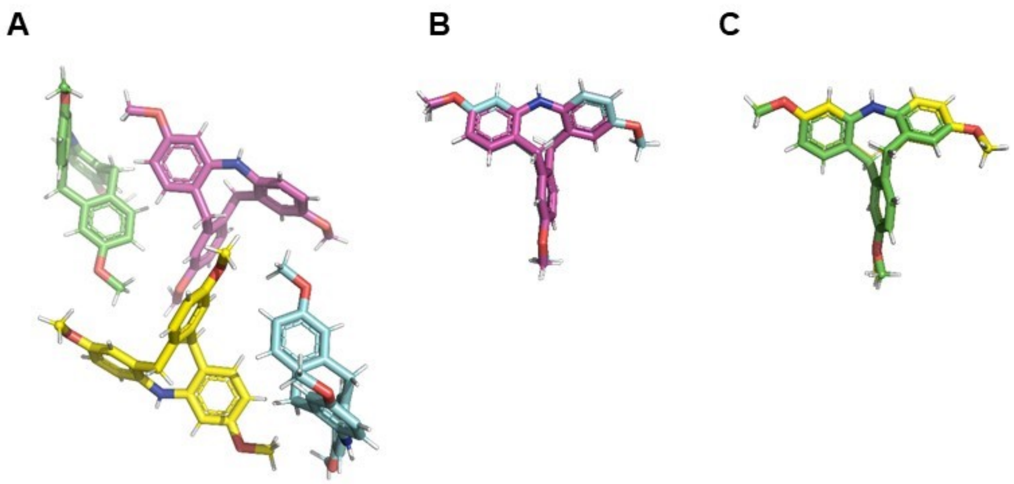


Figure S1. Crystal lattice view (A); First enantiomer (B) and second enantiomer (C) of **CTB-1NH**

B. Crystal structure of methylated analogue CTB-1NMe (Triclinic P-1 with two **CTB - 1NMe** molecules per crystal lattice). A small degree of disorder (86%/14%) was detected for the molecule located in the asymmetric unit; however, refinement of the disorder led to an incorrect geometry. Therefore, the structure was refined considering only the major conformation. Two independent molecules adopting a saddle conformation, related by a center of symmetry, are present in the crystal. Thus, the pink and orange molecules represent their symmetry-related counterparts generated by the inversion center. The pink conformer closely resembles that observed in CTB-1NH (see superposition Figure S3).

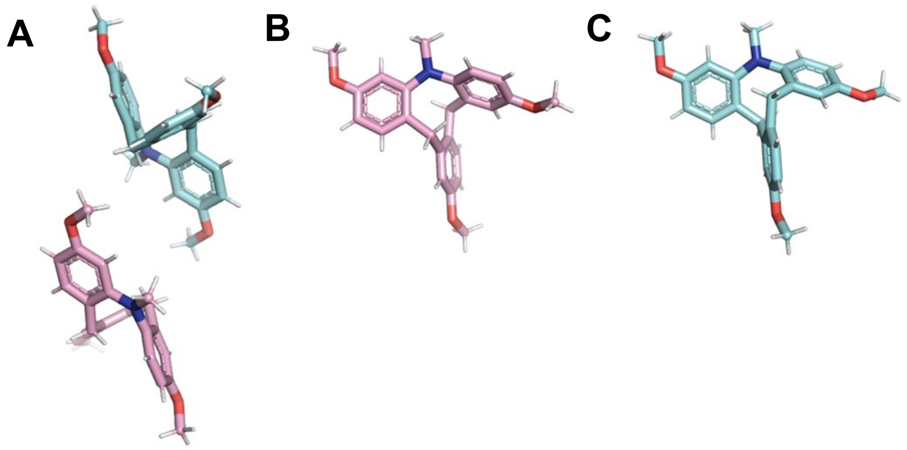


Figure S2. Crystal lattice view (A); conformation of CTB-1NMe in the crystal (B) with its centrosymmetry-related enantiomer (C).

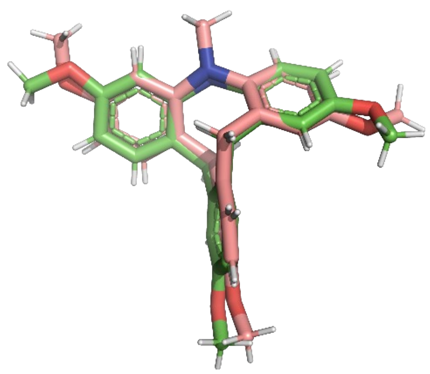


Figure S3. Superimposition of CTB-1NH (green) and CTB-1NMe (pink) conformation.

C. Crystal structure of acetylated analogue CTB-1NAc (Triclinic P-1 with two **CTB-1NAc** molecules per crystal lattice). The green molecule corresponds to the saddle conformation present in the asymmetric unit, while the blue one is its symmetry-related counterpart generated by the center of symmetry. Notably, the major saddle conformation observed in the previous crystals is absent here. The conformation detected in **CTB-1NAc** is the new one.

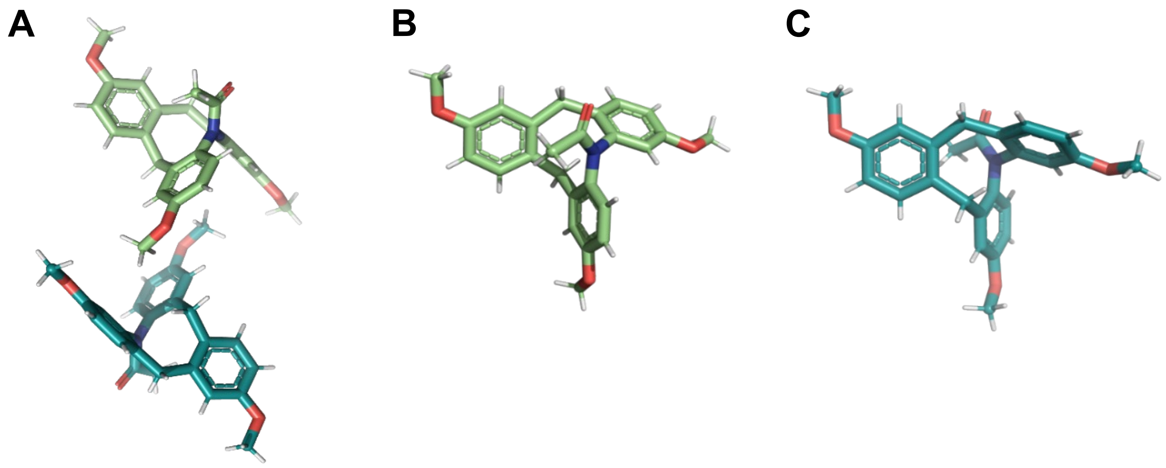


Figure S4. Crystal lattice view (A); conformation of **CTB-1NAc** in the crystal (B) with its centrosymmetry-related enantiomer (C)

D. Crystal structure of the dimethylated analogue CTB-2NMe (monoclinic *Cc*, with four CTB-2NMe molecules per unit cell). This space group contains a *c*-glide plane and an additional translation arising from the C-centred lattice. Consequently, four molecules are present in the crystal lattice and one molecule in asymmetric unit. Superposition of these four molecules reveals the presence of two enantiomers with the conformation rather close to the one observed in the **CTB-1NH** and **CTB-1NMe**.

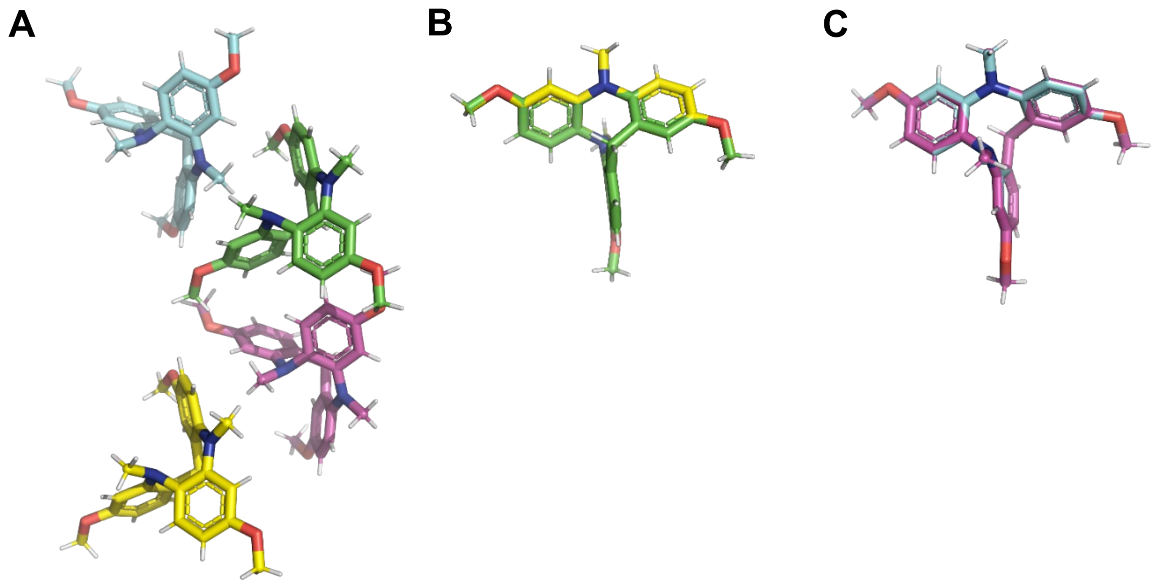


Figure S5. Crystal lattice view (A); First enantiomer (B) and second enantiomer (C) of **CTB-2NMe**

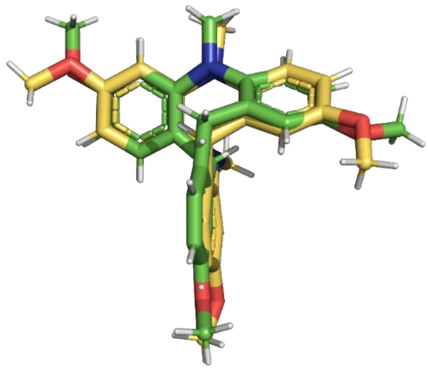


Figure S6. Superimposition of **CTB-1NMe** (green) and **CTB-2NMe** (yellow) conformations

E. Crystal structure of CTB-3N2Me (Crystal CSD-CCDC 752918, Orthorhombic Pbca with eight molecules per crystal lattice).[5]

This space group contains three glide plans, each associated with one axis. Consequently, eight molecules are present in the crystal. Analysis of the eight molecules reveals the presence of two enantiomers within the structure with the conformation close to the one observed in the **CTB-1NH** and **CTB-1NMe**.

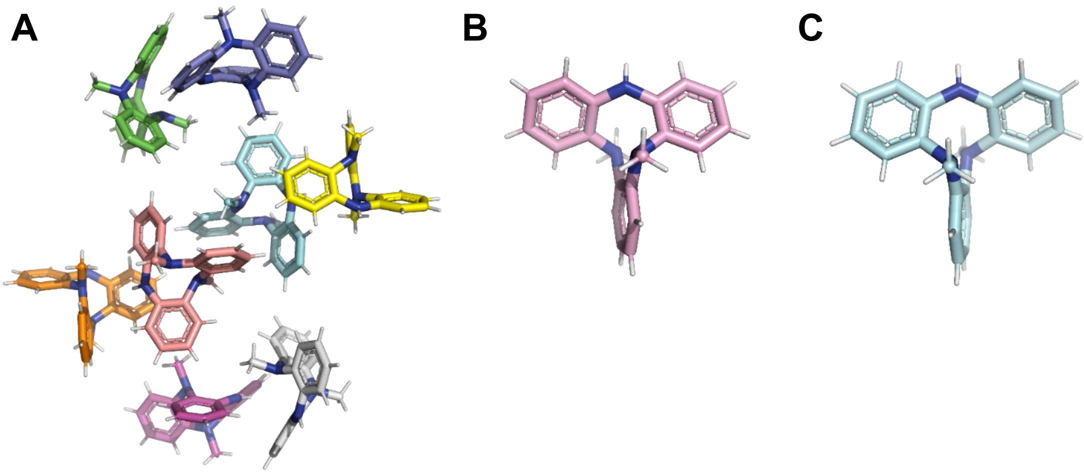


Figure S7. Crystal lattice view (A); conformation of **CTB-3N-2NMe** in the crystal (B) with its centrosymmetry-related enantiomer (C)

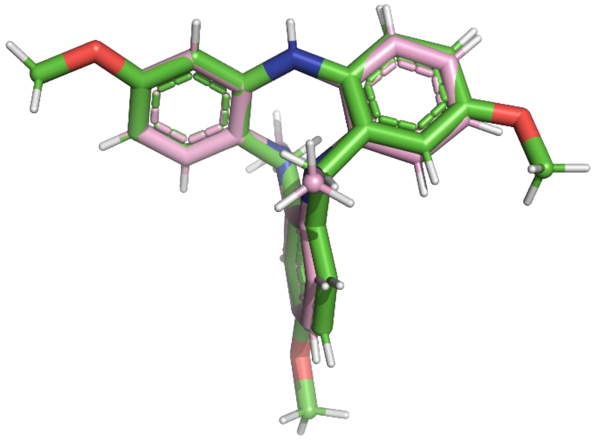
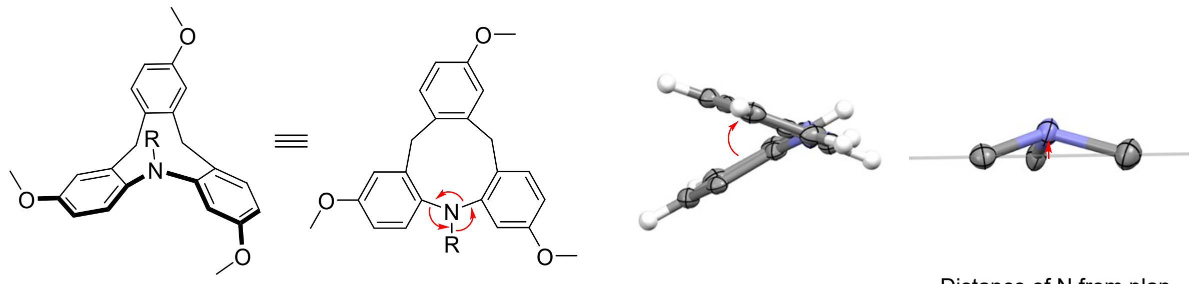


Figure S8. Superimposition of **CTB-1NH** (green) and **CTB-3N-2NMe** (pink)

6.3 Bond lengths and angles



Bond angles

Angle between the rings

Distance of N from plan through its substituents

			Diphenylamine[6,a] CCDC 221680	CTB-1NH[2,b]	CTB-1NMe	CTB-1NAc	N,N-diphenylacetanilide[7] CCDC 934151	CTB-3N-2Me[5] CCDC 752918	CTB-2NMe
N1	Bond length (Å)	C_{Ar}-N	1.400±0.004 1.400±0.004	1.3985±0.0007 1.403±0.003	1.417 1.433	1.438 1.433	1.440 1.440	1.395 1.420	1.410 1.425
		C-N			1.443	1.373	1.372		1.461
	Bond angles (°)	C_{Ar}-N-C_{Ar}	129±1	131.8±0.2	124.49	115.75	117.63	129.79	125.45
		C_{Ar}-N-C	115±1	113±2	119.45	120.05	122.53	113.43	117.63
		C_{Ar}-N-H	115±1	113.5±0.8	115.75	124.18	119.81	114.90	116.92
	Angle between the neighbouring rings (°)		±43 ± 5	±56.3±0.5	±65.59	±85.45	±69.69	±49.3	±57.54
	Distance of N from substituents plan (Å)		0.07± 0.03	0.07±0.09	0.046	0.008	0.013	0.093	0.001
N2	Bond length (Å)	C_{Ar}-N						1.414 1.453	1.409 1.441
		C-N						1.462	1.463
	Bond angles (°)	C_{Ar}-N-C_{Ar}						114.17	112.61
		C_{Ar}-N-C						117.08 111.77	117.31 113.26
	Angle between the neighbouring rings (°)							±80.68	±86.32
	Distance of N from substituents plan (Å)							0.349	0.346
N3	Bond length (Å)	C_{Ar}-N						1.424 1.455	
		C-N						1.464	
	Bond angles (°)	C_{Ar}-N-C_{Ar}						112.90	
		C_{Ar}-N-C						116.19 110.89	
	Angle between the neighbouring rings (°)							±83.32	
	Distance of N from substituents plan (Å)							0.381	

Table S1. Selected bond lengths and angles from crystallographic data

[a] Mean values calculated from eight independent molecules in the asymmetric unit. [b] Mean values calculated from two independent molecules in the asymmetric unit.

7 References

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