Electronic Supplementary Material (ESI) for Materials Chemistry Frontiers.

Supporting Information

Highly Efficient All Solution Processed Non-Doped Deep Blue Electroluminescent Devices from Oligocarbazole-End Capped Spirobifluorenes

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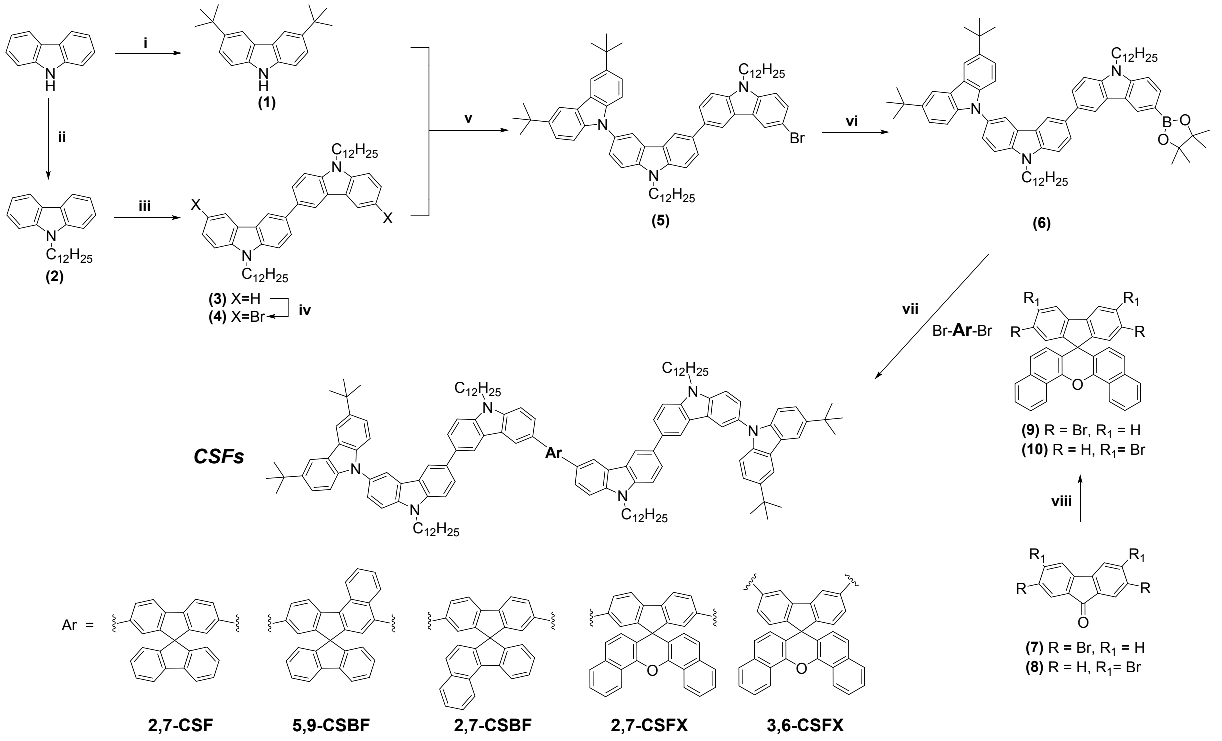
Materials Synthesis



Scheme S1 Synthesis of oligocarbazole-end capped spirobifluorenes (**CSFs**). *Reagents and conditions:* i) *tert*-BuCl, DCM, CH_3NO_2 ; ii) $C_{12}H_{25}Br$, KOH, DMF; iii) $FeCl_3$, $CHCl_3$; iv) NBS, THF, 0 °C; v) (±)-*trans*-1,2-diaminocyclohexane, CuI, K_3PO_4, toluene, reflux; vi) bis(pinacolato)diboron, $Pd(PPh_3)_2Cl_2$, CH_3CO_2K, toluene, reflux; vii) dibromo spirobifluorenes, $Pd(PPh_3)_4$, 2M Na_2CO_3, THF, reflux; viii) 1-naphthol, CH_3SO_3H.

***9-Dodecyl-9H-carbazole* (2):** Carbazole (20.00 g, 0.1196 mol) was dissolved in DMF (200 ml). Then, KOH (26.84 g, 0.4784 mol) was added. The mixture was stirred at room temperature for 1 hour. After that, the 1-bromododecane (57.44 ml, 0.2392 mol) was added to the mixture. Reaction mixture was stirred at room temperature for 18 hours. The reaction was quenched with water, and then extracted by dichloromethane. The combine organic layer was dried over sodium sulfate anhydrous and concentrated by vacuum. The crude product was purified by silica gel column chromatography using hexane as eluent and dried the product in vacuum. The product was obtained as yellow liquid (38.52 g, 96%). ^{1}H NMR (600 MHz, $CDCl_3$): δ 8.16 (2H, d, J = 7.7 Hz), 7.52 (2H, t, J = 7.6Hz), 7.46 (2H, d, J = 8.2 Hz), 7.29 (2H, t, J = 7.4Hz), 4.34 (2H, t, J = 7.3 Hz), 1.92 (2H, m), 1.44 (2H, m), 1.36 (4H, m), 1.31 (12H, s), 0.95 (3H, t, J = 7.0 Hz); ^{13}C NMR (151 MHz, $CDCl_3$): δ 140.49, 125.58, 122.88, 120.36, 118.72, 108.68, 43.11, 31.95, 29.64, 29.64, 29.61, 29.54, 29.45, 29.37, 29.00, 27.35, 22.72, 14.15; MADI-TOF (m/z) calcd for $C_{24}H_{33}N$: 335.5350, found 336.1631 ($M+H^+$).

***9,9'-Didodecyl-9H,9'H-3,3'-bicarbazole* (3):** $FeCl_3$ (38.71 g, 0.2386 mol) was added slowly to a stirred solution of **2** (20.00 g, 0.0597 mol) in 200 ml $CHCl_3$. The mixture was stirred at room temperature for 18 hours. After that, the reaction mixture was poured into methanol, then filtrated. The crude product was purified by silica gel column chromatography using hexane as eluent and dried the product in vacuum. The product was obtained as yellow liquid (31.93 g, 80%). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.40 (2H, s), 8.18 (2H, d, J = 7.7 Hz), 7.82 (2H, d, J = 8.4 Hz), 7.48 (4H, m), 7.42 (2H, d, J = 8.1 Hz), 7.25 (2H, m), 4.34 (4H, t, J = 7.2 Hz), 1.91 (4H, q, J = 7.4 Hz), 1.42 (4H, q, J = 7.5Hz), 1.35 (4H, q, J = 6.7Hz), 1.25 (28H, m), 0.87 (6H, t, J = 6.9Hz); ^{13}C NMR (151 MHz, $CDCl_3$) δ 140.94, 139.56, 133.39, 125.64, 125.54, 123.43, 123.09, 120.45, 118.95, 118.78, 108.87, 108.78, 43.25, 31.92, 29.62, 29.60, 29.53, 29.45, 29.34, 29.05, 27.36, 22.69, 14.11; MADI-TOF (m/z) calcd for $C_{48}H_{64}N_2$: 669.0540; found 669.1518 (M^+).

***6,6'-Dibromo-9,9'-didodecyl-9H,9'H-3,3'-bicarbazole* (4):** Solution of NBS (0.56 g, 3.1388 mol) in THF (20 ml) was very slowly added to the solution of **3** (1.00 g, 1.4947 mmol) in THF (80 ml) at 0 °C. The reaction was quenched with sodium thiosulphate solution, and then extracted by dichloromethane. The combine organic layer was dried over sodium sulfate anhydrous and concentrated by vacuum. The crude product was purified by silica gel column chromatography using hexane as eluent and dried the product in vacuum. The product was obtained as light-yellow liquid (0.93 g, 75%). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.33 (2H, s), 8.29 (2H, s), 7.83 (2H, d, J = 8.5Hz), 7.55 (2H,d, J = 8.6Hz), 7.49 (2H, d, J = 8.4Hz), 7.30 (2H, d, J = 8.6Hz), 4.31 (4H, t, J = 7.1Hz), 1.89 (4H, m), 1.39 (4H, m), 1.34 (4H, m), 1.24 (28H, m), 0.87 (6H, t, J = 6.9Hz); ^{13}C NMR (151 MHz, $CDCl_3$) δ 139.8899, 139.5724, 133.4916, 128.3657, 126.1788, 124.7765, 123.2127, 122.4721, 119.0395, 111.6130, 110.2660, 109.2327, 43.3966, 31.9195, 29.6066, 29.5689, 29.5011, 29.4061, 29.3342, 28.9906, 27.3085, 22.6894, 14.1144; MADI-TOF (m/z) calcd for $C_{48}H_{62}Br_2N_2$: 826.8460; found 827.2778 ($M+H^+$).

***6-Bromo-3'',6''-di-tert-butyl-9,9'-didodecyl-9H,9'H-3,3':6',9''-tercarbazole* (5):** A dried mixture of **4** (12.00 g, 0.0145 mol), 3,6-di-*tert*-butyl-9*H*-carbazole (1.31 g, 0.0047 mol) and K_3PO_4 (2.49 g, 0.0118 mol) were added CuI (0.45 g, 0.0023 mol) and toluene (100 ml), and then stirred at room temperature until dissolved. The mixture was degassed in N_2 atmosphere for 5 times followed by addition of (±)-*trans*-diaminocyclohexane (0.27 ml, 0.0023 mol). The reaction mixture was stirred at reflux under N_2 for 24 hours. After being cooled to room temperature, water was added and extracted with dichloromethane. The combined organic phases were dried over sodium sulfate anhydrous and the solvent was removed under pressure. The crude product was purified by silica gel column chromatography using hexane as eluent and dried the product in vacuum. The product obtains as pale-yellow solid (2.55 g, 53%). m.p. 75 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.39 (2H, d, J = 8.8Hz), 8.35 (1H, s), 8.32 (1H, s), 8.24 (2H, s), 7.90 (1H, d, J = 8.3Hz), 7.86 (1H, d, J = 8.3Hz), 7.64 (2H, m), 7.58 (2H, m), 7.51 (3H, m), 7.41 (2H, d, J = 8.3Hz), 7.31 (1H, d, J = 8.5Hz), 4.45 (2H, t, J = 6.3Hz), 4.31 (2H, t, J =

6.3Hz), 2.04 (2H, m), 1.91 (2H, m), 1.53 (18H, s), 1.45 (2H, m), 1.41 (2H, m), 1.30 (20H, m), 1.26 (12H, m), 0.90 (6H, m); ^{13}C NMR (151 MHz, $CDCl_3$) δ 142.42, 140.39, 140.26, 139.87, 139.84, 139.55, 133.51, 133.41, 129.47, 128.32, 126.15, 126.02, 125.12, 124.79, 123.91, 123.48, 123.22, 123.19, 123.09, 122.48, 119.32, 119.08, 119.00, 116.19, 111.60, 110.22, 109.66, 109.32, 109.25, 109.22, 43.56, 43.36, 34.76, 32.10, 31.93, 31.91, 29.66, 29.64, 29.59, 29.56, 29.49, 29.39, 29.36, 29.32, 29.18, 28.97, 27.43, 27.29, 22.70, 22.68, 14.11; MADI-TOF (m/z) calcd for $C_{68}H_{86}BrN_3$: 1025.3610; found 1025.8345 (M^+).

***3'',6''-Di-tert-butyl-9,9'-didodecyl-6-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-9H,9'H-3,3':6',9''-tercarbazole* (6): 5** (1.00 g, 0.9753 mmol), bis(pinacolato)diboron (0.50 g, 1.9501 mmol), $Pd(PPh_3)_2Cl_2$ (0.04 g, 0.0488 mmol), and CH_3CO_2K (1.15 g, 0.0117 mol) were dissolved in dry toluene (30 ml). The mixture was degassed in N_2 atmosphere for 5 times. Then, the mixture was stirred at reflux temperature for 24 hours under N_2 atmosphere. After being cooled to room temperature, water was added and extracted with dichloromethane. The combined organic phases were dried over sodium sulfate anhydrous and the solvent was removed under pressure. The pure compound was obtained by silica gel column chromatography using a mixture of dichloromethane and hexane as eluent and dried the product in vacuum. The product was obtained as pale-yellow solid (0.84 g, 80%). m.p. 98 ^{o}C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.66 (1H, s), 8.47 (1H, s), 8.37 (1H, s), 8.32 (1H, s), 8.18 (2H, s), 7.91 (1H, d, J = 8.2Hz), 7.89 (1H, d, J = 8.5Hz), 7.81 (1H, d, J = 8.5Hz), 7.60 (3H, m), 7.47 (3H, m), 7.39 (3H, m), 4.43 (2H, t, J = 7.1Hz), 4.32 (2H, t, J = 7.1Hz), 2.01 (2H, m), 1.89 (2H, m), 1.48 (18H, s), 1.39 (16H, m), 1.27 (20H, m), 1.23 (12H, s), 0.86 (6H, m); ^{13}C NMR (151 MHz, $CDCl_3$) δ 143.08, 142.33, 140.37, 140.21, 139.82, 139.69, 133.60, 133.35, 132.14, 129.42, 127.93, 126.00, 125.27, 125.02, 123.96, 123.78, 123.52, 123.18, 123.05, 122.82, 119.30, 119.08, 119.00, 116.13, 109.61, 109.28, 109.01, 108.19, 83.56, 43.57, 43.27, 34.75, 32.10, 31.93, 31.90, 29.66, 29.64, 29.59, 29.50, 29.42, 29.36, 29.32, 29.20, 29.01, 27.45, 27.31, 24.95, 22.70, 22.68, 14.12, 14.10; MADI-TOF (m/z) calcd for $C_{74}H_{98}BN_3O_2$: 1072.4270; found 1072.4045 (M^+).

***2',7'-Dibromospiro[dibenzo[c,h]xanthene-7,9'-fluorene]* (9):** A mixture of 2,7-Dibromo-9-fluorenone (1.00 g, 2.9586 mmol) 1-naphthol (1.71 g, 11.8344 mmol) and methane sulfonic acid (0.8 ml, 11.8344 mmol) was heated at 150 °C under nitrogen atmosphere for 24 h. The reaction mixture was then slowly added into water (20 ml) and extracted with DCM, washed with water and brine. The combined extracts were dried over sodium sulfate anhydrous, evaporated, and purified by column chromatography using hexane as eluent to obtain white solid product (1.28 g, 73%). m.p. 336 ^{o}C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.77 (2H, d, J = 8.4 Hz), 7.78 (2H, d, J = 8.1 Hz), 7.71 (4H, dd, J = 16.8, 7.9 Hz), 7.59 (2H, t, J = 7.5 Hz), 7.53 (2H, dd, J = 8.2, 1.5 Hz), 7.32 (2H, d, J = 8.6 Hz), 7.26 (2H, m), 6.37 (2H, d, J = 8.6 Hz); ^{13}C NMR (151 MHz, $CDCl_3$) δ 157.39, 145.81, 137.75, 133.72, 131.58, 129.70, 127.71, 127.00, 126.53, 125.05, 124.59, 123.50, 122.59, 121.77, 121.43, 116.36, 54.41; MALDI-TOF (m/z) calcd for $C_{33}H_{18}Br_2O$ 589.9704; found 590.1997 (M^+).

***3',6'-Dibromospiro[dibenzo[c,h]xanthene-7,9'-fluorene]* (10):** A mixture of 3,6-Dibromo-9H-fluoren-9-one (0.50 g, 1.4793 mmol) 1-naphthol (0.85 g, 5.9172 mmol) and methane sulfonic acid (3.0 ml, 14.7930 mmol) was heated at 150 °C under nitrogen atmosphere for 24

h. The reaction mixture was then slowly added into water (20 ml) and extracted with DCM, washed with water and brine. The combined extracts were dried over sodium sulfate anhydrous, evaporated, and purified by column chromatography using hexane as eluent to obtain white solid product (0.41 g, 47%). m.p. 318 °C; ^{1}H NMR (600 MHz, CDCl$_3$) δ 8.76 (2H, d, *J* = 8.4 Hz), 7.98 (2H, d, *J* = 1.1 Hz), 7.77 (2H, d, *J* = 8.1 Hz), 7.71 (2H, t, *J* = 7.6 Hz), 7.58 (2H, t, *J* = 7.5 Hz), 7.35 (2H, m), 7.29 (2H, d, *J* = 8.6 Hz), 7.03 (2H, d, *J* = 8.1 Hz), 6.37 (2H, d, *J* = 8.6 Hz); ^{13}C NMR (151 MHz, CDCl$_3$) δ 154.84, 145.83, 140.56, 133.66, 132.03, 127.96, 127.72, 126.89, 126.46, 125.01, 124.58, 123.50, 123.38, 122.40, 121.69, 116.53, 53.92; MALDI-TOF (m/z) calcd for $C_{33}H_{18}Br_2O$ 589.9704; found 590.1997 (M$^+$).

DFT calculation data

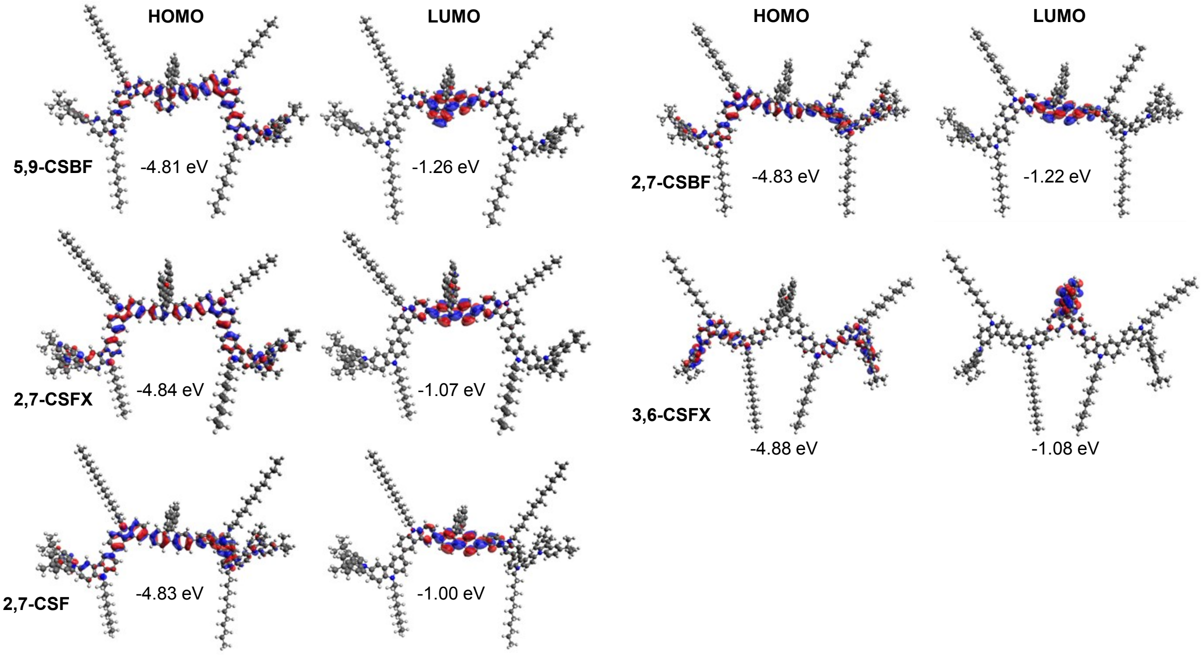


Fig. S1 The optimized structures, HOMOs and LUMOs of **CSFs** calculated by TD-DFT B3LYP/6-31G(d) in CH_2Cl_2.

Characterization data

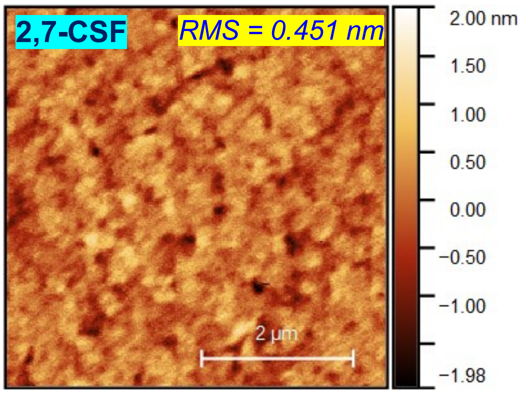


Fig. S2 Non-contact mode AFM image of **2,7-CSF** thin films spin-coated on ITO glasses.

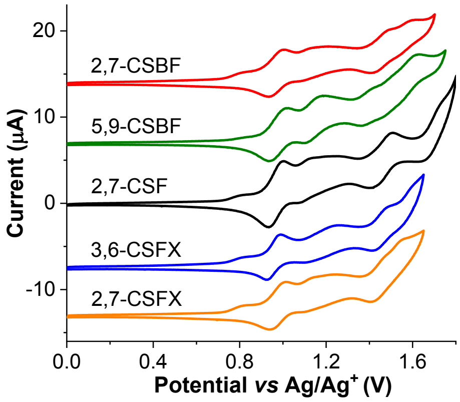


Fig. S3 CV curves of **CSFs** analysed in CH_2Cl_2 containing 0.1 M $TBAPF_6$ as a supporting electrolyte (scan rate of 50 mV s^{-1}; concentration of 1 mM) under argon atmosphere.

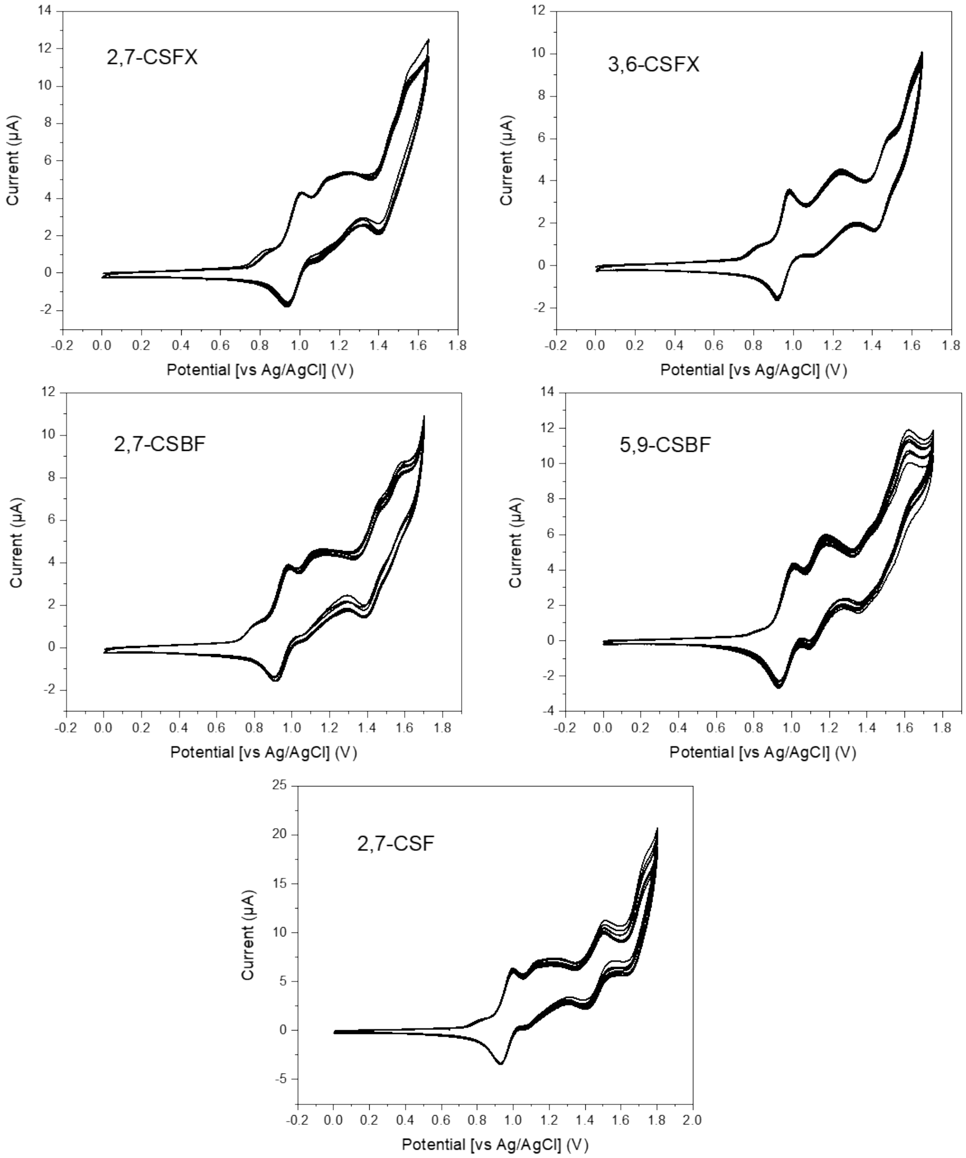


Fig. S4 Multiple CV scan traces of **CSFs** analysed in CH_2Cl_2 containing 0.1 M $TBAPF_6$ as a supporting electrolyte (scan rate of 50 mV s^{-1}; concentration of 1 mM) under argon atmosphere.

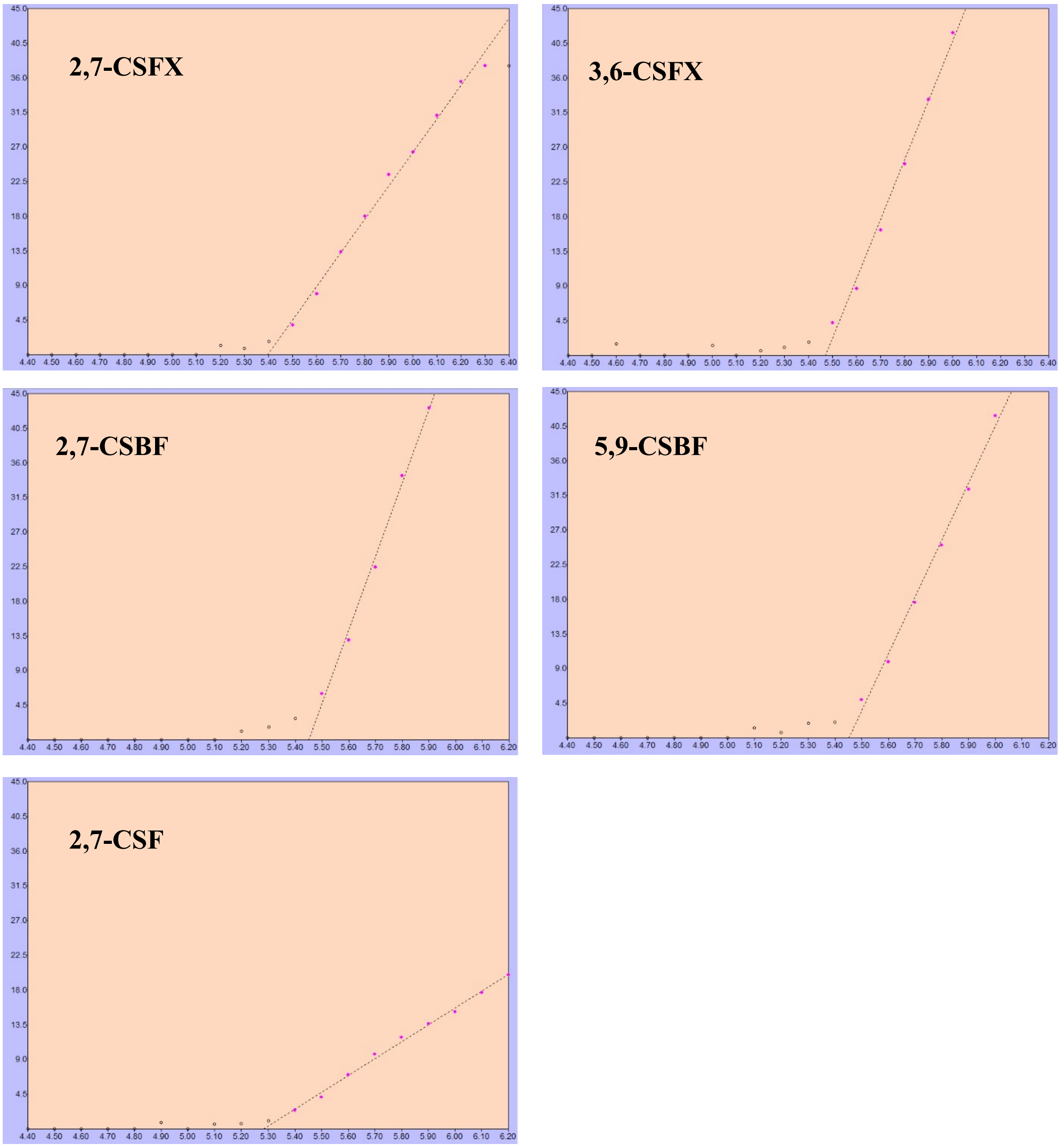


Fig. S5 Photoemission yield spectroscopy in air (PYSA) spectra of **CSFs**.

OLED device data

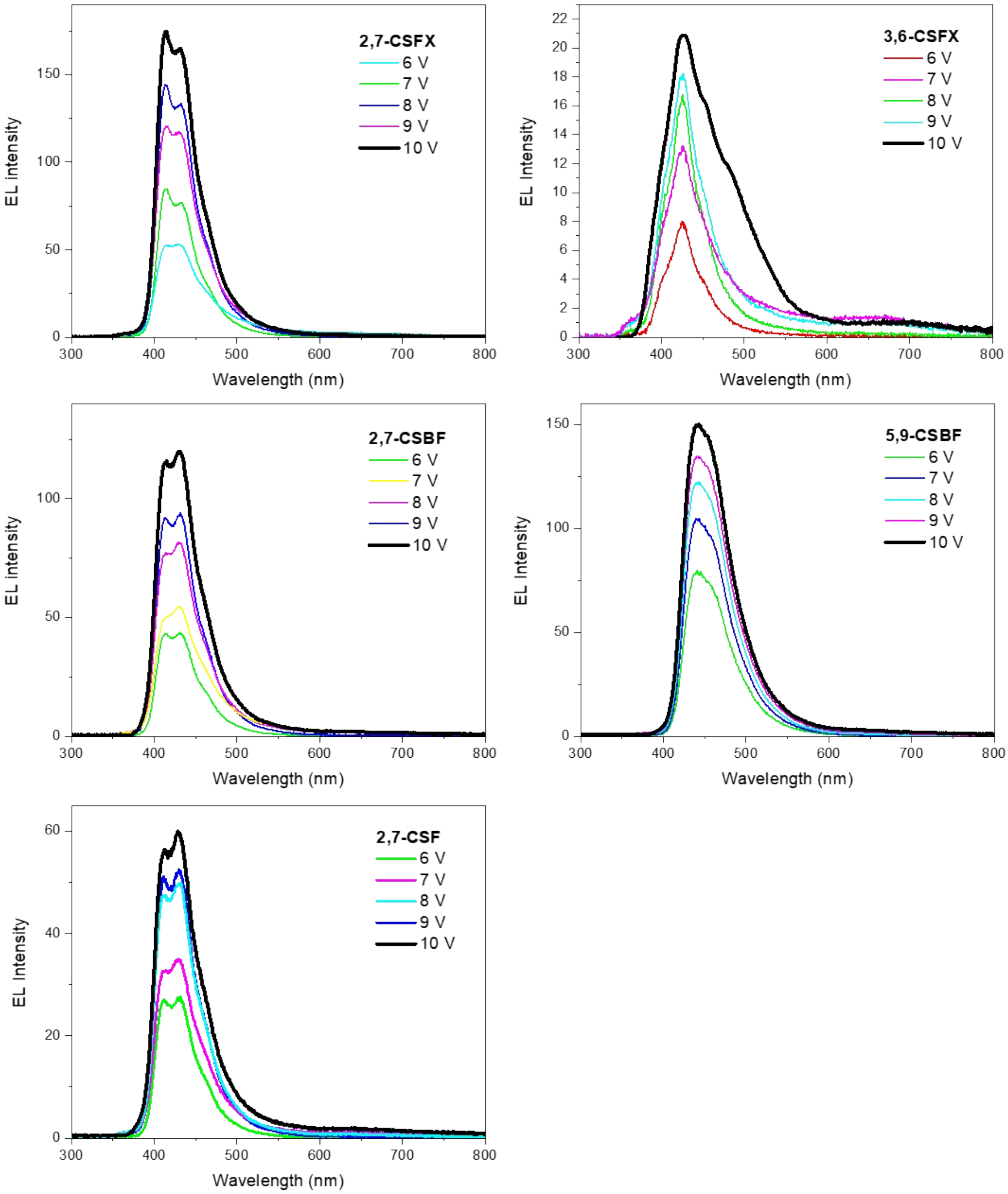


Fig. S6 EL spectra of the fabricated OLEDs at different applied voltages.

Copies of NMR spectra and HRMS mass spectra

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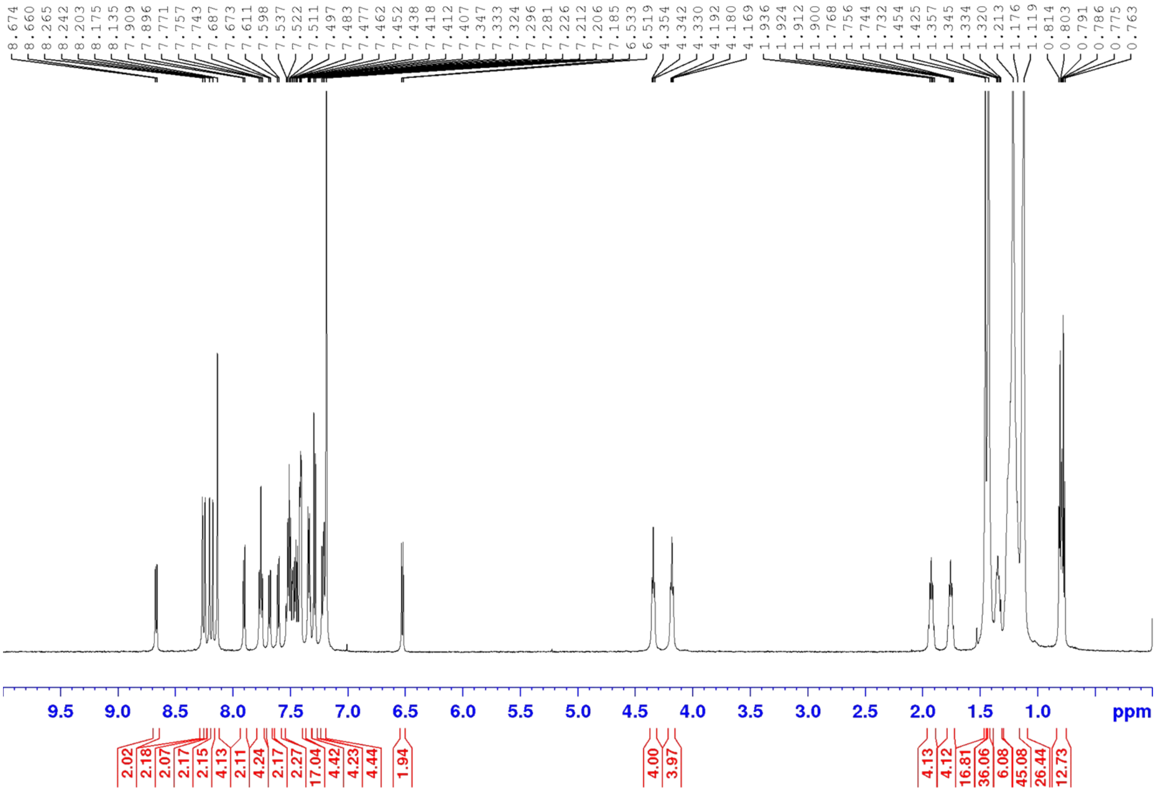

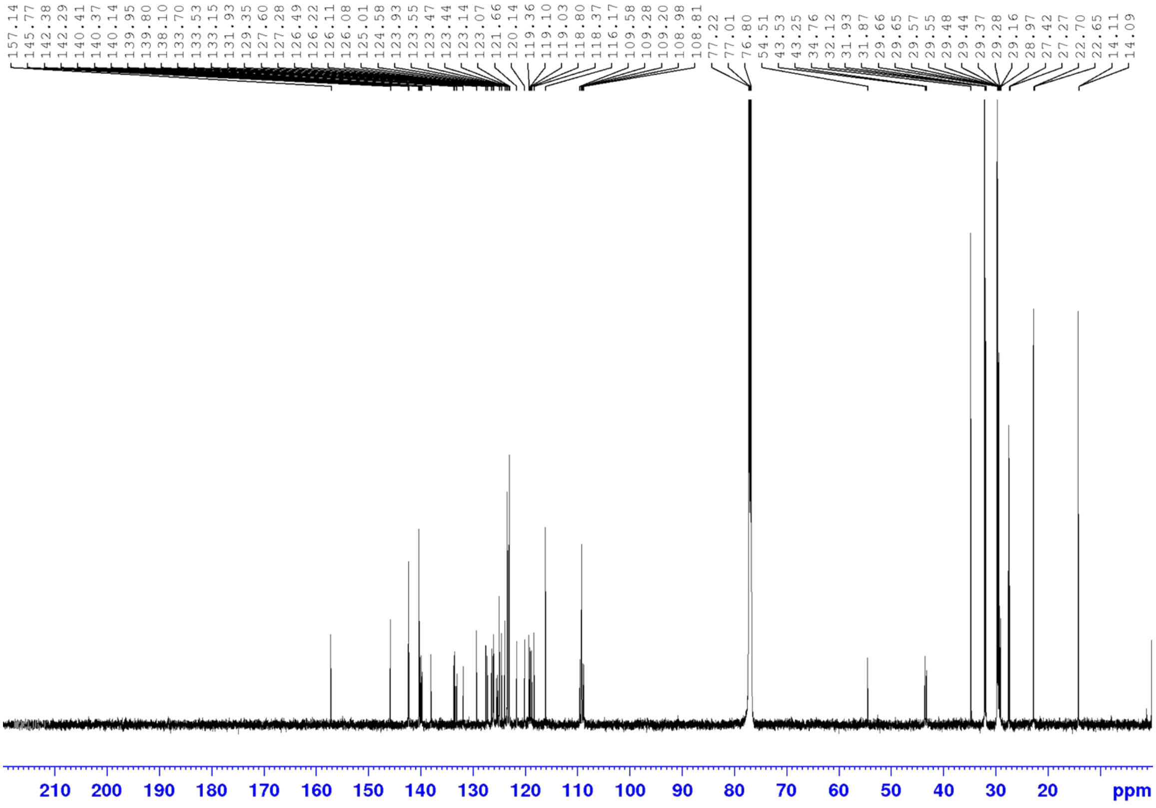

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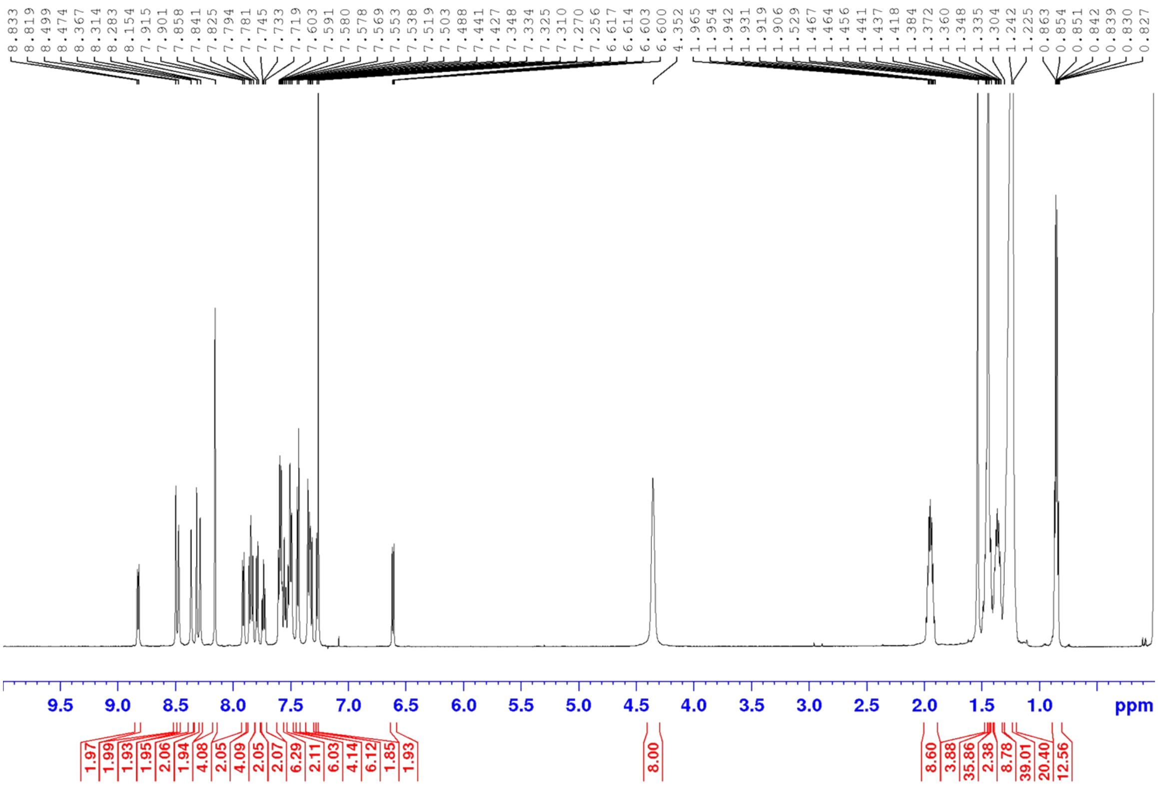
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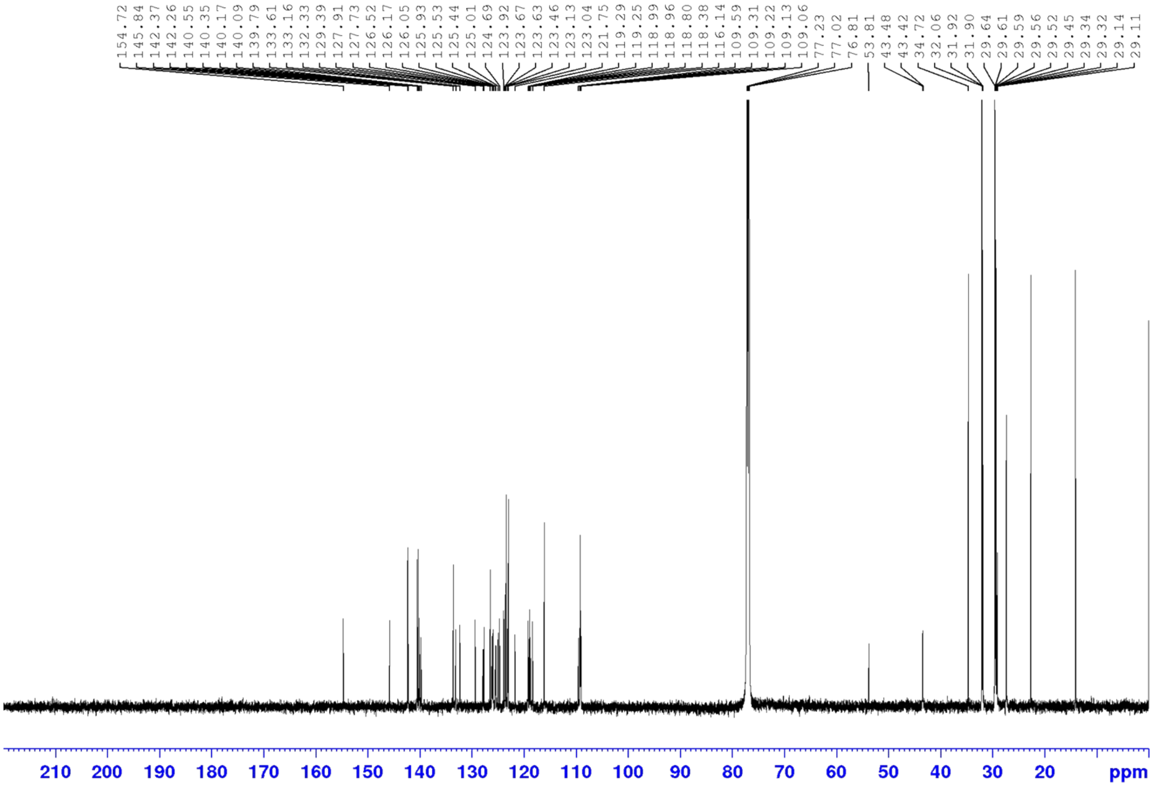
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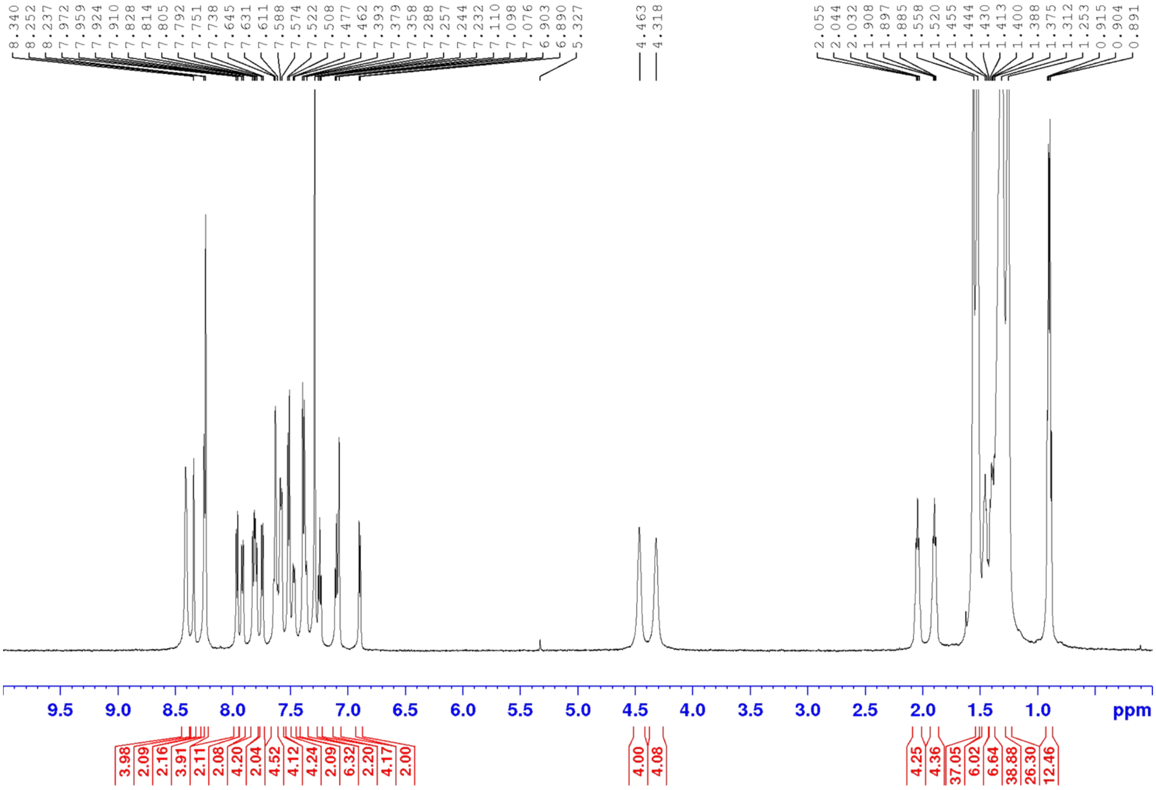
2,7-CSF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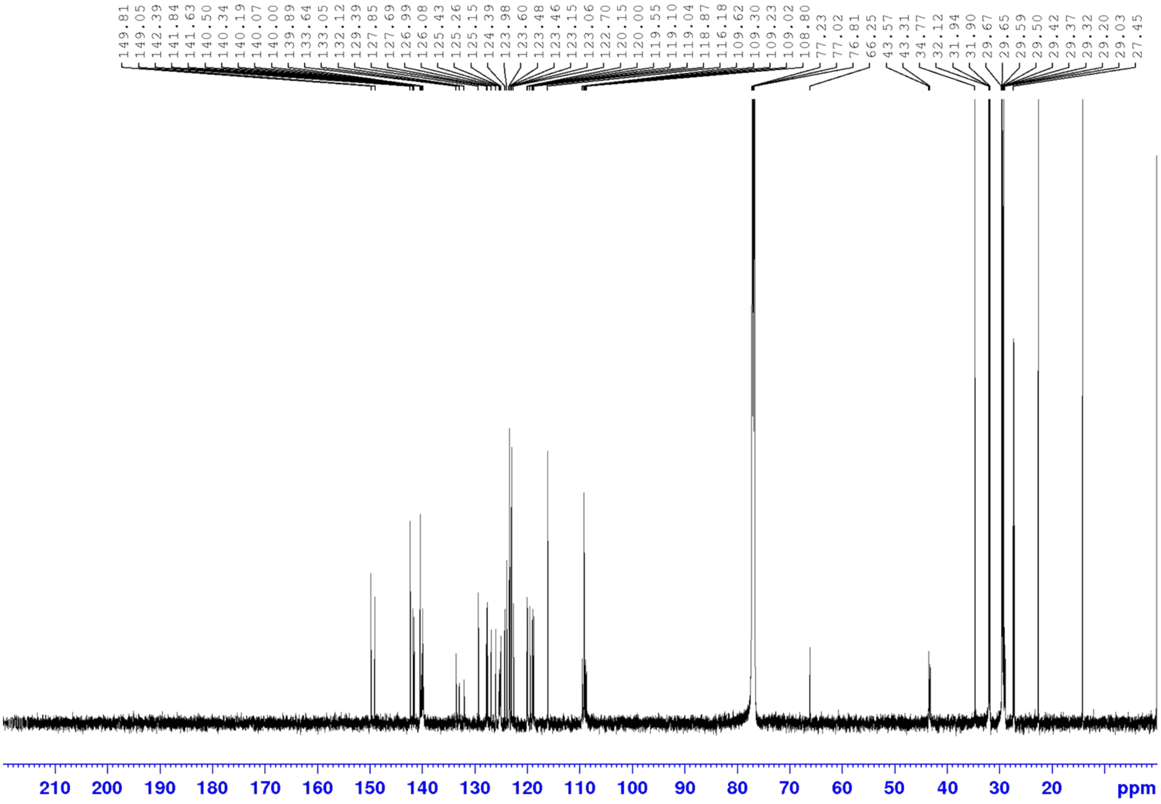
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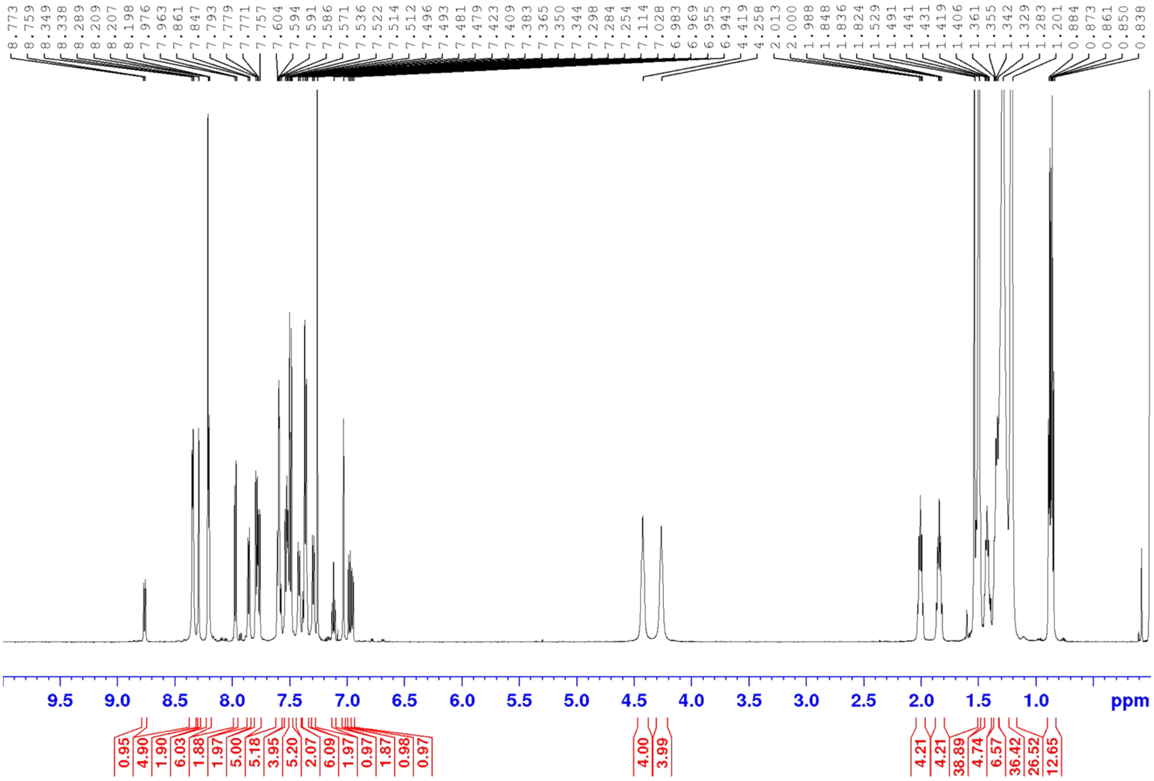
2,7-CSBF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7.591
7.586
7.571
7.536
7.522
7.514
7.512
7.496
7.493
7.481
7.479
7.423
7.409
7.383
7.365
7.350
7.344
7.298
7.284
7.254
7.114
7.028
6.983
6.969
6.955
6.943
4.419
4.258
2.013
2.000
1.988
1.848
1.836
1.824
1.529
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1.441
1.431
1.419
1.406
1.361
1.355
1.342
1.329
1.283
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0.861
0.850
0.838
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8.5
8.0
7.5
7.0
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
ppm
0.95
4.90
1.90
6.03
1.88
1.97
5.00
5.18
3.95
5.20
2.07
6.09
1.97
0.97
1.87
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3.99
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4.21
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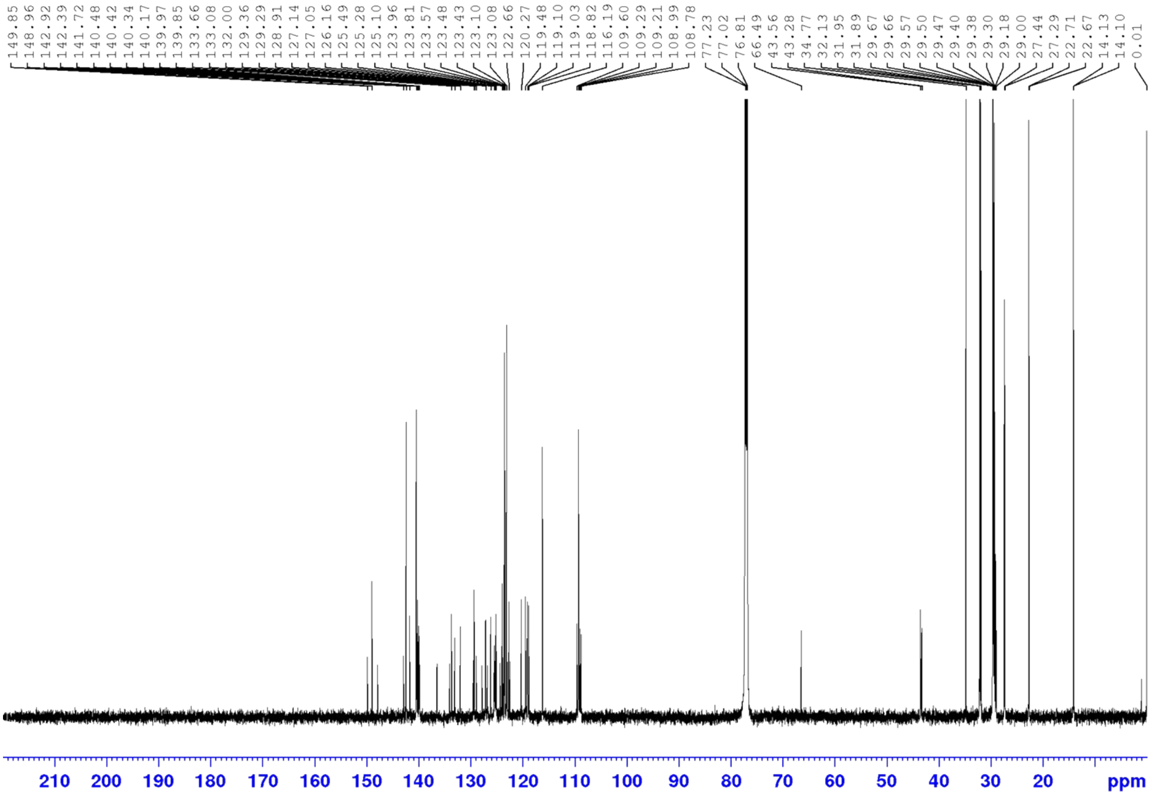
6.57
36.42
26.52
12.65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133.66
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132.00
129.36
129.29
128.91
127.14
127.05
126.16
125.49
125.28
125.10
123.96
123.81
123.57
123.48
123.43
123.10
123.08
122.66
120.27
119.48
119.10
119.03
118.82
116.19
109.60
109.29
109.21
108.99
108.78
77.23
77.02
76.81
66.49
43.56
43.28
34.77
32.13
31.95
31.89
29.67
29.66
29.57
29.50
29.47
29.40
29.38
29.30
29.18
29.00
27.44
27.29
22.71
22.67
14.13
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0.01
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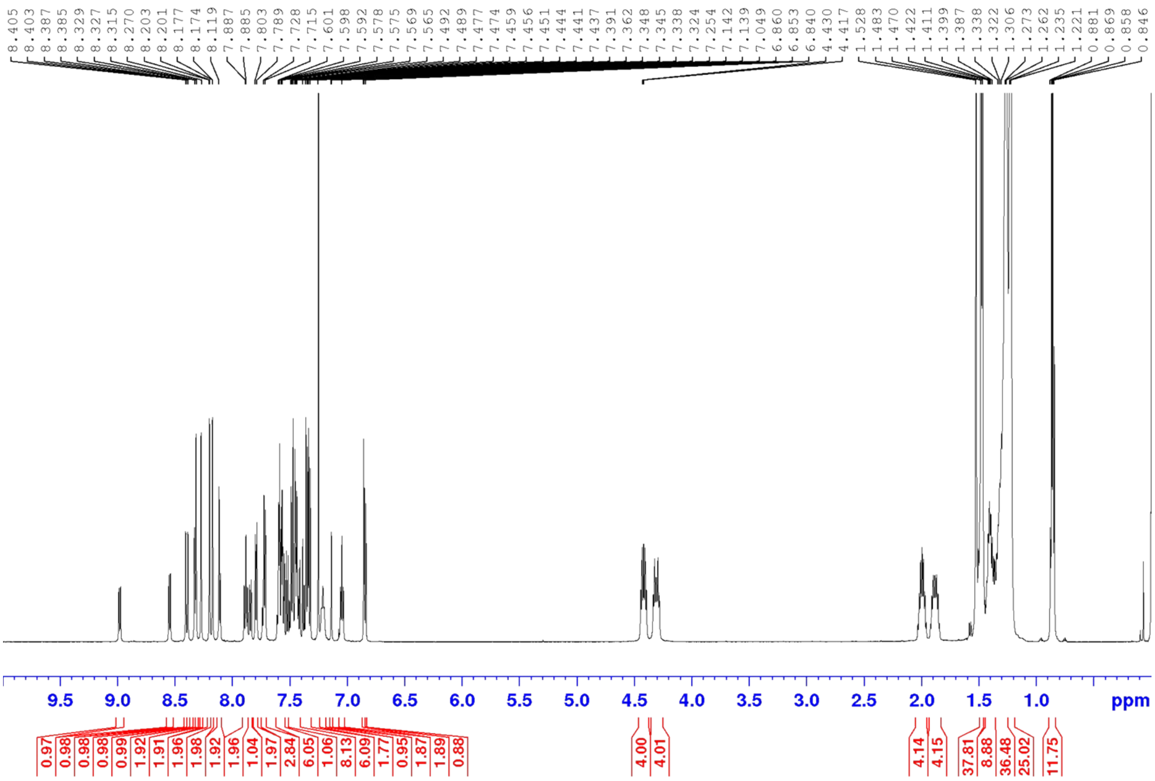
ppm

5,9-CSBF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8.119
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7.885
7.803
7.789
7.728
7.715
7.601
7.598
7.592
7.578
7.575
7.569
7.565
7.492
7.489
7.477
7.474
7.459
7.456
7.451
7.444
7.441
7.437
7.391
7.362
7.348
7.345
7.338
7.324
7.254
7.142
7.139
7.049
6.860
6.853
6.840
4.430
4.417
1.528
1.483
1.470
1.422
1.411
1.399
1.387
1.338
1.322
1.306
1.273
1.262
1.235
1.221
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0.858
0.846
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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
ppm
0.97
0.98
0.98
0.98
0.99
1.92
1.91
1.96
1.98
1.92
1.96
1.04
1.97
2.84
6.05
1.06
8.13
6.09
1.77
0.95
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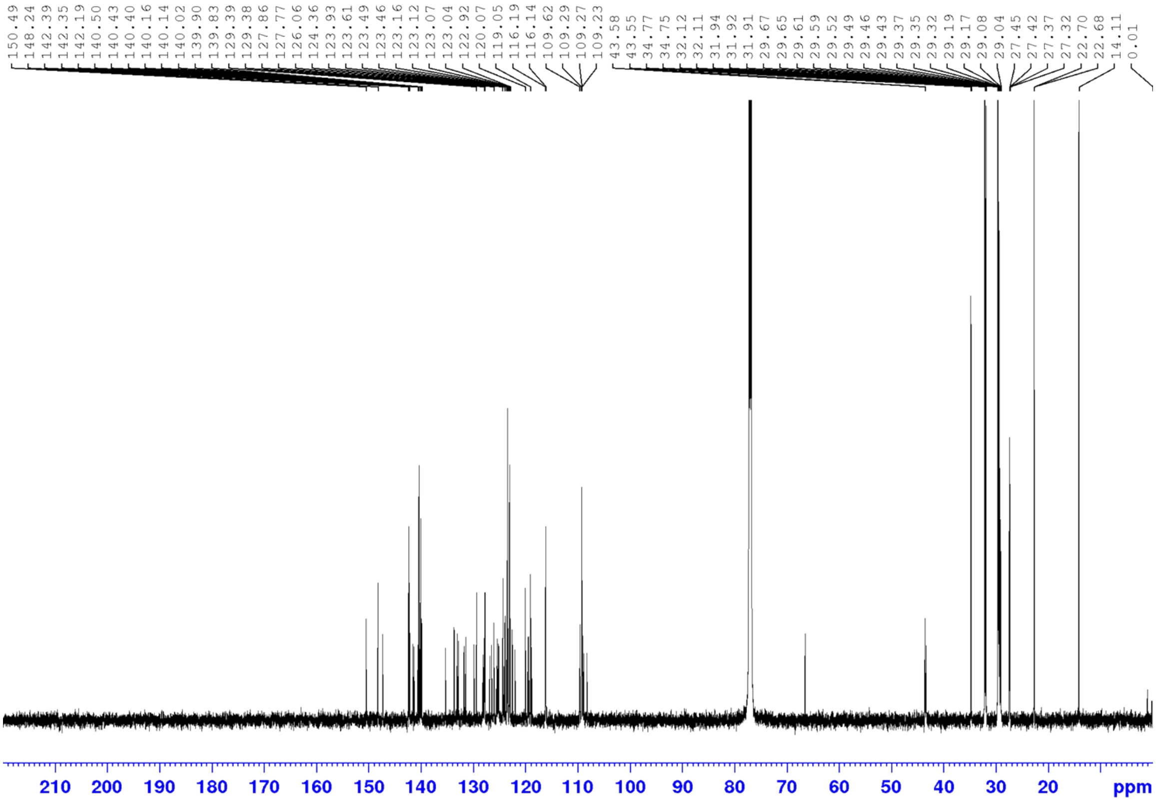
8.88
36.48
25.02
11.75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140.50
140.43
140.40
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140.14
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139.90
139.83
129.39
129.38
127.86
127.77
126.06
124.36
123.93
123.61
123.49
123.46
123.16
123.12
123.07
123.04
122.92
120.07
119.05
116.19
116.14
109.62
109.29
109.27
109.23
43.58
43.55
34.77
34.75
32.12
32.11
31.94
31.92
31.91
29.67
29.65
29.61
29.59
29.52
29.49
29.46
29.43
29.37
29.35
29.32
29.19
29.17
29.08
29.04
27.45
27.42
27.37
27.32
22.70
22.68
14.11
0.01
210
200
190
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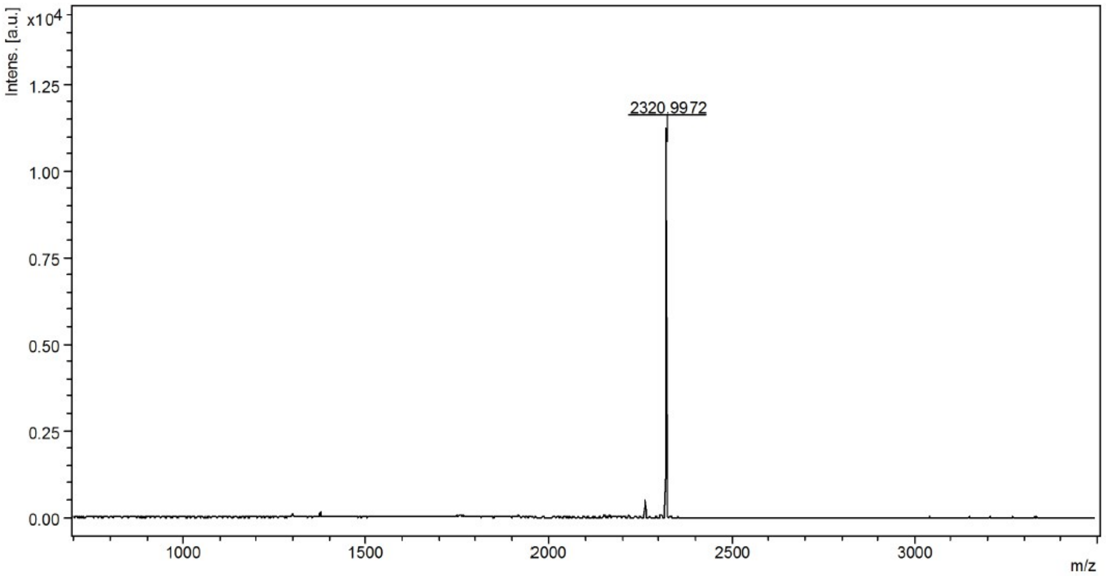
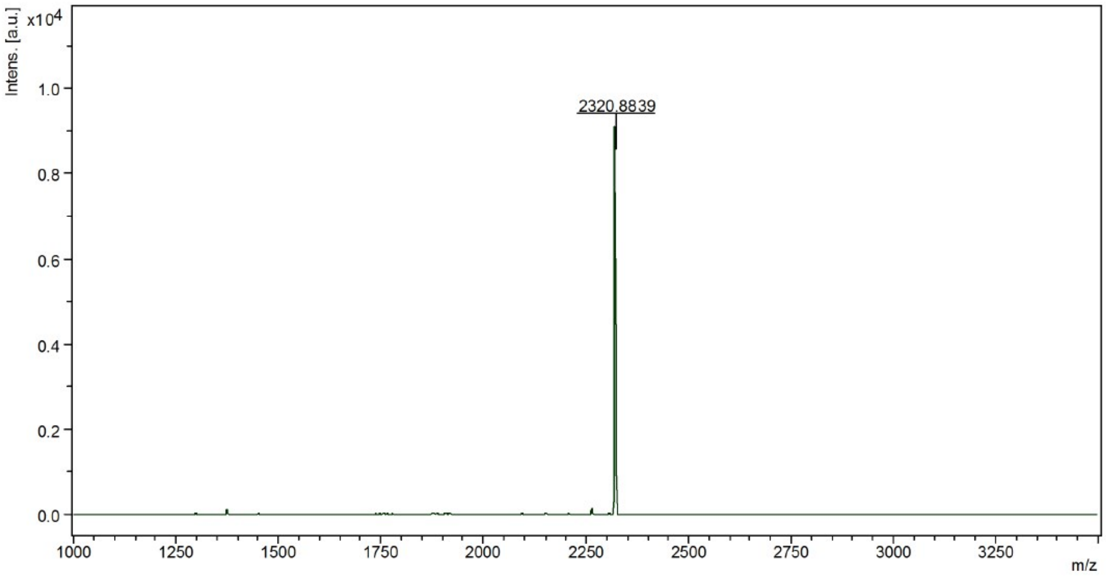
130
120
110
100
90
80
70
60
50
40
30
20
ppm

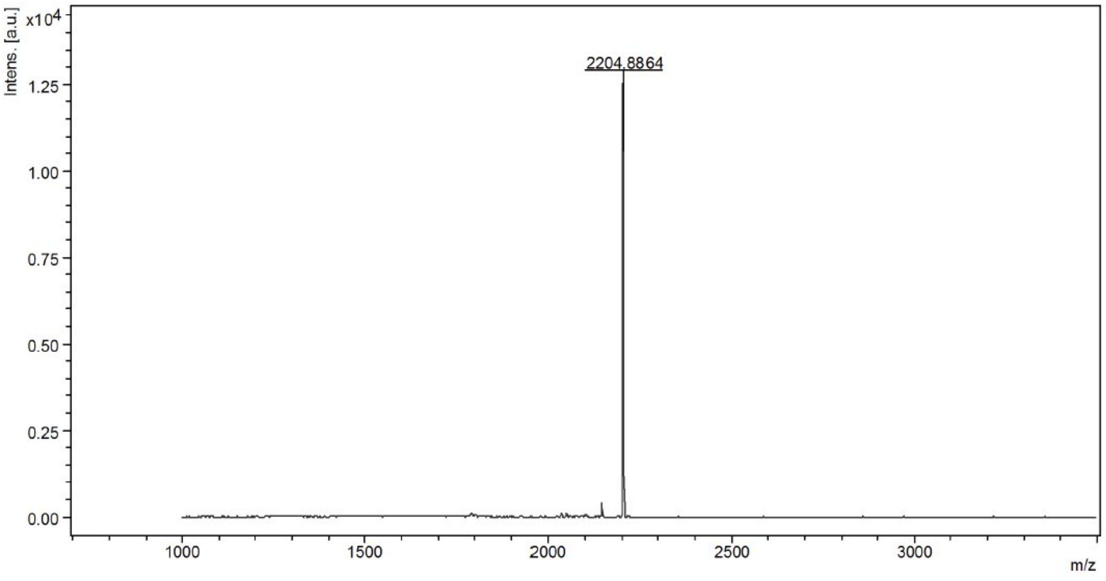
2,7-CSFX



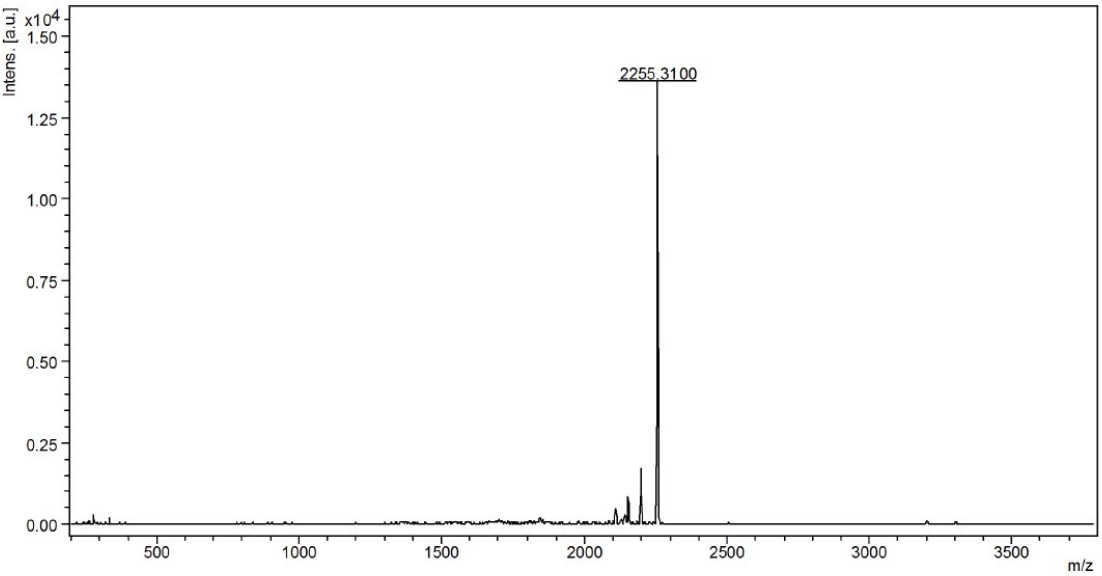
3,6-CSFX



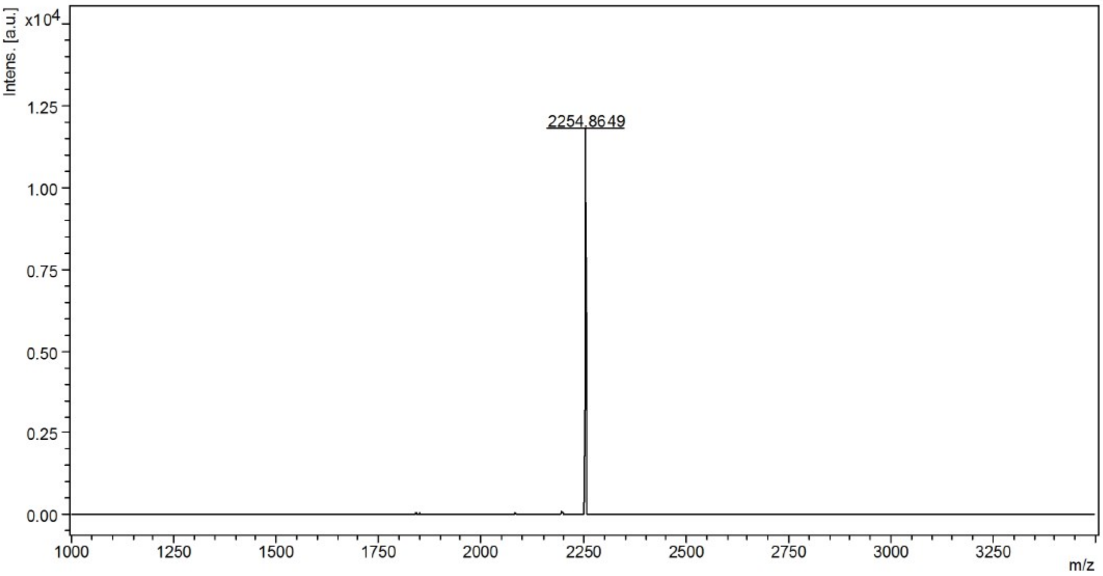
2,7-CSF



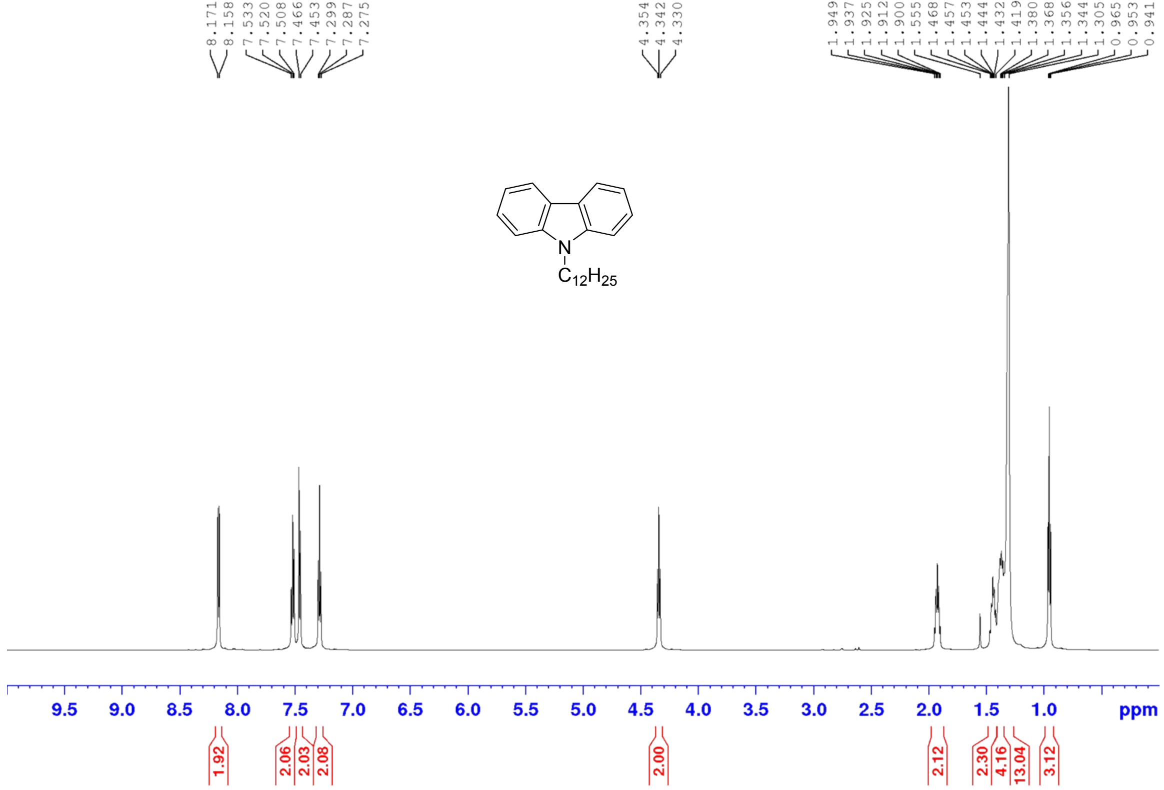
5,9-CSBF



2,7-CSBF



Compound 2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7.466
7.453
7.299
7.287
7.275
4.354
4.342
4.330
1.949
1.937
1.925
1.912
1.900
1.555
1.468
1.457
1.453
1.444
1.432
1.419
1.380
1.368
1.356
1.344
1.305
0.965
0.953
0.941
N
C12H25
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
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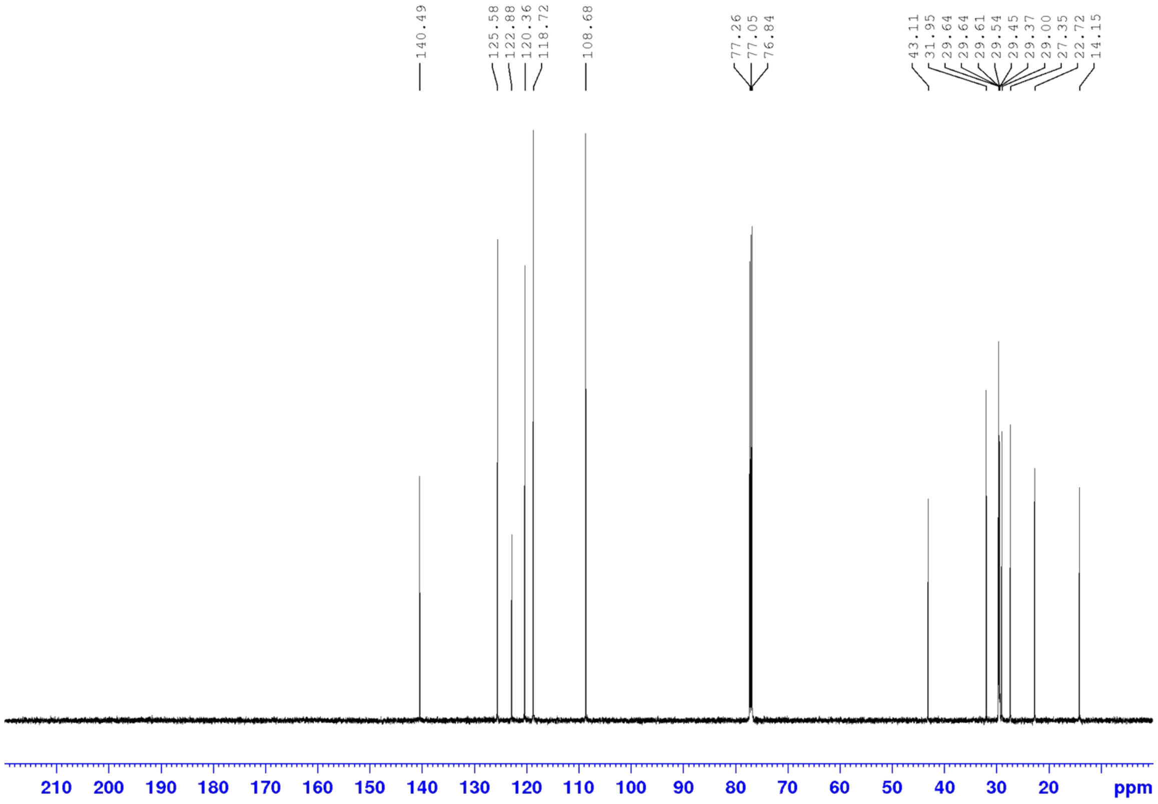
2.06
2.03
2.08
2.00
2.12
2.30
4.16
13.04
3.12


140.49
125.58
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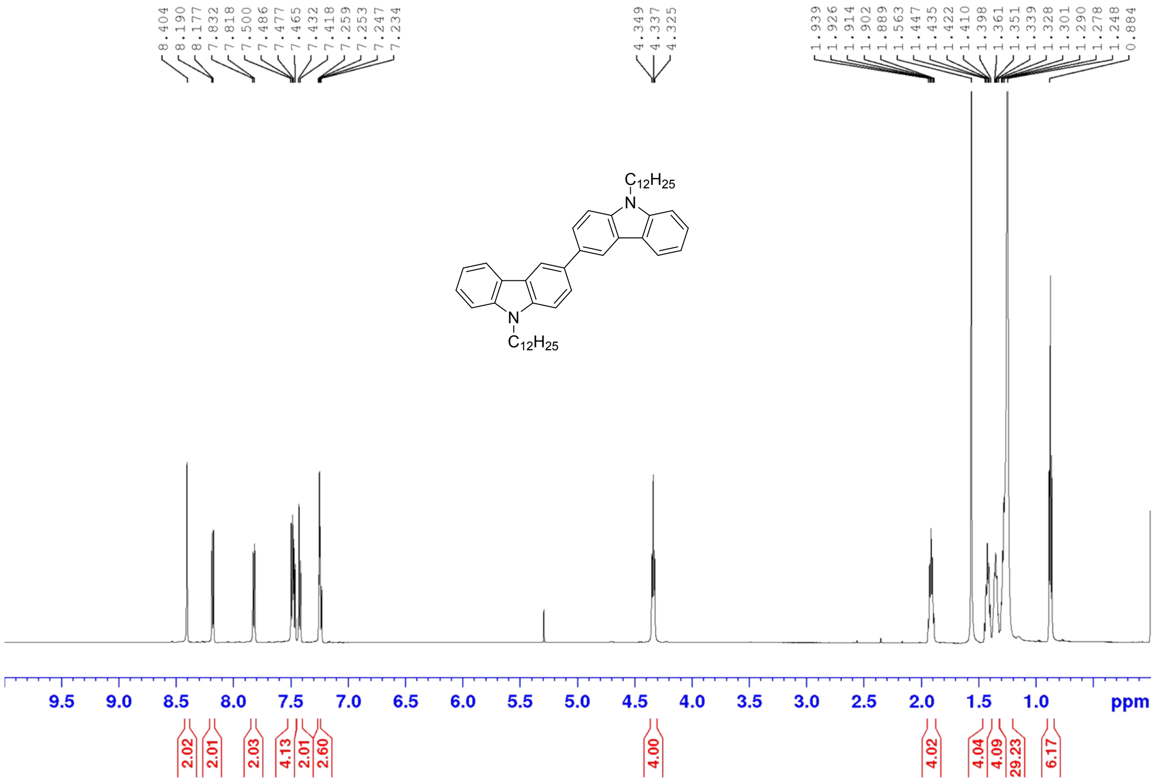
118.72
108.68
77.26
77.05
76.84
43.11
31.95
29.64
29.64
29.61
29.54
29.45
29.37
29.00
27.35
22.72
14.15
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

Compound 3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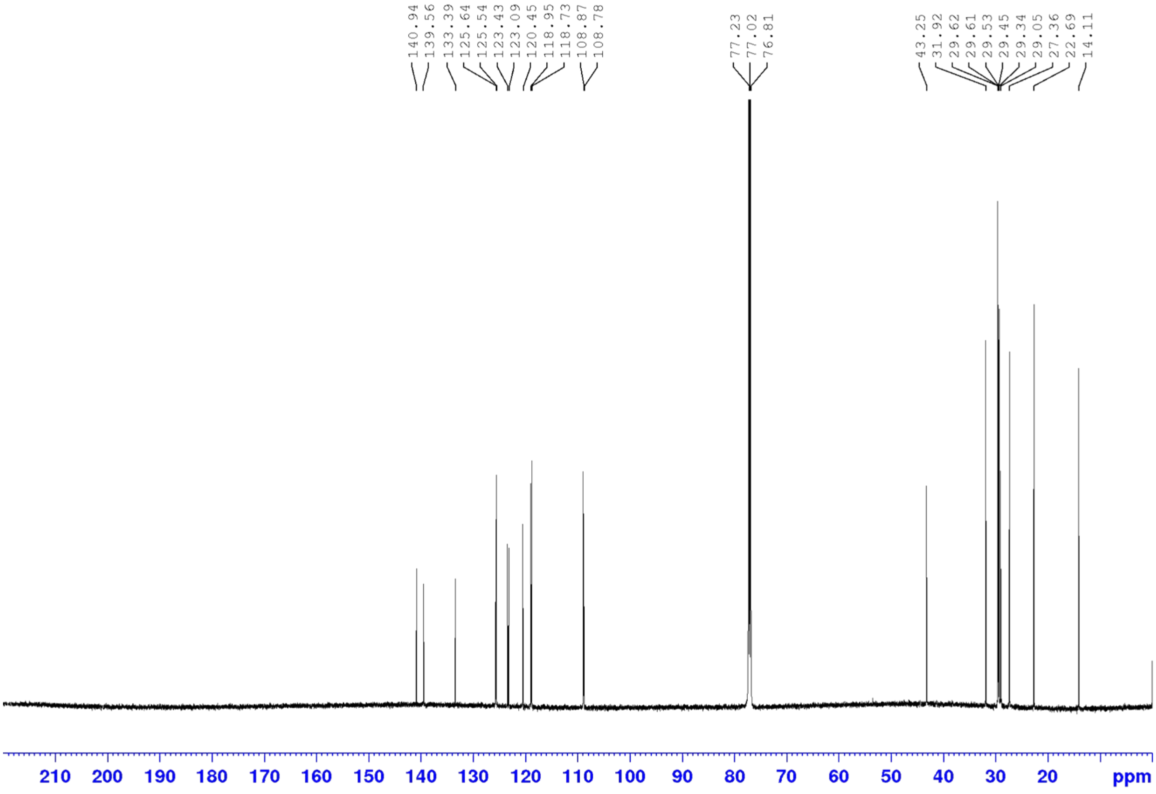
7.818
7.500
7.486
7.477
7.465
7.432
7.418
7.259
7.253
7.247
7.234
4.349
4.337
4.325
1.939
1.926
1.914
1.902
1.889
1.563
1.447
1.435
1.422
1.410
1.398
1.361
1.351
1.339
1.328
1.301
1.290
1.278
1.248
0.884
C12H25
N
N
C12H25
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
ppm
2.02
2.01
2.03
4.13
2.01
2.60
4.00
4.02
4.04
4.09
29.23
6.17


140.94
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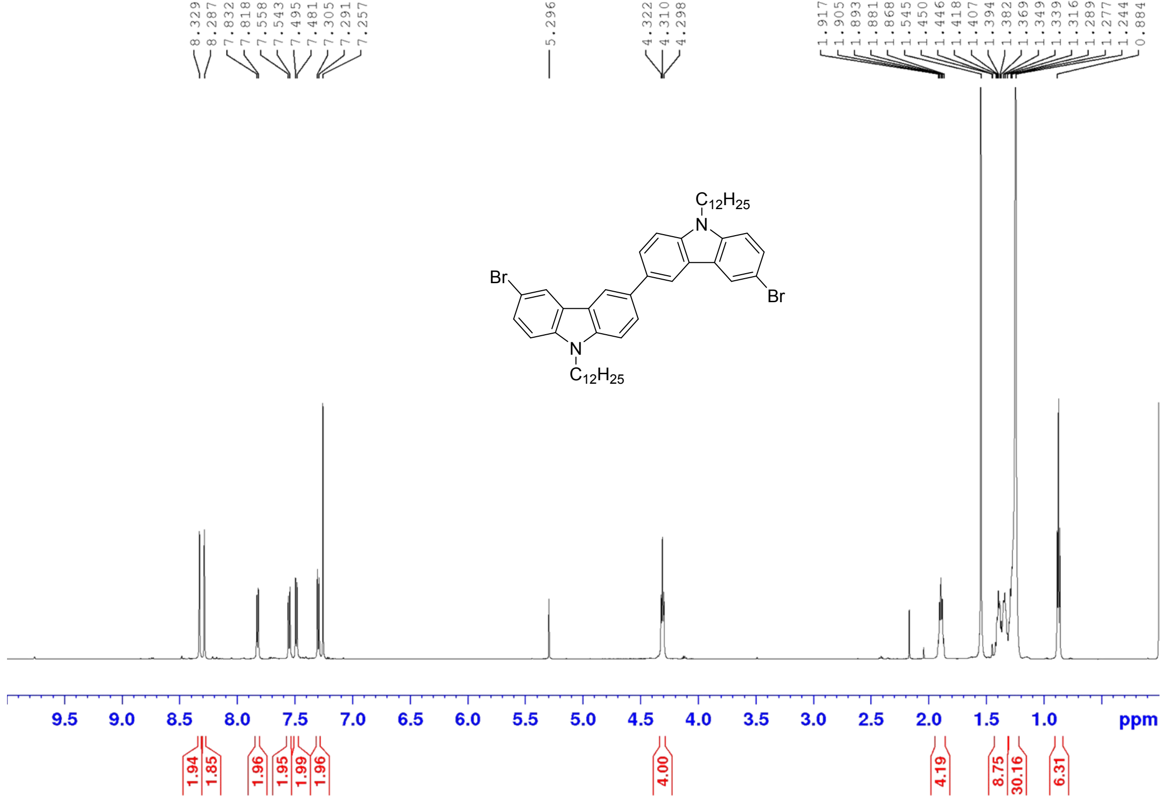
125.64
125.54
123.43
123.09
120.45
118.95
118.73
108.87
108.78
77.23
77.02
76.81
43.25
31.92
29.62
29.61
29.53
29.45
29.34
29.05
27.36
22.69
14.11
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

Compound 4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7.558
7.543
7.495
7.481
7.305
7.291
7.257
5.296
4.322
4.310
4.298
1.917
1.905
1.893
1.881
1.868
1.545
1.450
1.446
1.418
1.407
1.394
1.382
1.369
1.349
1.339
1.316
1.289
1.277
1.244
0.884
Br
Br
N
N
$C_{12}H_{25}$
$C_{12}H_{25}$
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
ppm
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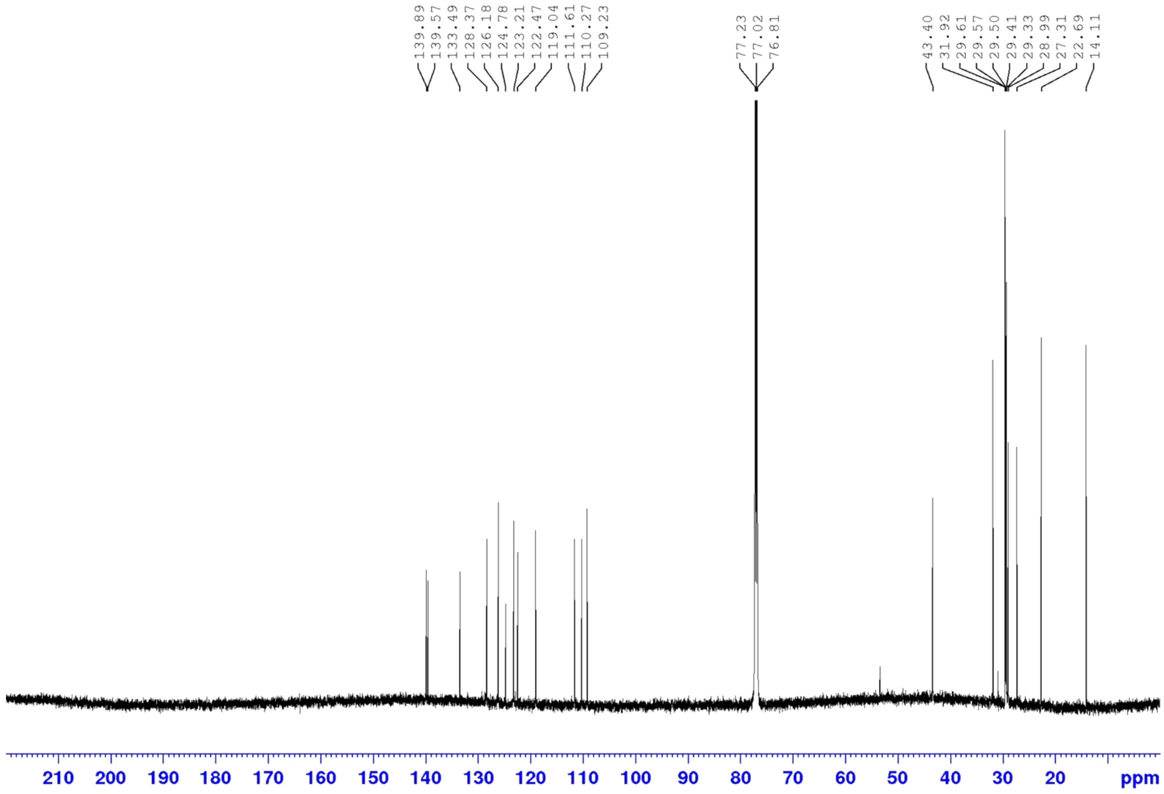
1.85
1.96
1.95
1.99
1.96
4.00
4.19
8.75
30.16
6.31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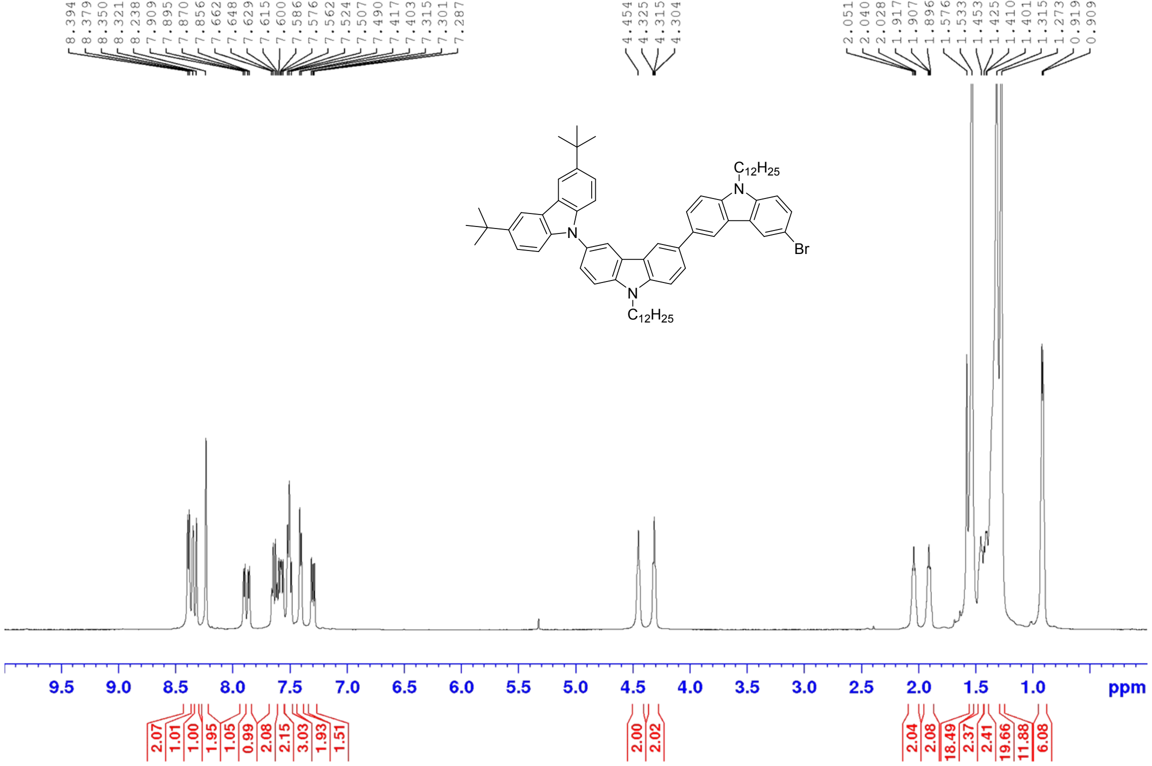
139.57
133.49
128.37
126.18
124.78
123.21
122.47
119.04
111.61
110.27
109.23
77.23
77.02
76.81
43.40
31.92
29.61
29.57
29.50
29.41
29.33
28.99
27.31
22.69
14.11
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

Compound 5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7.895
7.870
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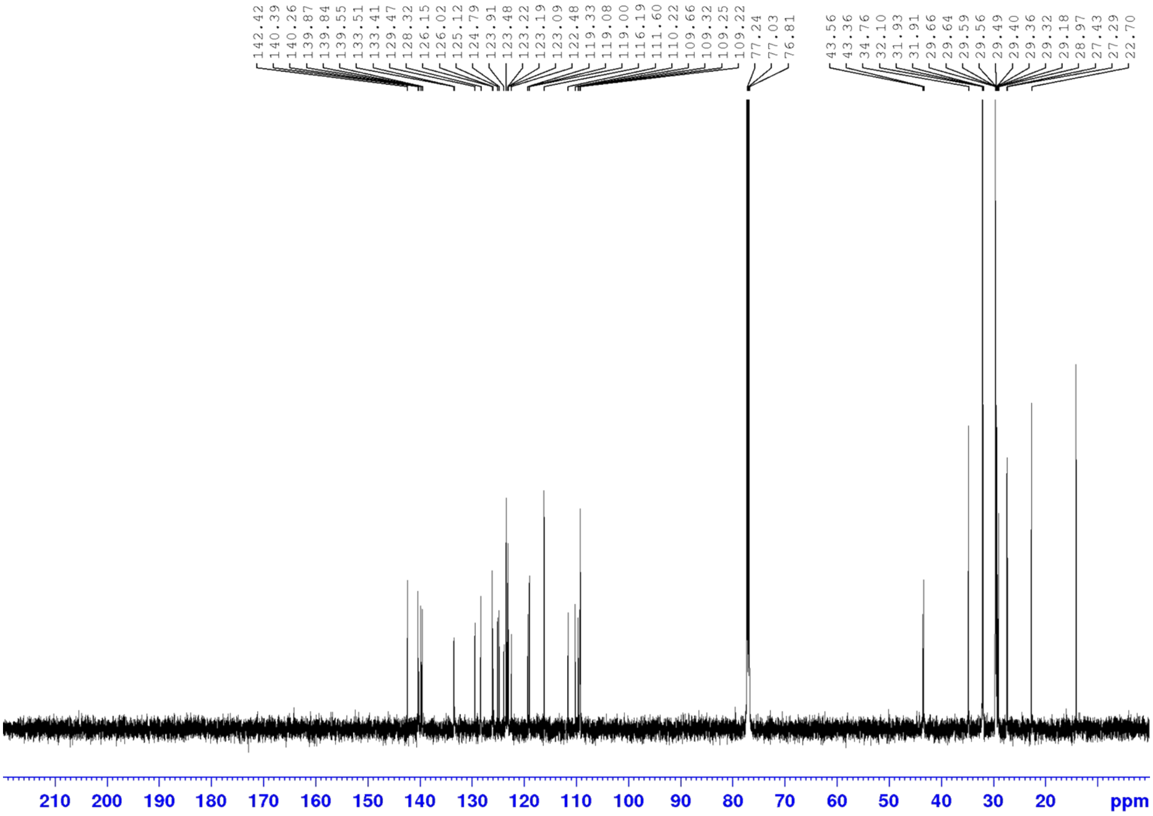
7.662
7.648
7.629
7.615
7.600
7.586
7.576
7.562
7.524
7.507
7.490
7.417
7.403
7.315
7.301
7.287
4.454
4.325
4.315
4.304
2.051
2.040
2.028
1.917
1.907
1.896
1.576
1.533
1.453
1.425
1.410
1.401
1.315
1.273
0.919
0.909
$C_{12}H_{25}$
N
N
N
Br
$C_{12}H_{25}$
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
ppm
2.07
1.01
1.00
1.95
1.05
0.99
2.08
2.15
3.03
1.93
1.51
2.00
2.02
2.04
2.08
18.49
2.37
2.41
19.66
11.88
6.08


142.42
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140.26
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139.84
139.55
133.51
133.41
129.47
128.32
126.15
126.02
125.12
124.79
123.91
123.48
123.22
123.19
123.09
122.48
119.33
119.08
119.00
116.19
111.60
110.22
109.66
109.32
109.25
109.22
77.24
77.03
76.81
43.56
43.36
34.76
32.10
31.93
31.91
29.66
29.64
29.59
29.56
29.49
29.40
29.36
29.32
29.18
28.97
27.43
27.29
22.70
210
200
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150
140
130
120
110
100
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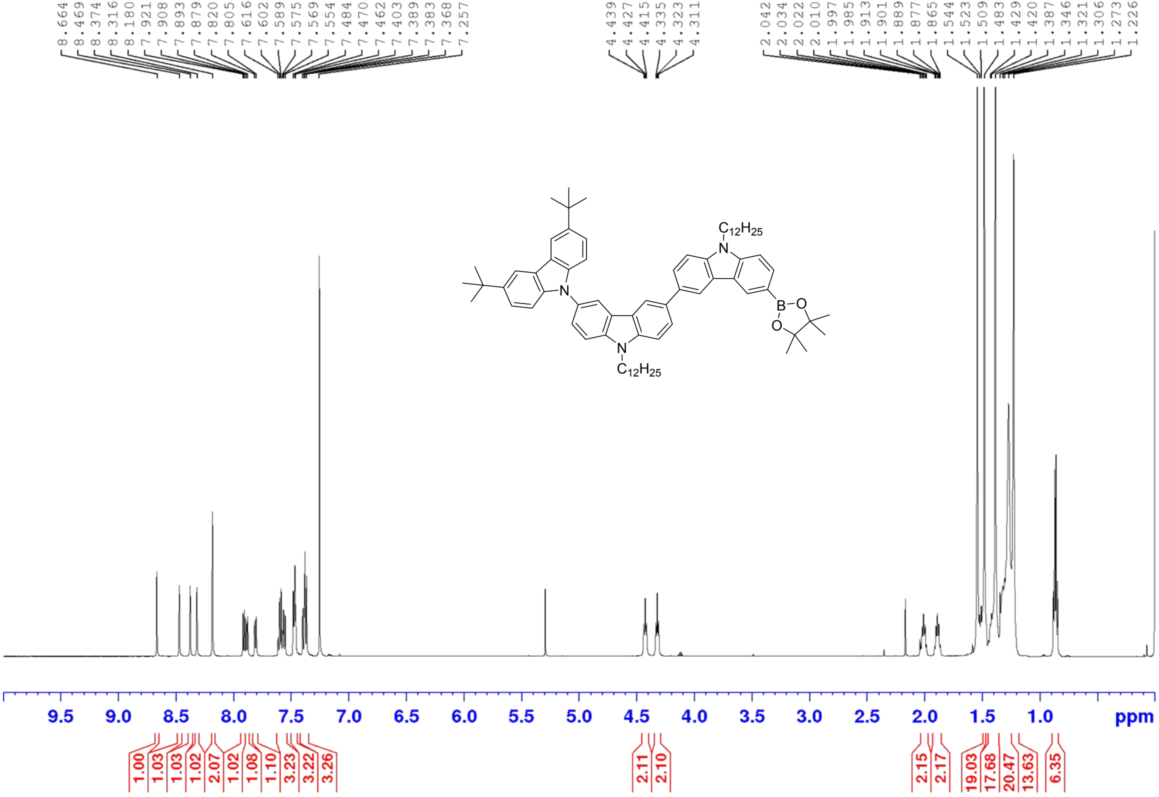
80
70
60
50
40
30
20
ppm

Compound 6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7.893
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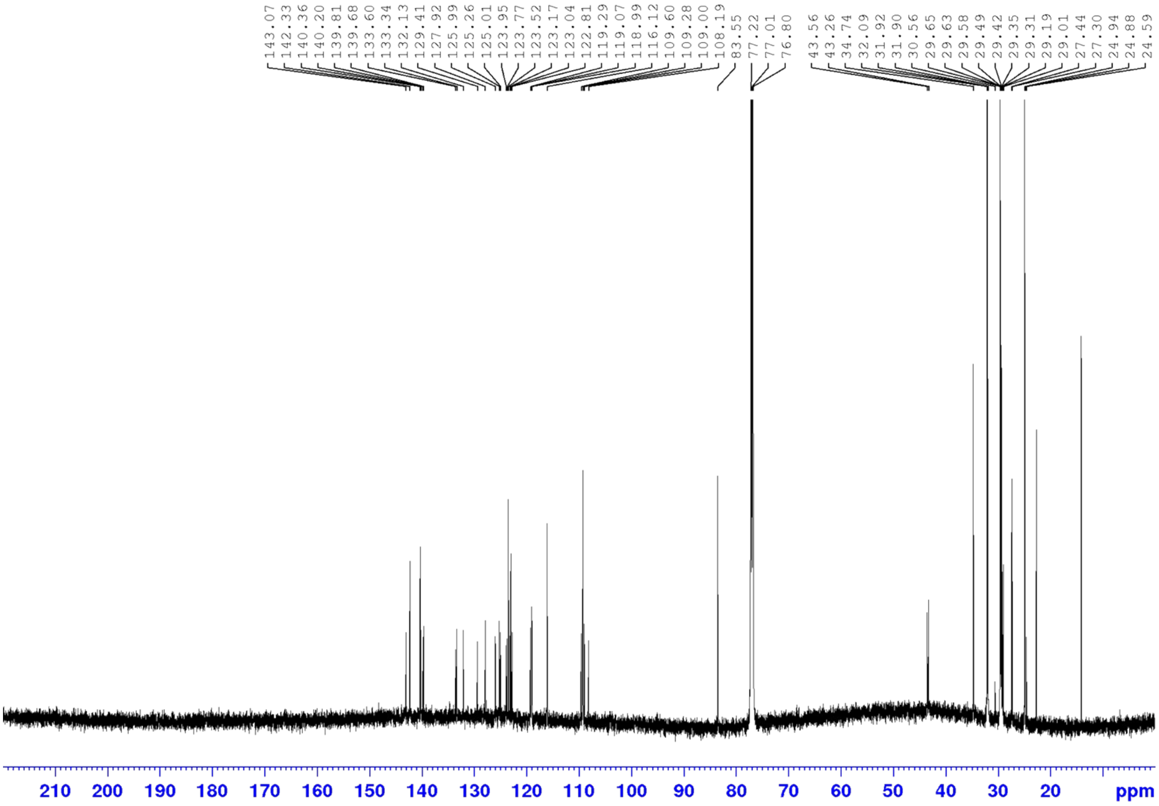
7.820
7.805
7.616
7.602
7.589
7.575
7.569
7.554
7.484
7.470
7.462
7.403
7.389
7.383
7.368
7.257
4.439
4.427
4.415
4.335
4.323
4.311
2.042
2.034
2.022
2.010
1.997
1.985
1.913
1.901
1.889
1.877
1.865
1.544
1.523
1.509
1.483
1.429
1.420
1.387
1.346
1.321
1.306
1.273
1.226
C12H25
N
N
N
B
O
O
C12H25
9.5
9.0
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
ppm
1.00
1.03
1.03
1.02
2.07
1.02
1.08
1.10
3.23
3.22
3.26
2.11
2.10
2.15
2.17
19.03
17.68
20.47
13.63
6.35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140.36
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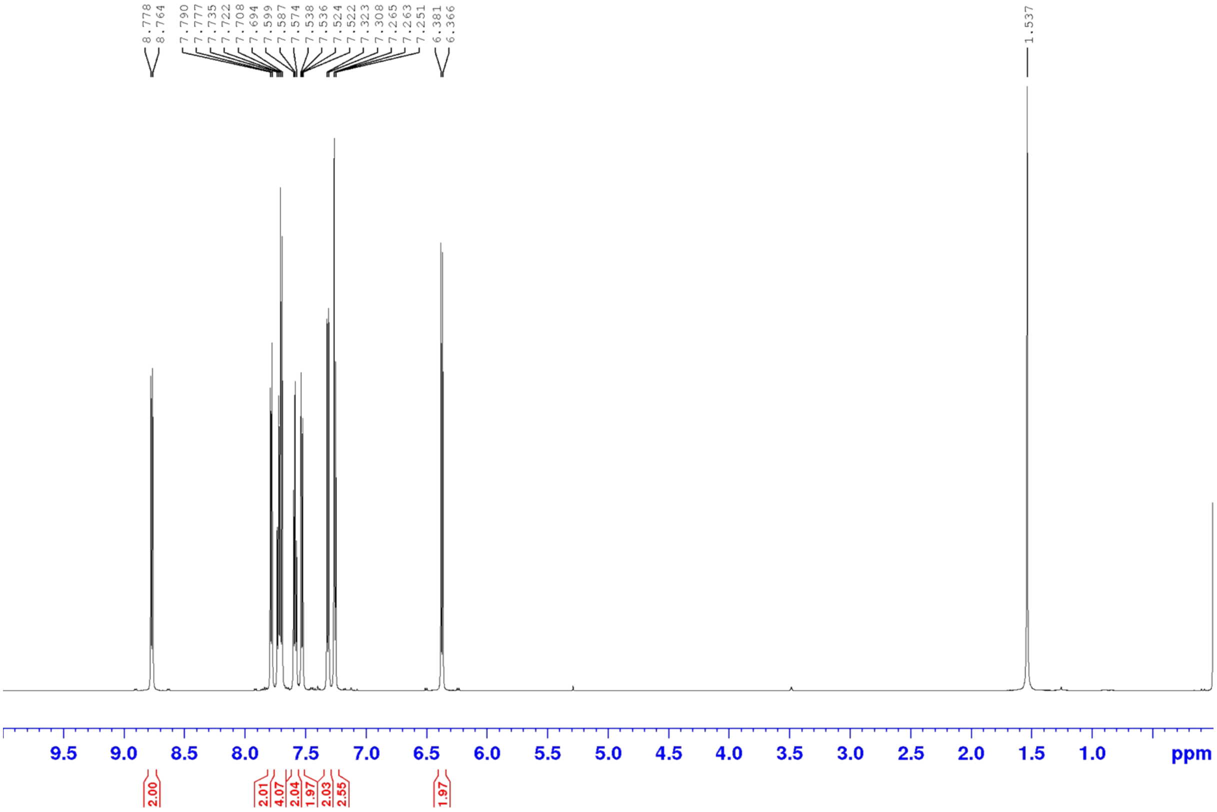
139.81
139.68
133.60
133.34
132.13
129.41
127.92
125.99
125.26
125.01
123.95
123.77
123.52
123.17
123.04
122.81
119.29
119.07
118.99
116.12
109.60
109.28
109.00
108.19
83.55
77.22
77.01
76.80
43.56
43.26
34.74
32.09
31.92
31.90
30.56
29.65
29.63
29.58
29.49
29.42
29.35
29.31
29.19
29.01
27.44
27.30
24.94
24.88
24.59
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

Compound 9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7.694
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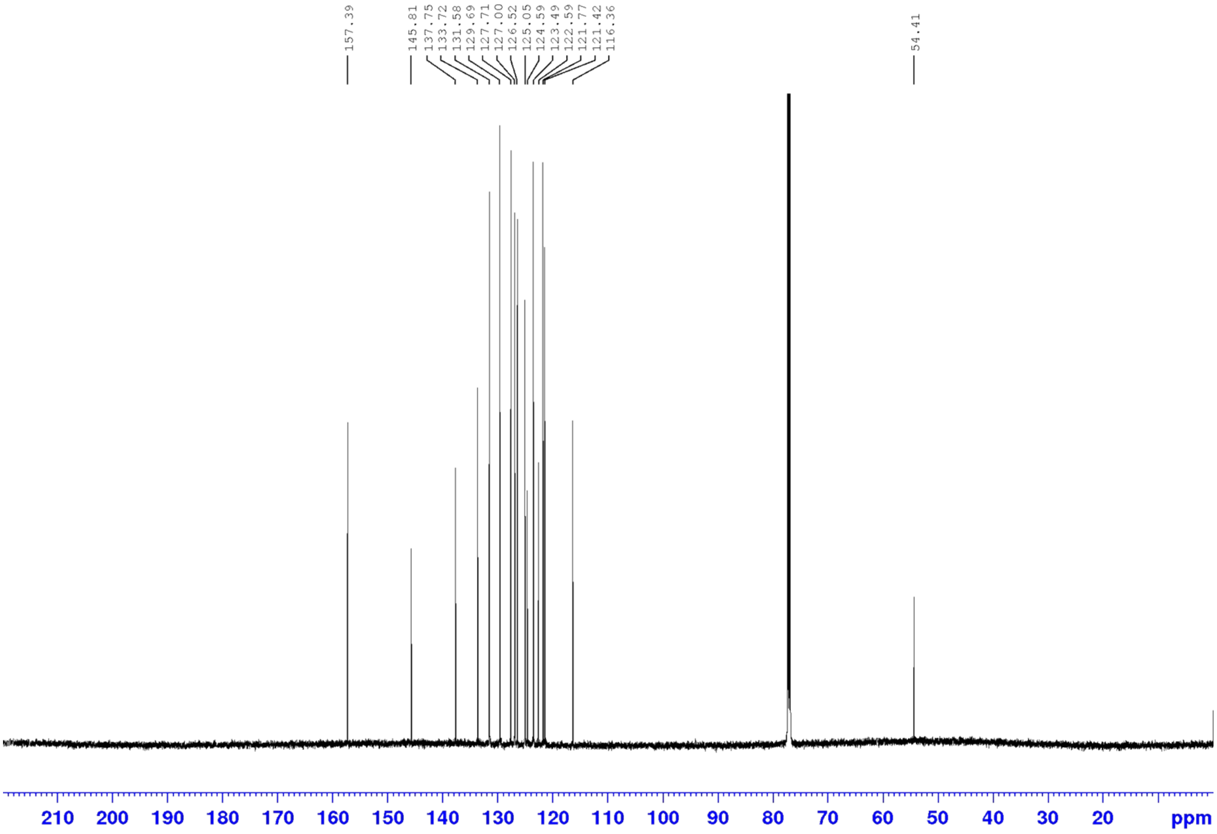
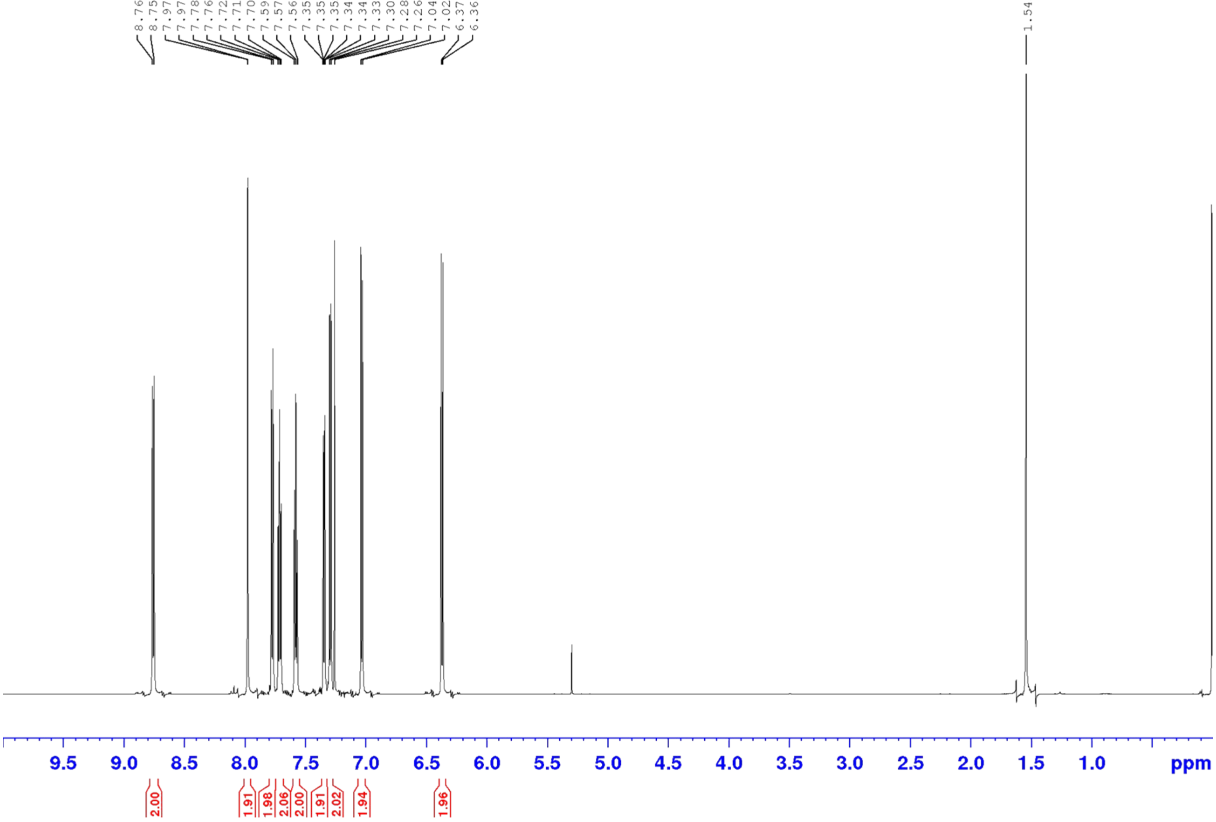
7.587
7.574
7.538
7.536
7.524
7.522
7.323
7.308
7.265
7.263
7.251
6.381
6.366
1.537
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
ppm
2.00
2.01
4.07
2.04
1.97
2.03
2.55
1.97


157.39
145.81
137.75
133.72
131.58
129.69
127.71
127.00
126.52
125.05
124.59
123.49
122.59
121.77
121.42
116.36
54.41
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

Compound 10


8.765
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7.979
7.977
7.781
7.768
7.726
7.714
7.701
7.591
7.579
7.566
7.354
7.354
7.352
7.341
7.340
7.339
7.302
7.288
7.260
7.041
7.027
6.378
6.363
1.543
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
ppm
2.00
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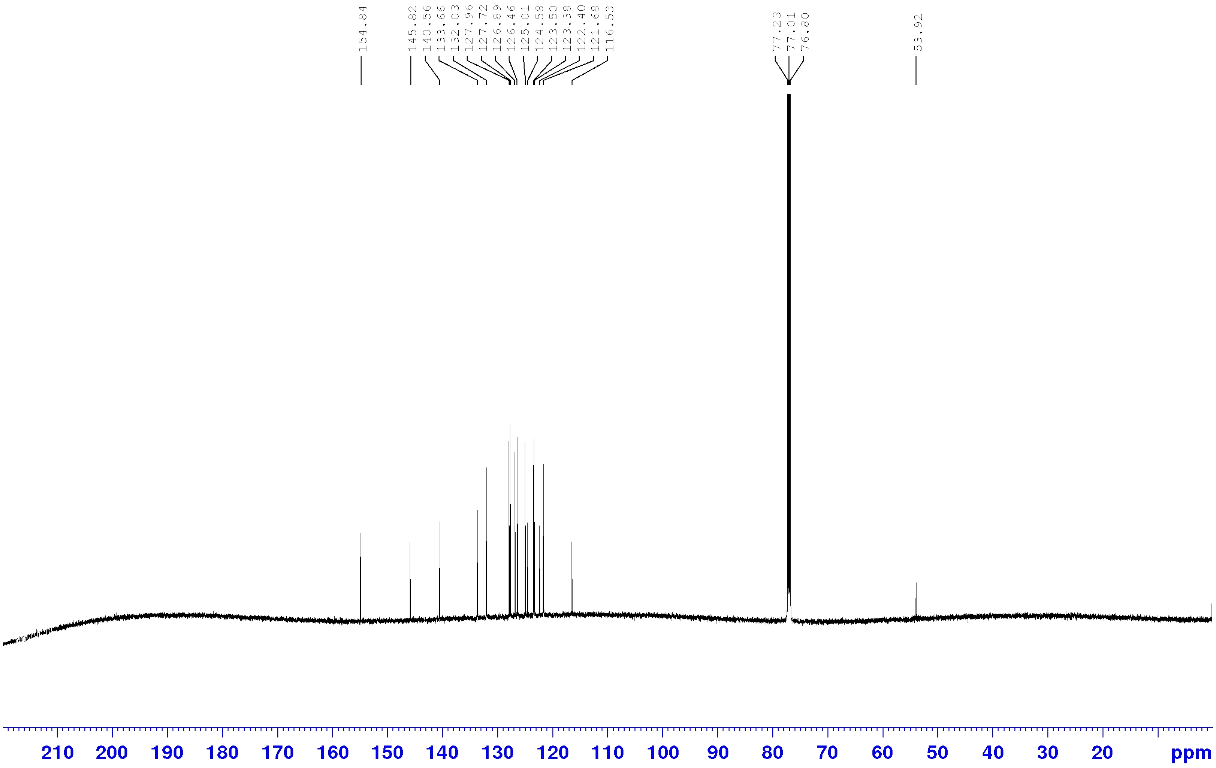
1.98
2.06
2.00
1.91
2.02
1.94
1.96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122.40
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116.53
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77.01
76.80
53.92
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
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20
ppm