Supporting Information

Efficient synthesis of 1,5-disubstituted carbohydrazones using K_2CO_3 as carbonyl donor

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General information:

All reagents were purchased from commercial suppliers and used without fuether purification. Solvents were freshly distilled prior to use. ^{1}H-NMR, ^{13}C-NMR spectra were measured on a Bruker AM400 NMR spectrometer (400 MHz or 100MHz, respectively) with *d6*-DMSO as solvent. ESI-MS spectral data were recorded on a Finnigan LCQDECA mass spectrometer.

General procedure for the sulfonylhydrazones.

To a rapidly stirred suspension of sulfonylhydrazide (2.5 mmol) in methanol (10 mL) was added aldehyde or ketone (2 mmol) dropwise (added as a methanol solution). When ketone was used, concentrated hydrochloric acid (0.1 ml) was added to reaction medium. After reflux for 1 hour, the mixture was cooled to 0 °C. The crystalline precipitate was collected by filtration, washed with a small quantity of methanol, dried in vacuo.

General procedure for the carbonylation of various tosylhydrazone derivatives

A reflux tube equipped with a magnetic stir bar charged with tosylhydrazone (0.5mmol), K_2CO_3 (0.75 mmol), diethyl phosphite (0.5 mmol), DMSO (2 mL), and the reaction vessel was placed in a 60ºC oil bath. After stirring at this temperature for 10 h, the reaction mixture was then allowed to cool to ambient temperature, and diluted with 20 mL of ethyl acetate, and washed with brine (15 mL), water (15 mL), and then the organic layer was dried over Na_2SO_4. After concentrated in vacuo, the crude product was purified by column chromatography (column-layer chromatographic silica gel, 37-54μm, CH_2Cl_2/EtOAc = 5/1). The identity and purity of the known product was confirmed by ^{1}H-NMR, ^{13}C-NMR and ESI-MS.

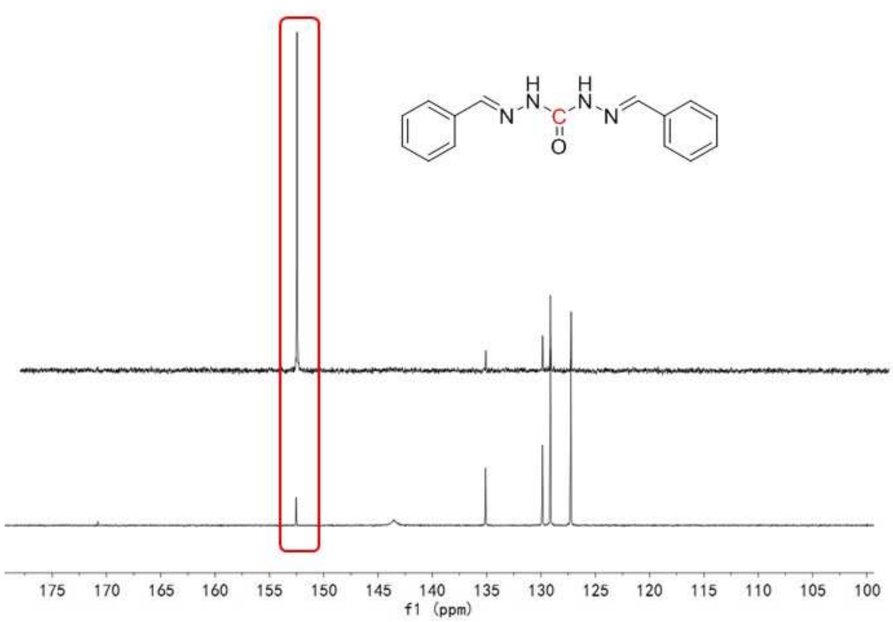
General procedure for one-pot carbonylation reactions

A reflux tube equipped with a magnetic stir bar charged with aldehyde (0.5mmol), tosyl hydrazide (0.6mmol), K_2CO_3 (0.75 mmol), diethyl phosphite (0.5 mmol), DMSO (2 mL), and the reaction vessel was placed in a 60ºC oil bath. After stirring at this temperature for 10 h, the reaction mixture was then allowed to cool to ambient temperature, and diluted with 20 mL of ethyl acetate, and washed with brine (15 mL), water (15 mL), and then the organic layer was dried over Na_2SO_4. After concentrated in vacuo, the crude product was purified by column chromatography (column-layer chromatographic silica gel, 37-54μm, CH_2Cl_2/EtOAc = 5/1). The identity and purity of the known product was confirmed by ^{1}H-NMR, ^{13}C-NMR and ESI-MS.

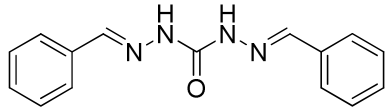
Investigation of carbonylation reaction using K_2CO_3–^{13}C as the base

A reflux tube equipped with a magnetic stir bar charged with tosylhydrazone **1a** (0.5mmol), K_2CO_3-^{13}C (0.75 mmol), diethyl phosphite (0.5 mmol), DMSO (2 mL), and the reaction vessel was placed in a 60ºC oil bath. After stirring at this temperature for 10 h, the reaction mixture was then allowed to cool to ambient temperature, and diluted with 20 mL of ethyl acetate, and washed with brine (15 mL), water (15 mL), and then the organic layer was dried over Na_2SO_4. After concentrated in vacuo, the crude product was purified by column chromatography (column-layer chromatographic silica gel, 37-54μm, CH_2Cl_2/EtOAc = 5/1). The isolated product was monitored by ^{13}C-NMR.

Figure S1: The ^{13}C-NMR spectrum contrast of carbonylation product using different K_2CO_3

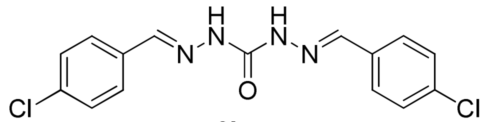


Spectroscopic data of products



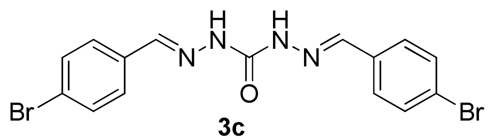
3a

White solid, ^{1}H-NMR (400 MHz, *d6*-DMSO) δ= 10.72 (s, 2H), 8.21 (s, 2H), 7.75-7.77 (d, J=7.2, 4H), 7.39-7.46 (m, 6H). ^{13}C-NMR (100 MHz, *d6*-DMSO), δ=152.5, 135.1, 129.8, 129.1, 127.2. HRMS (ESI): m/z = 289.1055 $[M+Na]^+$.



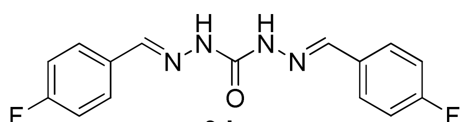
3b

White solid, ^{1}H-NMR (400 MHz, *d6*-DMSO) δ= 10.79 (s, 2H), 8.17 (s, 2H), 7.77-7.79 (d, J=8.4, 4H), 7.49-7.51 (d, J=8.4, 4H). ^{13}C-NMR (100 MHz, *d6*-DMSO), δ=152.3, 134.2, 134.0, 130.4, 129.2, 128.8. HRMS (ESI): m/z = 357.0253 $[M+Na]^+$.



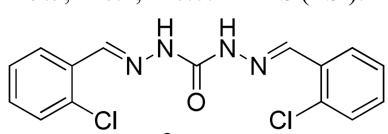
3c

White solid, ^{1}H-NMR (400 MHz, *d6*-DMSO) δ= 10.80 (s, 2H), 8.15 (s, 2H), 7.70-7.72 (d, J=8.4, 4H), 7.62-7.64 (d, J=8.4, 4H). ^{13}C-NMR (100 MHz, *d6*-DMSO), δ=152.3, 134.3, 132.1, 129.1, 123.0. HRMS (ESI): m/z = 444.9262 $[M+Na]^+$.



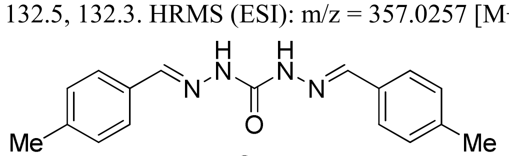
3d

White solid, ^{1}H-NMR (400 MHz, *d6*-DMSO) δ= 10.70 (s, 2H), 8.18 (s, 2H), 7.79-7.83 (m, 4H), 7.25-7.30 (m, 4H). ^{13}C-NMR (100 MHz, *d6*-DMSO), δ=164.4, 161.9, 152.5, 131.7, 131.6, 129.4, 129.3, 116.2, 116.0. HRMS (ESI): m/z = 325.0845 $[M+Na]^+$.



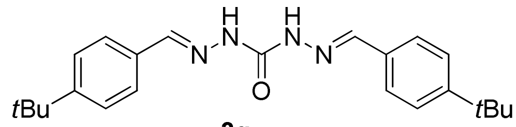
3e

White solid, ^{1}H-NMR (400 MHz, *d6*-DMSO) δ= 11.06 (s, 2H), 8.59 (s, 2H), 8.18 (s, 2H) 7.41-7.53 (m, 6H). ^{13}C-NMR (100 MHz, *d6*-DMSO), δ=157.1, 144.2, 137.8, 137.0, 136.0, 134.9, 132.5, 132.3. HRMS (ESI): m/z = 357.0257 $[M+Na]^+$.



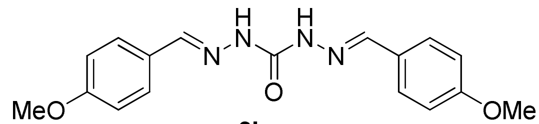
3f

White solid, ^{1}H-NMR (400 MHz, *d6*-DMSO) δ= 10.58 (s, 2H), 8.14 (s, 2H), 7.63-7.65 (d, J=8.0, 4H), 7.24-7.26 (d, J=8.0, 4H), 2.34 (s, 6H). ^{13}C-NMR (100 MHz, *d6*-DMSO), δ=152.5, 139.5, 132.4, 129.7, 127.2, 21.4. HRMS (ESI): m/z = 317.1330 $[M+Na]^+$.



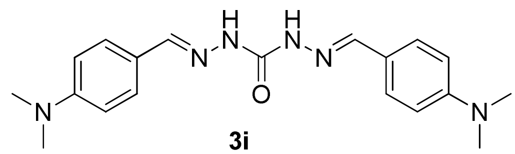
3g

colorless oil, ^{1}H-NMR (400 MHz, *d6*-DMSO) δ= 10.63 (s, 2H), 8.18 (s, 2H), 7.67-7.69 (d, J=8.4, 4H), 7.43-7.45 (d, J=8.4, 4H), 1.29 (s, 18H). ^{13}C-NMR (100 MHz, *d6*-DMSO), δ=152.5, 143.3, 132.4, 127.0, 125.8, 34.9, 31.4. HRMS (ESI): m/z = 401.2282 $[M+Na]^+$.



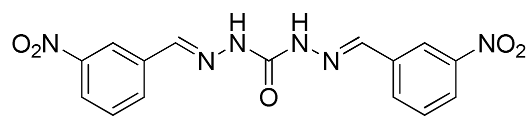
3h

White solid, ^{1}H-NMR (400 MHz, *d6*-DMSO) δ= 10.48 (s, 2H), 8.11 (s, 2H), 7.67-7.69 (d, J=8.4, 4H), 6.98-7.01 (d, J=8.8, 4H), 3.80 (s, 6H). ^{13}C-NMR (100 MHz, *d6*-DMSO), δ=160.7, 152.5, 128.7, 127.7, 114.6, 55.7. HRMS (ESI): m/z = 349.1243 $[M+Na]^+$.



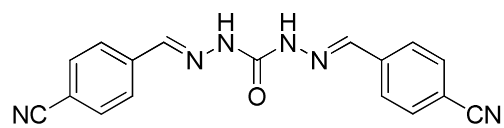
3i

Yellow solid, ^{1}H-NMR (400 MHz, *d6*-DMSO) δ= 10.23 (s, 2H), 8.02 (s, 2H), 7.53-7.55 (d, J=8.8, 4H), 6.73-6.75 (d, J=8.8, 4H), 2.96 (s, 12H). ^{13}C-NMR (100 MHz, *d6*-DMSO), δ=152.6, 151.5, 128.4, 122.7, 112.2, 40.3. HRMS (ESI): m/z =375.1868 $[M+Na]^+$.



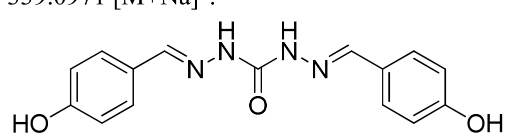
3j

Yellow solid, ^{1}H-NMR (400 MHz, *d6*-DMSO) δ= 11.21 (s, 2H), 8.60 (s, 2H), 8.27 (s, 2H), 8.04-8.06 (m, 2H), 7.79-7.83 (m, 2H), 7.62-7.67 (m, 2H). ^{13}C-NMR (100 MHz, *d6*-DMSO), δ=152.1, 148.4, 138.8, 133.9, 130.6, 129.2, 128.4, 124.9. HRMS (ESI): m/z = 379.0725 $[M+Na]^+$.



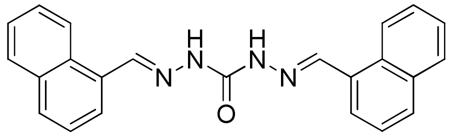
3k

White solid, ^{1}H-NMR (400 MHz, *d6*-DMSO) δ= 11.09 (s, 2H), 8.24 (s, 2H), 7.89-7.93 (m, 8H). ^{13}C-NMR (100 MHz, *d6*-DMSO), δ=152.1, 139.5, 133.0, 127.8, 119.2, 111.7. HRMS (ESI): m/z = 339.0971 $[M+Na]^+$.



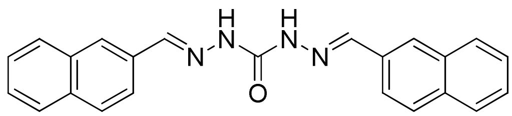
3l

White solid, ^{1}H-NMR (400 MHz, *d6*-DMSO) δ= 10.36 (s, 2H), 9.80 (s, 2H), 8.05 (s, 2H), 7.55-7.57 (d, J=8.4, 4H), 6.80-6.82 (d, J=8.4, 4H). ^{13}C-NMR (100 MHz, *d6*-DMSO), δ=159.2, 152.6, 128.8, 126.2, 115.9. HRMS (ESI): m/z = 321.0933 $[M+Na]^+$.



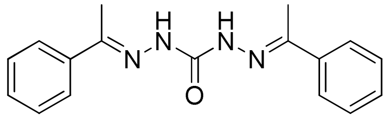
3m

White solid, ^{1}H-NMR (400 MHz, *d6*-DMSO) δ= 10.88 (s, 2H), 9.01 (s, 2H), 8.59 (s, 2H), 8.14 (s, 2H), 8.00-8.02 (d, J=8.0, 4H), 7.58-7.69 (m, 6H). ^{13}C-NMR (100 MHz, *d6*-DMSO), δ=152.5, 133.9, 130.8, 130.3, 130.2, 129.2, 127.5, 126.6, 126.1, 126.0, 123.9. HRMS (ESI): m/z = 389.1340 [M+Na]$^+$.



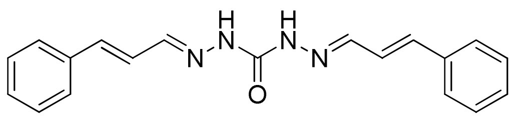
3n

White solid, ^{1}H-NMR (400 MHz, *d6*-DMSO) δ= 10.87 (s, 2H), 8.38 (s, 2H), 8.11-8.13 (d, J=10.0, 4H), 7.94-8.00 (m, 6H), 7.55-7.58 (m, 4H). ^{13}C-NMR (100 MHz, *d6*-DMSO), δ=152.5, 133.9, 133.4, 132.9, 128.7, 128.6, 128.3, 128.2, 127.7, 127.2, 127.1, 123.4. HRMS (ESI): m/z = 389.1348 [M+Na]$^+$.



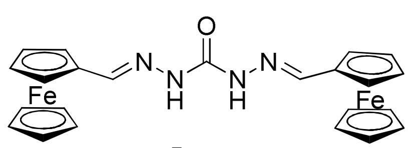
5a

White solid, ^{1}H-NMR (400 MHz, *d6*-DMSO) δ= 9.86 (s, 2H), 7.80-7.83 (m, 4H), 7.39-7.45 (m, 6H), 2.28 (s, 6H). ^{13}C-NMR (100 MHz, *d6*-DMSO), δ=152.6, 138.6, 129.3, 128.8, 126.4, 13.8. HRMS (ESI): m/z = 317.1346 [M+Na]$^+$.



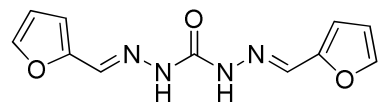
5b

White solid, ^{1}H-NMR (400 MHz, *d6*-DMSO) δ= 10.57 (s, 2H), 7.95-7.96 (d, J=5.6, 2H), 7.56-7.58 (d, J=7.6, 4H), 7.37-7.41 (m, 4H), 7.30-7.33 (m, 2H), 6.94-6.96 (d, J=6.8, 2H). ^{13}C-NMR (100 MHz, *d6*-DMSO), δ=152.2, 137.4, 136.5, 129.3, 129.0, 127.2, 126.1. HRMS (ESI): m/z = 341.1344 [M+Na]$^+$.



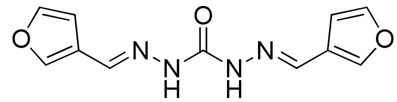
5c

Red solid, ^{1}H-NMR (400 MHz, *d6*-DMSO) δ= 10.20 (s, 2H), 7.95 (s, 2H), 4.67 (s, 4H), 4.40 (s, 4H), 4.22 (s, 10H). ^{13}C-NMR (100 MHz, *d6*-DMSO), δ=152.2, 80.3, 70.0, 69.5, 69.3, 67.6, 60.2. HRMS (ESI): m/z = 505.0345 [M+Na]$^+$.



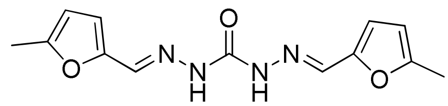
5d

White solid, ^{1}H-NMR (400 MHz, *d6*-DMSO) δ= 10.61 (s, 2H), 8.08 (s, 2H), 7.79 (d, J=1.2, 2H), 6.83-6.84 (d, J=3.2, 2H), 6.61 (m, 2H). ^{13}C-NMR (100 MHz, *d6*-DMSO), δ=152.2, 150.2, 144.8, 133.8, 112.5, 112.1. HRMS (ESI): m/z = 269.0643 $[M+Na]^+$.



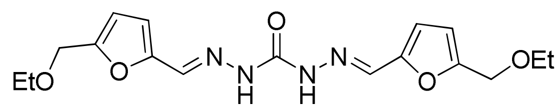
5e

White solid, ^{1}H-NMR (400 MHz, *d6*-DMSO) δ= 10.48 (s, 2H), 8.10 (s, 2H), 8.05 (s, 2H), 7.74 (s, 2H), 6.91 (s, 2H). ^{13}C-NMR (100 MHz, *d6*-DMSO), δ=152.4, 144.9, 144.6, 123.3, 107.9. HRMS (ESI): m/z =269.0635 $[M+Na]^+$.



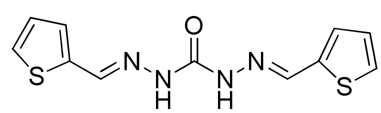
5f

White solid, ^{1}H-NMR (400 MHz, *d6*-DMSO) δ= 10.46 (s, 2H), 7.98 (s, 2H), 6.69-7.70 (d, J=3.2, 2H), 6.22-6.23 (m, 2H), 2.33 (s, 6H). ^{13}C-NMR (100 MHz, *d6*-DMSO), δ=154.1, 152.3, 148.6, 113.9, 108.8, 13.9. HRMS (ESI): m/z = 297.0947 $[M+Na]^+$.



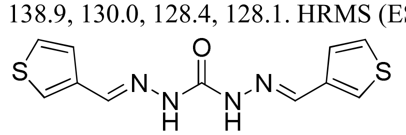
5g

White solid, ^{1}H-NMR (400 MHz, *d6*-DMSO) δ= 10.62 (s, 2H), 8.03 (s, 2H), 6.78-6.79 (d, J=3.2, 2H), 6.54-6.50 (d, J=3.6, 2H), 4.42 (s, 4H), 3.45-3.50 (m, 4H), 1.11-1.14 (m, 6H). ^{13}C-NMR (100 MHz, *d6*-DMSO), δ=153.8, 152.2, 150.0, 113.1, 111.8, 65.3, 64.1, 15.4. HRMS (ESI): m/z = 385.1463 $[M+Na]^+$.



5h

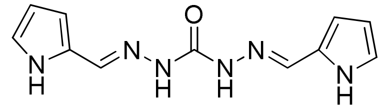
Yellow solid, ^{1}H-NMR (400 MHz, *d6*-DMSO) δ= 10.56 (s, 2H), 8.36 (s, 2H), 7.61-7.63 (d, J=5.2, 2H), 7.37-7.38 (m, 2H), 7.10-7.12 (m, 2H). ^{13}C-NMR (100 MHz, *d6*-DMSO), δ=152.1, 139.7, 138.9, 130.0, 128.4, 128.1. HRMS (ESI): m/z = 301.0155 $[M+Na]^+$.



5i

Yellow solid, ^{1}H-NMR (400 MHz, *d6*-DMSO) δ= 10.53 (s, 2H), 8.20 (s, 2H), 7.81-7.82 (m, 2H), 7.60-7.63 (m, 4H). ^{13}C-NMR (100 MHz, *d6*-DMSO), δ=152.5, 138.3, 127.6, 127.0, 125.5. HRMS

(ESI): m/z = 301.0187 [M+Na]$^+$.

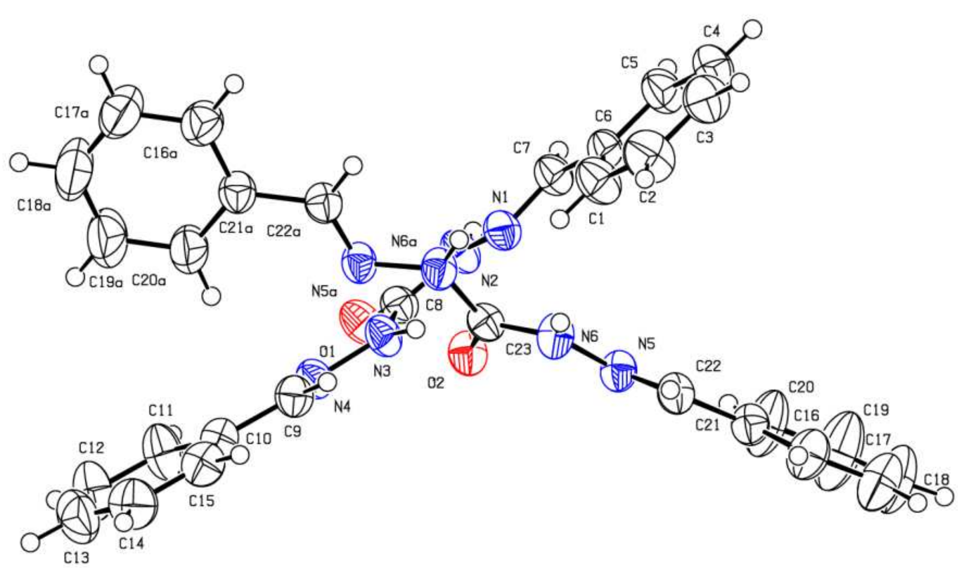


5j

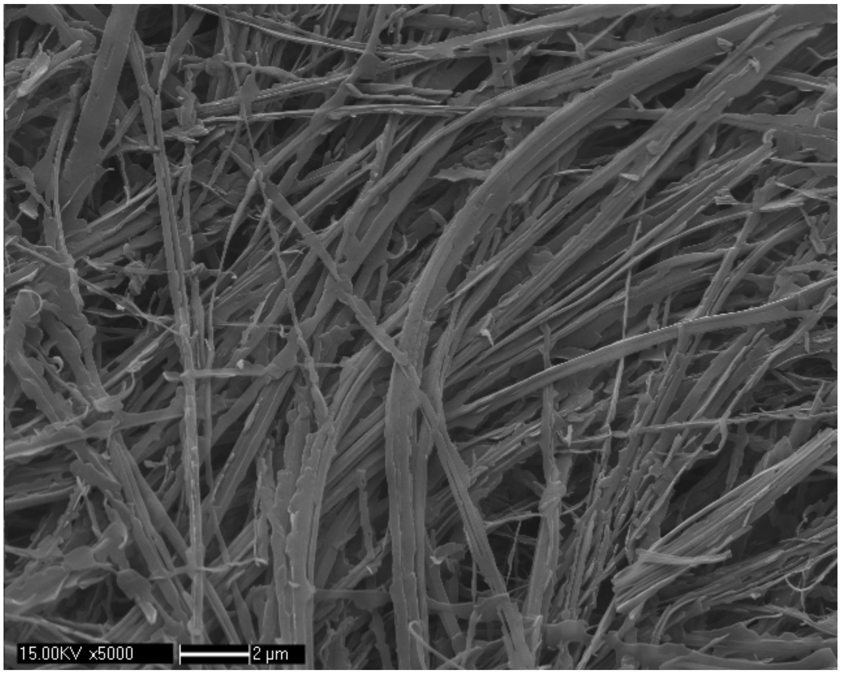
Yellow solid, ^{1}H-NMR (400 MHz, *d6*-DMSO) δ= 11.36 (s, 2H), 10.29 (s, 2H), 7.92 (s, 2H), 6.94 (s, 2H), 6.38 (s, 2H), 6.11-6.12 (d, J=2.8, 2H). ^{13}C-NMR (100 MHz, *d6*-DMSO), δ=179.6, 152.6, 128.0, 121.8, 112.2, 109.4. HRMS (ESI): m/z = 267.0938 [M+Na]$^+$.

Crystallographic Data of 3a

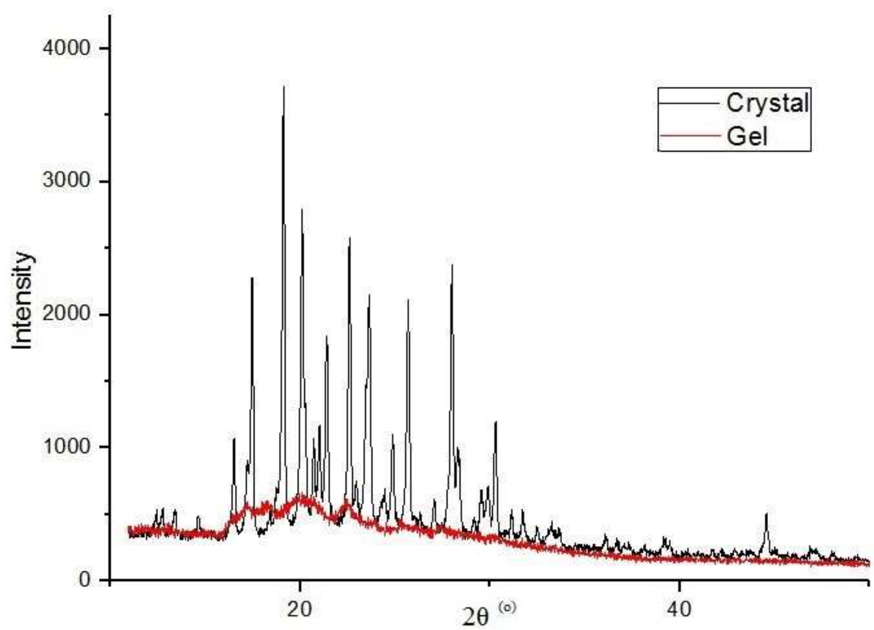
Chemical formula	$C_{15}H_{14}N_4O$
formula weight	266.30
temperature/K	296
crystal system	monoclinic
space group	P 2/c
a (Å)	14.3095(6)
b (Å)	8.5597(4)
c (Å)	17.1468(8)
α(deg)	90
β (deg)	97.135(3)
γ (deg)	90
V, Å^3	2083.96(16)
Z	6
ρ, g/cm^3	1.273



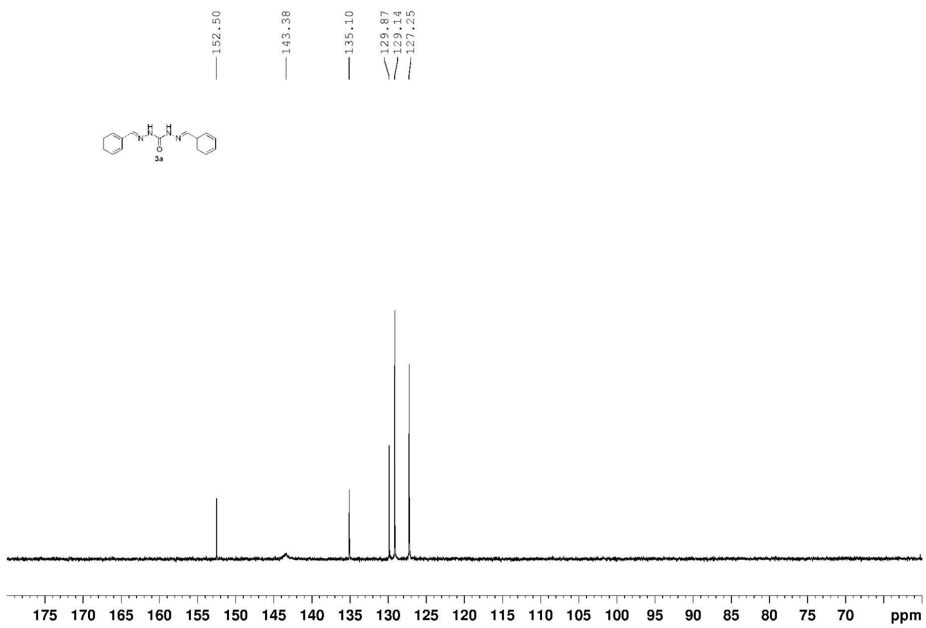
SEM image of the xerogel obtained from the gel of 3a in $CHCl_3$

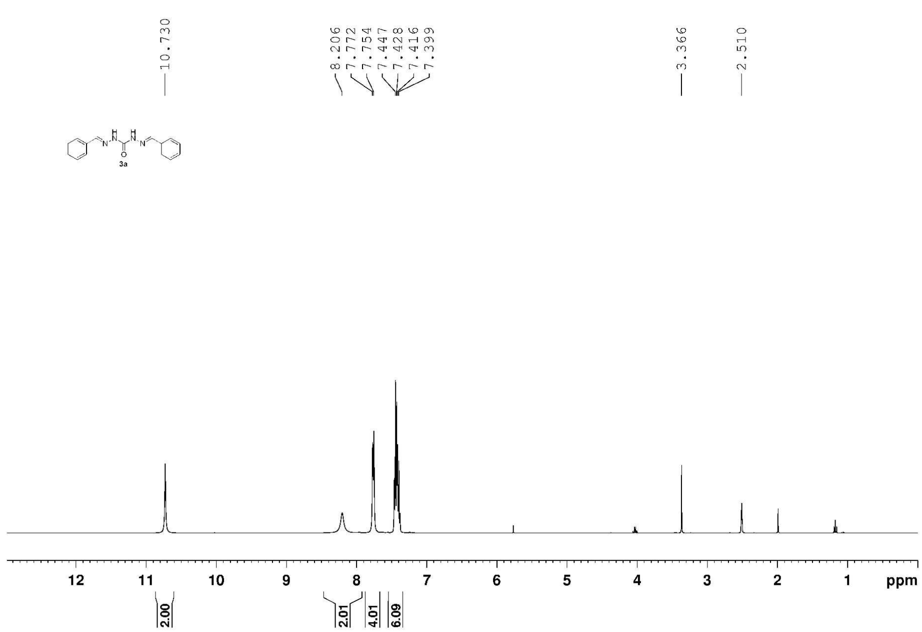


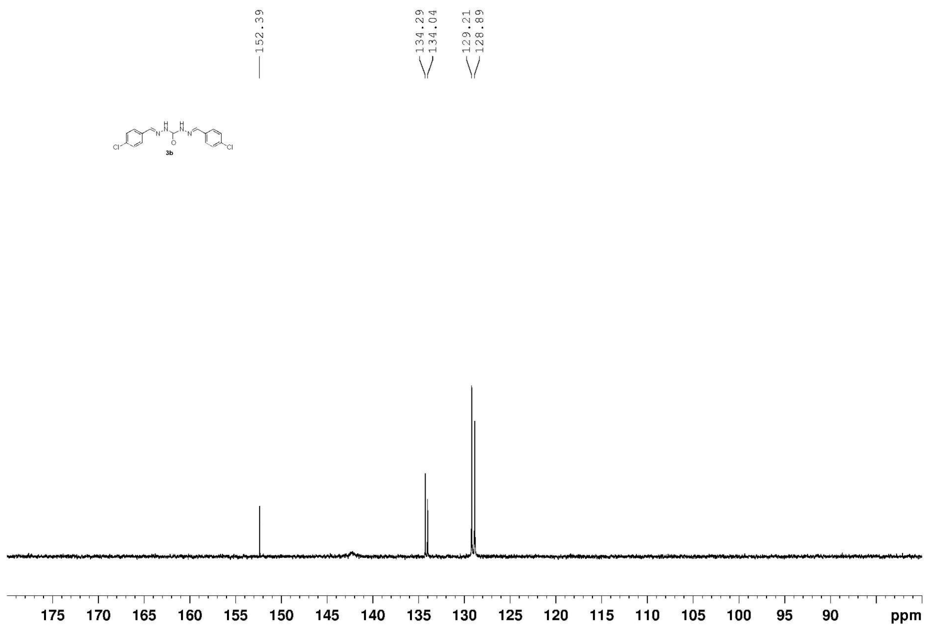
Powder X-ray diffraction patterns of the single crystal and gel (red line) of 3a

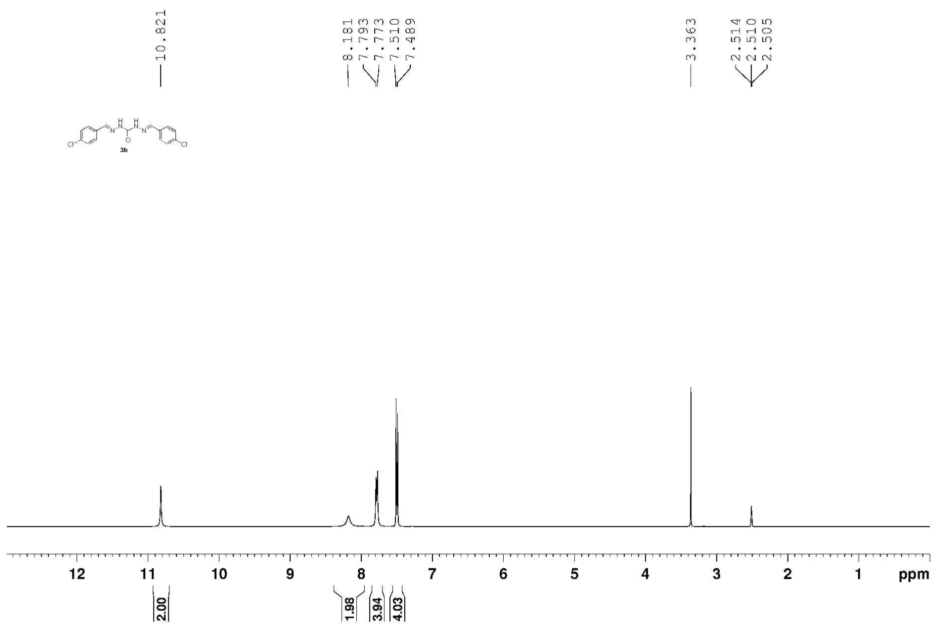


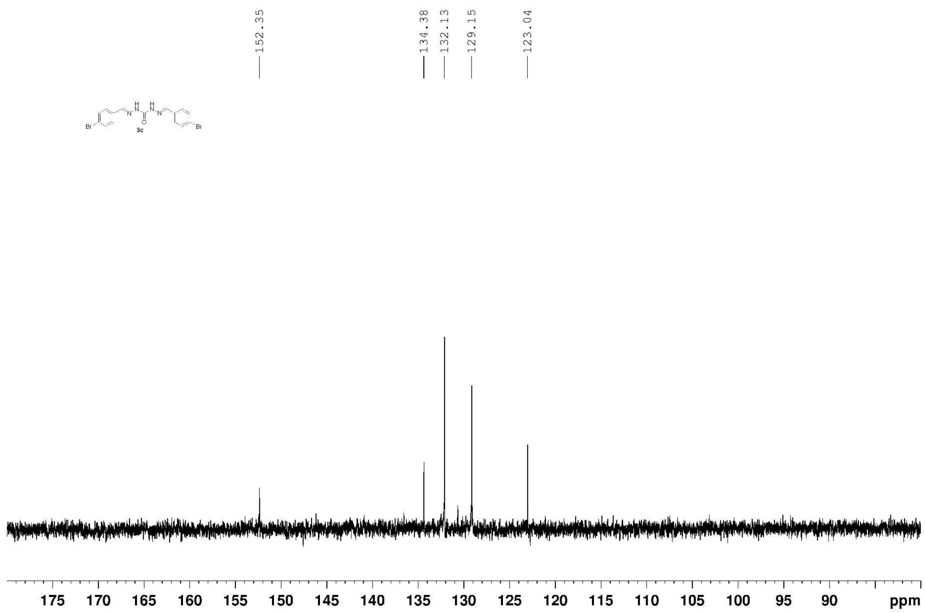
^{1}H-NMR and ^{13}C-NMR spectra

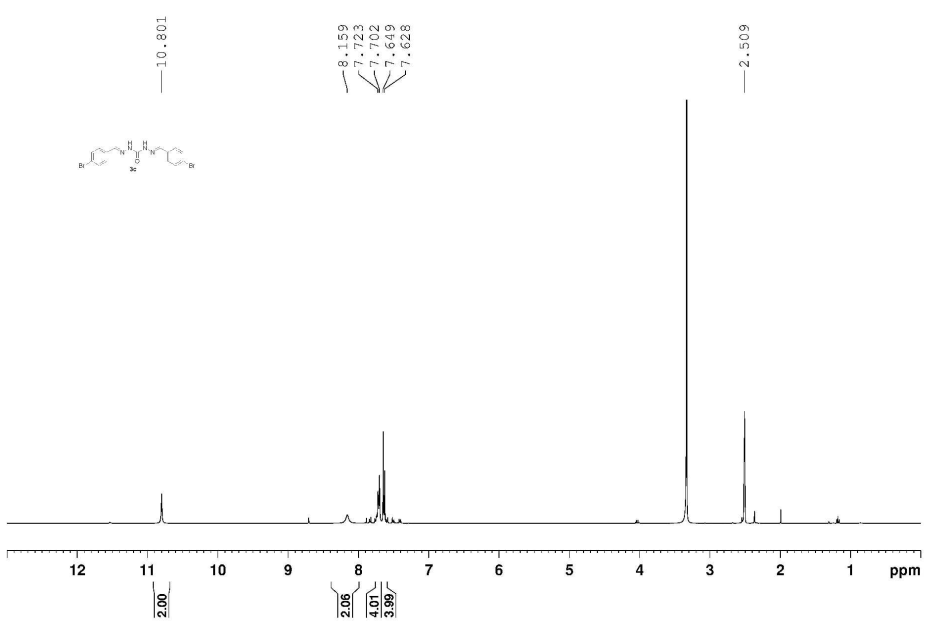


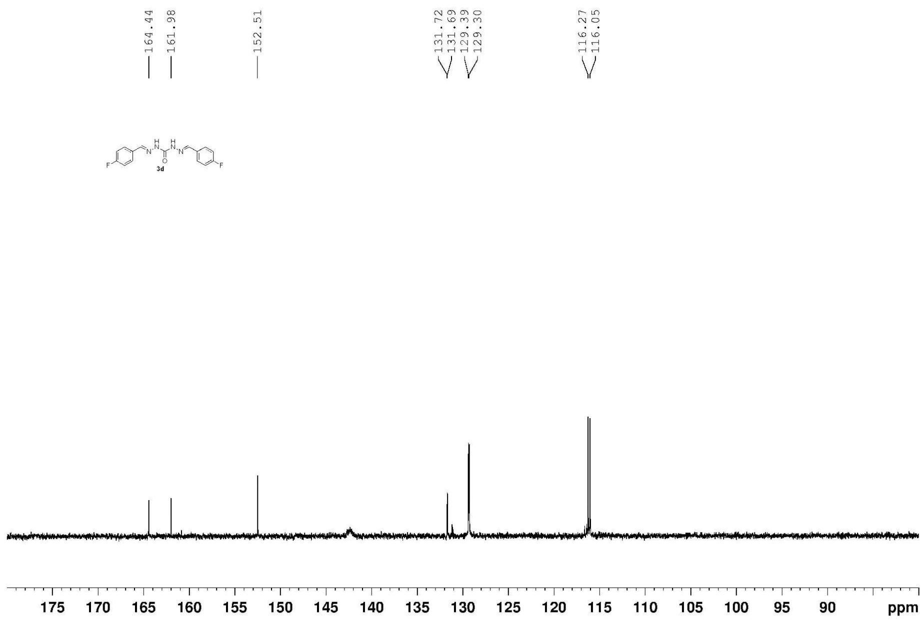


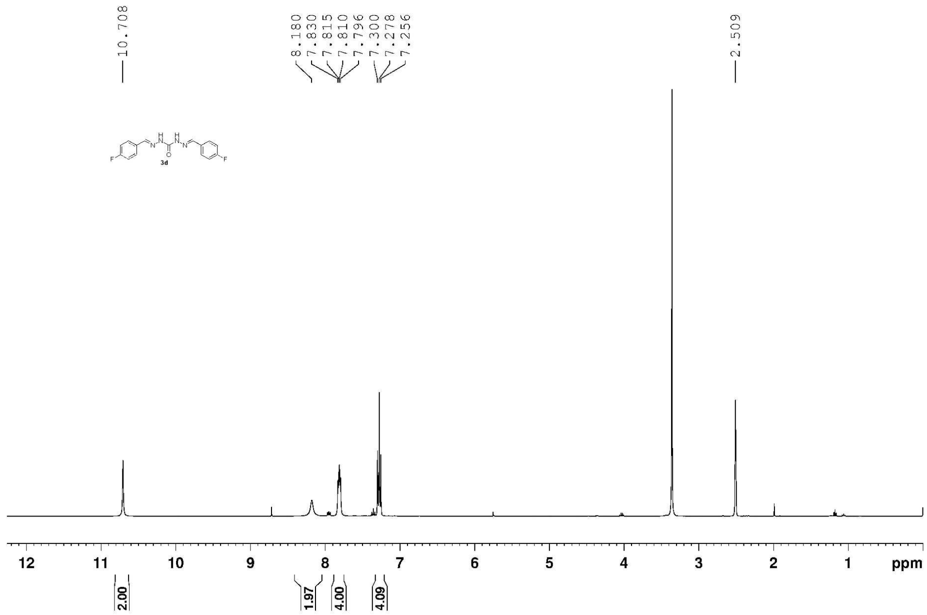

152.39
134.29
134.04
129.21
128.89
3b
175 170 165 160 155 150 145 140 135 130 125 120 115 110 105 100 95 90 ppm

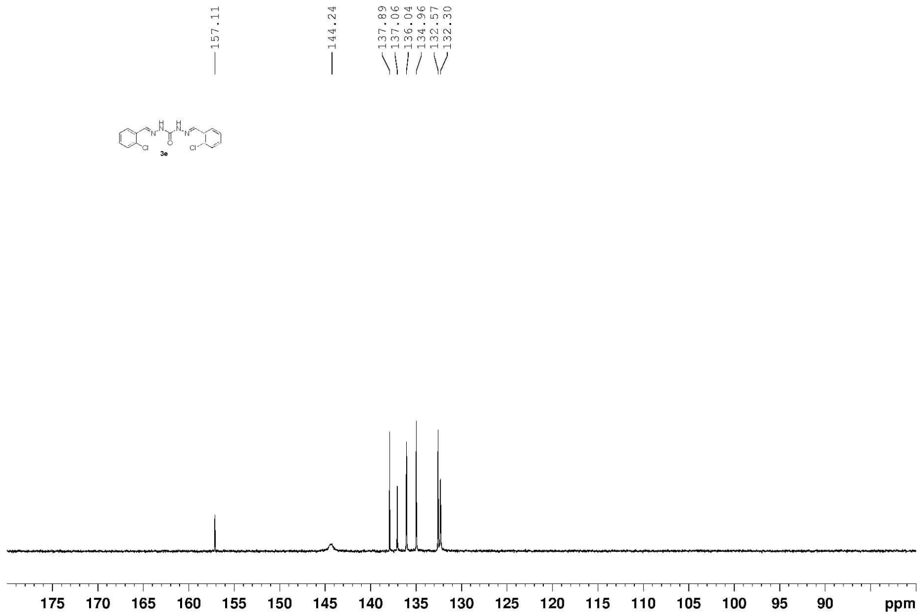

10.821
8.181
7.793
7.773
7.510
7.489
3.363
2.514
2.510
2.505
3b
12 11 10 9 8 7 6 5 4 3 2 1 ppm
2.00
1.98
3.94
4.03

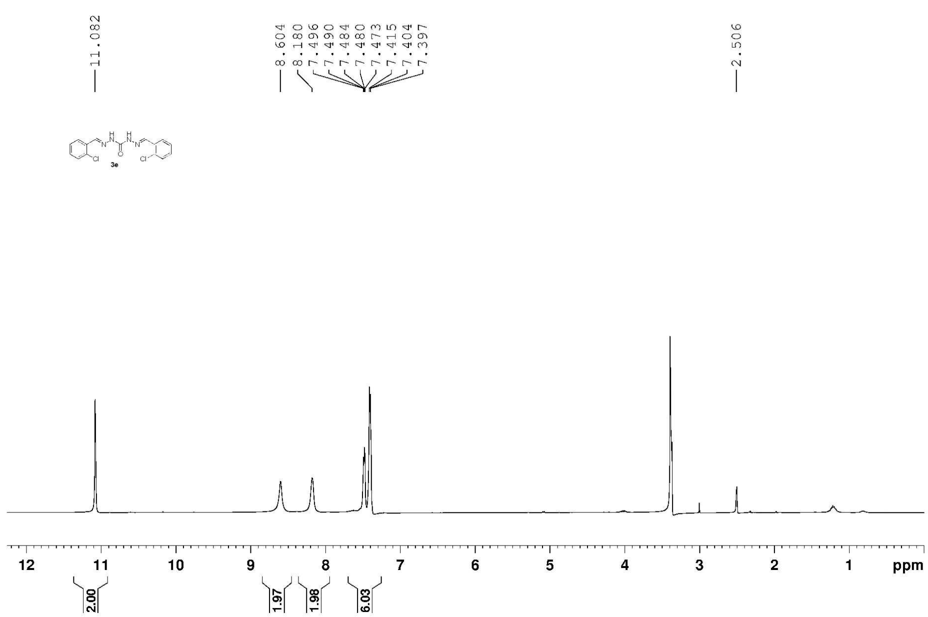

152.35
134.38
132.13
129.15
123.04
3c
175 170 165 160 155 150 145 140 135 130 125 120 115 110 105 100 95 90 ppm

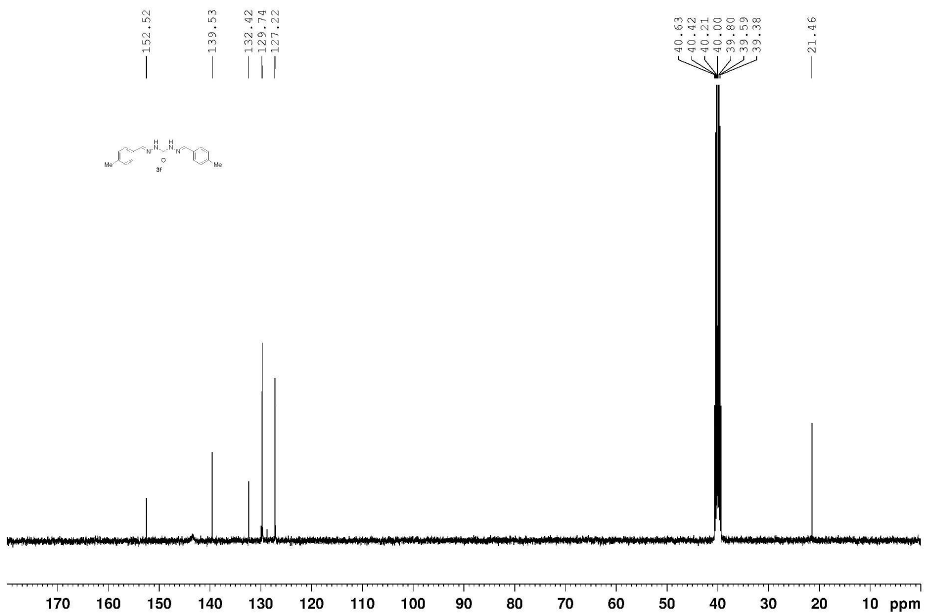

10.801
8.159
7.723
7.702
7.649
7.628
2.509
3c
12 11 10 9 8 7 6 5 4 3 2 1 ppm
2.00
2.06
4.01
3.99

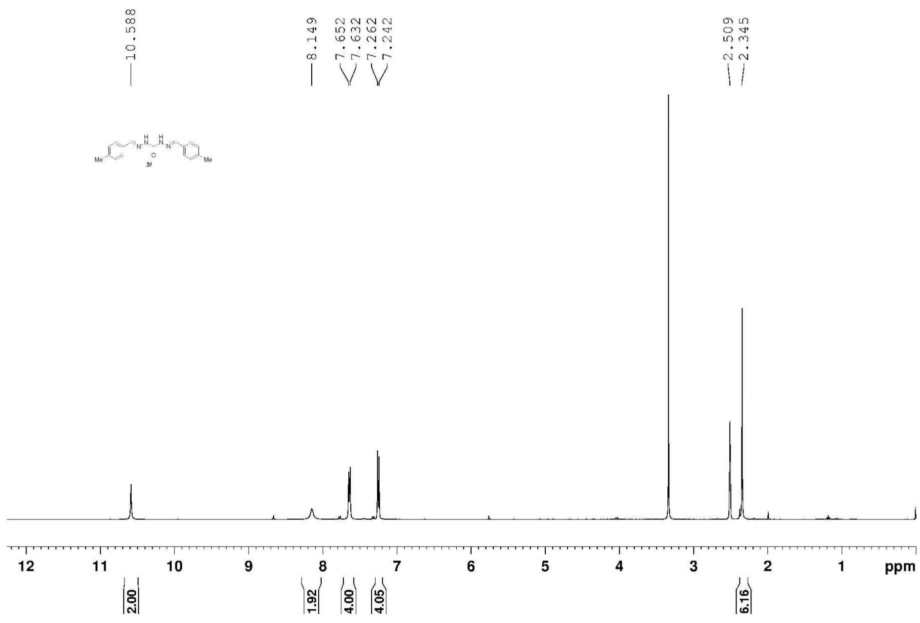

164.44
161.98
152.51
131.72
131.69
129.39
129.30
116.27
116.05
3d
175 170 165 160 155 150 145 140 135 130 125 120 115 110 105 100 95 90 ppm

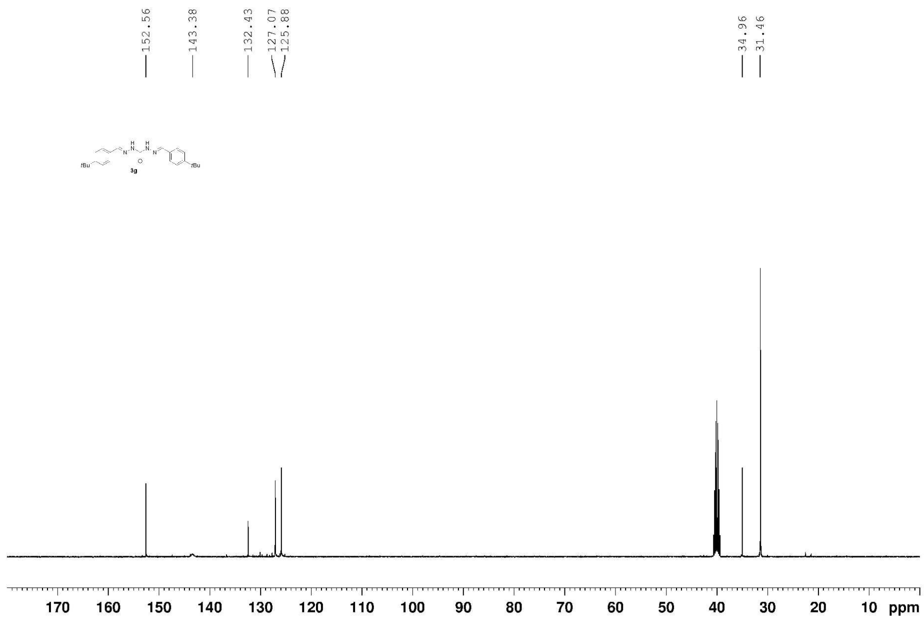

10.708
8.180
7.830
7.815
7.810
7.796
7.300
7.278
7.256
2.509
3d
12 11 10 9 8 7 6 5 4 3 2 1 ppm
2.00
1.97
4.00
4.09

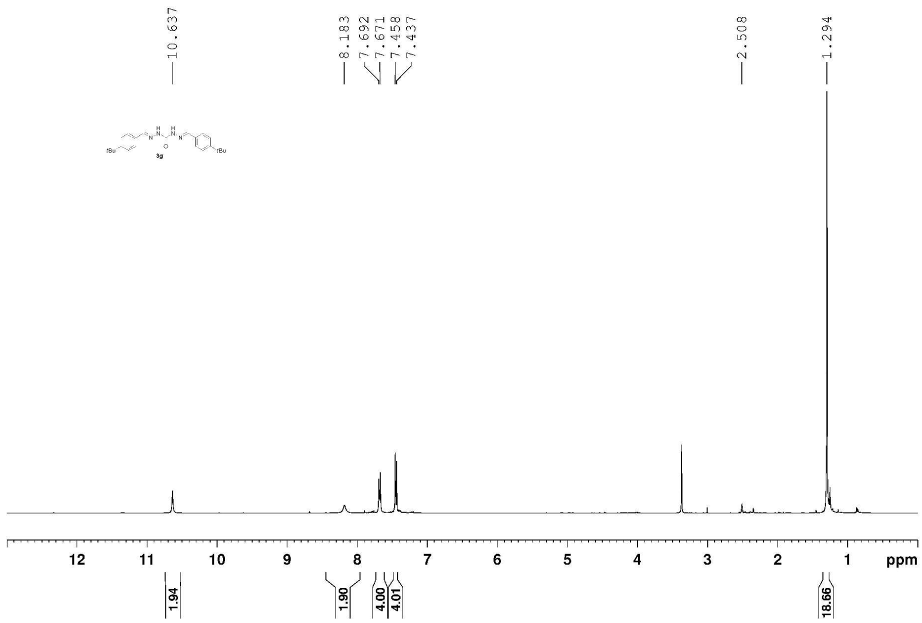

157.11
144.24
137.89
137.06
136.04
134.96
132.57
132.30
3e
ppm

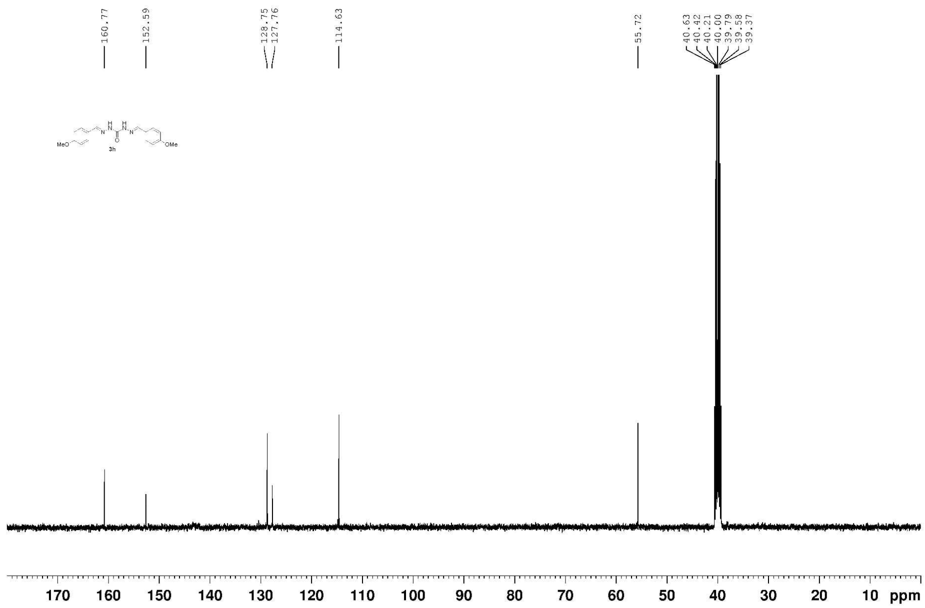

11.082
8.604
8.180
7.496
7.490
7.484
7.480
7.473
7.415
7.404
7.397
2.506
3e
2.00
1.97
1.98
6.03
ppm

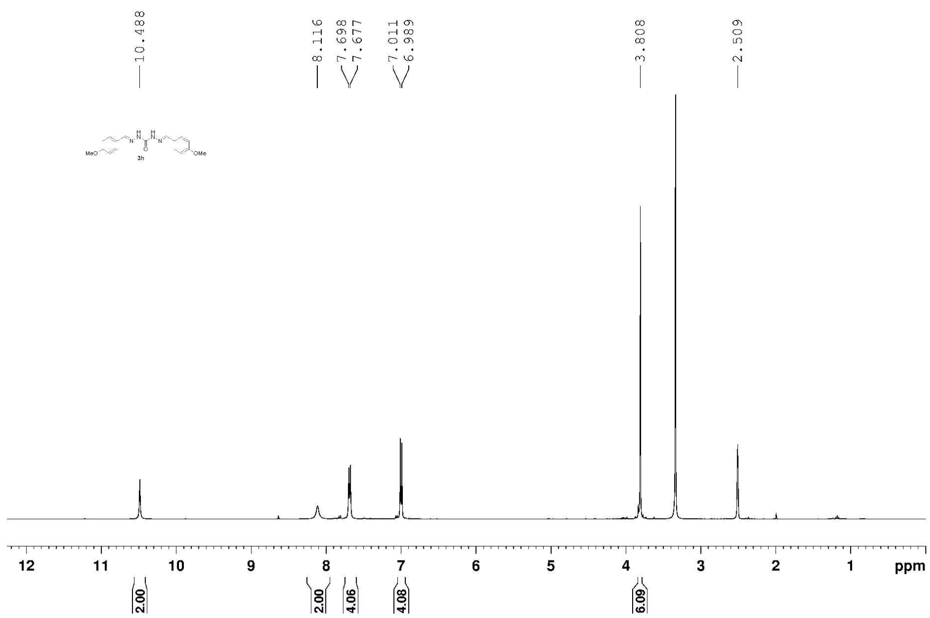

152.52
139.53
132.42
129.74
127.22
40.63
40.42
40.21
40.00
39.80
39.59
39.38
21.46
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

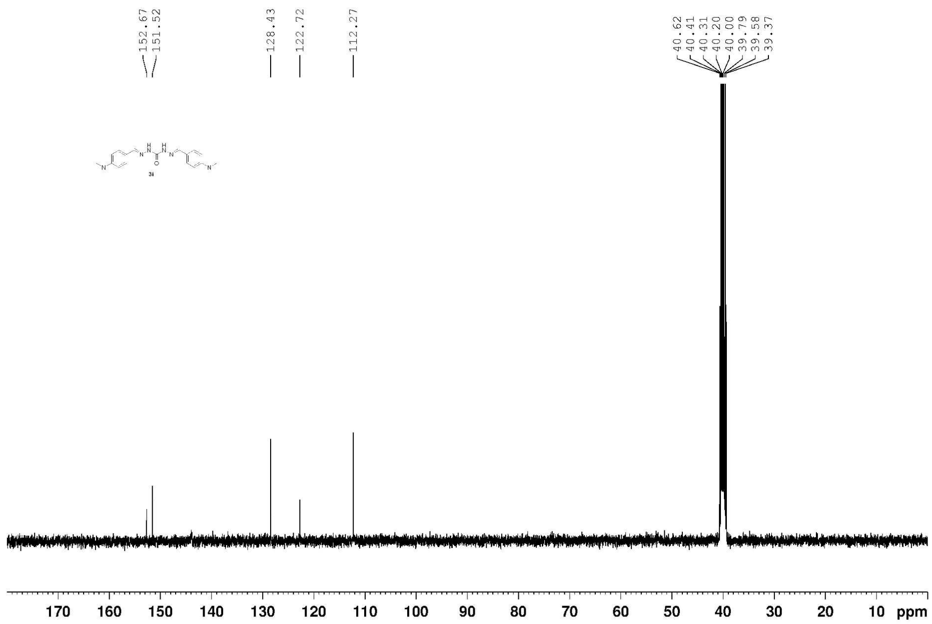

10.588
8.149
7.652
7.632
7.262
7.242
2.509
2.345
12 11 10 9 8 7 6 5 4 3 2 1 ppm
2.00
1.92
4.00
4.05
6.16

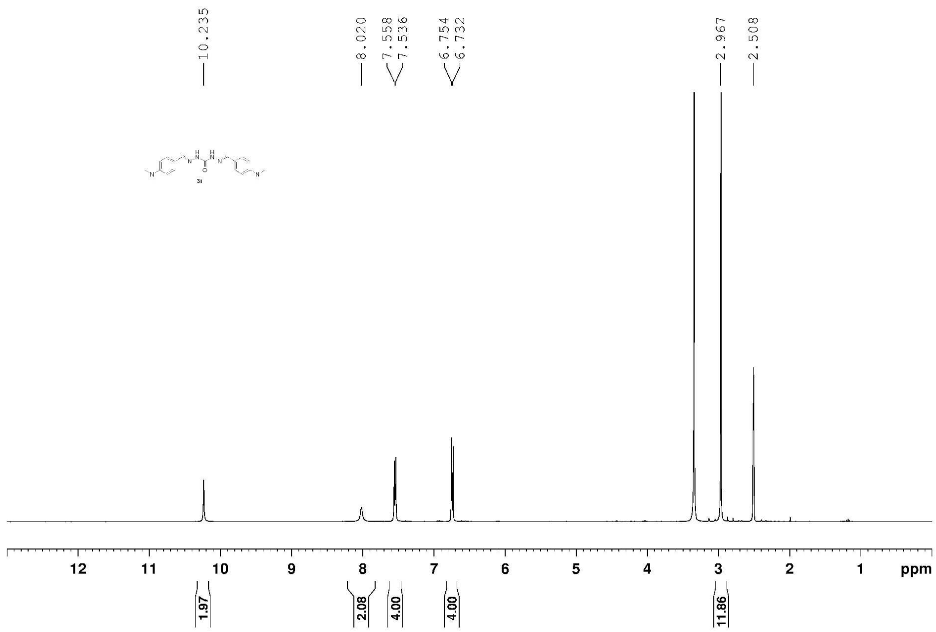

152.56
143.38
132.43
127.07
125.88
34.96
31.46
3g
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

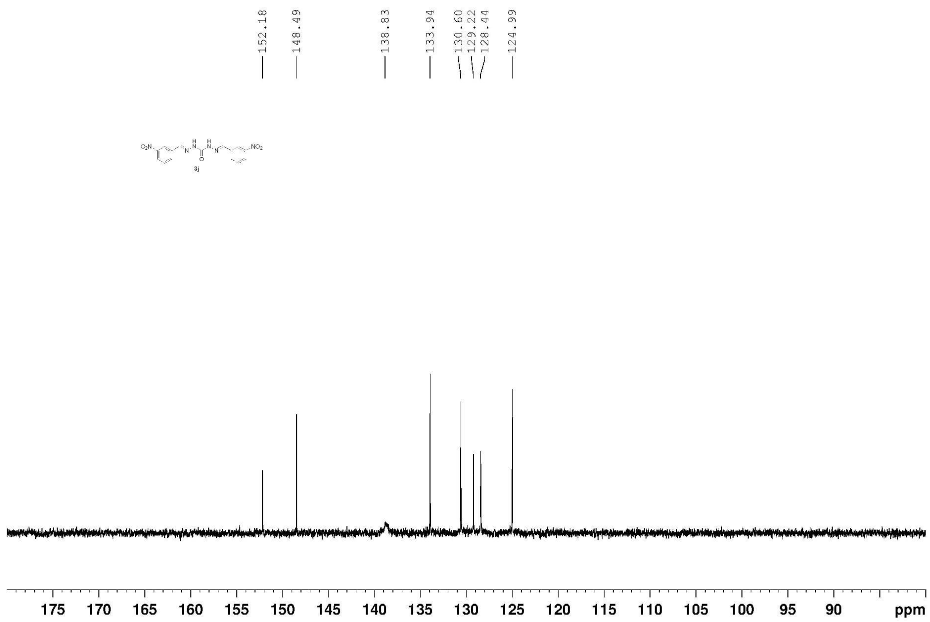

10.637
8.183
7.692
7.671
7.458
7.437
2.508
1.294
3g
12 11 10 9 8 7 6 5 4 3 2 1 ppm
1.94
1.90
4.00
4.01
18.66

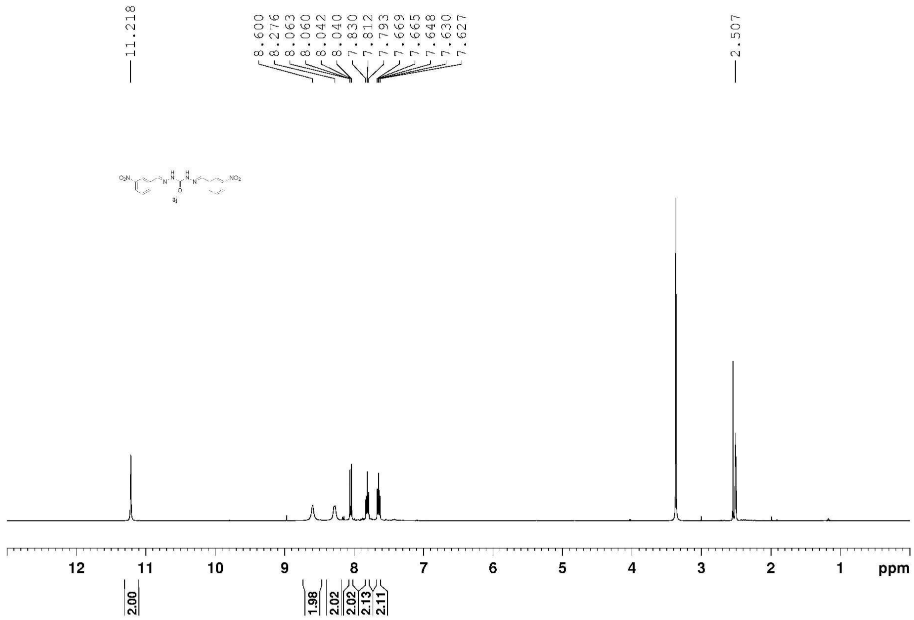


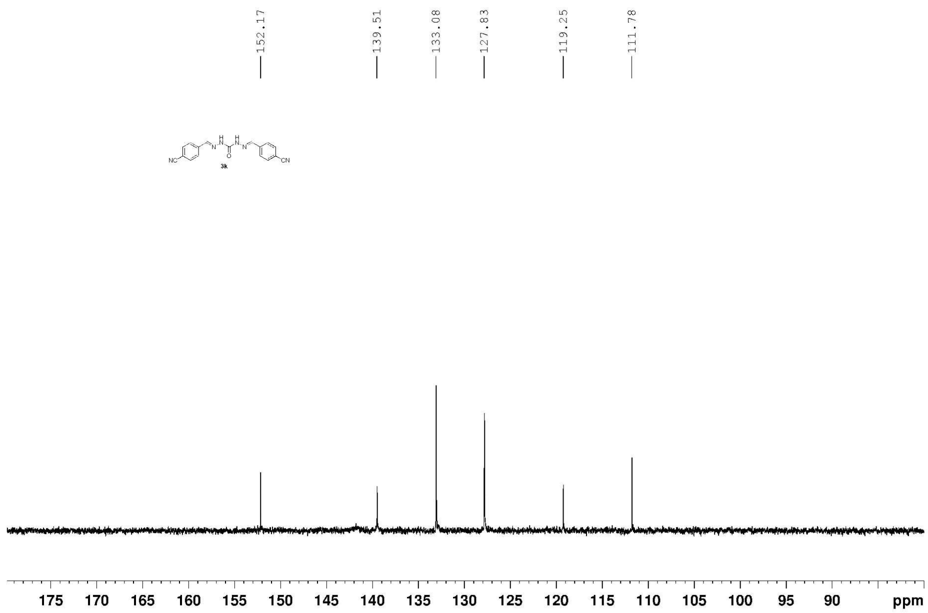


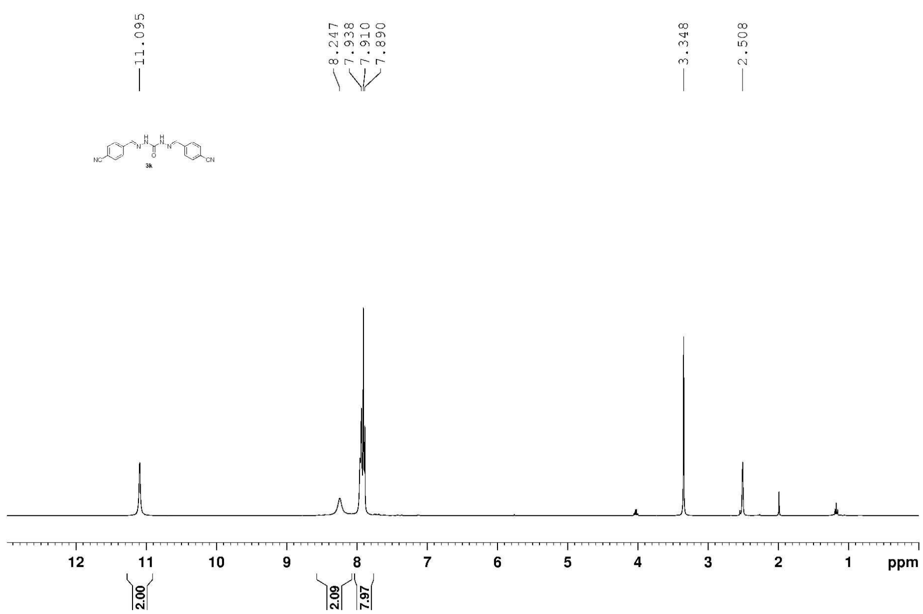

152.67
151.52
128.43
122.72
112.27
40.62
40.41
40.31
40.20
40.00
39.79
39.58
39.37
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

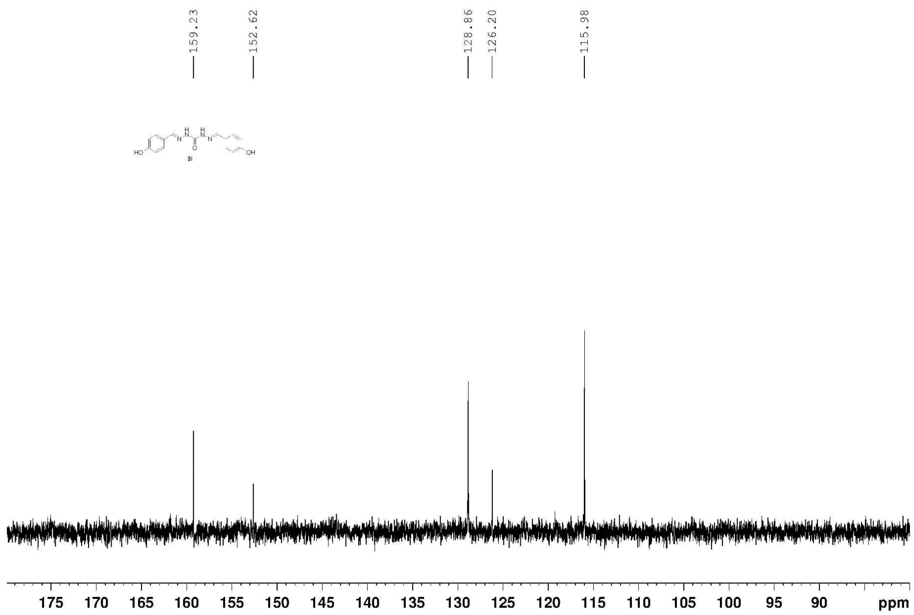

10.235
8.020
7.558
7.536
6.754
6.732
2.967
2.508
12 11 10 9 8 7 6 5 4 3 2 1 ppm
1.97
2.08
4.00
4.00
11.86

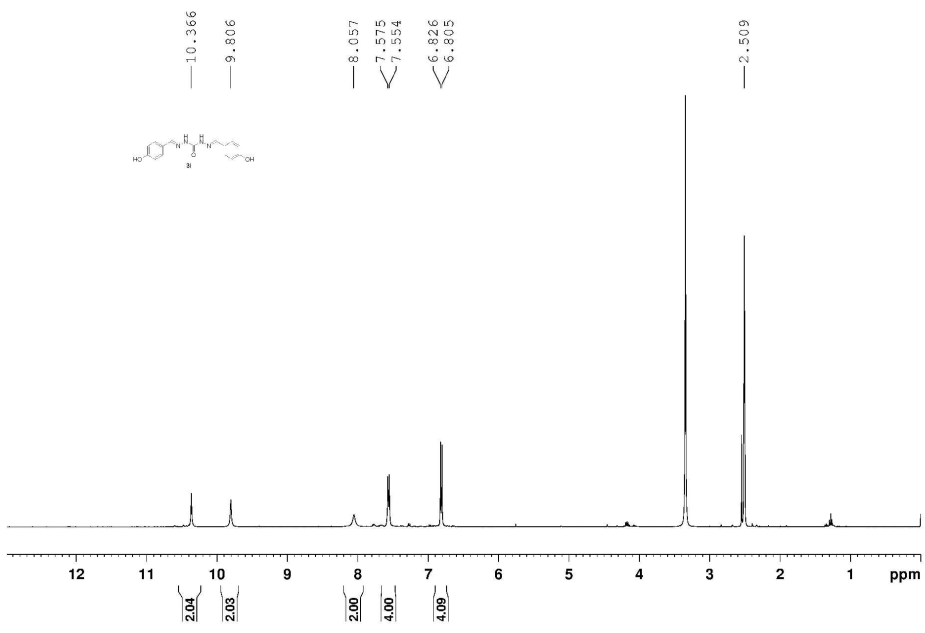

152.18
148.49
138.83
133.94
130.60
129.22
128.44
124.99
175 170 165 160 155 150 145 140 135 130 125 120 115 110 105 100 95 90 ppm

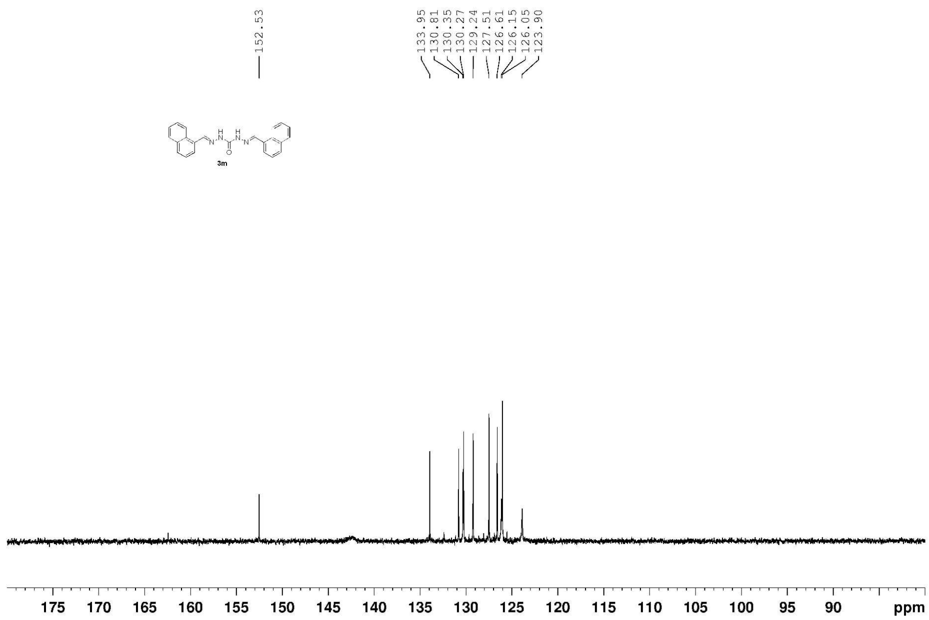

11.218
8.600
8.276
8.063
8.060
8.042
8.040
7.830
7.812
7.793
7.669
7.665
7.648
7.630
7.627
2.507
12 11 10 9 8 7 6 5 4 3 2 1 ppm
2.00
1.98
2.02
2.02
2.13
2.11

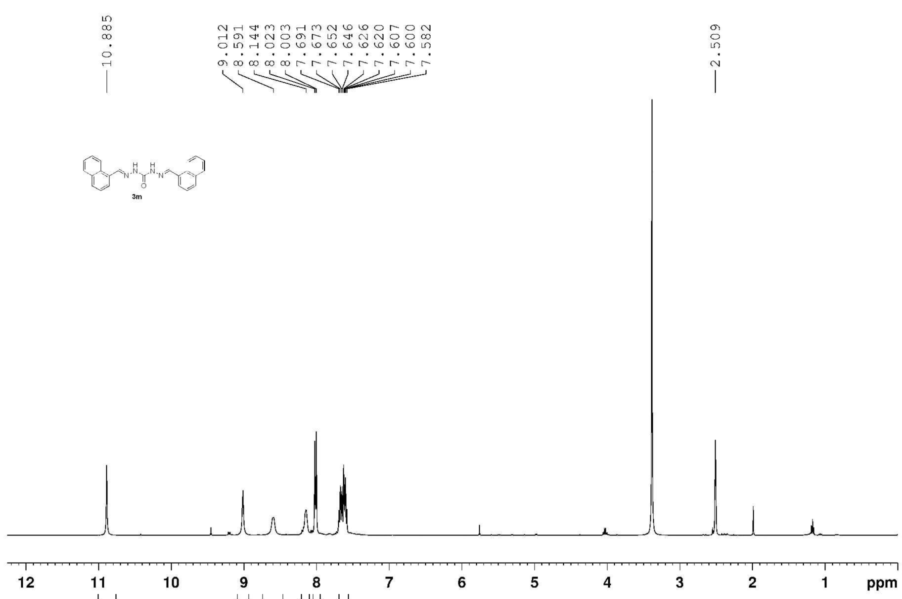

152.17
139.51
133.08
127.83
119.25
111.78
3k
175 170 165 160 155 150 145 140 135 130 125 120 115 110 105 100 95 90 ppm

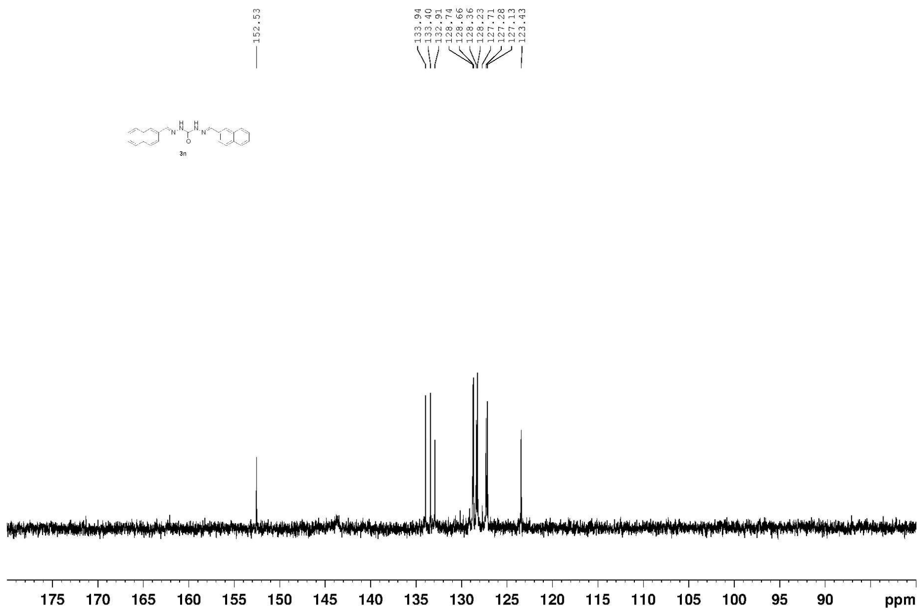

11.095
8.247
7.938
7.910
7.890
3.348
2.508
3k
12 11 10 9 8 7 6 5 4 3 2 1 ppm
2.00
2.09
7.97

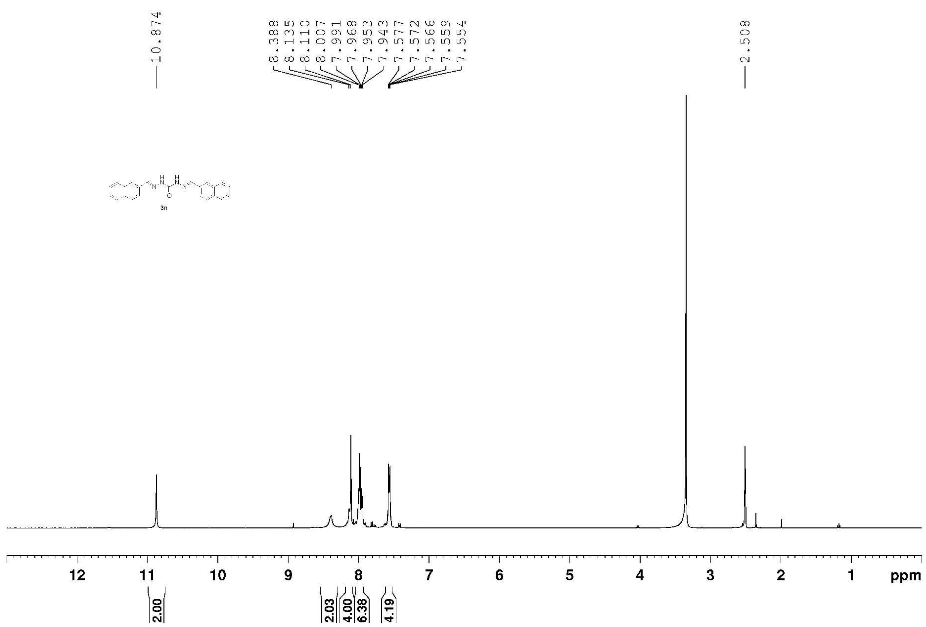

159.23
152.62
128.86
126.20
115.98
175 170 165 160 155 150 145 140 135 130 125 120 115 110 105 100 95 90 ppm

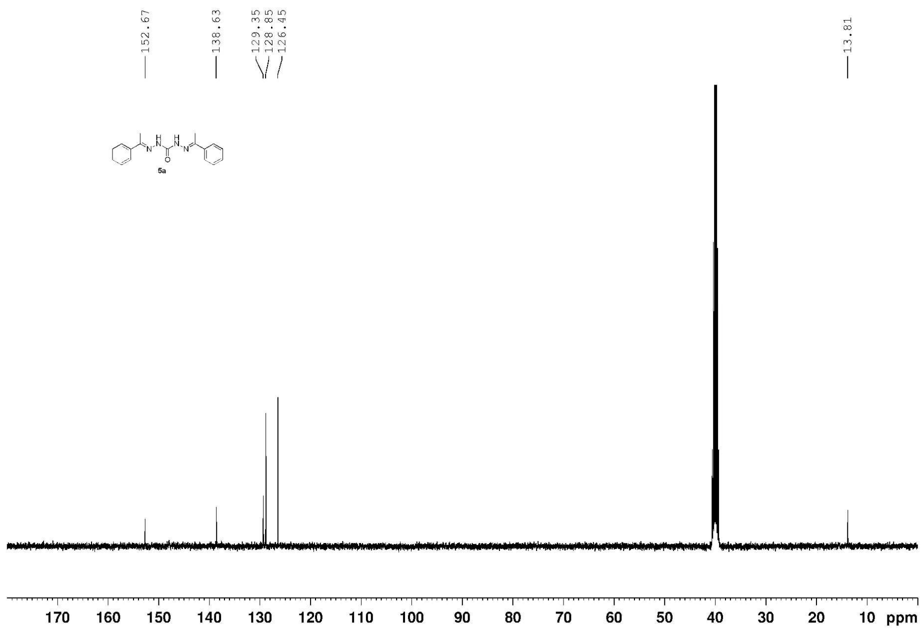

10.366
9.806
8.057
7.575
7.554
6.826
6.805
2.509
12 11 10 9 8 7 6 5 4 3 2 1 ppm
2.04
2.03
2.00
4.00
4.09

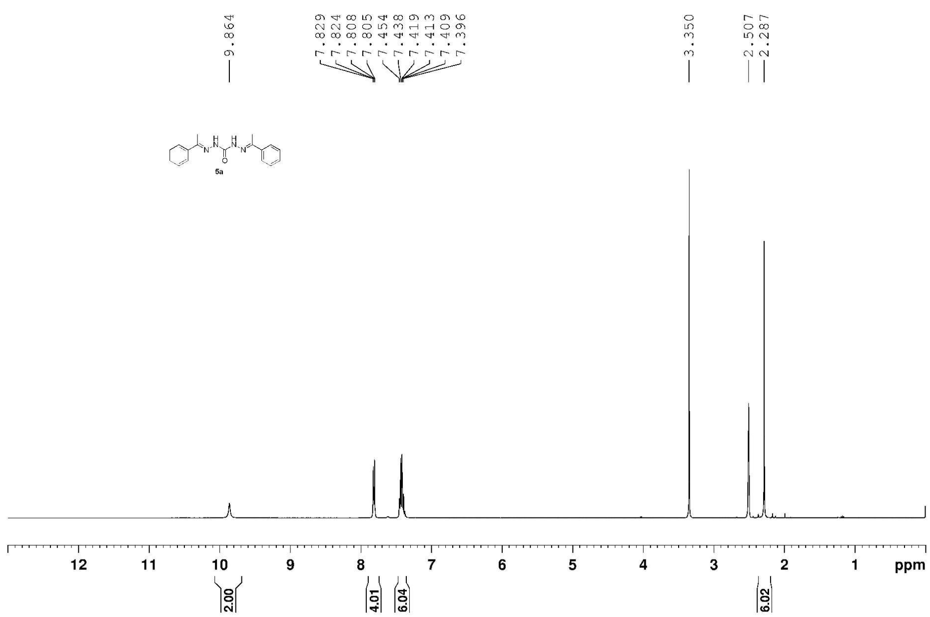

152.53
133.95
130.81
130.35
130.27
129.24
127.51
126.61
126.15
126.05
123.90
3m
175 170 165 160 155 150 145 140 135 130 125 120 115 110 105 100 95 90 ppm

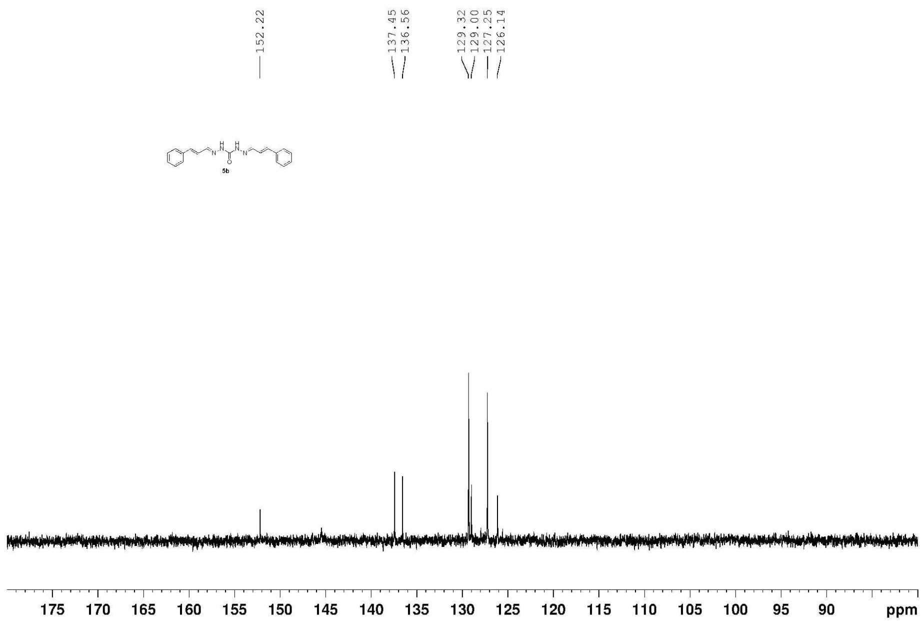

10.885
9.012
8.591
8.144
8.023
8.003
7.691
7.673
7.652
7.646
7.626
7.620
7.607
7.600
7.582
2.509
3m
12 11 10 9 8 7 6 5 4 3 2 1 ppm
2.00
1.92
1.97
2.08
4.13
6.14

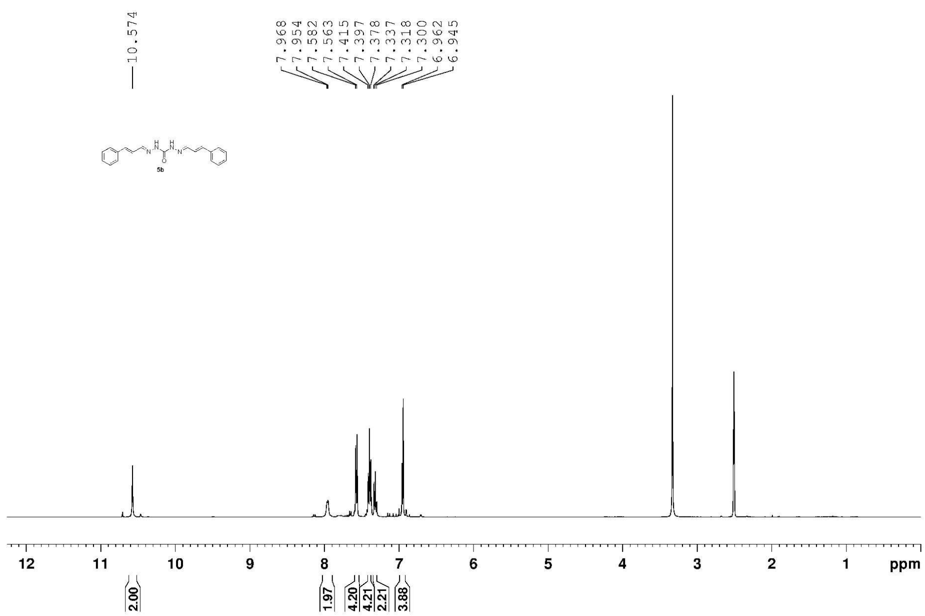

152.53
133.94
133.40
132.91
128.74
128.66
128.36
128.23
127.71
127.28
127.13
123.43
3n
175 170 165 160 155 150 145 140 135 130 125 120 115 110 105 100 95 90 ppm

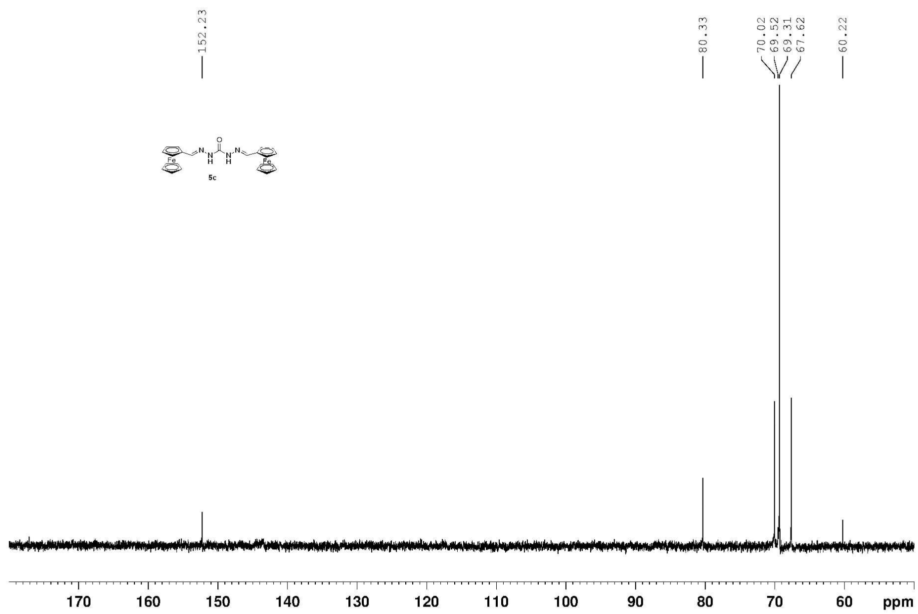

10.874
8.388
8.135
8.110
8.007
7.991
7.968
7.953
7.943
7.577
7.572
7.566
7.559
7.554
2.508
3n
12 11 10 9 8 7 6 5 4 3 2 1 ppm
2.00
2.03
4.00
6.38
4.19

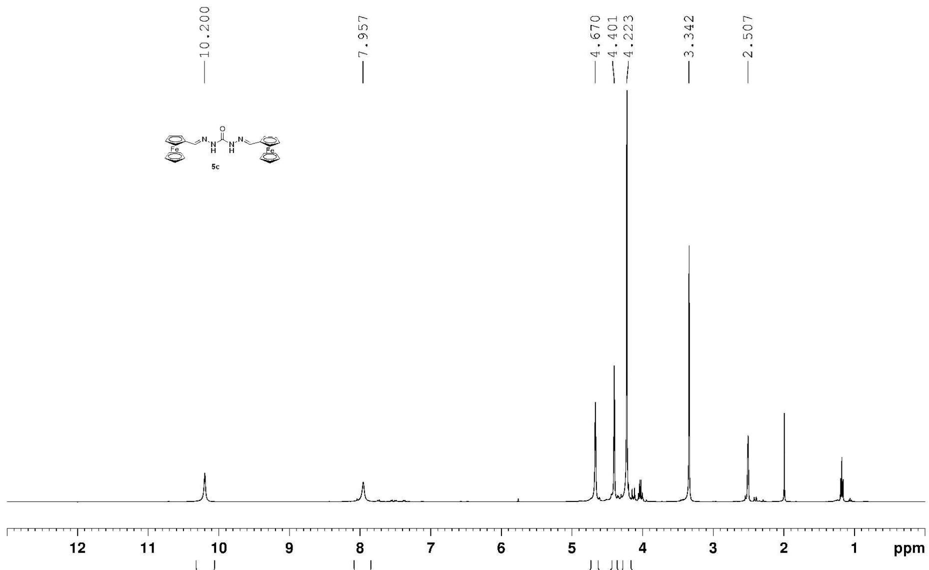

152.67
138.63
129.35
128.85
126.45
13.81
5a
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

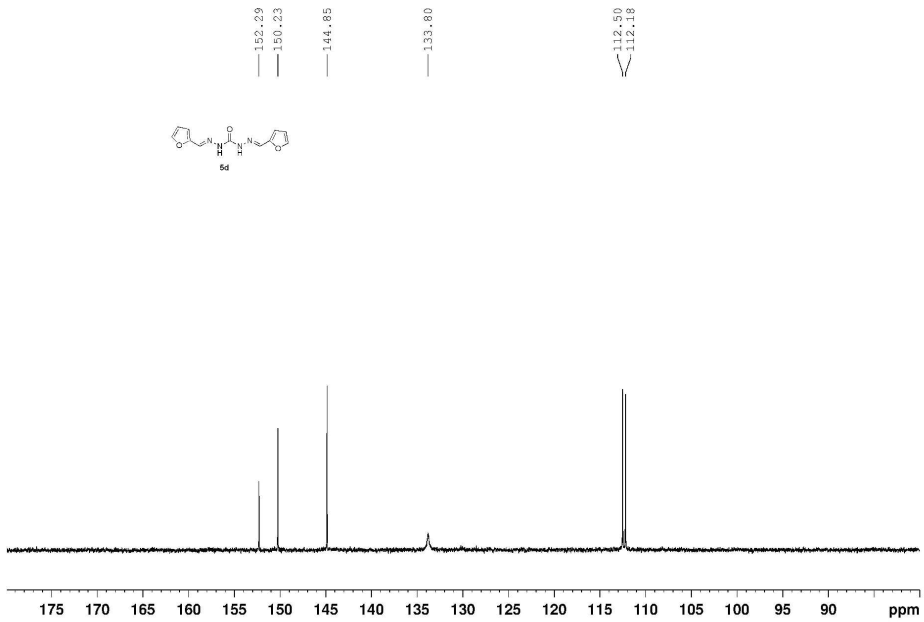

9.864
7.829
7.824
7.808
7.805
7.454
7.438
7.419
7.413
7.409
7.396
3.350
2.507
2.287
5a
12 11 10 9 8 7 6 5 4 3 2 1 ppm
2.00
4.01
6.04
6.02

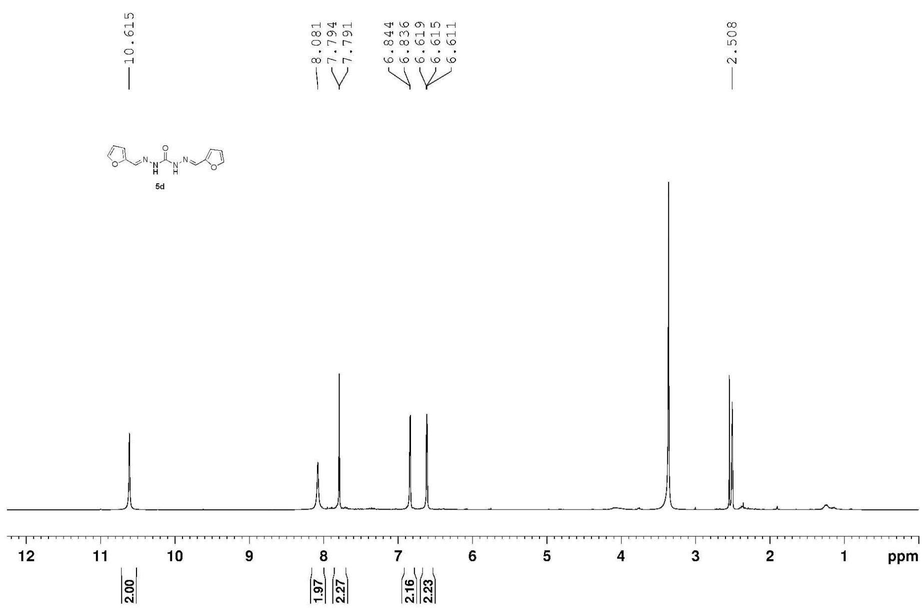

152.22
137.45
136.56
129.32
129.00
127.25
126.14
5b
175 170 165 160 155 150 145 140 135 130 125 120 115 110 105 100 95 90 ppm

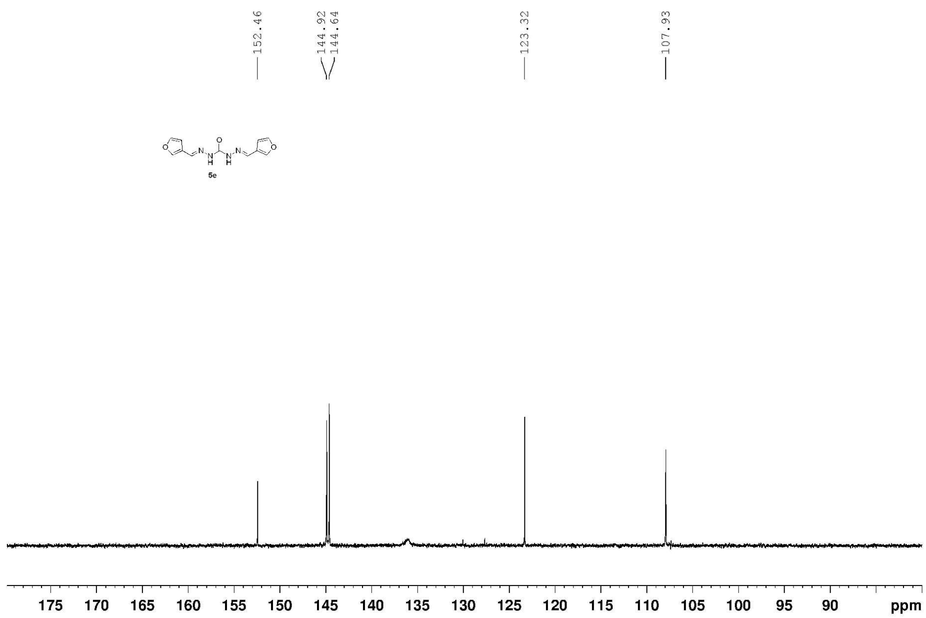

10.574
7.968
7.954
7.582
7.563
7.415
7.397
7.378
7.337
7.318
7.300
6.962
6.945
5b
12 11 10 9 8 7 6 5 4 3 2 1 ppm
2.00
1.97
4.20
4.21
2.21
3.88

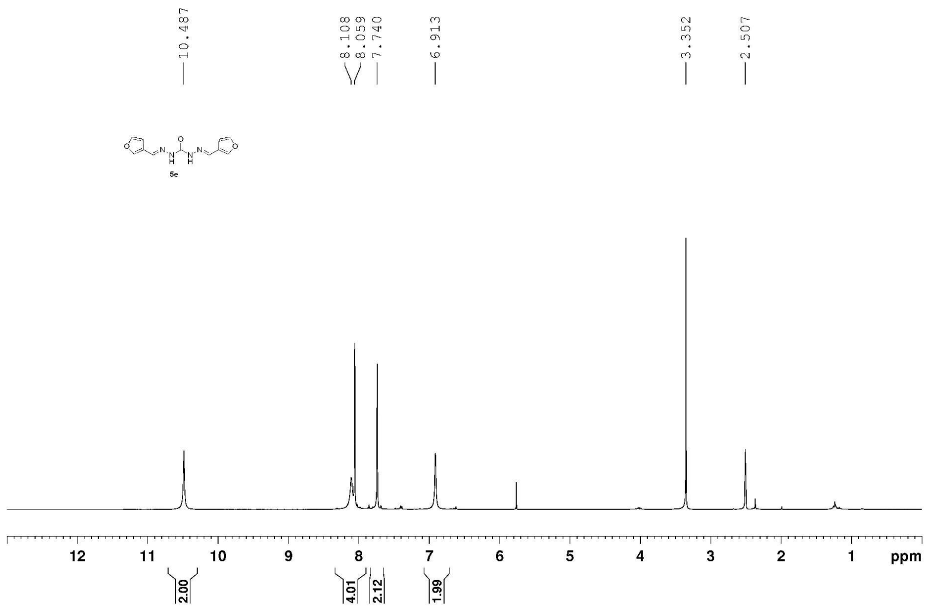

152.23
80.33
70.02
69.52
69.31
67.62
60.22
5c
170
160
150
140
130
120
110
100
90
80
70
60
ppm

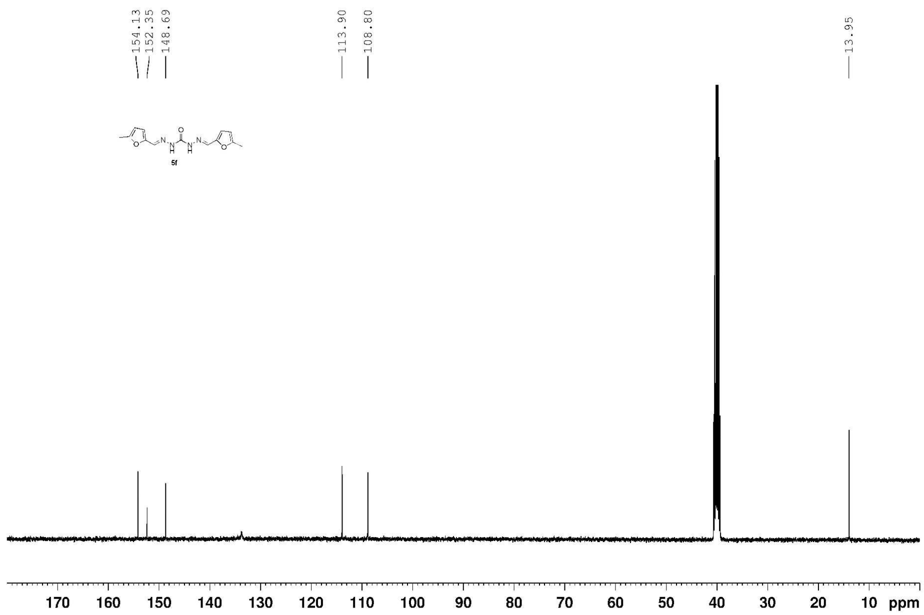

10.200
7.957
4.670
4.401
4.223
3.342
2.507
5c
12
11
10
9
8
7
6
5
4
3
2
1
ppm
2.00
1.98
3.89
3.97
10.24

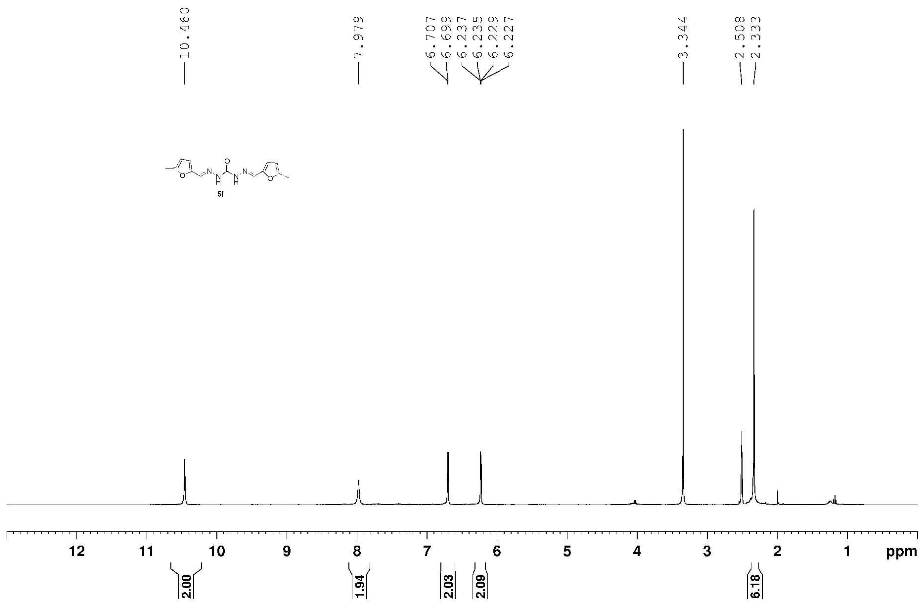

152.29
150.23
144.85
133.80
112.50
112.18
5d
175 170 165 160 155 150 145 140 135 130 125 120 115 110 105 100 95 90 ppm

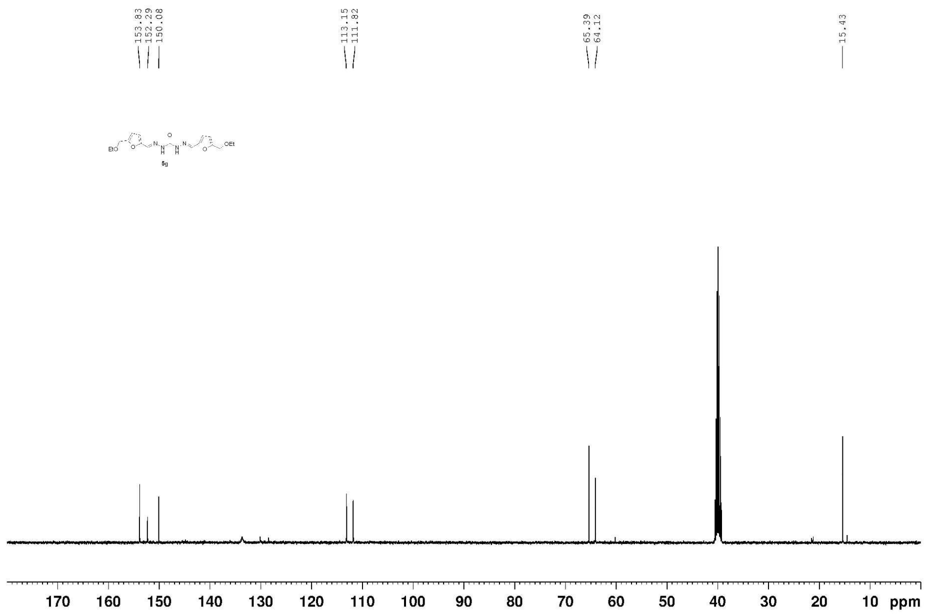

10.615
8.081
7.794
7.791
6.844
6.836
6.619
6.615
6.611
2.508
5d
12 11 10 9 8 7 6 5 4 3 2 1 ppm
2.00
1.97
2.27
2.16
2.23

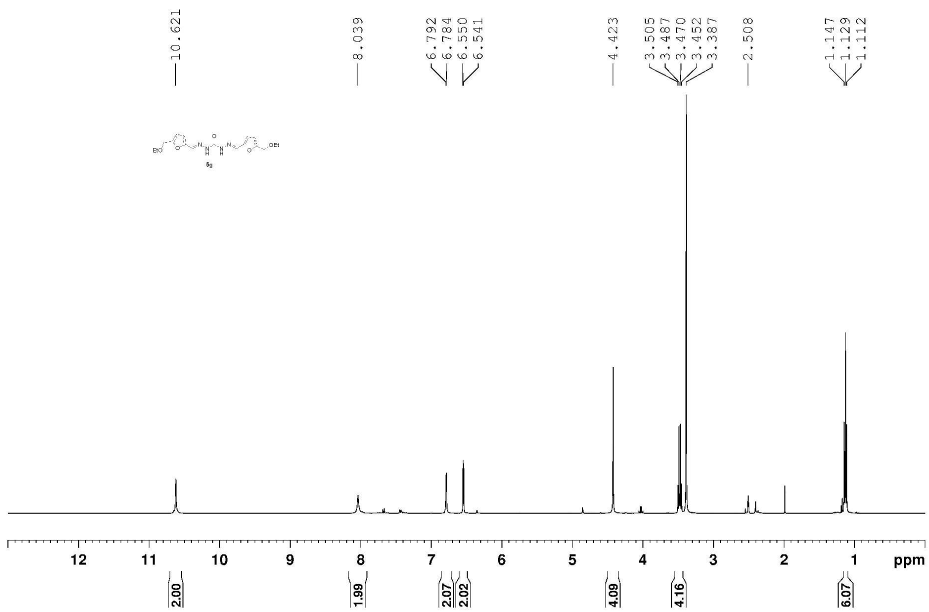

152.46
144.92
144.64
123.32
107.93
5e
175 170 165 160 155 150 145 140 135 130 125 120 115 110 105 100 95 90 ppm

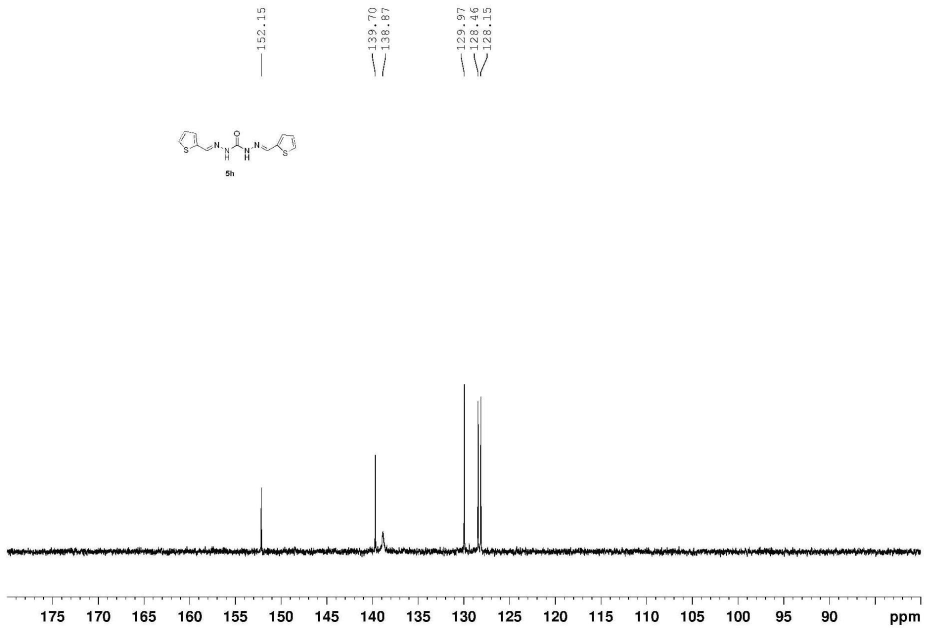

10.487
8.108
8.059
7.740
6.913
3.352
2.507
5e
12 11 10 9 8 7 6 5 4 3 2 1 ppm
2.00
4.01
2.12
1.99

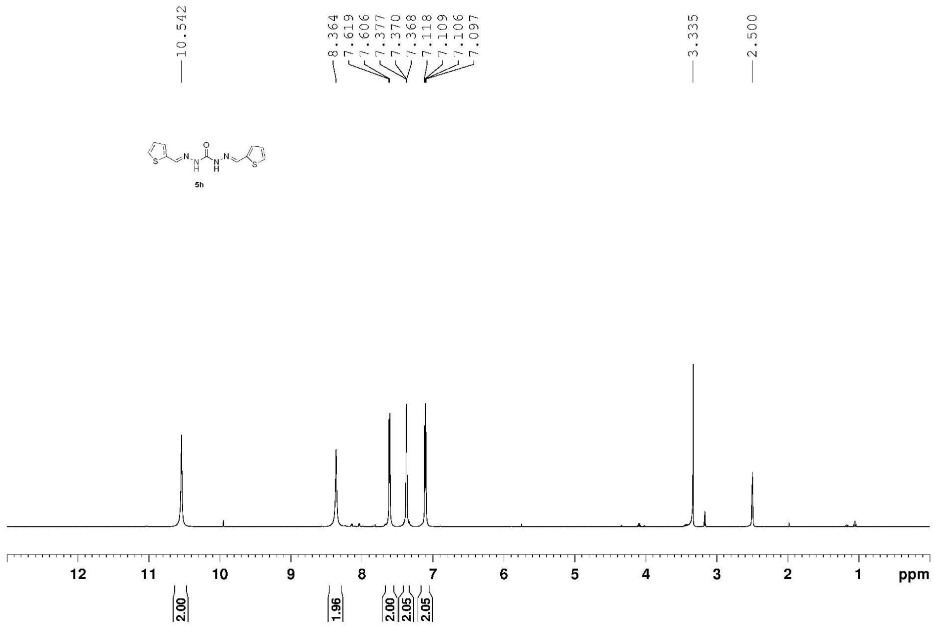

154.13
152.35
148.69
113.90
108.80
13.95
5f
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

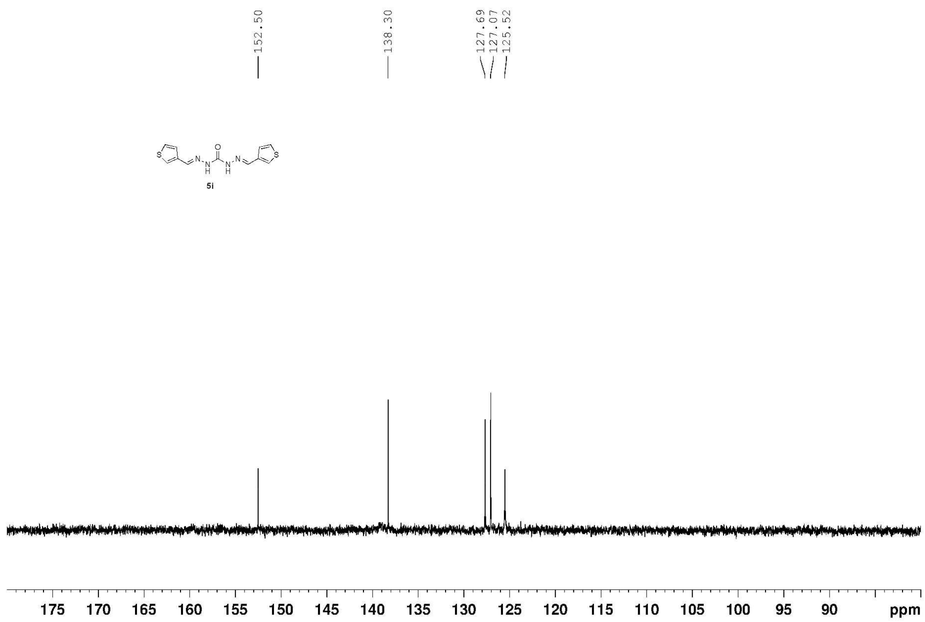

10.460
7.979
6.707
6.699
6.237
6.235
6.229
6.227
3.344
2.508
2.333
5f
12 11 10 9 8 7 6 5 4 3 2 1 ppm
2.00
1.94
2.03
2.09
6.18


153.83
152.29
150.08
113.15
111.82
65.39
64.12
15.43
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

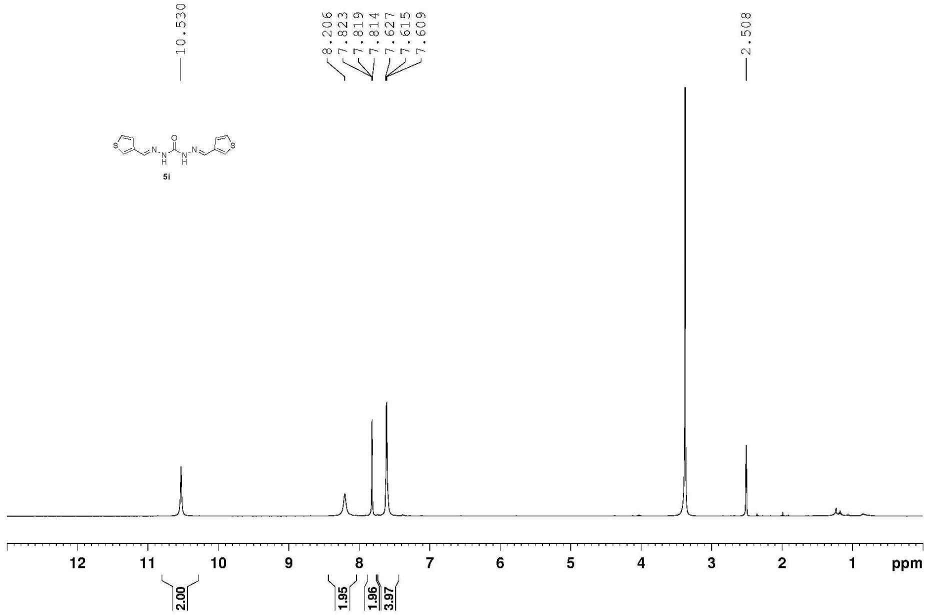

10.621
8.039
6.792
6.784
6.550
6.541
4.423
3.505
3.487
3.470
3.452
3.387
2.508
1.147
1.129
1.112
12 11 10 9 8 7 6 5 4 3 2 1 ppm
2.00
1.99
2.07
2.02
4.09
4.16
6.07


152.15
139.70
138.87
129.97
128.46
128.15
5h
175 170 165 160 155 150 145 140 135 130 125 120 115 110 105 100 95 90 ppm

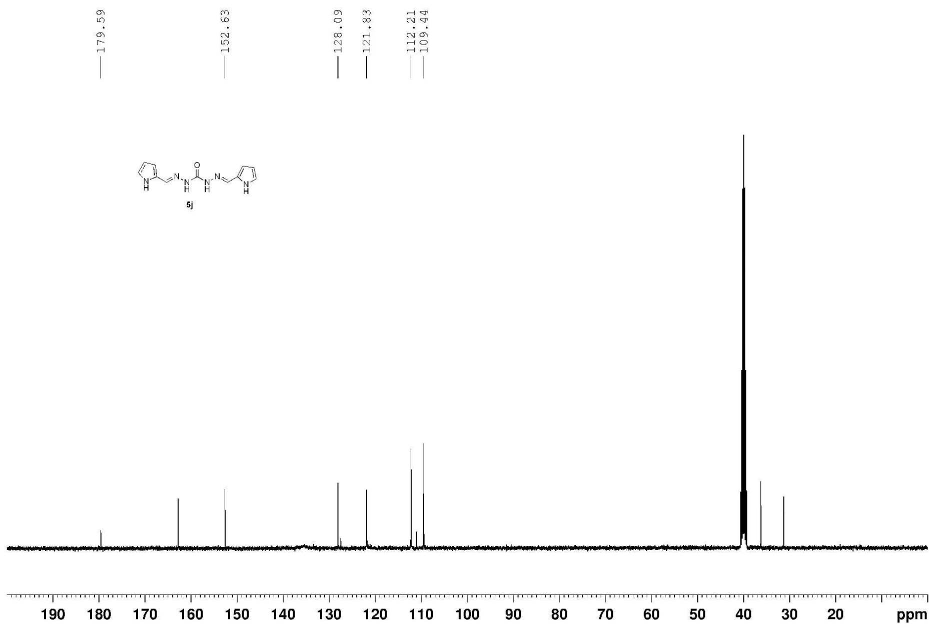

10.542
8.364
7.619
7.606
7.377
7.370
7.368
7.118
7.109
7.106
7.097
3.335
2.500
5h
12 11 10 9 8 7 6 5 4 3 2 1 ppm
2.00
1.96
2.00
2.05
2.05

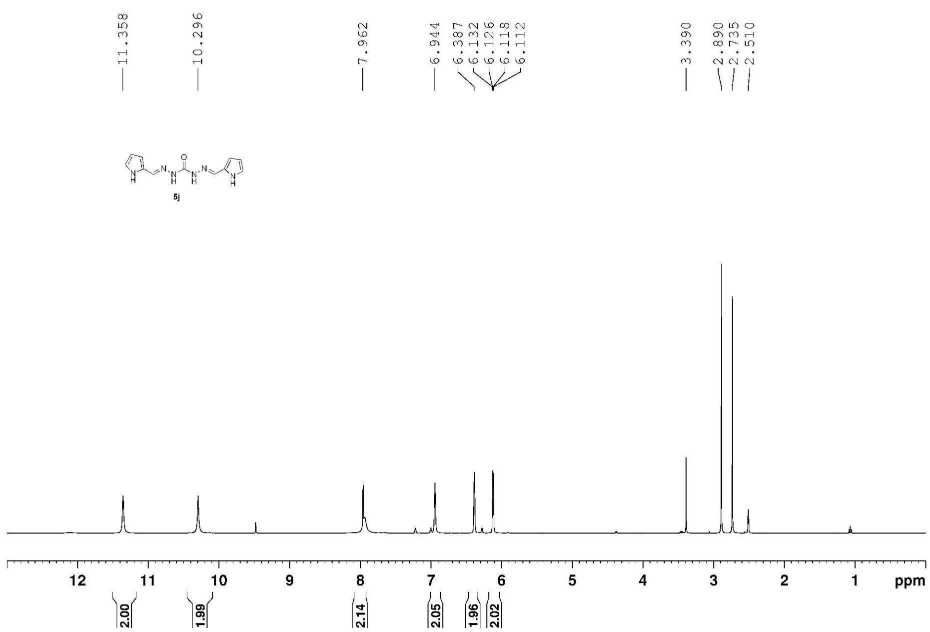


152.50
138.30
127.69
127.07
125.52
5i
175 170 165 160 155 150 145 140 135 130 125 120 115 110 105 100 95 90 ppm



10.530
8.206
7.823
7.819
7.814
7.627
7.615
7.609
2.508
5i
12 11 10 9 8 7 6 5 4 3 2 1 ppm
2.00
1.95
1.96
3.97


179.59
152.63
128.09
121.83
112.21
109.44
5j
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 ppm


11.358
10.296
7.962
6.944
6.387
6.132
6.126
6.118
6.112
3.390
2.890
2.735
2.510
5j
12 11 10 9 8 7 6 5 4 3 2 1 ppm
2.00
1.99
2.14
2.05
1.96
2.02