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Pd-Ni nanoparticles supported on titanium oxide as effective catalysts for Suzuki-Miyaura coupling reactions

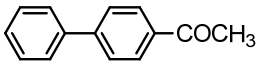
Dongxu Han, Zhiguo Zhang (✉), Zongbi Bao, Huabin Xing, Qilong Ren (✉)

Key Laboratory of Biomass Chemical Engineering of Ministry of Education, College of Chemical and Biological Engineering, Zhejiang University, Hangzhou 310027, China

E-mails: zhiguo.zhang@zju.edu.cn (Zhang Z); renql@zju.edu.cn (Ren Q)

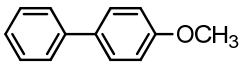
Electronic supplementary information

NMR spectra of biphenyl products



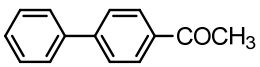
4-acetylbiphenyl (Table3, 1):

^{1}H NMR (400 MHz, $CDCl_3$): δ=8.03 (d, 2H), 7.70 (d, 2H), 7.62 (d, 2H), 7.48 (t, 2H), 7.41 (t, 1H), 2.65 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$): δ=197.52 (s), 145.42 (s), 139.47 (s), 135.42 (s), 130.54 (s), 128.56 (s), 127.88 (s), 126.86 (s), 115.00 (s), 26.32 (s).



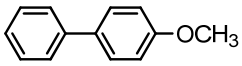
4-methoxybiphenyl (Table3, 2):

^{1}H NMR (400 MHz, $CDCl_3$): δ=7.57 (m, 4H), 7.44 (t, 2H), 7.33 (t, 1H), 7.01 (t, 2H), 3.87 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$): δ=158.77 (s), 140.46 (s), 133.41 (s), 128.38 (s), 127.82 (s), 126.35 (d, J = 7.7 Hz), 113.83 (s), 54.98 (s).



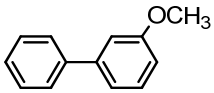
4-acetylbiphenyl (Table3, 3):

^{1}H NMR (400 MHz, $CDCl_3$): δ=8.03 (d, 2H), 7.70 (d, 2H), 7.62 (d, 2H), 7.48 (t, 2H), 7.41 (t, 1H), 2.65 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$): δ=197.48 (s), 145.46 (s), 139.54 (s), 135.50 (s), 128.63 (s), 128.59 (s), 127.90 (s), 126.95 (s), 126.90 (s), 26.36 (s).



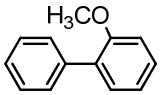
4-methoxybiphenyl (Table3, 4):

^{1}H NMR (400 MHz, $CDCl_3$): δ=7.56 (m, 4H), 7.43 (t, 2H), 7.32 (t, 1H), 7.00 (d, 2H), 3.86 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$): δ=158.78 (s), 140.47 (s), 133.42 (s), 128.38 (s), 127.82 (s), 126.40 (s), 126.32 (s), 113.83 (s), 55.00 (s).



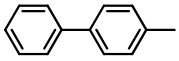
3-methoxybiphenyl (Table3, 5):

^{1}H NMR (400 MHz, $CDCl_3$): δ=7.62 (d, 2H), 7.47 (t, 2H), 7.39 (m, 2H), 7.23 (d, 1H), 7.17 (s, 1H), 6.95 (m, 1H), 3.89 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$): δ=159.56 (s), 142.41 (s), 140.74 (s), 129.40 (s), 128.38 (s), 127.06 (s), 126.85 (s), 119.32 (s), 112.53 (s), 112.30 (s), 4.93 (s).



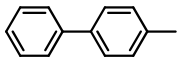
2-methoxybiphenyl (Table3, 6):

^{1}H NMR (400 MHz, $CDCl_3$): δ= 7.56 (d, 2H), 7.45 (t, 2H), 7.36 (m, 3H), 7.07 (t, 1H), 7.03 (m, 1H), 3.84 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$): δ=156.08 (s), 138.17 (s), 130.54 (s), 130.33 (s), 129.19 (s), 128.26 (s), 127.63 (s), 126.57 (s), 120.46 (s), 110.82 (s), 55.17 (s).



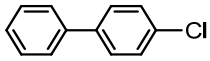
4-methylbiphenyl (Table3, 7):

^{1}H NMR (400 MHz, $CDCl_3$): δ=7.60 (d, 2H), 7.52 (d, 2H), 7.44 (t, 2H), 7.35 (t, 1H), 7.29 (d, 2H), 2.43 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$): δ=140.81 (s), 138.00 (s), 136.68 (s), 129.14 (s), 128.37 (s), 126.83 (s), 126.65 (s), 126.63 (s), 20.77 (s).



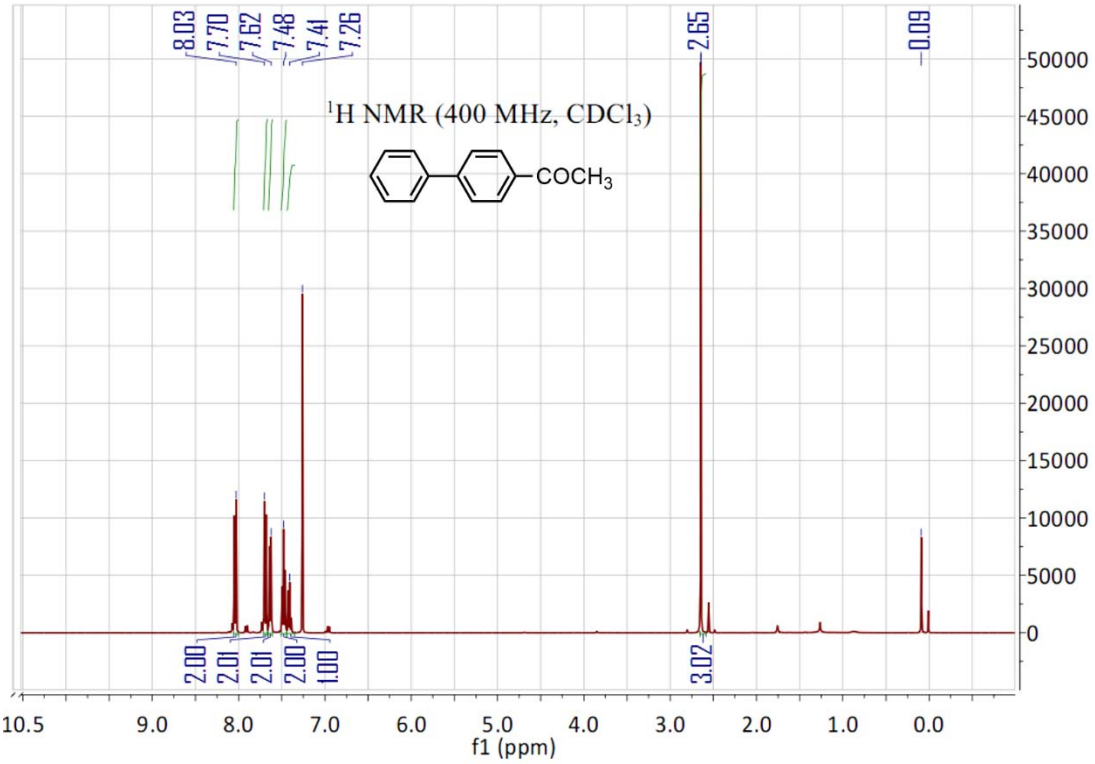
4-methylbiphenyl (Table3, 8):

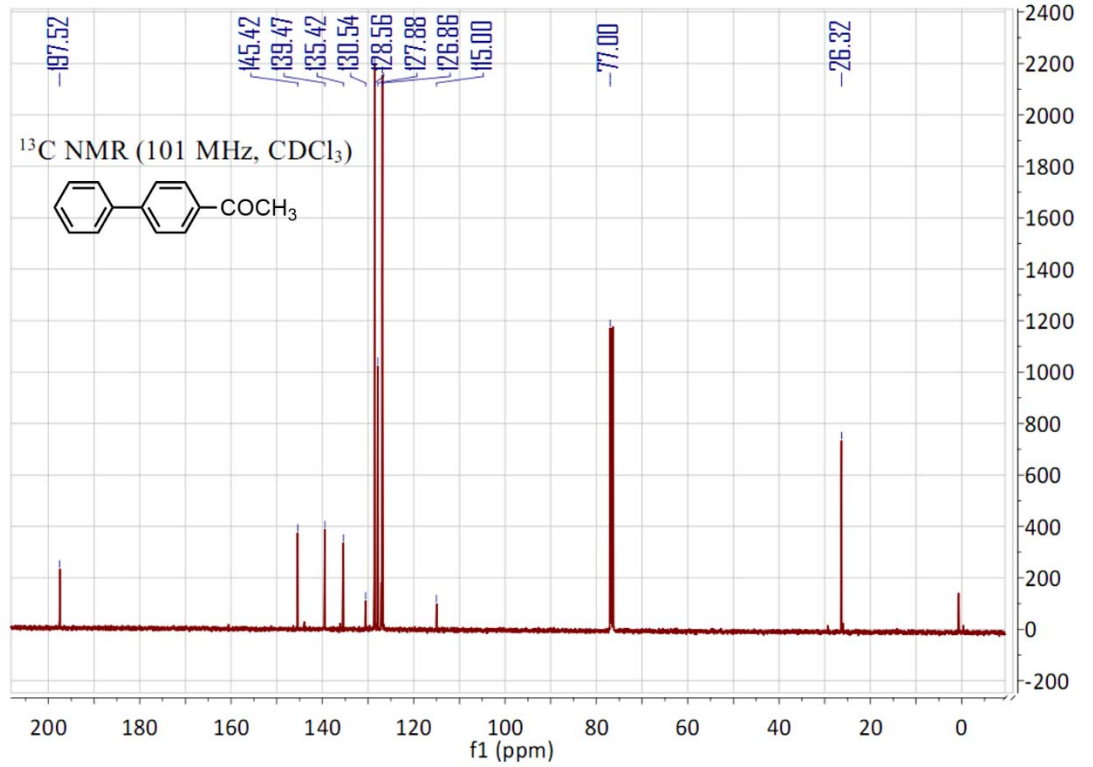
^{1}H NMR (400 MHz, $CDCl_3$): δ=7.60 (d, 2H), 7.52 (d, 2H), 7.46 (t, 2H), 7.35 (t, 1H), 7.29 (d, 2H), 2.43 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$): δ=140.81 (s), 138.00 (s), 136.68 (s), 129.14 (s), 128.37 (s), 126.83 (s), 126.65 (s), 126.63 (s), 20.77 (s).

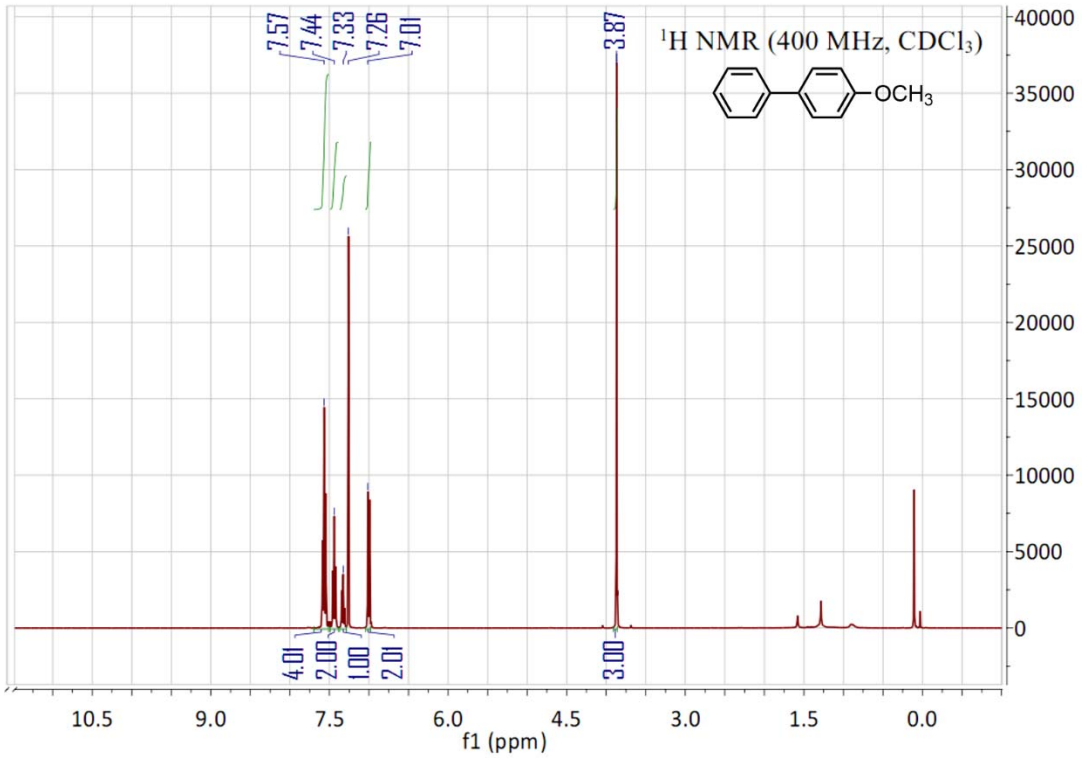


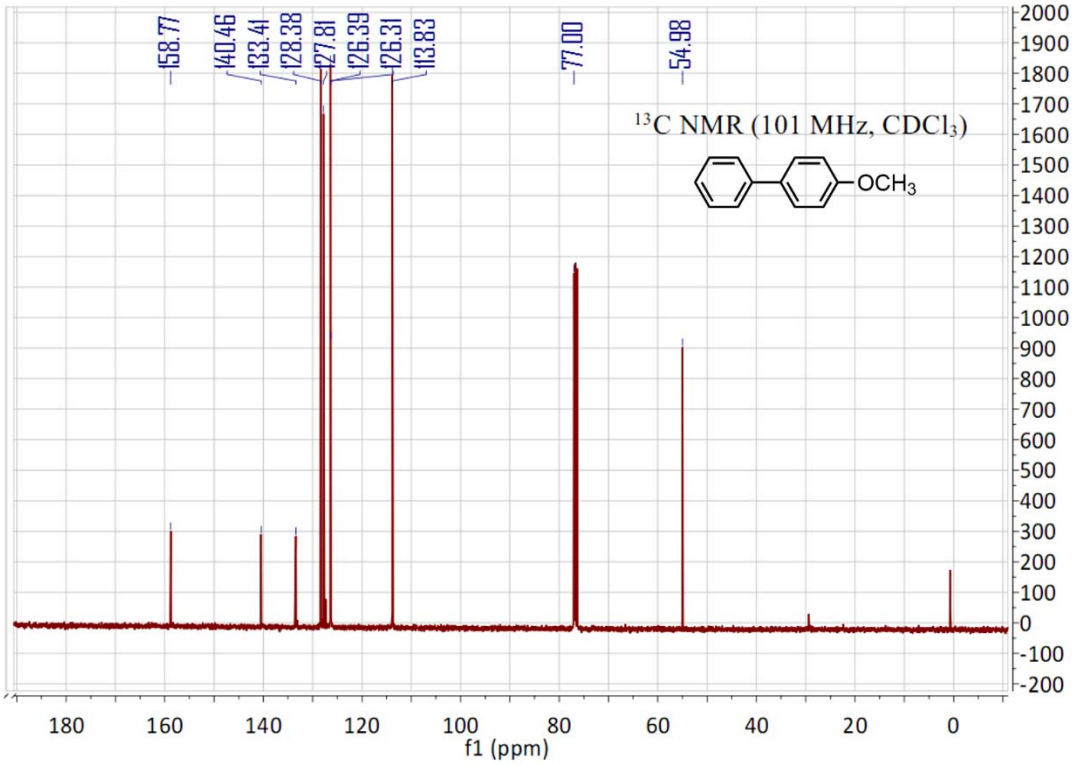
4-chloridebiphenyl (Table3, 9):

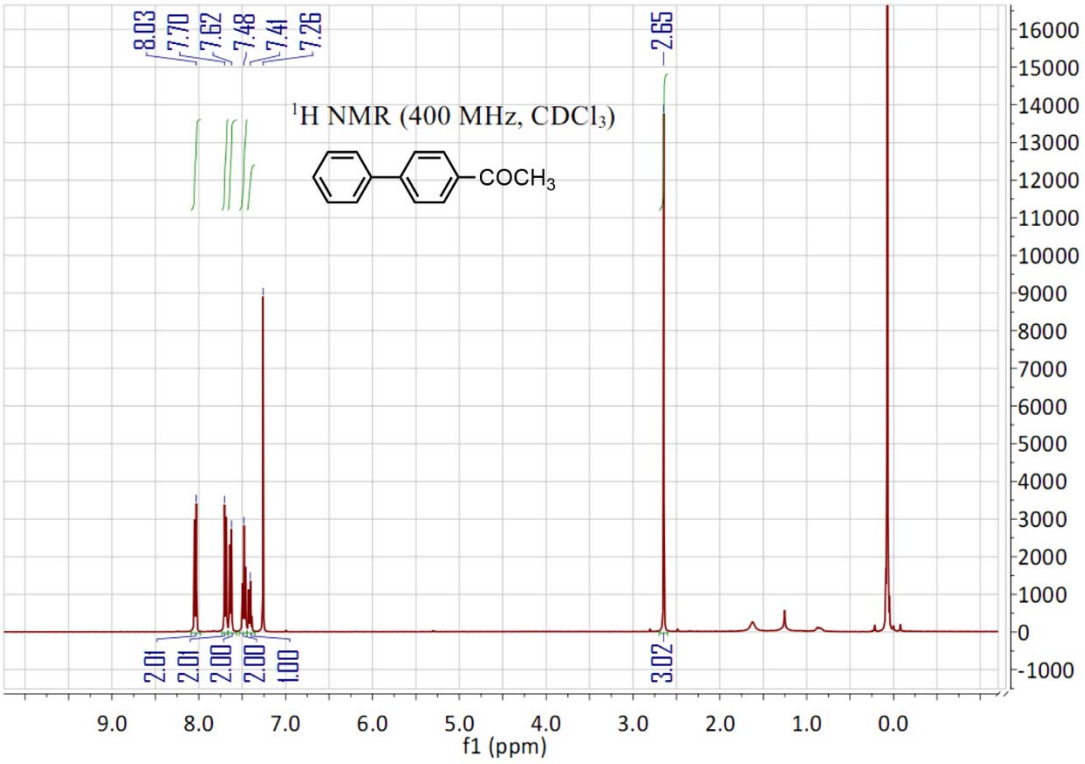
^{1}H NMR (400 MHz, $CDCl_3$): δ=7.52 (m, 4H), 7.44 (m, 5H). ^{13}C NMR (101 MHz, $CDCl_3$): δ=139.65 (s), 139.32 (s), 133.03 (s), 128.57 (s), 128.54 (s), 128.05 (s), 127.25 (s), 126.65 (s).

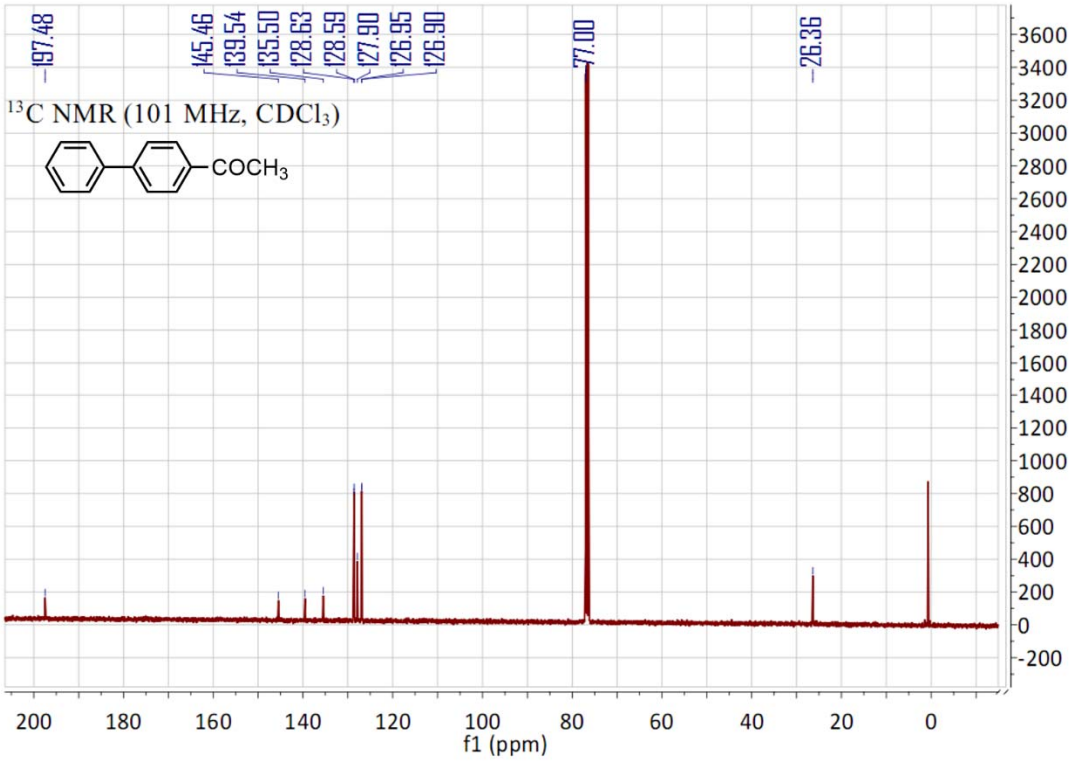

8.03
7.70
7.62
7.48
7.41
7.26
2.65
0.09
^{1}H NMR (400 MHz, $CDCl_3$)
COCH3
2.00
2.01
2.01
2.00
1.00
3.02
f1 (ppm)

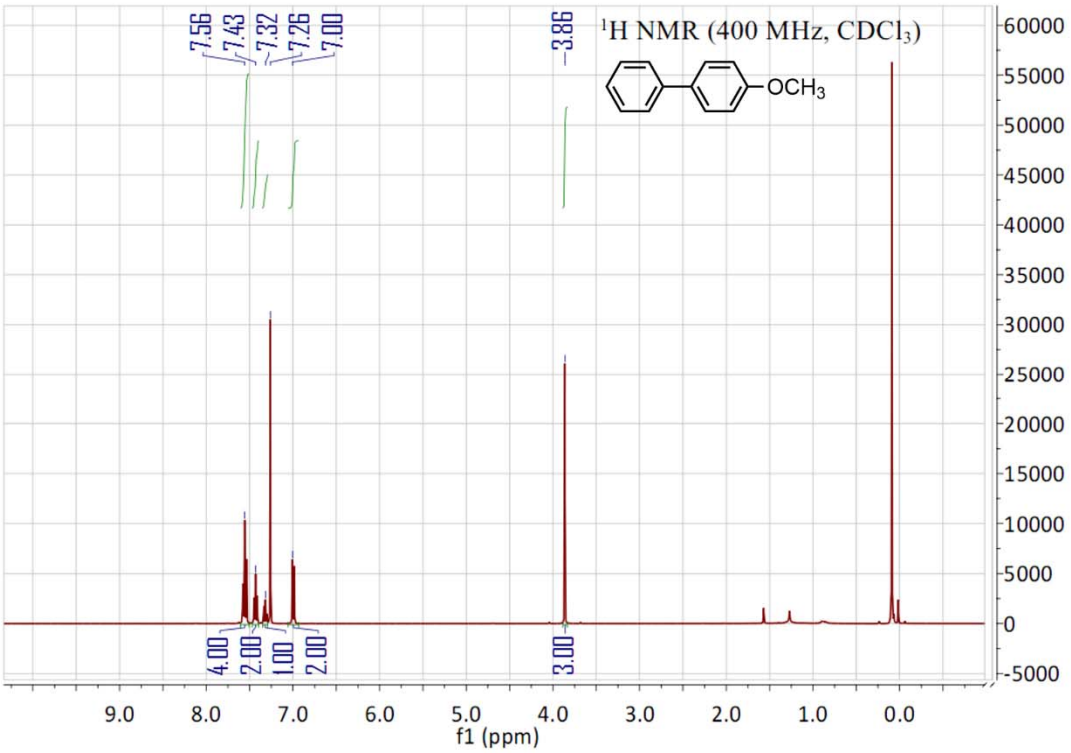

197.52
145.42
139.47
135.42
130.54
128.56
127.88
126.86
115.00
77.00
26.32
^{13}C NMR (101 MHz, $CDCl_3$)
COCH3
f1 (ppm)

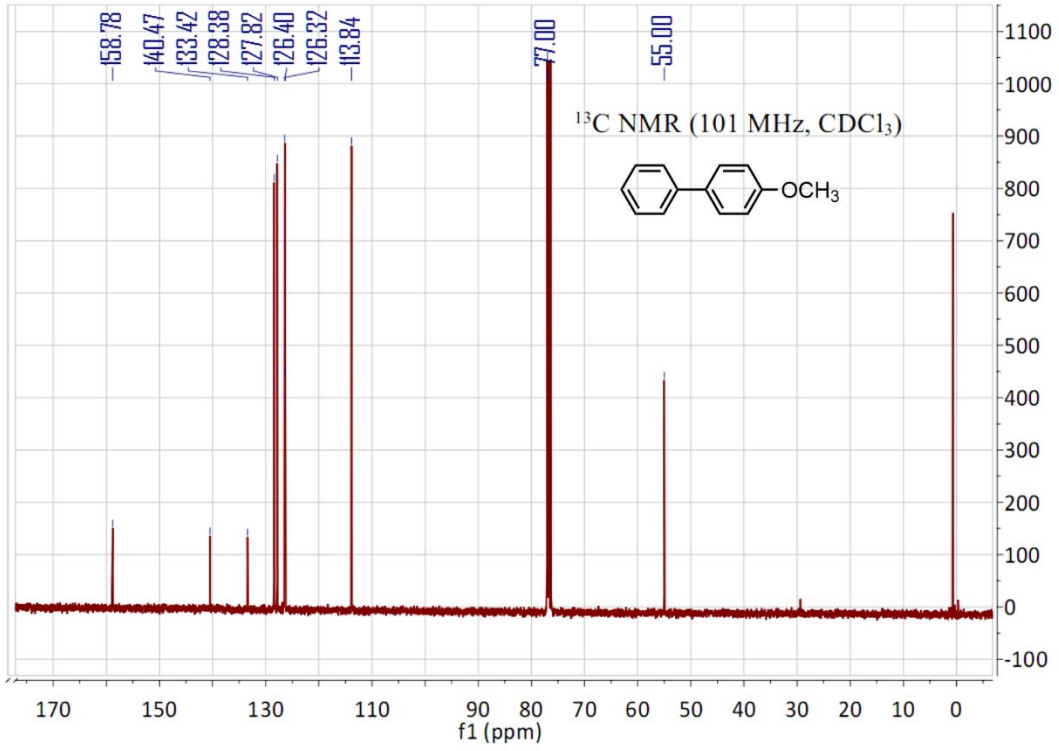

7.57
7.44
7.33
7.26
7.01
3.87
4.01
2.00
1.00
2.01
3.00
^{1}H NMR (400 MHz, $CDCl_3$)
OCH_3
40000
35000
30000
25000
20000
15000
10000
5000
0
10.5
9.0
7.5
6.0
4.5
3.0
1.5
0.0
f1 (ppm)

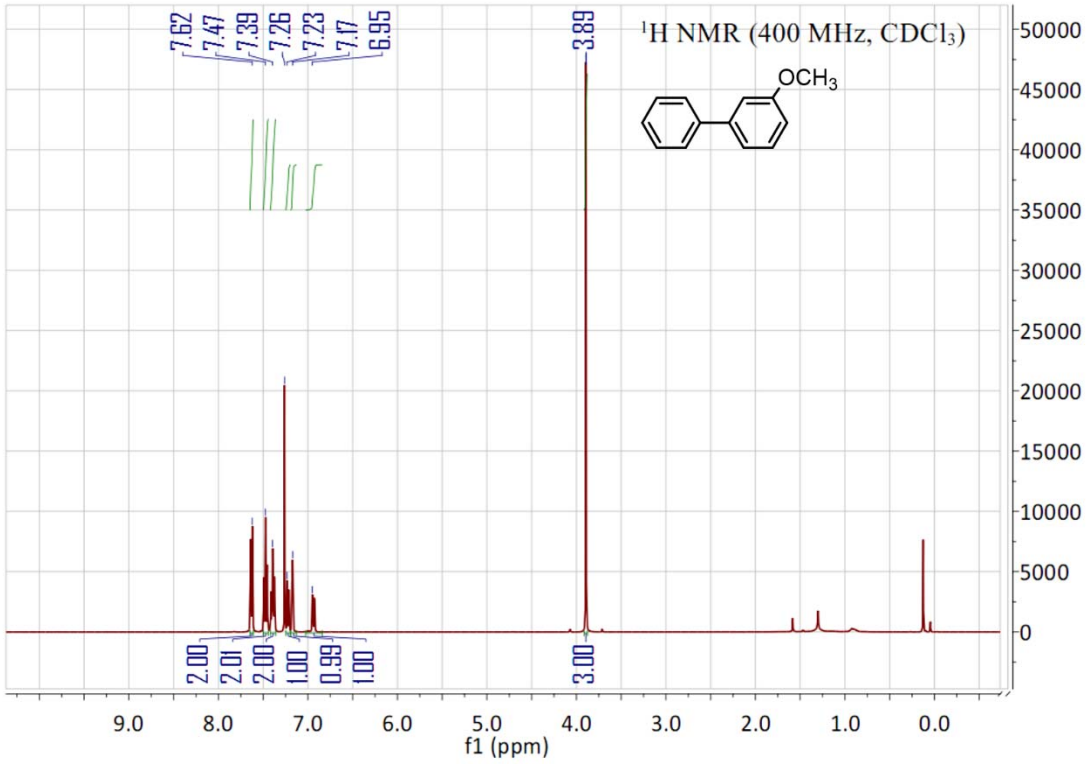

158.77
140.46
133.41
128.38
127.81
126.39
126.31
113.83
77.00
54.98
^{13}C NMR (101 MHz, $CDCl_3$)
OCH_3
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
-100
-200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)

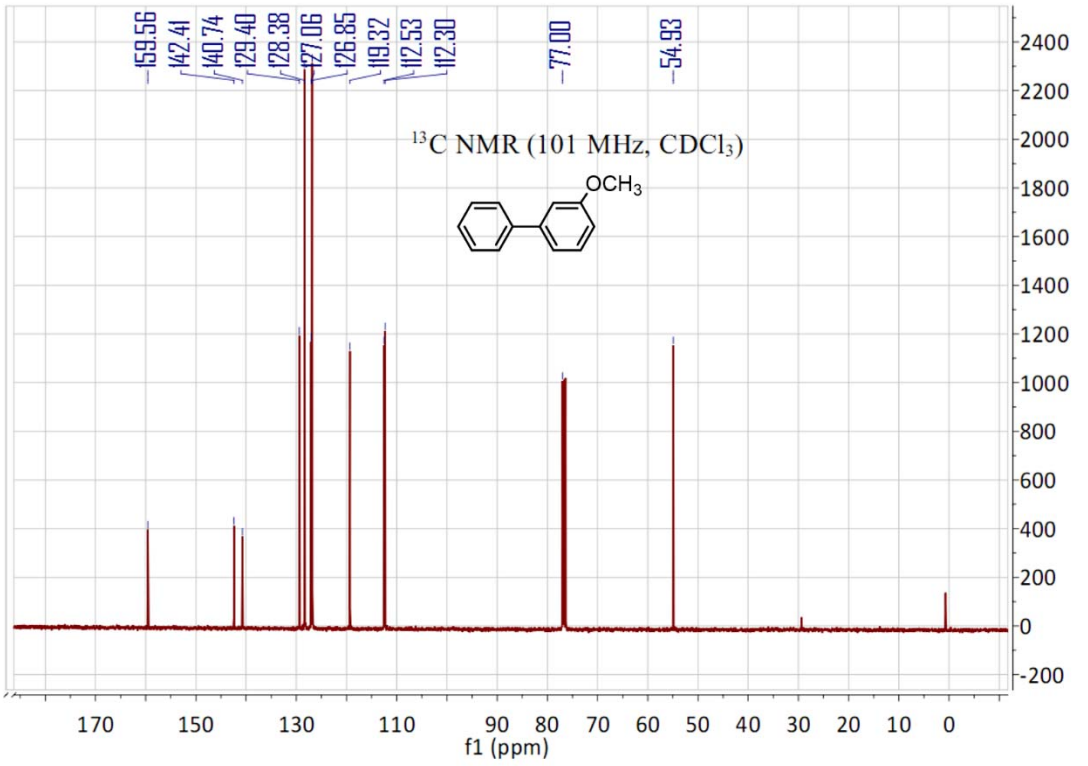

8.03
7.70
7.62
7.48
7.41
7.26
2.65
^{1}H NMR (400 MHz, $CDCl_3$)
$COCH_3$
2.01
2.01
2.00
2.00
1.00
3.02
f1 (ppm)

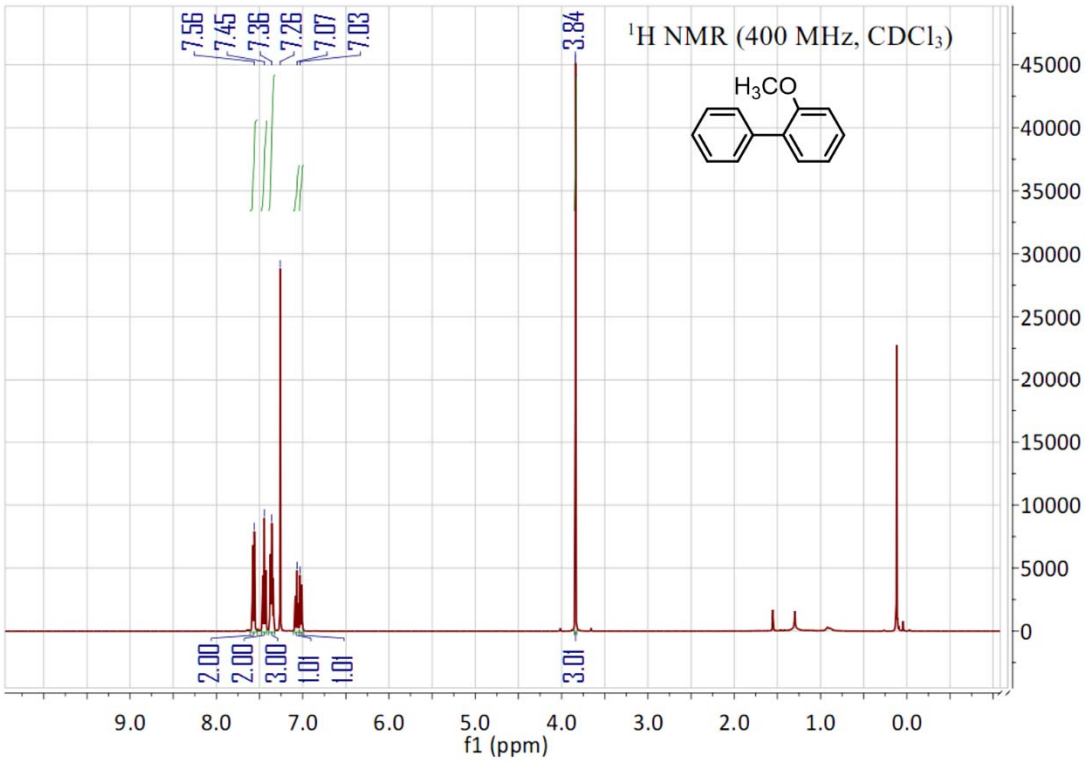

197.48
145.46
139.54
135.50
128.63
128.59
127.90
126.95
126.90
77.00
26.36
^{13}C NMR (101 MHz, $CDCl_3$)
$COCH_3$
f1 (ppm)

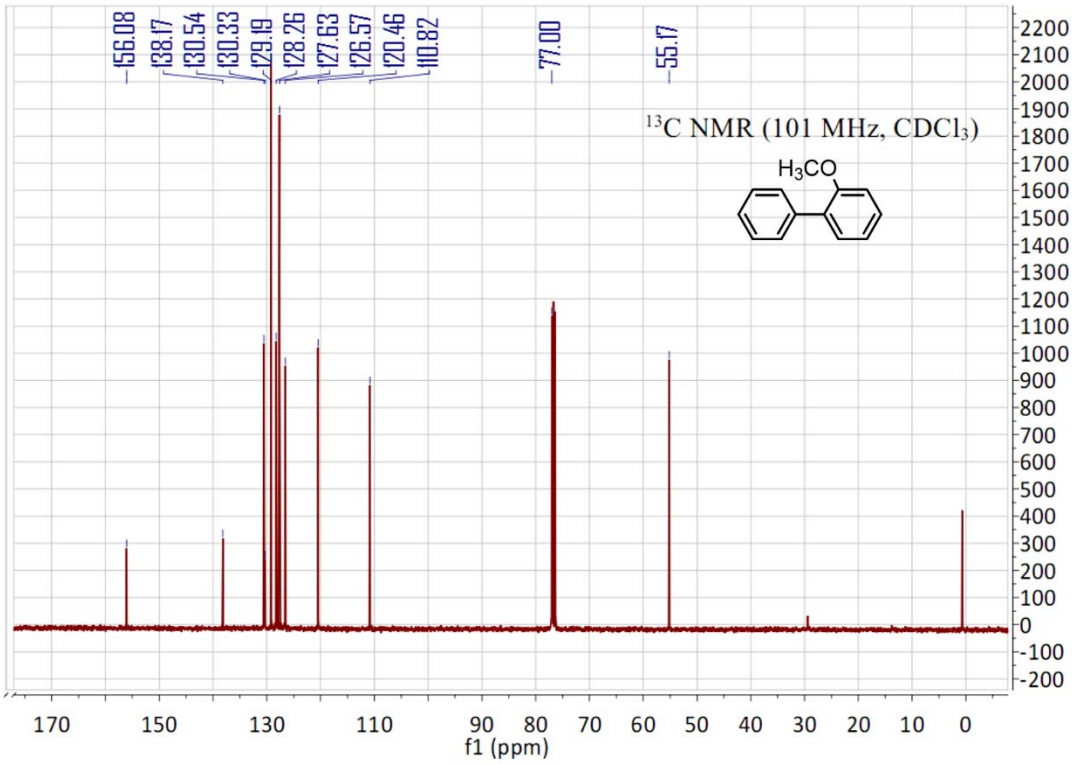

7.56
7.43
7.32
7.26
7.00
3.86
^{1}H NMR (400 MHz, $CDCl_3$)
OCH_3
4.00
2.00
1.00
2.00
3.00
f1 (ppm)

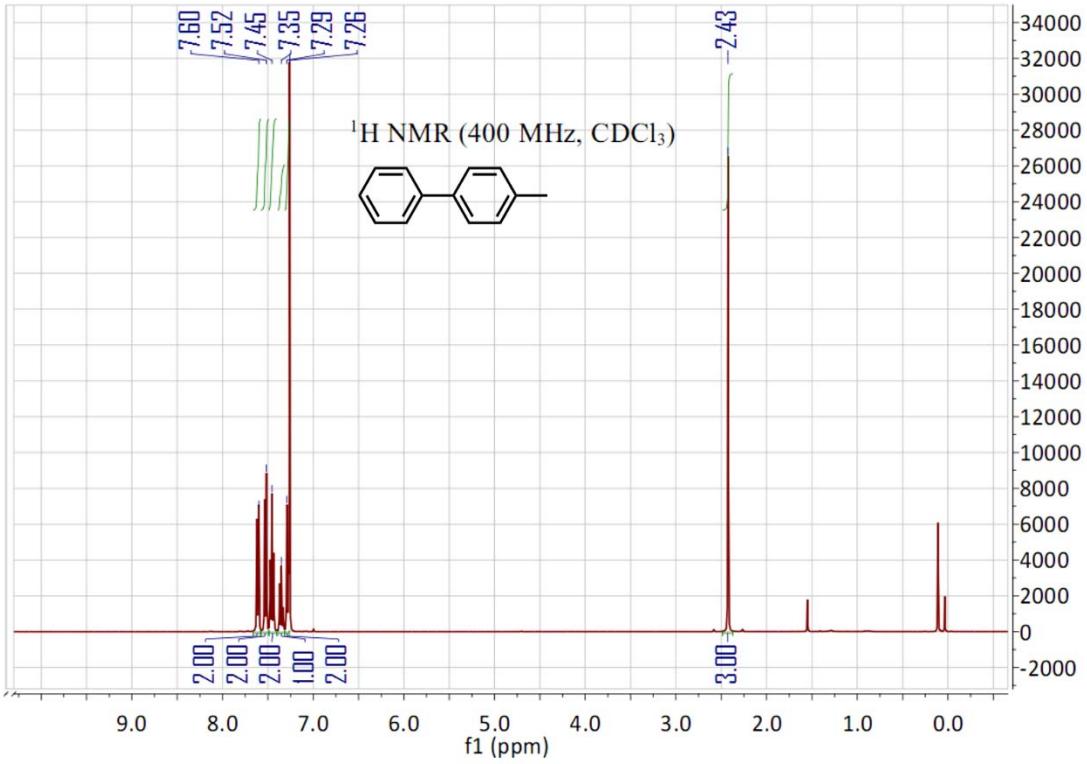

158.78
140.47
133.42
128.38
127.82
126.40
126.32
113.84
77.00
55.00
^{13}C NMR (101 MHz, $CDCl_3$)
OCH_3
f1 (ppm)

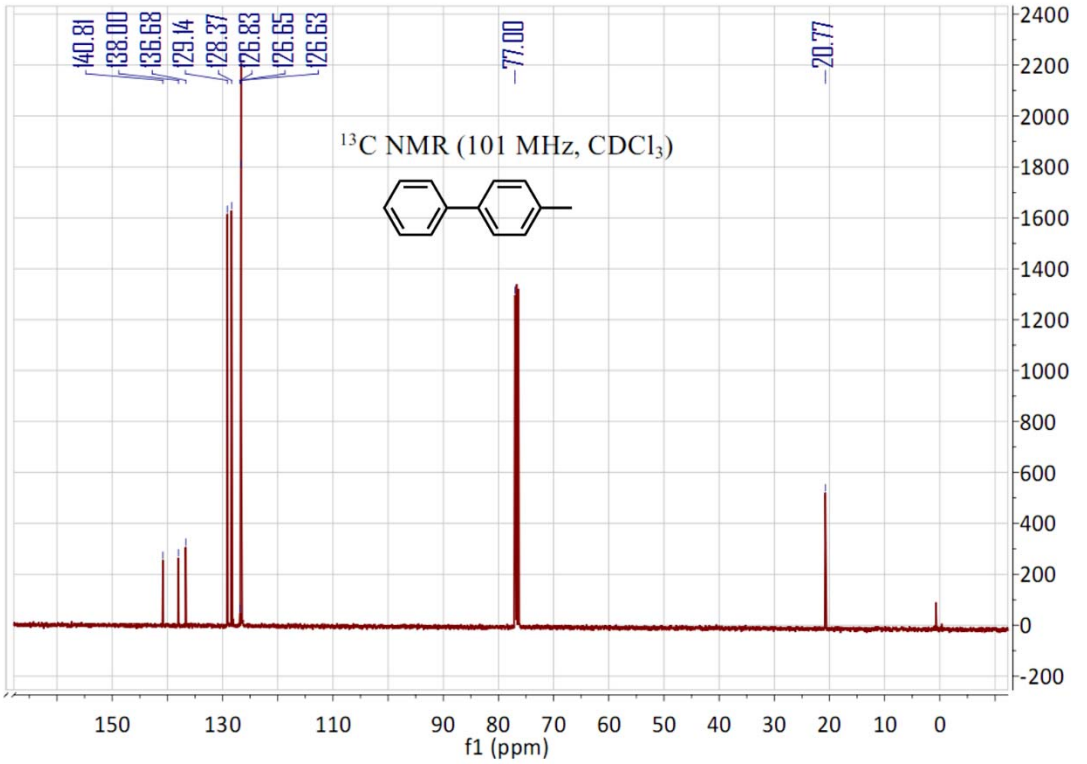

7.62
7.47
7.39
7.26
7.23
7.17
6.95
3.89
^{1}H NMR (400 MHz, $CDCl_3$)
OCH_3
2.00
2.01
2.00
1.00
0.99
1.00
3.00
f1 (ppm)

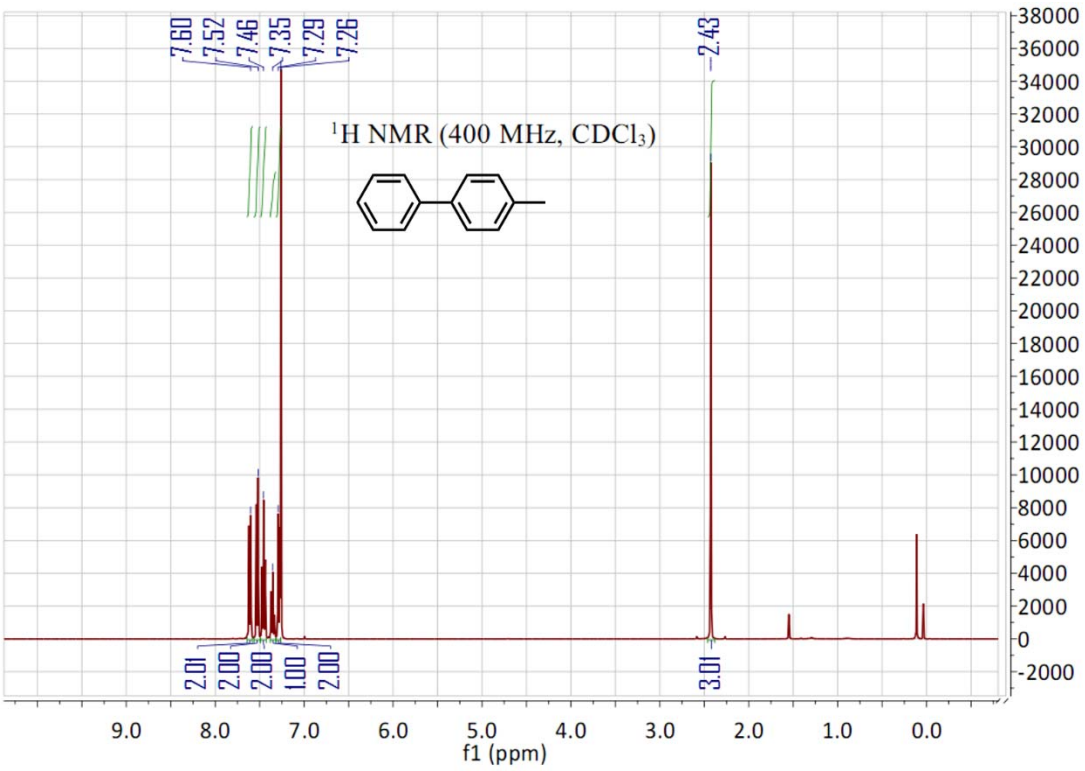

159.56
142.41
140.74
129.40
128.38
127.06
126.85
119.32
112.53
112.30
77.00
54.93
^{13}C NMR (101 MHz, $CDCl_3$)
OCH_3
f1 (ppm)

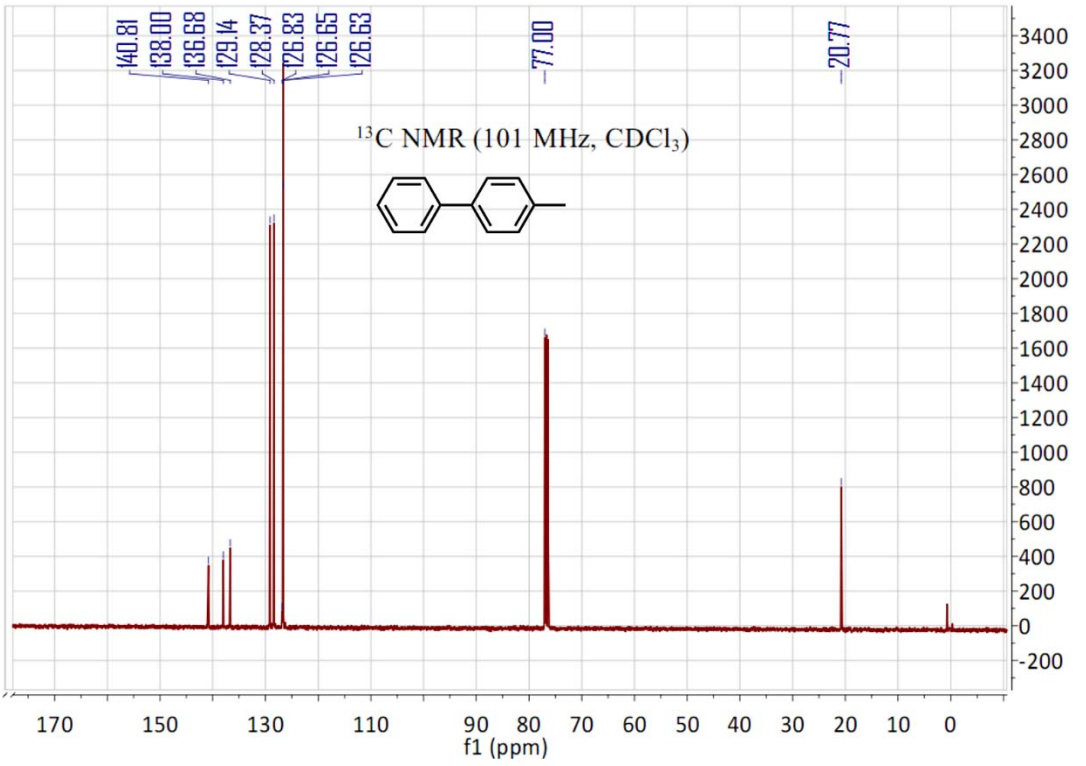

7.56
7.45
7.36
7.26
7.07
7.03
3.84
^{1}H NMR (400 MHz, $CDCl_3$)
H_3CO
2.00
2.00
3.00
1.01
1.01
3.01
f1 (ppm)

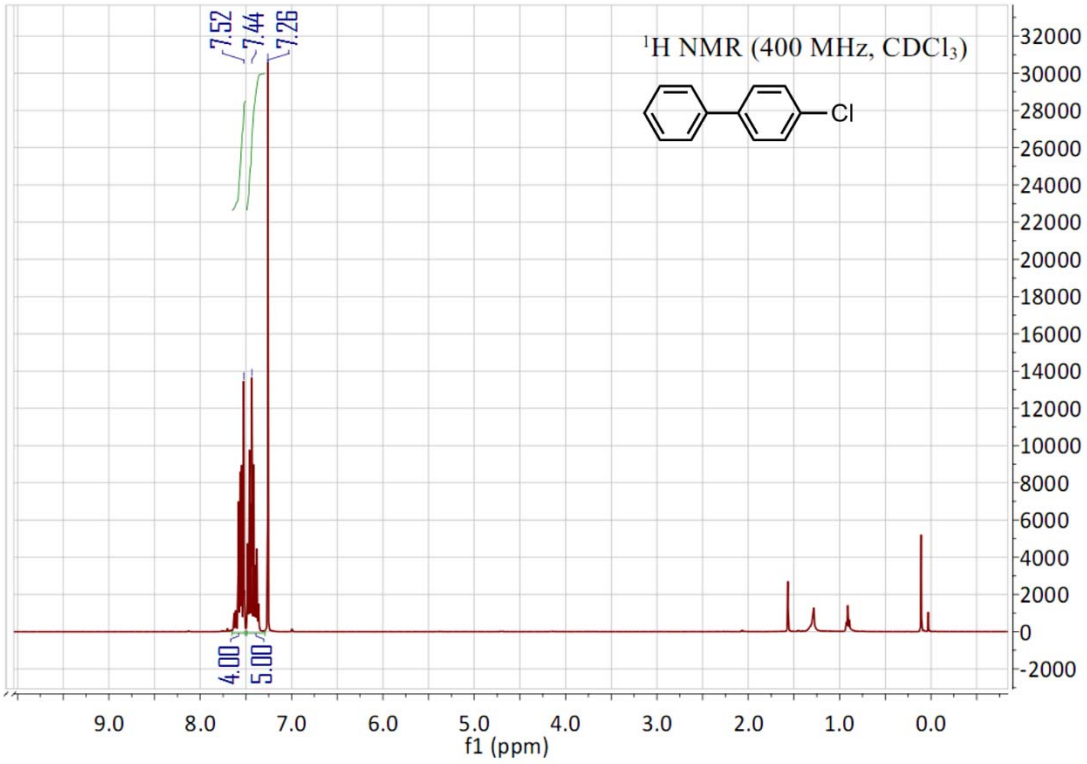

156.08
138.17
130.54
130.33
129.19
128.26
127.63
126.57
120.46
110.82
77.00
55.17
^{13}C NMR (101 MHz, $CDCl_3$)
H_3CO
f1 (ppm)

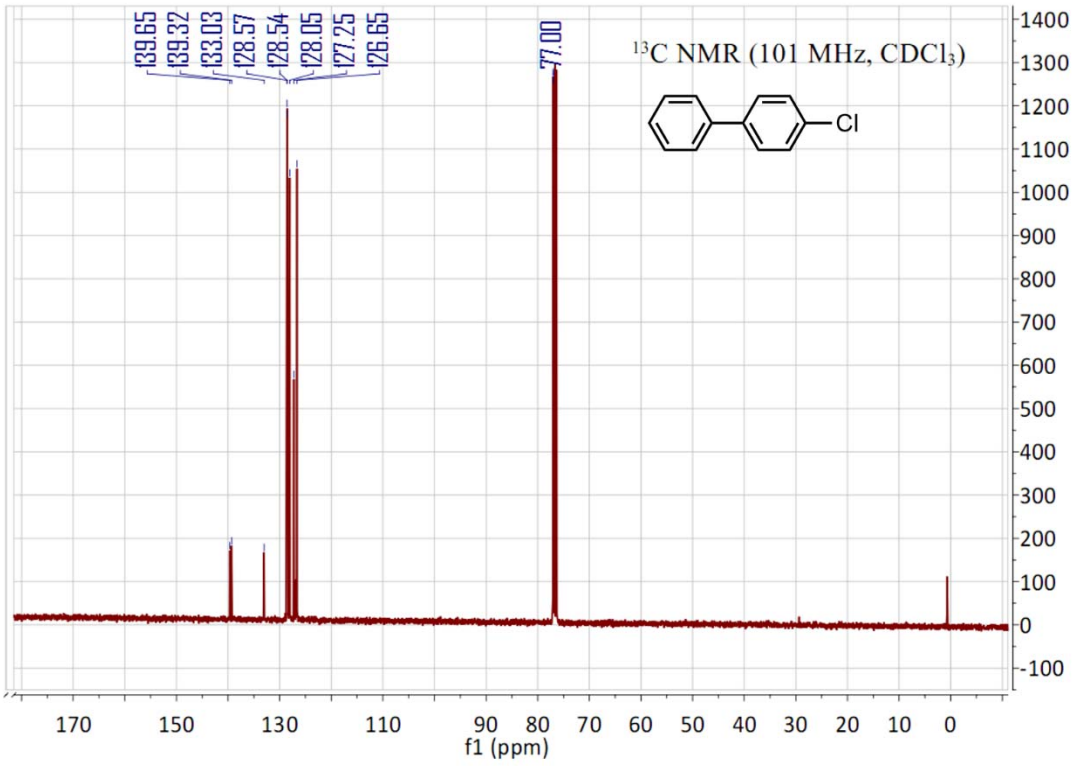

7.60
7.52
7.45
7.35
7.29
7.26
2.43
^{1}H NMR (400 MHz, $CDCl_3$)
2.00
2.00
2.00
1.00
2.00
3.00
f1 (ppm)


140.81
138.00
136.68
129.14
128.37
126.83
126.65
126.63
77.00
20.77
^{13}C NMR (101 MHz, $CDCl_3$)
f1 (ppm)


7.60
7.52
7.46
7.35
7.29
7.26
2.43
^{1}H NMR (400 MHz, $CDCl_3$)
2.01
2.00
2.00
1.00
2.00
3.01
f1 (ppm)


140.81
138.00
136.68
129.14
128.37
126.83
126.65
126.63
77.00
20.77
^{13}C NMR (101 MHz, $CDCl_3$)
f1 (ppm)


7.52
7.44
7.26
^{1}H NMR (400 MHz, $CDCl_3$)
Cl
4.00
5.00
f1 (ppm)


139.65
139.32
133.03
128.57
128.54
128.05
127.25
126.65
77.00
^{13}C NMR (101 MHz, $CDCl_3$)
Cl
f1 (ppm)