Electronic Supplementary Material (ESI) for Organic & Biomolecular Chemistry.


# Asymmetric α-Alkylation of β-keto esters and β-keto amides by Phase-transfer catalysis

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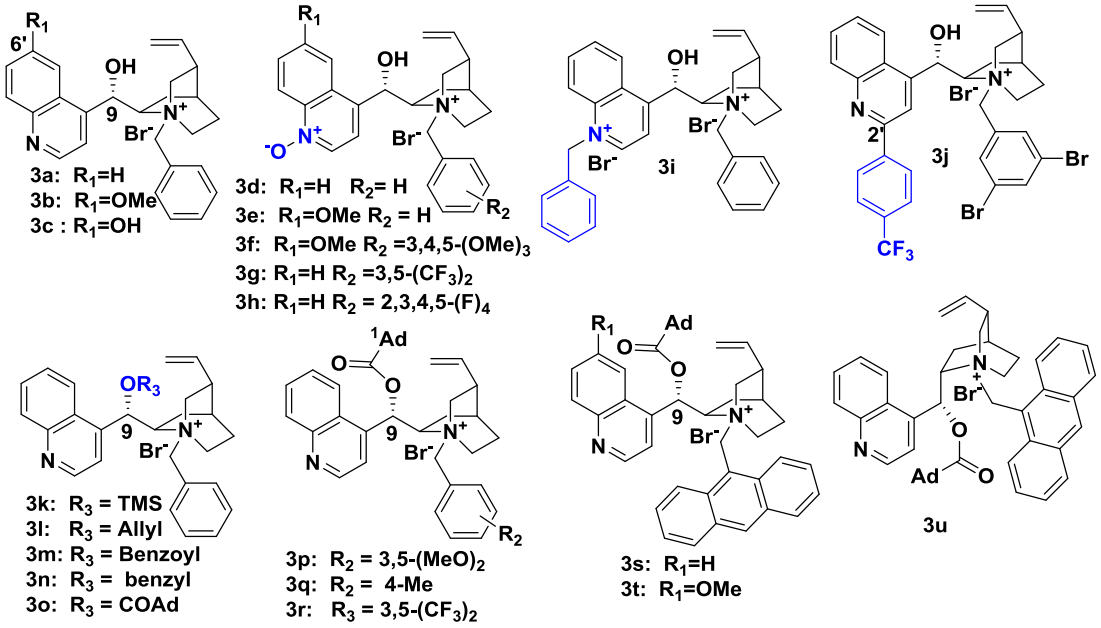
# A. General Information:

Unless otherwise stated, all commercial reagents and solvents were used without further additional purification. Analytical TLC was visualized with UV light at 254 nm. Thin layer chromatography was carried out on TLC aluminum sheets with silica gel 60 $F_{254}$. Purification of reaction products was carried out with chromatography on silica gel 60 (200-300 mesh)... $^{1}$H NMR (400 MHz) spectra was obtained at 25 ℃; $^{13}$C NMR (100 MHz) were recorded on a VARIAN INOVA-400M and AVANCE II 400 spectrometer at 25 ℃. Chemical shifts are reported as δ (ppm) values relative to TMS as internal standard and coupling constants (J) in Hz. The enantiomeric excesses (*ee*) were determined by HPLC. HPLC analyses were performed on equipped with Diacel Chiralpak AD-H, OJ-H and AS-H chiral column (0.46 cm × 25 cm), using mixtures of n-hexane/isopropyl alcohol as mobile phase, at 25 ℃. Mass spectra are reported by using electron ionization and electrospray ionization techniques. Melting points were determined with a hot plate apparatus. Optical rotations were measured on a digital polarimeter with a sodium lamp at 25 $^{o}$C .

## Materials:

## 1. Phase transfer catalysts:




**Cinchona alkaloid catalysts 3a**, **3c, 3i, 3j 3k-3u** were prepared according to our previous papers (*Eur. J. Org. Chem*. **2010**, *34*, 6525–6530; *J. Org.Chem.* **2012**, 77, 9601–9608; *Green Chemistry* **2016**, *18*, 5493-5499).The *N*-oxide catalysts **3d-3h** were prepared according to the previous paper (*J. Org.Chem.* **2016**, *81*, 7042-7050).

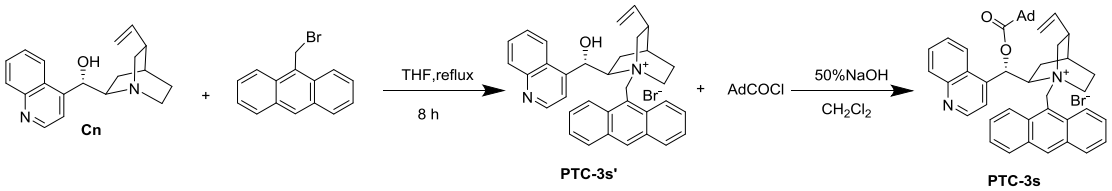
## 2. β-keto esters and β-keto amides

β-keto esters **1a**-**1t** β-keto amides **5a**-**5i** were prepared according to the literature procedure （*Eur. J. Org. Chem*. **2010**, *34*, 6525–6530; *Synlett*. **2011**, 425–429; *Green Chemistry* **2016**, *18*, 5493-5499）

## 3. Commercial grade reagents and solvents:

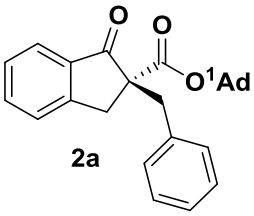
Halohydrocarbons was purchased from Meryer and Energy-Chemical; Commercial grade reagents, bases and solvents were purchased from Sinoreagent, Meryer and Energy-Chemical without further purifications.

## 4. General Procedure for the Synthesis of PTC 3s

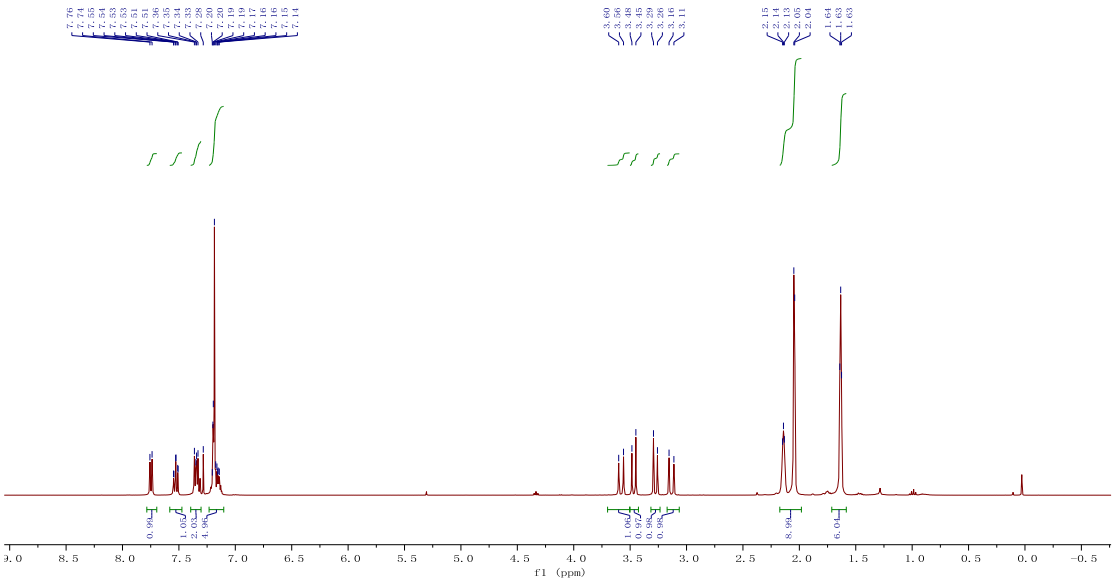


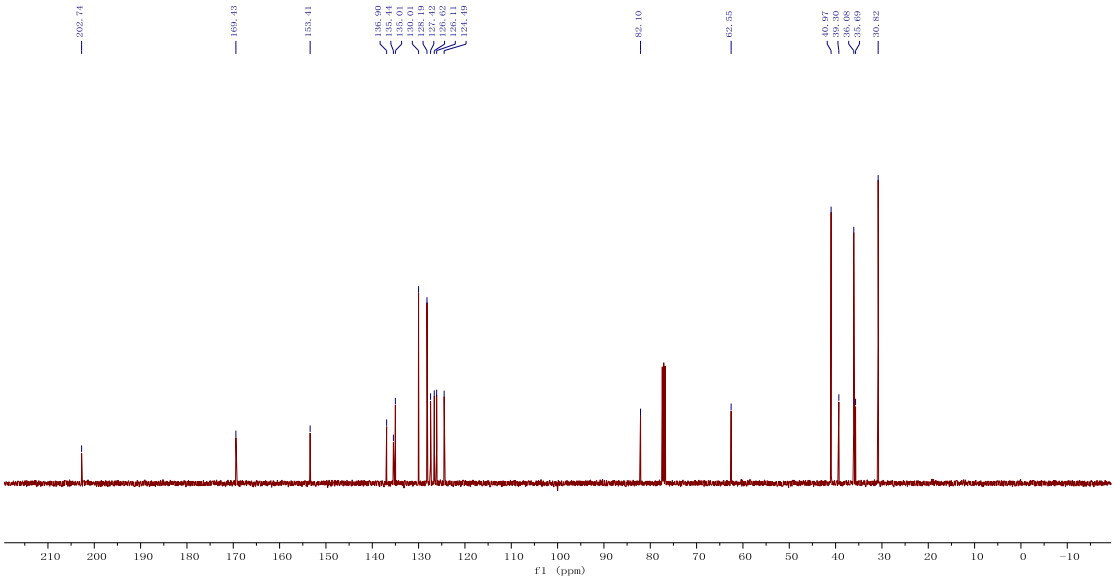

The phase-transfer catalysts **3s** was synthesized by an analogous procedure as reported by Jorgensen (*Angew.Chem., Int. Ed.* **2006**, *45*, 6551-6554). To To a flame-dried flask equipped with a magnetic stirring bar and a reflux condenser was added **Cn** (1.47 g, 5 mmol), THF (50 mL), and 9-(bromomethyl)anthracene (1.75g, 6.5 mmol). The mixture was heated to reflux under $N_2$ for 8 hours and then cooled to room temperature and poured onto $Et_2O$ (150 mL) with stirring. The resulting suspension was stirred for 1 h and the precipitated solids were isolated by filtration, which was recrystallized from MeOH/$Et_2O$ to afford the product **3s'** as yellow crystal (2.06 g, 71% yield). To a flame-dried flask equipped with a magnetic stirring bar was added **3s'**(0.56g, 1 mmol), $CH_2Cl_2$ (10 mL) and adamantane carbonyl chloride (0.6 g, 3.2 mmol).Then 50% w/w NaOH solution (1 mL) was added, and the suspension was stirred vigorously at room temperature for 30 min, during which time the solid fully dissolved. Water (15 mL) was then added, and the two layers were separated. The aqueous layer was extracted with $CH_2Cl_2$ (3×10 mL). The combined organic fractions were dried by $Na_2SO_4$, filtered, and concentrated to 3 mL and then poured onto $Et_2O$ (30 mL). The precipitate was filtered and washed thoroughly with $Et_2O$ to give the product **3s** as a white solid (0.46 g, 64% yield)

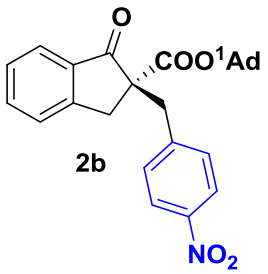
# C. NMR spectra and HPLC




2a

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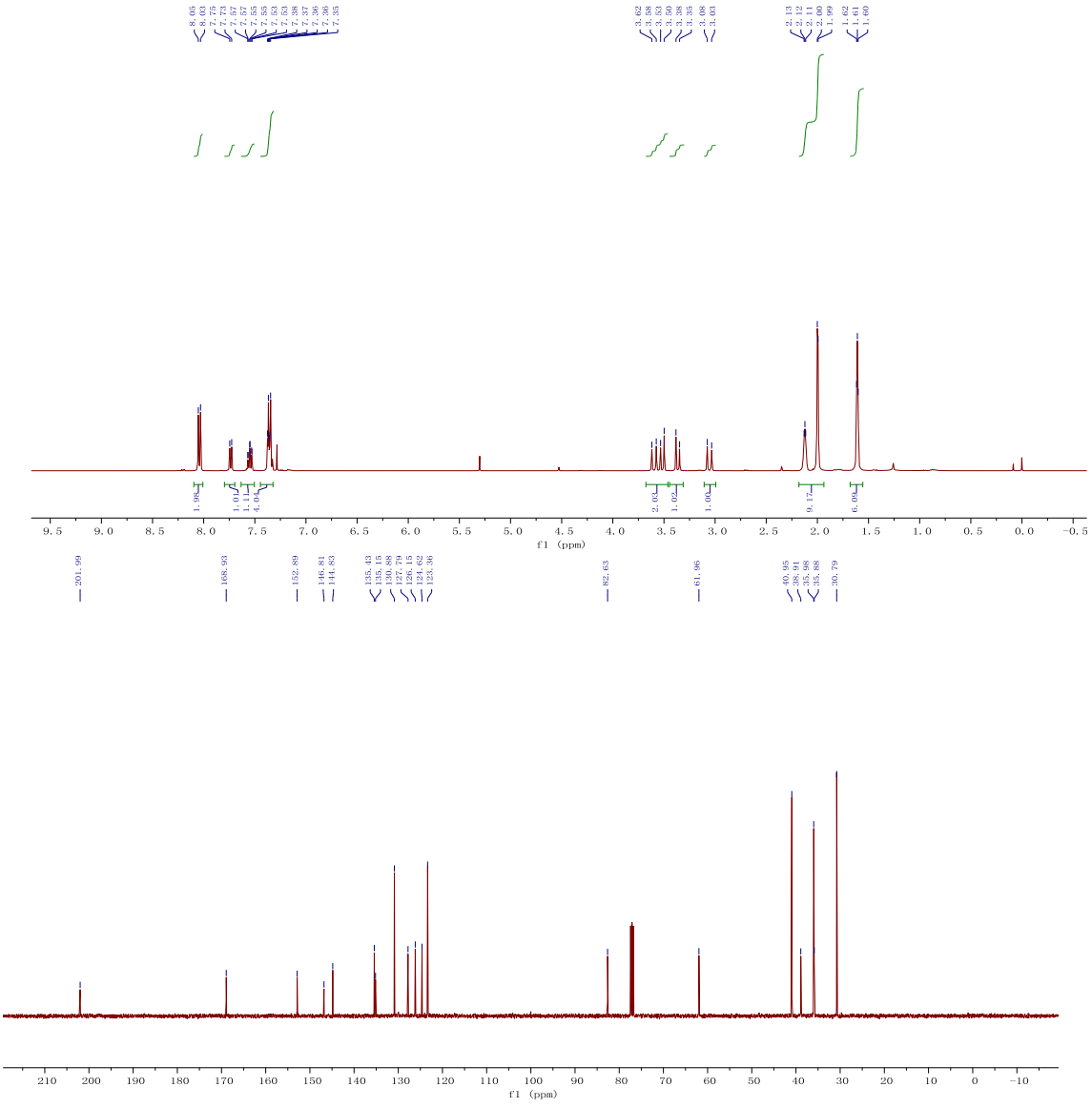
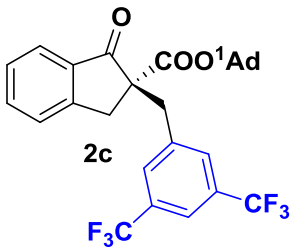
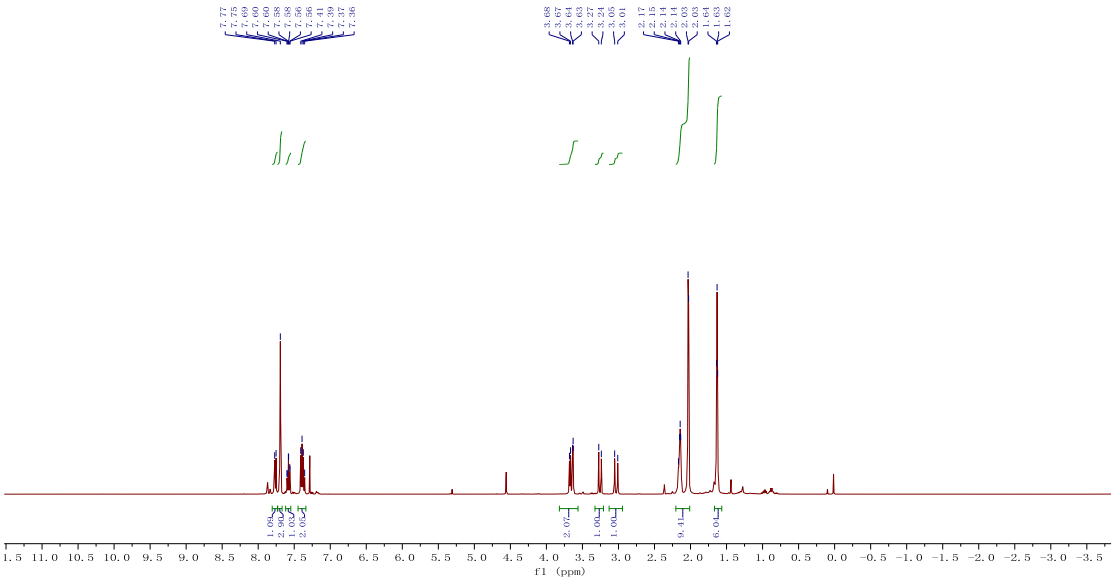
COO1Ad
2b
NO2


f1 (ppm)
f1 (ppm)


O
COO1Ad
2c
CF3
F3C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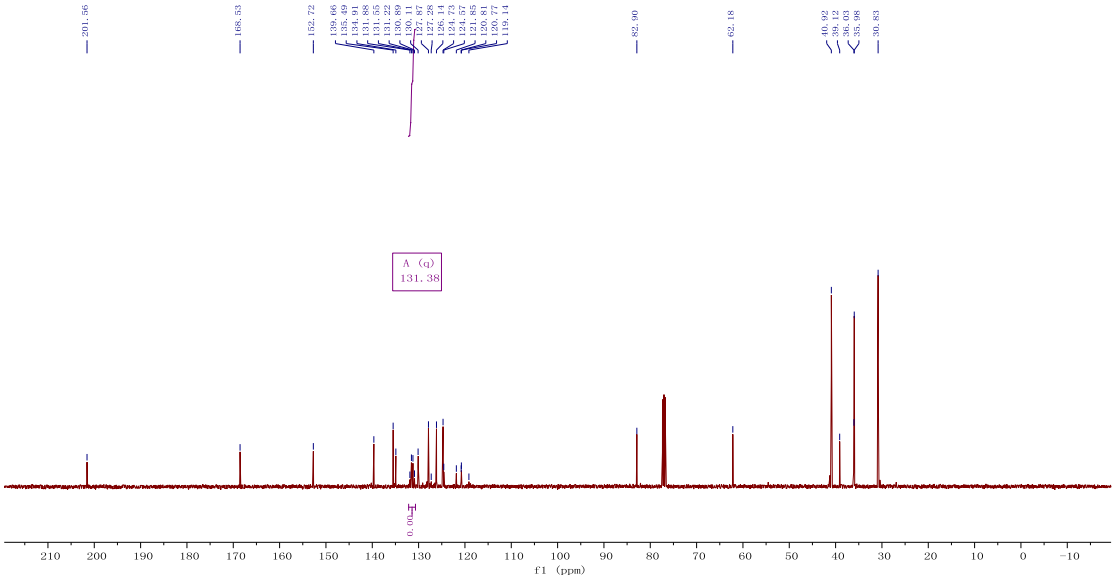
7.58
7.38
7.36
7.36
7.41
7.39
7.37
7.36
3.68
3.67
3.64
3.63
3.37
3.34
3.05
3.01
2.17
2.15
2.14
2.14
2.03
1.64
1.63
1.62
1.00
0.98
2.02
1.03
2.05
2.07
1.06
1.00
9.41
6.04
f1 (ppm)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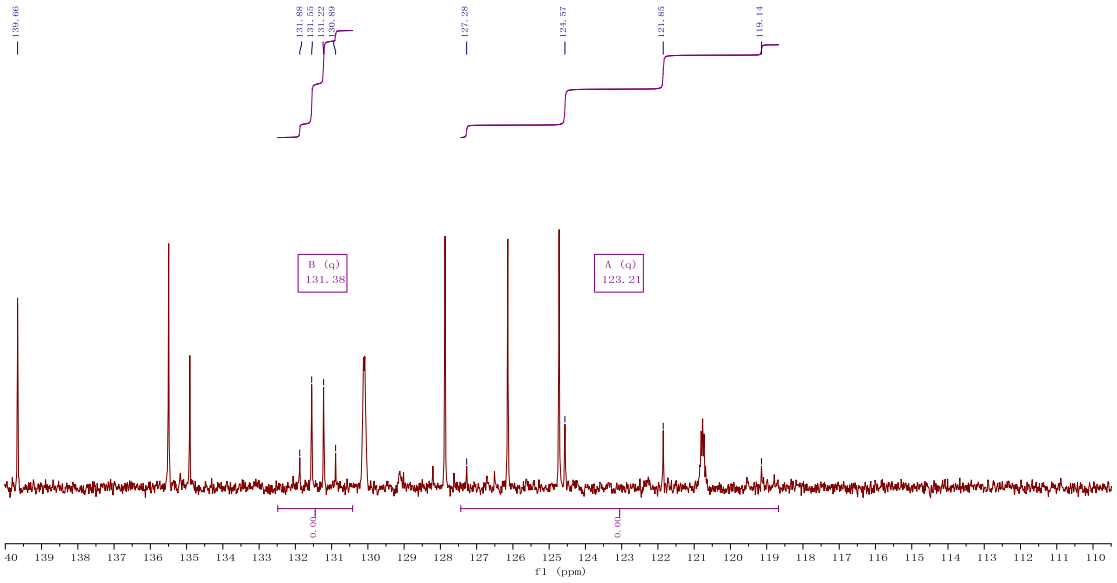
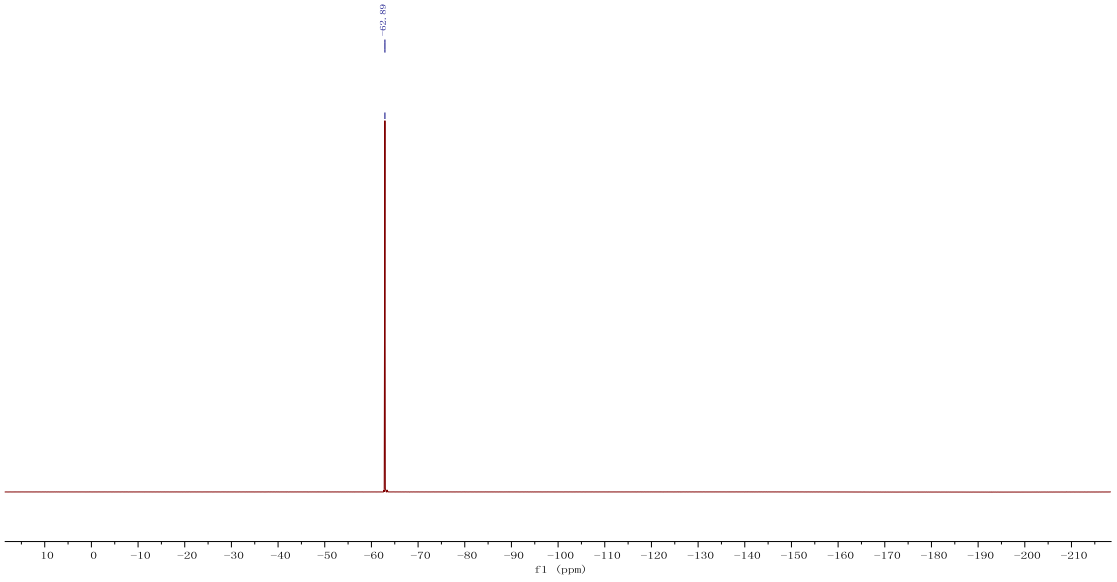
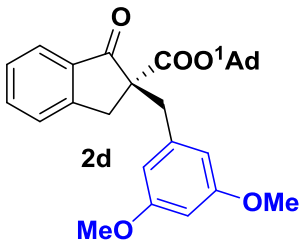
139.66
135.49
134.91
134.58
131.55
131.22
130.89
130.51
129.87
127.28
126.14
124.73
124.57
121.85
120.81
120.77
119.14
82.90
62.18
40.92
39.12
36.03
35.98
30.83
f1 (ppm)

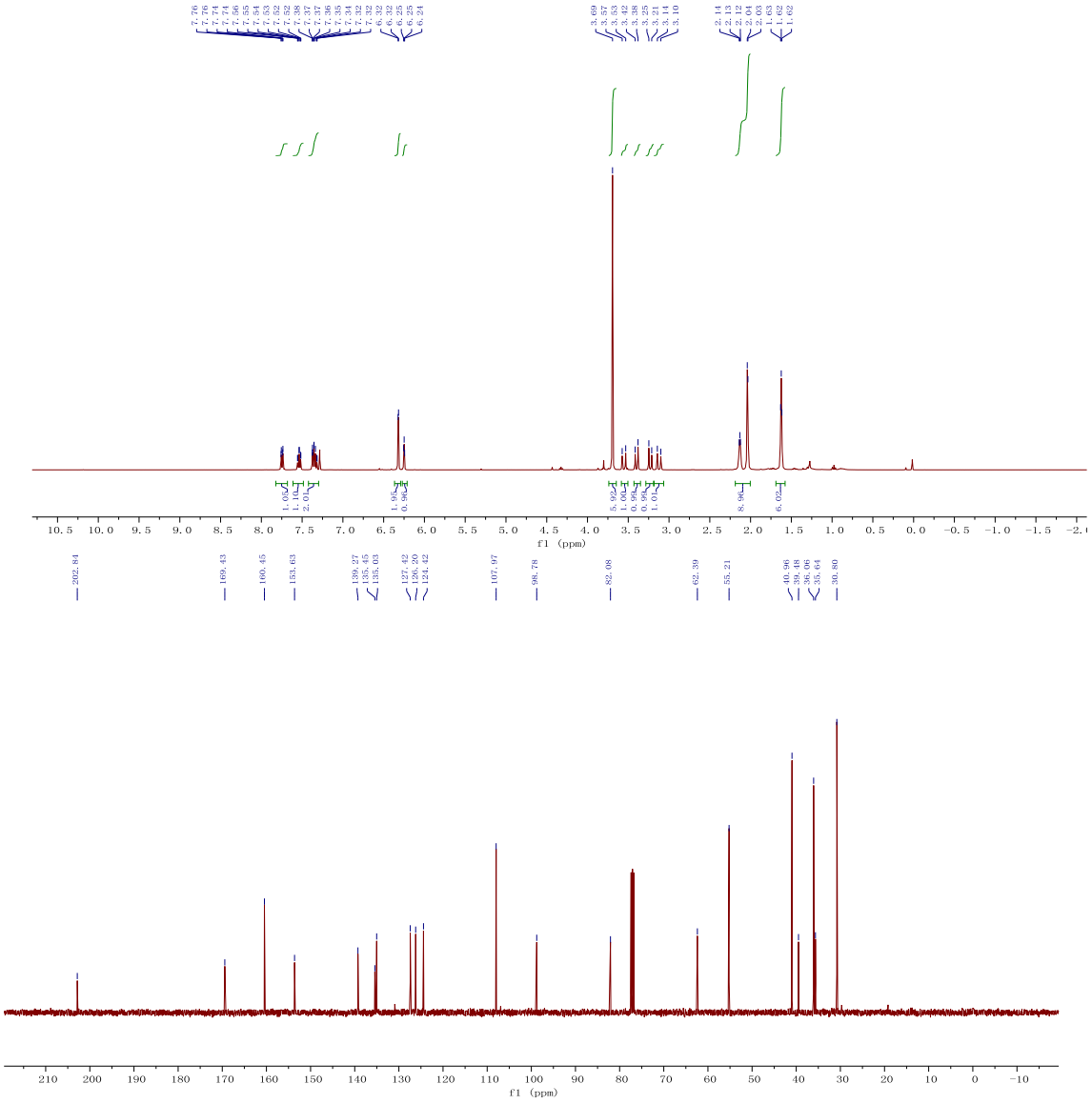

A (q)
131.38
0.04
f1 (ppm)

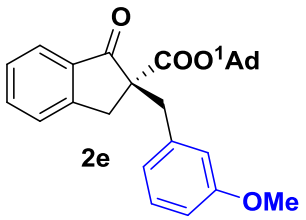
$^{13}$C NMR (101 MHz, Chloroform-$d$) $\delta$ 131.38 (q, $J$ = 33.2 Hz), 123.21 (q, $J$ = 272.7 Hz).

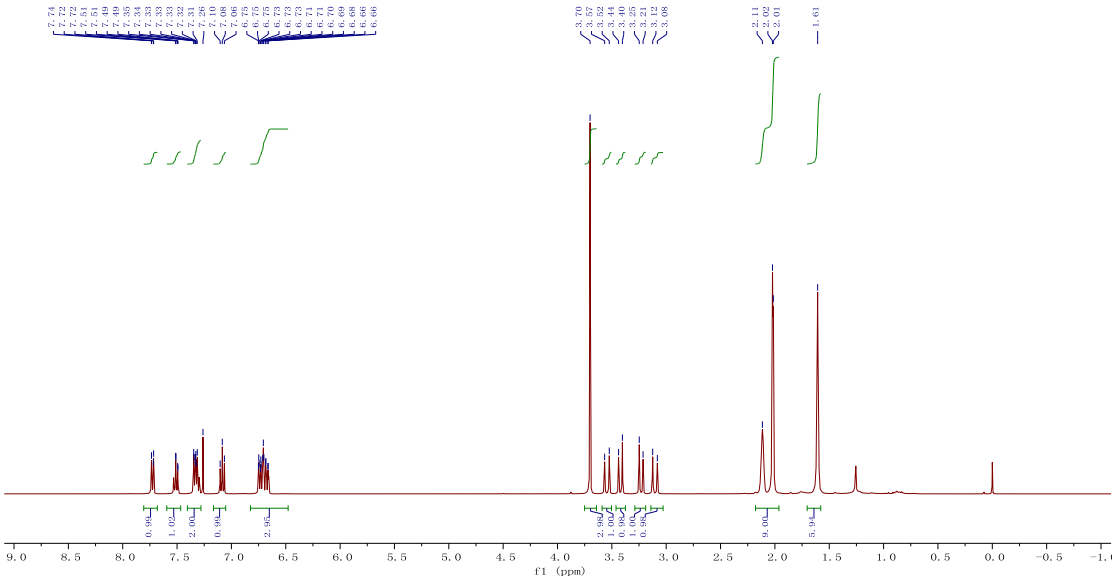



O
COO1Ad
2d
OMe
MeO


f1 (ppm)
f1 (ppm)


O
COO1Ad
2e
OMe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7.28
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7.08
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6.70
6.69
6.68
6.66
6.66
3.70
3.57
3.52
3.44
3.40
3.35
3.21
3.12
3.08
2.11
2.02
2.01
1.61
0.96
1.02
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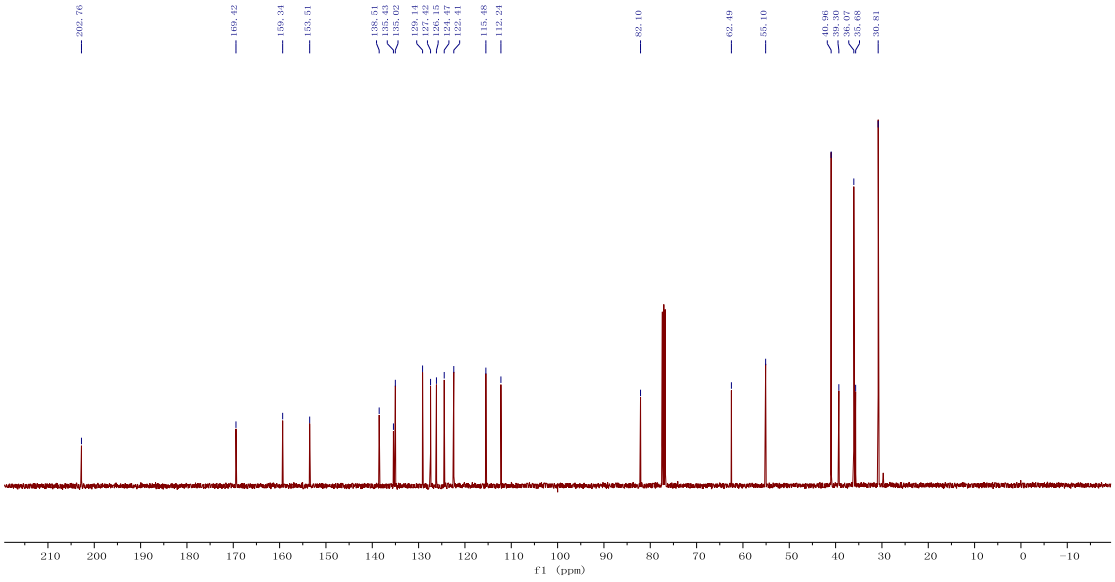
1.03
0.98
1.04
0.94
9.06
5.94
f1 (ppm)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135.02
129.14
127.42
126.15
124.47
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55.10
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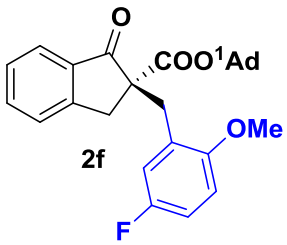
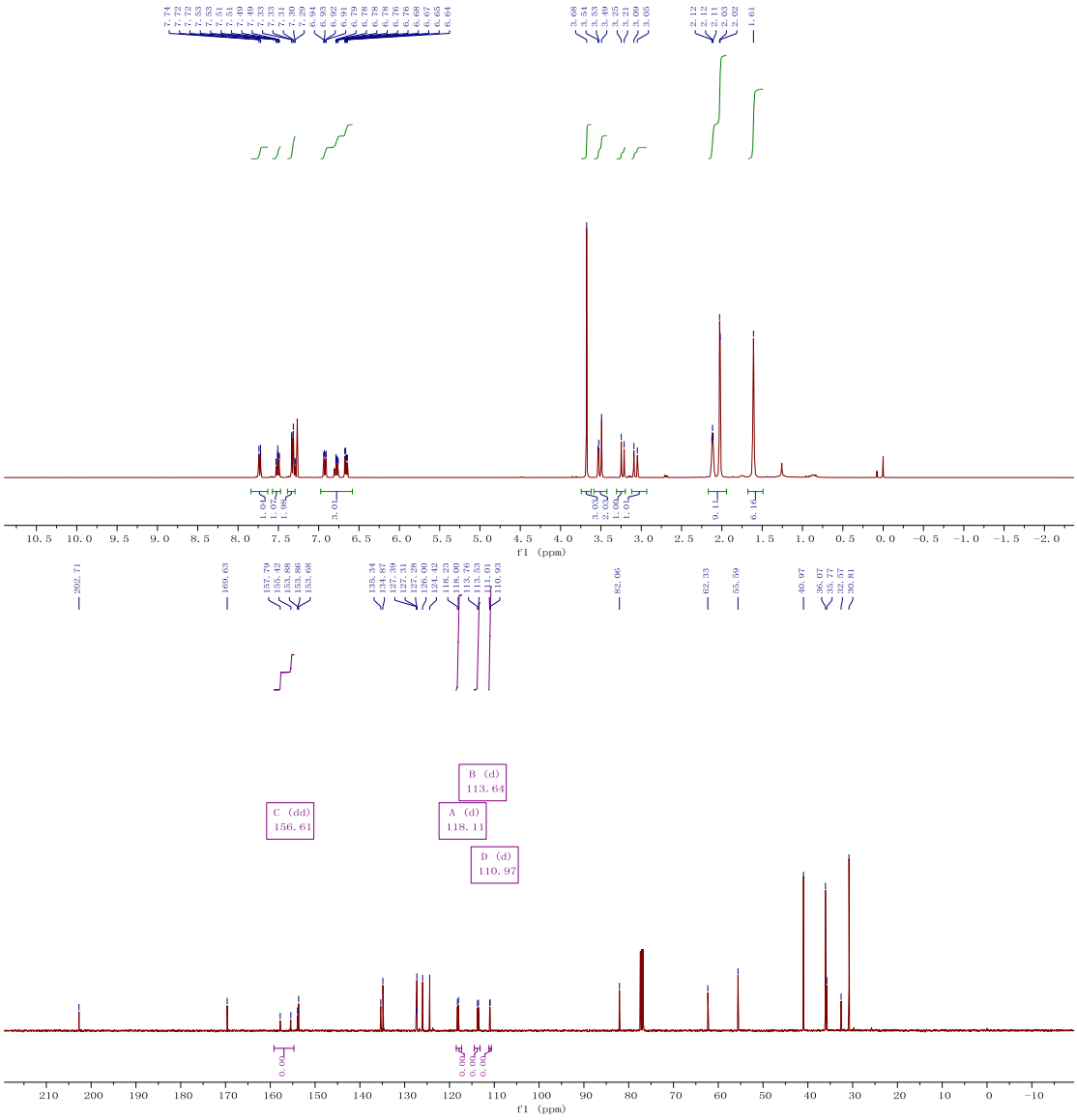
39.30
36.07
35.68
30.81
f1 (ppm)


O
COO1Ad
OMe
F

2f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7.72
7.72
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7.53
7.51
7.51
7.49
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7.33
7.33
7.31
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6.91
6.79
6.78
6.78
6.76
6.76
6.68
6.67
6.65
6.64
3.68
3.54
3.53
3.49
3.25
3.21
3.09
3.05
2.12
2.12
2.11
2.03
2.02
1.61
1.07
1.07
1.05
3.01
3.03
2.03
1.00
1.00
9.11
6.10
f1 (ppm)
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169.63
157.79
155.42
153.88
153.86
153.68
135.34
134.87
127.39
127.31
127.28
126.00
124.42
118.23
118.00
113.76
113.53
111.03
110.93
82.06
62.33
55.69
40.97
36.07
35.77
35.57
30.81
B (d)
113.64
C (dd)
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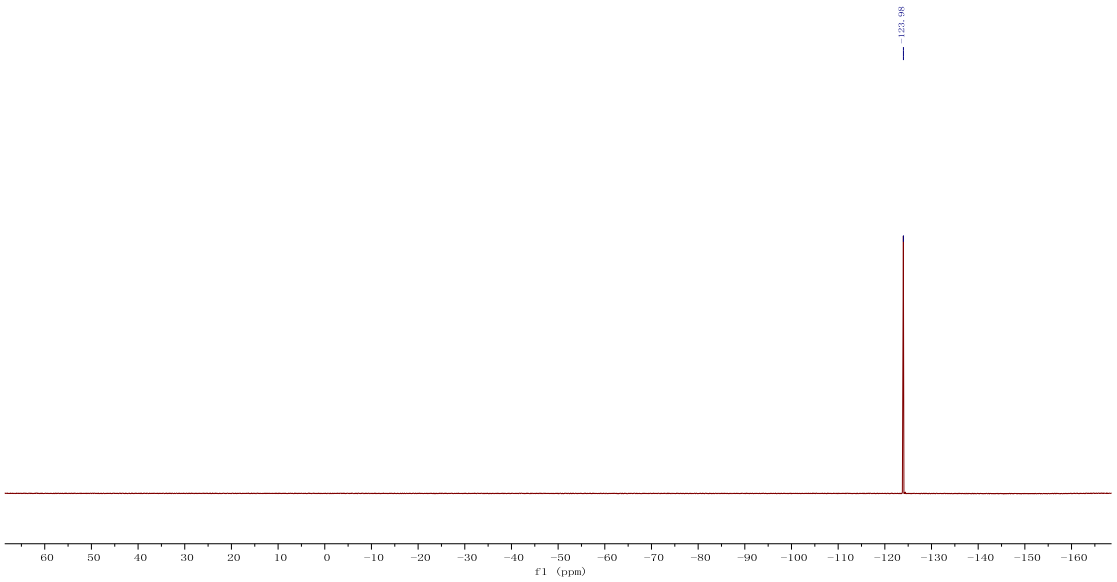
A (d)
118.11
D (d)
110.97
0.00
0.00
0.00
0.04
f1 (ppm)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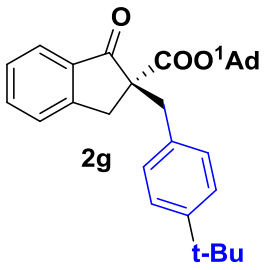
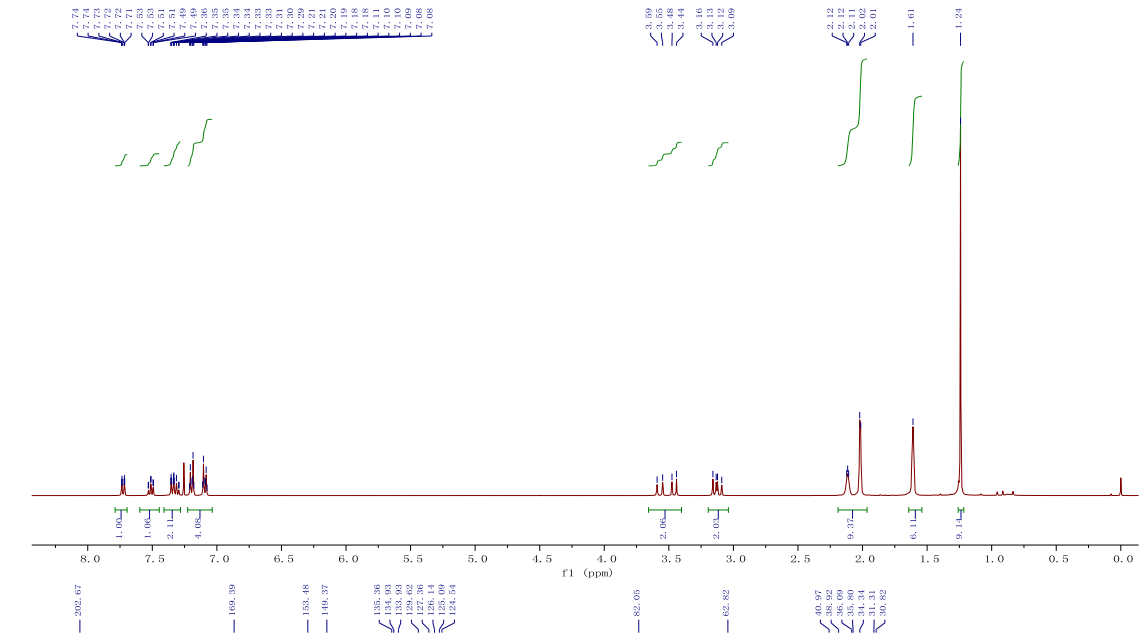
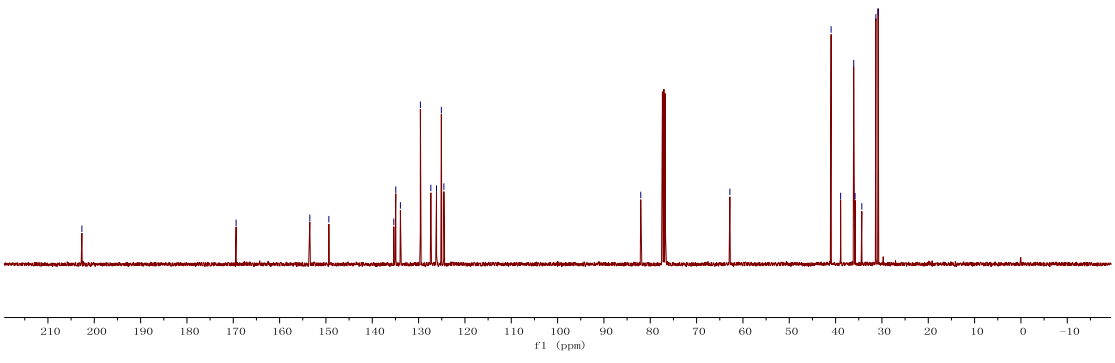
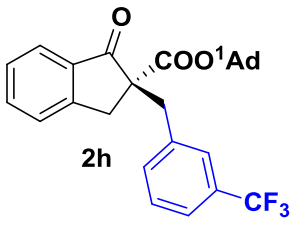
f1 (ppm)

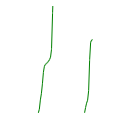


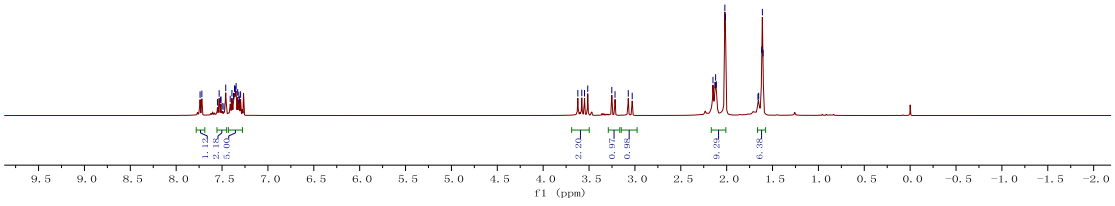

2g

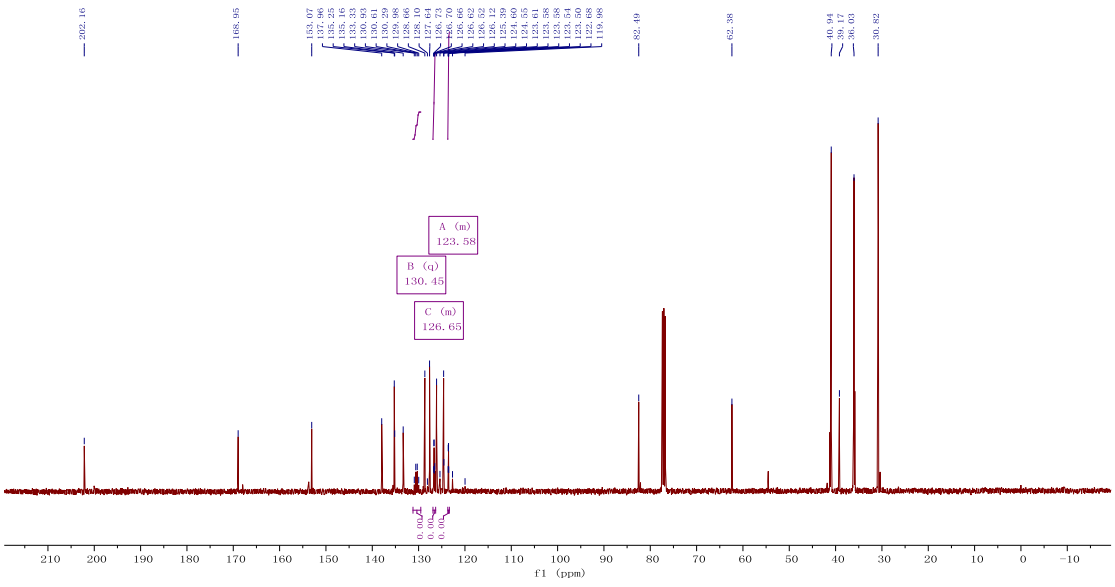




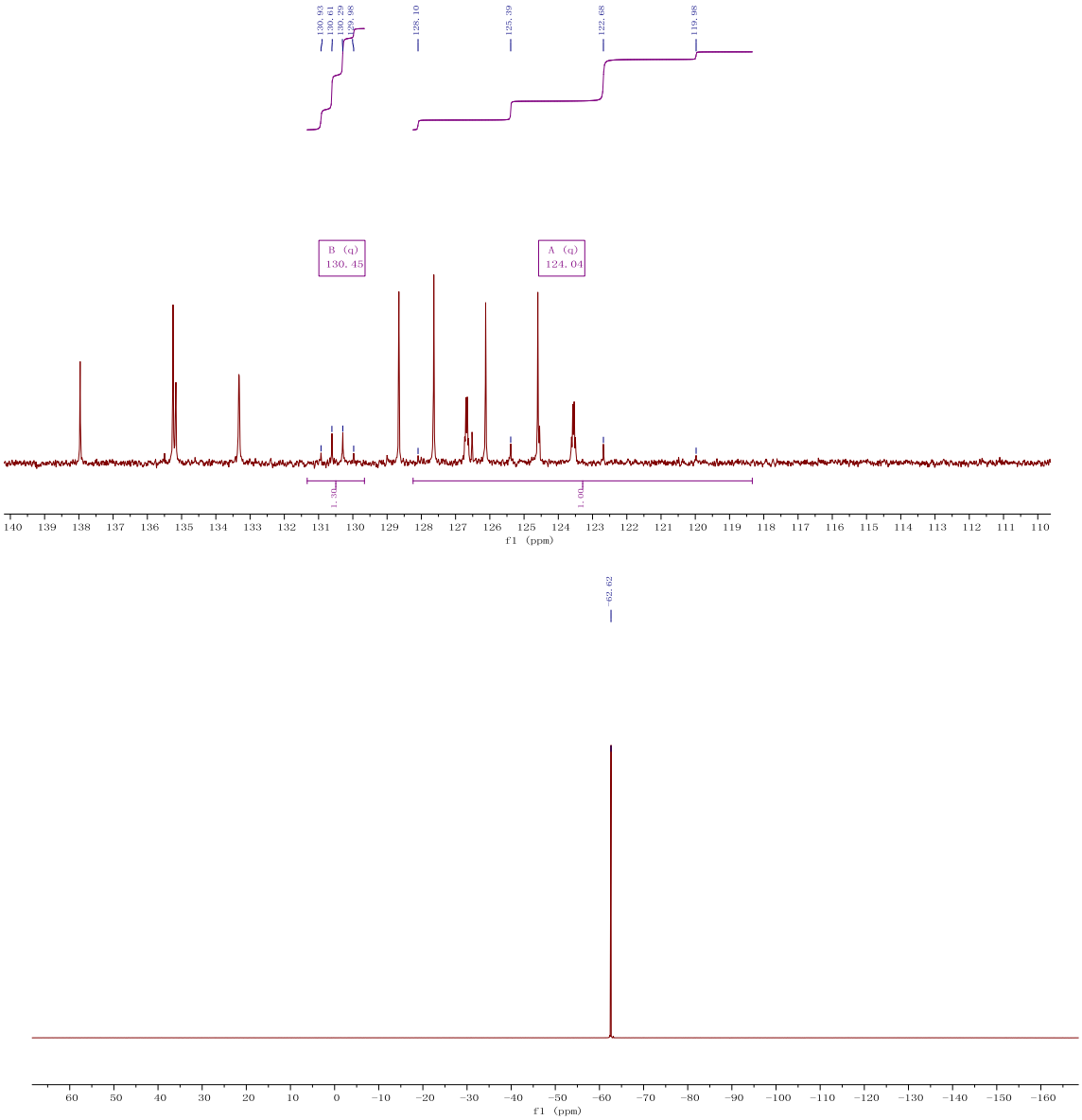

O
COO1Ad
2h
CF3

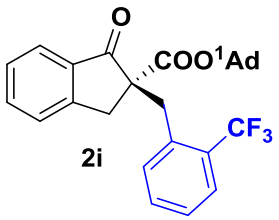



f1 (ppm)

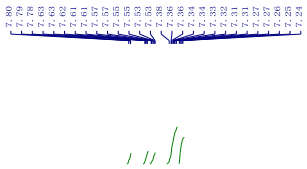

A (m)
123.58
B (q)
130.45
C (m)
126.65
f1 (ppm)

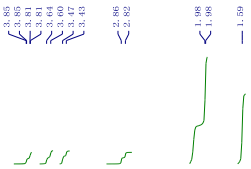
$^{13}$C NMR (101 MHz, Chloroform-*d*) δ 130.45 (q, $J$ = 32.0 Hz), 124.04 (q, $J$ = 272.3 Hz).

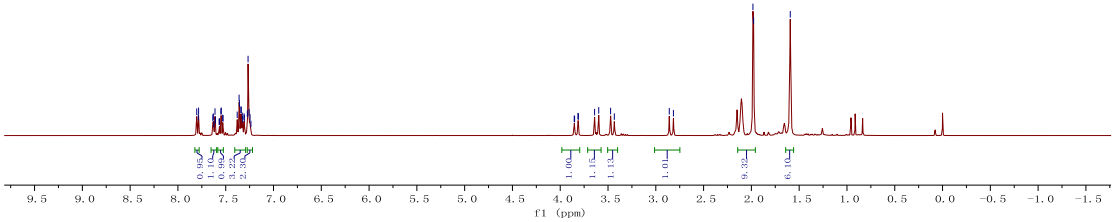


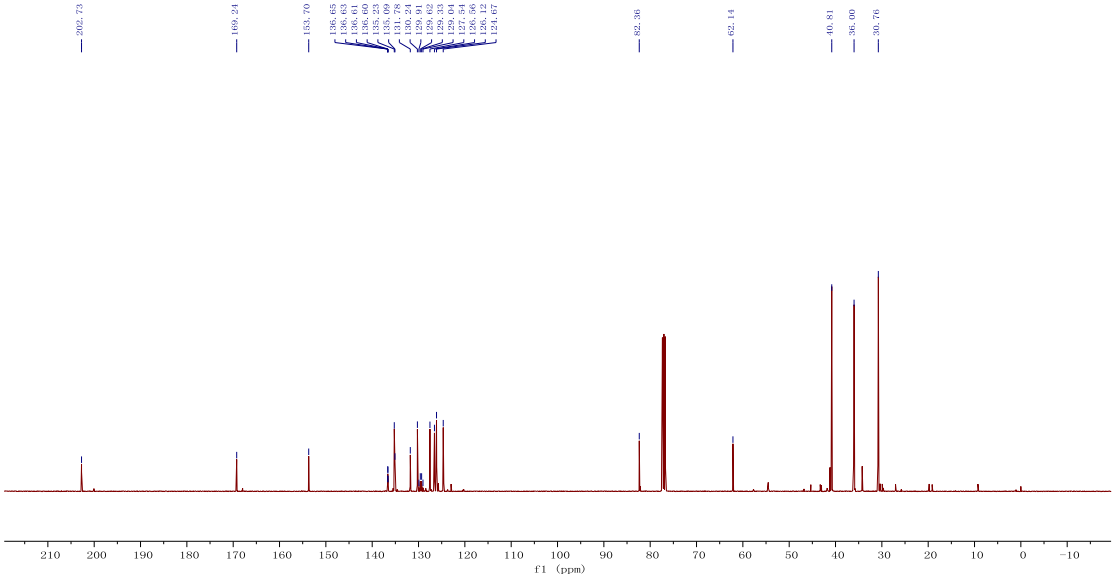



2i

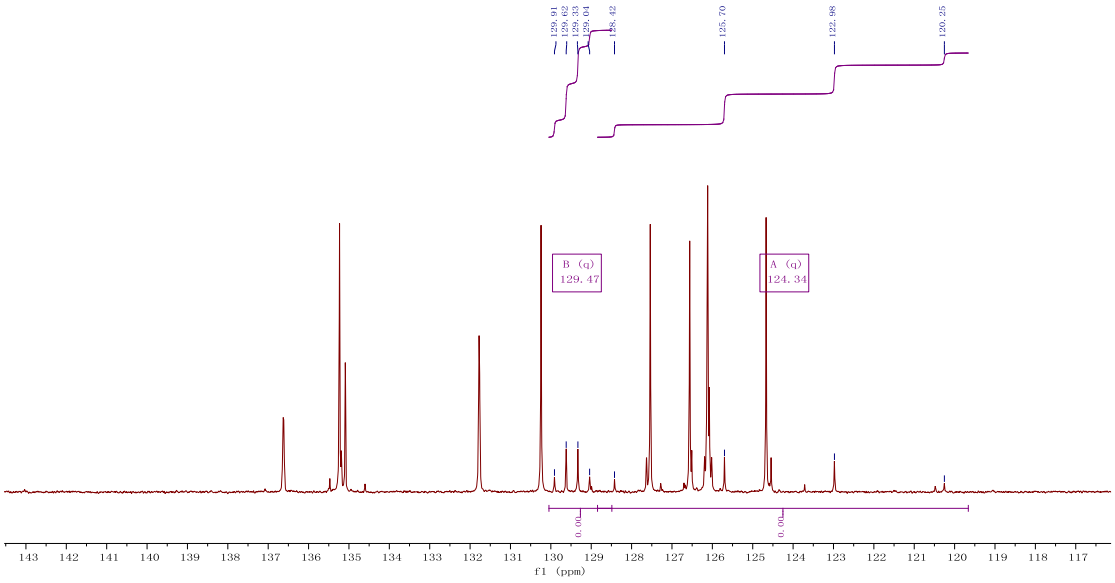


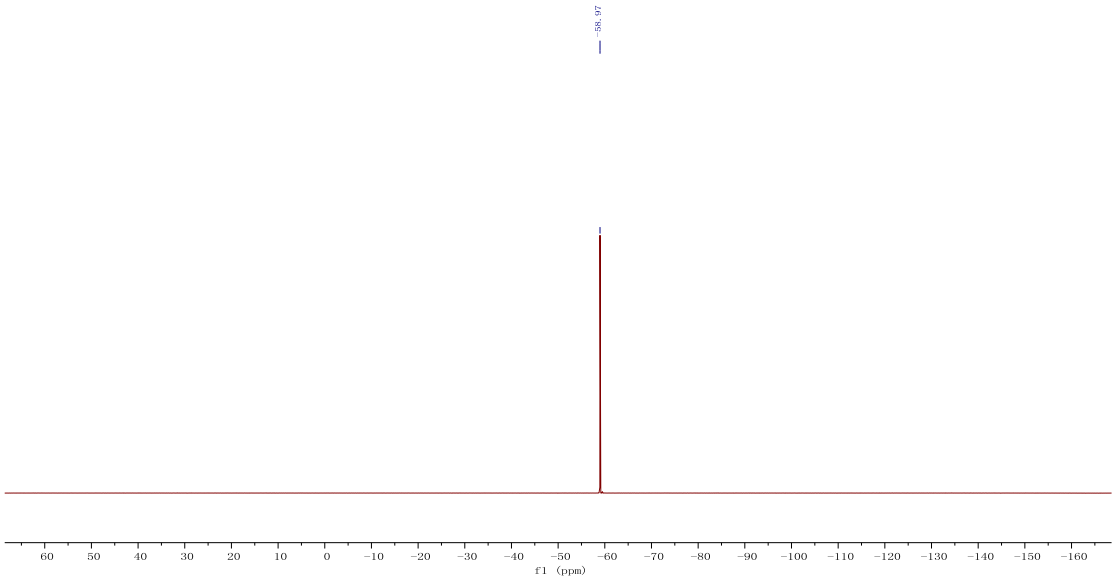


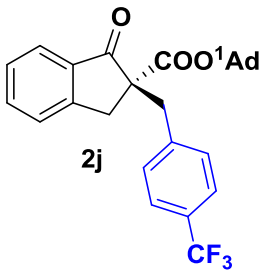


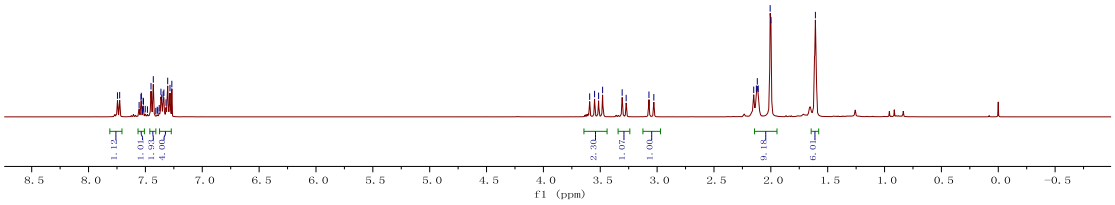
$^{13}$C NMR (101 MHz, Chloroform-*d*) δ 129.47 (q, $J$ = 29.2 Hz), 124.34 (q, $J$ = 274.0 Hz).

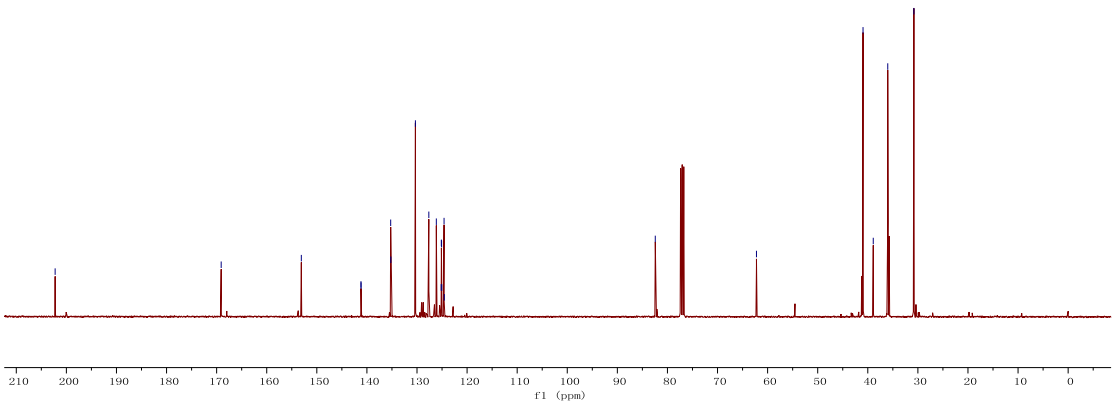


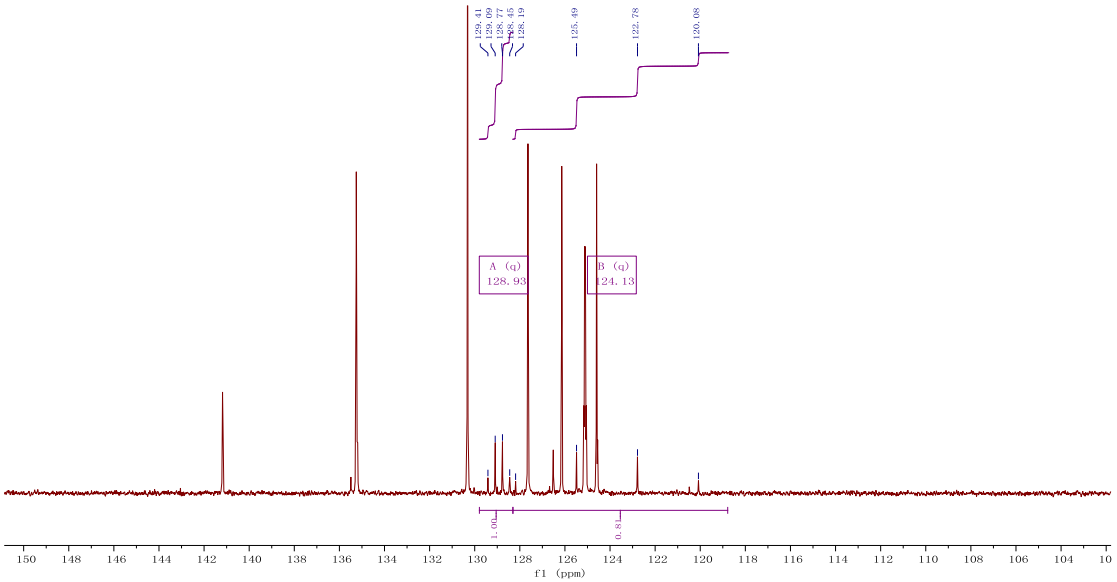


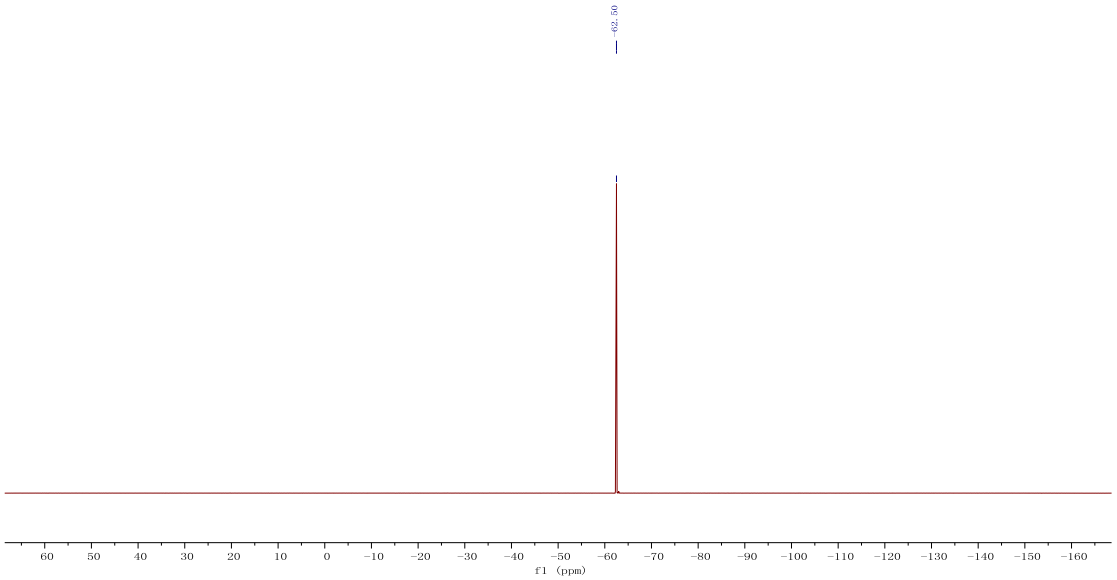

2j

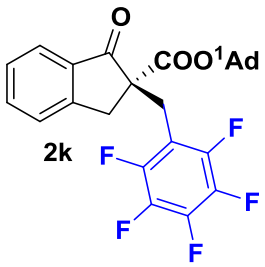


$^{13}$C NMR (101 MHz, Chloroform-*d*) δ 128.93 (q, $J$ = 32.4 Hz), 124.13 (q, $J$ = 271.9 Hz).

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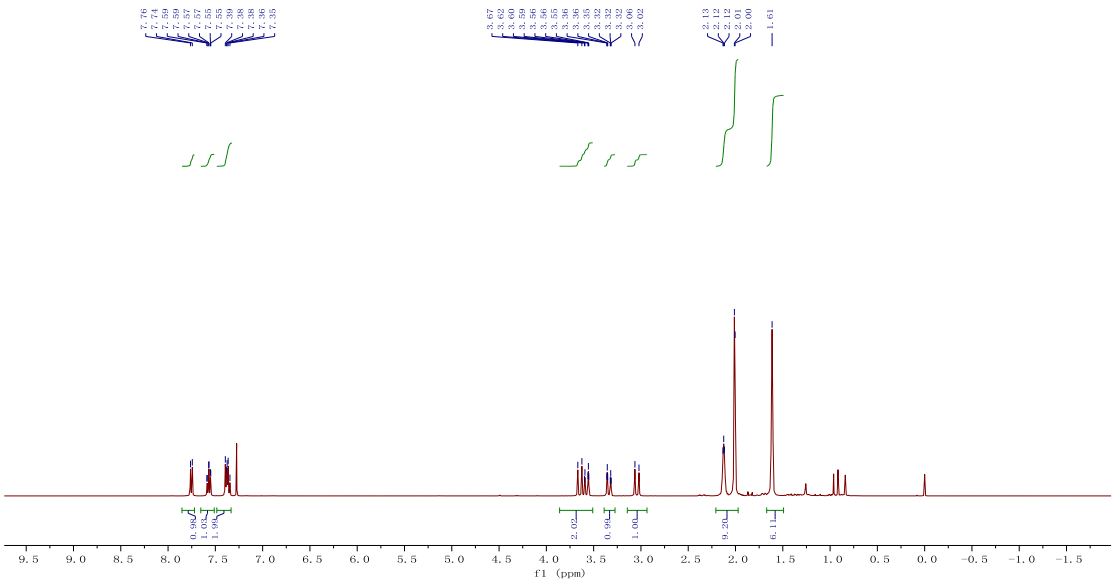
2k
F
F
F
F
F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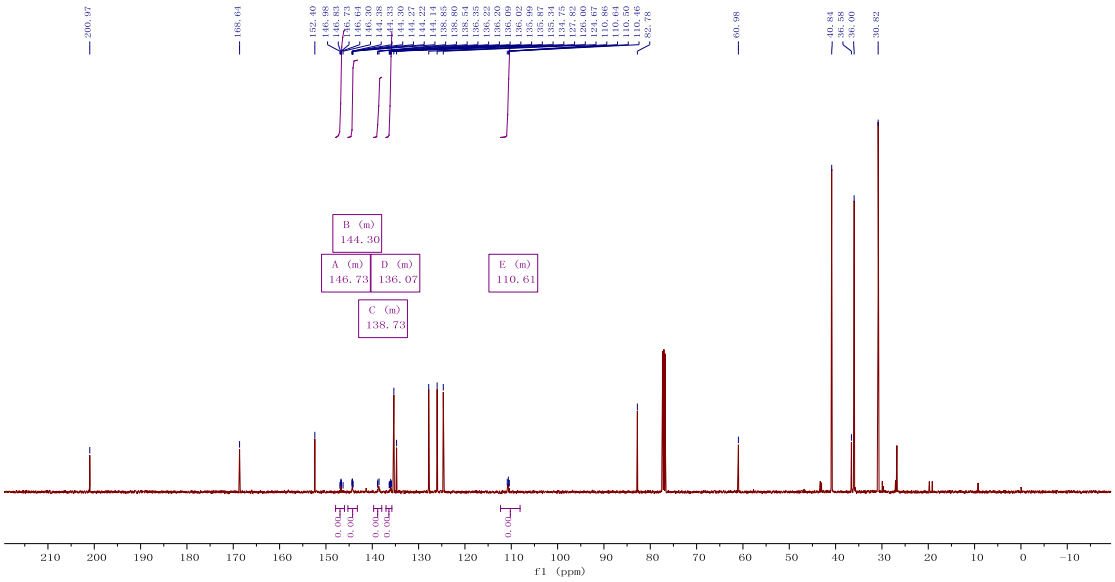
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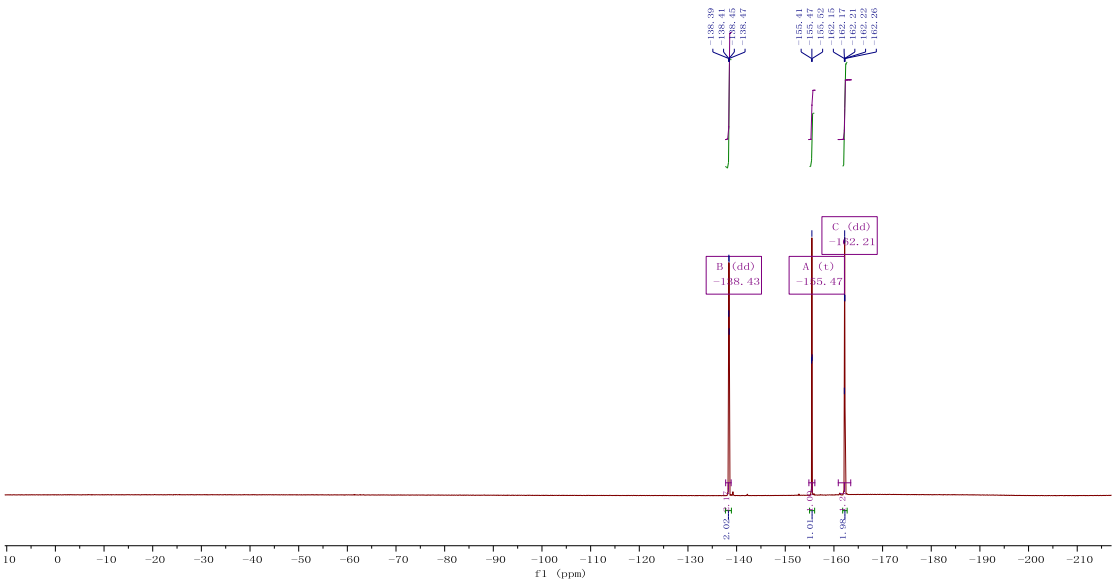
D (m)
136.07
E (m)
110.61
C (m)
138.73
f1 (ppm)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−138.45
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−155.52
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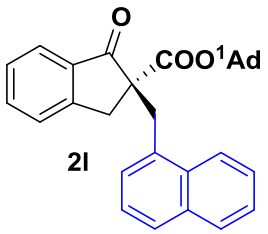
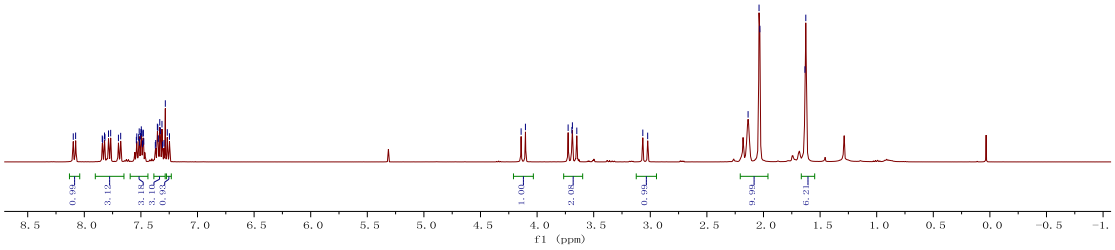
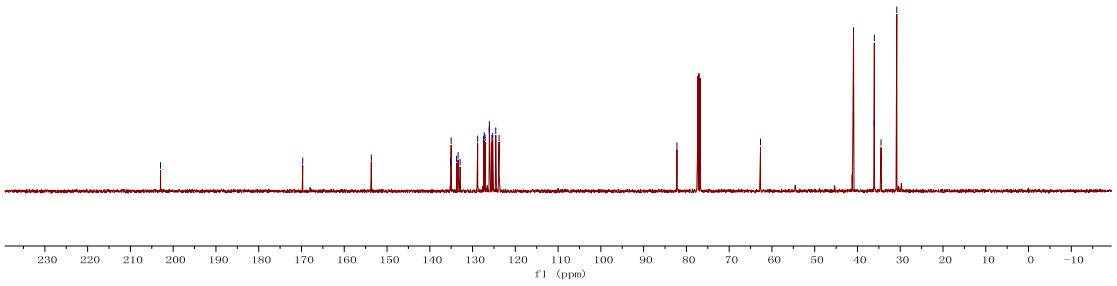
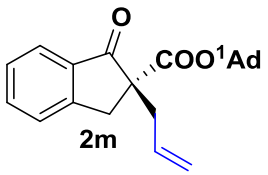
−162.17
−162.21
−162.22
−162.26
B (dd)
−138.43
A (t)
−155.47
C (dd)
−162.21
2.02
1.01
1.08
10 0 −10 −20 −30 −40 −50 −60 −70 −80 −90 −100 −110 −120 −130 −140 −150 −160 −170 −180 −190 −200 −210
f1 (ppm)




2l



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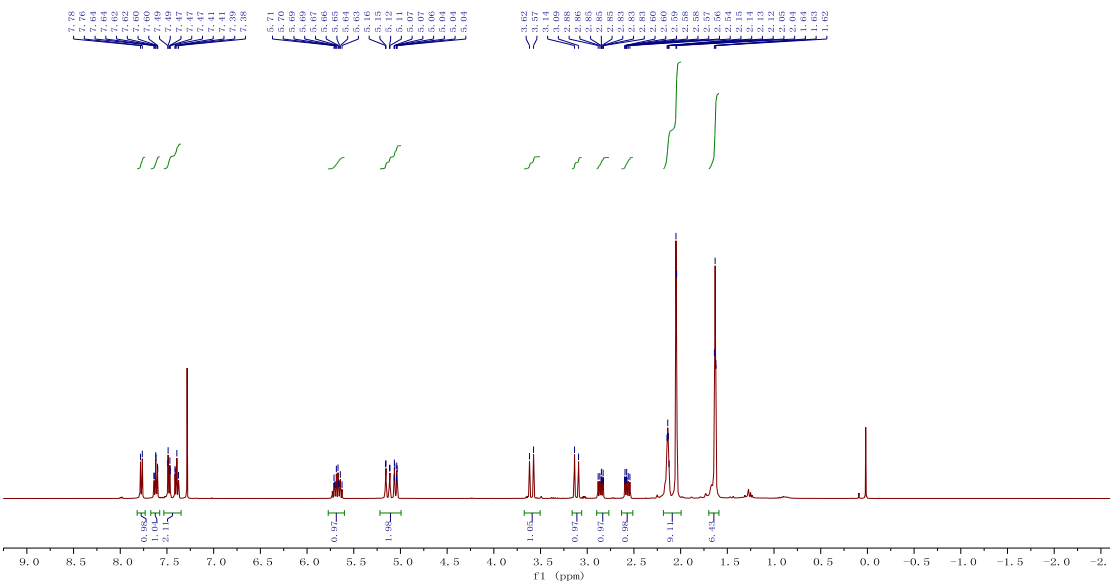
2m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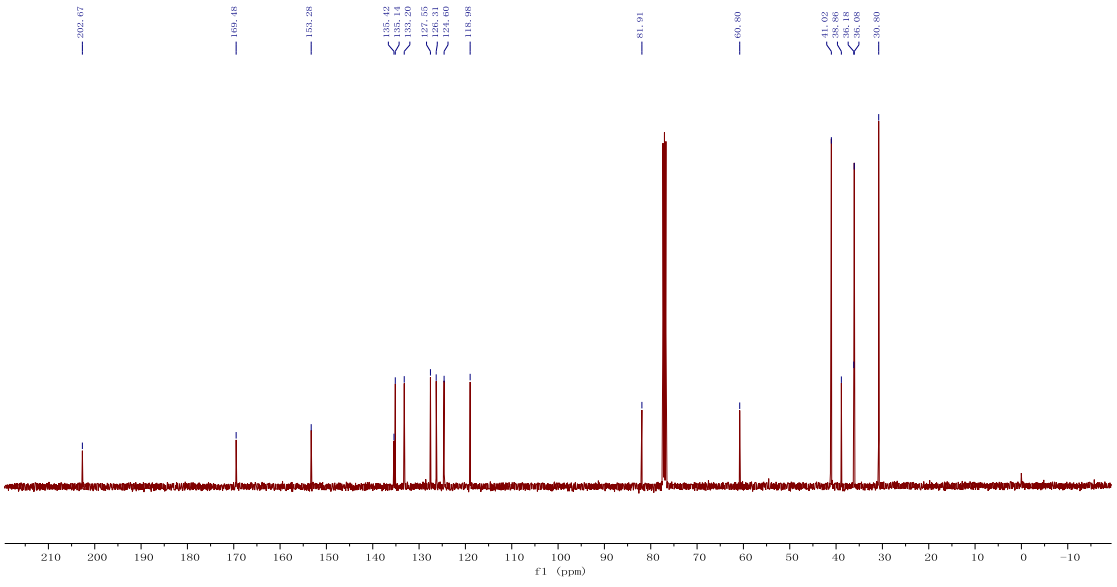
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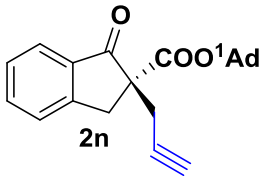
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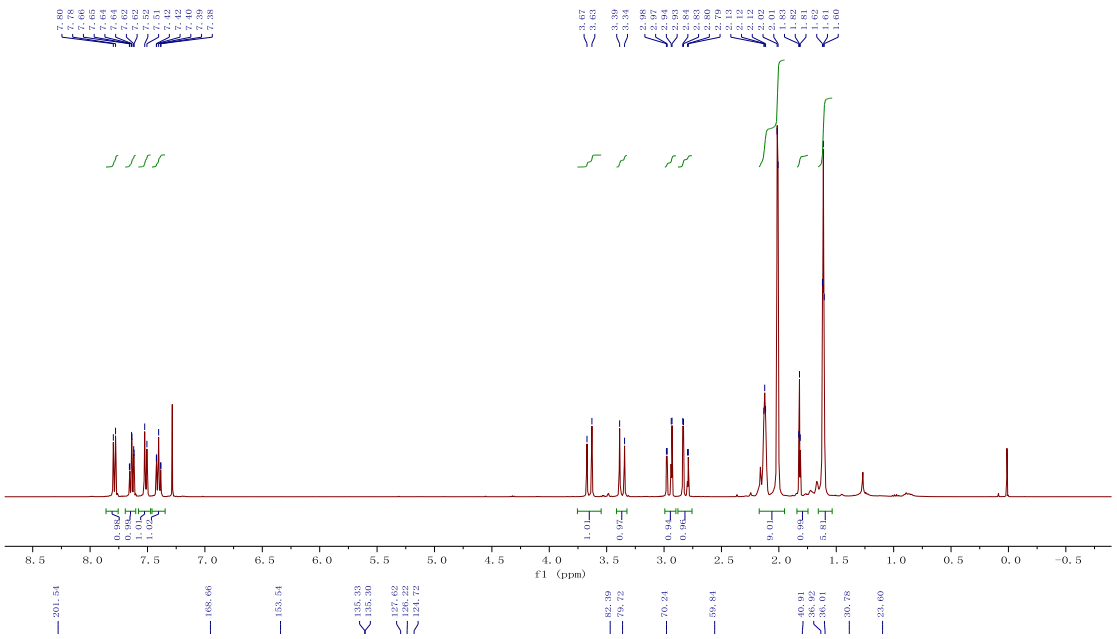
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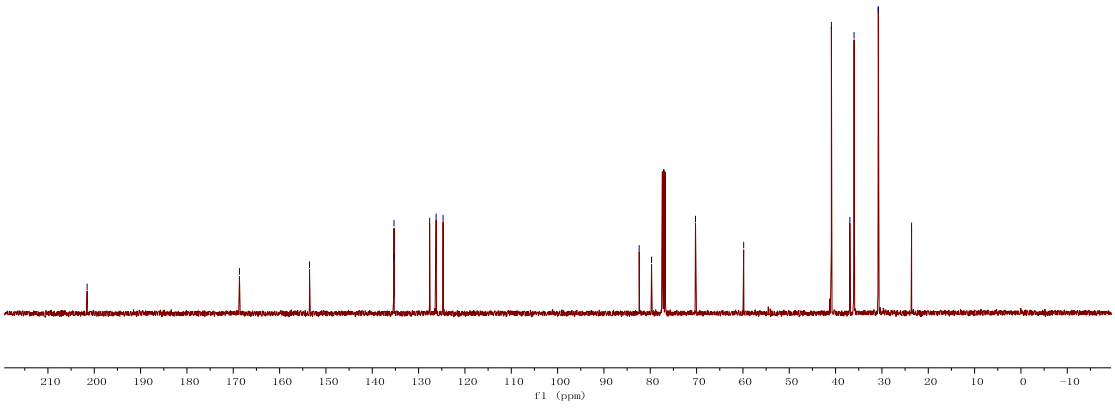
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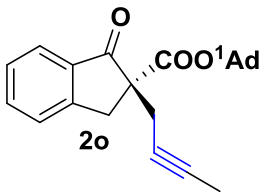
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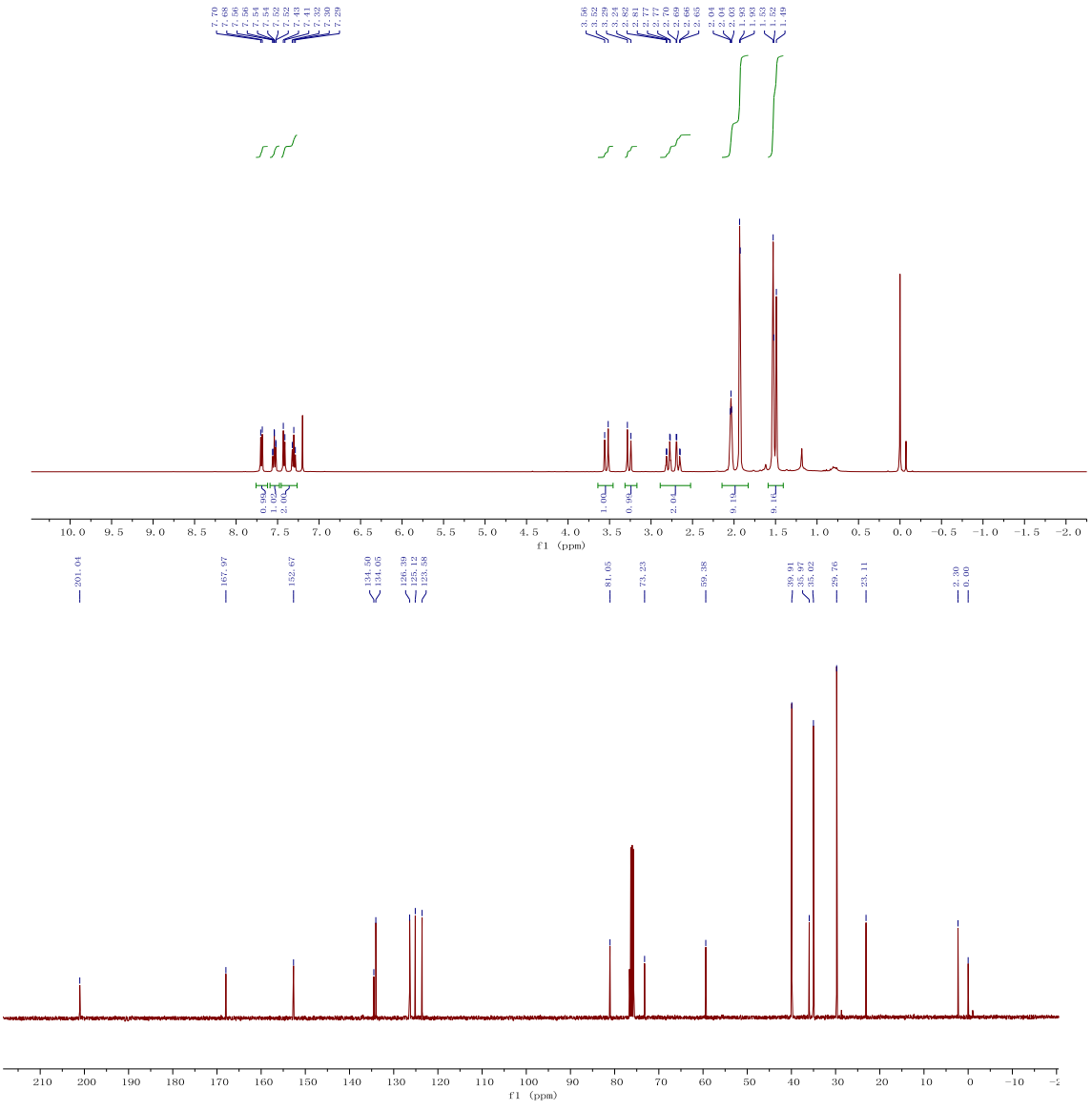
COO1Ad
2o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7.52
7.52
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7.41
7.32
7.29
3.56
3.52
3.29
3.24
2.82
2.81
2.77
2.77
2.70
2.69
2.66
2.65
2.04
2.04
2.03
1.93
1.93
1.53
1.52
1.49
0.99
1.02
2.00
1.00
0.99
2.04
9.19
9.16
f1 (ppm)
201.04
167.97
152.67
134.50
134.05
126.39
125.12
123.58
81.05
73.23
59.38
39.91
35.97
35.02
29.76
23.11
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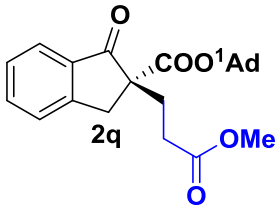
0.00
f1 (ppm)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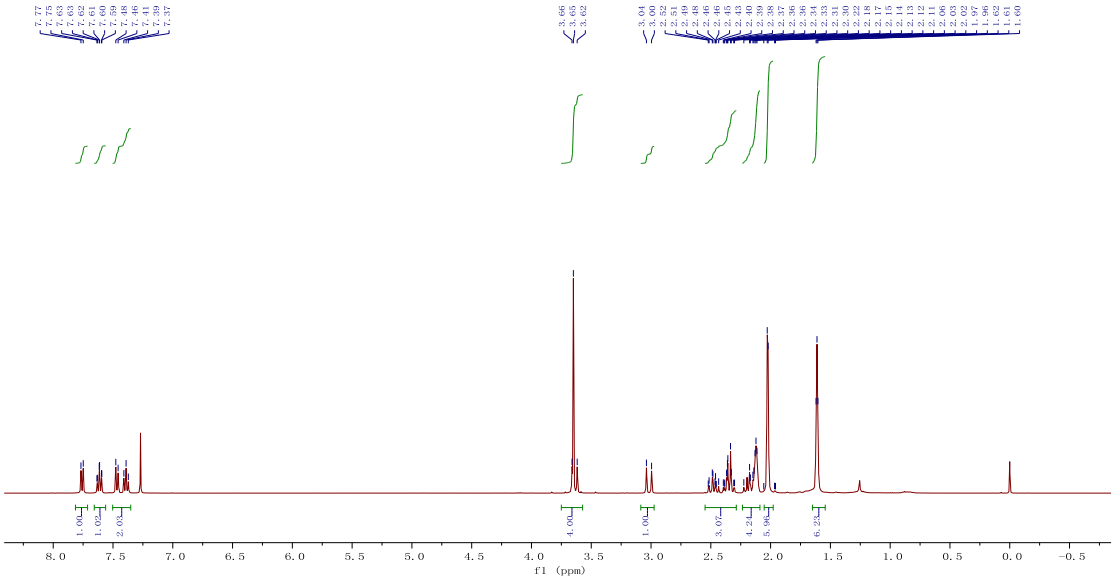
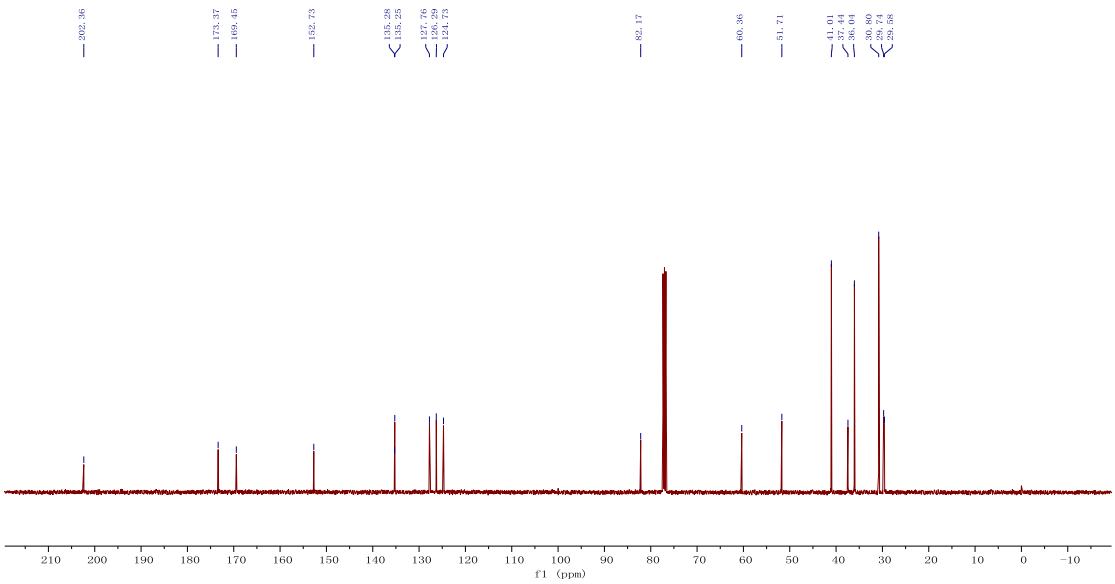
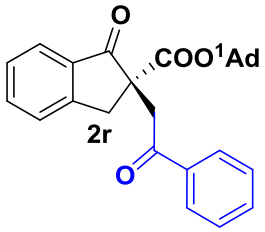
COO¹Ad
2q
OMe
O


f1 (ppm)


f1 (ppm)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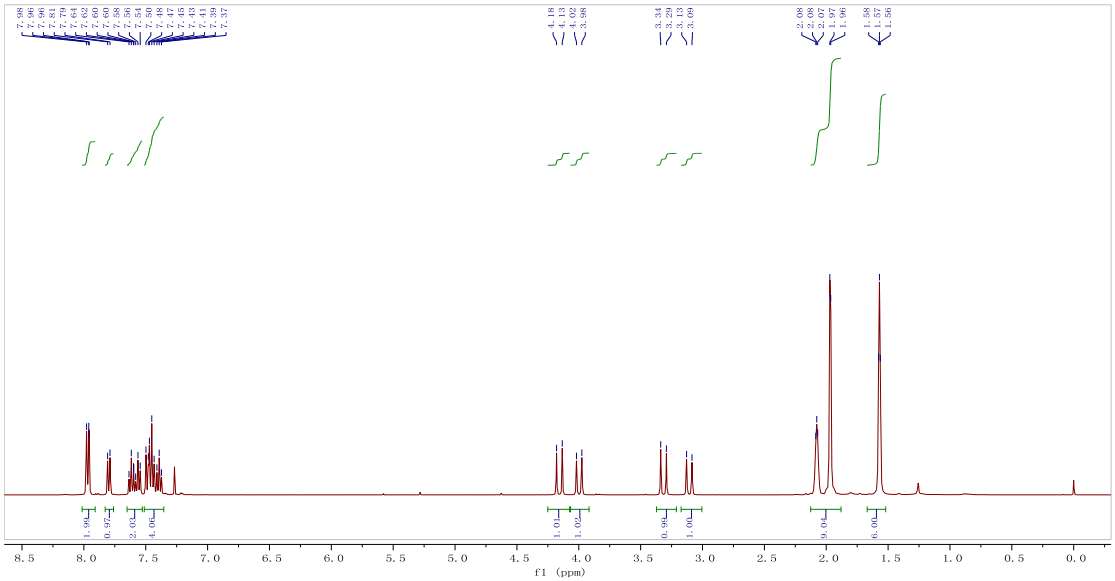
2r
O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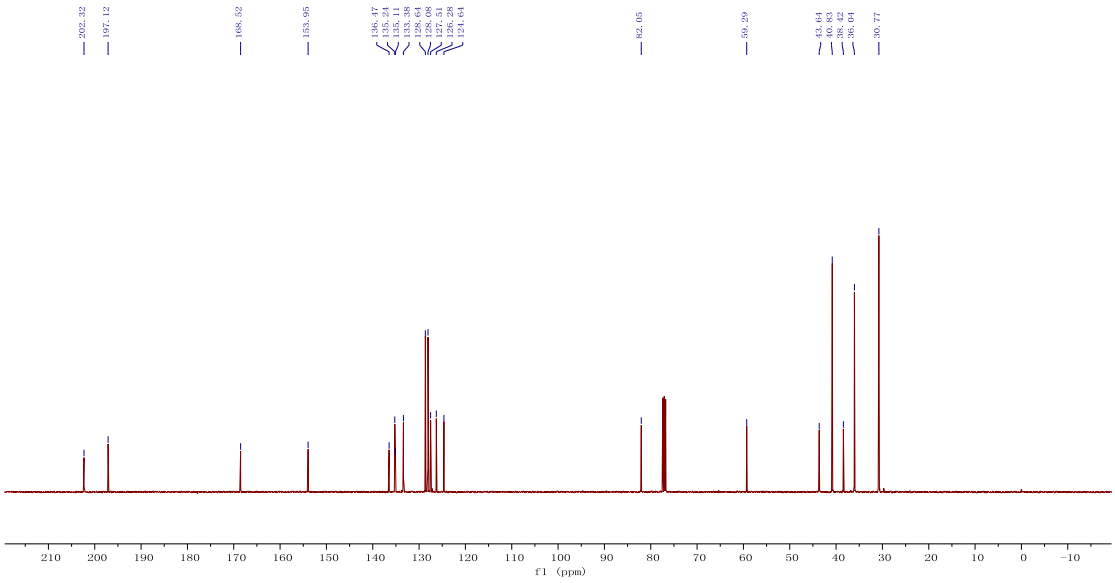
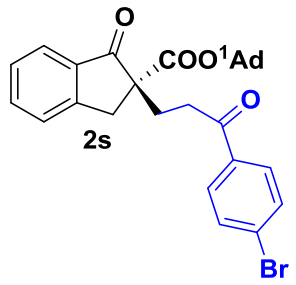

f1 (ppm)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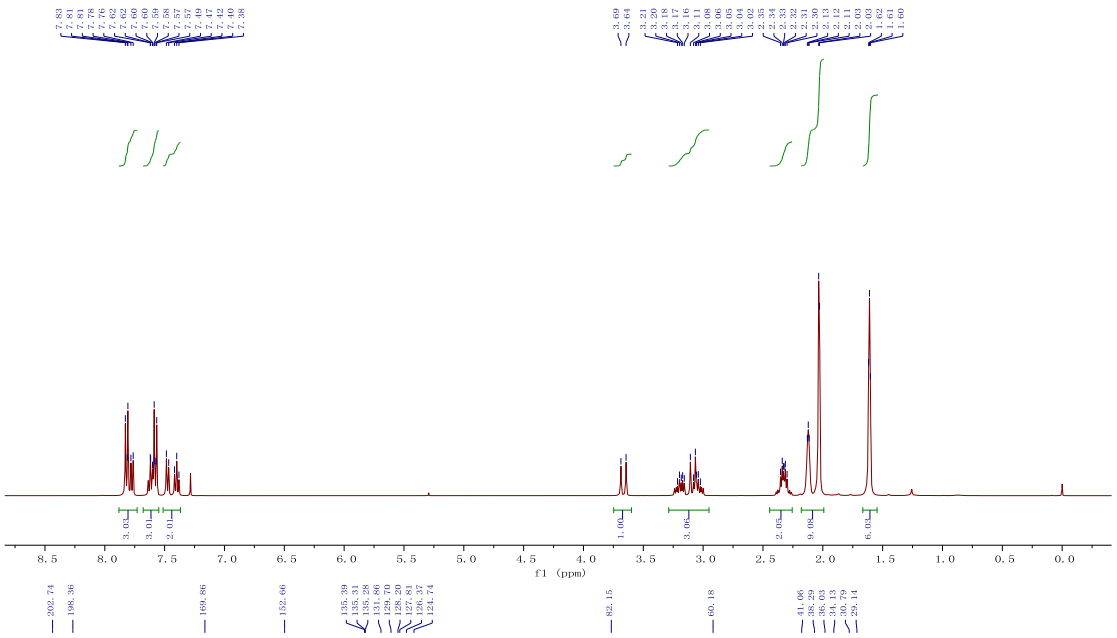
O
2s
Br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7.47
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7.40
7.38
3.69
3.64
3.21
3.20
3.18
3.17
3.15
3.11
3.08
3.06
3.05
3.04
3.02
2.35
2.34
2.33
2.32
2.31
2.30
2.15
2.12
2.11
2.03
2.00
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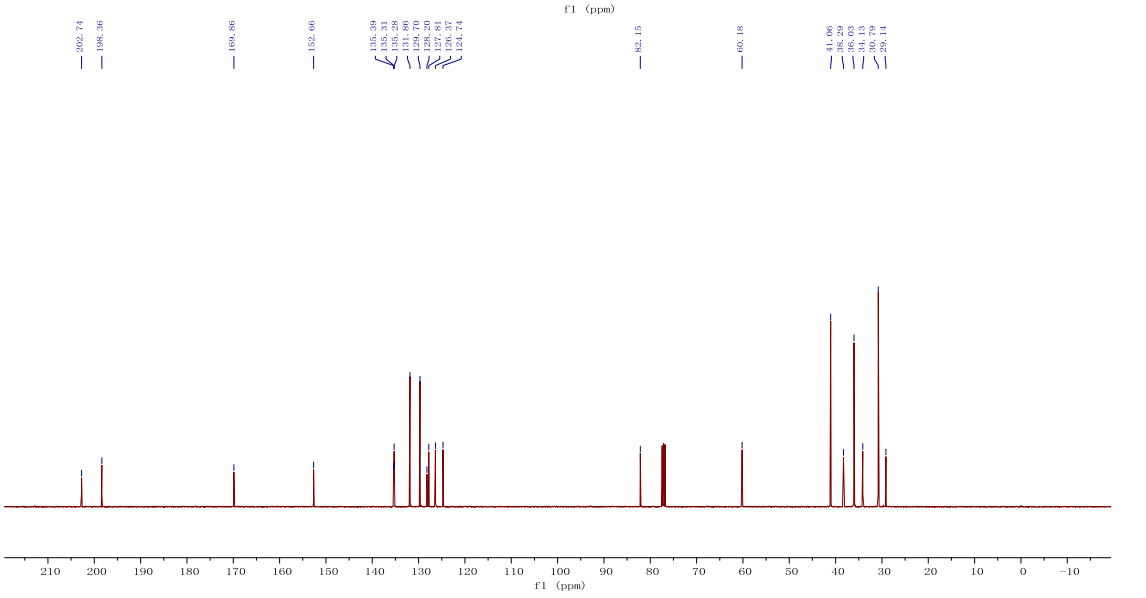
1.61
1.60
3.03
3.01
2.01
1.00
3.06
2.05
9.08
6.03
f1 (ppm)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128.20
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126.37
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38.29
36.03
34.13
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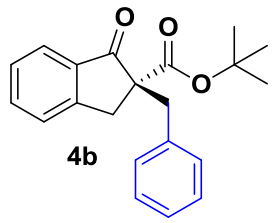
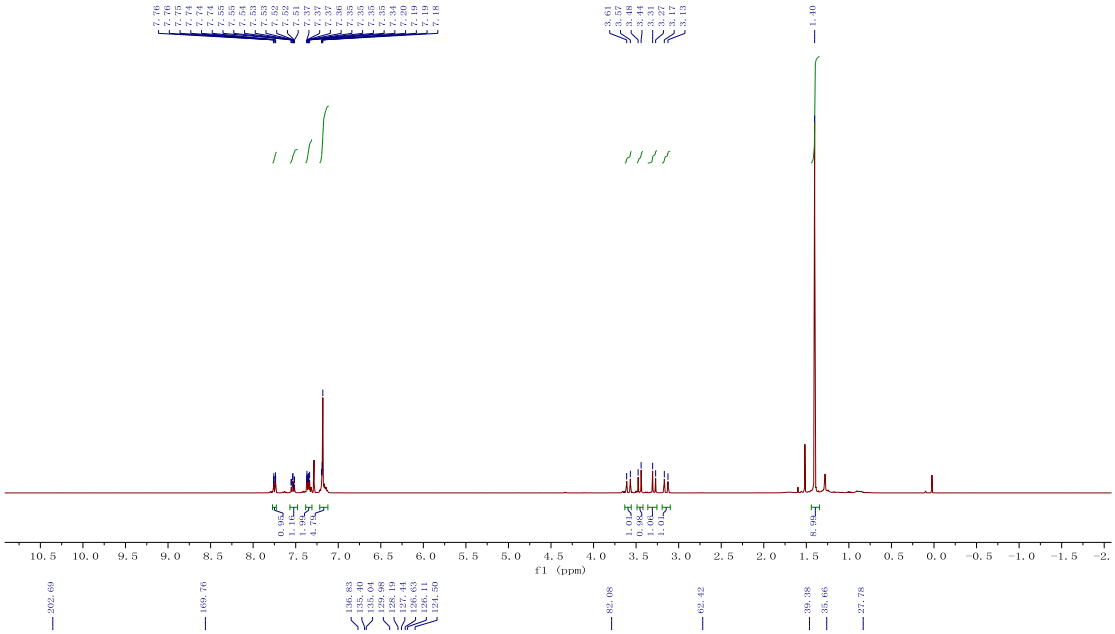
29.14
f1 (ppm)


O
O
O
4b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7.51
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7.37
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7.35
7.35
7.35
7.34
7.34
7.20
7.19
7.18
3.64
3.57
3.48
3.44
3.31
3.27
3.17
3.13
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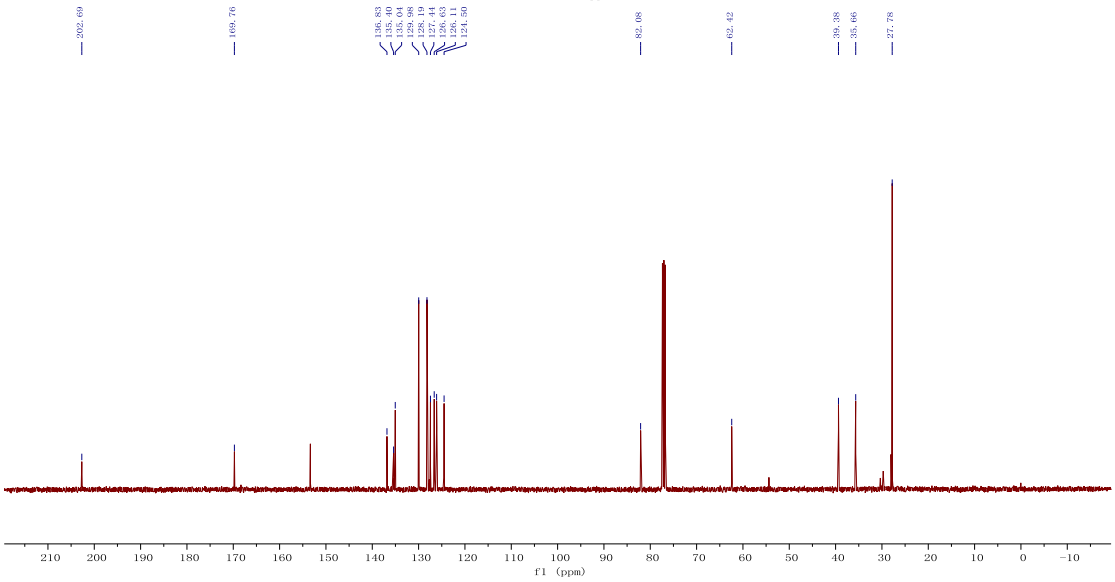
1.14
1.98
4.78
1.01
0.98
1.00
1.00
8.98
f1 (ppm)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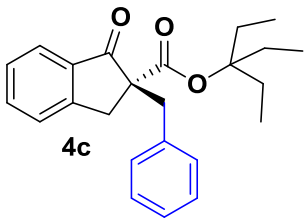
27.78
f1 (ppm)


O
O
O
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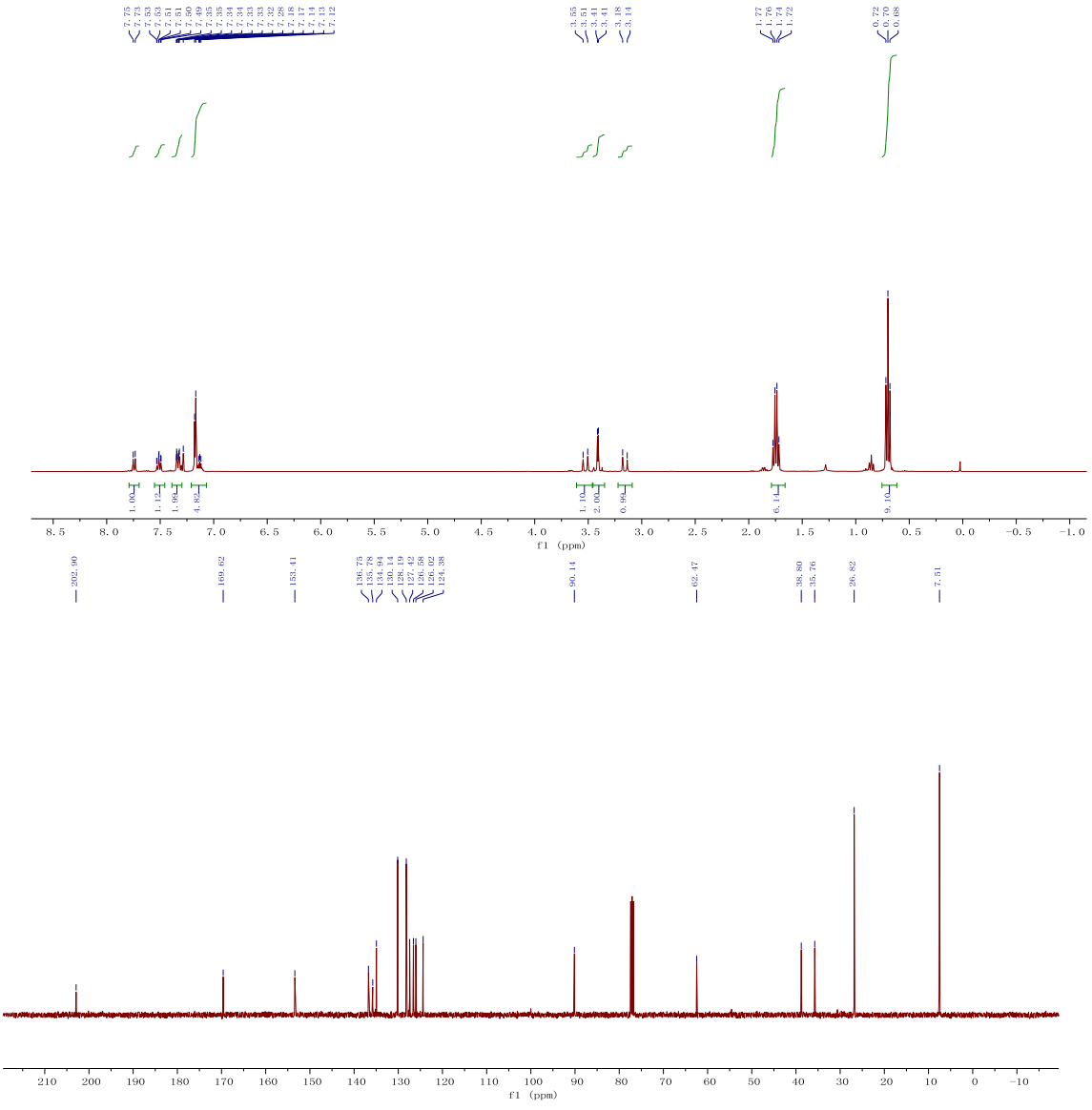
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7.12
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3.51
3.41
3.18
3.14
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1.76
1.74
1.72
0.72
0.70
0.68
1.00
1.12
1.99
4.80
1.10
2.00
0.98
6.14
9.10
f1 (ppm)
202.90
169.62
153.41
136.73
135.78
134.94
130.14
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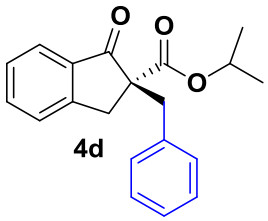
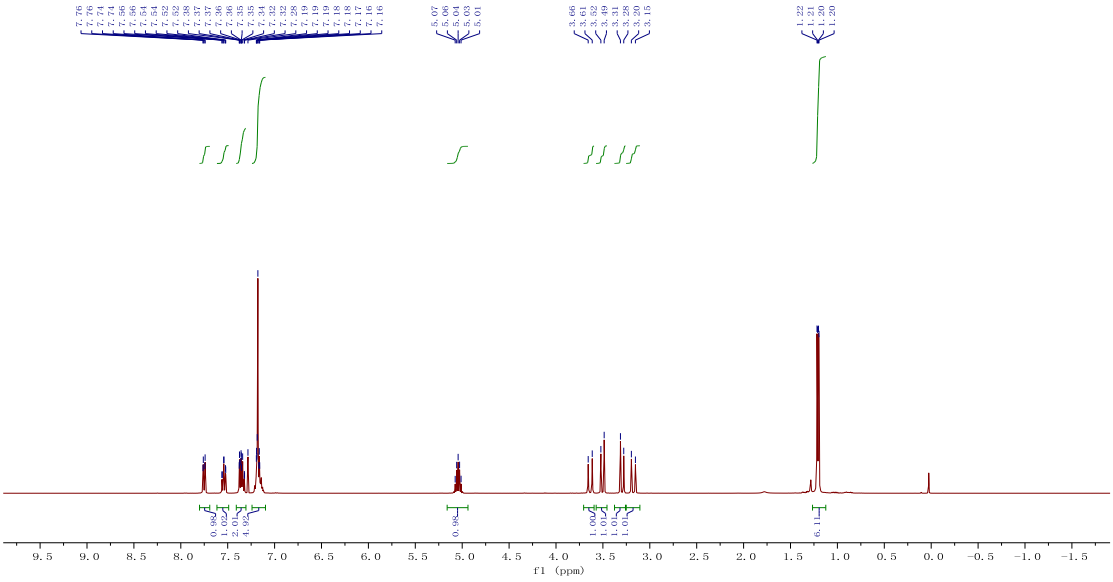
38.80
35.76
26.82
7.51
f1 (ppm)


O
O
O
4d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7.17
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5.07
5.06
5.04
5.03
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3.52
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3.28
3.20
3.15
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1.21
1.20
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1.01
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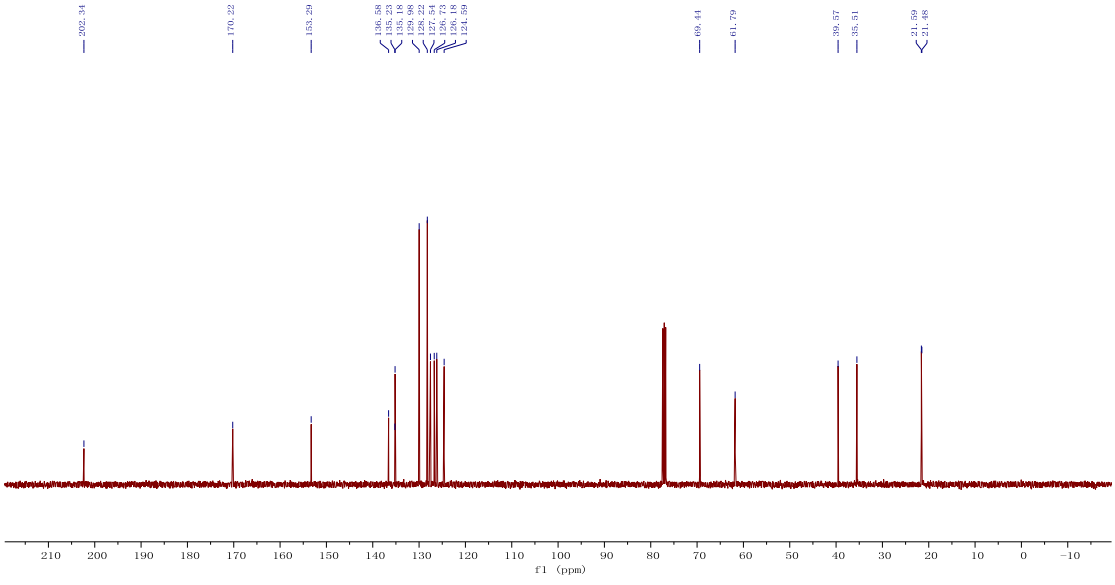
6.11
f1 (ppm)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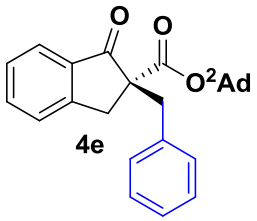
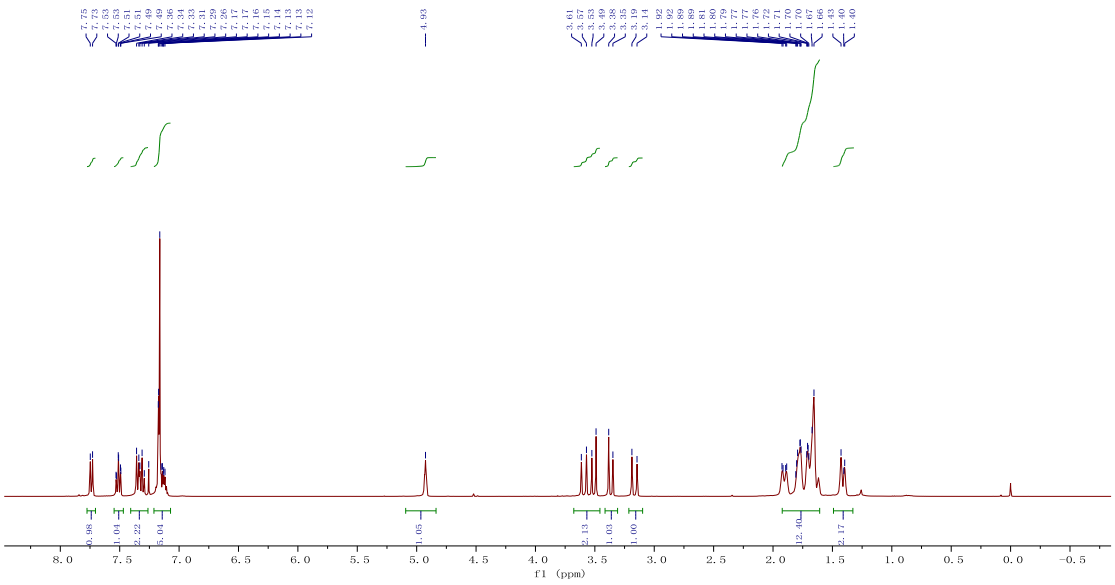
35.51
21.69
21.48
f1 (ppm)


O
O
O²Ad
4e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7.17
7.16
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7.12
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3.38
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3.19
3.14
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1.77
1.77
1.76
1.72
1.71
1.70
1.70
1.67
1.66
1.43
1.40
1.40
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1.04
2.22
5.04
1.05
2.13
1.03
1.00
12.40
2.17
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7.5
7.0
6.5
6.0
5.5
5.0
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3.0
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1.5
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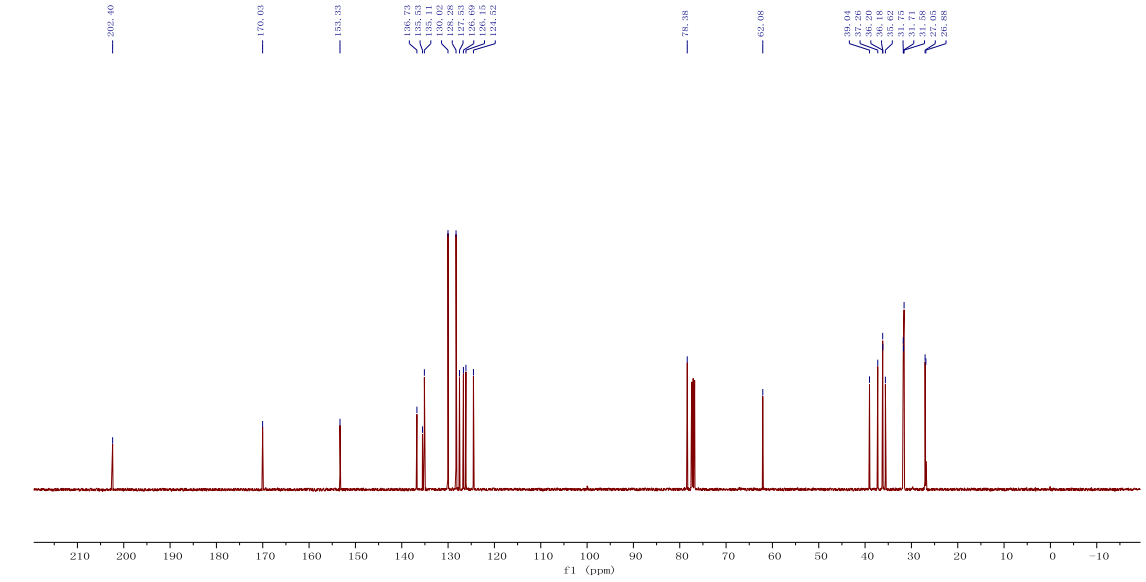
0.5
0.0
-0.5
f1 (ppm)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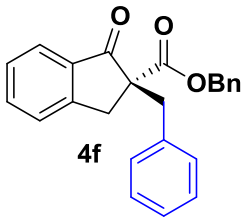
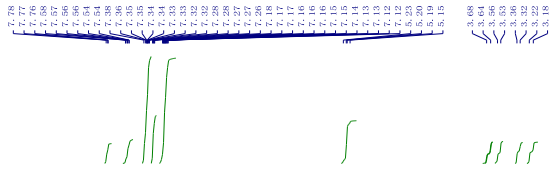
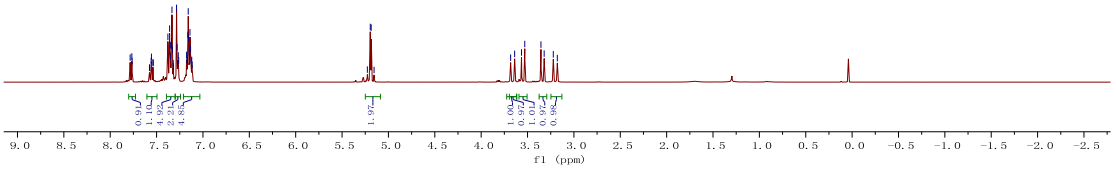
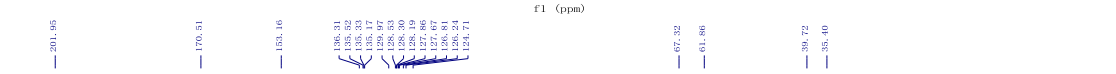
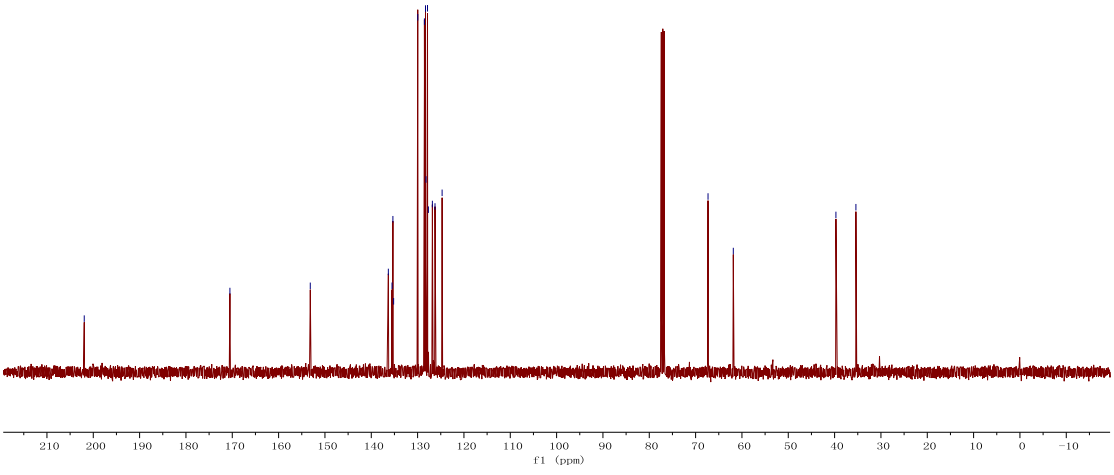
126.89
126.15
124.52
78.38
62.08
39.04
37.26
36.70
36.18
35.62
31.75
31.71
31.58
27.05
26.88
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

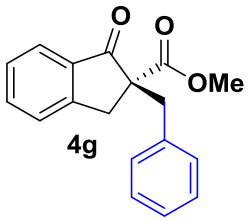

O
O
OBn
4f









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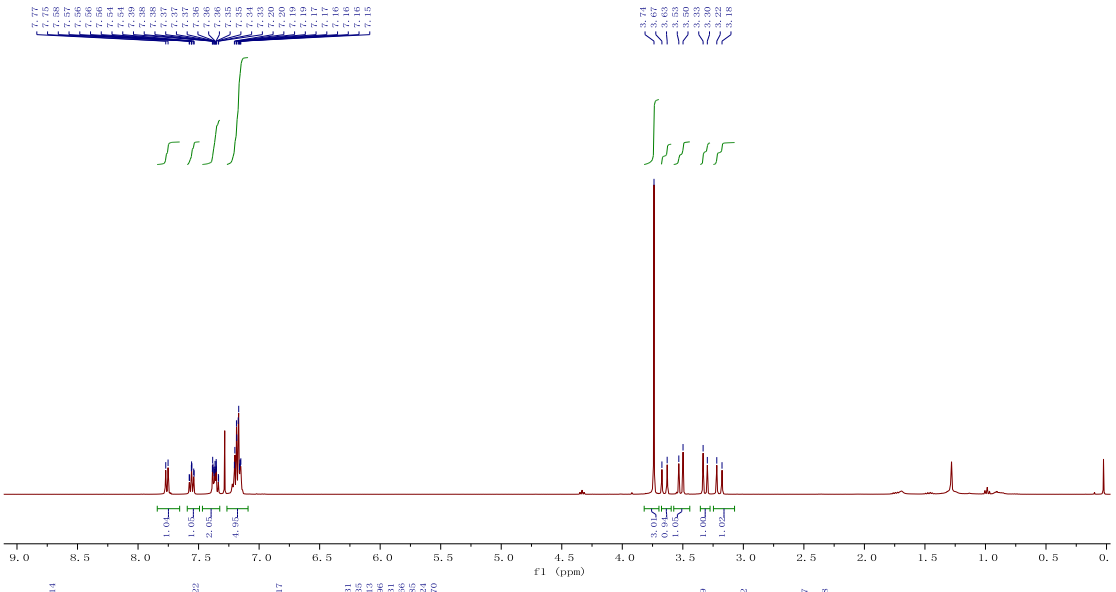

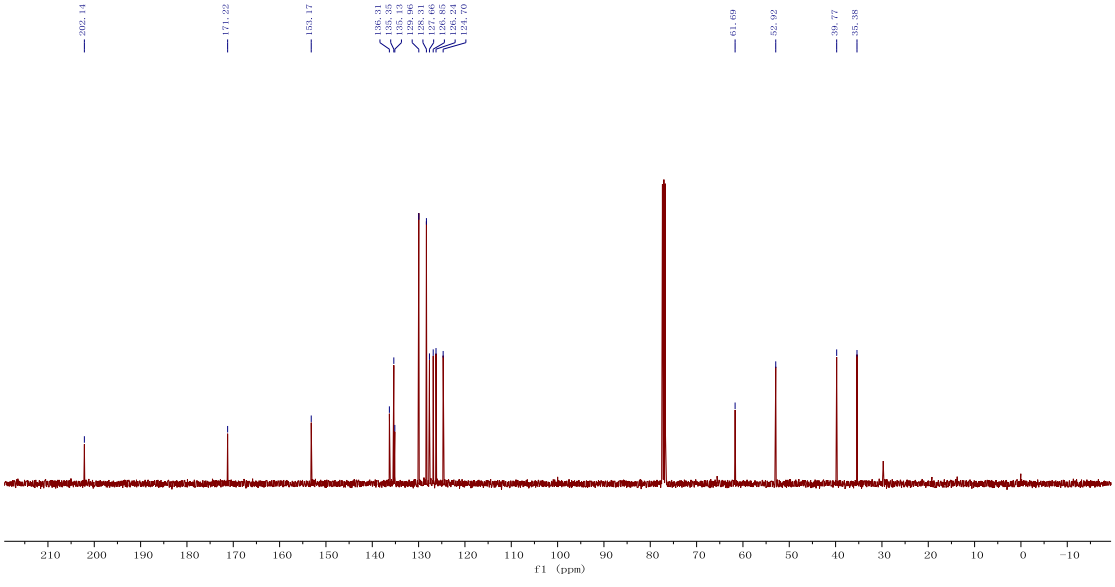

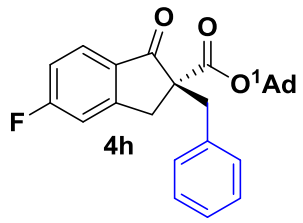
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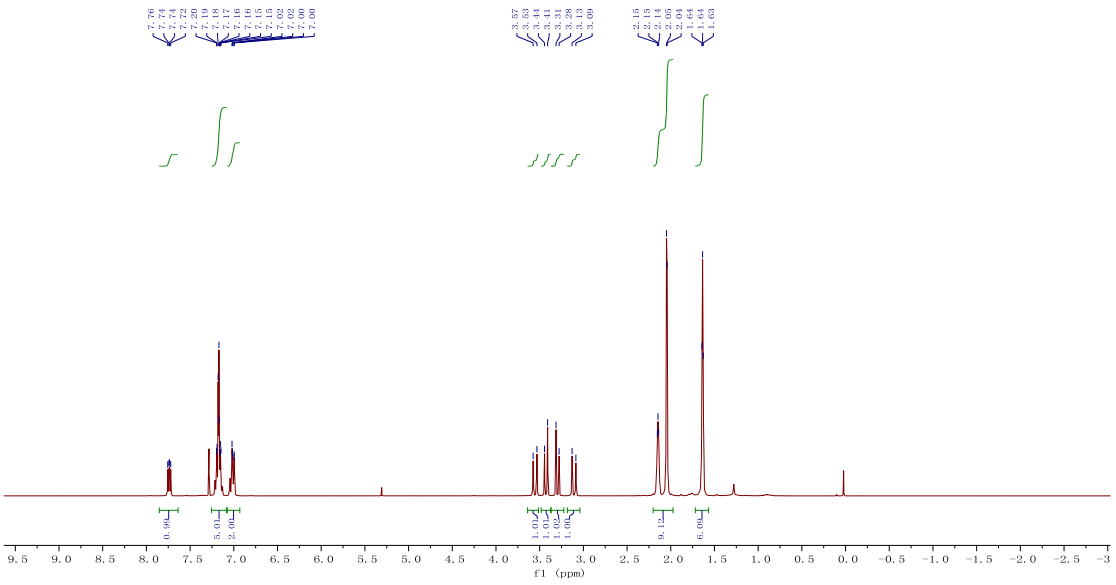
O
O1Ad
F
4h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7.17
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7.02
7.02
7.00
7.00
3.57
3.53
3.44
3.41
3.33
3.28
3.13
3.09
2.15
2.15
2.14
2.05
2.04
1.64
1.64
1.63
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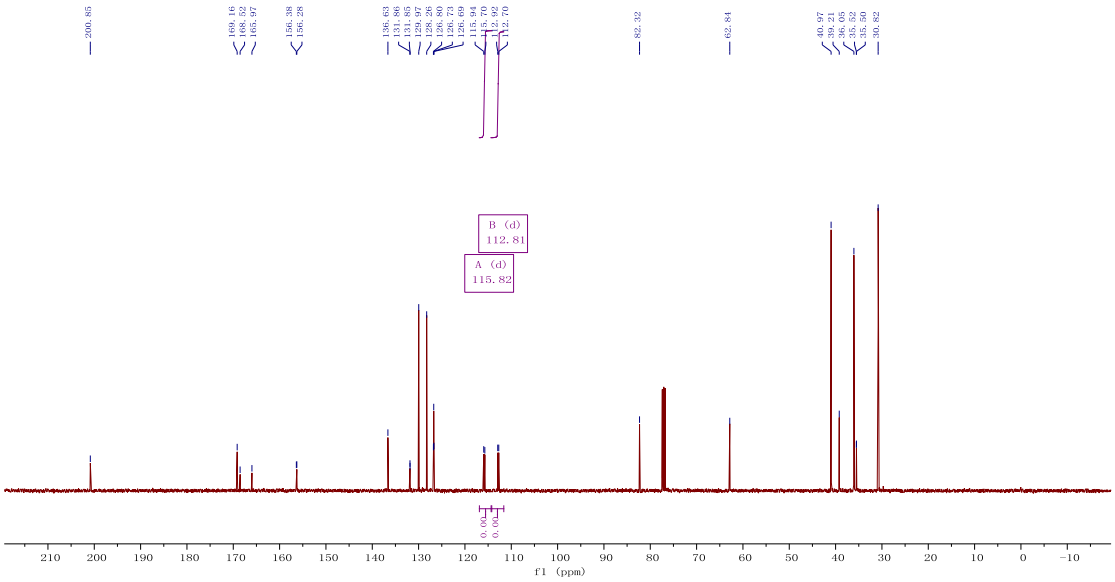
5.01
2.00
1.01
0.94
1.00
1.00
9.12
6.08
f1 (ppm)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115.94
115.70
112.92
112.70
82.32
62.84
40.97
39.21
36.65
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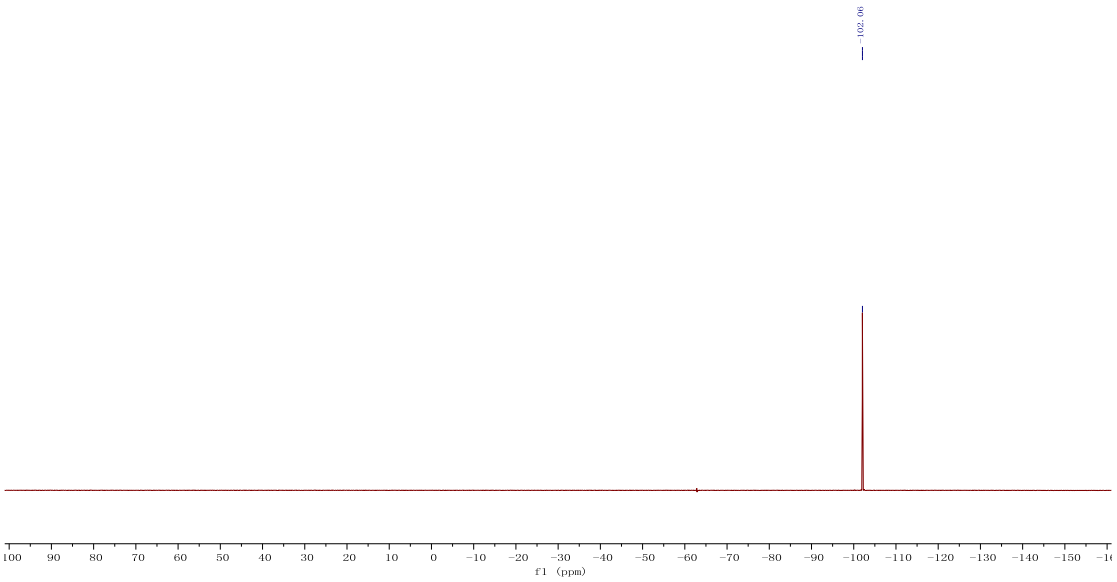
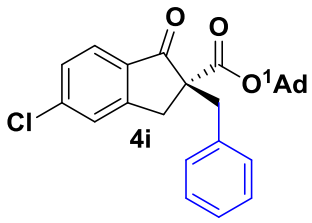
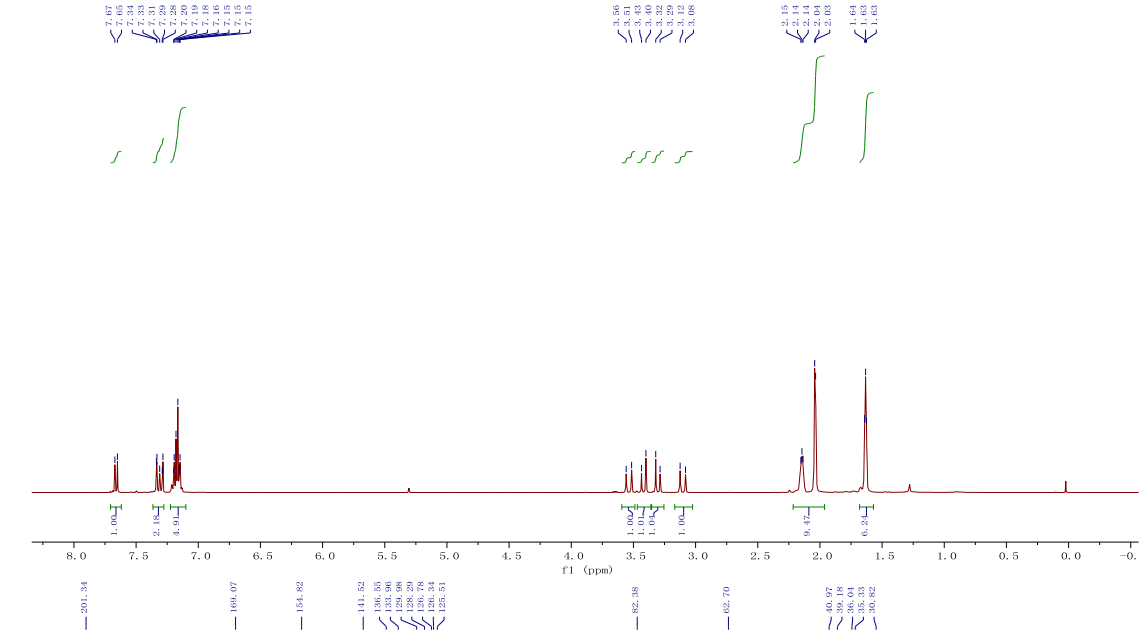
35.50
30.82
B (d)
112.81
A (d)
115.82
0.04
0.04
f1 (ppm)


-102.06
100 90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 −90 −100 −110 −120 −130 −140 −150
f1 (ppm)


O
O
O1Ad
Cl
4i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7.28
7.20
7.19
7.18
7.16
7.15
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7.15
3.56
3.51
3.43
3.40
3.32
3.29
3.12
3.08
2.15
2.14
2.14
2.04
2.03
1.64
1.63
1.63
1.00
2.18
4.91
1.00
1.01
1.04
1.00
9.47
6.24
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
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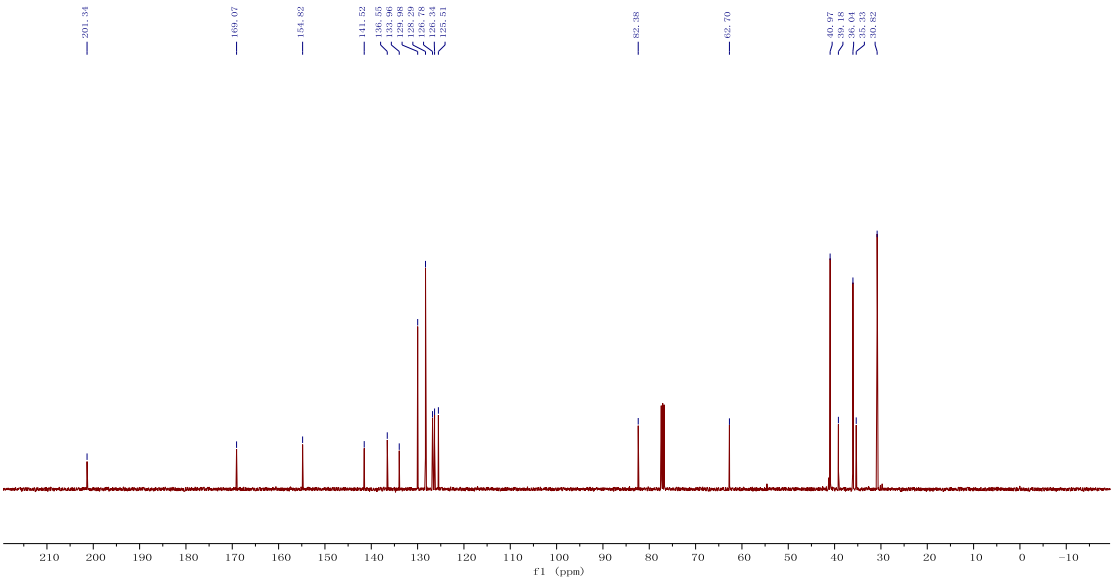
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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129.98
128.29
126.78
126.34
125.51
82.38
62.70
40.97
39.36
36.04
35.33
30.82
210
200
190
180
170
160
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140
130
120
110
100
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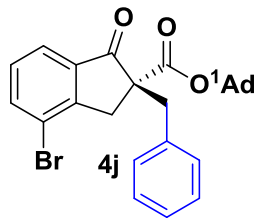
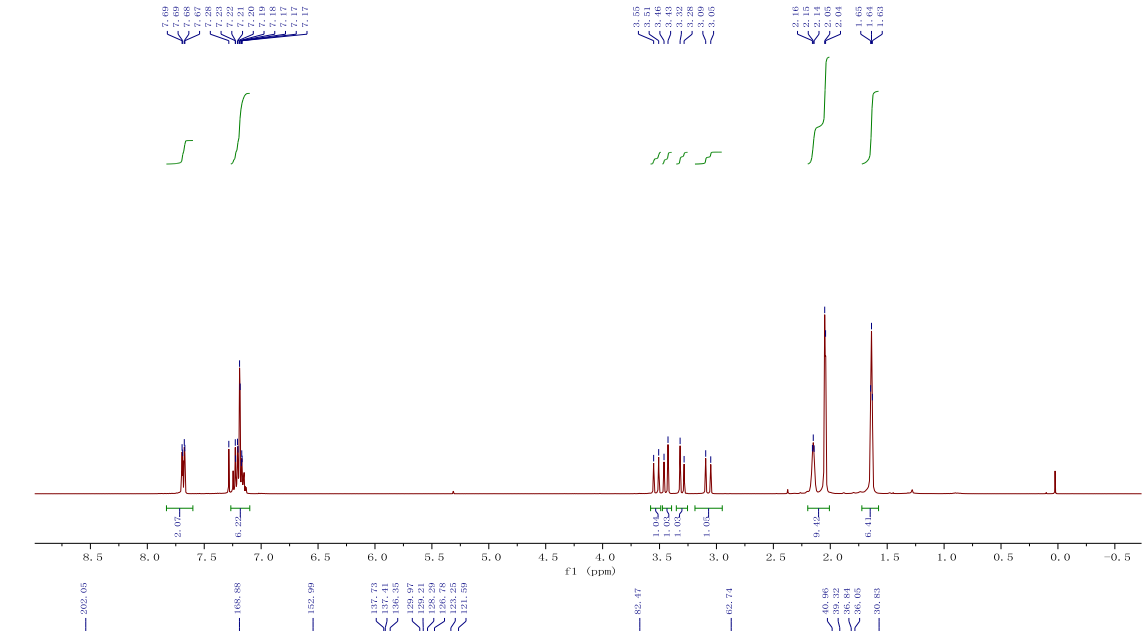
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)


O
O
O1Ad
Br
4j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7.19
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7.17
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3.51
3.46
3.43
3.32
3.28
3.09
3.05
2.16
2.15
2.14
2.05
2.04
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2.07
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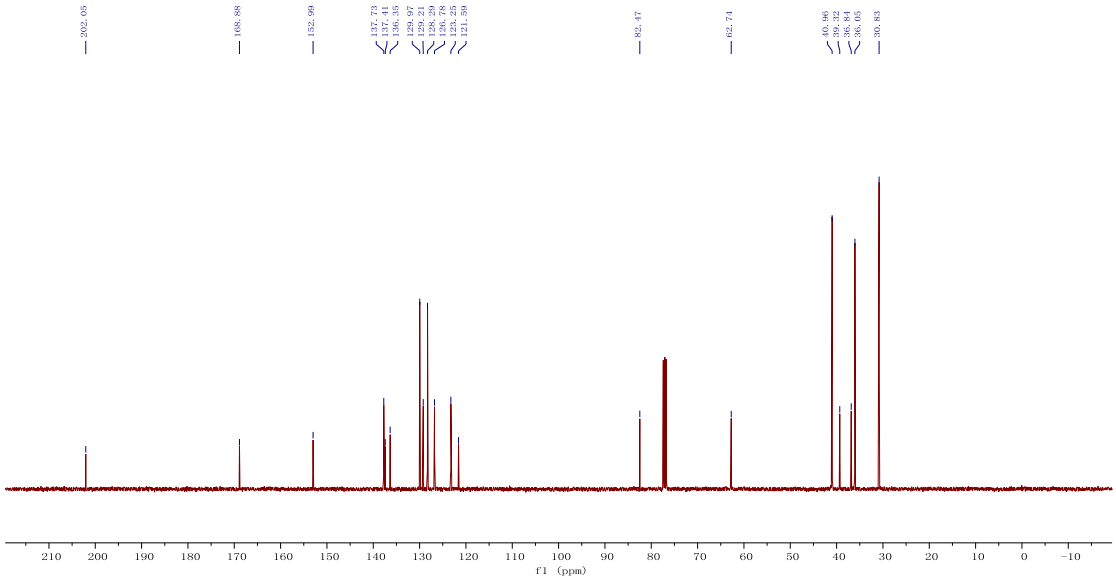
1.04
1.03
1.02
1.00
9.42
6.41
f1 (ppm)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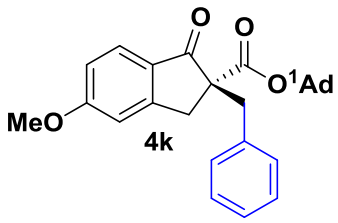
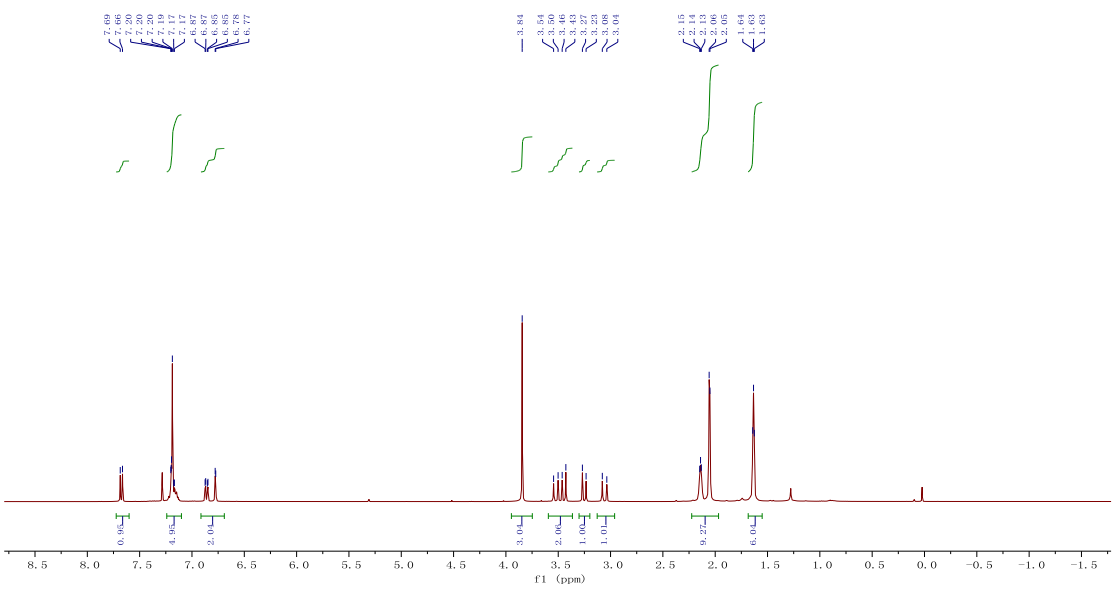
39.32
38.84
36.05
30.83
f1 (ppm)


O
O
O
1
Ad
MeO
4k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3.27
3.23
3.08
3.04
2.15
2.14
2.13
2.06
2.05
1.64
1.63
1.63
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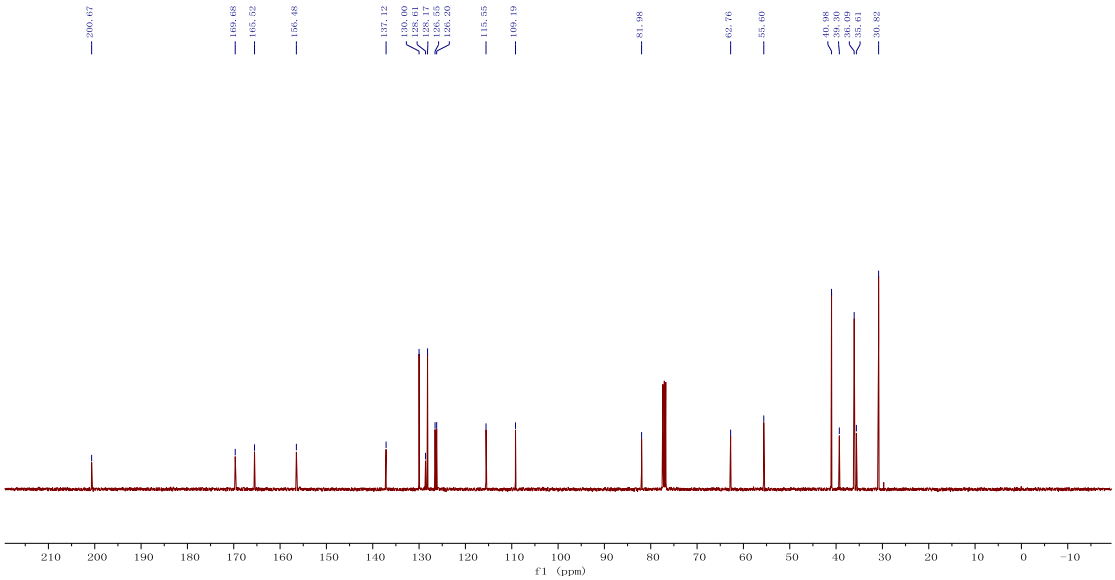
4.95
2.04
3.04
2.00
1.00
1.01
9.27
6.04
f1 (ppm)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128.17
126.55
126.20
115.55
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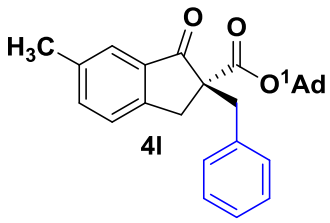
55.60
40.98
39.30
36.09
35.61
30.82
f1 (ppm)

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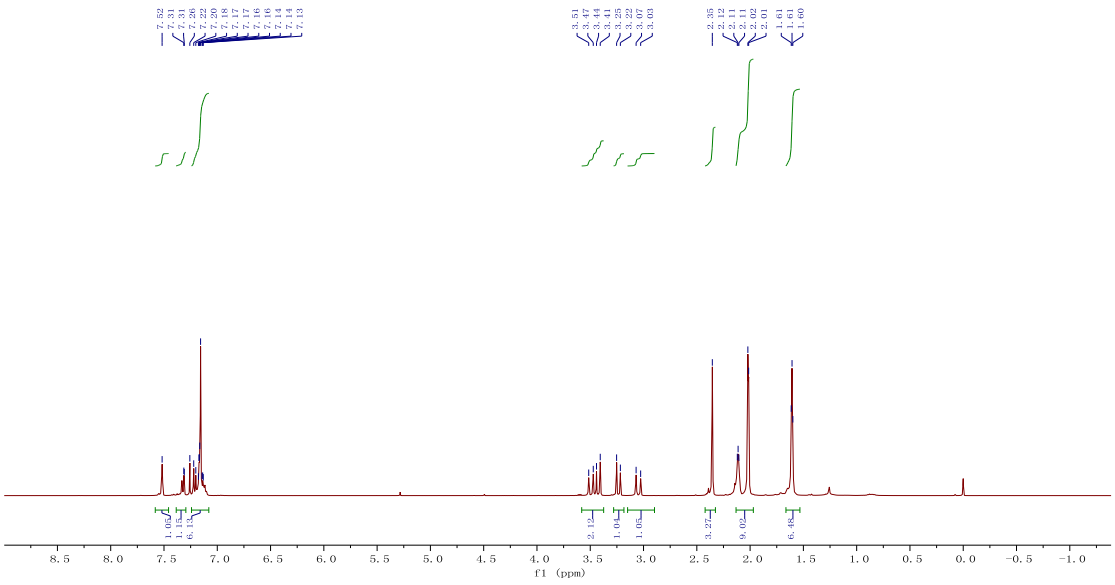
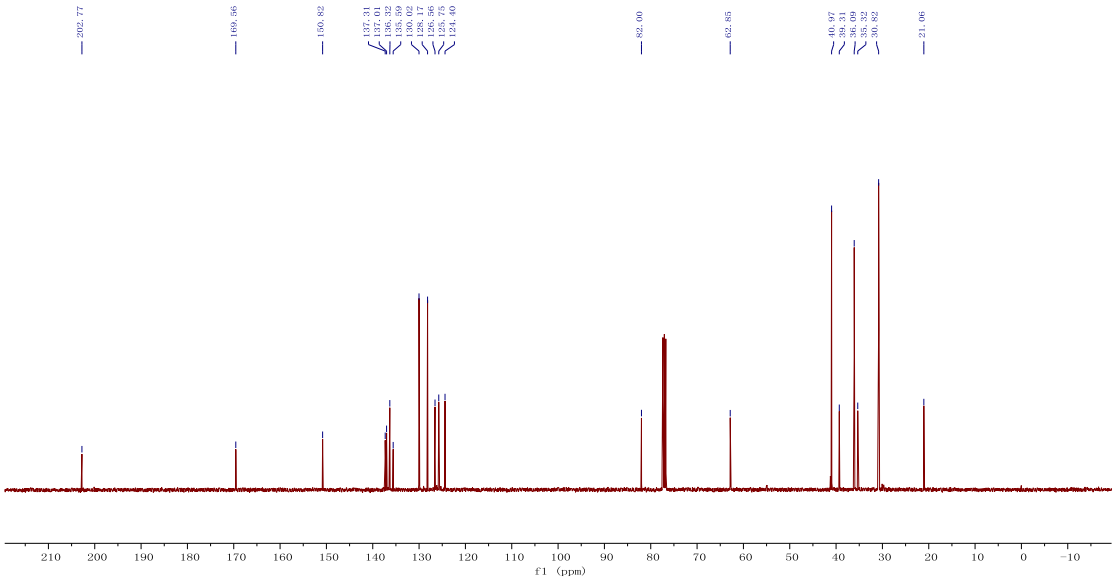
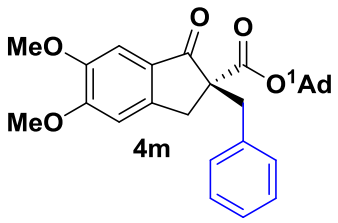
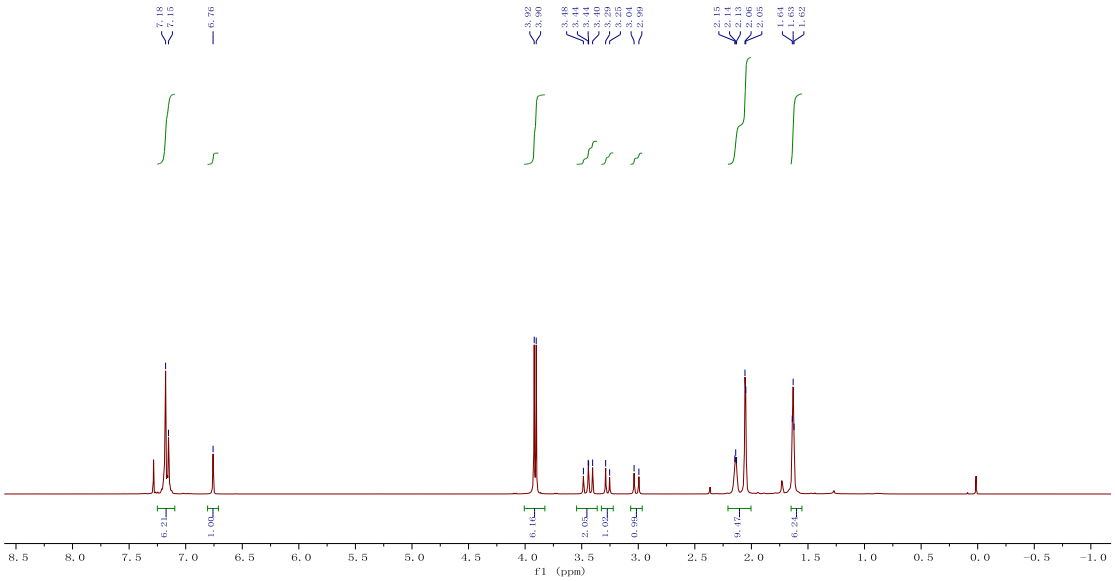



MeO
MeO
O
O
O1Ad
4m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3.44
3.40
3.29
3.25
3.04
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2.15
2.14
2.13
2.06
2.05
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1.63
1.62
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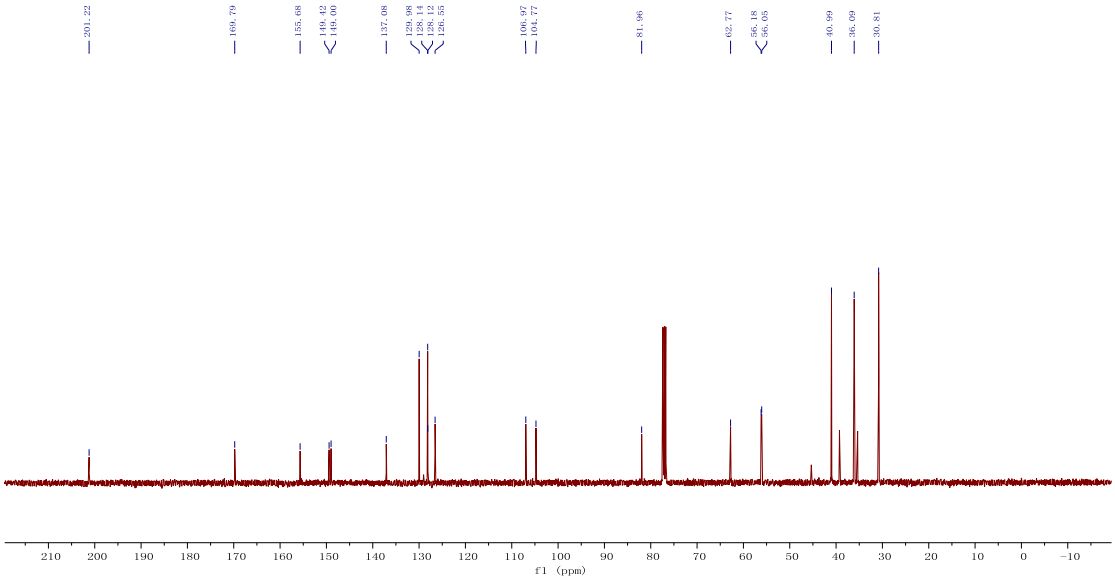
6.16
2.05
1.02
0.98
9.47
6.24
f1 (ppm)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128.14
128.12
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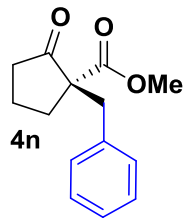
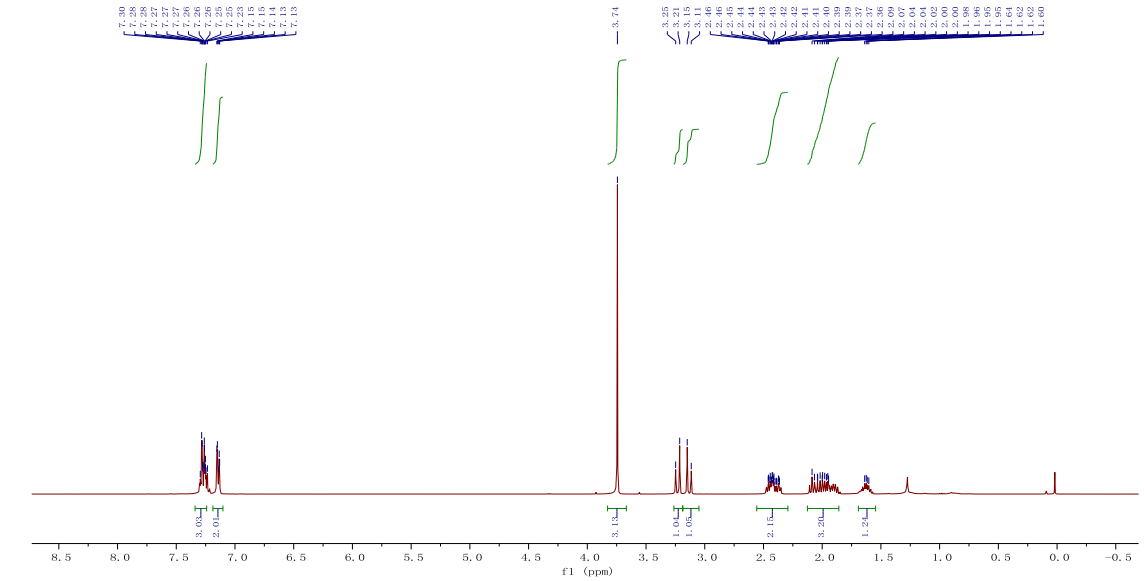
62.77
56.18
56.05
40.99
36.09
30.81
f1 (ppm)


O
O
OMe
4n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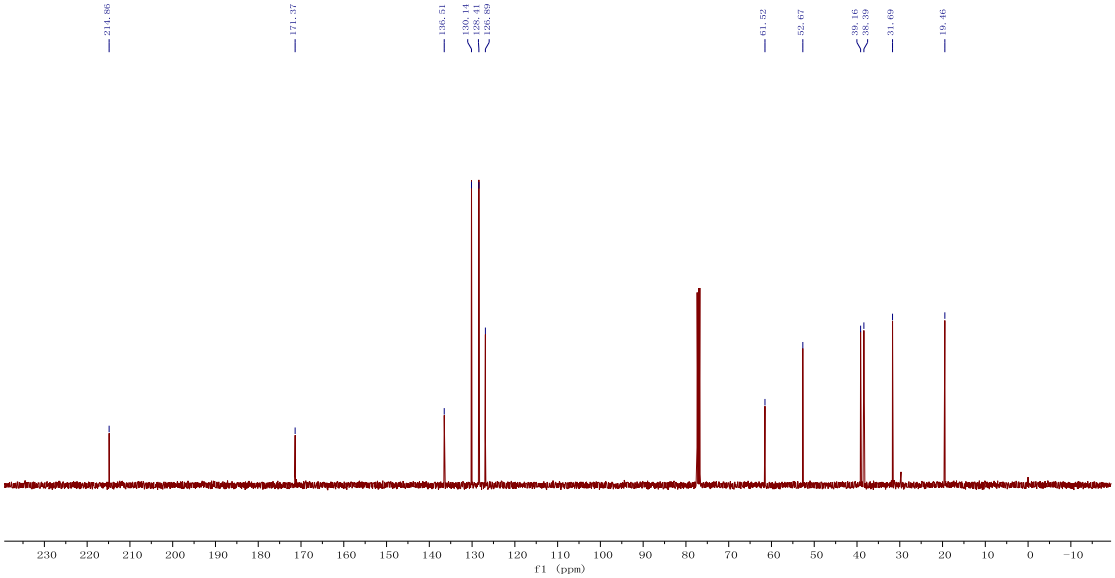
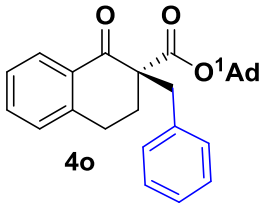
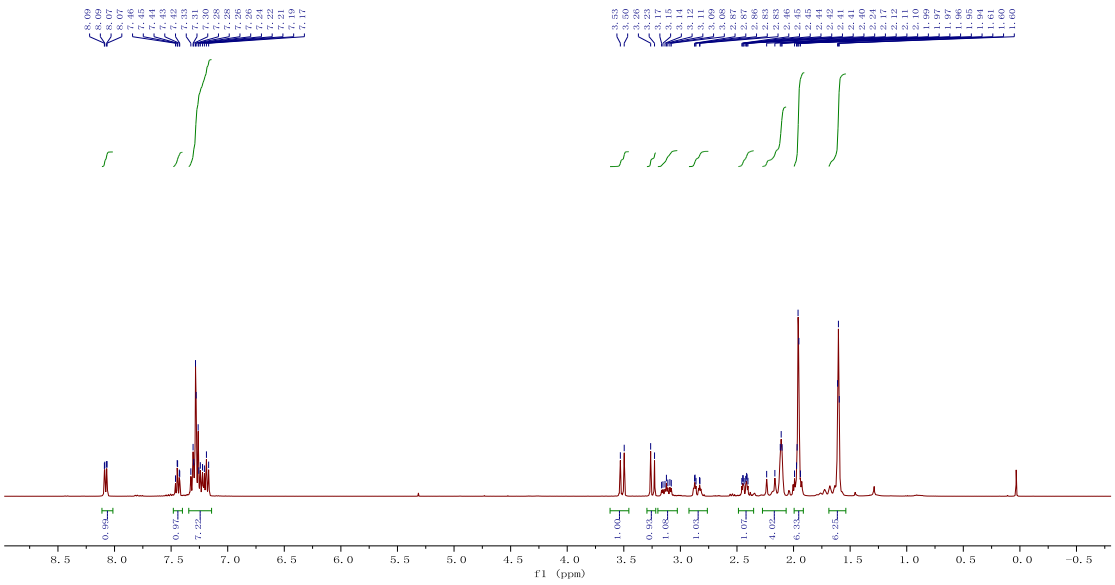
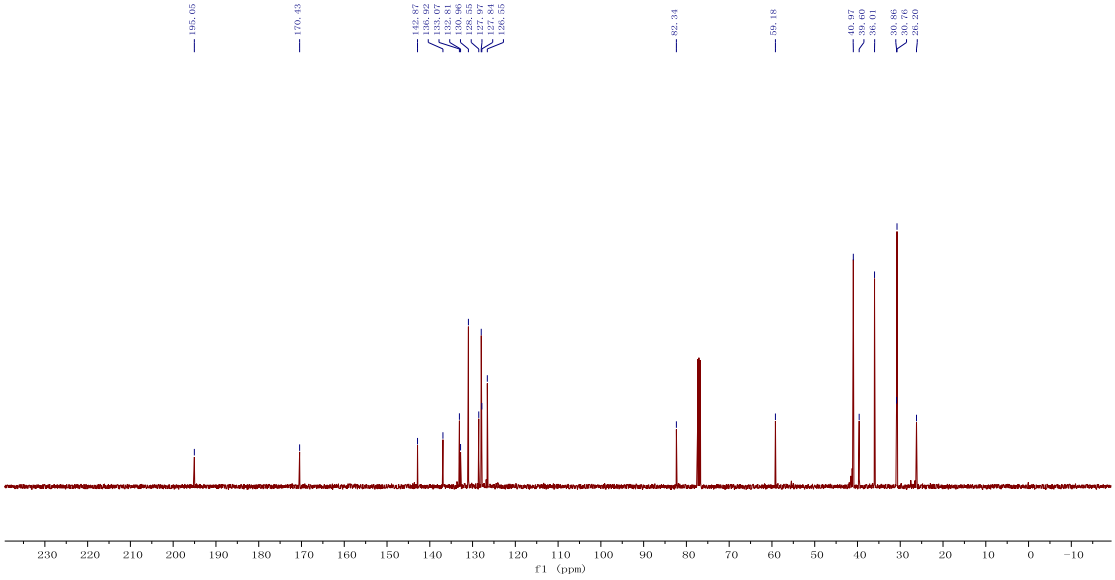
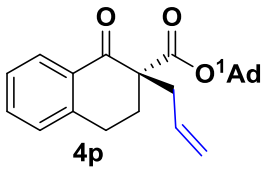

f1 (ppm)




4o



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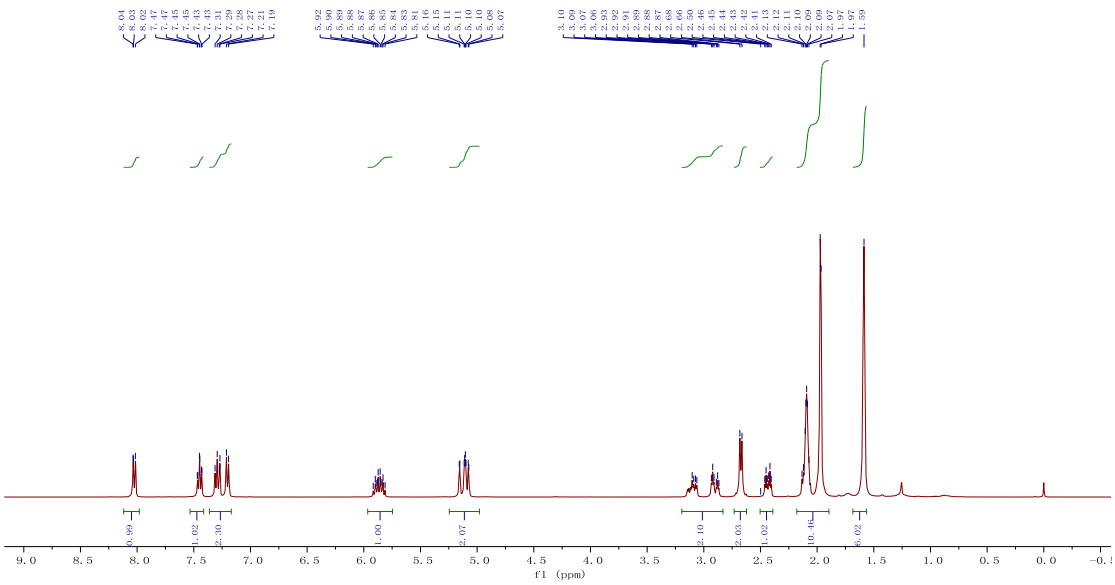
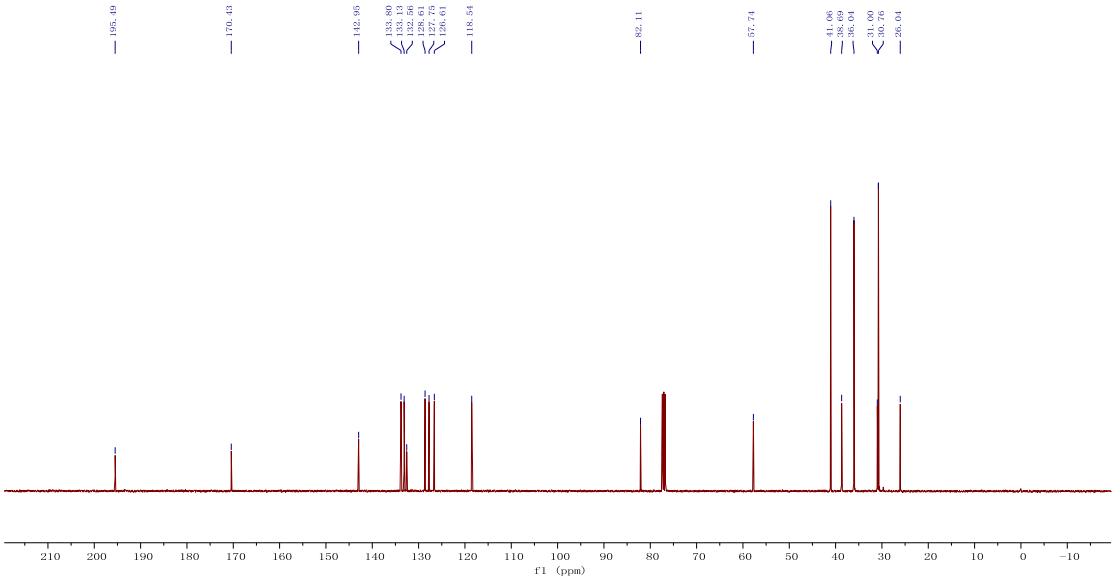
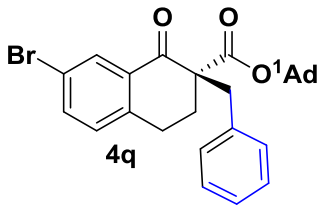
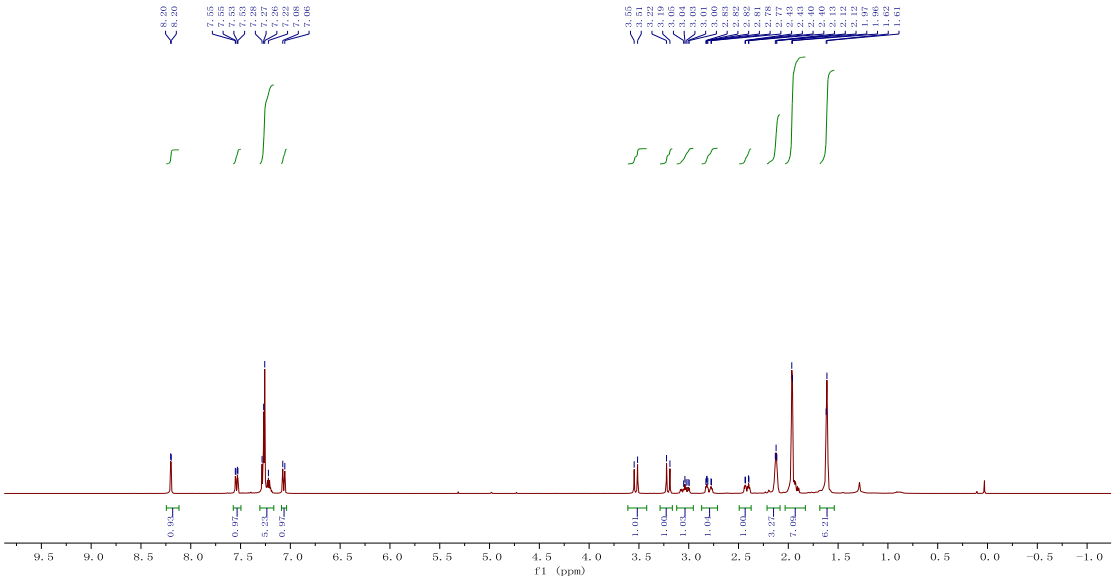



O
O
Br
O1Ad
4q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3.22
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3.05
3.04
3.03
3.01
3.00
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2.82
2.82
2.81
2.78
2.77
2.43
2.43
2.40
2.40
2.13
2.12
2.12
1.97
1.96
1.62
1.61
0.93
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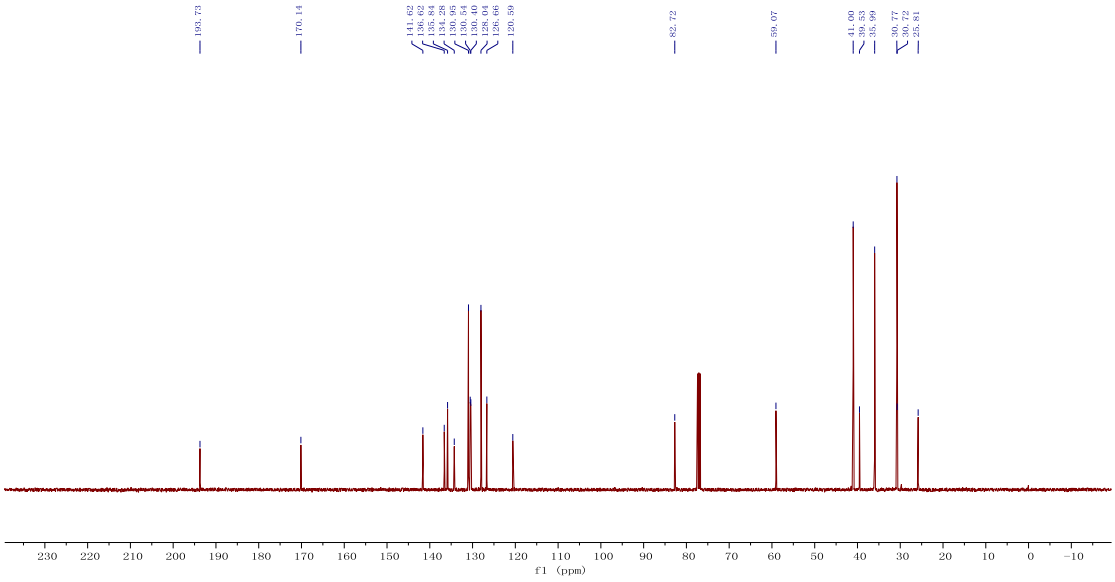
1.00
1.03
1.04
1.00
3.27
7.08
6.21
f1 (ppm)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130.54
130.40
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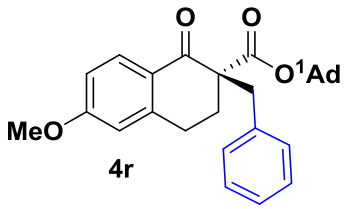
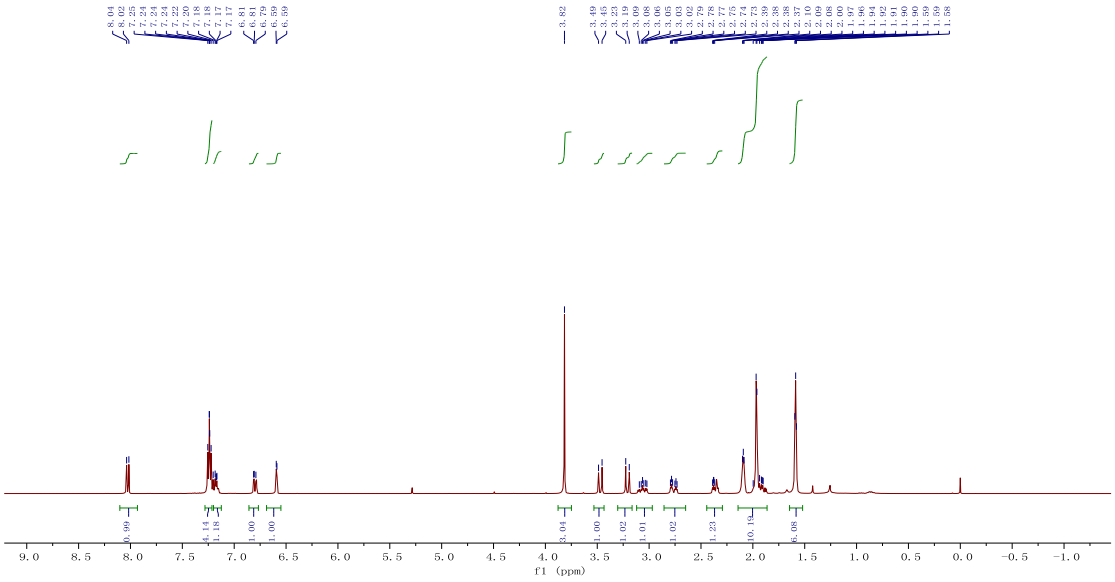
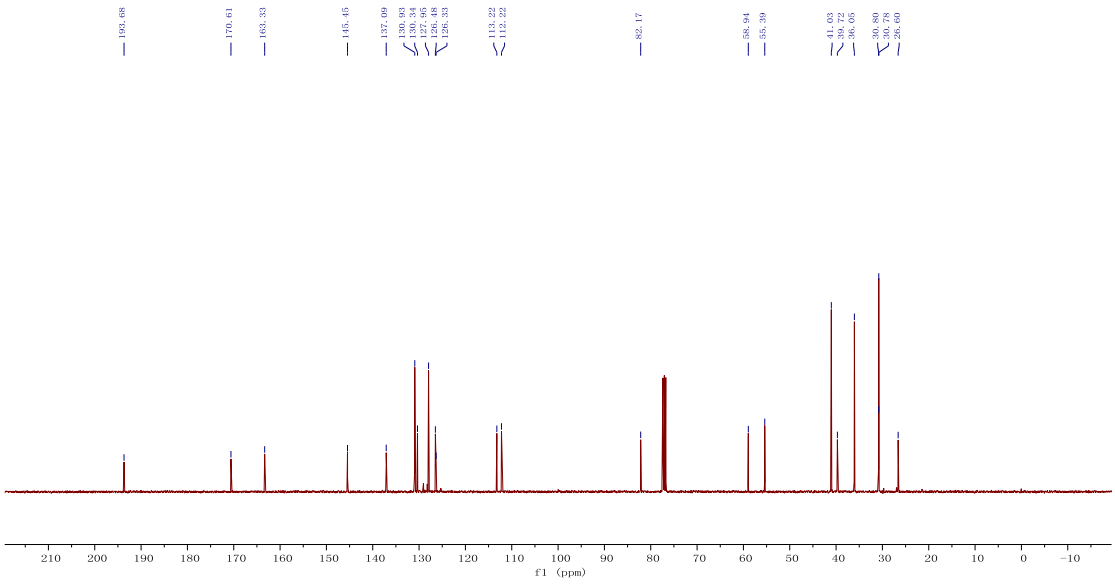
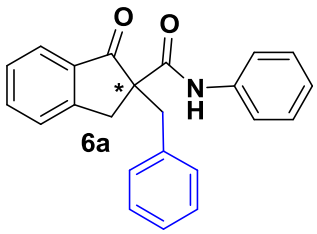
35.99
30.77
30.72
25.81
f1 (ppm)

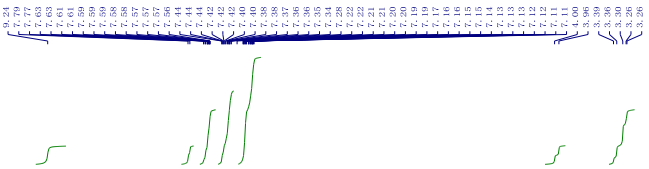


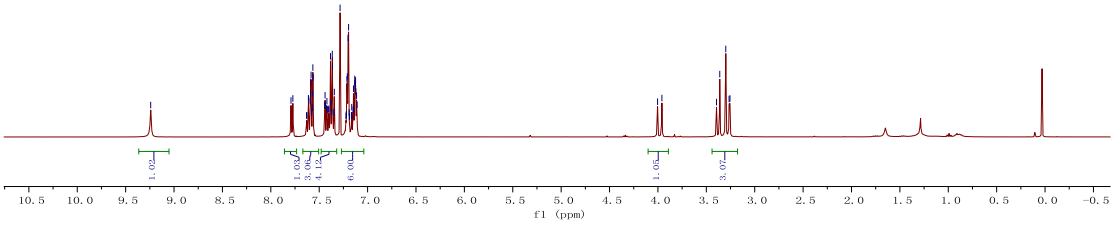

4r




O
O
N
H
*
6a

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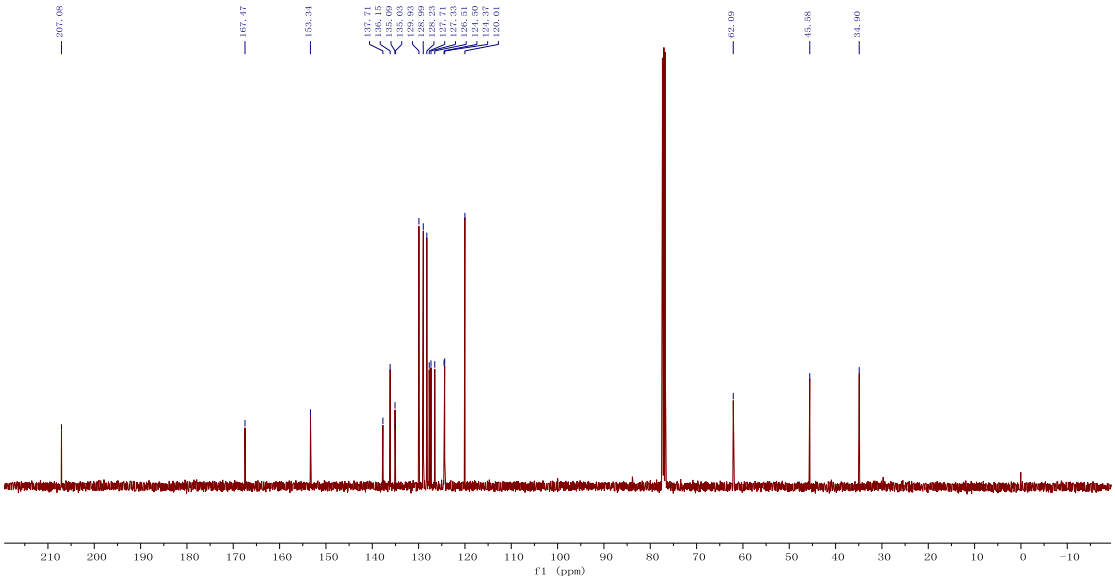
4.12
6.00
1.05
3.07
f1 (ppm)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124.50
124.37
120.01
62.09
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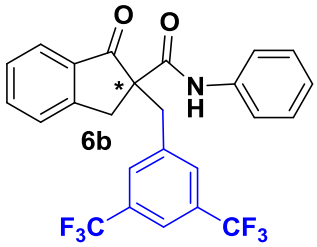
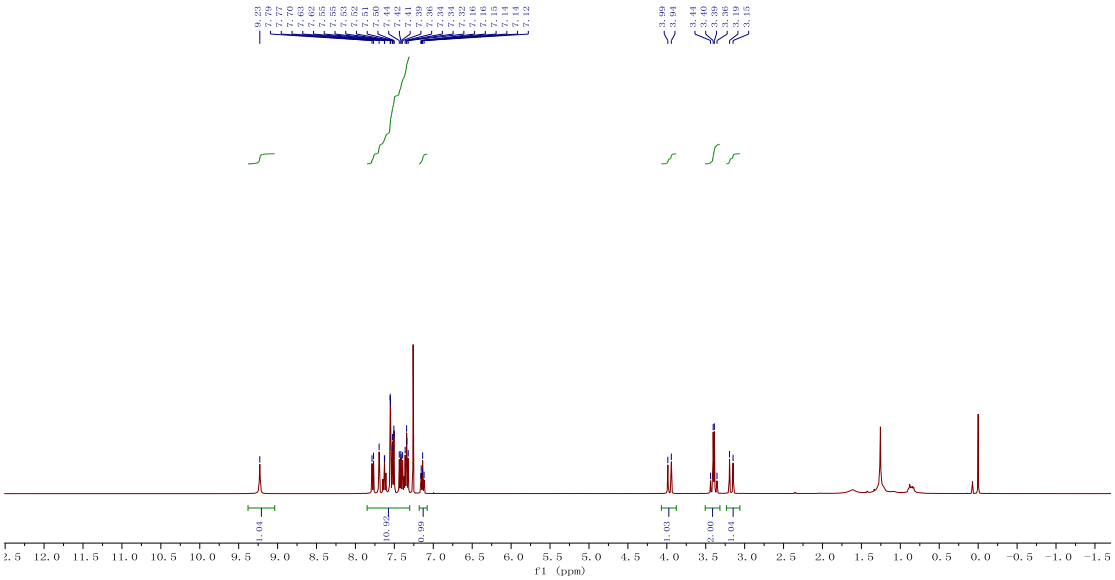
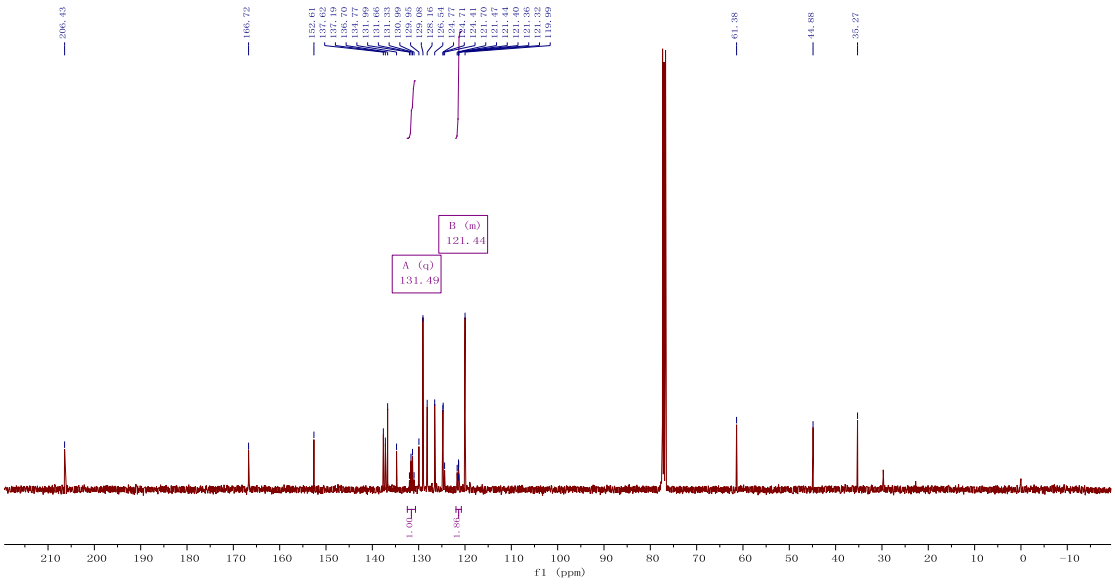
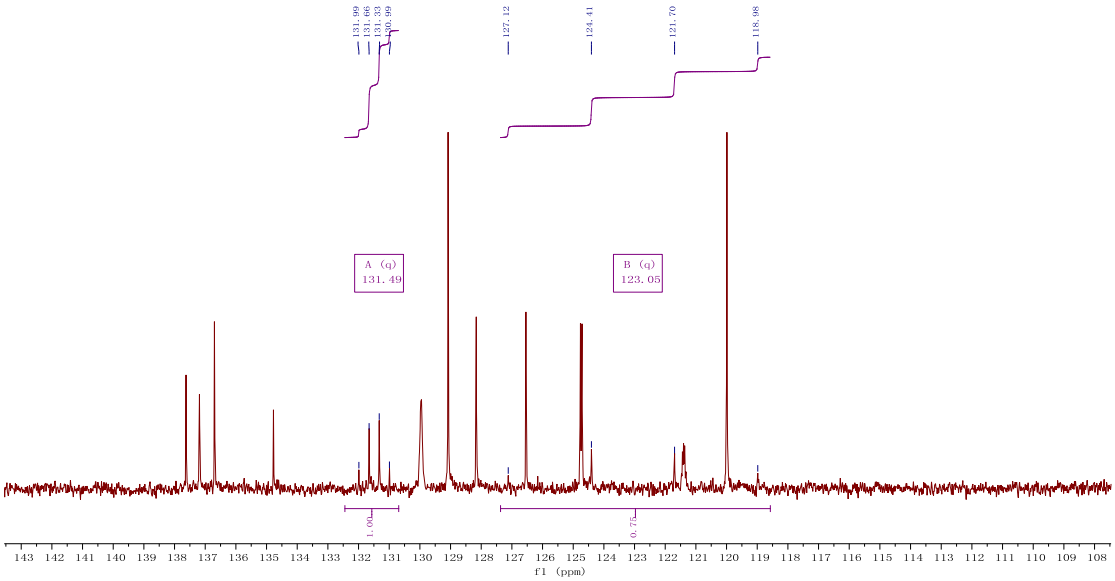
34.90
f1 (ppm)

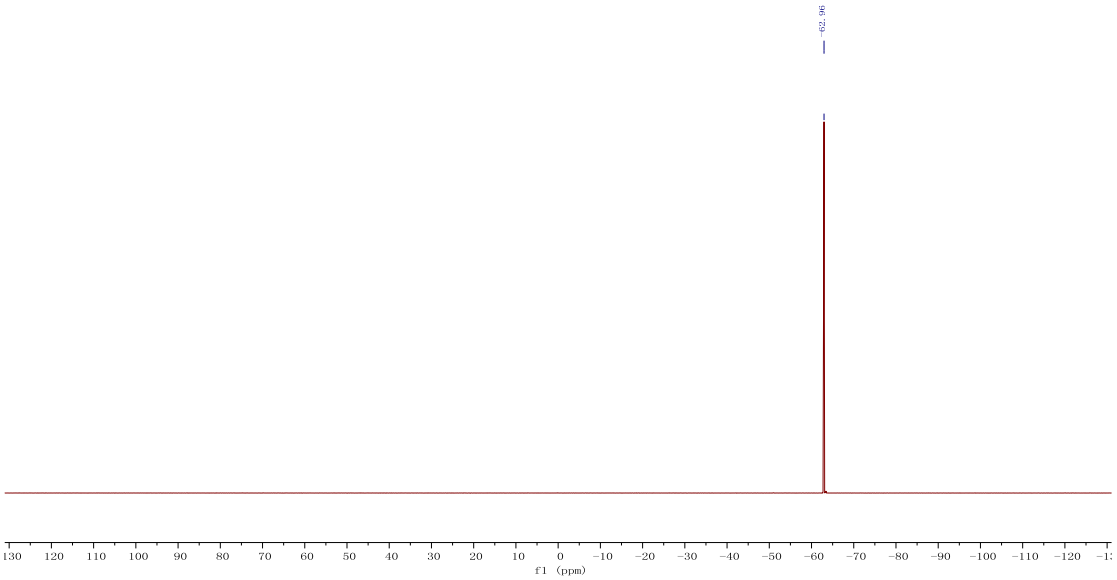

O
O
N
H
*
6b
F3C
CF3

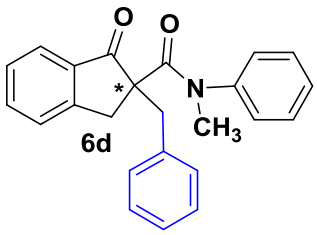

9.23
7.79
7.77
7.70
7.63
7.62
7.55
7.53
7.52
7.51
7.50
7.44
7.42
7.41
7.39
7.36
7.34
7.32
7.16
7.15
7.14
7.14
7.12
3.99
3.94
3.44
3.40
3.38
3.36
3.19
3.15
1.04
10.92
8.99
1.03
2.00
1.04
f1 (ppm)

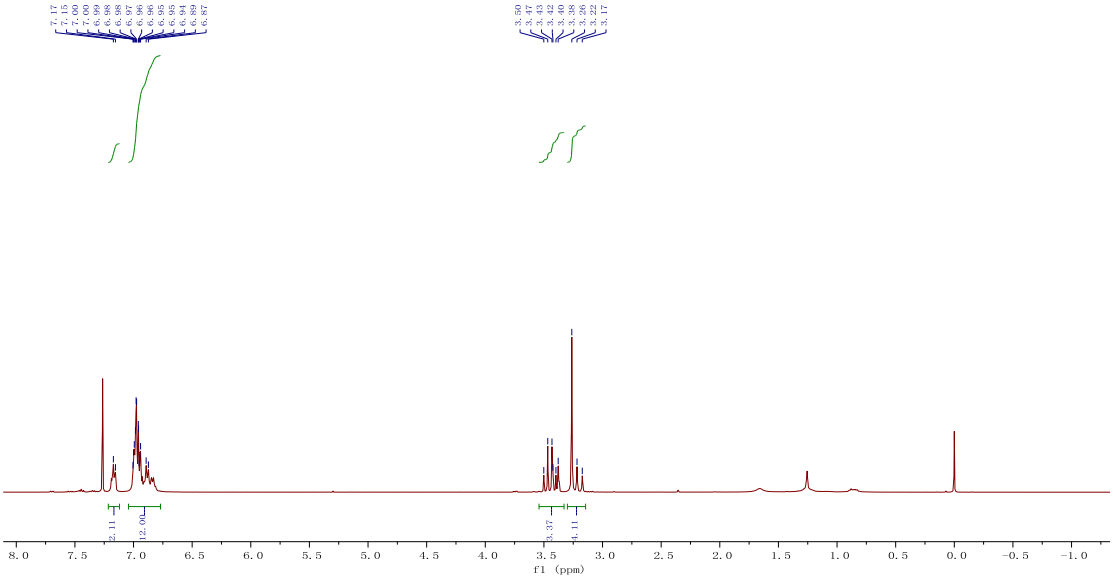

206.43
166.72
152.61
137.82
137.19
136.70
134.77
134.09
131.66
131.33
130.99
130.65
129.98
128.16
126.54
124.77
124.71
124.41
121.70
121.47
121.44
121.40
121.36
121.32
119.99
61.38
44.88
35.27
B (m)
121.44
A (q)
131.49
1.00
1.88
f1 (ppm)

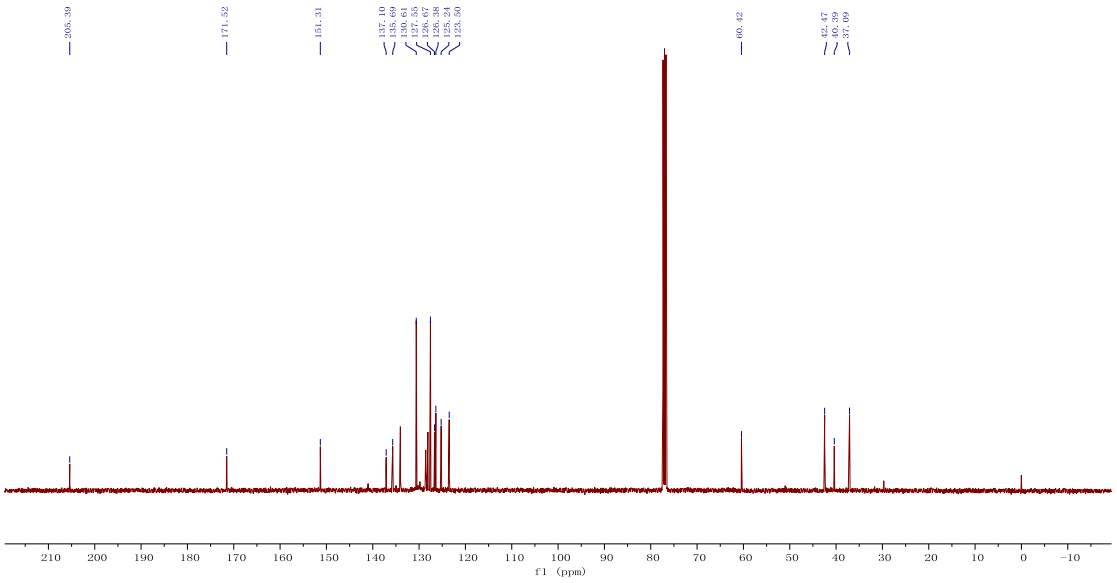
$^{13}$C NMR (101 MHz, Chloroform-*d*) δ 131.49 (q, $J$ = 33.5 Hz), 123.05 (q, $J$ = 273.0 Hz).

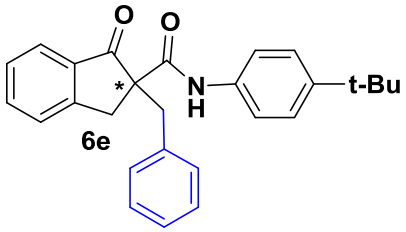


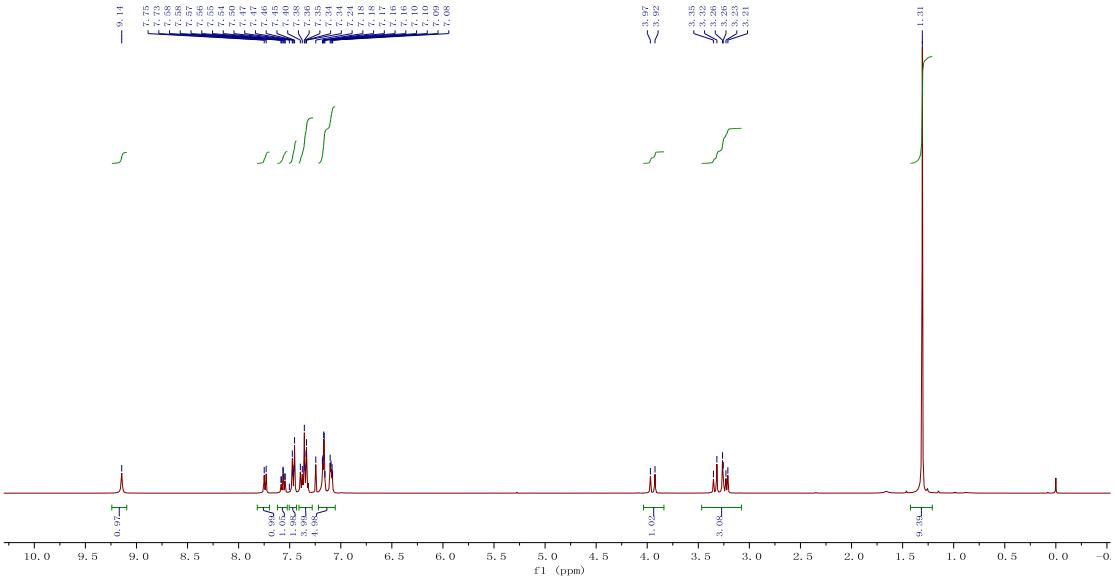

O
O
*
N
CH3
6d

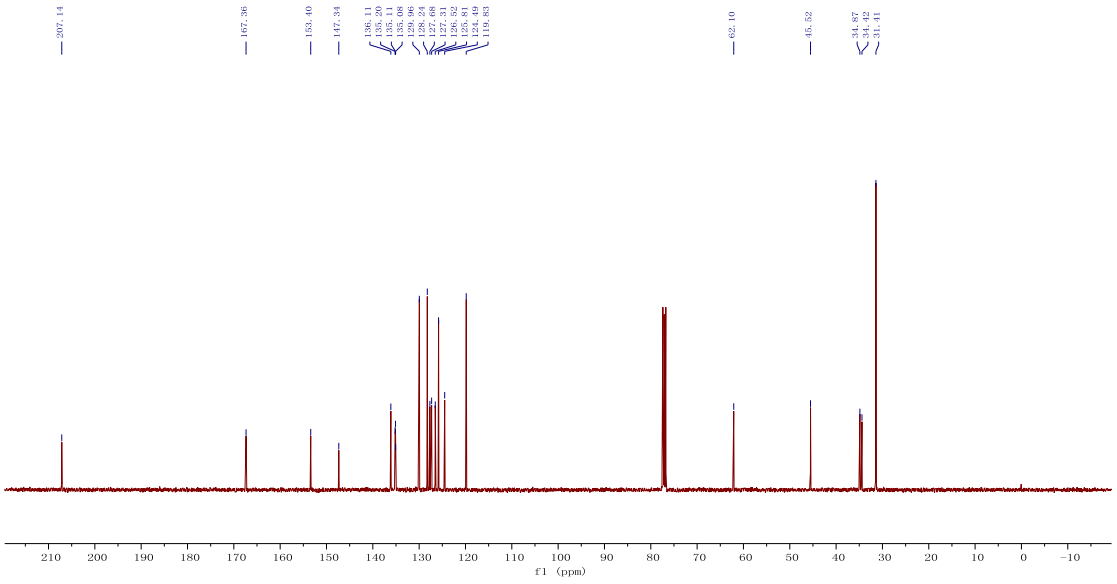

7.17
7.15
7.00
6.99
6.98
6.98
6.97
6.96
6.96
6.95
6.95
6.94
6.89
6.87
3.50
3.47
3.43
3.42
3.40
3.38
3.26
3.22
3.17
2.11
2.00
3.37
4.11
f1 (ppm)

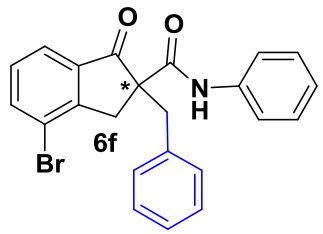

205.39
171.52
151.34
137.10
135.69
130.61
127.55
126.67
126.38
125.24
123.50
60.42
42.47
40.39
37.09
f1 (ppm)

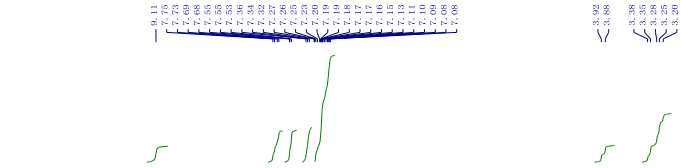

O
O
N
H
t-Bu
*

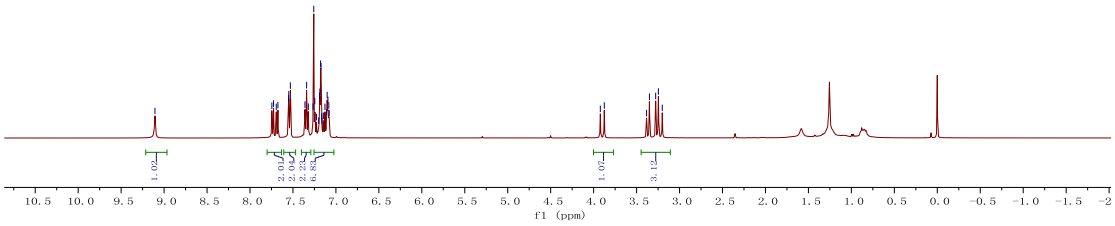
6e

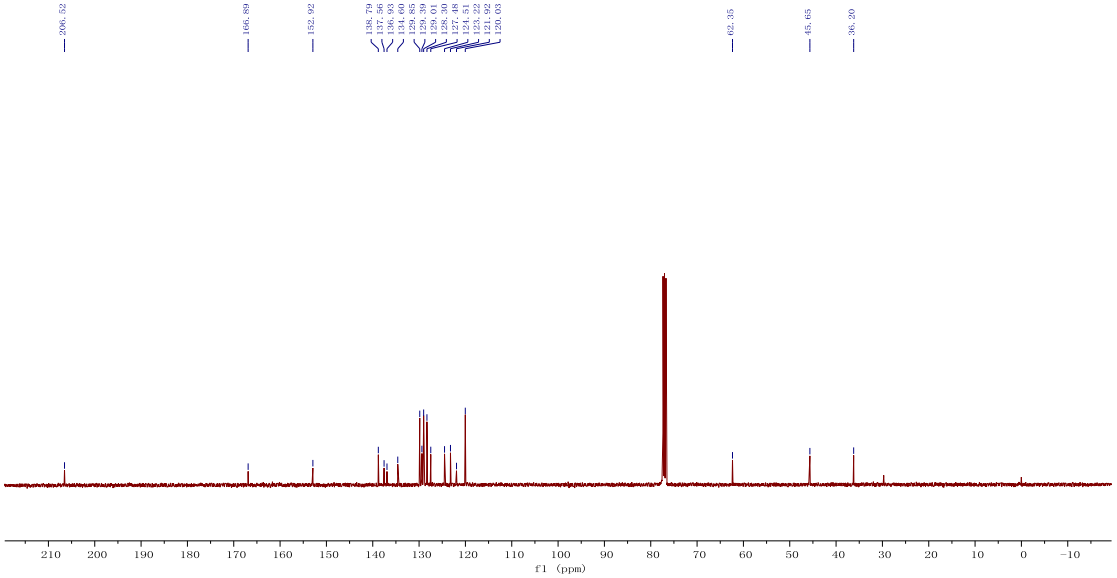

9.14
7.75
7.73
7.58
7.57
7.56
7.55
7.54
7.50
7.47
7.47
7.46
7.45
7.40
7.38
7.36
7.35
7.34
7.34
7.24
7.18
7.17
7.16
7.16
7.10
7.09
7.08
3.97
3.92
3.35
3.32
3.26
3.26
3.23
3.21
1.31
0.97
0.98
1.03
1.98
3.99
4.98
1.02
3.08
9.39
f1 (ppm)

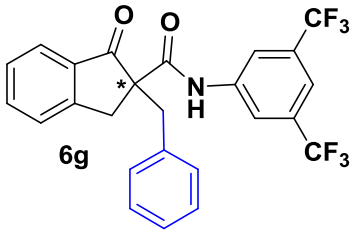

207.14
167.36
153.40
147.34
136.11
135.59
135.11
135.08
129.96
129.84
128.68
127.31
126.52
125.81
124.49
119.83
62.10
45.52
34.87
34.42
31.41
f1 (ppm)


O
O
N
H
*
6f
Br

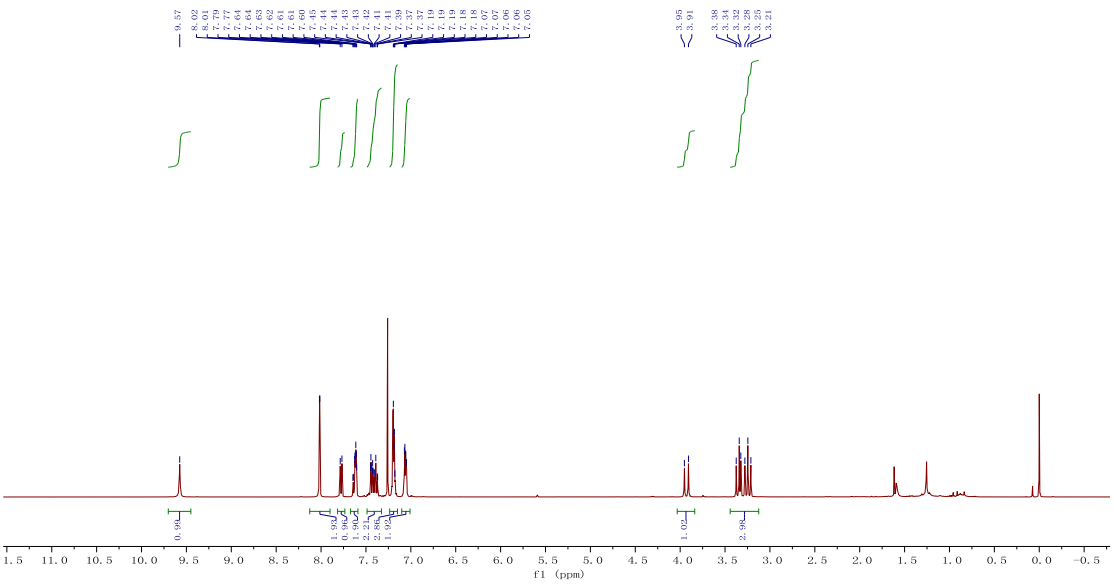

9.11
7.75
7.73
7.69
7.68
7.55
7.53
7.36
7.34
7.32
7.27
7.26
7.25
7.23
7.20
7.19
7.19
7.18
7.17
7.17
7.16
7.15
7.13
7.11
7.10
7.09
7.08
7.08
3.92
3.88
3.38
3.35
3.28
3.25
3.20

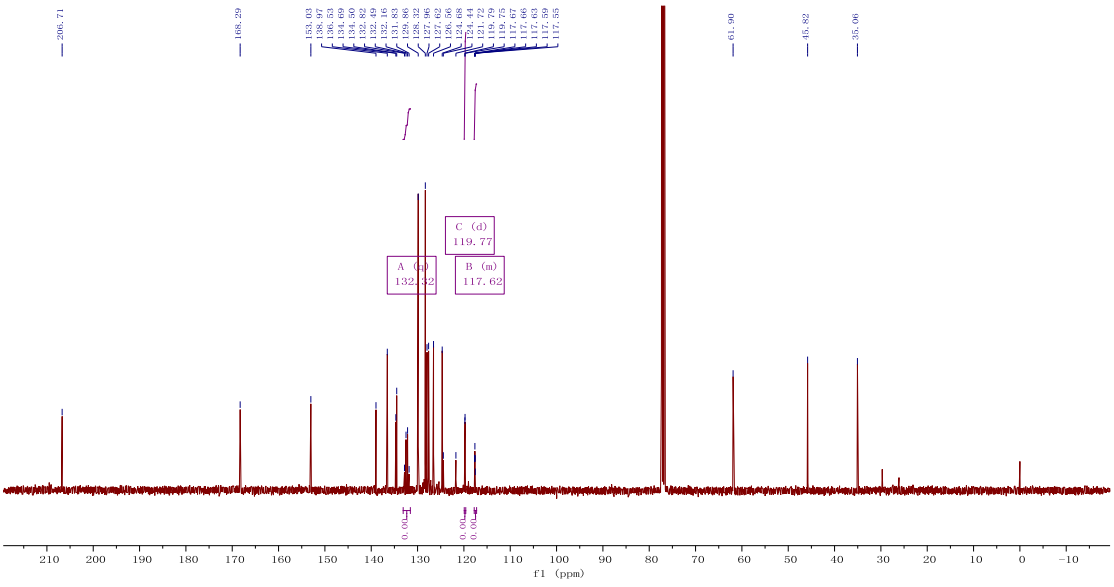

1.02
2.04
2.04
2.23
6.85
1.07
3.12
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 −0.5 −1.0 −1.5 −2
f1 (ppm)


206.52
166.89
152.92
138.79
137.96
136.55
134.60
129.85
129.39
129.10
128.30
127.48
124.51
123.22
121.92
120.03
62.35
45.65
36.20
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

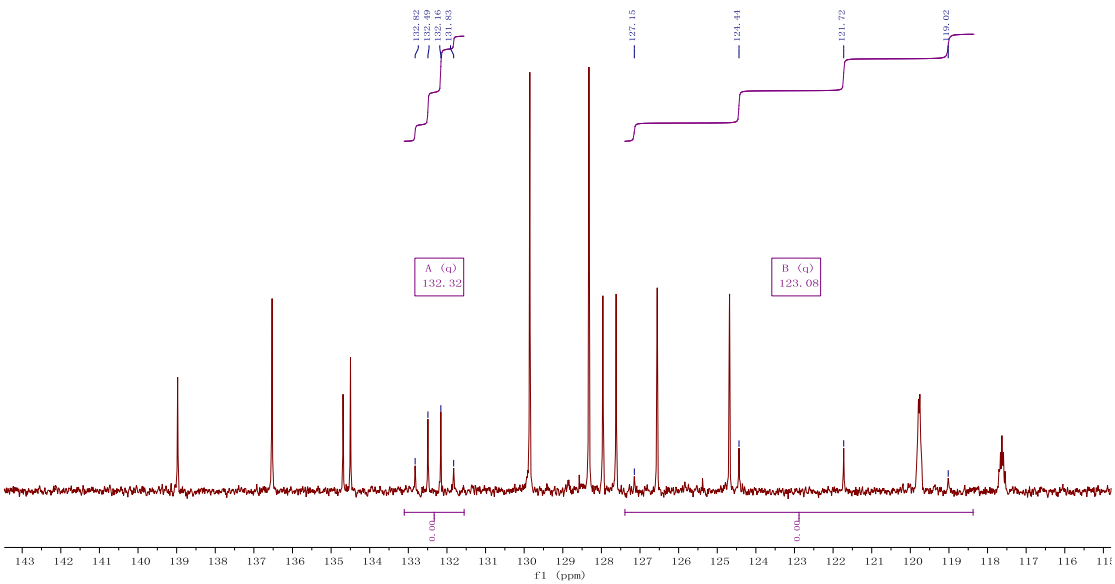


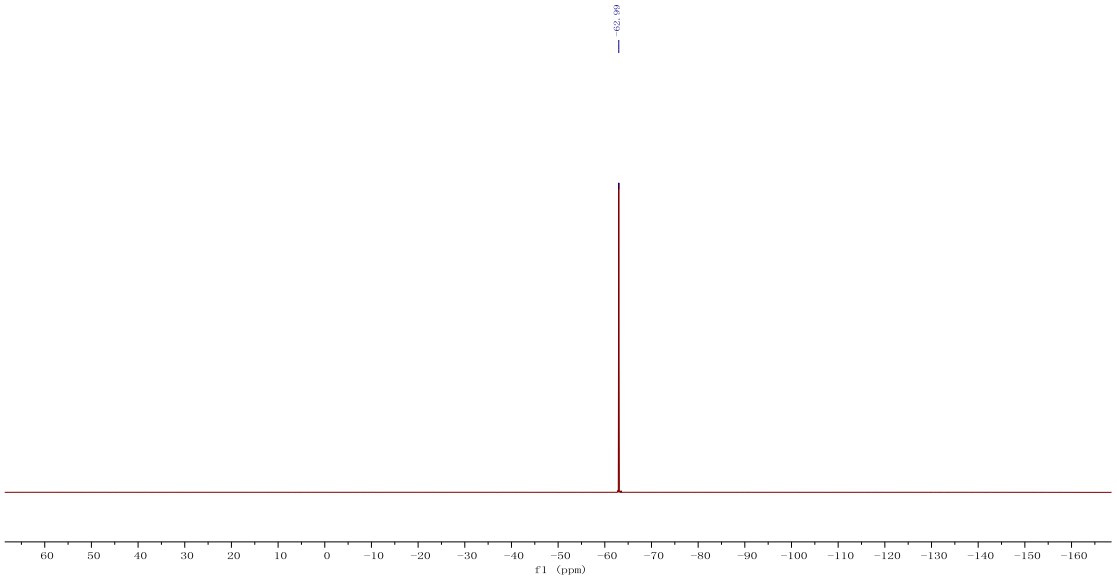

6g

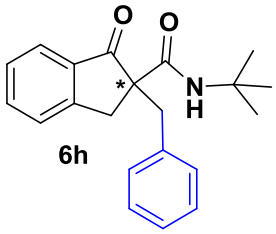




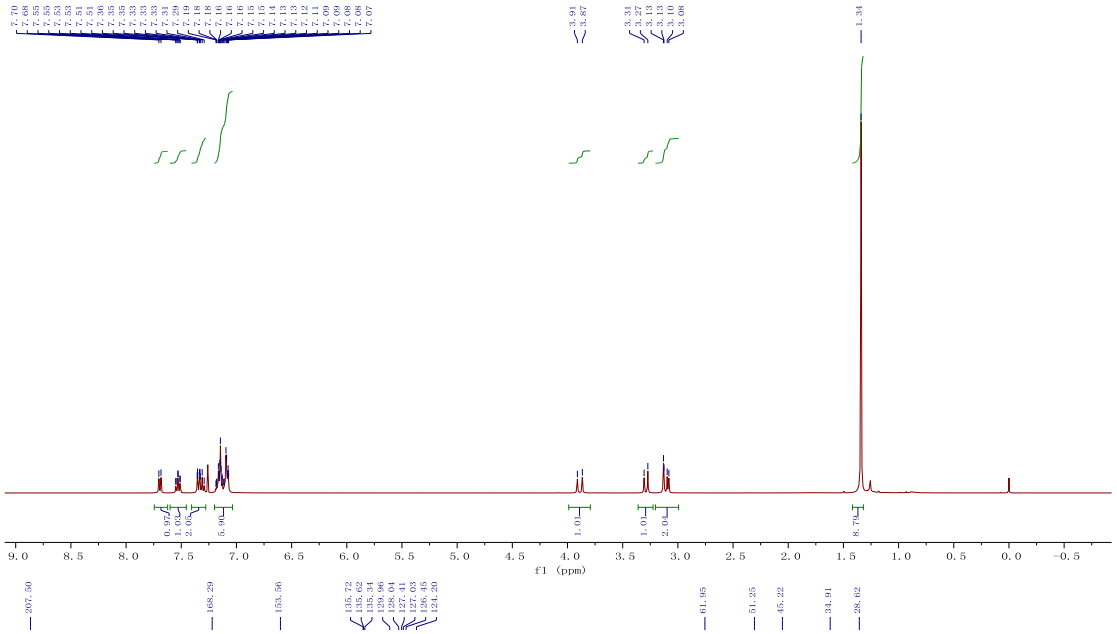
$^{13}$C NMR (101 MHz, Chloroform-$d$) δ 132.32 (q, $J$ = 33.4 Hz), 123.08 (q, $J$ = 272.5 Hz).

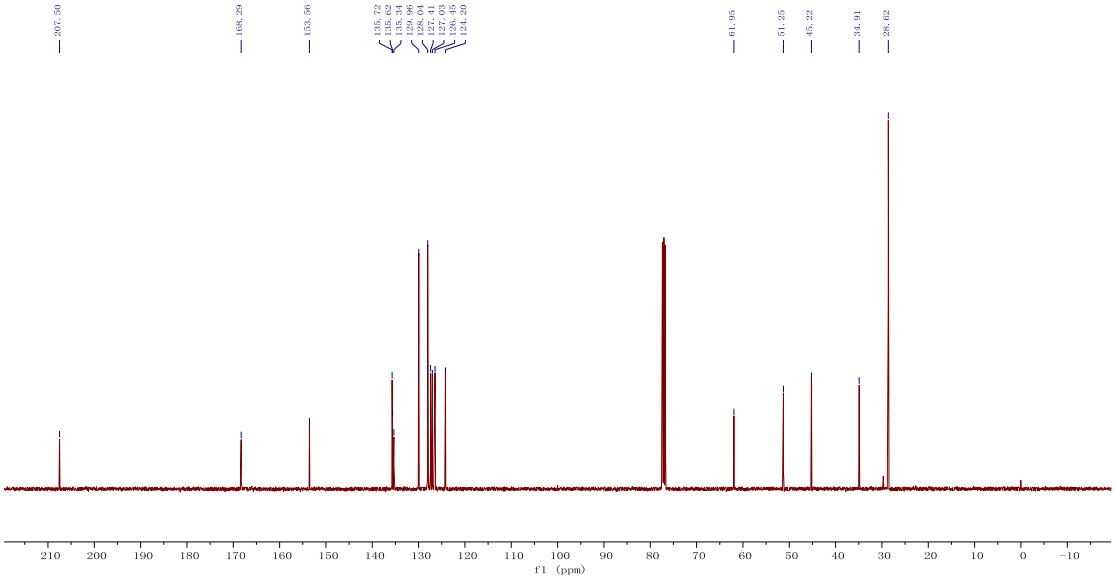


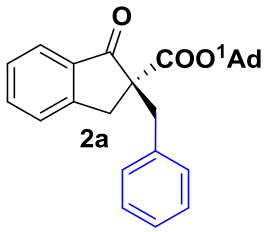

O
O
*
N
H

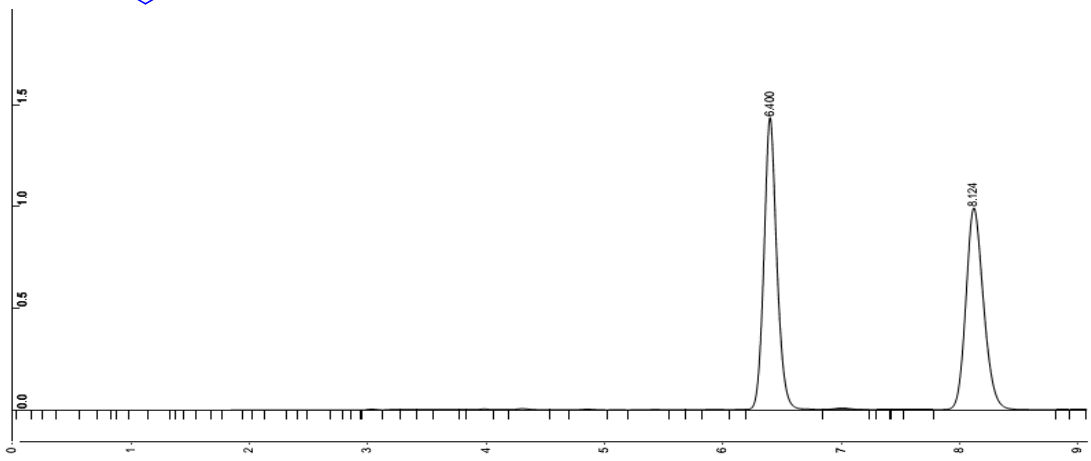
6h


7.70
7.68
7.55
7.55
7.53
7.53
7.51
7.51
7.36
7.35
7.35
7.33
7.33
7.31
7.29
7.19
7.18
7.18
7.16
7.16
7.16
7.15
7.15
7.14
7.13
7.13
7.12
7.11
7.09
7.09
7.08
7.08
7.07
3.91
3.87
3.31
3.27
3.13
3.13
3.10
3.08
1.34
0.97
1.03
2.05
5.94
1.01
1.01
2.04
8.70
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
0.0
−0.5
f1 (ppm)

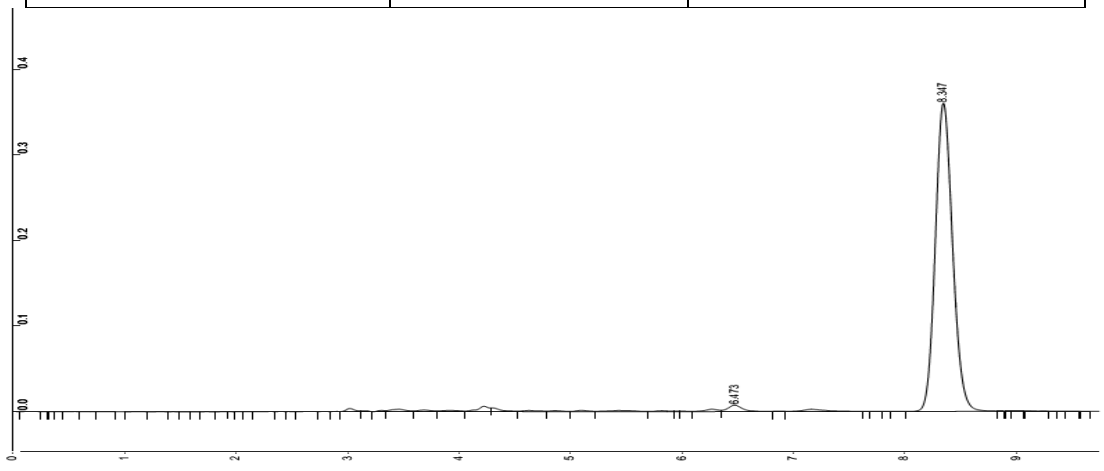

207.50
168.29
153.56
135.72
135.62
135.34
129.96
129.64
127.41
127.03
126.45
124.20
61.95
51.25
45.22
34.91
28.62
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

# HPLC



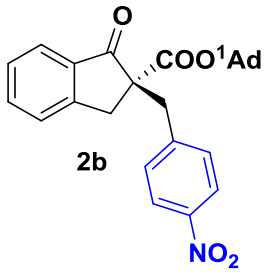




| R.Time | Area | Area% |
|---|---|---|
| **6.400** | **109604296** | **51.2533** |
| **8.124** | **104244136** | **48.7467** |

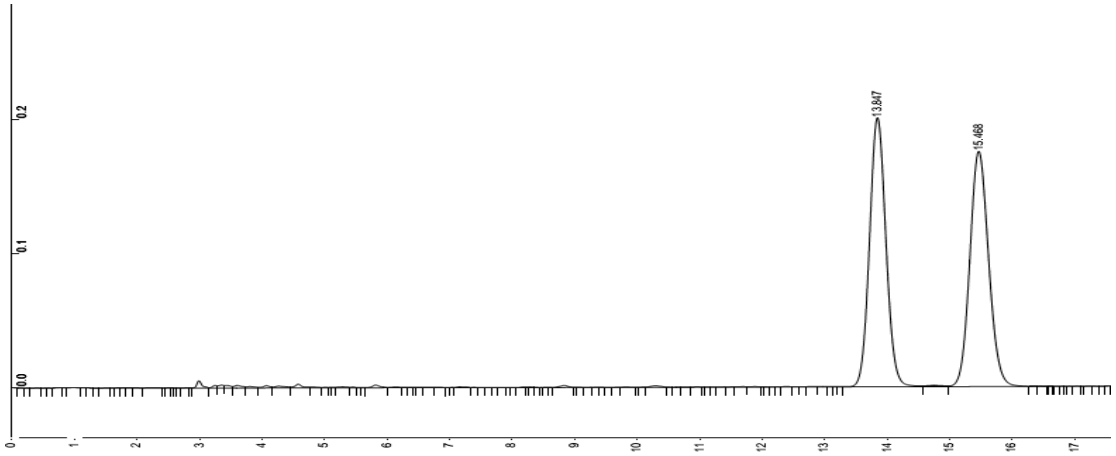



| R.Time | Area | Area% |
|---|---|---|
| **6.473** | **477388** | **1.2135** |
| **8.347** | **38862400** | **98.7865** |

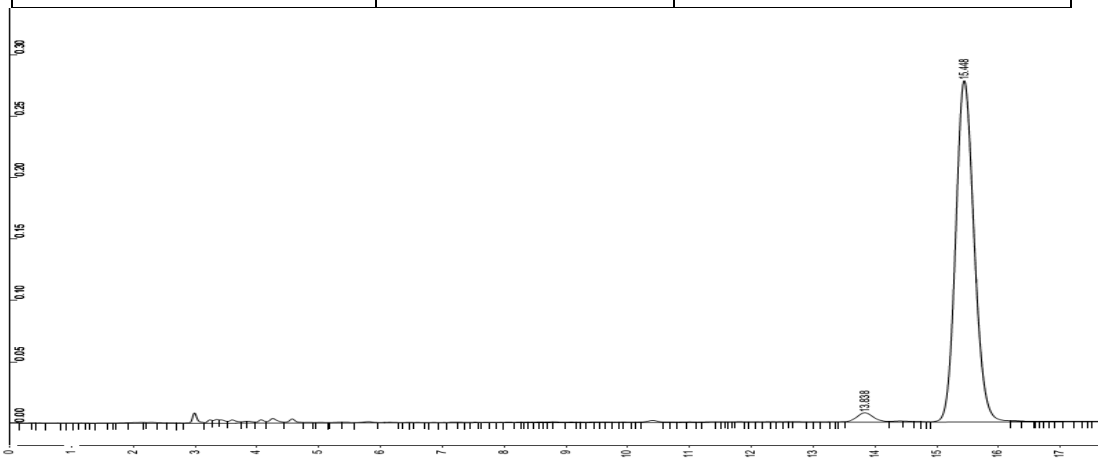
98% ee




2b

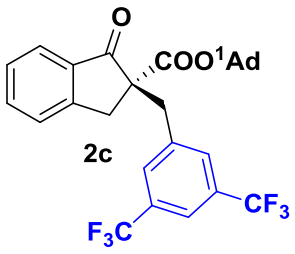


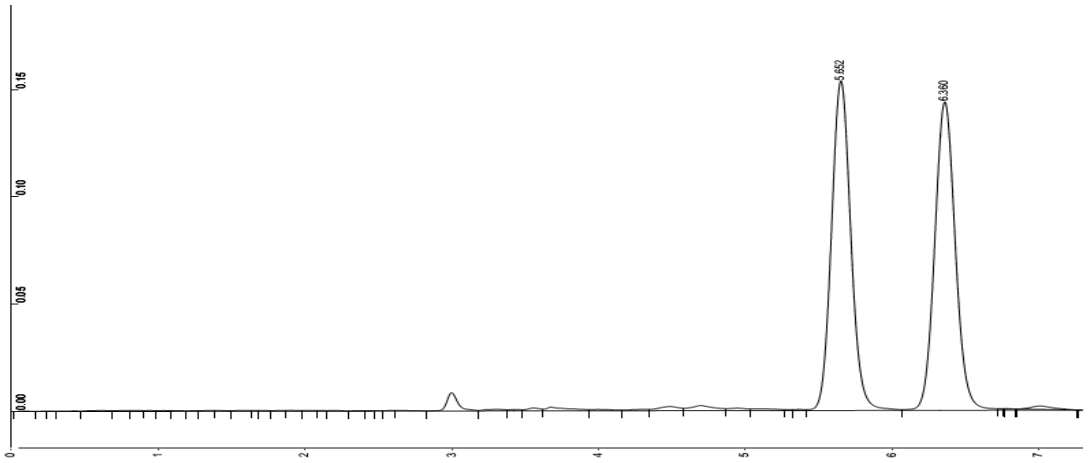

| R.Time | Area | Area% |
|---|---|---|
| **13.847** | **36757624** | **50.0855** |
| **15.468** | **36632064** | **49.9145** |



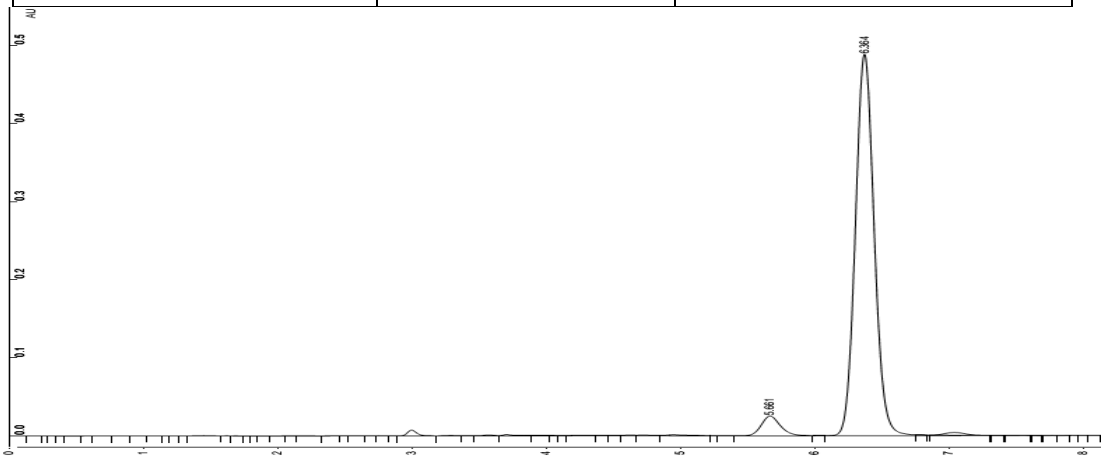

| R.Time | Area | Area% |
|---|---|---|
| **13.8838** | **1445586** | **2.0036** |
| **15.448** | **70831112** | **97.9964** |

96% ee



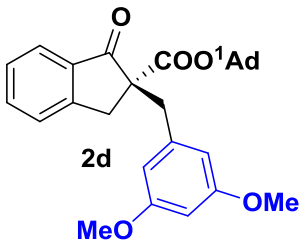



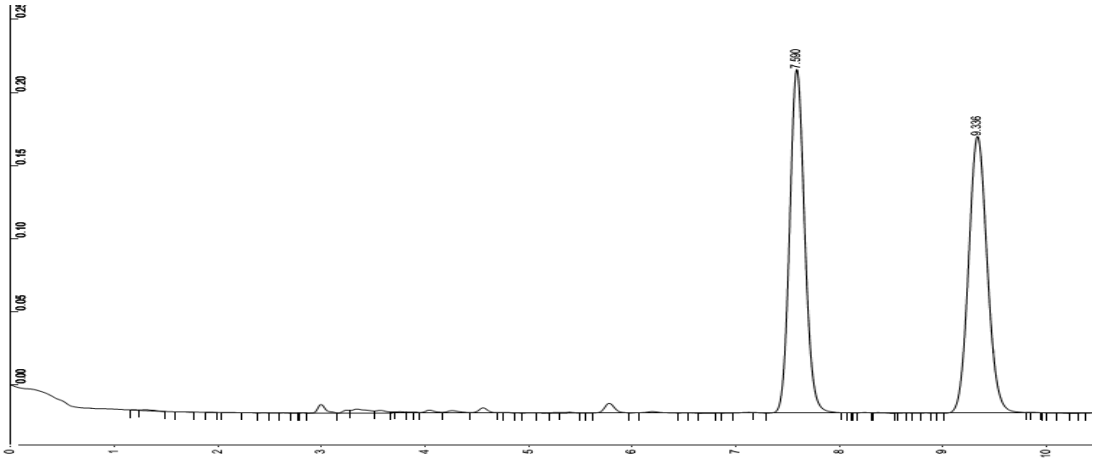

| R.Time | Area | Area% |
|---|---|---|
| **5.652** | **14075206** | **49.9304** |
| **6.360** | **14114440** | **50.0696** |



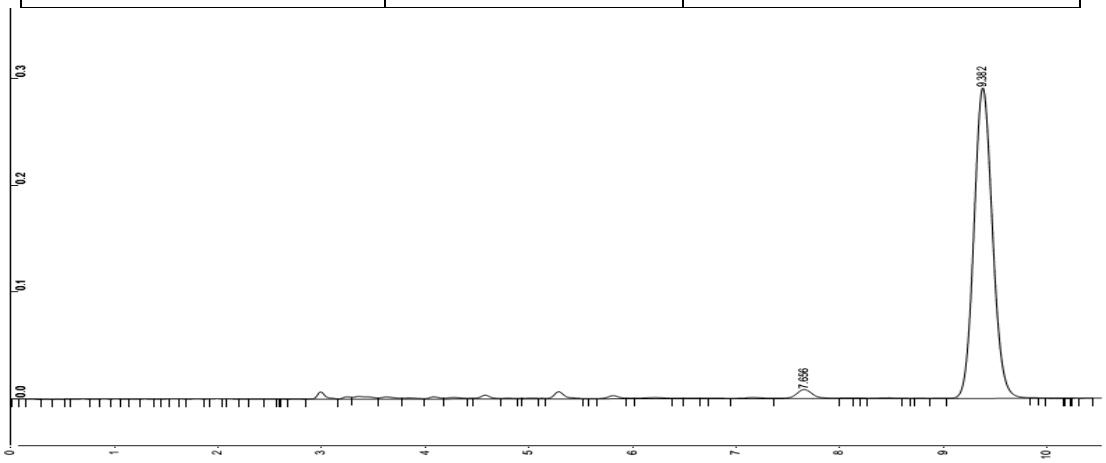

| R.Time | Area | Area% |
|---|---|---|
| **5.661** | **2458936** | **3.4057** |
| **6.364** | **69741693** | **96.5943** |

93% ee



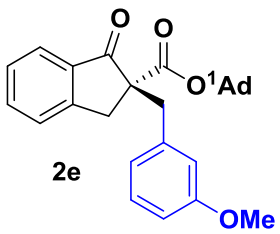



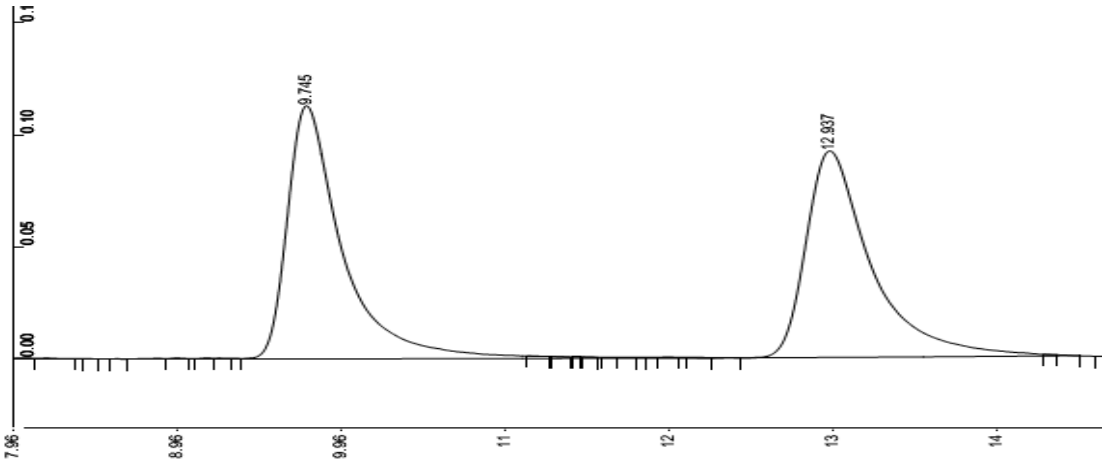

| R.Time | Area | Area% |
|---|---|---|
| **7.590** | **23743540** | **49.9869** |
| **9.336** | **23755956** | **50.0131** |



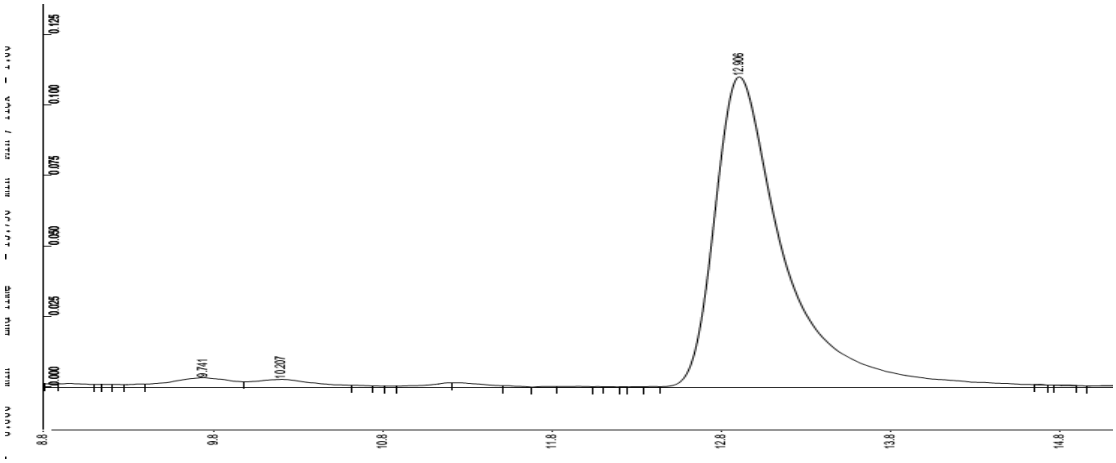

| R.Time | Area | Area% |
|---|---|---|
| **7.656** | **994714** | **2.1223** |
| **9.382** | **46092088** | **97.8777** |

96% ee



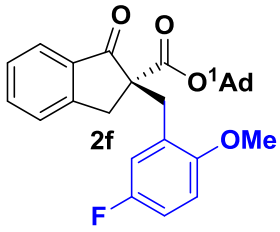



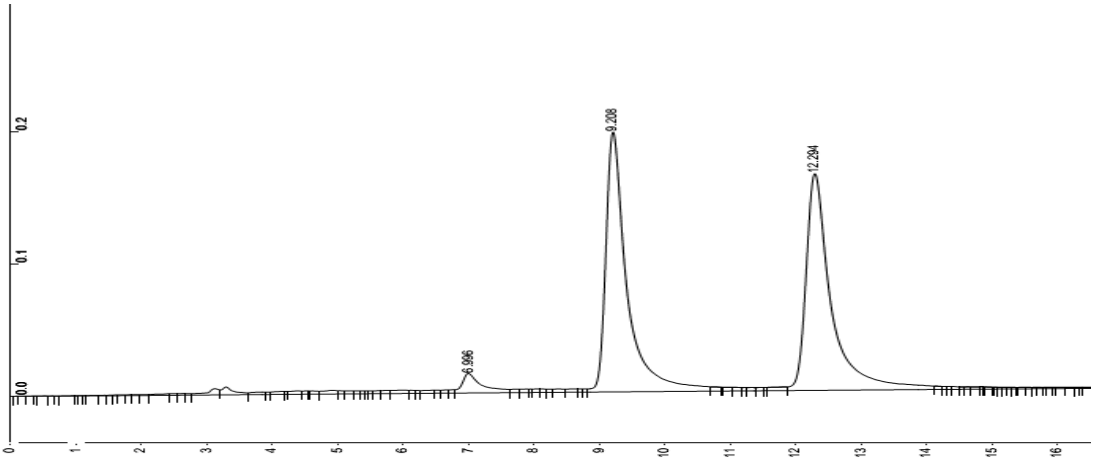

| R.Time | Area | Area% |
|---|---|---|
| **9.745** | **26413488** | **50.0531** |
| **12.937** | **26357445** | **49.9469** |



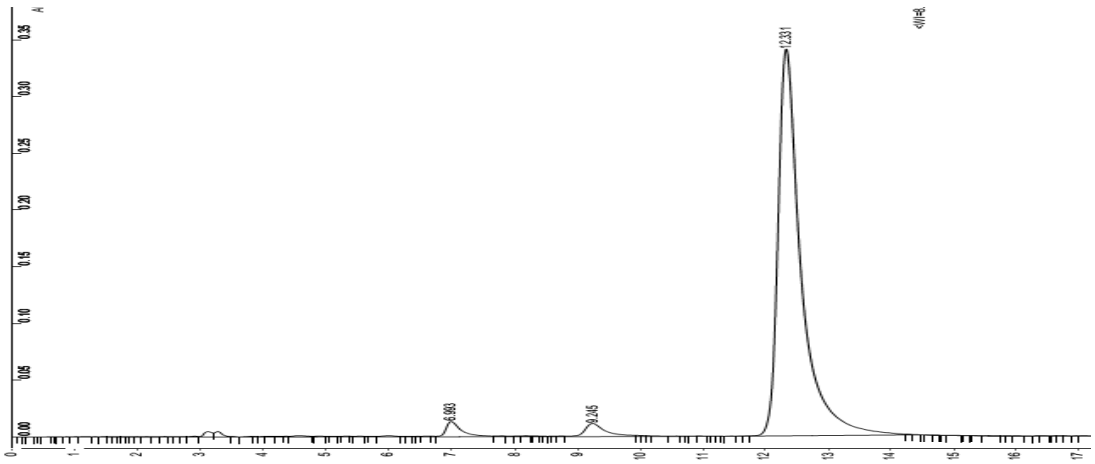

| R.Time | Area | Area% |
|---|---|---|
| **9.741** | **693973** | **2.5355** |
| **12.906** | **26676289** | **97.4645** |

95% ee



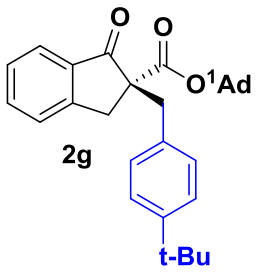



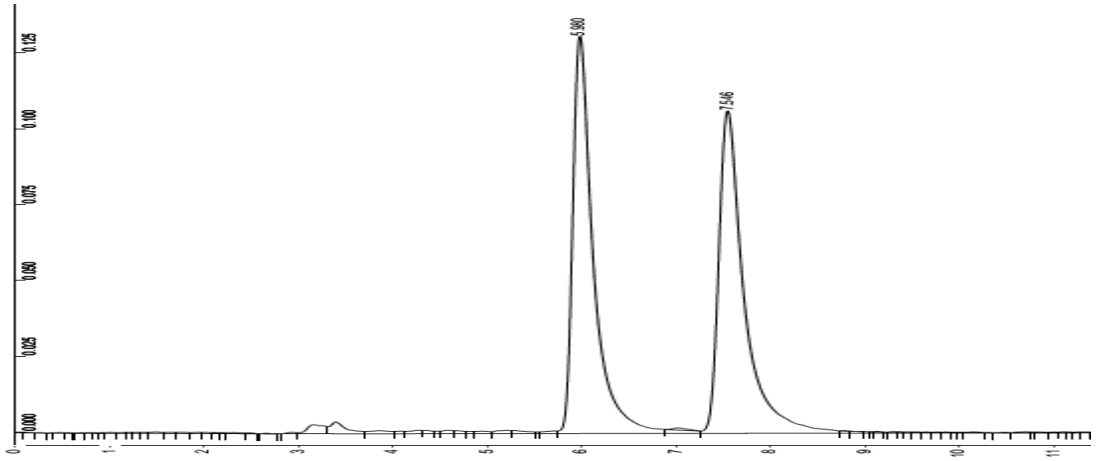

| R.Time | Area | Area% |
|---|---|---|
| **9.208** | **45892396** | **49.8896** |
| **12.294** | **46095505** | **50.1104** |



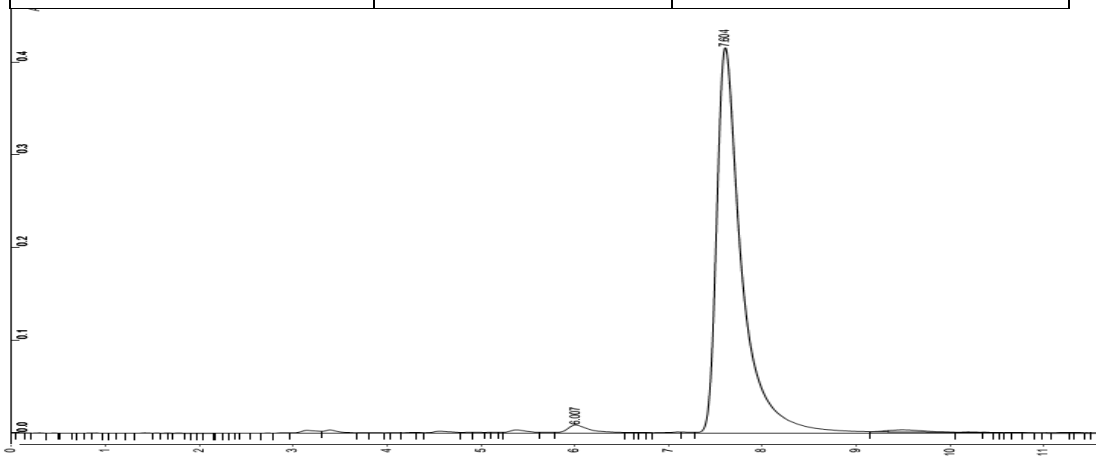

| R.Time | Area | Area% |
|---|---|---|
| **9.245** | **2536022** | **2.5770** |
| **12.331** | **96134969** | **97.4230** |

95% ee



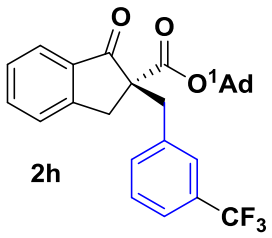



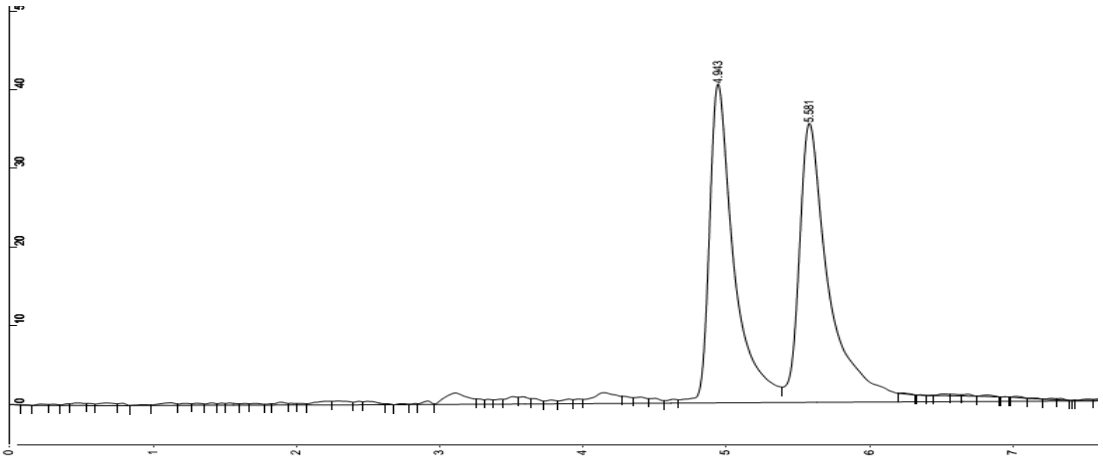

| R.Time | Area | Area% |
|---|---|---|
| **5.980** | **19907940** | **49.7831** |
| **7.546** | **20081378** | **50.2169** |



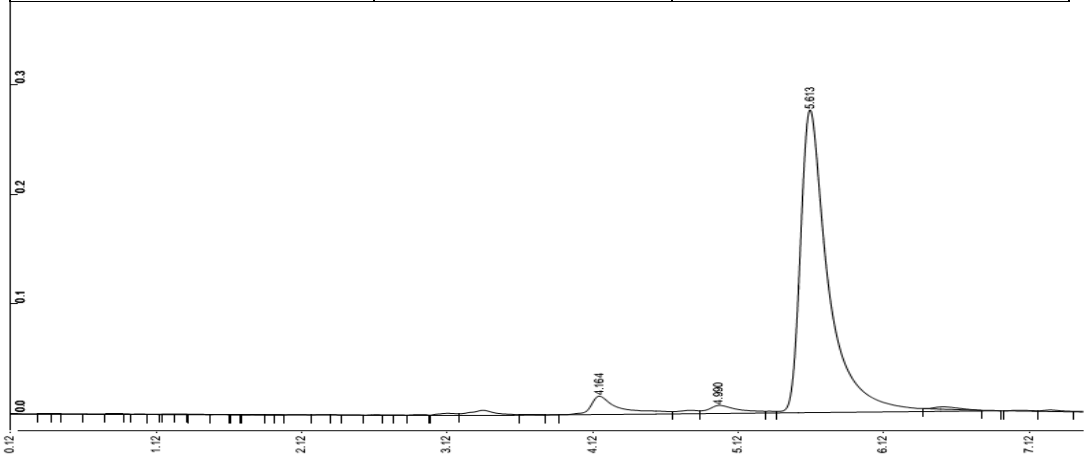

| R.Time | Area | Area% |
|---|---|---|
| **6.007** | **1669556** | **2.0876** |
| **7.604** | **78304792** | **97.9124** |

96% ee



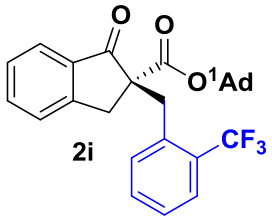




| R.Time | Area | Area% |
|---|---|---|
| **4.943** | **5613326** | **49.4146** |
| **5.582** | **5745671** | **50.5854** |

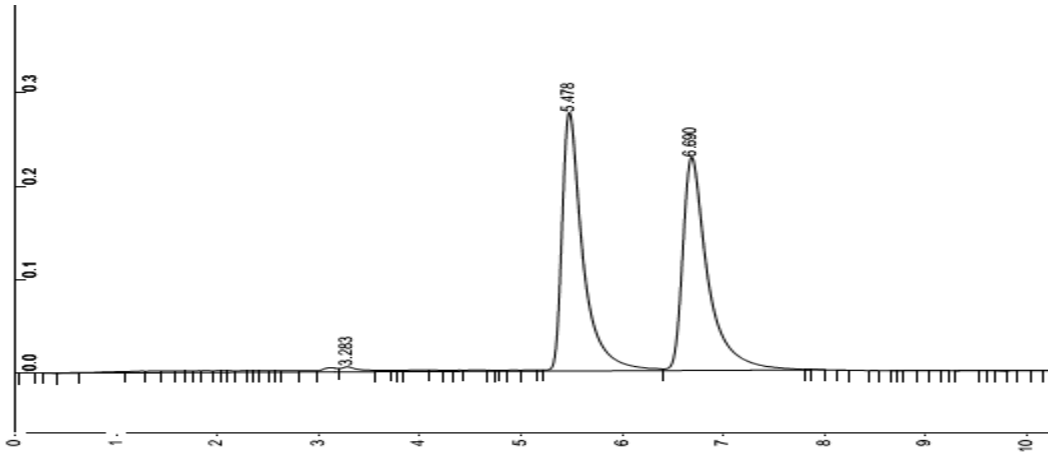



| R.Time | Area | Area% |
|---|---|---|
| **4.990** | **705193** | **1.8685** |
| **5.613** | **37035964** | **98.1315** |

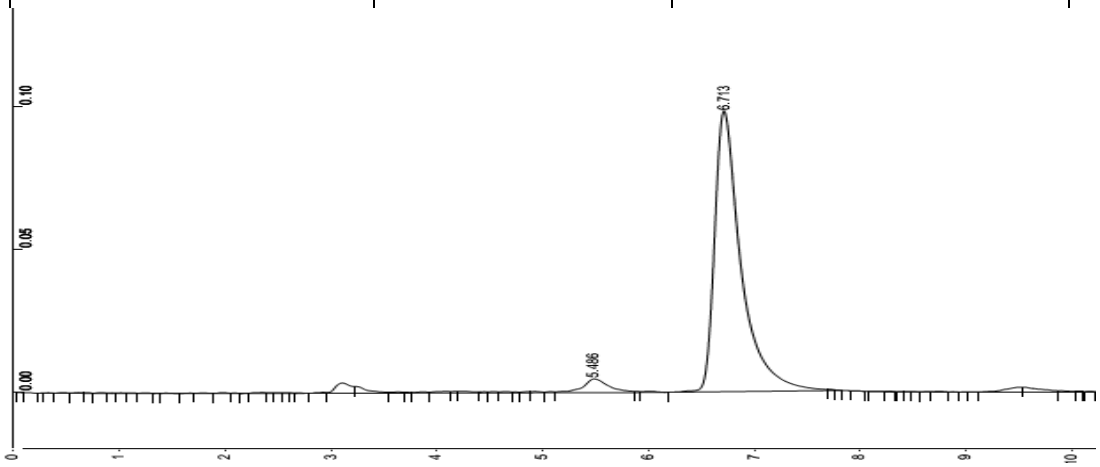
96% ee




2i

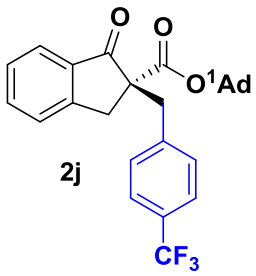



| R.Time | Area | Area% |
|---|---|---|
| **5.478** | **39809744** | **49.7792** |
| **6.690** | **40162903** | **50.2208** |

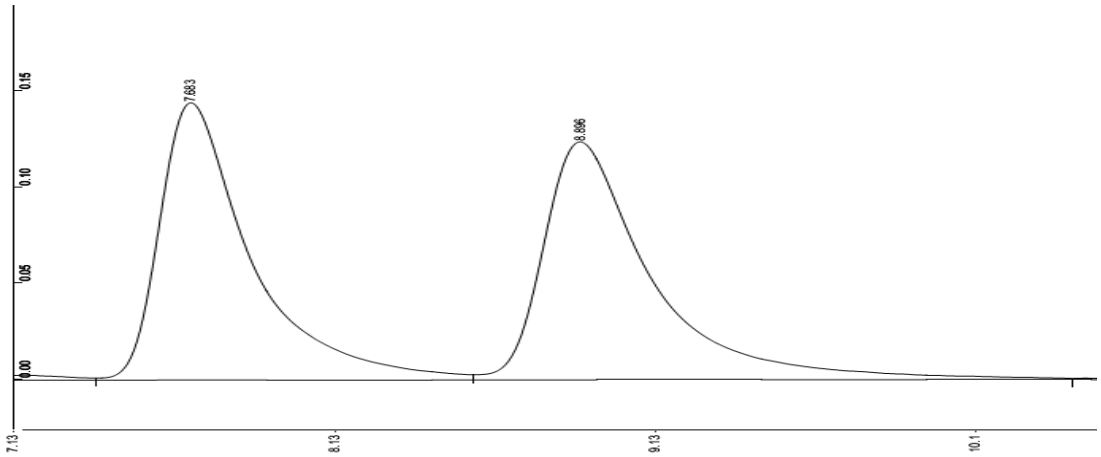



| R.Time | Area | Area% |
|---|---|---|
| **5.486** | **779251** | **4.0009** |
| **6.713** | **18896837** | **95.9991** |

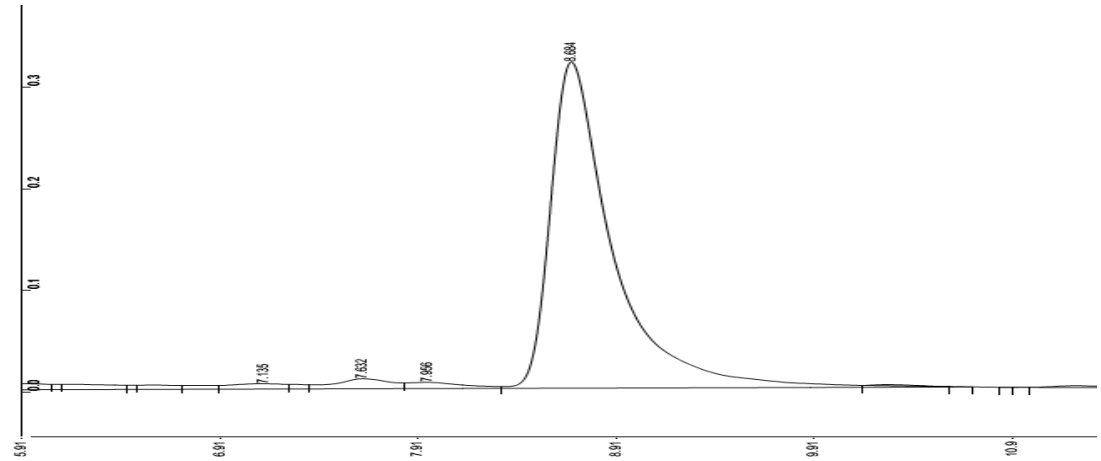
92% ee




2j

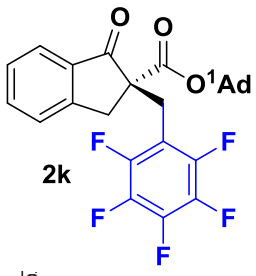



| R.Time | Area | Area% |
|---|---|---|
| **7.683** | **28628800** | **49.7594** |
| **8.896** | **28905655** | **50.2406** |

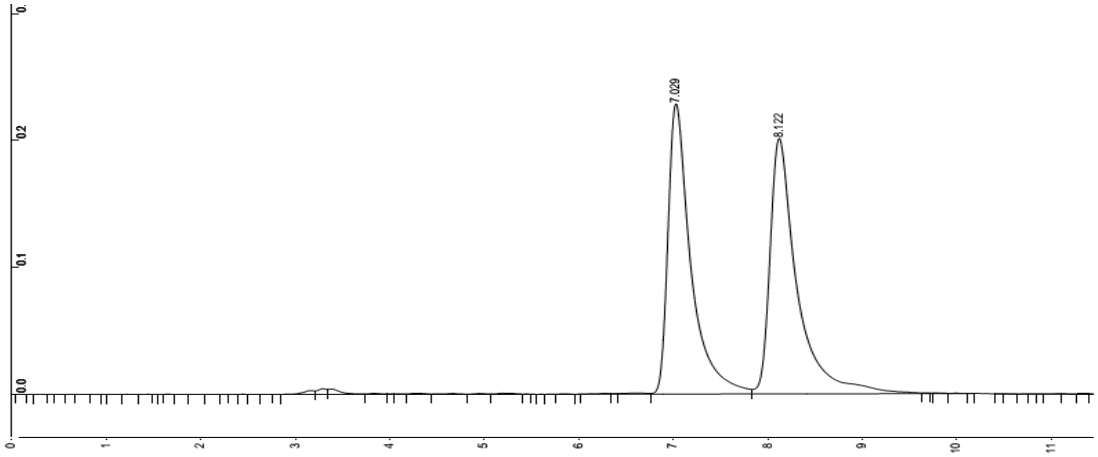



| R.Time | Area | Area% |
|---|---|---|
| **7.632** | **1797814** | **2.4988** |
| **8.684** | **70114752** | **97.5012** |

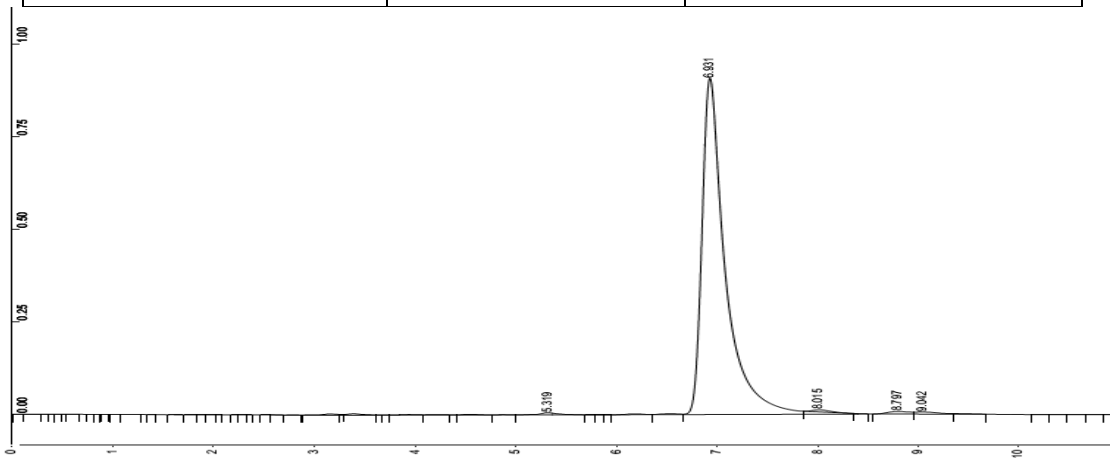
95% ee




2k

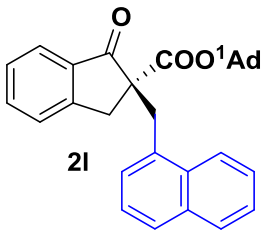



| R.Time | Area | Area% |
|---|---|---|
| **7.029** | **38441140** | **48.9184** |
| **8.122** | **40141076** | **51.0816** |

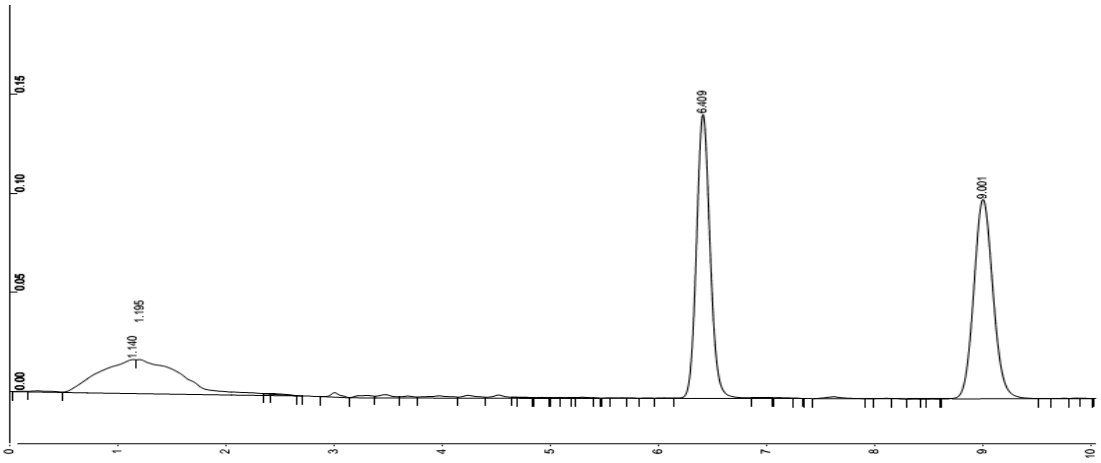



| R.Time | Area | Area% |
|---|---|---|
| **6.931** | **145993456** | **99.0163** |
| **8.122** | **1450405** | **0.9837** |

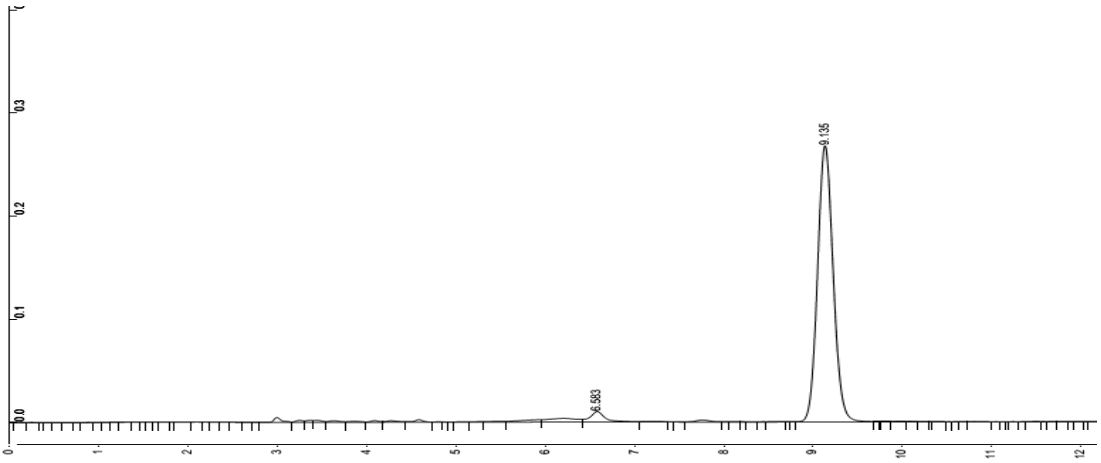
98% ee




2l



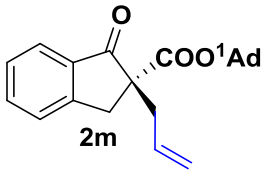

| R.Time | Area | Area% |
|---|---|---|
| **6.409** | **12579544** | **51.0799** |
| **9.001** | **12440818** | **48.9201** |

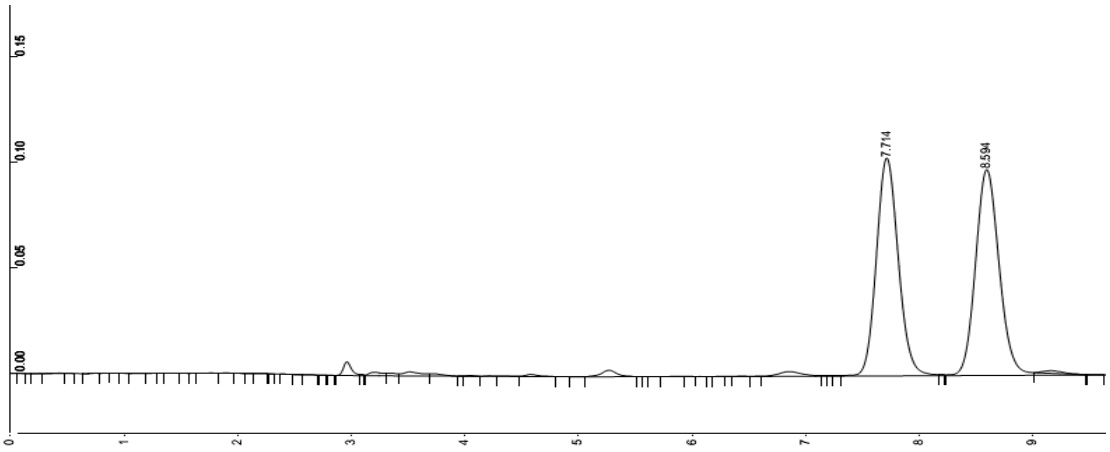



;

| R.Time | Area | Area% |
|---|---|---|
| **6.583** | **1367431** | **3.0894** |
| **9.135** | **42934164** | **96.9106** |

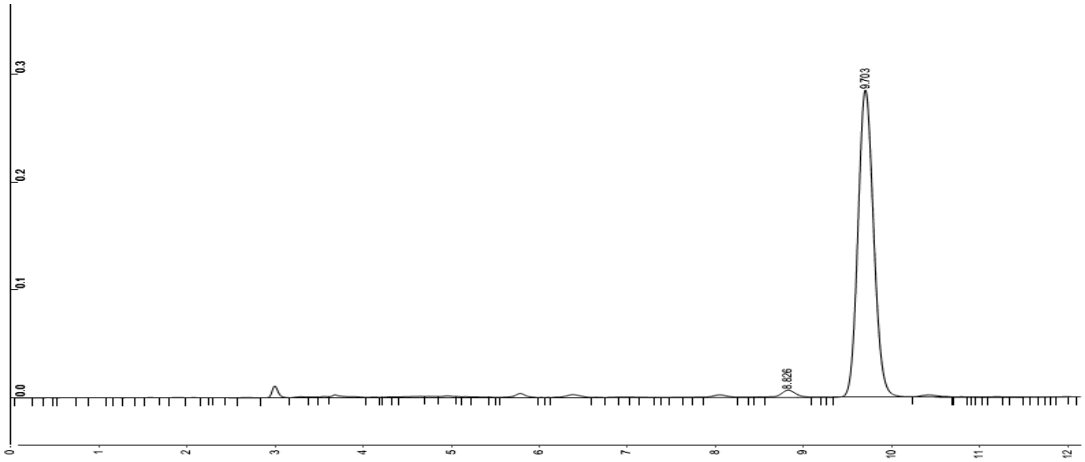
94% ee



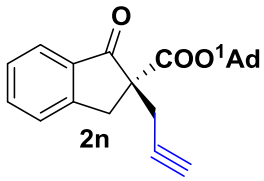

| R.Time | Area | Area% |
|---|---|---|
| **7.714** | **13856219** | **49.3116** |
| **8.594** | **14243090** | **50.6884** |

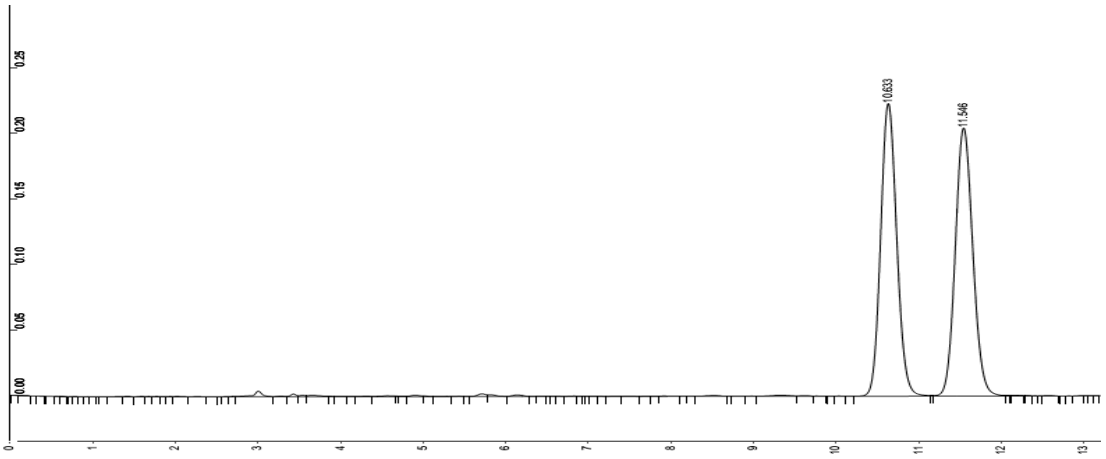
Flow rate: 1.0 mL/min



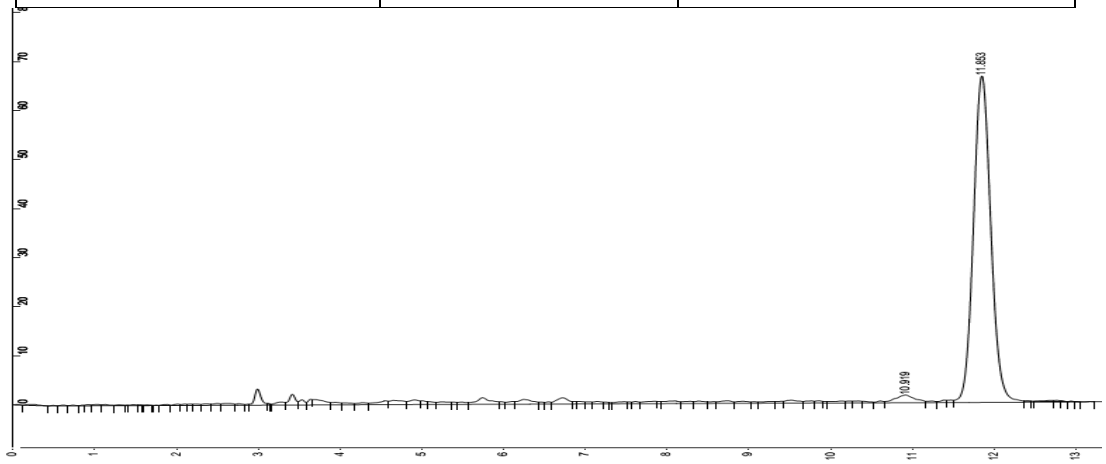

| R.Time | Area | Area% |
|---|---|---|
| **8.826** | **789045** | **1.5152** |
| **9.703** | **5137758** | **98.4848** |

97% ee (Flow rate: 0.9 mL/min)



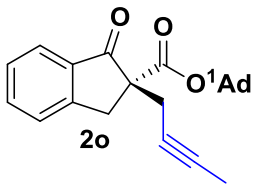




| R.Time | Area | Area% |
|---|---|---|
| **10.633** | **30160874** | **49.8519** |
| **11.546** | **30340132** | **50.1481** |

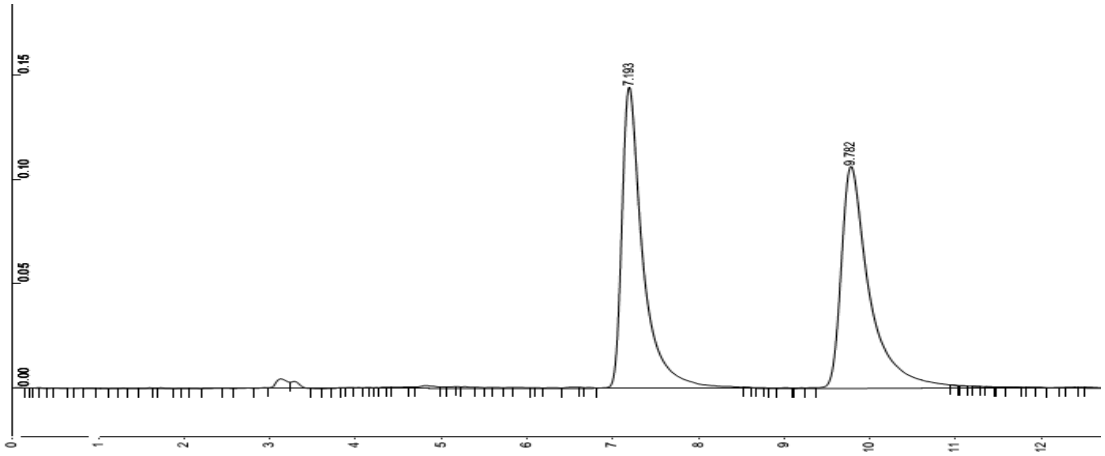



| R.Time | Area | Area% |
|---|---|---|
| **10.919** | **254019** | **1.5126** |
| **11.853** | **16539515** | **98.4874** |

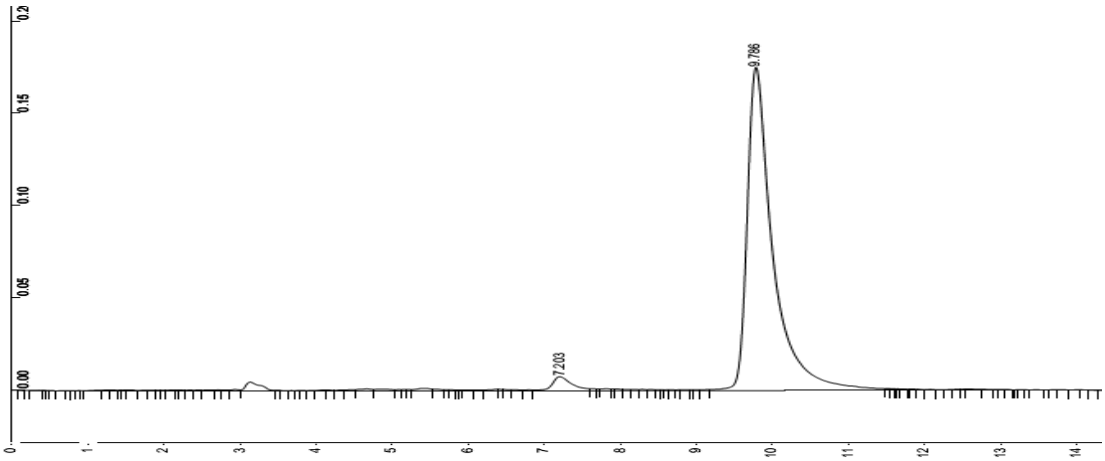
97% ee




2o

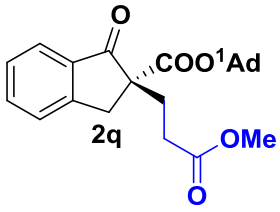


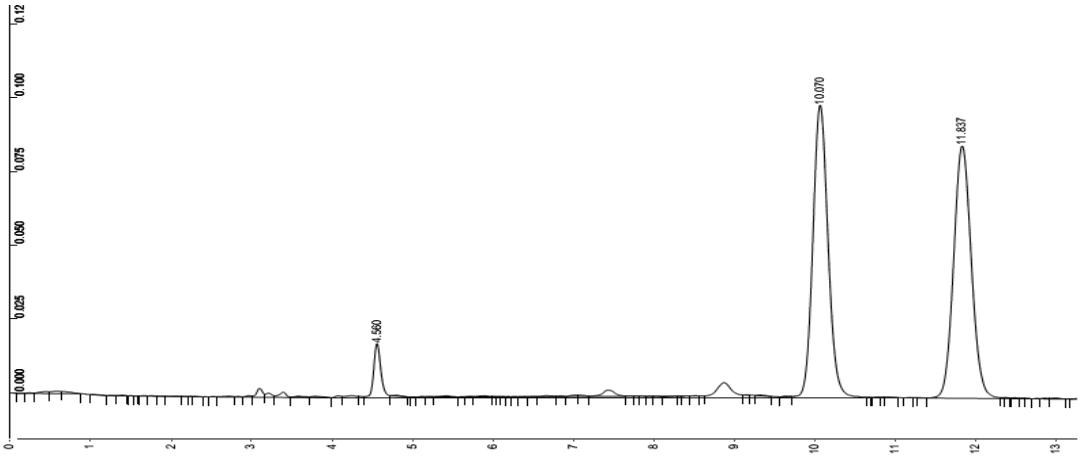

| R.Time | Area | Area% |
|---|---|---|
| **7.193** | **24703928** | **49.8555** |
| **9.782** | **24847122** | **50.1455** |



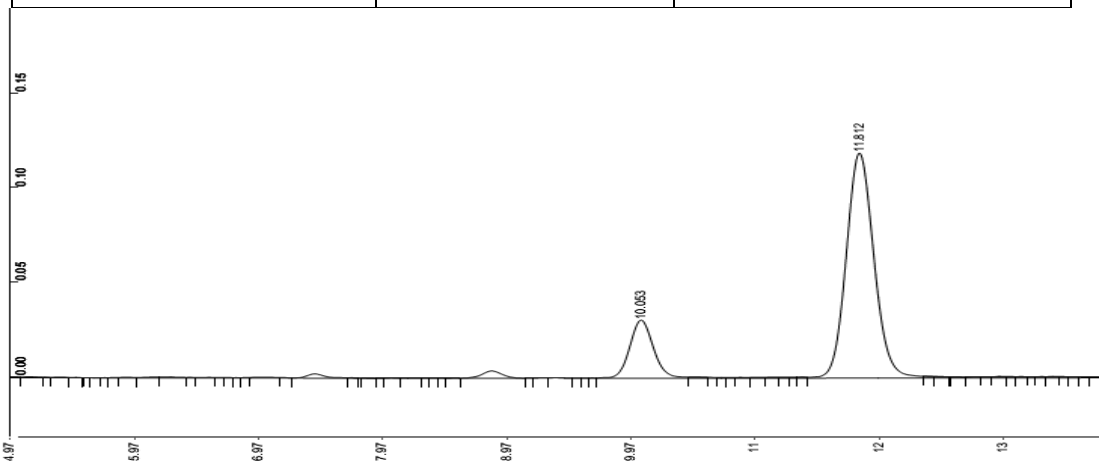

| R.Time | Area | Area% |
|---|---|---|
| **7.203** | **1332219** | **2.5500** |
| **9.786** | **50911663** | **97.4500** |

95% ee



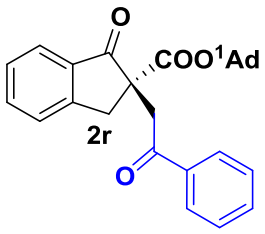



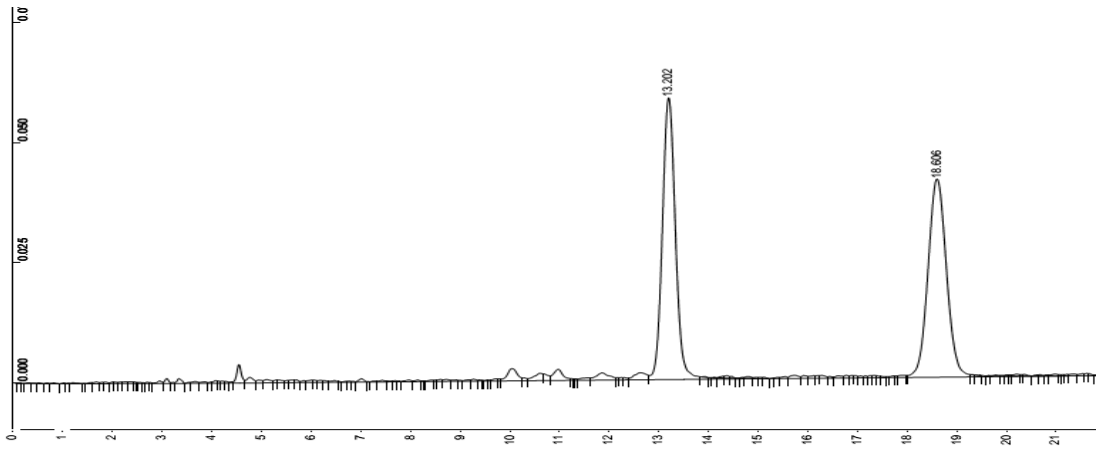

| R.Time | Area | Area% |
|---|---|---|
| **10.070** | **12963944** | **49.2031** |
| **11.837** | **13126453** | **50.7969** |



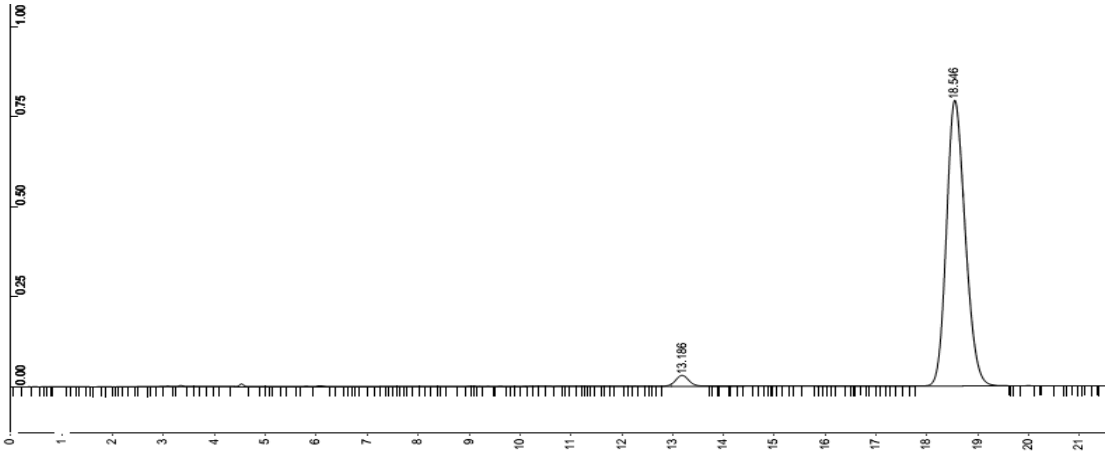

| R.Time | Area | Area% |
|---|---|---|
| **10.053** | **4320303** | **17.4966** |
| **11.812** | **20371940** | **82.5034** |

65% ee



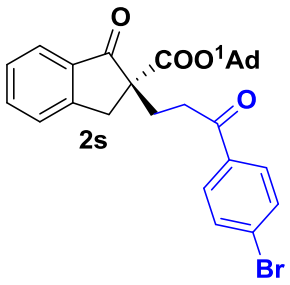



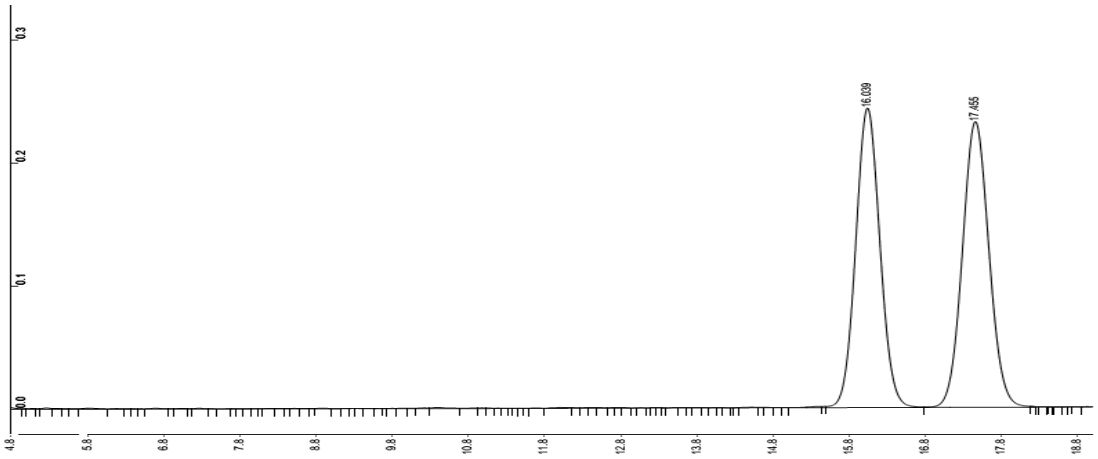

| R.Time | Area | Area% |
|---|---|---|
| **13.202** | **10765787** | **50.0675** |
| **18.606** | **10736776** | **49.9325** |



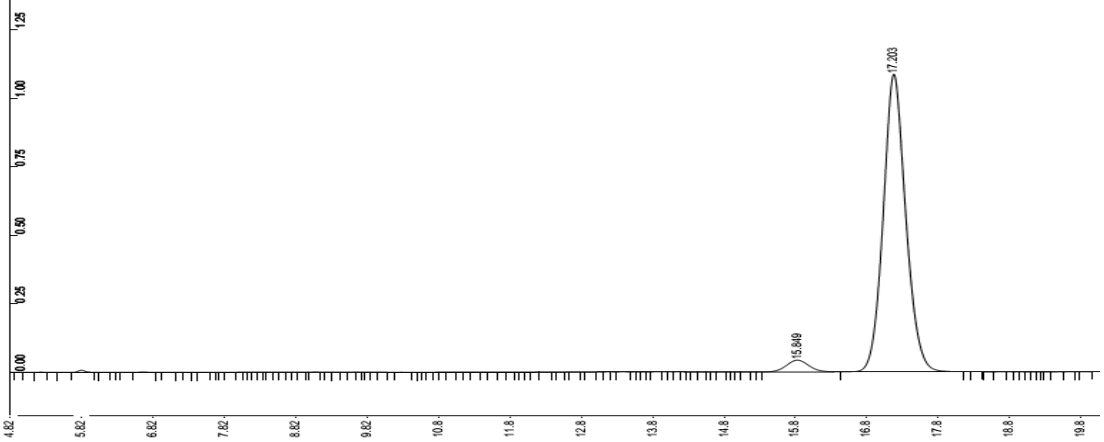

| R.Time | Area | Area% |
|---|---|---|
| **13.186** | **6255667** | **2.0775** |
| **18.546** | **294859471** | **97.9225** |

96% ee



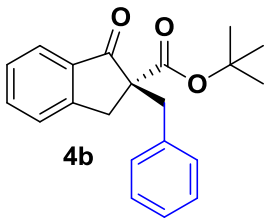




| R.Time | Area | Area% |
|---|---|---|
| **16.039** | **53752908** | **48.8273** |
| **17.455** | **56334876** | **51.1727** |

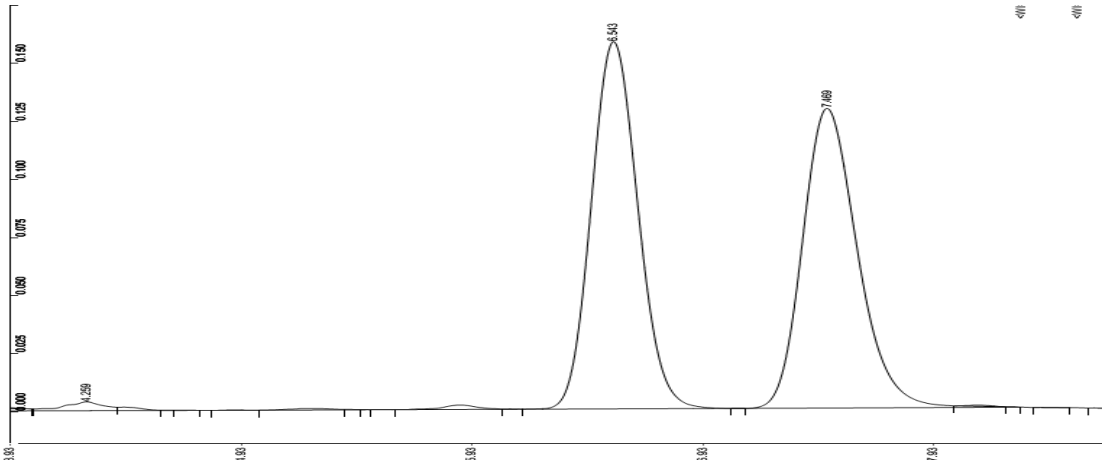



| R.Time | Area | Area% |
|---|---|---|
| **15.849** | **9468890** | **3.0053** |
| **17.455** | **305604148** | **96.9947** |

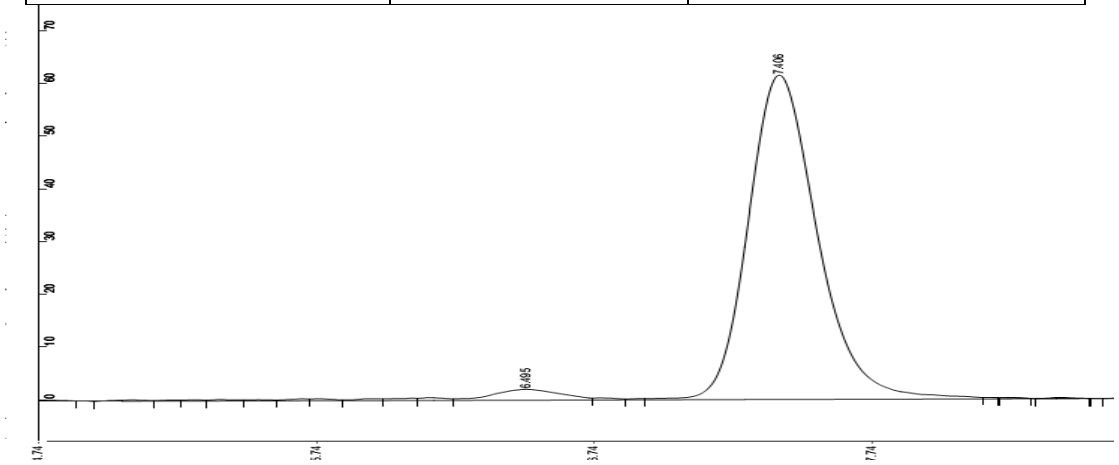
94% ee




**4b**

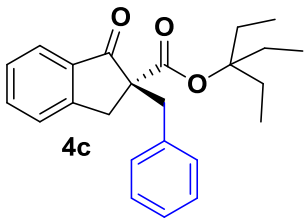



| R.Time | Area | Area% |
|---|---|---|
| **6.543** | **22162344** | **50.7566** |
| **7.469** | **21284016** | **49.2434** |

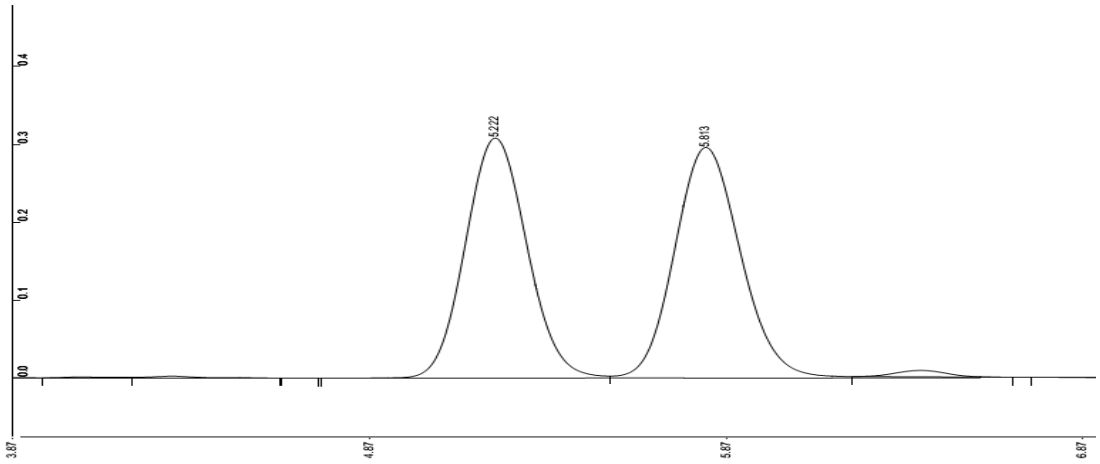



| R.Time | Area | Area% |
|---|---|---|
| **6.495** | **334543** | **3.0132** |
| **7.406** | **10768038** | **96.9868** |

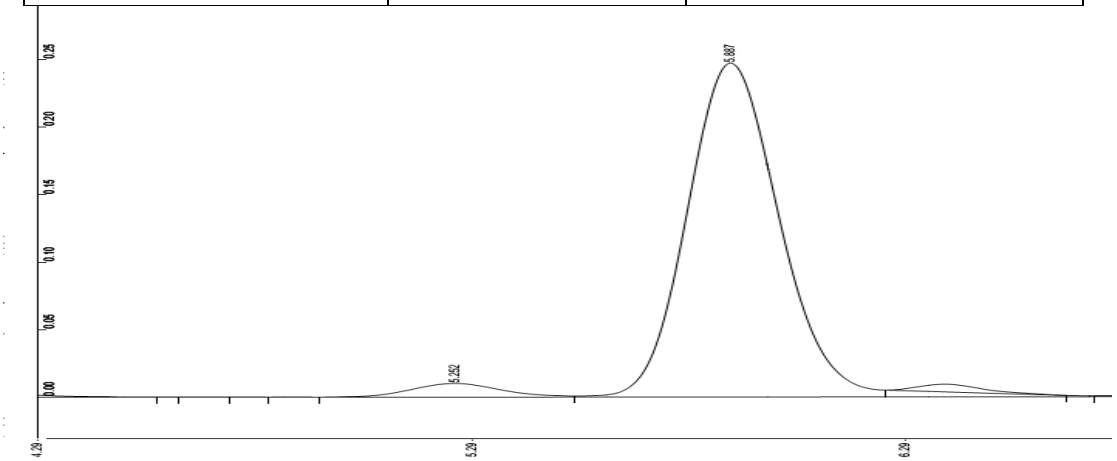
94% ee




**4c**

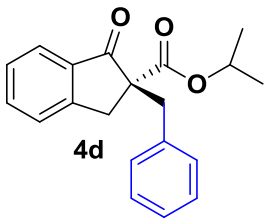


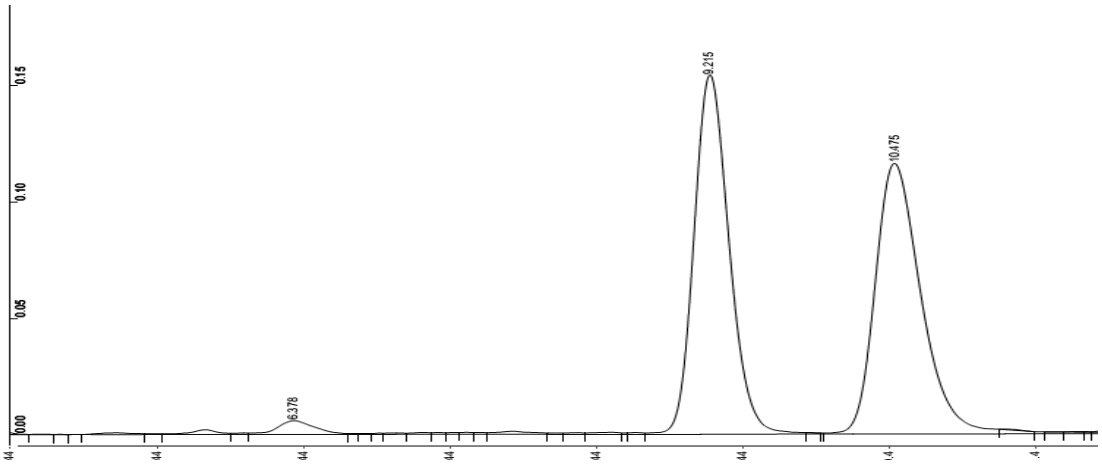

| R.Time | Area | Area% |
|---|---|---|
| **5.222** | **36961892** | **49.5267** |
| **5.813** | **38335240** | **50.4733** |



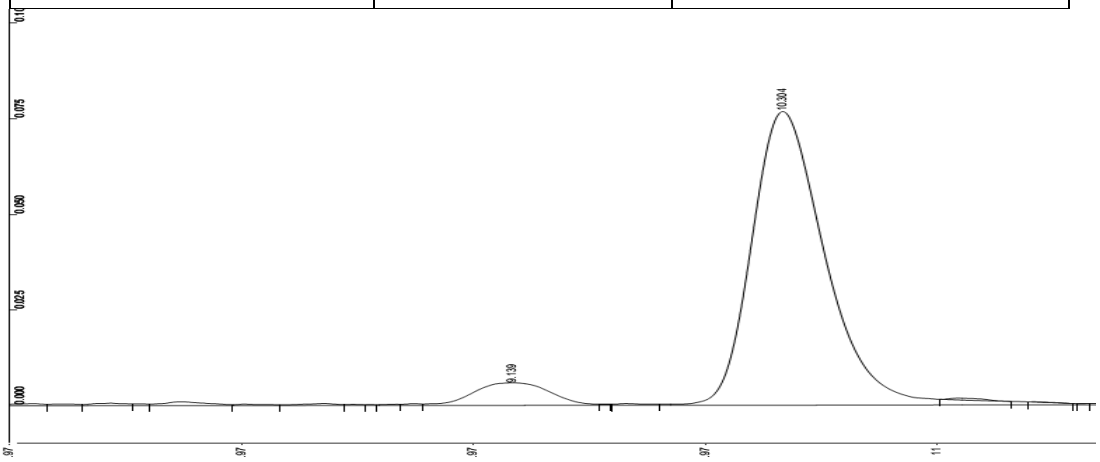

| R.Time | Area | Area% |
|---|---|---|
| **5.252** | **1430999** | **3.4209** |
| **5.887** | **40400069** | **96.5791** |

93% ee



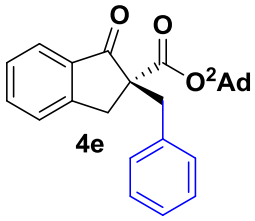



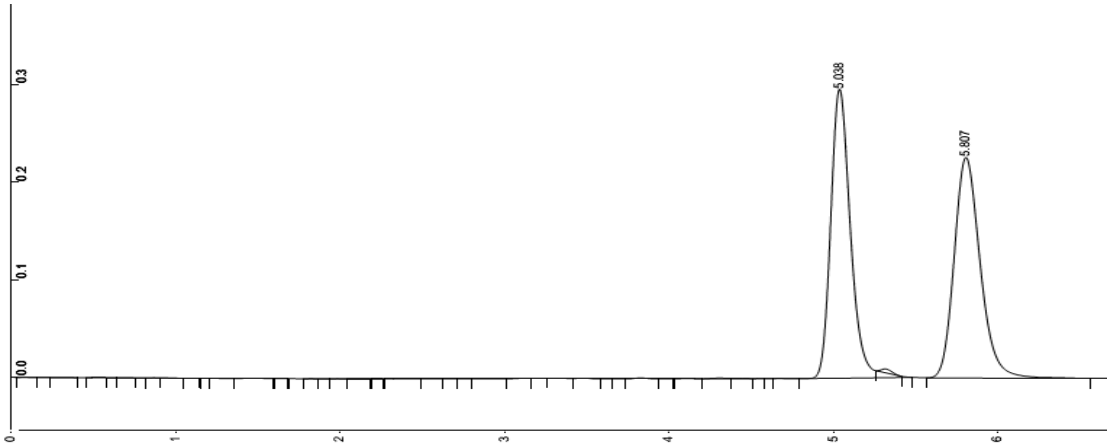

| R.Time | Area | Area% |
|---|---|---|
| **9.215** | **25669780** | **49.8746** |
| **10.475** | **25783716** | **50.1254** |



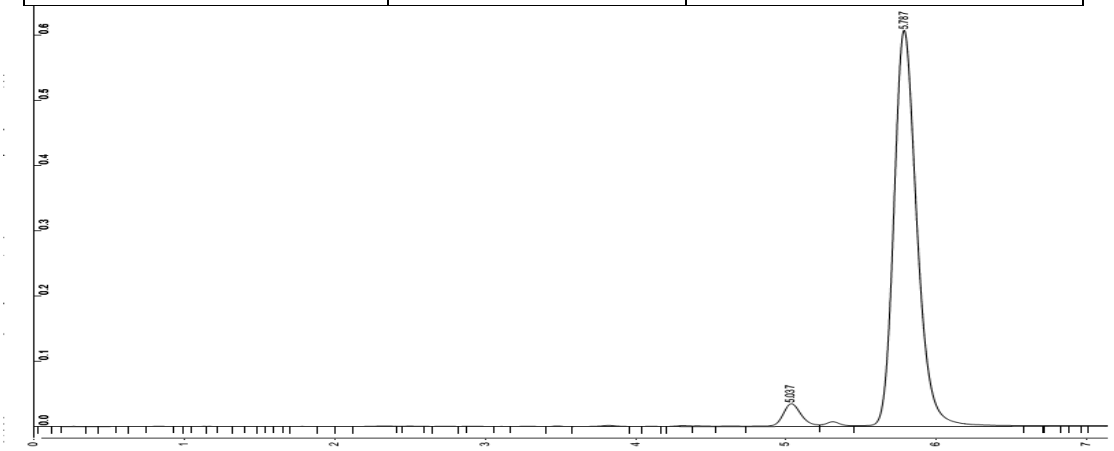

| R.Time | Area | Area% |
|---|---|---|
| **9.139** | **1006747** | **6.3715** |
| **10.304** | **14794038** | **93.6285** |

87% ee



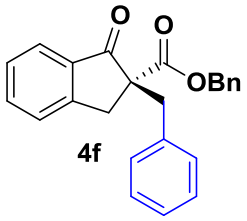




| R.Time | Area | Area% |
|---|---|---|
| **5.038** | **24808116** | **49.9163** |
| **5.807** | **24891310** | **50.0837** |

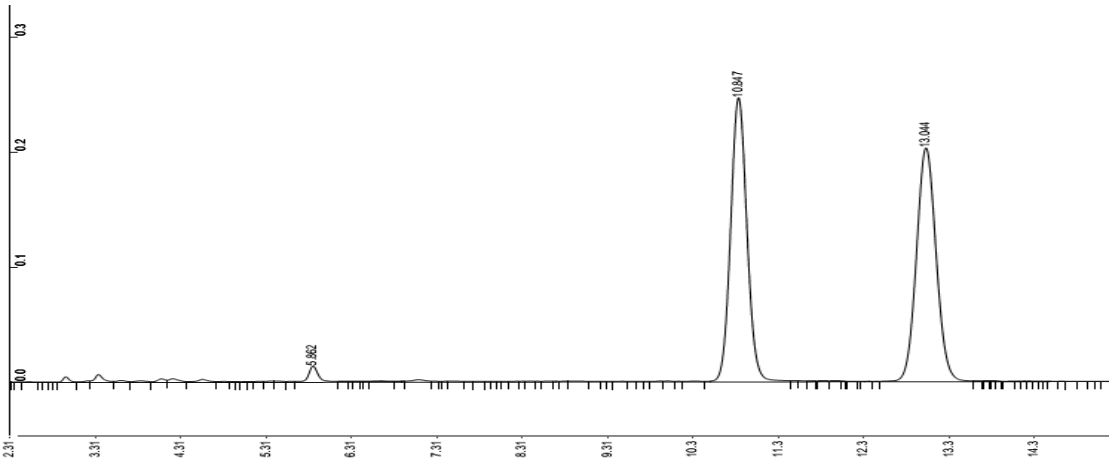



| R.Time | Area | Area% |
|---|---|---|
| **5.037** | **2913720** | **3.9148** |
| **5.787** | **71514603** | **96.0852** |

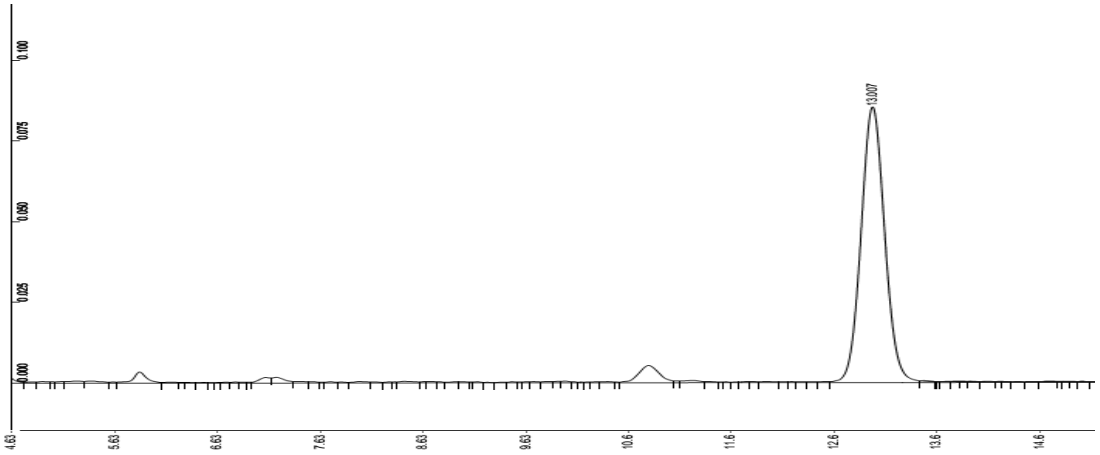
92% ee




4f

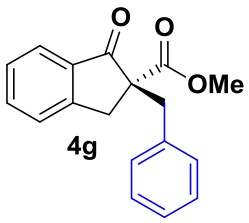



| R.Time | Area | Area% |
|---|---|---|
| **10.847** | **33161938** | **50.1096** |
| **13.044** | **32875396** | **49.8904** |

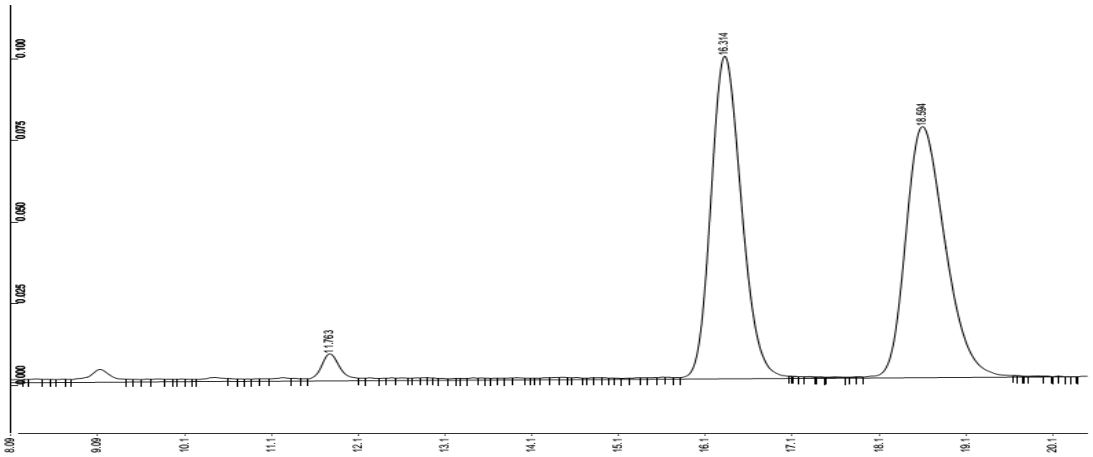



| R.Time | Area | Area% |
|---|---|---|
| **10.825** | **1830741** | **4.0378** |
| **13.007** | **43509320** | **95.9622** |

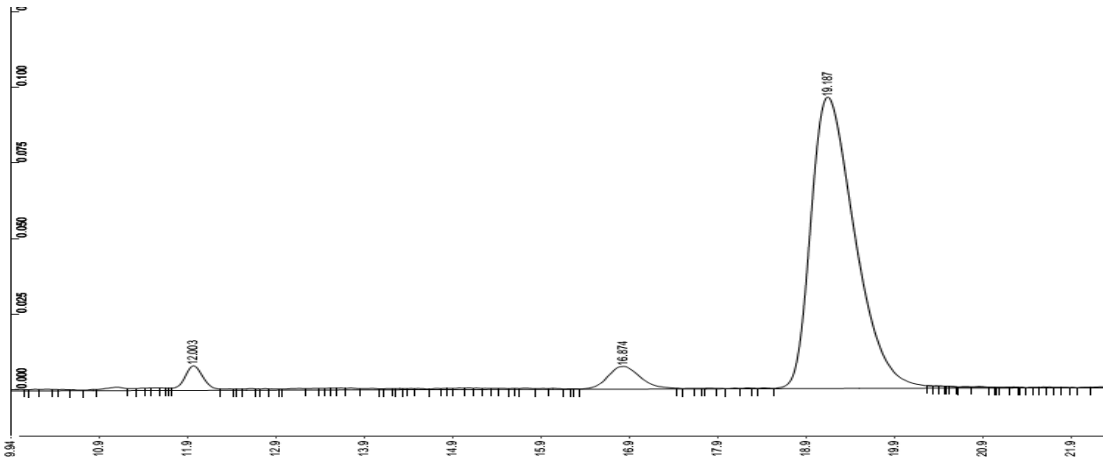
92% ee




4g

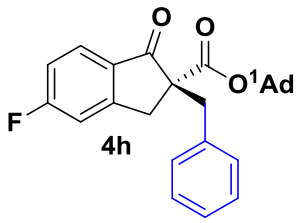


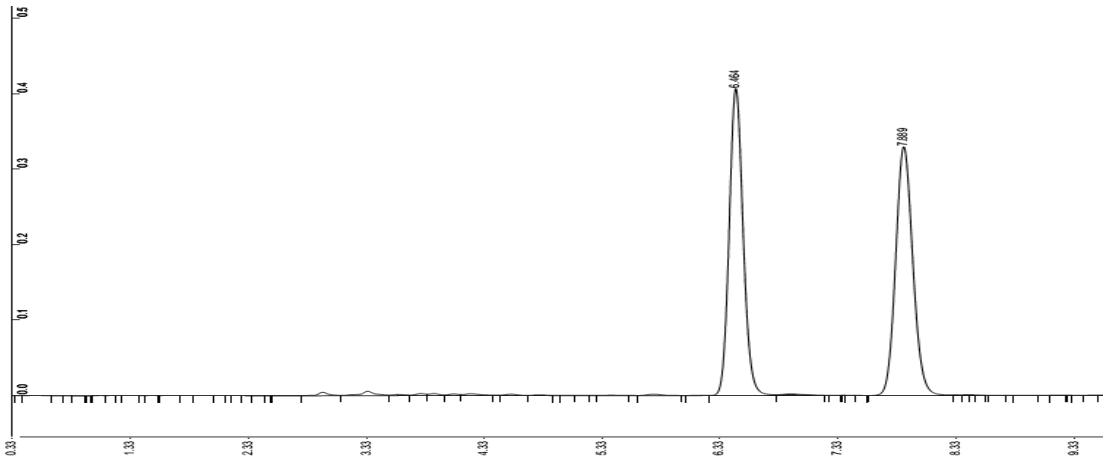

| R.Time | Area | Area% |
|---|---|---|
| **16.314** | **24339678** | **50.2061** |
| **18.594** | **24311070** | **49.7939** |



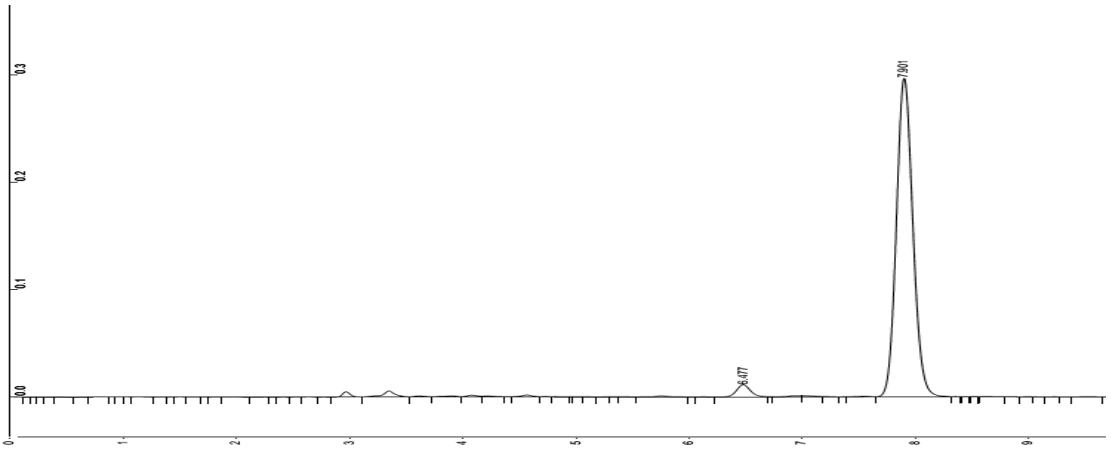

| R.Time | Area | Area% |
|---|---|---|
| **16.874** | **1927662** | **4.5142** |
| **19.187** | **36315056** | **95.4858** |

91% ee



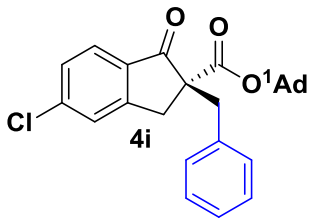



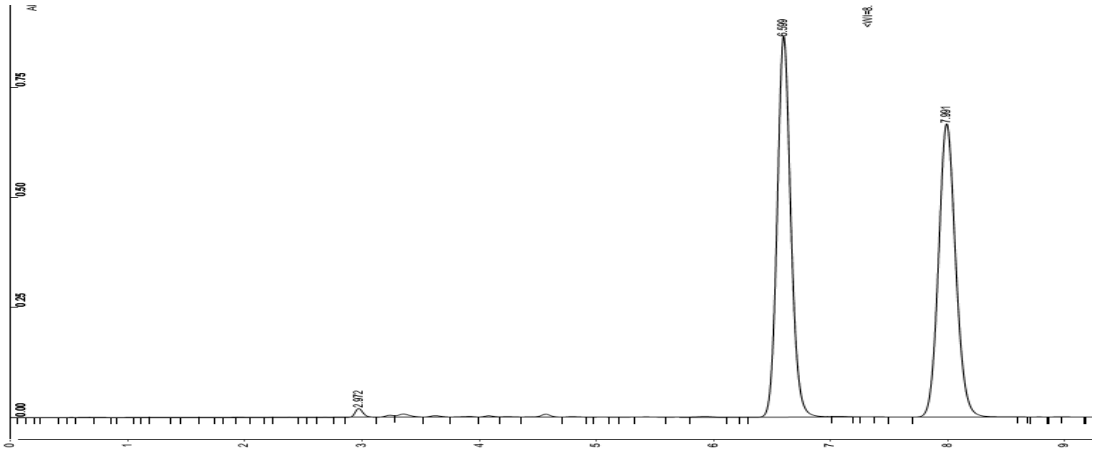

| R.Time | Area | Area% |
|---|---|---|
| **6.464** | **33638120** | **50.1127** |
| **7.889** | **33486836** | **49.8873** |



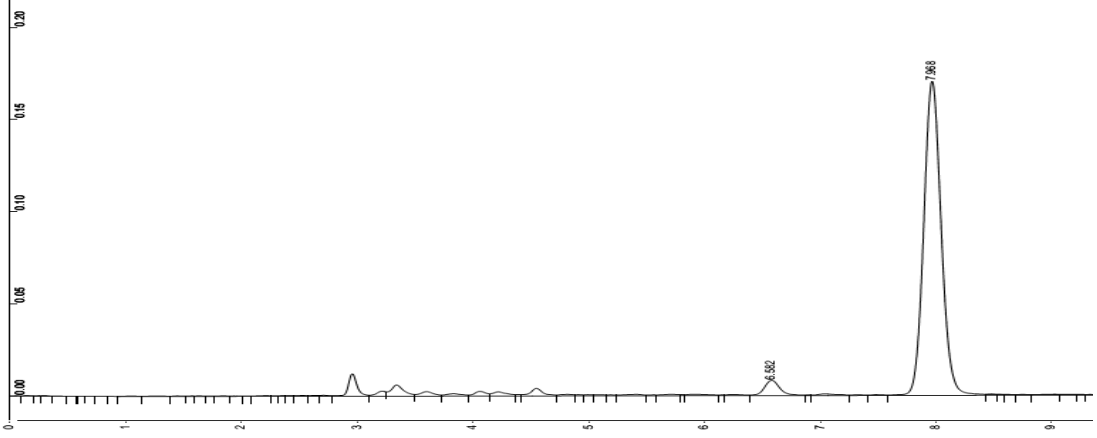

| R.Time | Area | Area% |
|---|---|---|
| **6.477** | **1035653** | **3.0056** |
| **7.901** | **33421793** | **96.9944** |

94% ee



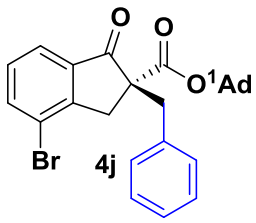



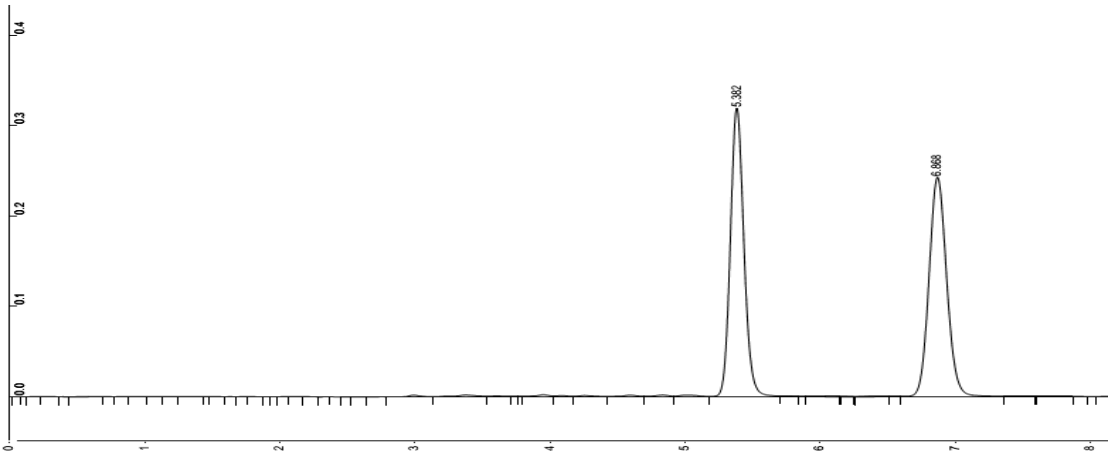

| R.Time | Area | Area% |
|---|---|---|
| **6.599** | **70025480** | **51.0180** |
| **7.991** | **67892240** | **48.9820** |



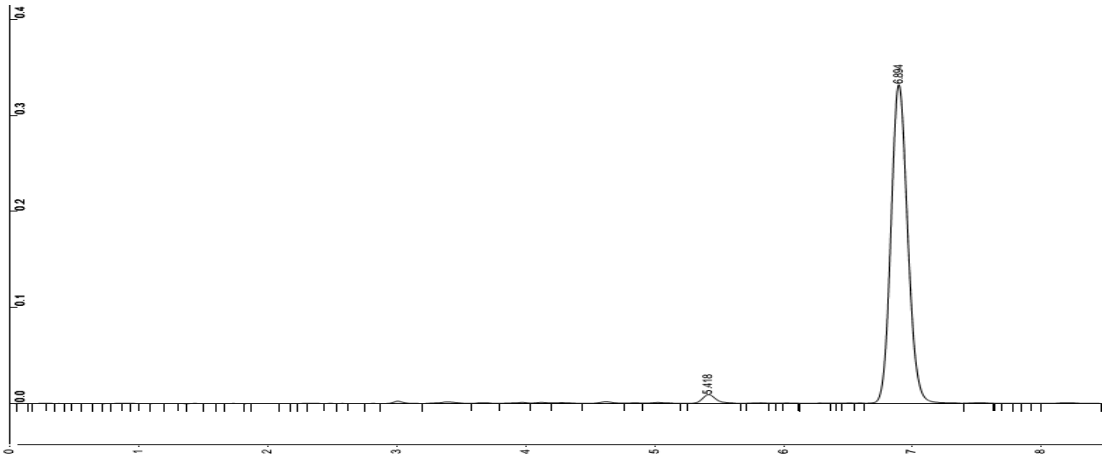

| R.Time | Area | Area% |
|---|---|---|
| **6.582** | **768684** | **3.5524** |
| **7.968** | **20867477** | **96.4476** |

93% ee



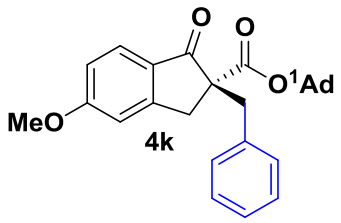



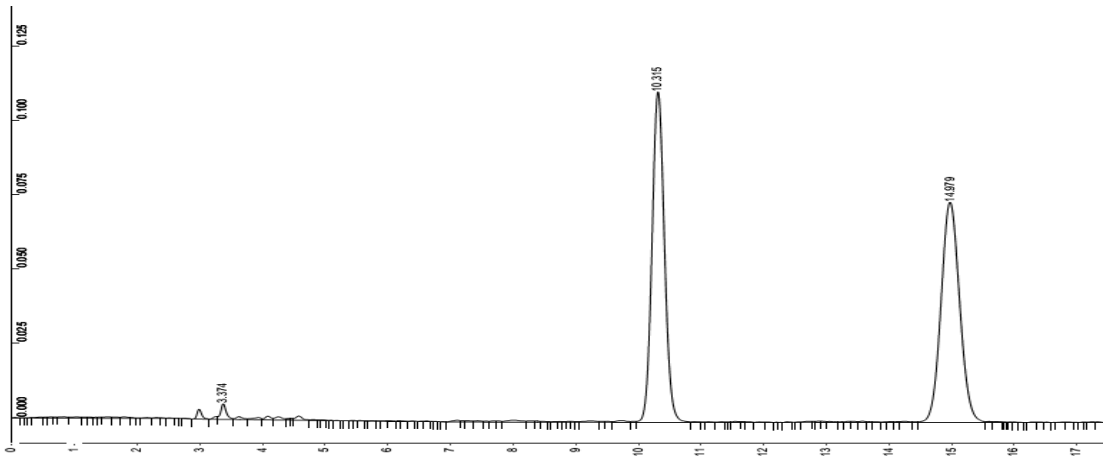

| R.Time | Area | Area% |
|---|---|---|
| **5.382** | **22611284** | **50.1100** |
| **6.868** | **22512020** | **49.8900** |



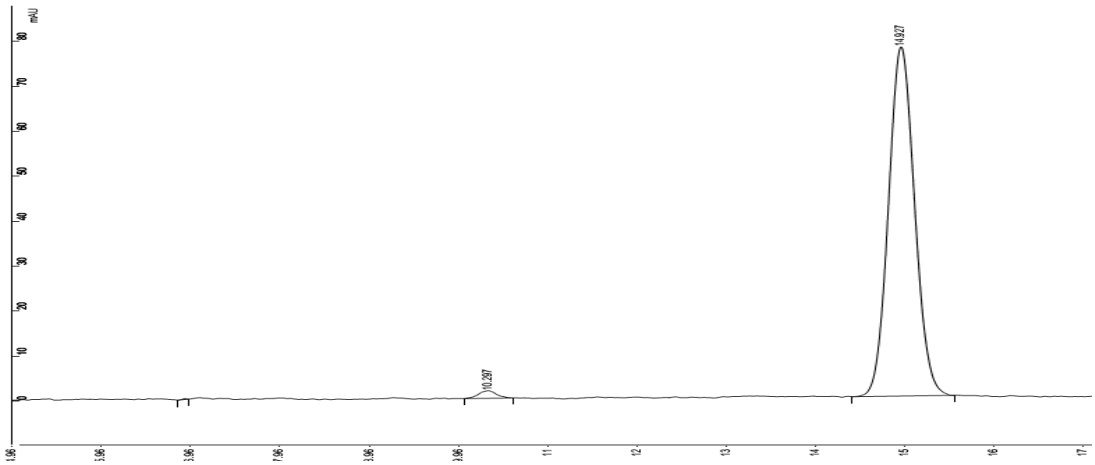

| R.Time | Area | Area% |
|---|---|---|
| **5.418** | **871272** | **2.2138** |
| **6.894** | **38485129** | **97.7862** |

96% ee



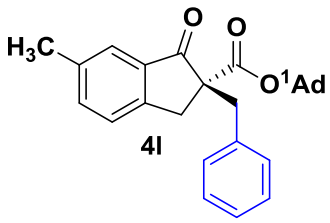




| R.Time | Area | Area% |
|---|---|---|
| **10.315** | **15267869** | **50.0486** |
| **14.979** | **15251754** | **49.9514** |

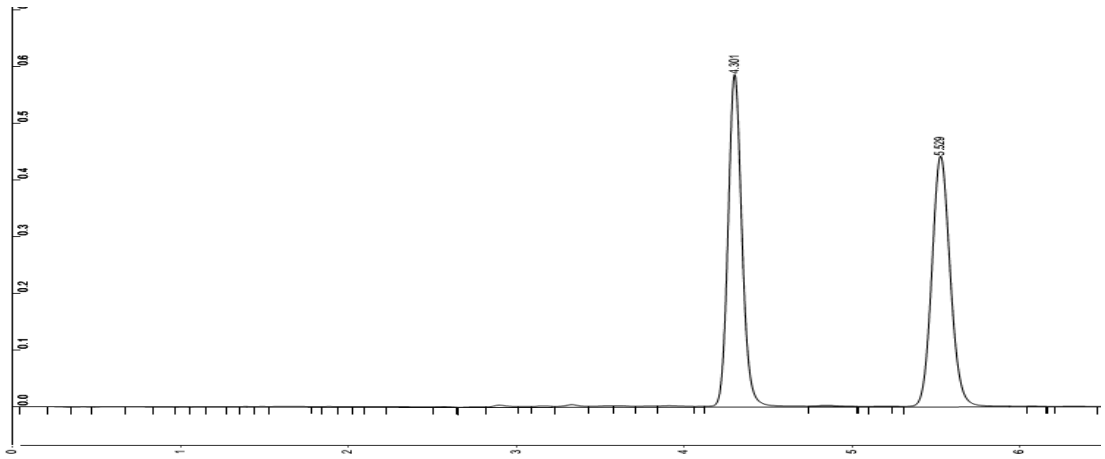



| R.Time | Area | Area% |
|---|---|---|
| **10.297** | **234707** | **1.0808** |
| **14.927** | **21481337** | **98.9192** |

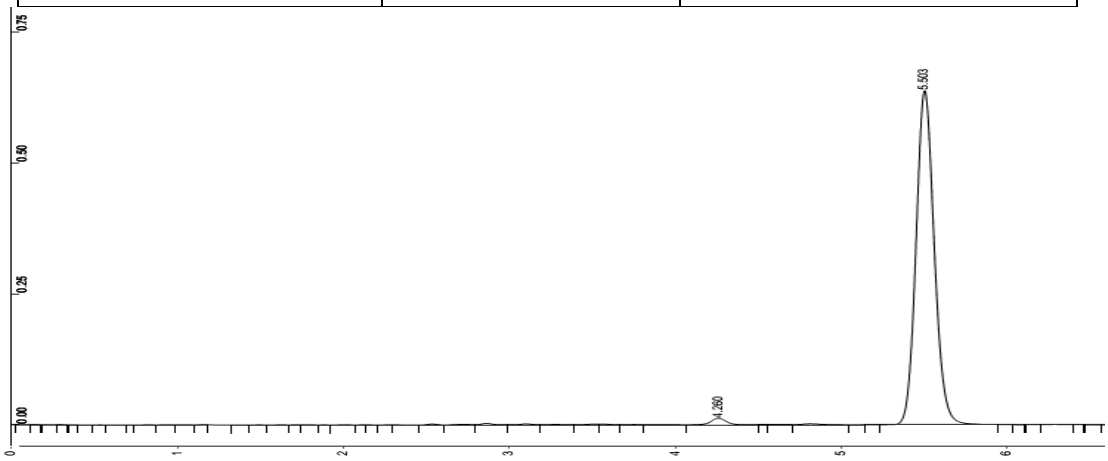
98% ee




4l

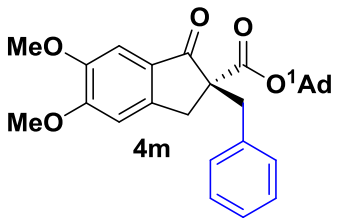


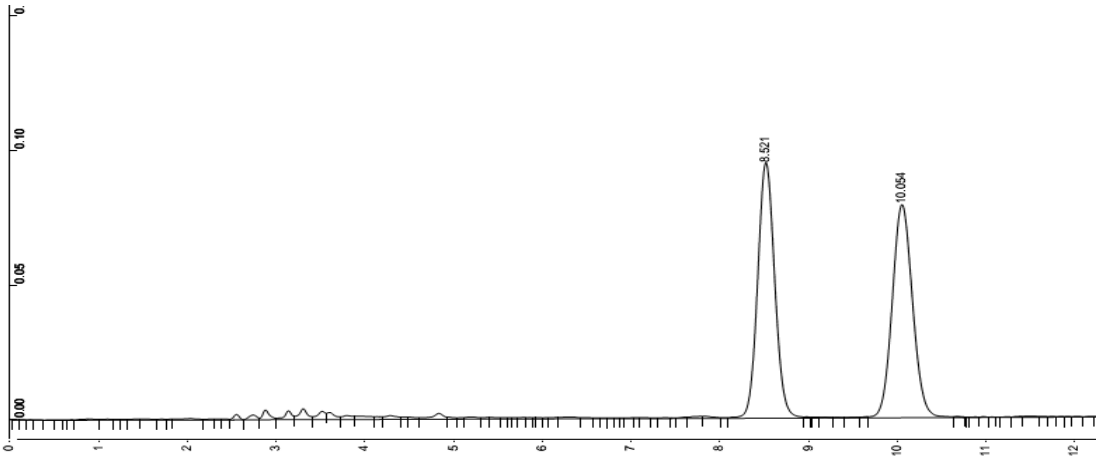

| R.Time | Area | Area% |
|---|---|---|
| **4.301** | **34357620** | **50.0557** |
| **5.529** | **34281132** | **49.9443** |



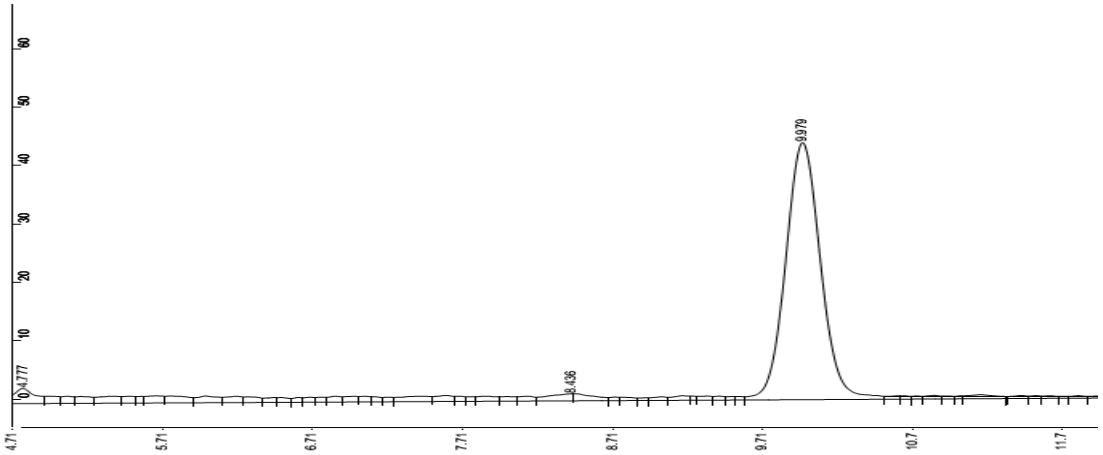

| R.Time | Area | Area% |
|---|---|---|
| **4.260** | **880141** | **1.4931** |
| **5.503** | **58067083** | **98.5069** |

97% ee



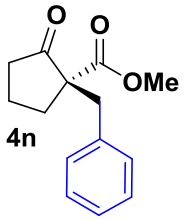



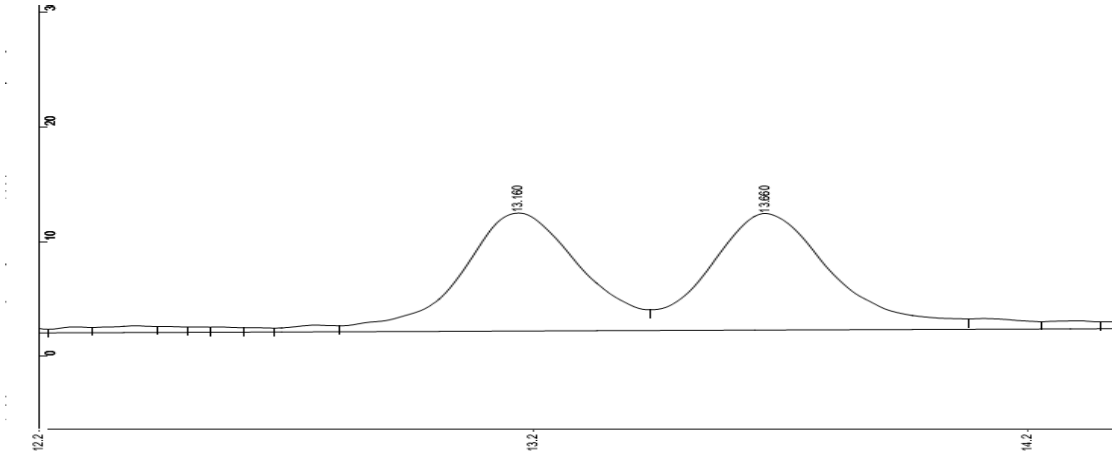

| R.Time | Area | Area% |
|---|---|---|
| **8.521** | **12759539** | **49.6858** |
| **10.054** | **12850461** | **50.3142** |



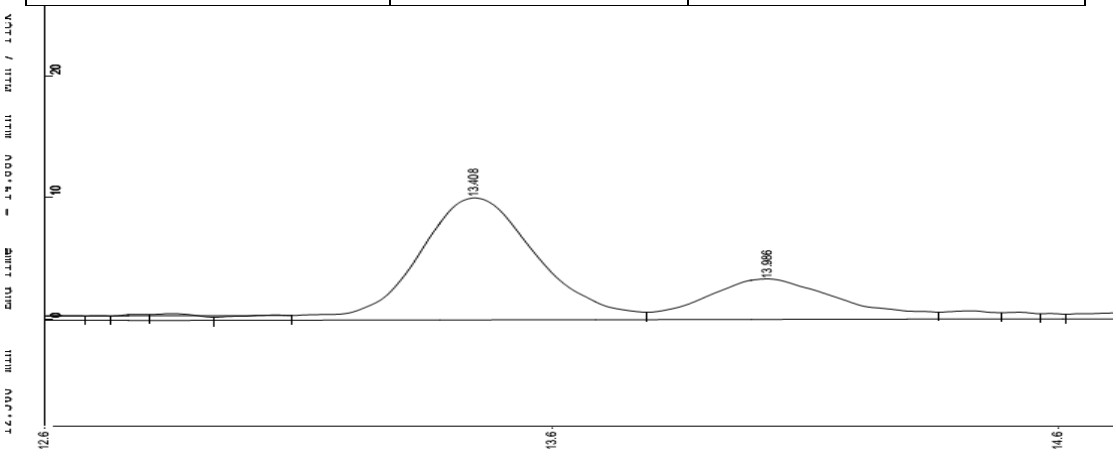

| R.Time | Area | Area% |
|---|---|---|
| **8.436** | **141327** | **1.0382** |
| **9.979** | **13471368** | **98.9618** |

98% ee



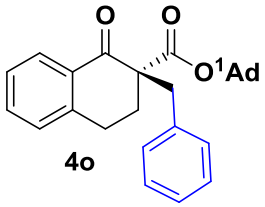




| R.Time | Area | Area% |
|---|---|---|
| **13.160** | **1730132** | **49.7700** |
| **13.660** | **1746123** | **50.2300** |

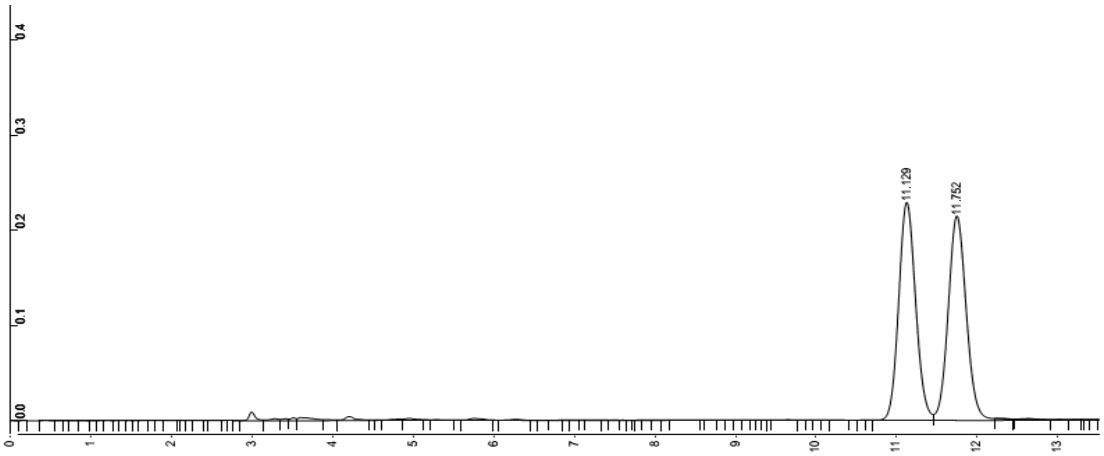



| R.Time | Area | Area% |
|---|---|---|
| **13.408** | **1730132** | **77.0134** |
| **13.986** | **516402** | **22.9866** |

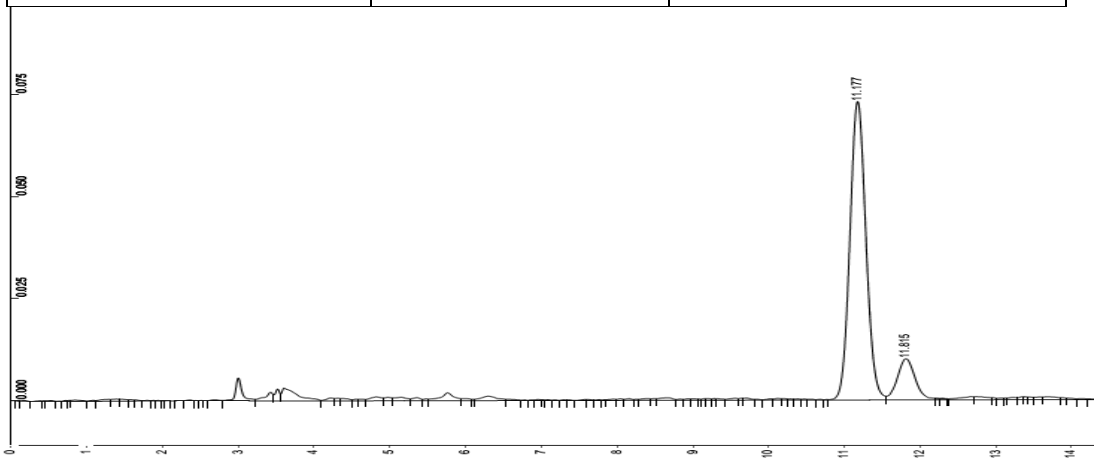
54% ee




4o

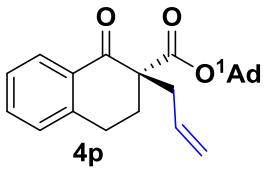



| R.Time | Area | Area% |
|---|---|---|
| **11.129** | **33440278** | **49.5442** |
| **11.752** | **34055628** | **50.4558** |

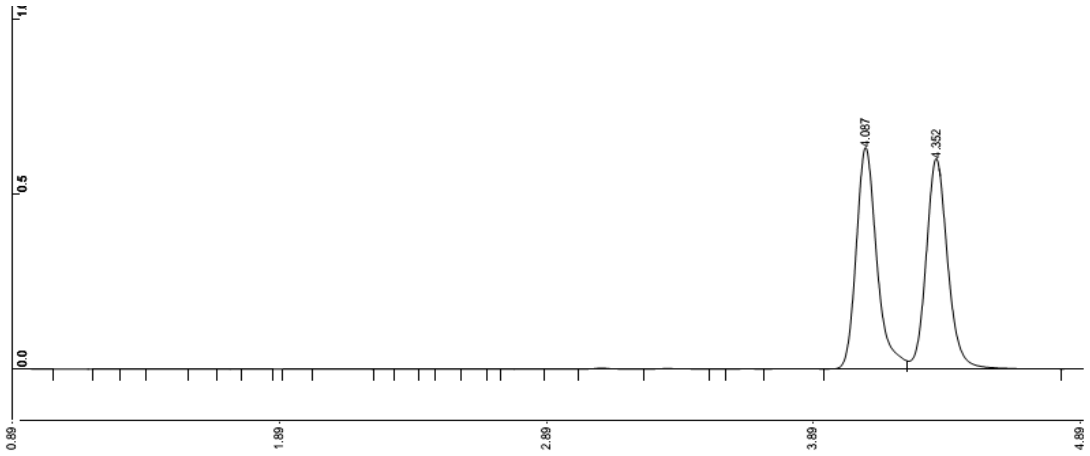



| R.Time | Area | Area% |
|---|---|---|
| **11.177** | **10736129** | **89.5516** |
| **11.815** | **1252633** | **10.4484** |

79% ee

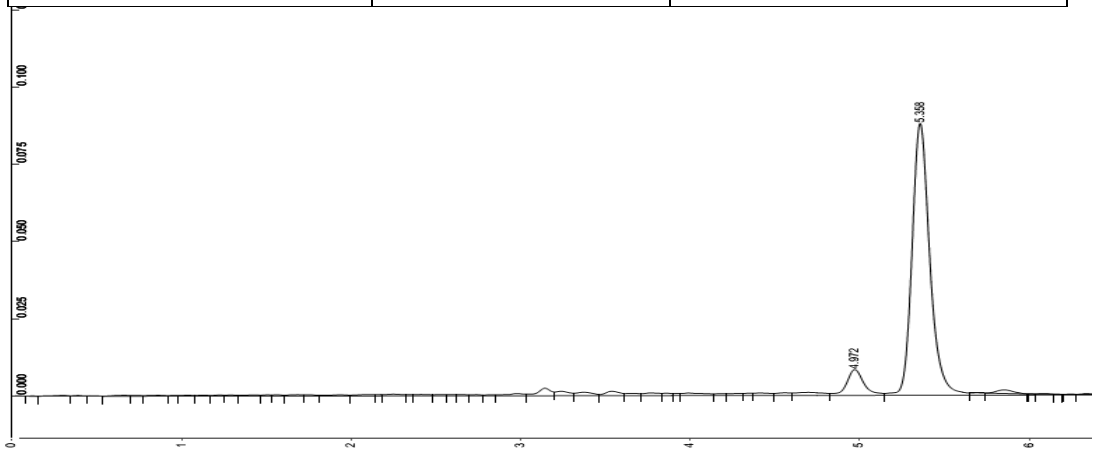



4p




Flow rate : 1.2 ml/min

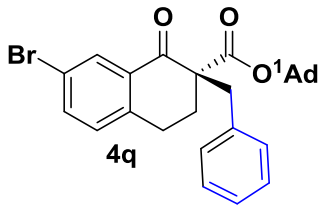
| R.Time | Area | Area% |
|---|---|---|
| **4.087** | **34240768** | **50.0139** |
| **4.352** | **34221764** | **49.9861** |

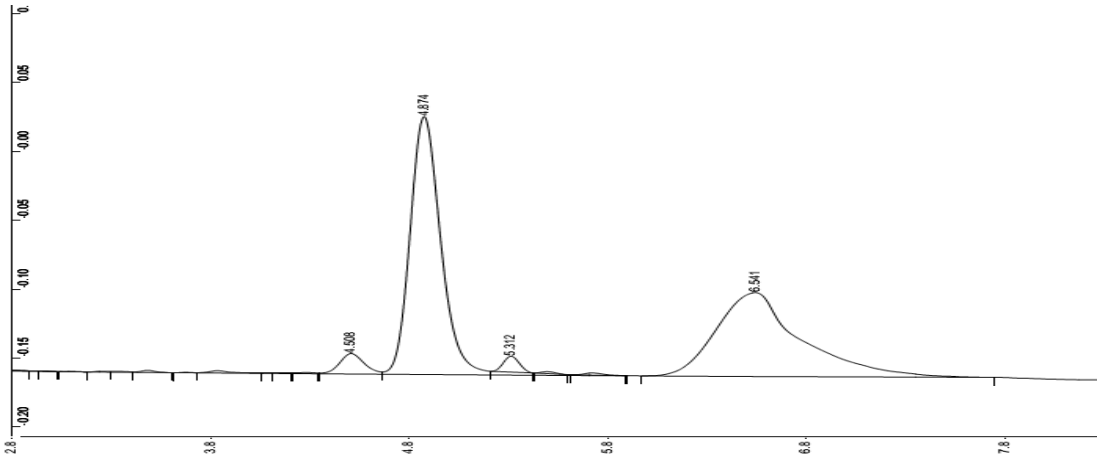



Flow rate : 1 ml/min

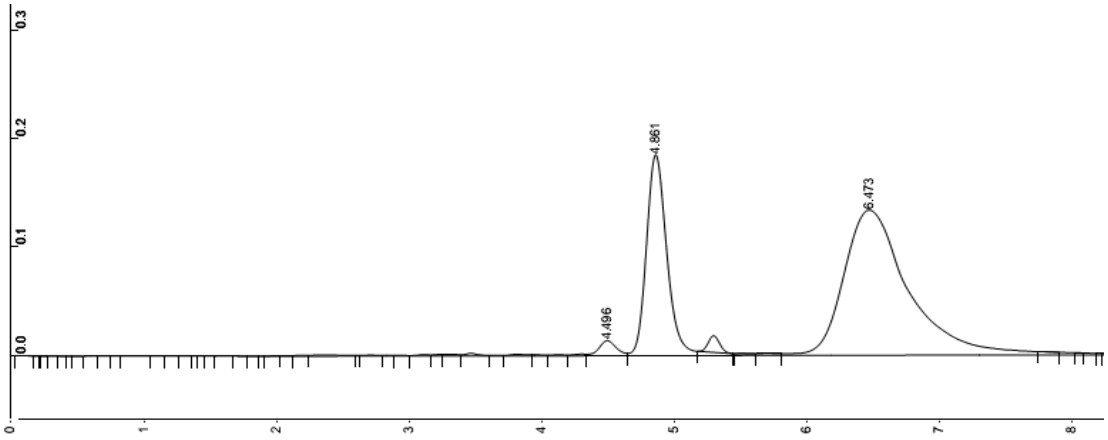
| R.Time | Area | Area% |
|---|---|---|
| **4.972** | **577560** | **6.5031** |
| **5.358** | **6657249** | **93.4969** |

87% ee



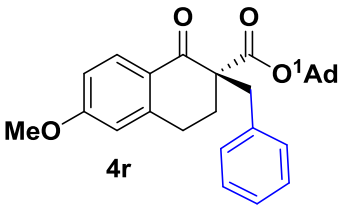




| R.Time | Area | Area% |
|---|---|---|
| **4.874** | **20331758** | **51.0435** |
| **6.541** | **19500460** | **48.9565** |

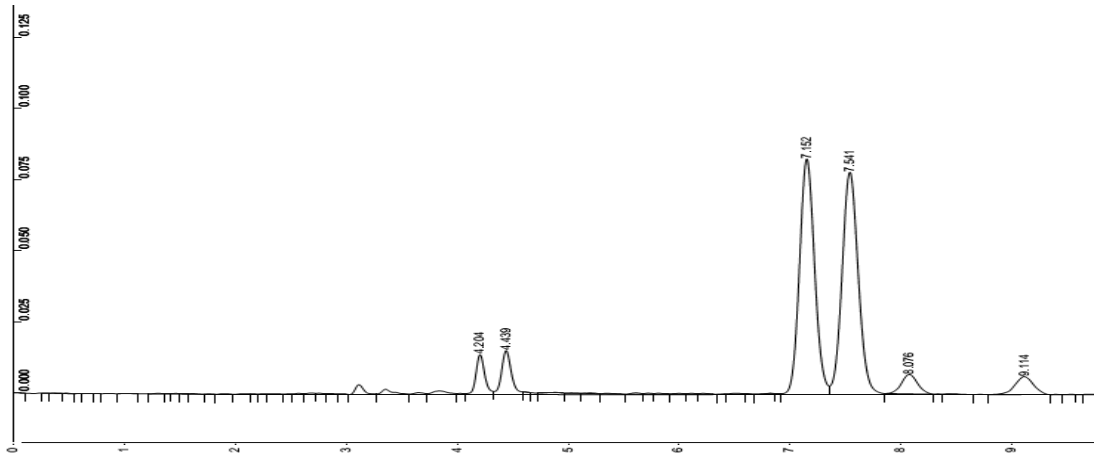



| R.Time | Area | Area% |
|---|---|---|
| **4.861** | **18530596** | **29.0987** |
| **6.473** | **45788092** | **70.9013** |

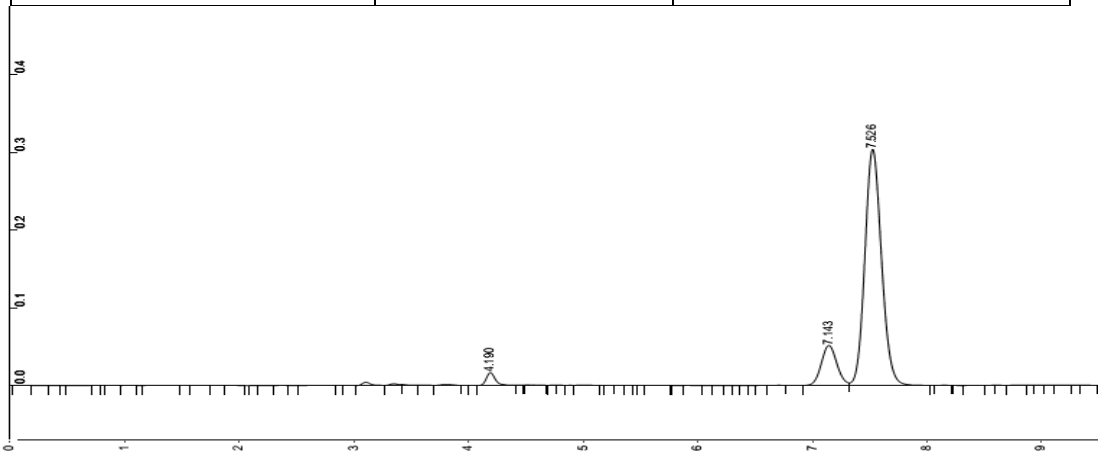
42% ee




4r

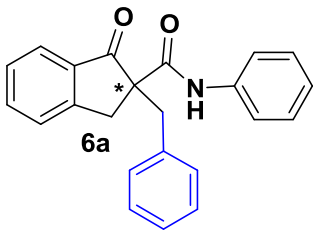


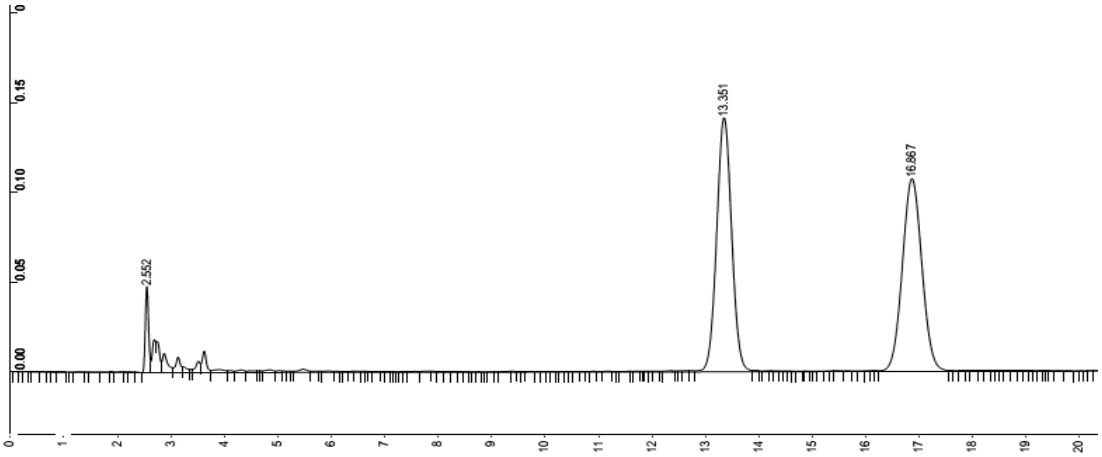

| R.Time | Area | Area% |
|---|---|---|
| **7.152** | **7849960** | **49.4338** |
| **7.541** | **8058685** | **50.5662** |



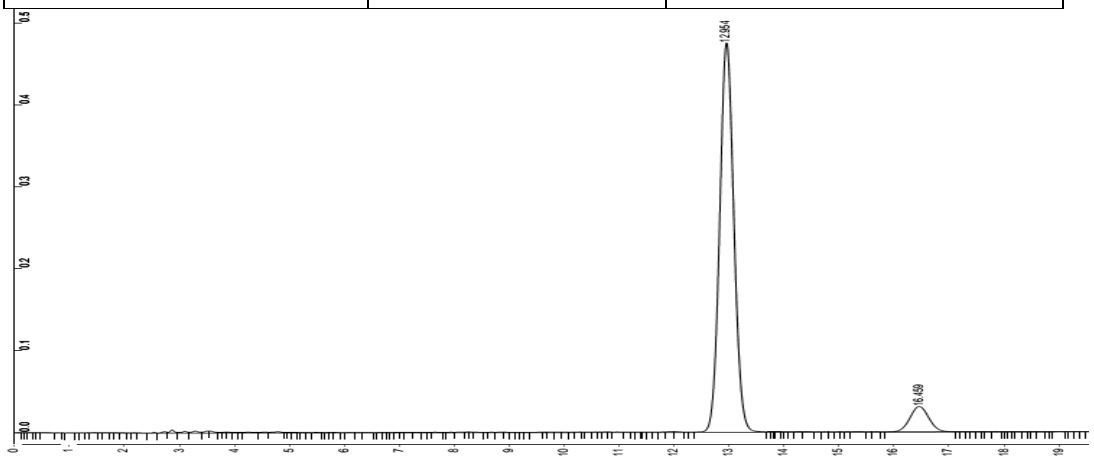

| R.Time | Area | Area% |
|---|---|---|
| **7.143** | **4908864** | **11.0146** |
| **7.526** | **39658019** | **88.9854** |

78% ee



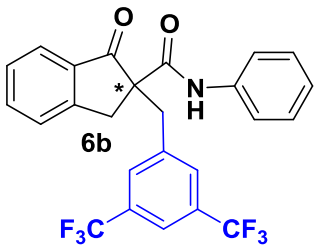



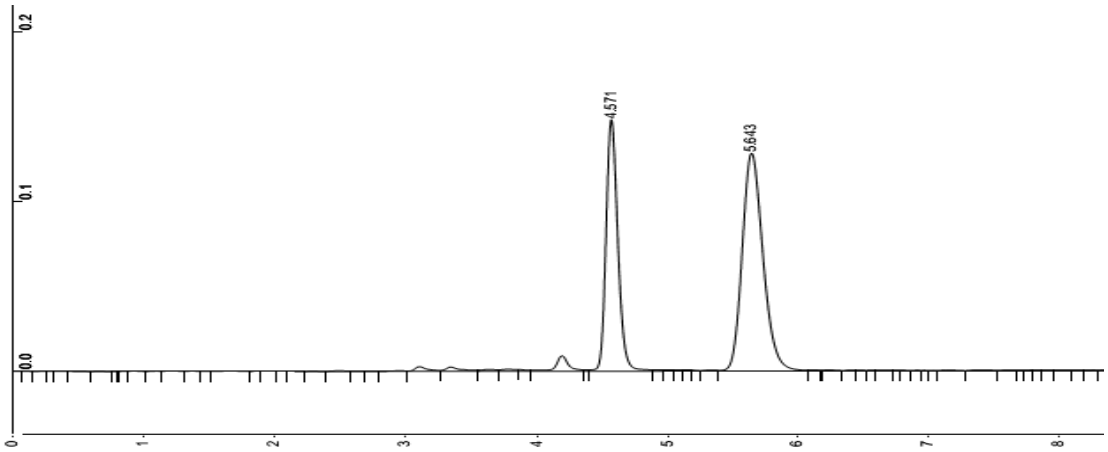

| R.Time | Area | Area% |
|---|---|---|
| **13.351** | **27902086** | **50.4752** |
| **16.867** | **27589322** | **49.5248** |



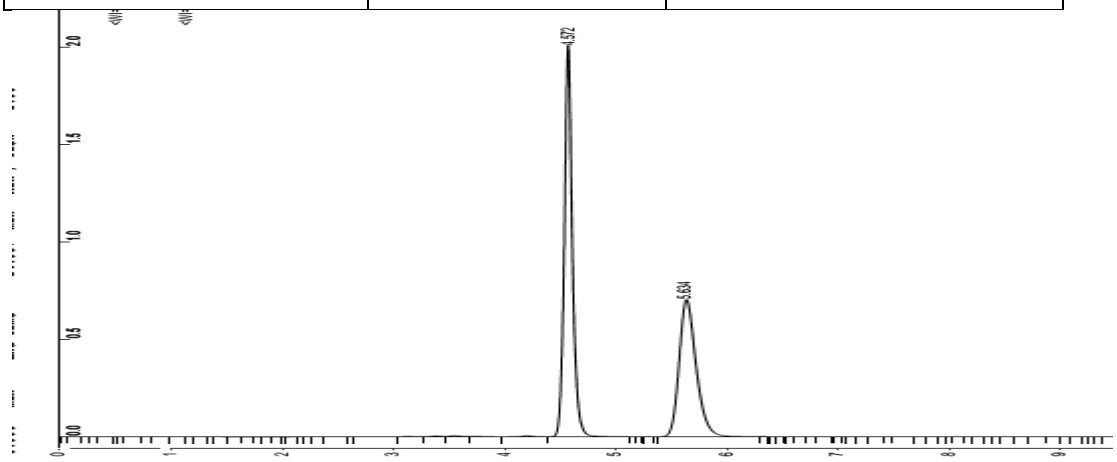

| R.Time | Area | Area% |
|---|---|---|
| **12.954** | **85831080** | **93.5339** |
| **16.459** | **27589322** | **6.4661** |

87% ee



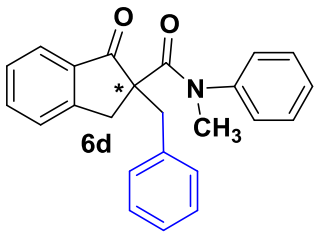



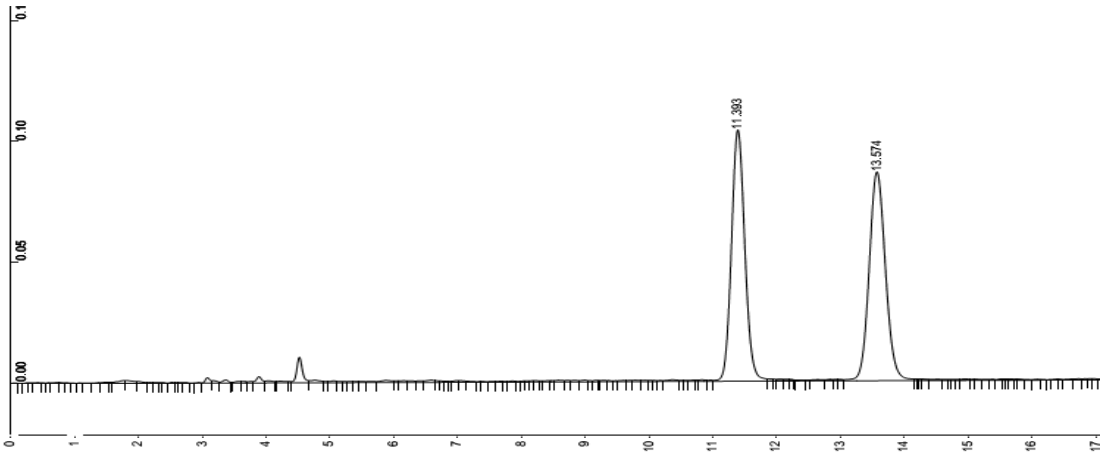

| R.Time | Area | Area% |
|---|---|---|
| **4.571** | **75901728** | **48.5230** |
| **5.643** | **80596680** | **51.4770** |



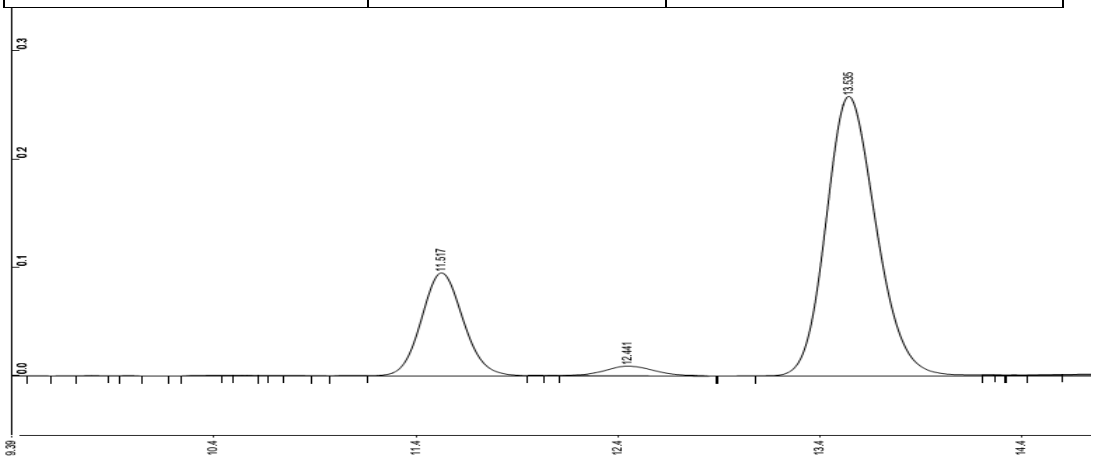

| R.Time | Area | Area% |
|---|---|---|
| **4.572** | **184527650** | **78.6322** |
| **5.634** | **50150780** | **21.3678** |

57% ee



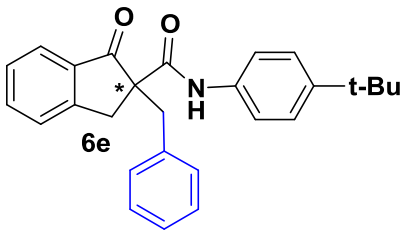



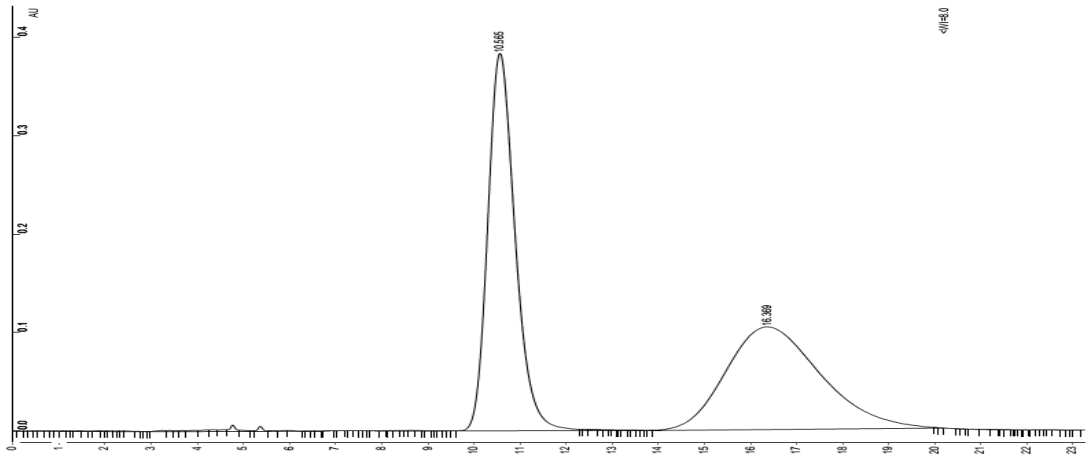

| R.Time | Area | Area% |
|---|---|---|
| **11.393** | **15406534** | **49.6131** |
| **13.574** | **15646840** | **50.3869** |



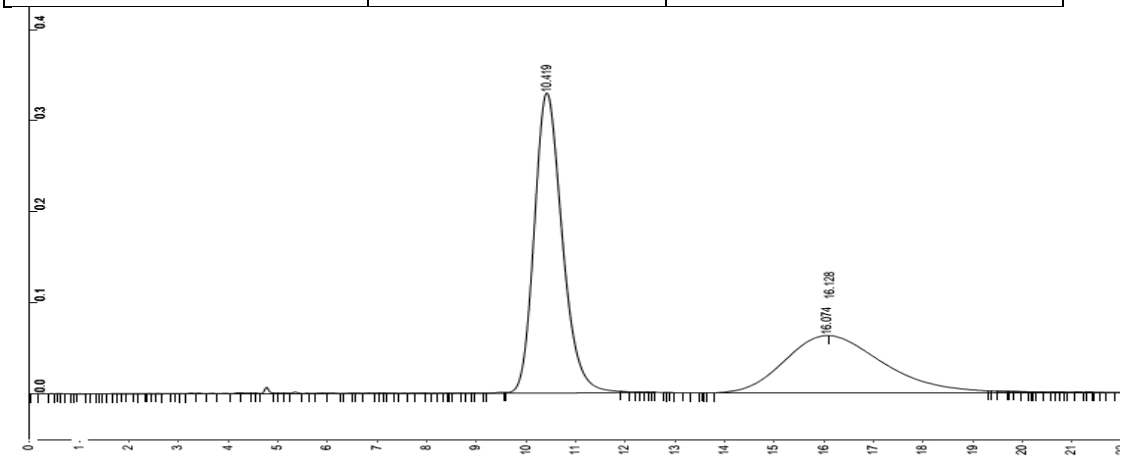

| R.Time | Area | Area% |
|---|---|---|
| **11.517** | **15406534** | **21.8131** |
| **13.556** | **15646840** | **78.1869** |

56% ee



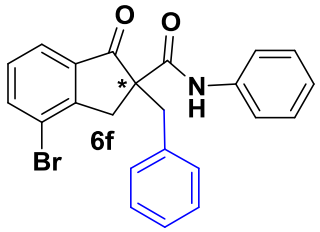



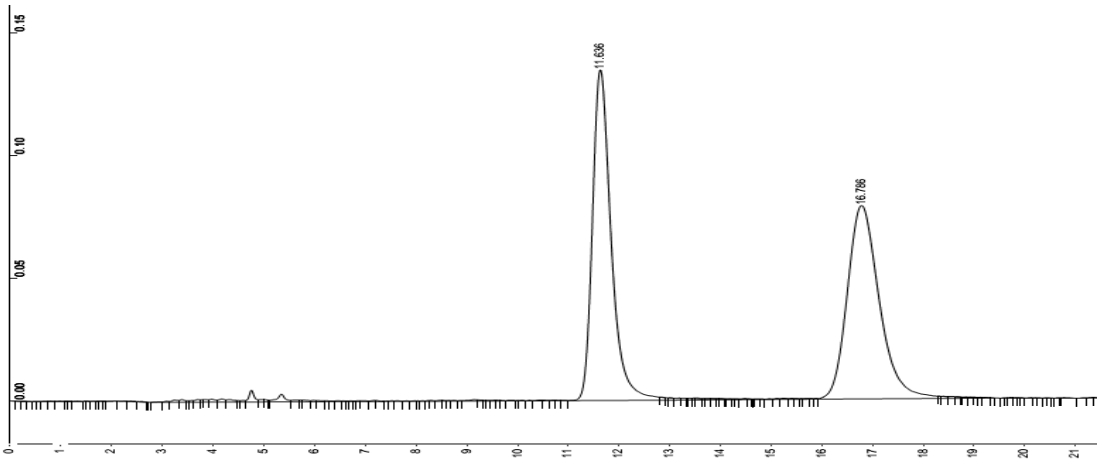

| R.Time | Area | Area% |
|---|---|---|
| **10.565** | **158087536** | **51.5267** |
| **16.369** | **1487119632** | **48.4733** |



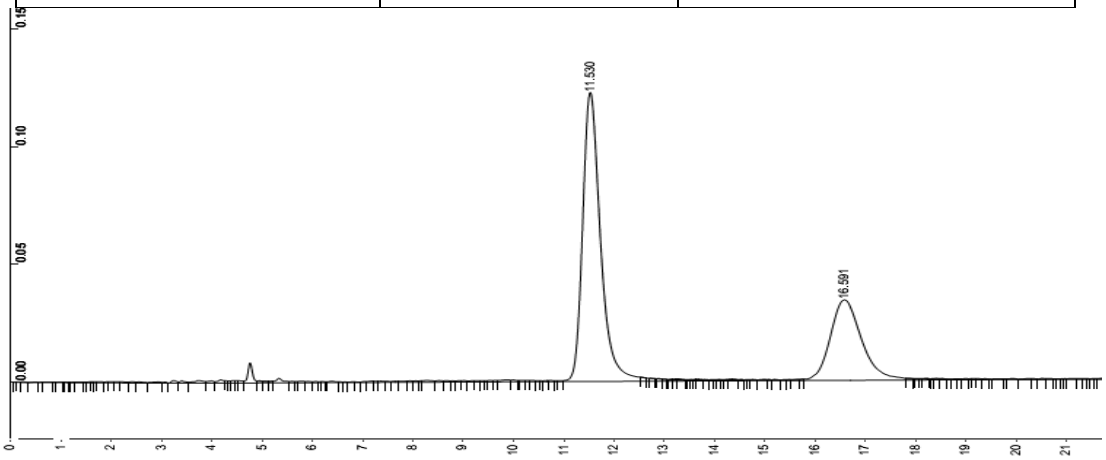

| R.Time | Area | Area% |
|---|---|---|
| **10.419** | **128629400** | **63.0451** |
| **16.128** | **75544251** | **36.9549** |

26% ee



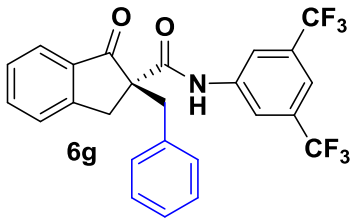



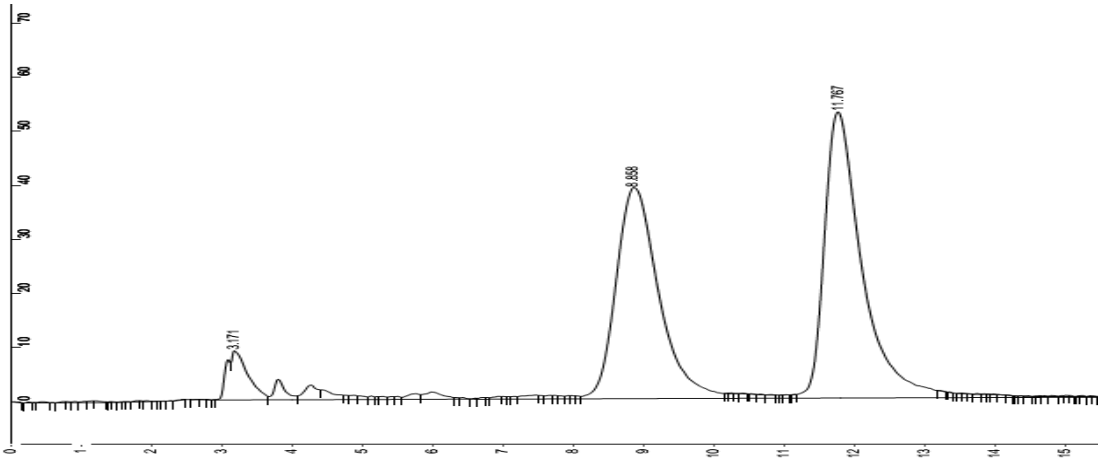

| R.Time | Area | Area% |
|---|---|---|
| **11.636** | **34964120** | **50.2648** |
| **16.786** | **34595688** | **49.7352** |



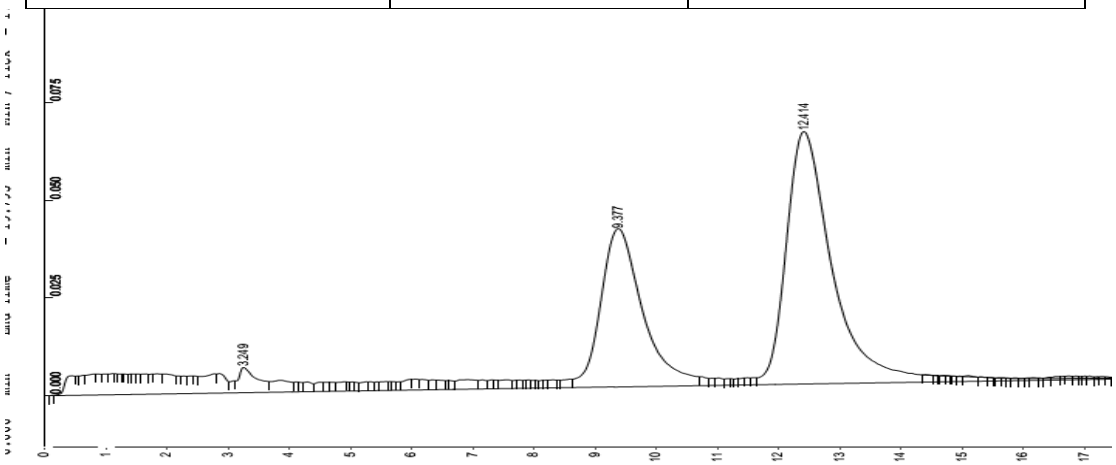

| R.Time | Area | Area% |
|---|---|---|
| **11.530** | **34964120** | **71.2940** |
| **16.591** | **14775715** | **28.7060** |

43% ee



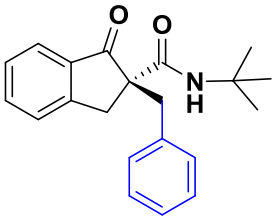



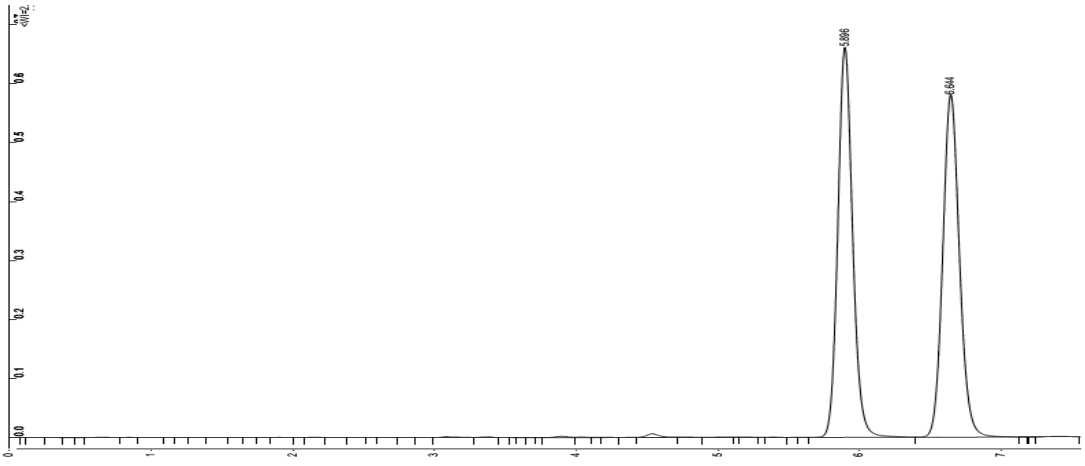

| R.Time | Area | Area% |
|---|---|---|
| **8.858** | **16854862** | **48.8910** |
| **11.767** | **17619503** | **51.1090** |



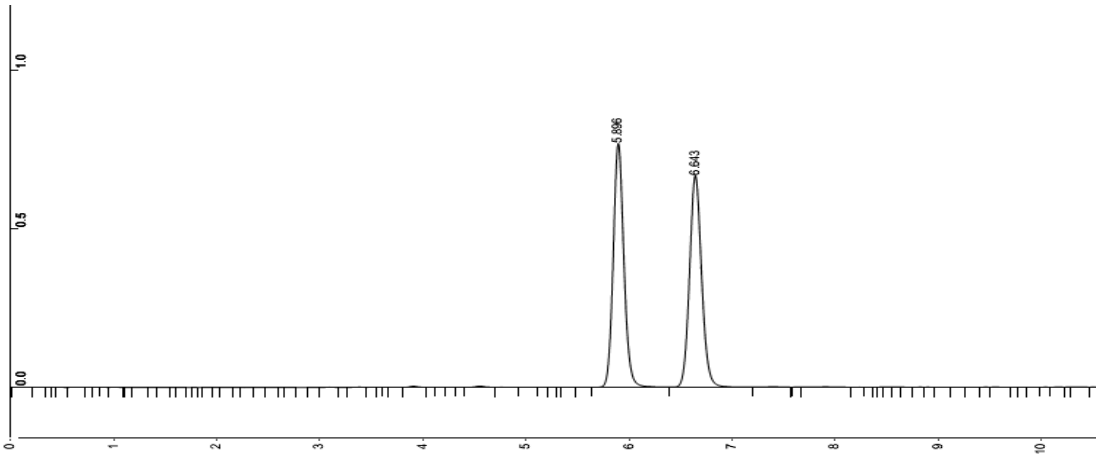

| R.Time | Area | Area% |
|---|---|---|
| **9.377** | **19267998** | **34.6232** |
| **12.414** | **36382543** | **65.3768** |

31% ee




| R.Time | Area | Area% |
|---|---|---|
| **5.896** | **47955040** | **50.2162** |
| **6.644** | **47542156** | **49.7838** |




| R.Time | Area | Area% |
|---|---|---|
| **5.896** | **55396676** | **48.0026** |
| **6.643** | **60013065** | **51.9974** |

4% ee