Supporting Information for

Highly Regioselective α-Formylation and α-Acylation of BODIPY Dyes *via* Tandem Cross-Dehydrogenative Coupling with *in situ* Deprotection

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Contents:

1. Synthesis of compounds 1a-d and 2a-f

BODIPYs **1a-d** (Figure S1) were synthesized according to literature procedures.[1] Compounds **2a** and **2b** (Figure S1) are commercial reagents. Compounds **2c-f** (Figure S1) were prepared from the aldol condensation reaction of aldehyde and ethylene glycol by following literature procedures.[2] Compound 2-phenyl-1,3-dioxolane **2d** was used as an example to show the **general procedure for the preparation of 2-substituted 1,3-dioxolanes 2c-f.** To benzaldehyde (5.0 g, 27.0 mmol) in 30 mL of anhydrous toluene was added *p*-toluenesulfonic acid (22 mg, 0.1 mmol) and ethylene glycol (2.5 g, 40.3 mmol) at 120 ^{o}C. The reaction mixture was refluxed for 24 h. Upon completion, the reaction mixture was cooled to room temperature and was washed three times with saturated $NaHCO_3$ solution (50 mL) and brine (50 mL), dried over Na_2SO_4, filtered, and evaporated to provide crude products **2c-f** in 87%-96% yields.

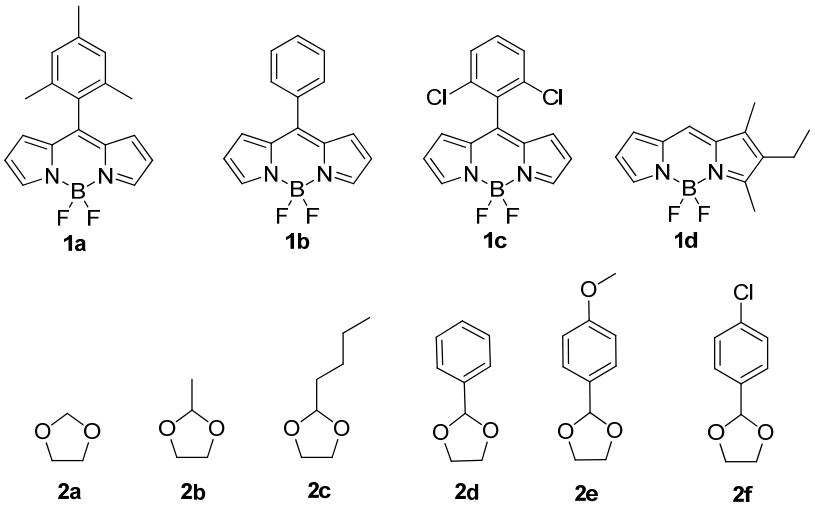
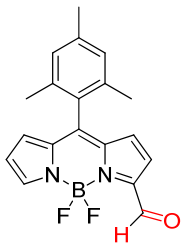
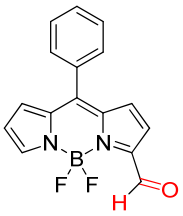


Figure S1. Chemical structure of BODIPYs **1a-d**, 1,3-dioxolane **2a** and its derivatives **2b-f.**

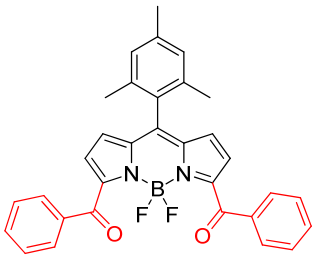
2. Table S1. Selected Geometrical Parameters of 4a, 4b, 5c and 7 obtained from crystallography



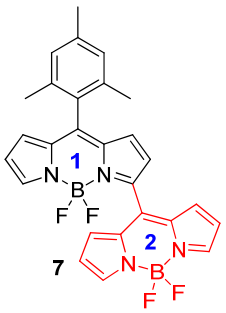
4a



4b



5c

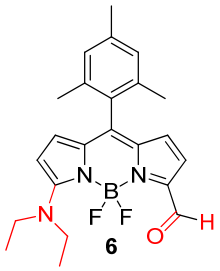


7

	4a	4b	5c	7
B-N bond distances (Å)	1.5483(39) 1.5476(28)	1.542(31) 1.546(37)	1.5416(27) 1.5531(23)	1.5608(78) (1) 1.5702(91) (1) 1.5466(66) (2) 1.5348(78) (2)
dihedral angles between *meso*-aryl group and dipyyrin core (deg)	75.774(70)	55.066(79)	80.372(40)	83.133(129)
dihedral angles of two pyrrole rings in dipyyrin core (deg)	9.838(90)	2.722(130)	19.303(68)	6.137(142) (1) 12.067(235) (2)
dihedral angles between two central BN_2C_3 six-membered rings	/	/	/	61.919(94)

3. Photophysical properties

3.1 Table S2: Photophysical properties of 6 in different solvents at room temperature.



6

solvent	λ_{abs}^{max} [nm]	λ_{em}^{max} [nm]	log ε [a]	Φ [b]	Stokes shift [cm^{-1}] [c]
cyclohexane	481	560	4.59	0.18	2930
toluene	477	556	4.63	0.01	2980
$CHCl_3$	472	548	4.57	0.006	2940
THF	467	532	4.48	0.005	2620
CH_3CN	461	525	4.48	0.003	2640
MeOH	467	519	4.48	0.002	2150

[a] Molar absorption coefficient at λ_{abs}^{max}. [b] Fluorescence quantum yields determined using fluorescein (Φ = 0.90 in 0.1 N NaOH aqueous solution) as standard. [c] Stokes shift values rounded to nearest 10 cm^{-1}.

3.2 UV-vis absorption and fluorescence emission spectra of 6 recorded in various solvents.

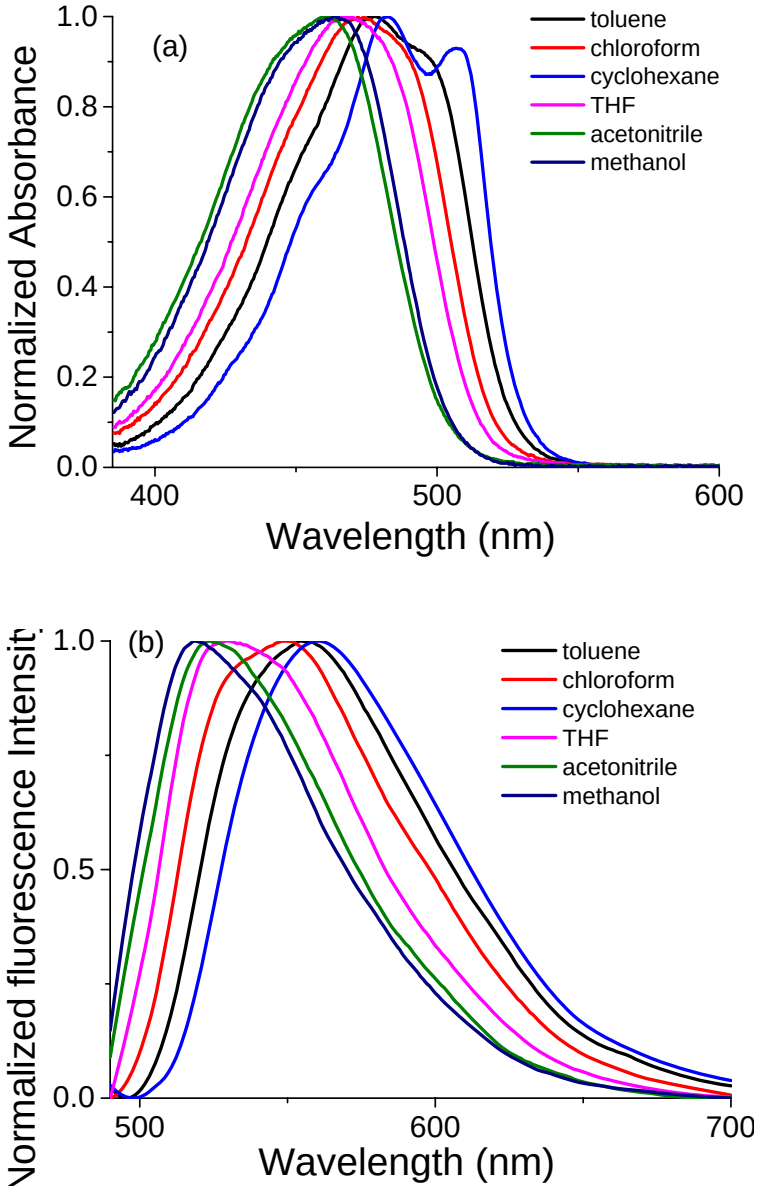


Figure S2. Absorption (a) and fluorescence emission (b) spectra of **6** recorded in different solvents (excitation at 460 nm).

3.3 UV-vis absorption and fluorescence emission spectra recorded in dichloromethane (excitation at 480 nm).

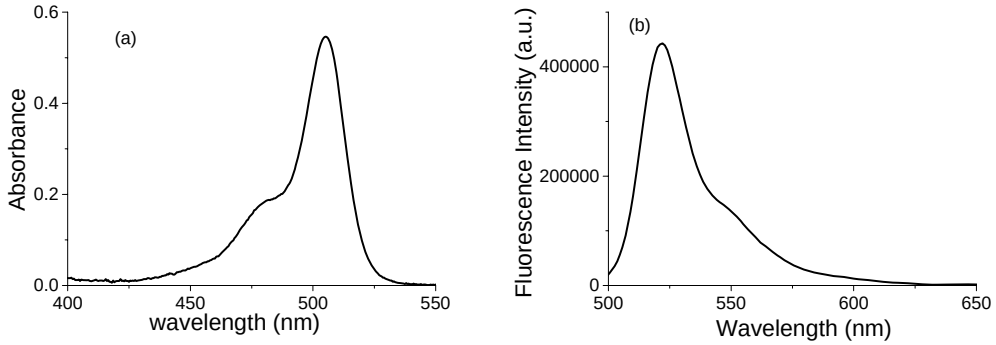


Figure S3. Absorption (a) and fluorescence emission (b) spectra of **3a**.

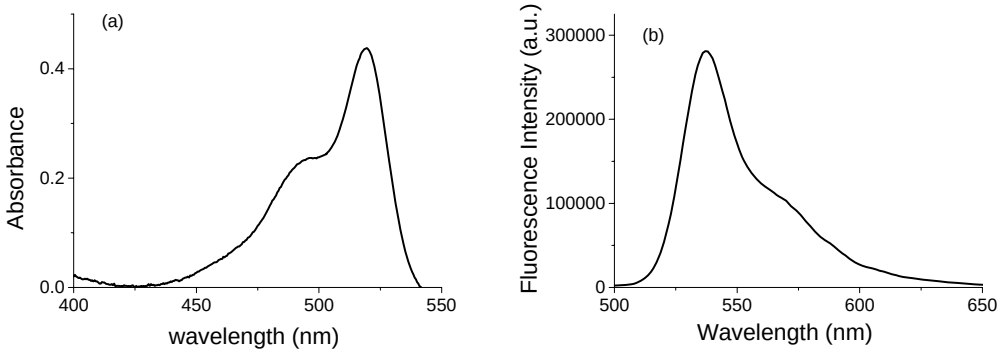


Figure S4. Absorption (a) and fluorescence emission (b) spectra of **4a**.

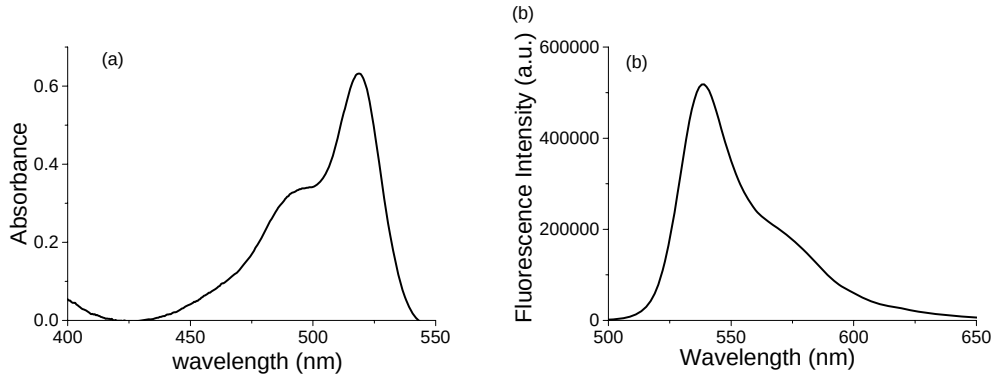


Figure S5. Absorption (a) and fluorescence emission (b) spectra of **4b**.

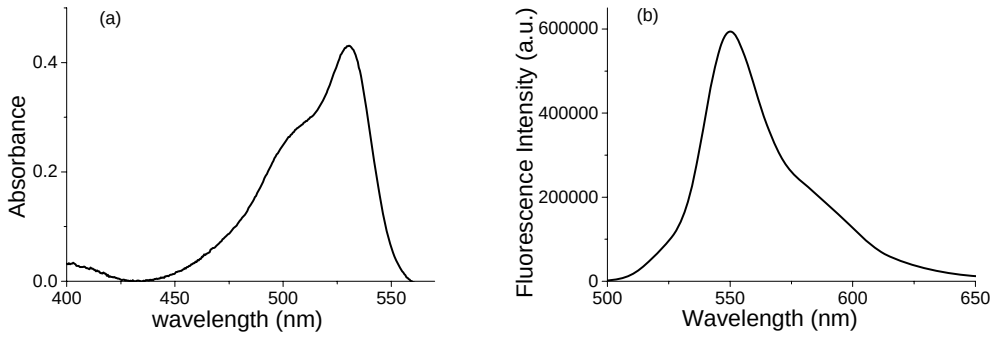


Figure S6. Absorption (a) and fluorescence emission (b) spectra of **4c**.

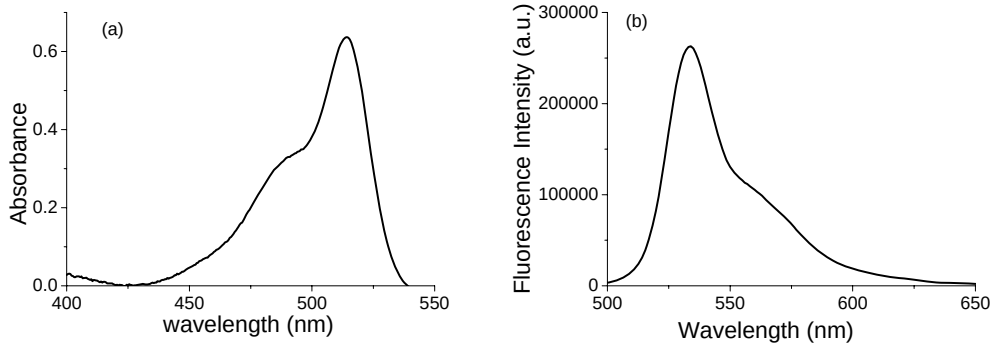


Figure S7. Absorption (a) and fluorescence emission (b) spectra of **4d**.

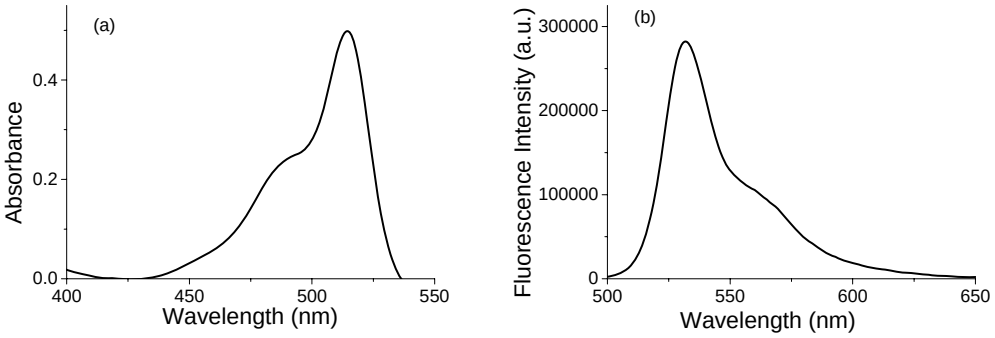


Figure S8. Absorption (a) and fluorescence emission (b) spectra of **4e**.

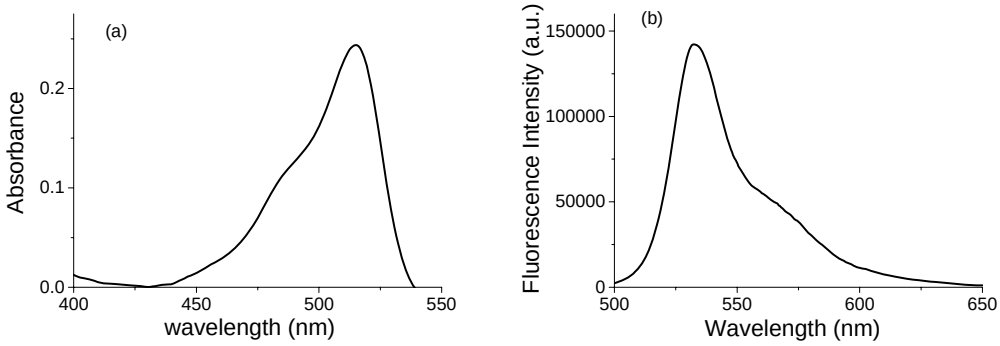


Figure S9. Absorption (a) and fluorescence emission (b) spectra of **4f**.

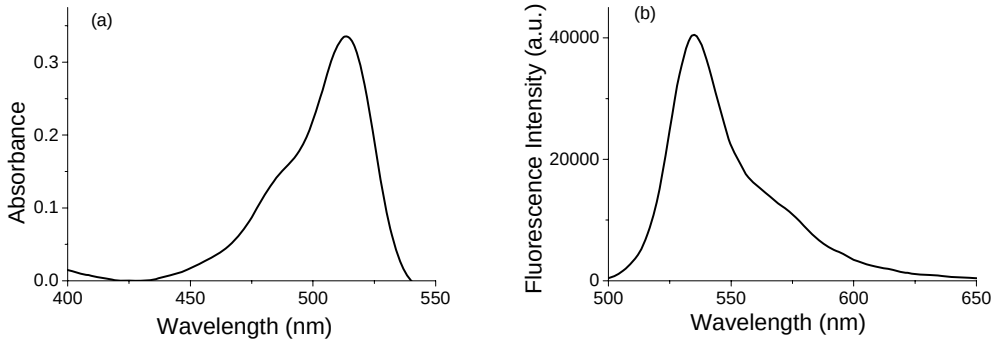


Figure S10. Absorption (a) and fluorescence emission (b) spectra of **4g**.

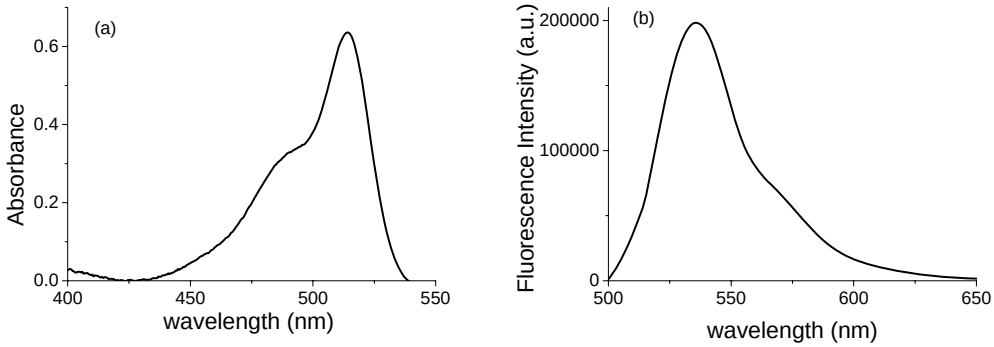


Figure S11. Absorption (a) and fluorescence emission (b) spectra of **4h**.

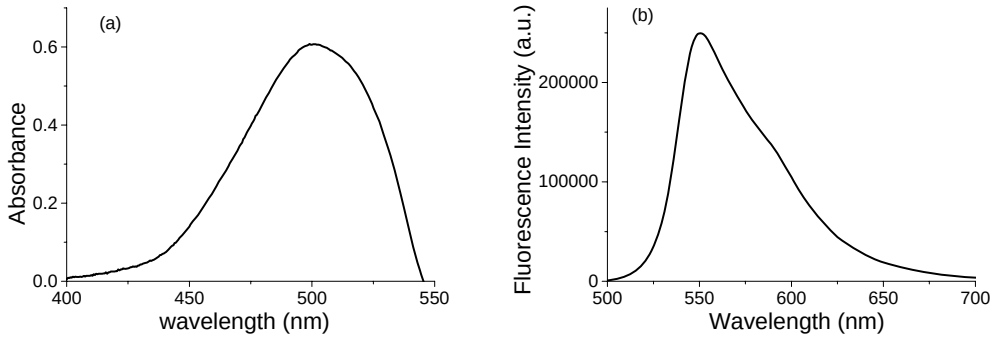


Figure S12. Absorption (a) and fluorescence emission (b) spectra of **4i**.

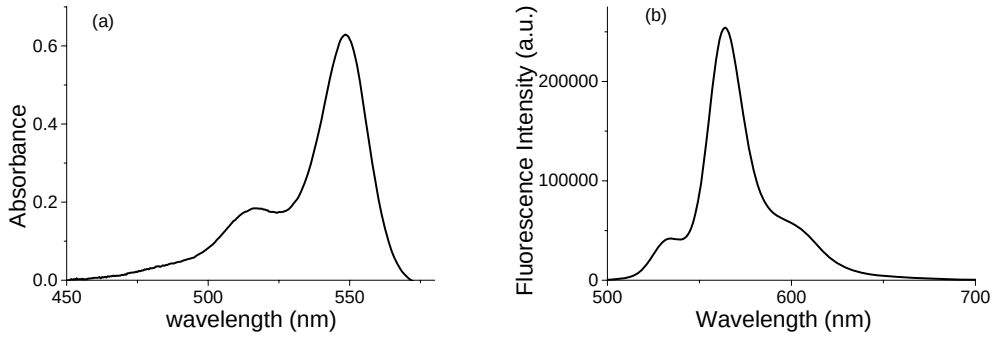


Figure S13. Absorption (a) and fluorescence emission (b) spectra of **5a**.

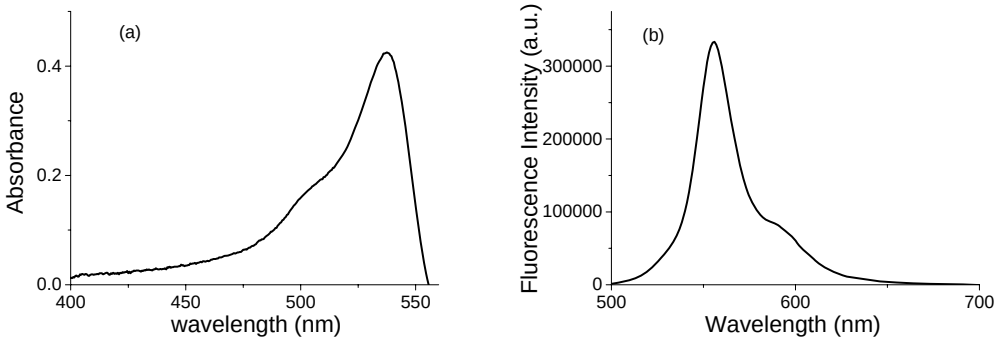


Figure S14. Absorption (a) and fluorescence emission (b) spectra of **5b**.

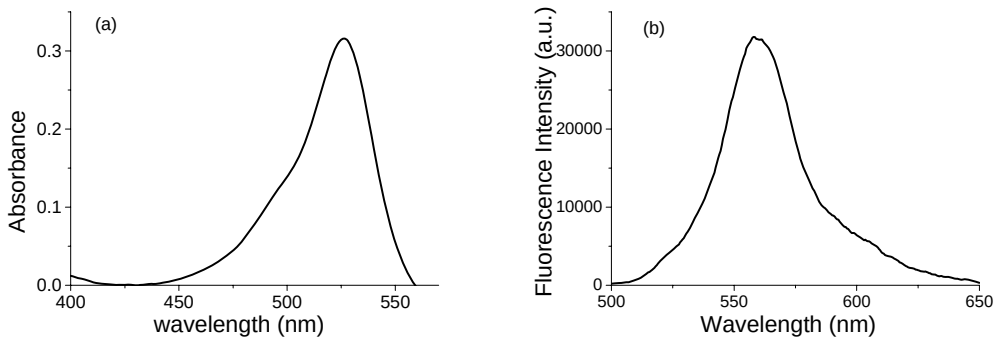


Figure S15. Absorption (a) and fluorescence emission (b) spectra of **5c**.

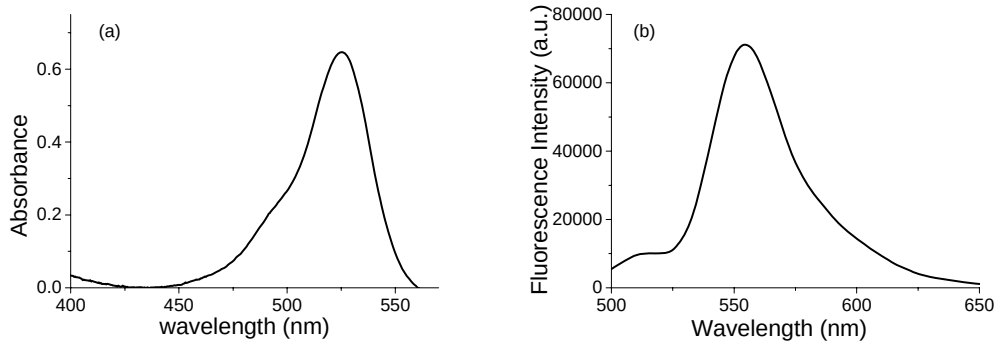


Figure S16. Absorption (a) and fluorescence emission (b) spectra of **5d**.

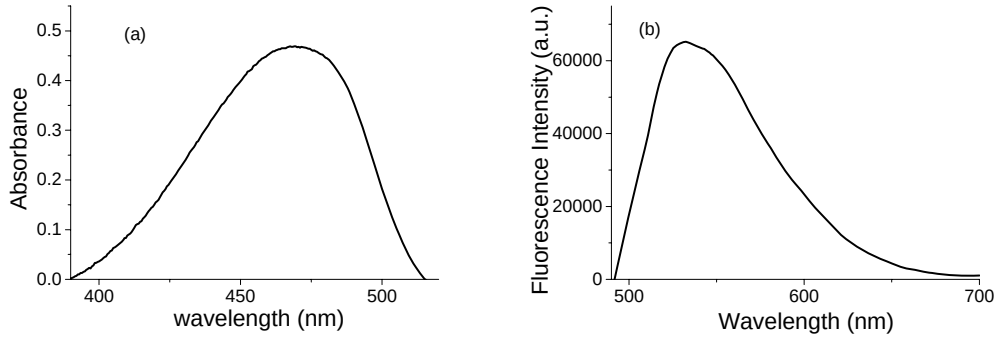


Figure S17. Absorption (a) and fluorescence emission (b) spectra of **6**.

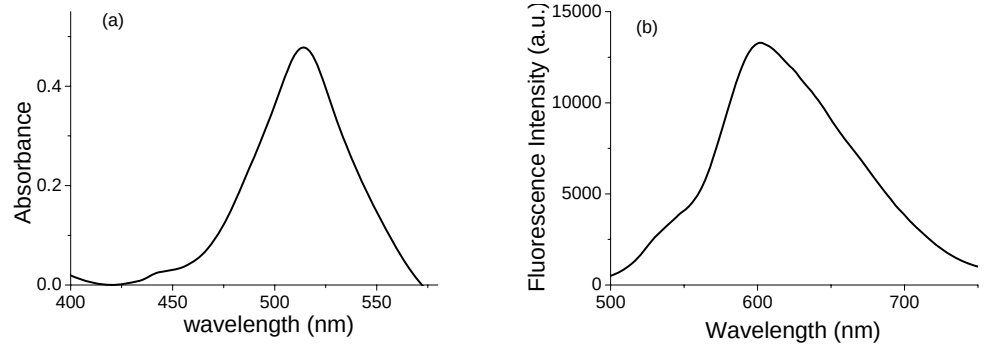


Figure S18. Absorption (a) and fluorescence emission (b) spectra of **7**.

3.4 Photooxidation of 1,3-diphenylisobenzofuran (DPBF) with BODIPY dimer 7

Singlet oxygen ($^1O_2$) quantum yields Φ_Δ of the triplet photosensitizers were calculated according to a modified literature method.[3] The irradiation wavelength for the samples and the reference was the same using a 532 nm laser. The absorbance of DPBF was adjusted around 1.4 at 416 nm in toluene, and the absorbance of the photosensitizer **7** was adjusted to 0.2-0.3 at the irradiation wavelength. The photooxidation of DPBF was monitored at 60 s intervals. The quantum yields of singlet oxygen generation (Φ_Δ) were calculated according to equation (S2), using Rose Bengal (Φ_Δ = 0.80 in MeOH) as the reference,

$$\Phi_\Delta^{sam} = \Phi_\Delta^{std} \frac{m^{sam} F^{std}}{m^{std} F^{sam}} \qquad \text{(S1)}$$

where the superscripts *sam* and *std* designate BODIPY dimer **7** and the standard Rose Bengal, respectively; Φ_Δ is the quantum yield of singlet oxygen; m is the slope of a plot of difference in change in absorbance of DPBF (at 416 nm) with the irradiation time and F is the absorption correction factor, which is given by $F = 1 - 10^{-A}$ (A is the absorbance at the irradiation wavelength).

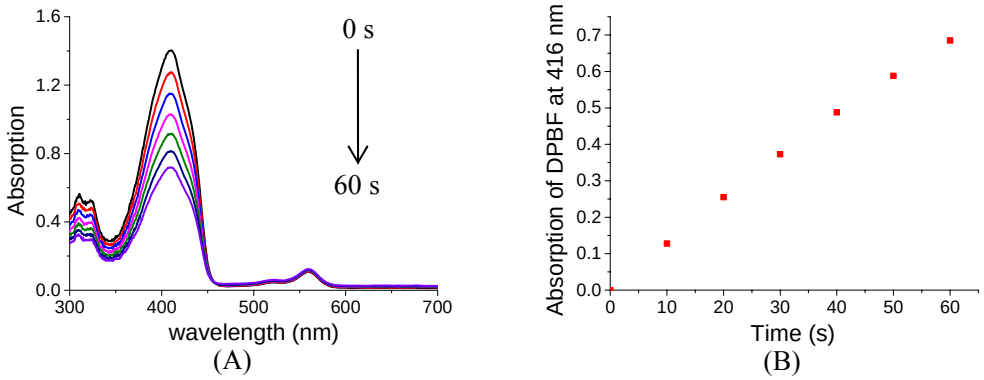
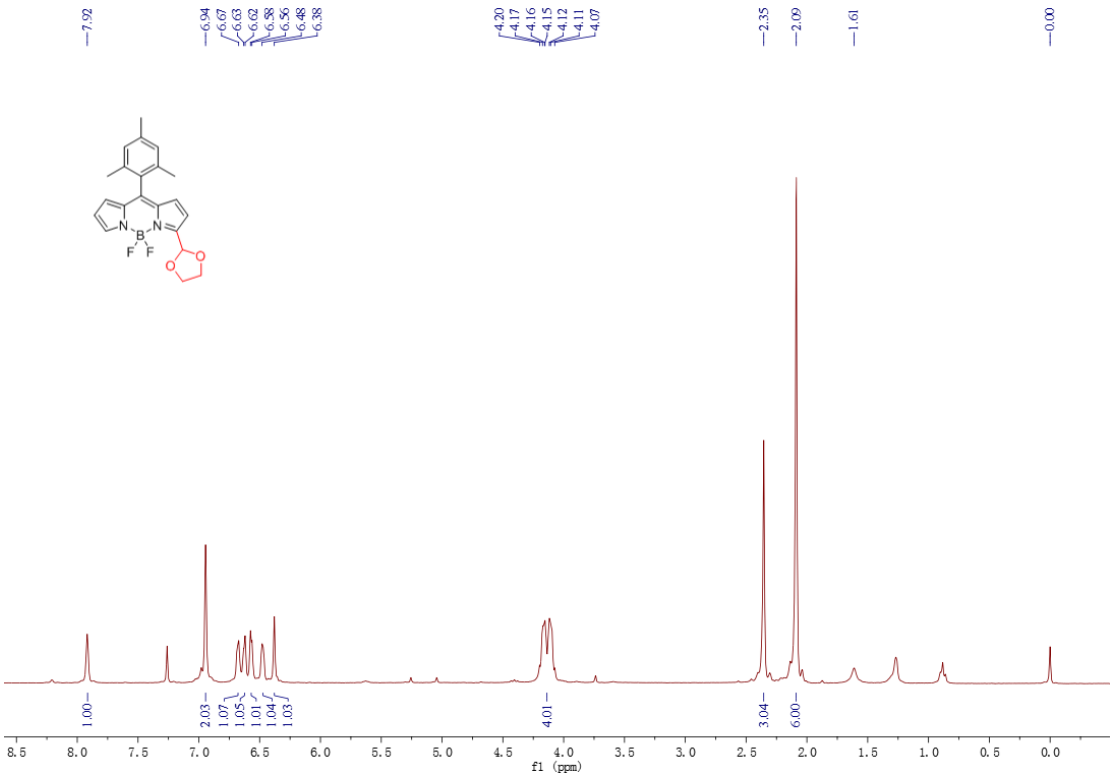


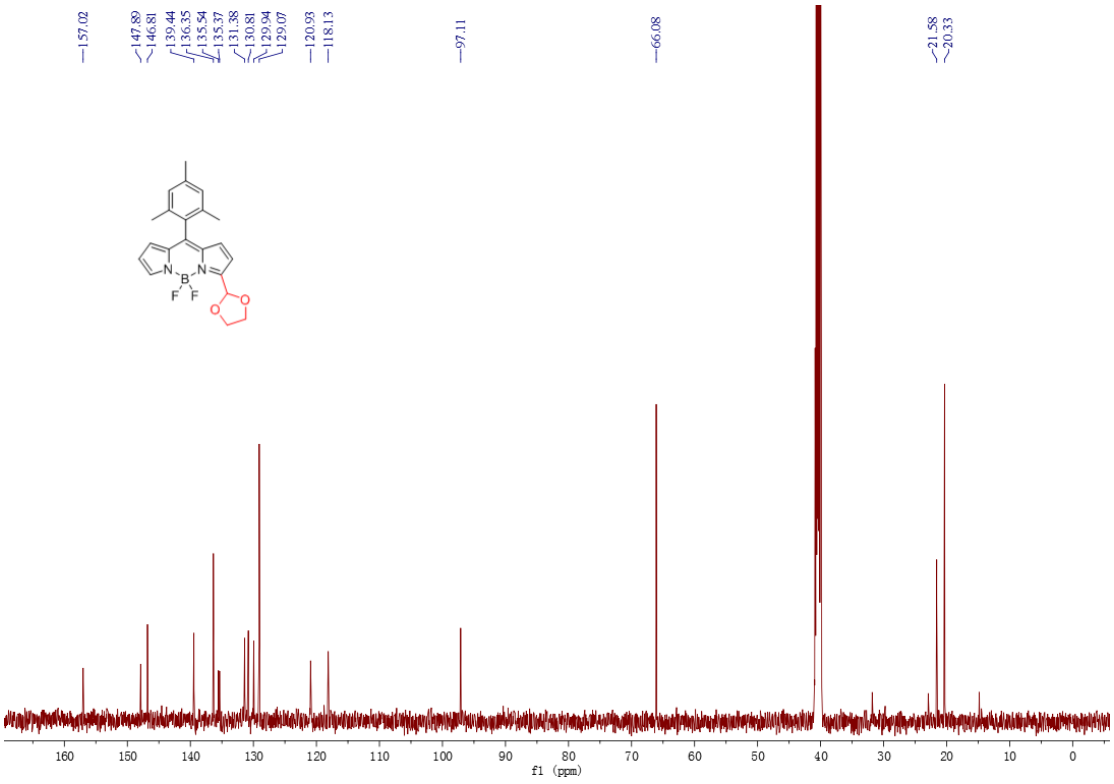
Figure S19. (A) Changes in the absorption spectrum of **DPBF** upon irradiation in the presence of Rose Bengal (**RB**) in methanol (recorded at 10 s intervals). (B) Plot of change in absorbance of DPBF at 416 nm *vs* irradiation time ($_{irr}$ = 532 nm) in the presence of Rose Bengal (**RB**) in methanol.

4. NMR and HRMS spectra of all new compounds

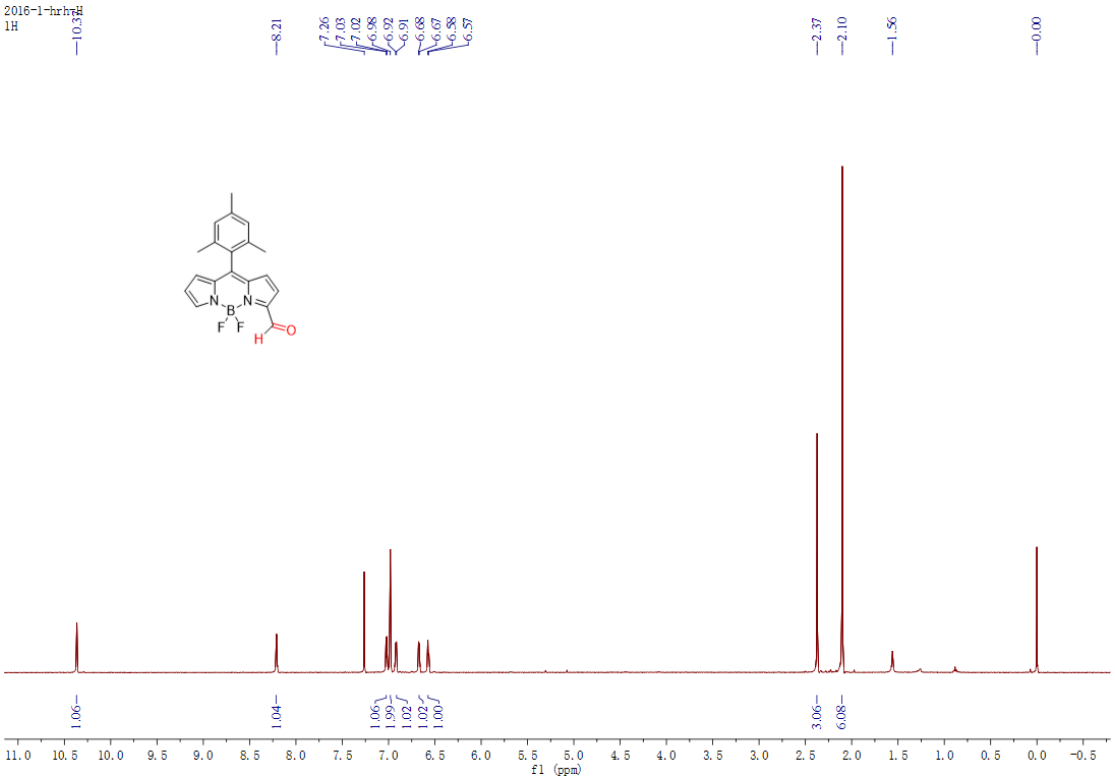
^{1}H NMR spectrum of **3a** in $CDCl_3$



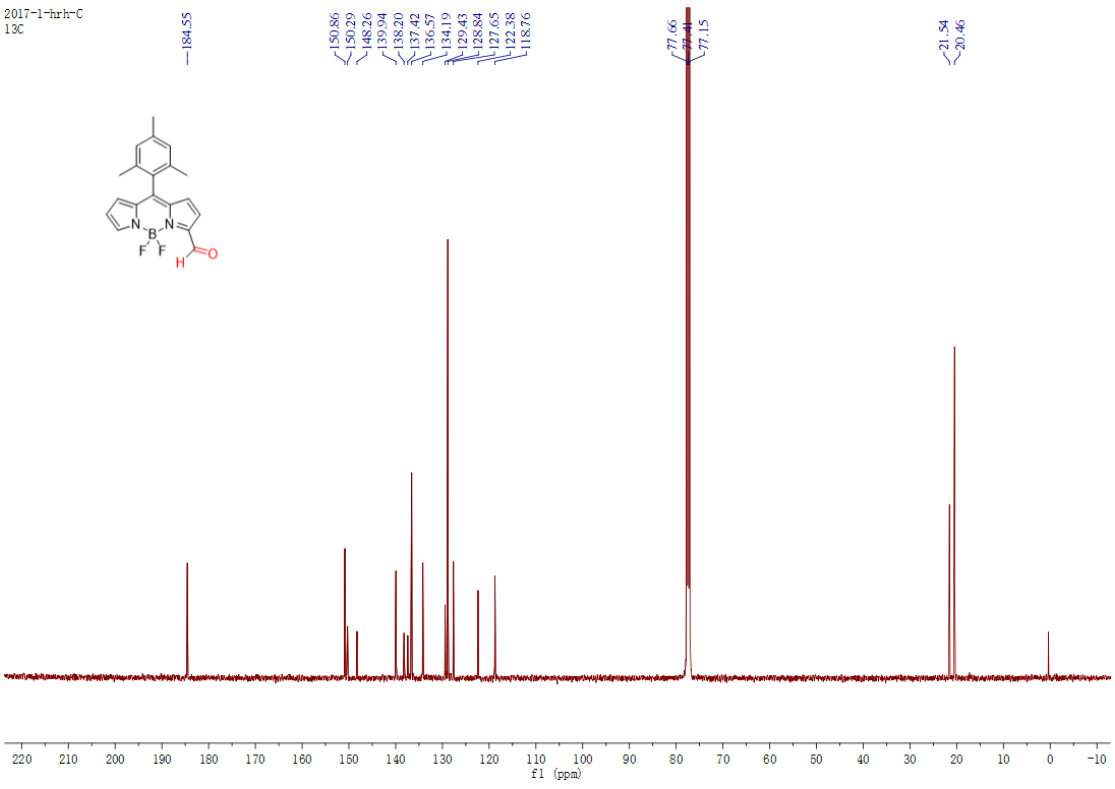
^{13}C NMR spectrum of **3a** in d_6-DMSO



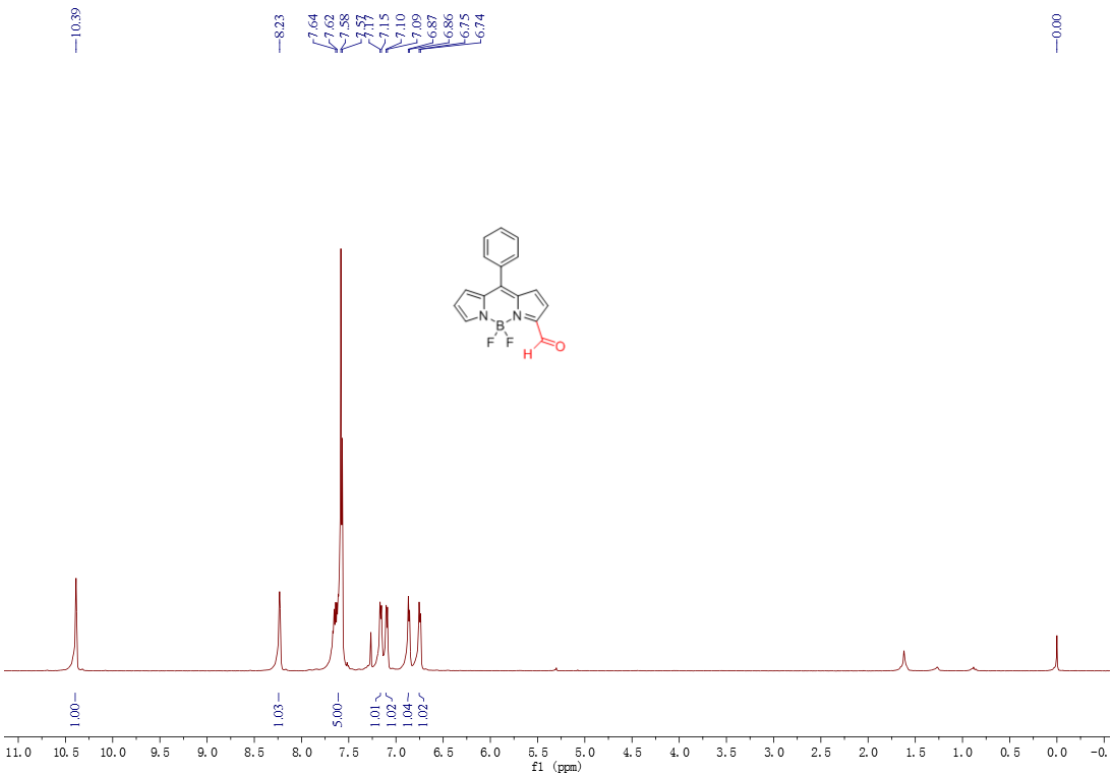
^{1}H NMR spectrum of **4a** in $CDCl_3$



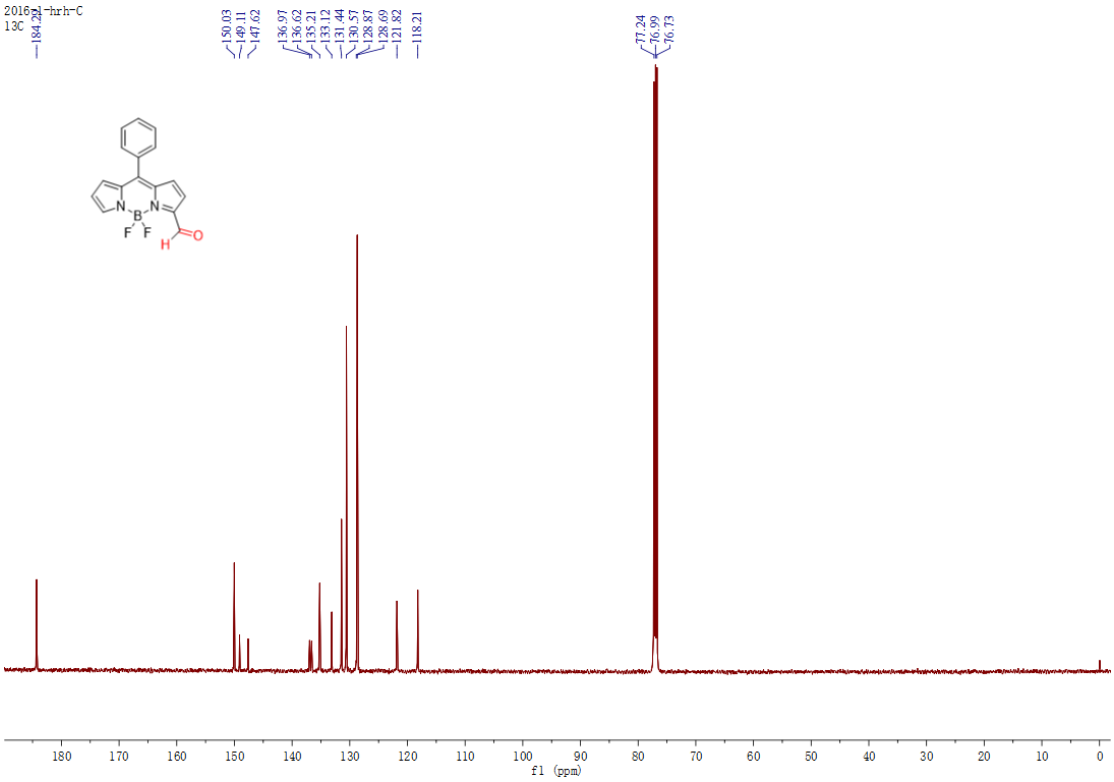
^{13}C NMR spectrum of **4a** in $CDCl_3$



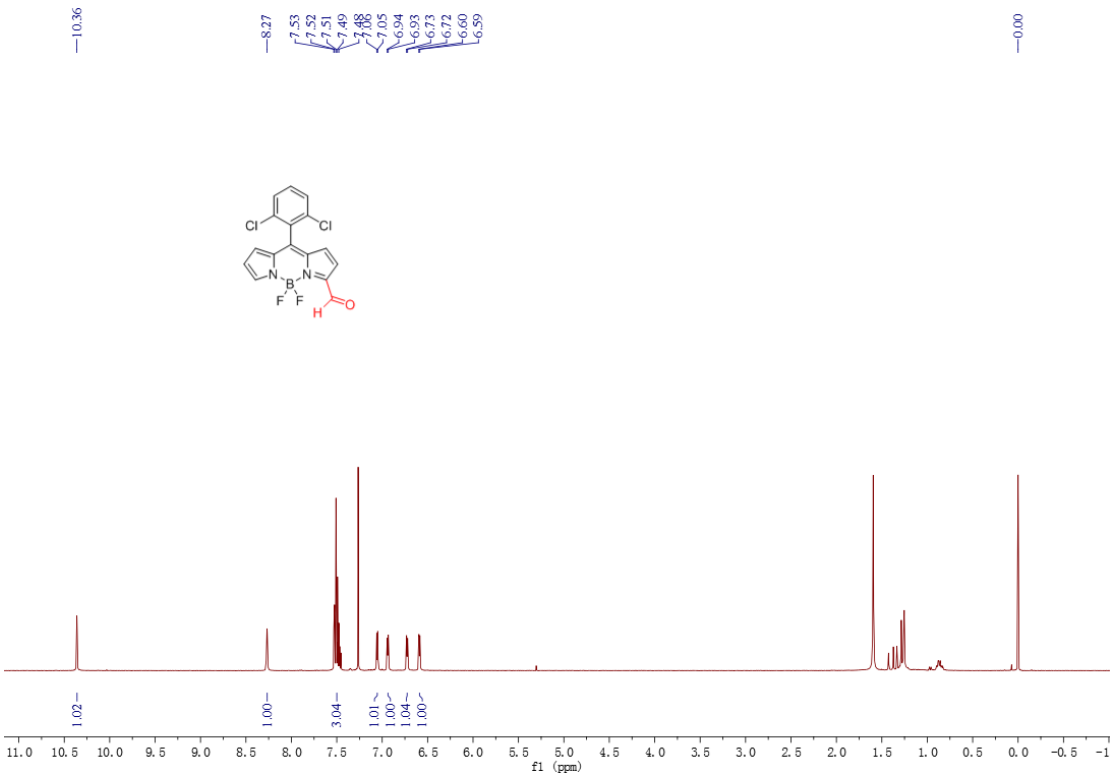
^{1}H NMR spectrum of **4b** in $CDCl_3$



^{13}C NMR spectrum of **4b** in $CDCl_3$



^{1}H NMR spectrum of **4c** in $CDCl_3$



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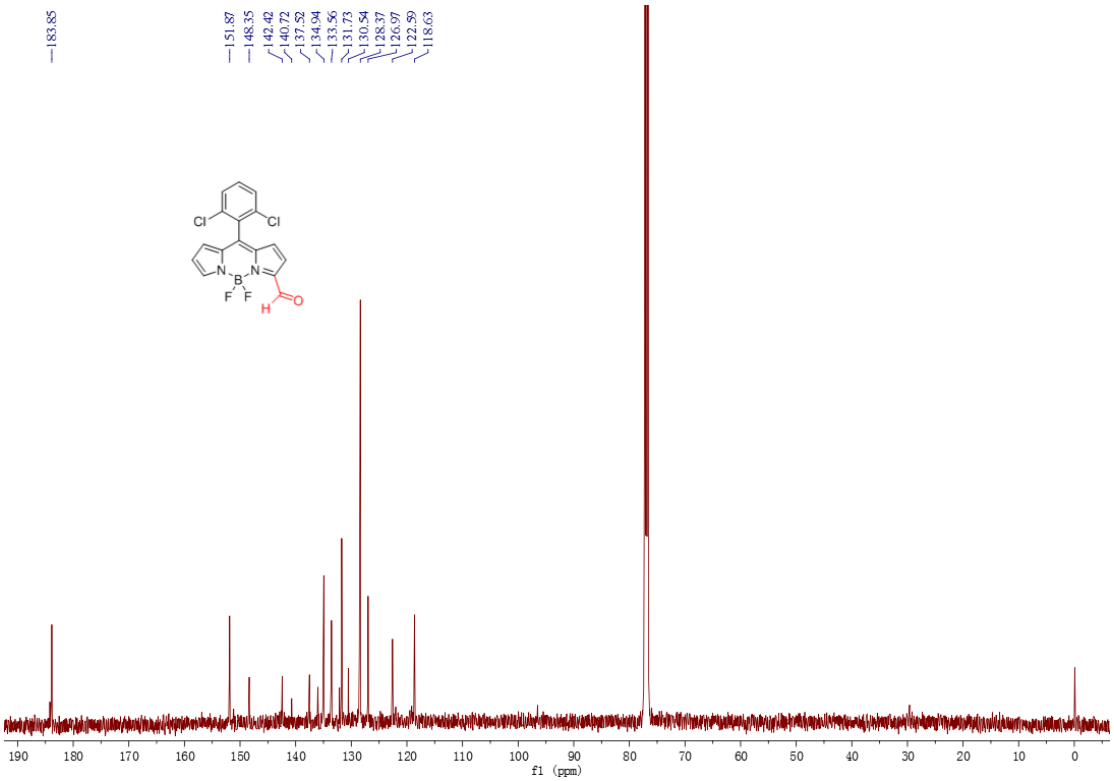
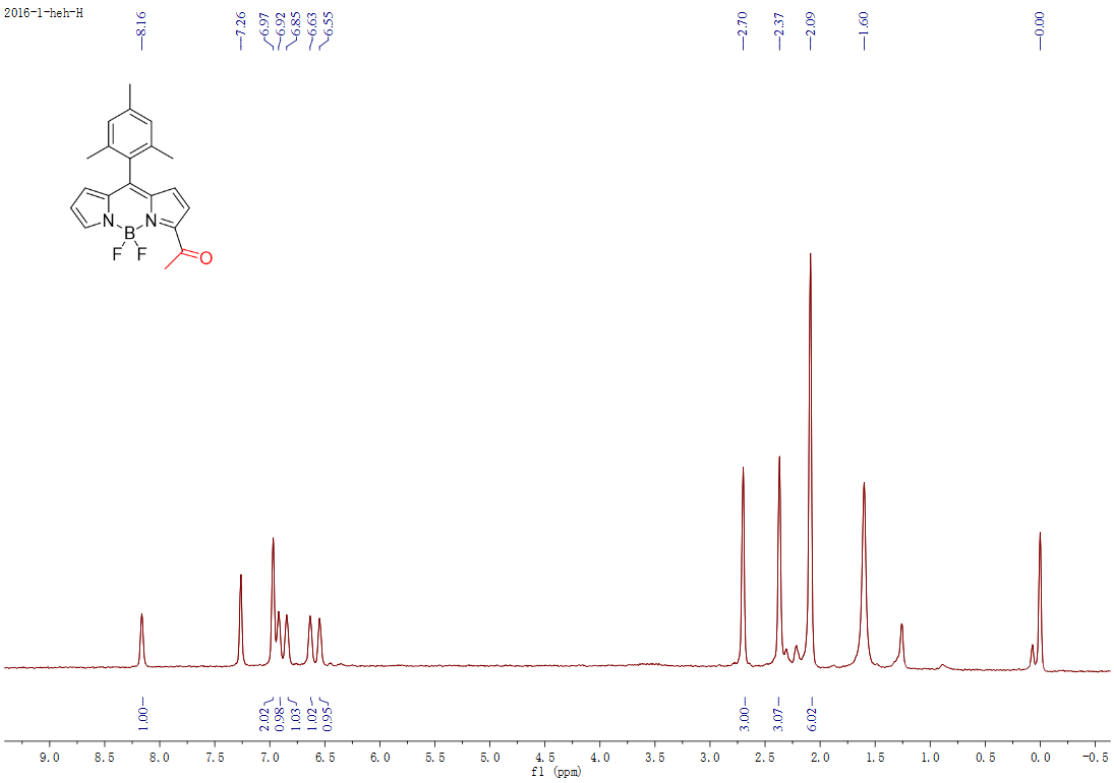
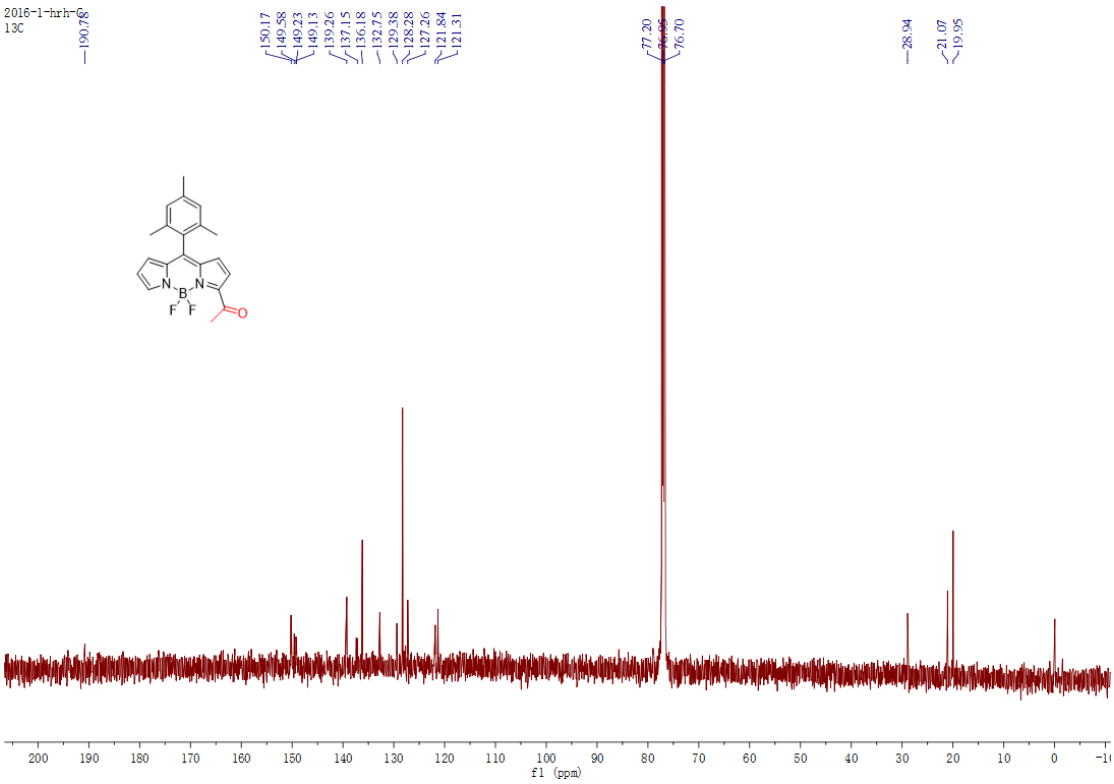


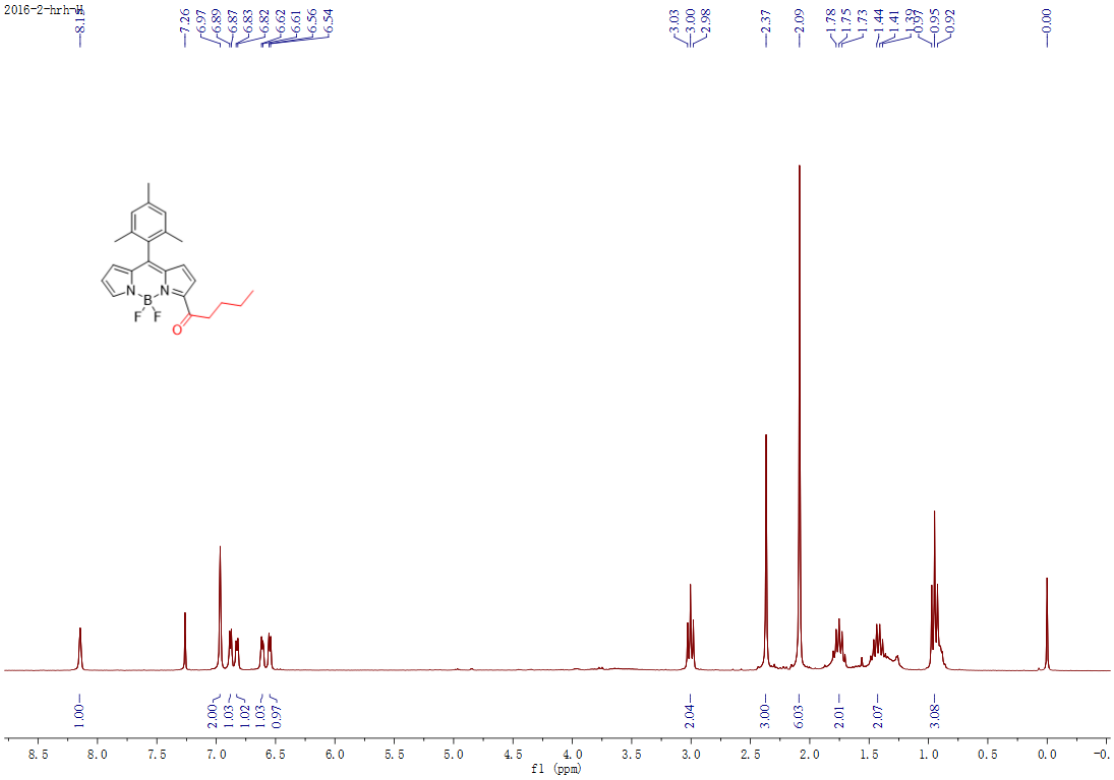
^{1}H NMR spectrum of **4d** in $CDCl_3$



^{13}C NMR spectrum of **4d** in $CDCl_3$



^{1}H NMR spectrum of **4e** in $CDCl_3$



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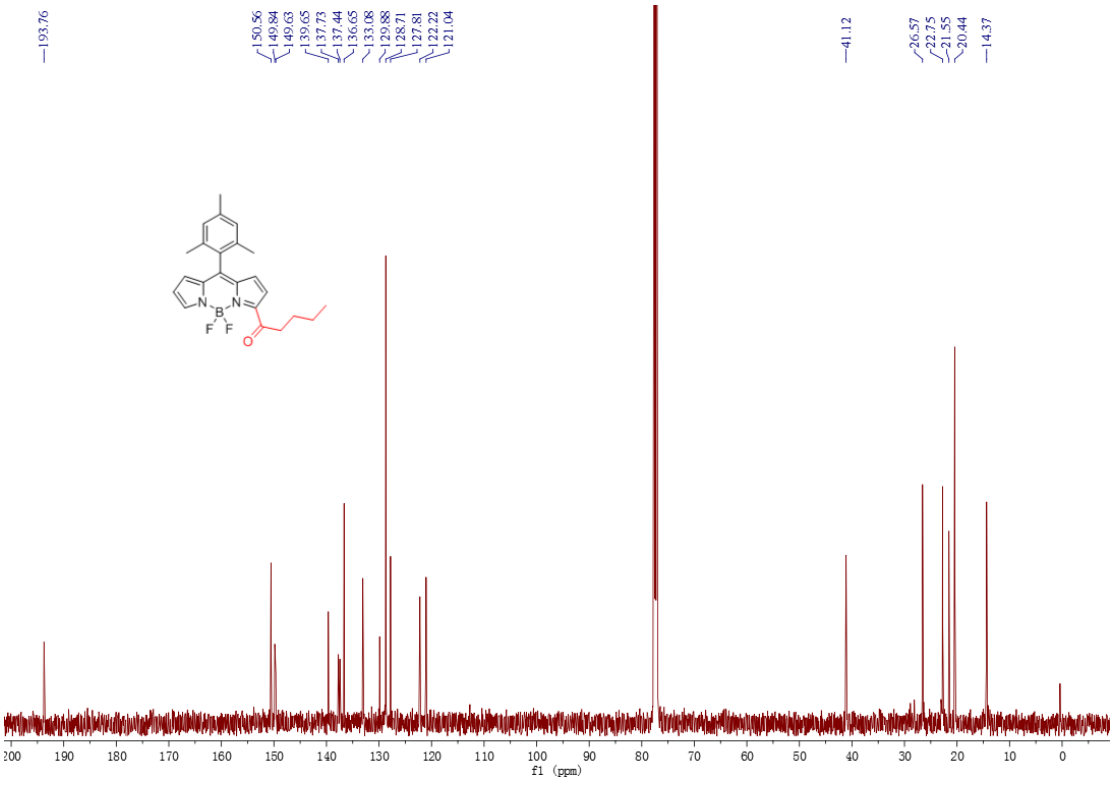
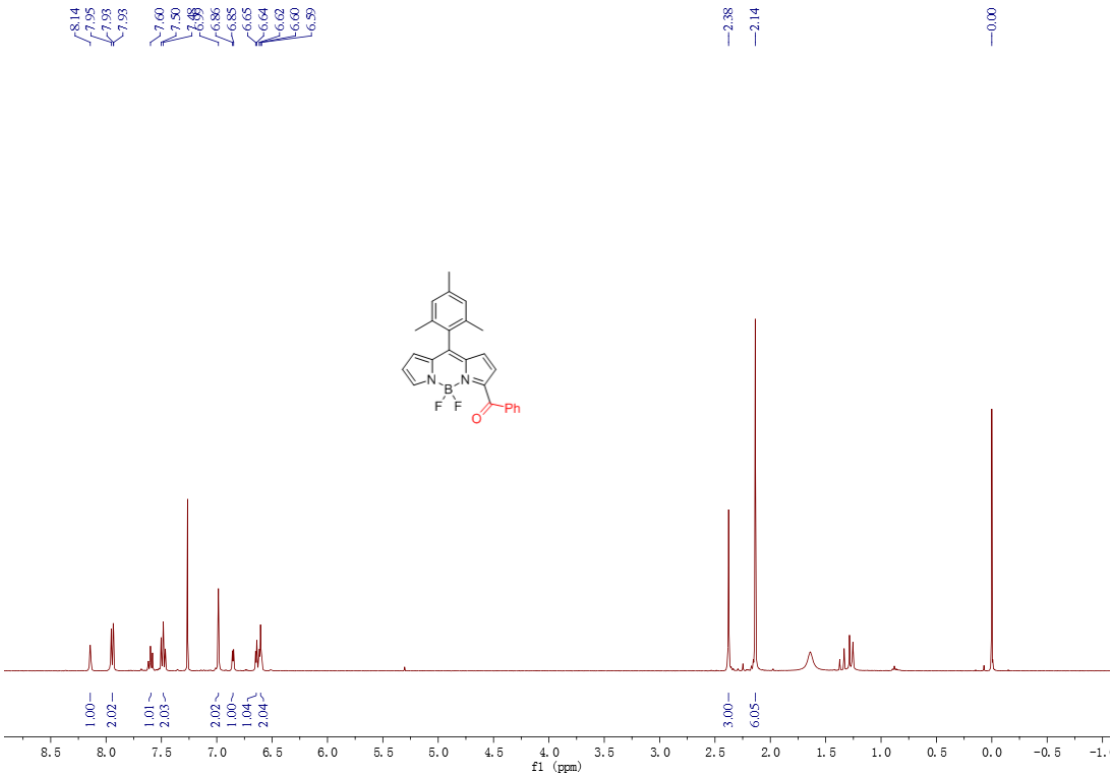
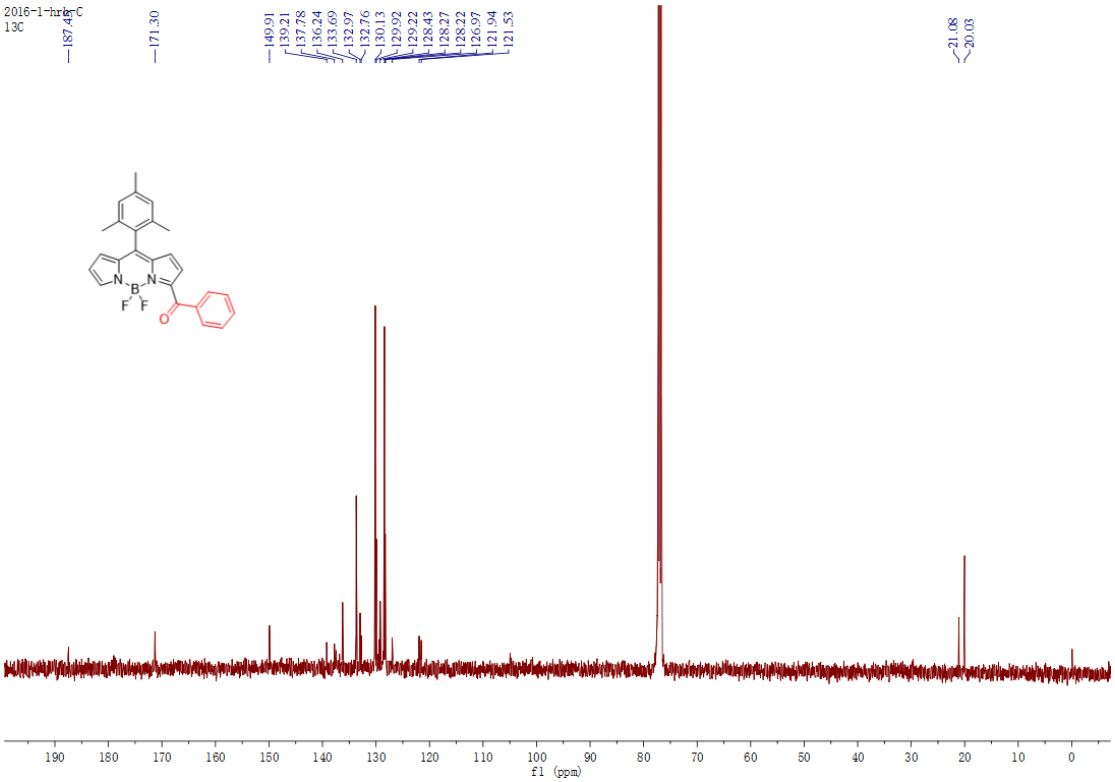


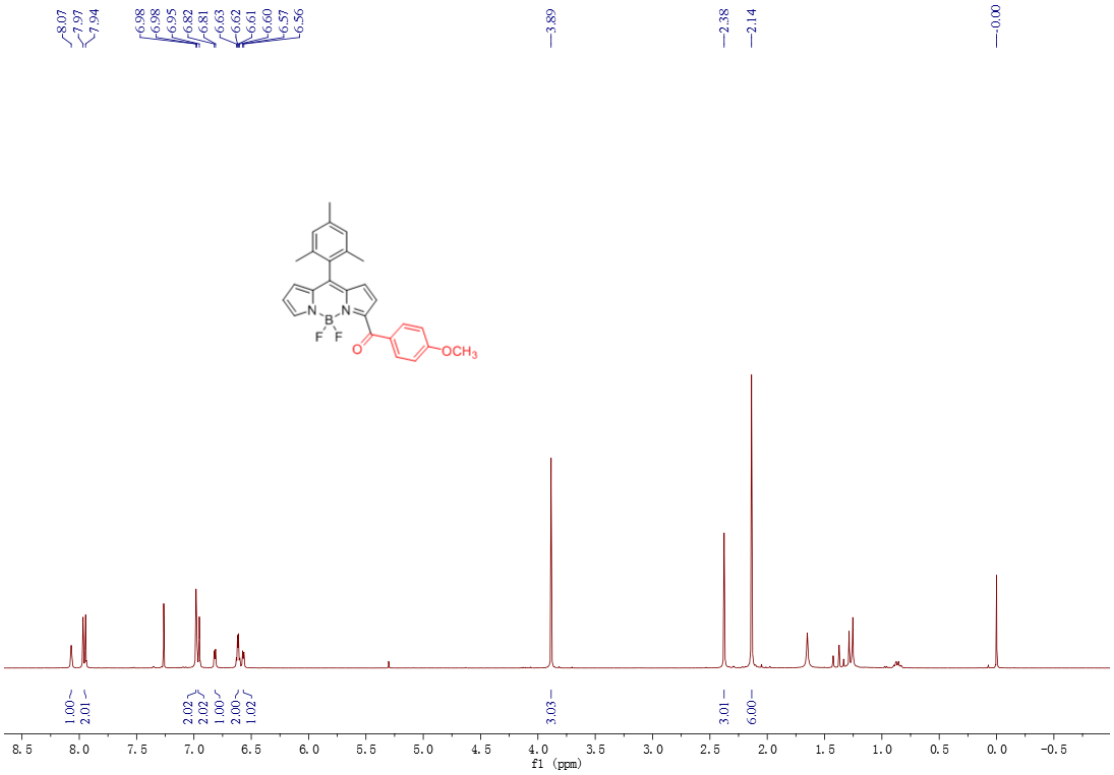
^{1}H NMR spectrum of **4f** in $CDCl_3$



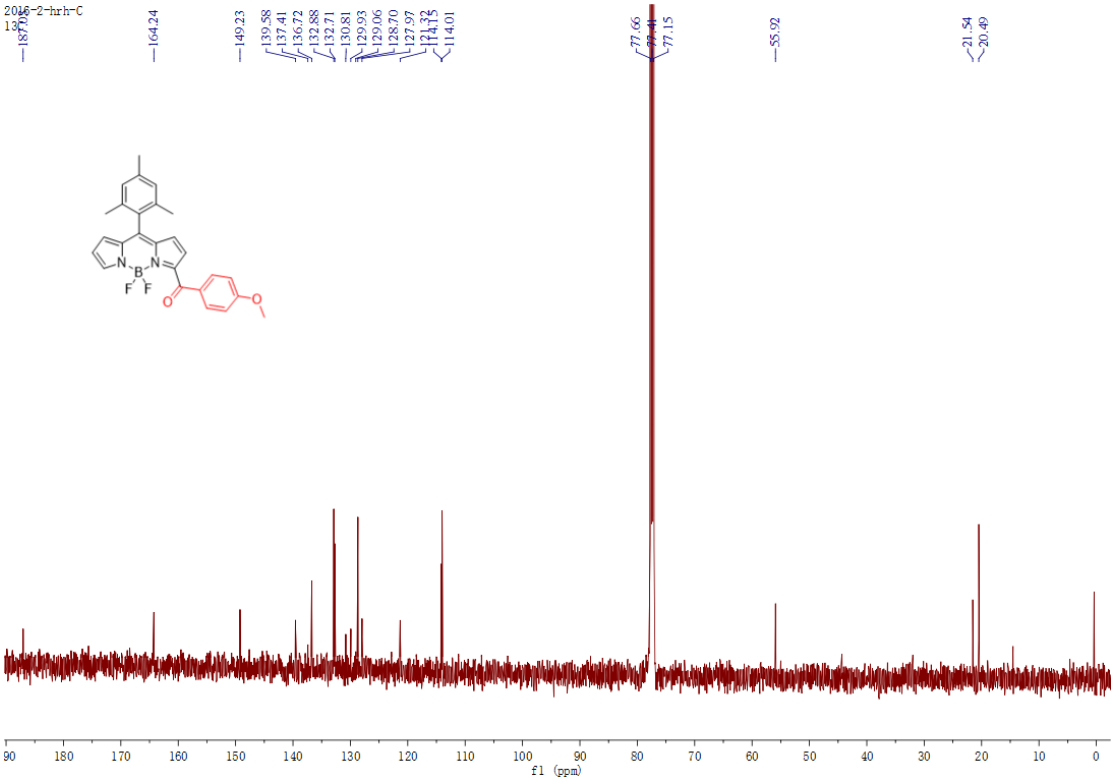
^{13}C NMR spectrum of **4f** in $CDCl_3$



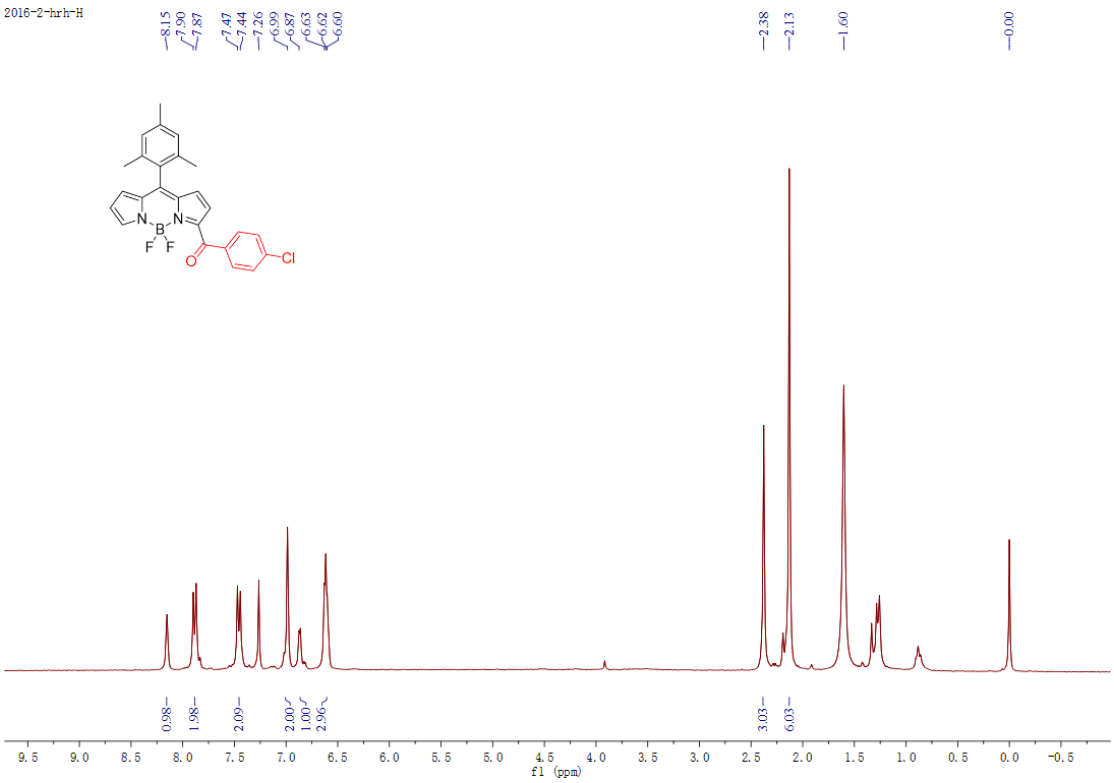
^{1}H NMR spectrum of **4g** in $CDCl_3$



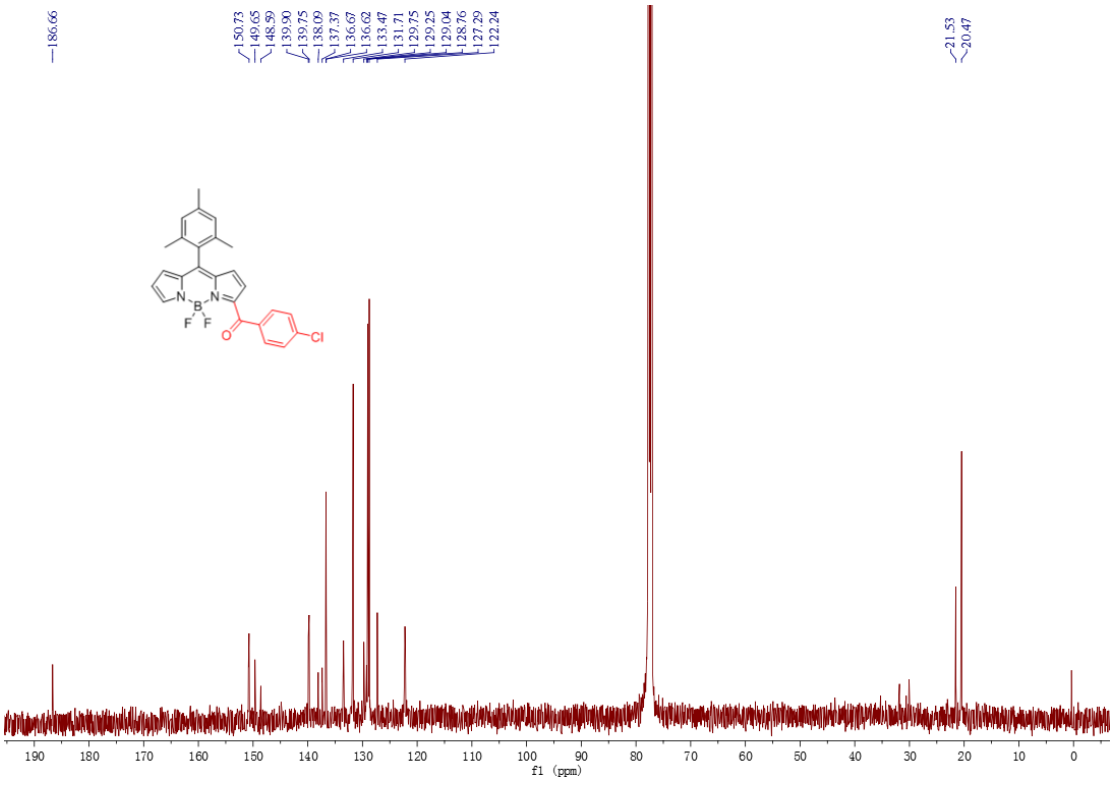
^{13}C NMR spectrum of **4g** in $CDCl_3$



^{1}H NMR spectrum of **4h** in $CDCl_3$



^{13}C NMR spectrum of **4h** in $CDCl_3$



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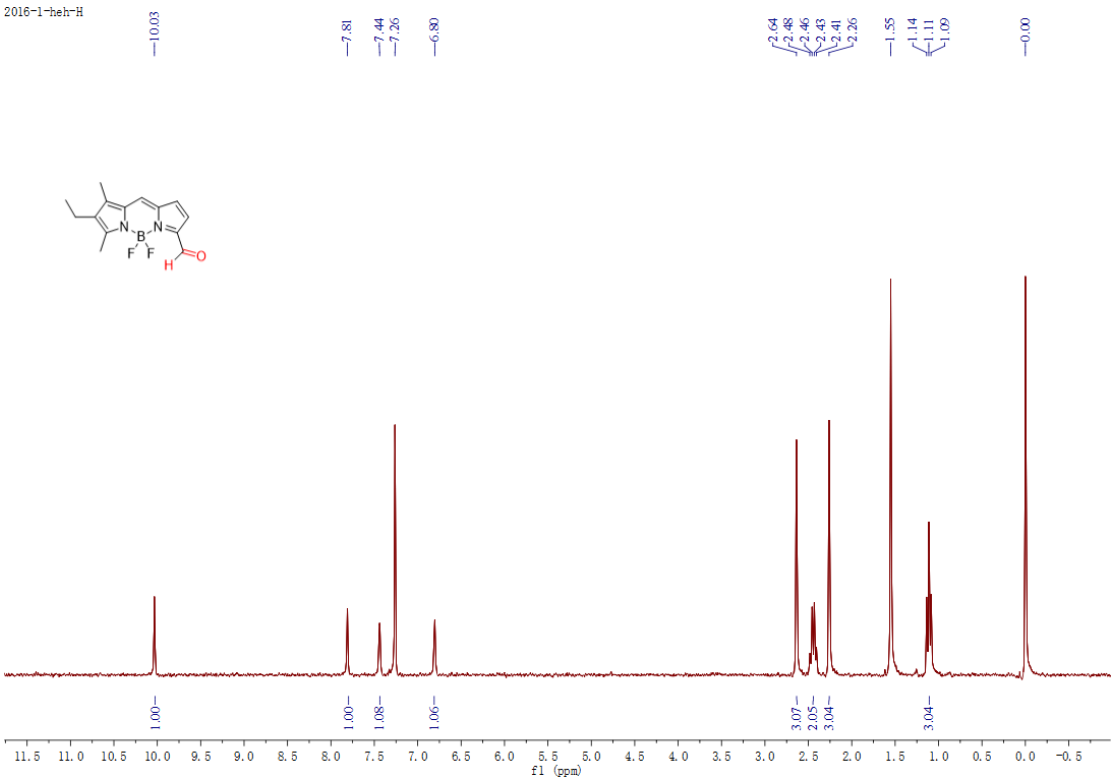
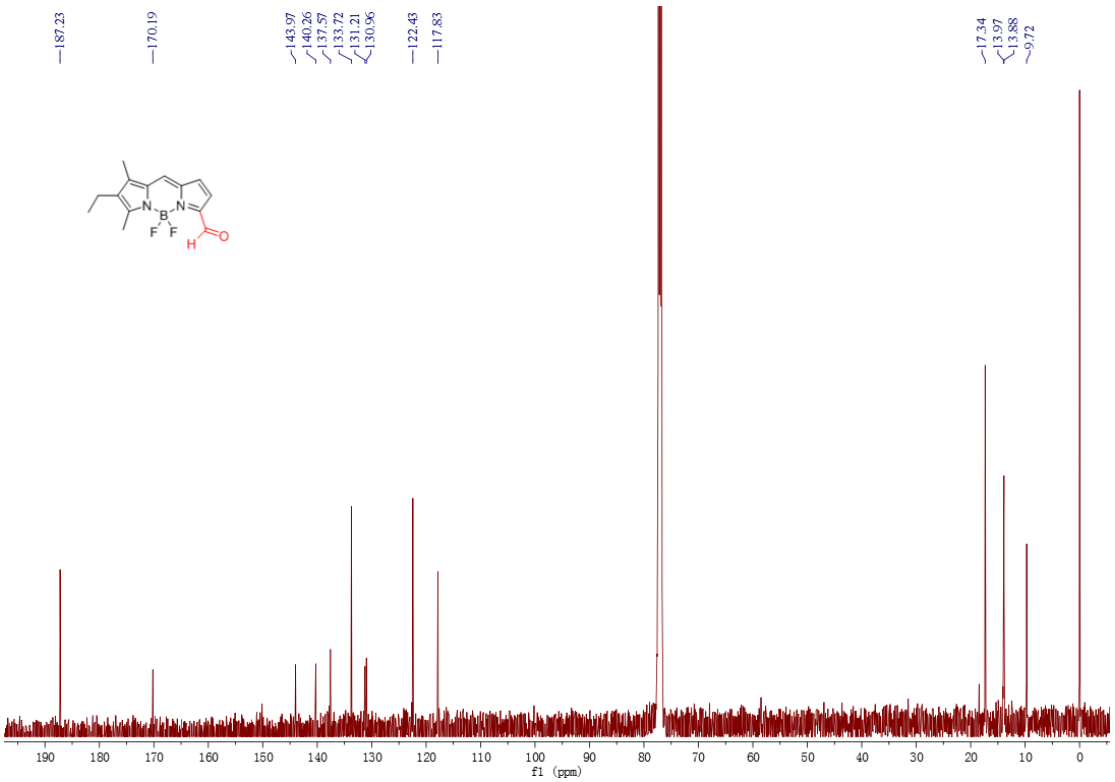
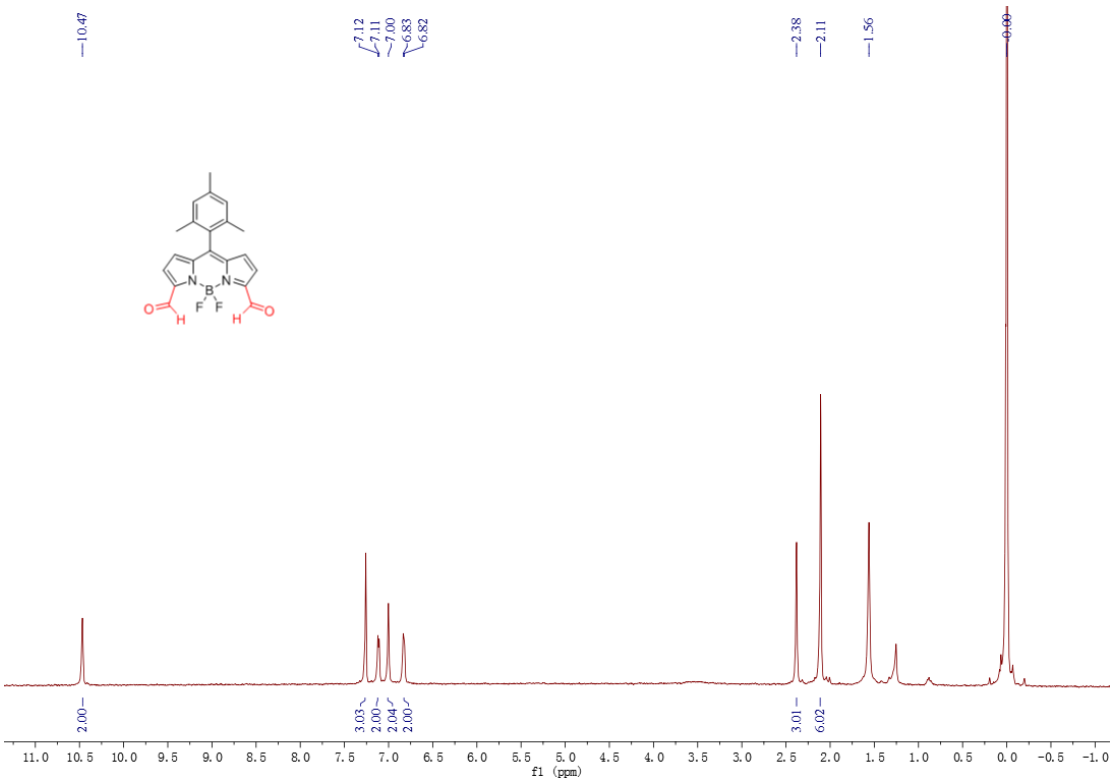


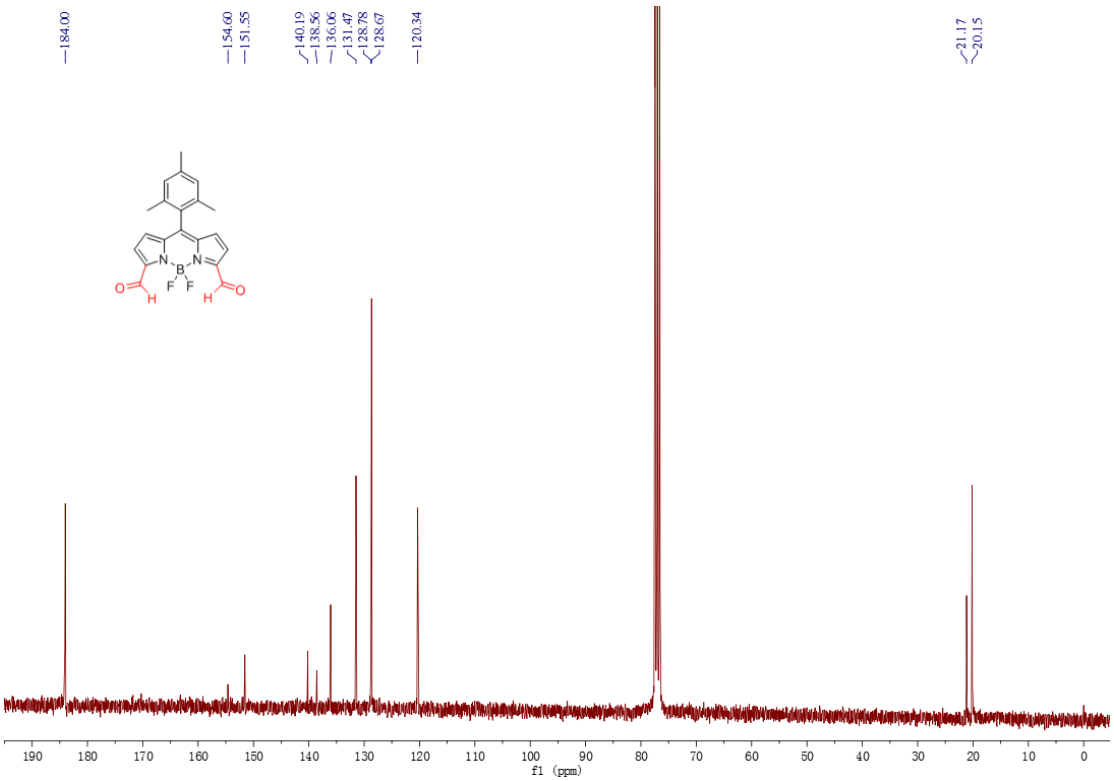
^{13}C NMR spectrum of **4i** in $CDCl_3$



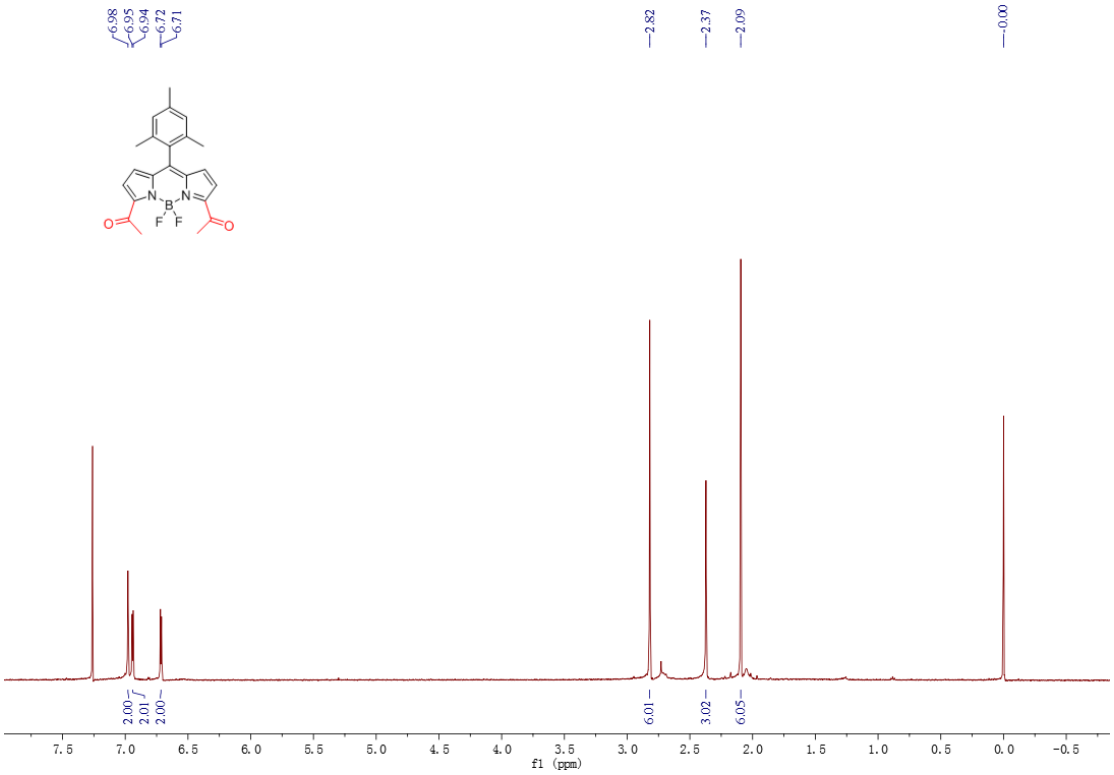
^{1}H NMR spectrum of **5a** in $CDCl_3$



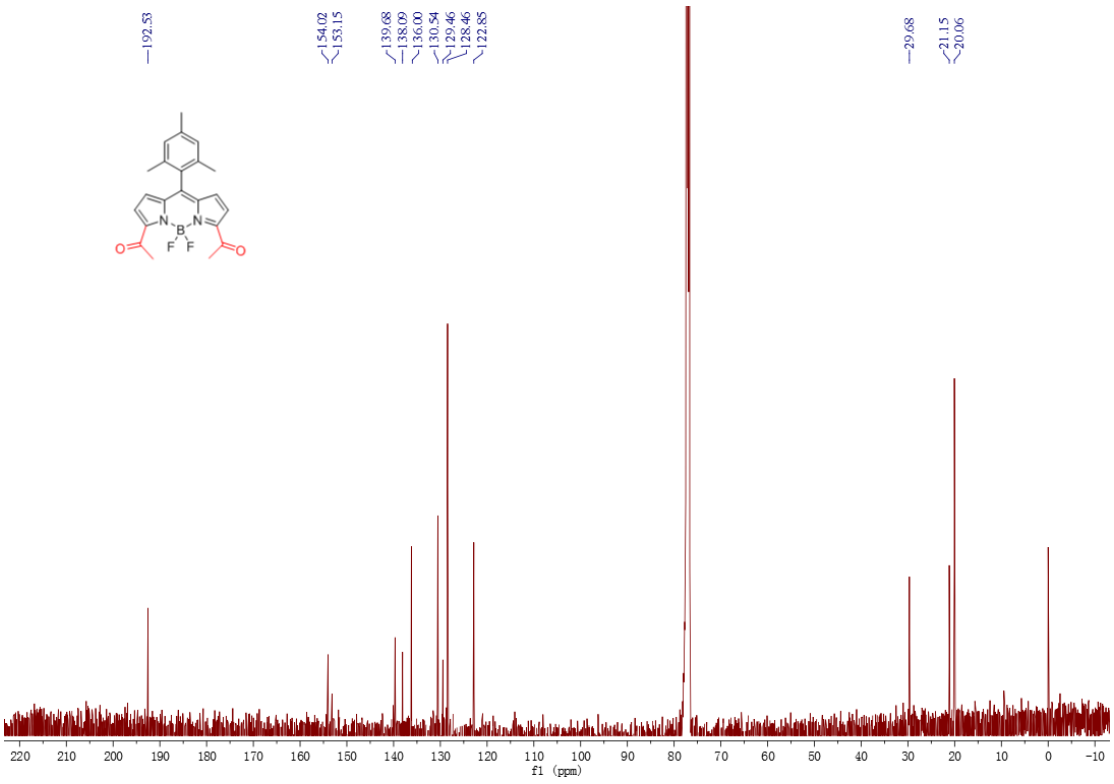
^{13}C NMR spectrum of **5a** in $CDCl_3$



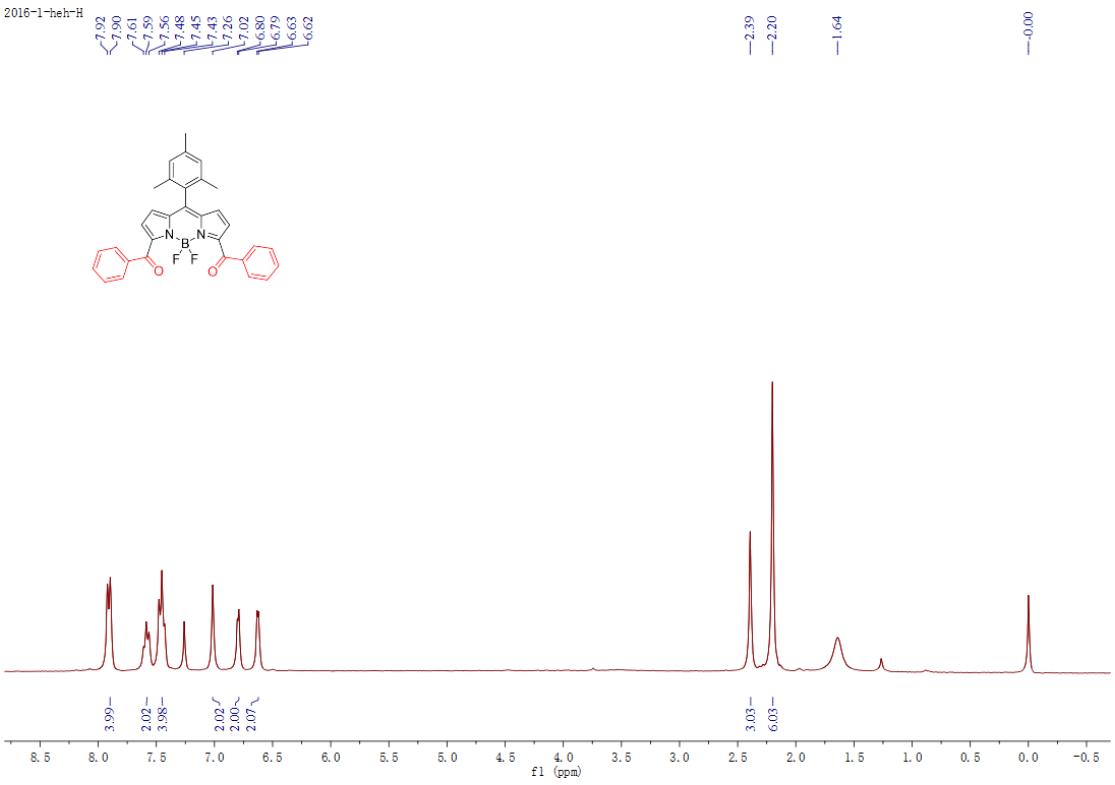
^{1}H NMR spectrum of 5**b** in $CDCl_3$



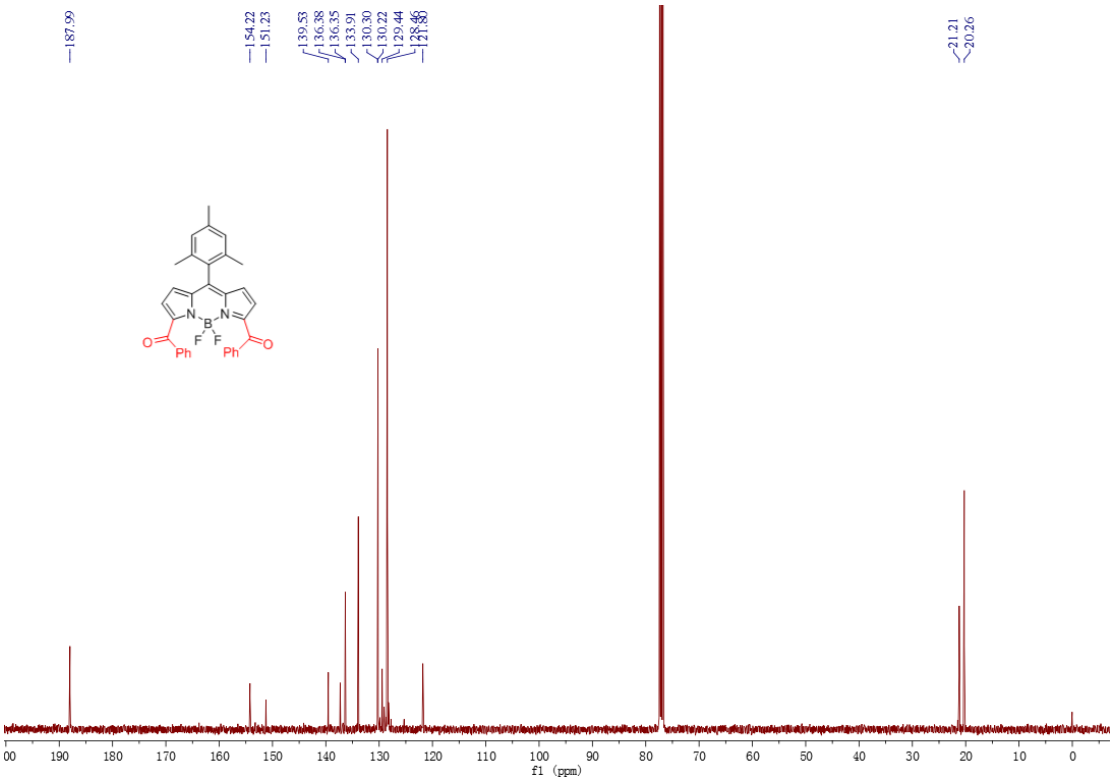
^{13}C NMR spectrum of **5b** in $CDCl_3$



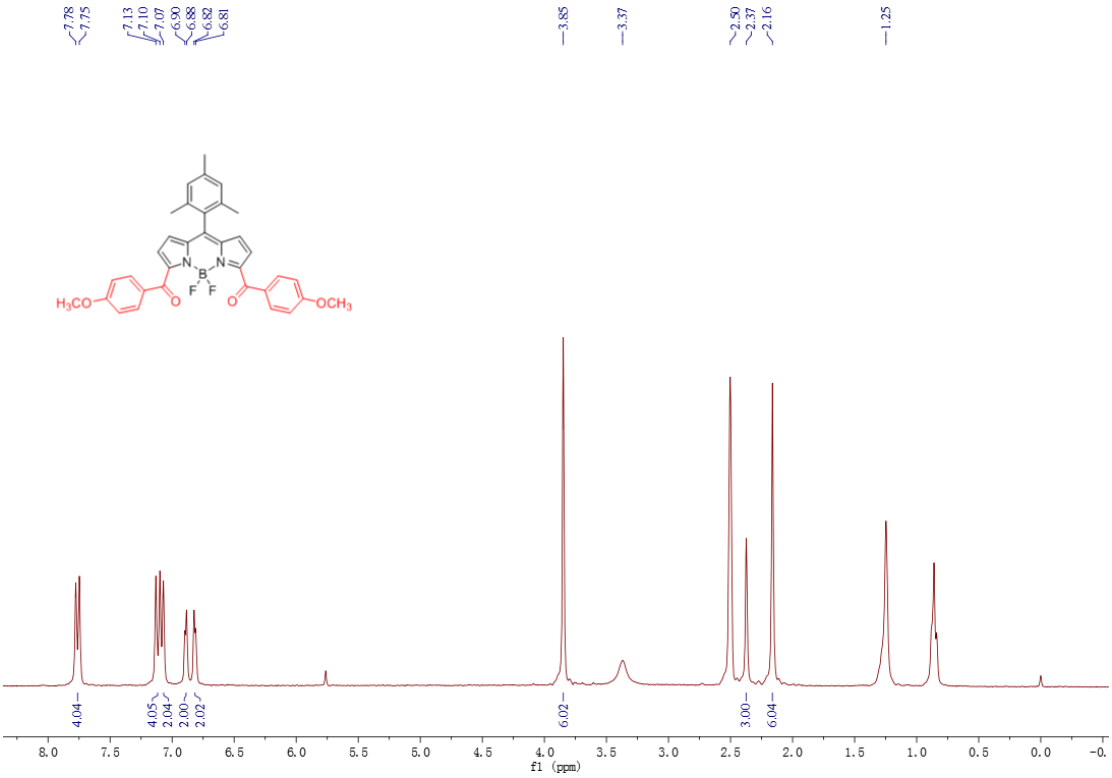
^{1}H NMR spectrum of **5c** in $CDCl_3$



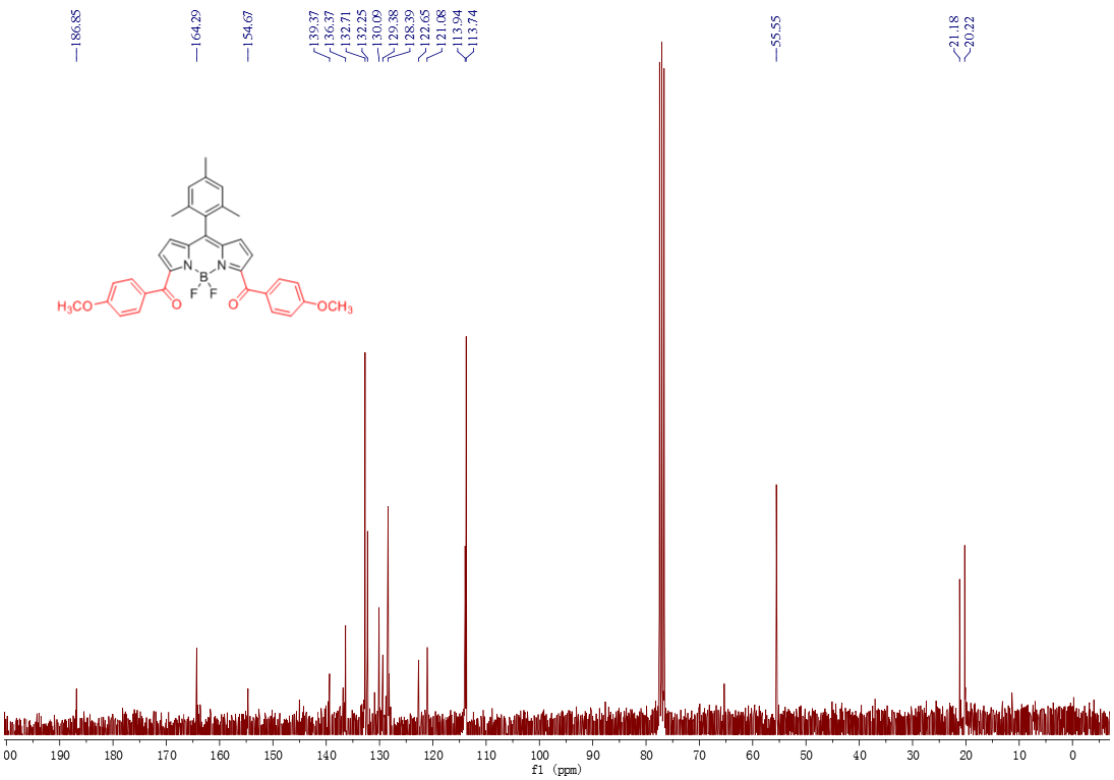
^{13}C NMR spectrum of **5c** in $CDCl_3$



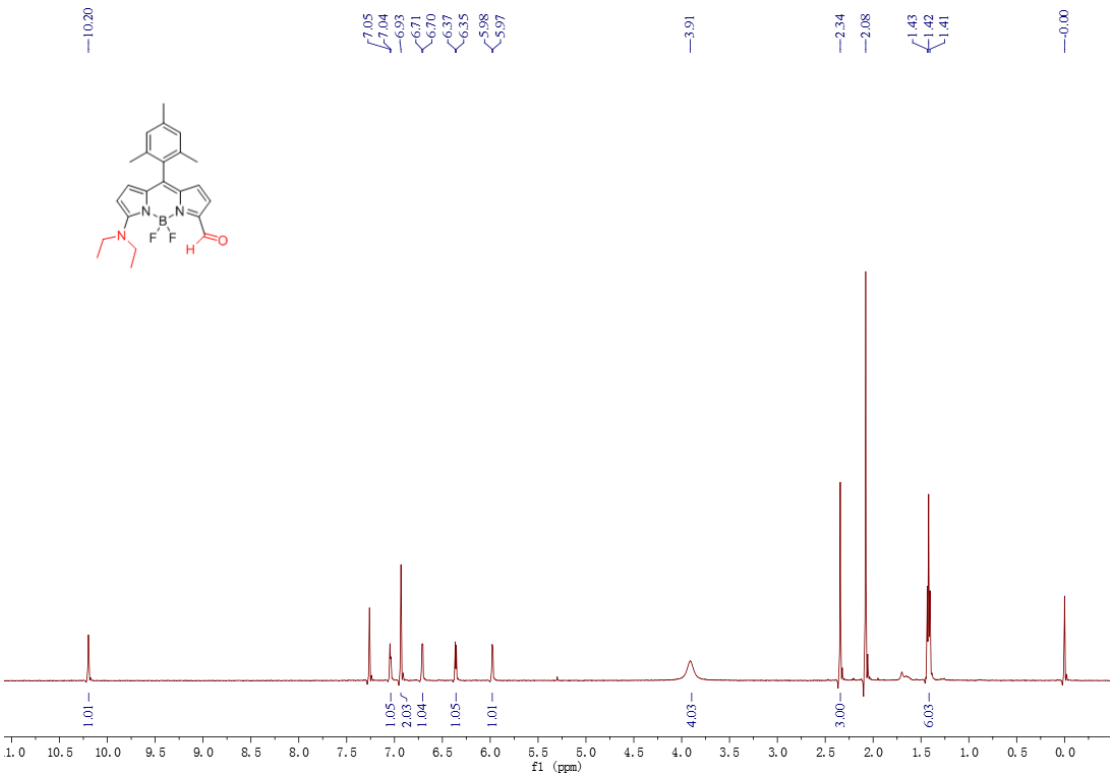
^{1}H NMR spectrum of **5d** in DMSO



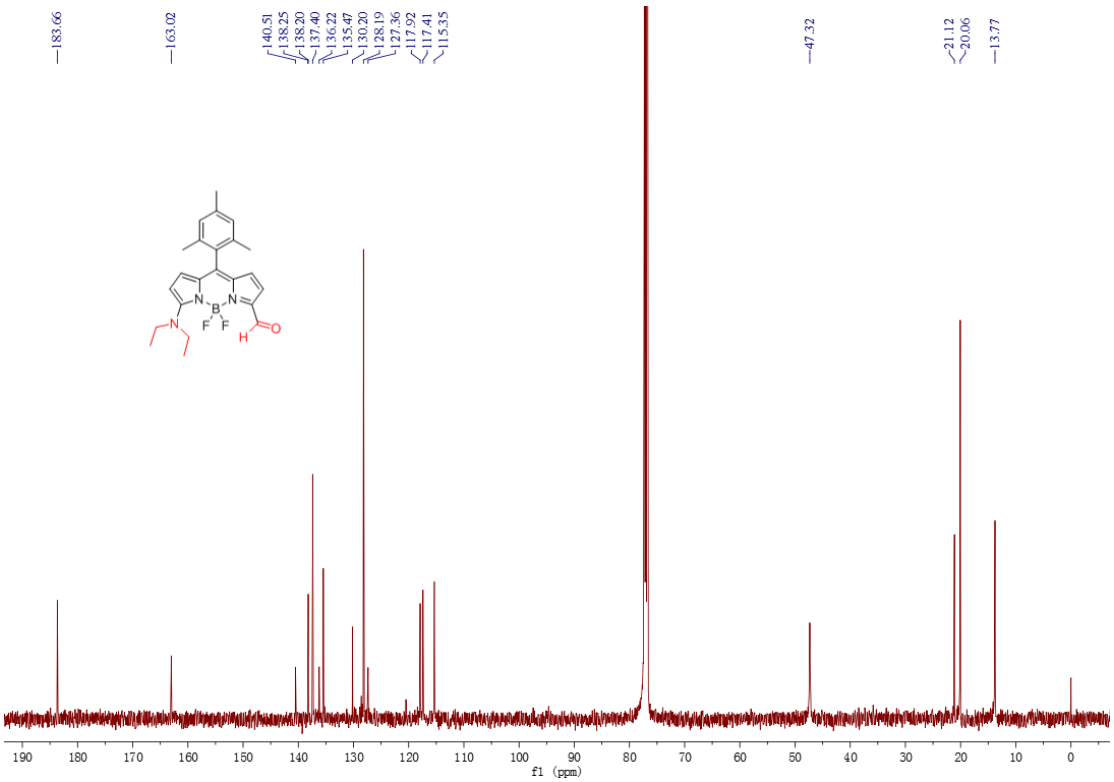
^{13}C NMR spectrum of **5d** in $CDCl_3$



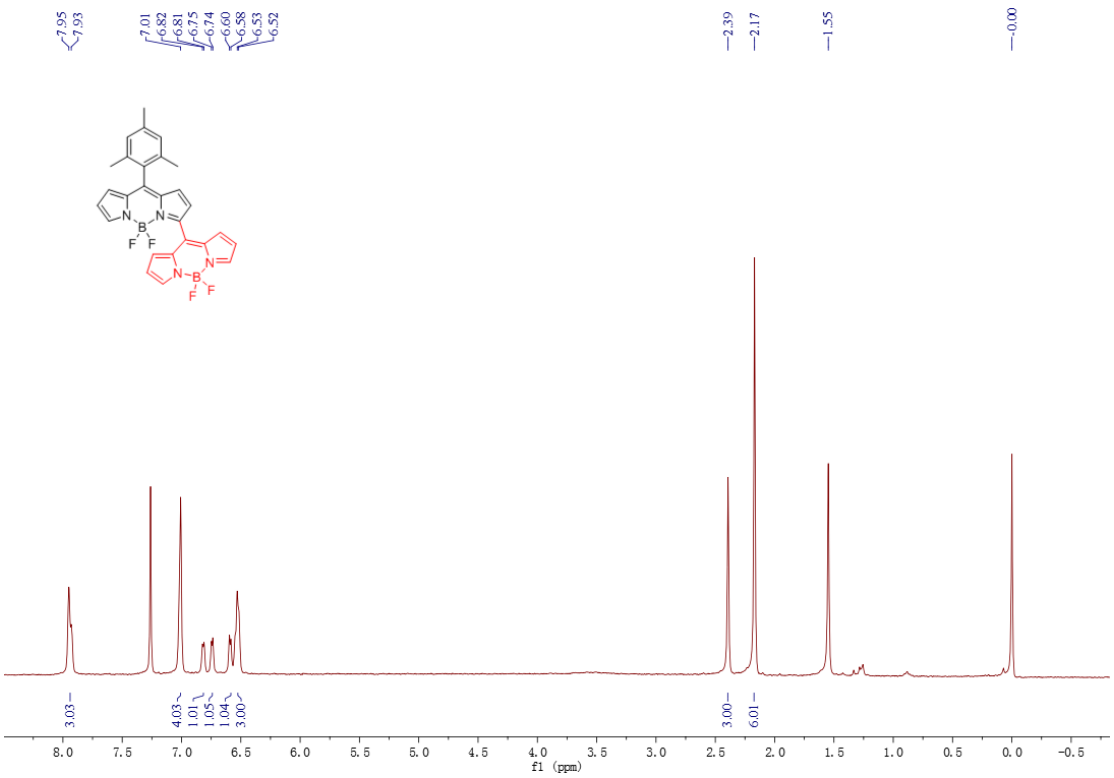
^{1}H NMR spectrum of **6** in $CDCl_3$



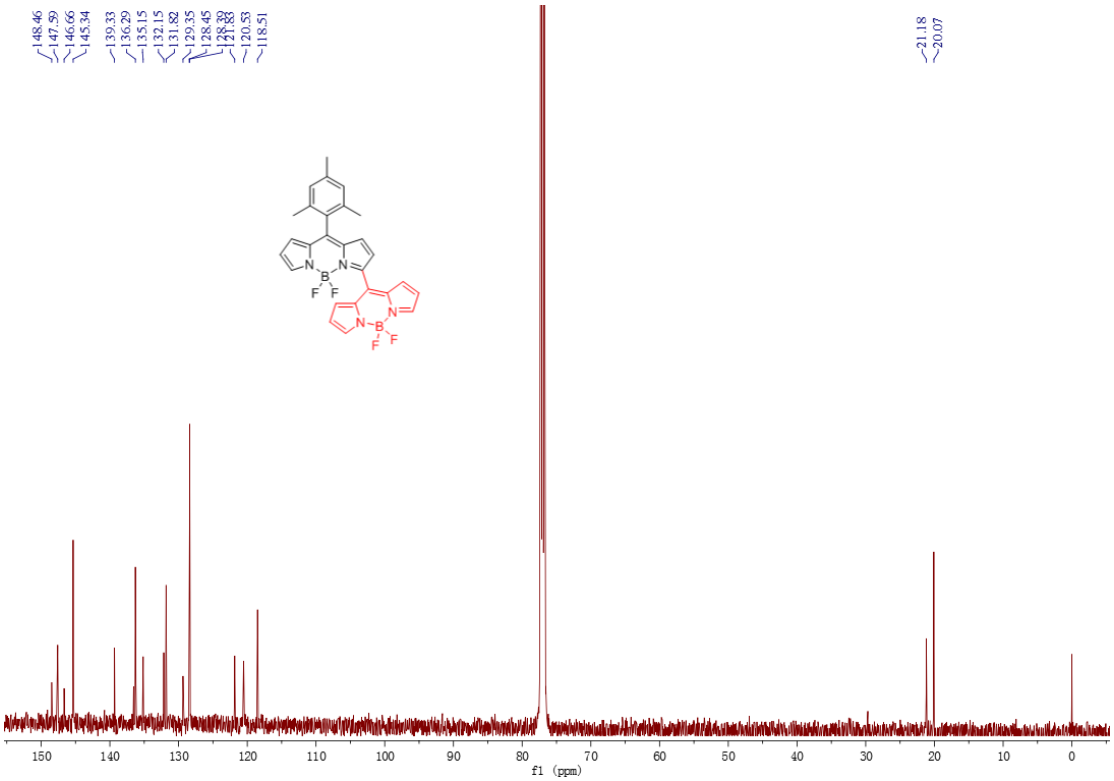
^{13}C NMR spectrum of **6** in $CDCl_3$



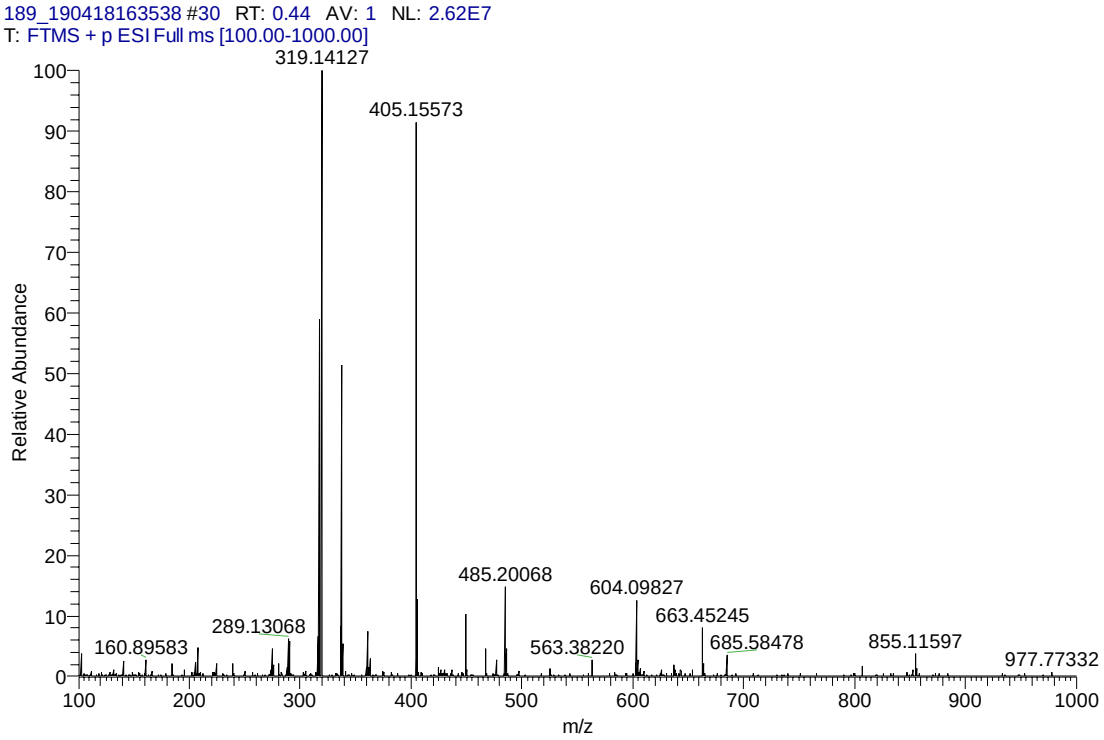
^{1}H NMR spectrum of **7** in $CDCl_3$

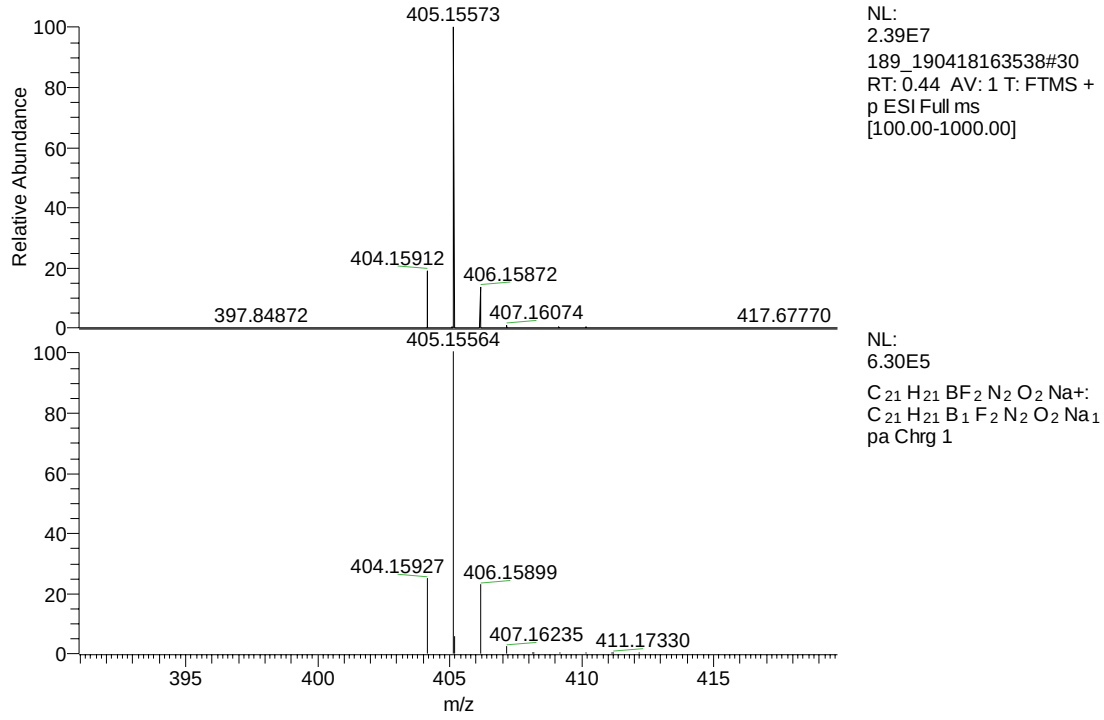


^{13}C NMR spectrum of **7** in $CDCl_3$

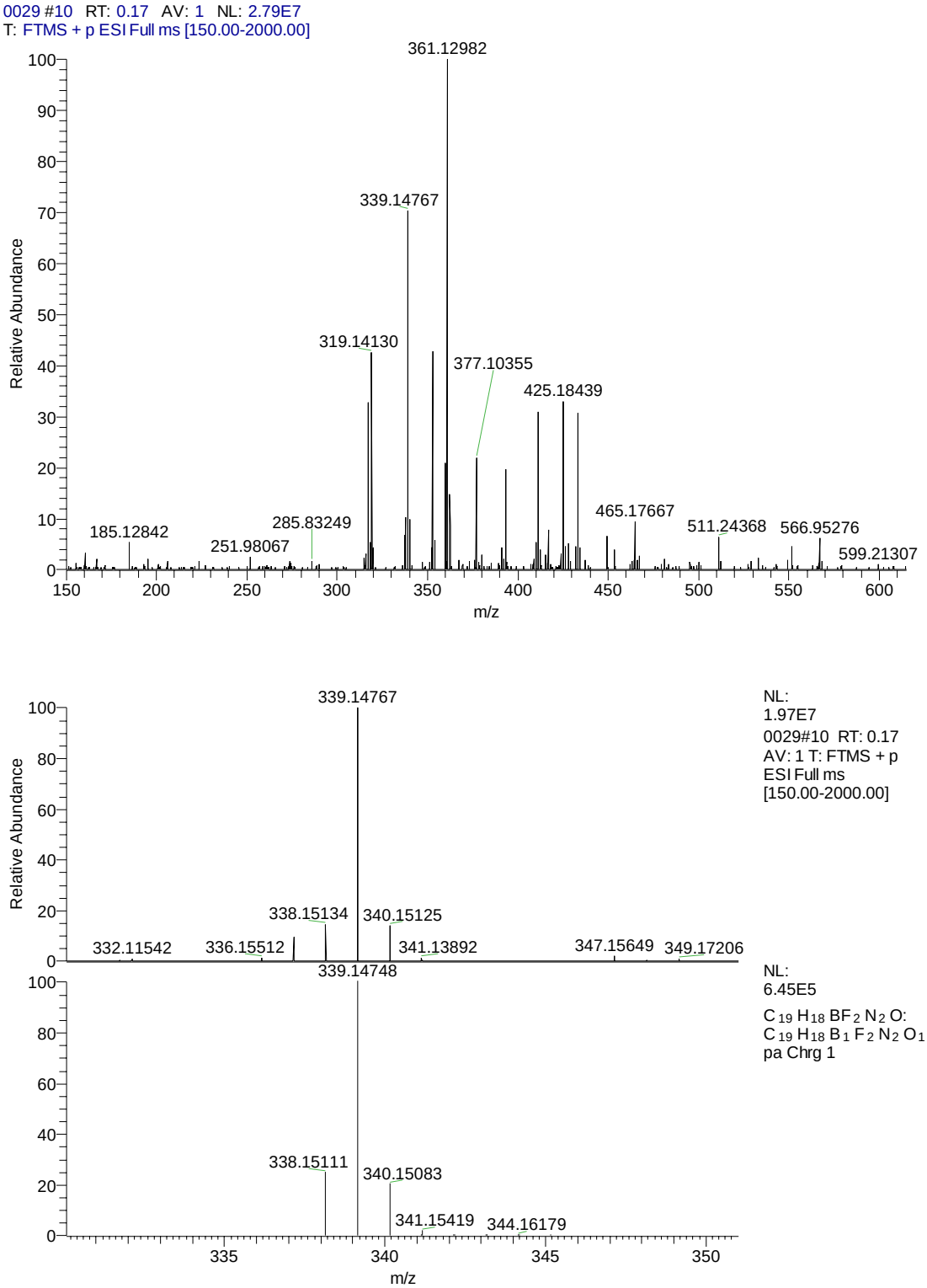


HRMS for **3a**

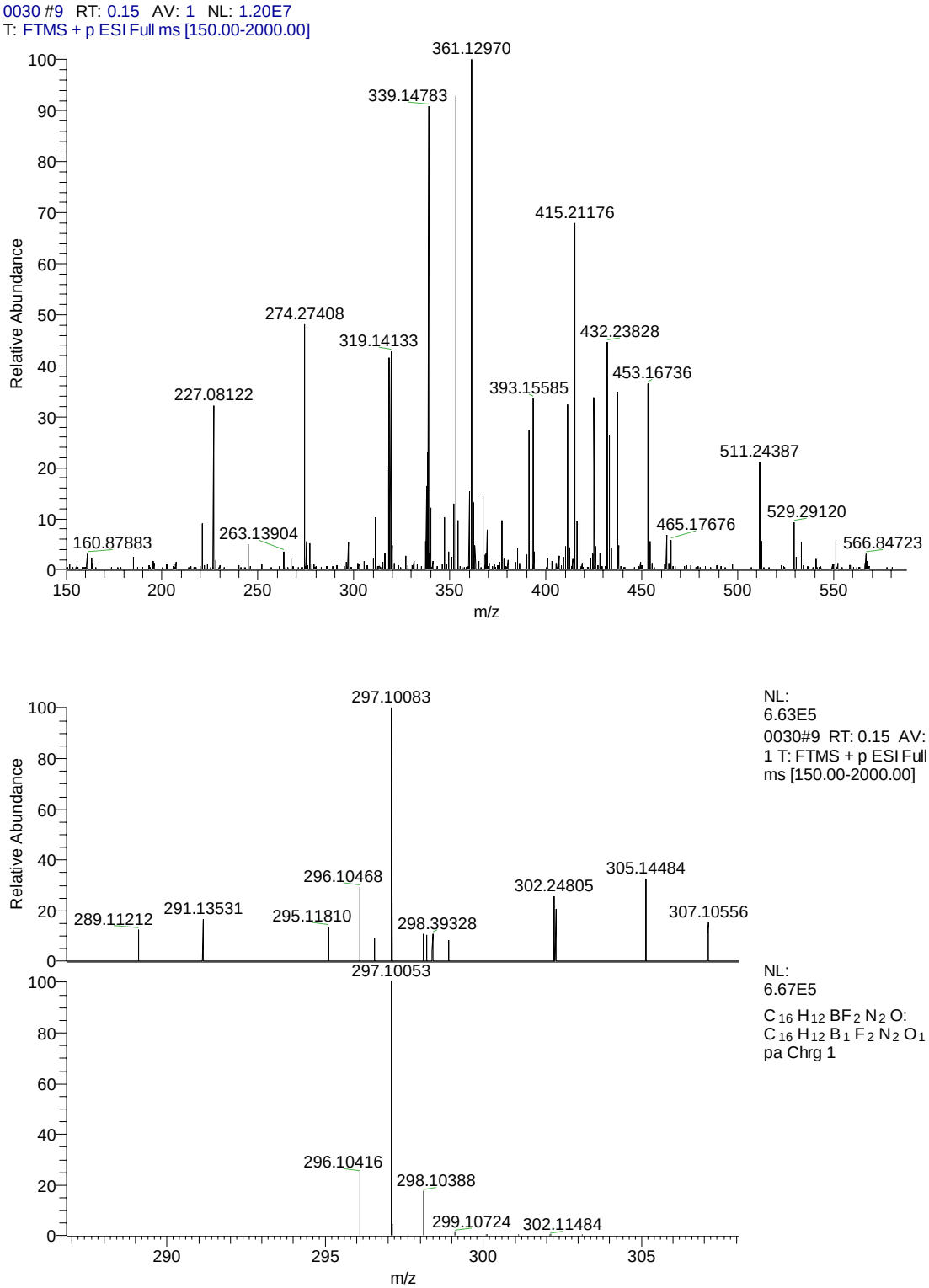

189_190418163538 #30 RT: 0.44 AV: 1 NL: 2.62E7
T: FTMS + p ESI Full ms [100.00-1000.00]
319.14127
405.15573
485.20068
604.09827
663.45245
289.13068
160.89583
563.38220
685.58478
855.11597
977.77332
Relative Abundance
m/z


405.15573
404.15912
406.15872
397.84872
407.16074
417.67770
NL:
2.39E7
189_190418163538#30
RT: 0.44 AV: 1 T: FTMS +
p ESI Full ms
[100.00-1000.00]
405.15564
404.15927
406.15899
407.16235
411.17330
NL:
6.30E5
C21 H21 BF2 N2 O2 Na+:
C21 H21 B1 F2 N2 O2 Na1
pa Chrg 1
Relative Abundance
m/z

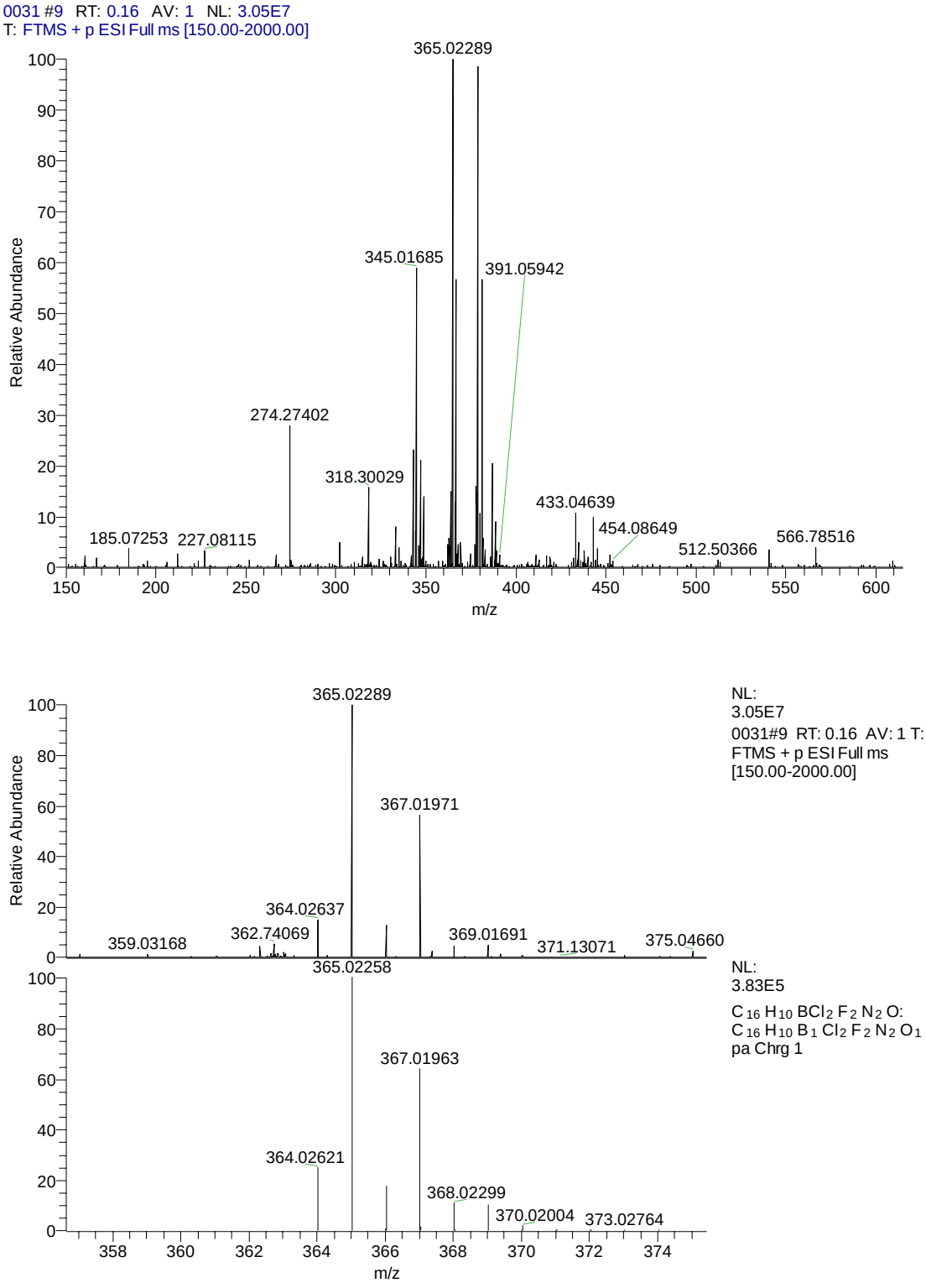
HRMS for **4a**


0029 #10 RT: 0.17 AV: 1 NL: 2.79E7
T: FTMS + p ESI Full ms [150.00-2000.00]
361.12982
339.14767
319.14130
377.10355
425.18439
465.17667
511.24368
566.95276
599.21307
285.83249
185.12842
251.98067
Relative Abundance
m/z
339.14767
338.15134
340.15125
332.11542
336.15512
341.13892
347.15649
349.17206
NL:
1.97E7
0029#10 RT: 0.17
AV: 1 T: FTMS + p
ESI Full ms
[150.00-2000.00]
339.14748
338.15111
340.15083
341.15419
344.16179
NL:
6.45E5
C19 H18 BF2 N2 O:
C19 H18 B1 F2 N2 O1
pa Chrg 1
Relative Abundance
m/z

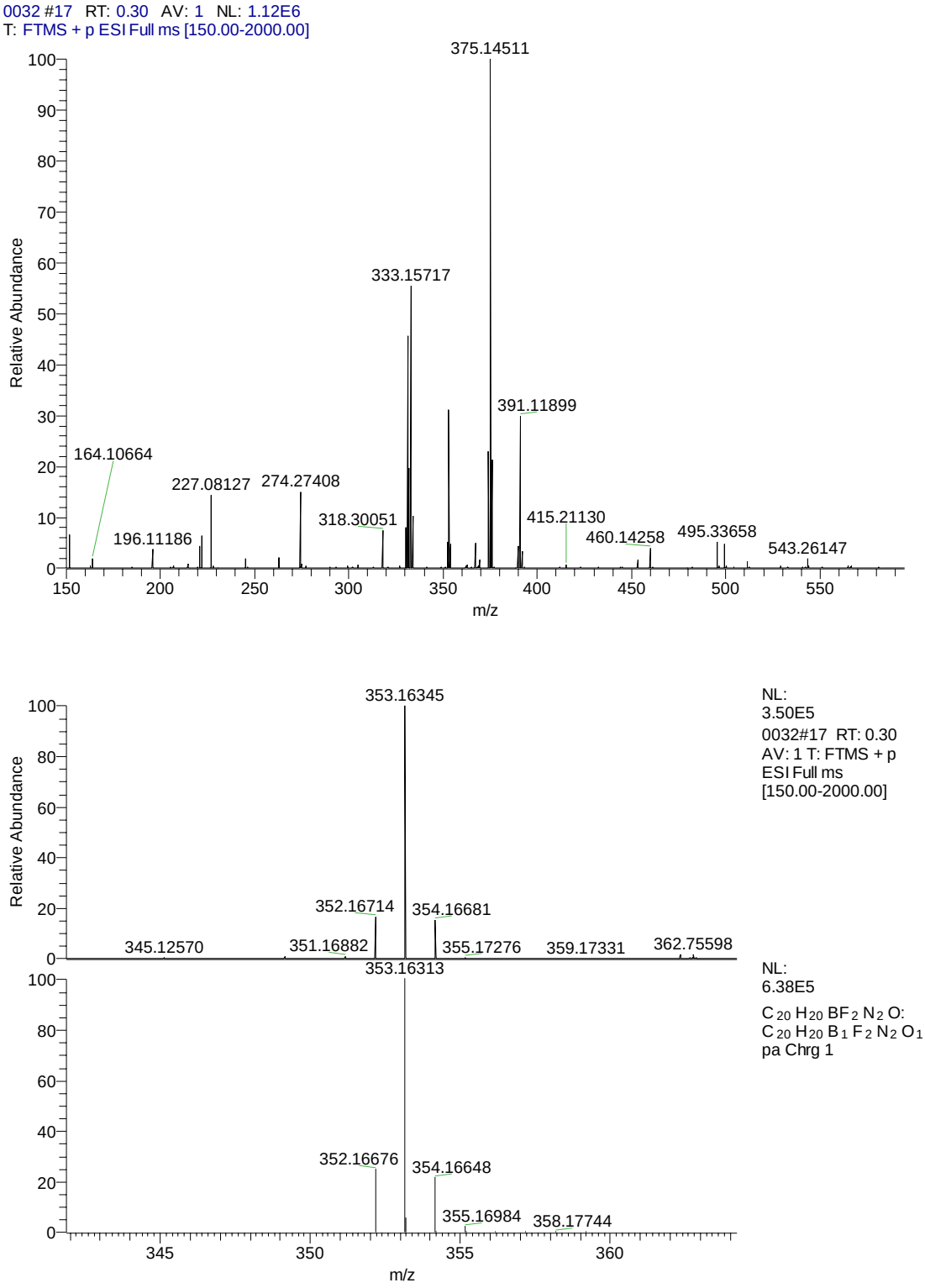
HRMS for **4b**


0030 #9 RT: 0.15 AV: 1 NL: 1.20E7
T: FTMS + p ESI Full ms [150.00-2000.00]
361.12970
339.14783
415.21176
274.27408
319.14133
432.23828
453.16736
227.08122
393.15585
511.24387
529.29120
465.17676
160.87883
263.13904
566.84723
Relative Abundance
m/z
297.10083
296.10468
305.14484
302.24805
289.11212
291.13531
295.11810
298.39328
307.10556
NL:
6.63E5
0030#9 RT: 0.15 AV:
1 T: FTMS + p ESI Full
ms [150.00-2000.00]
297.10053
296.10416
298.10388
299.10724
302.11484
NL:
6.67E5
C 16 H 12 BF 2 N 2 O:
C 16 H 12 B 1 F 2 N 2 O 1
pa Chrg 1

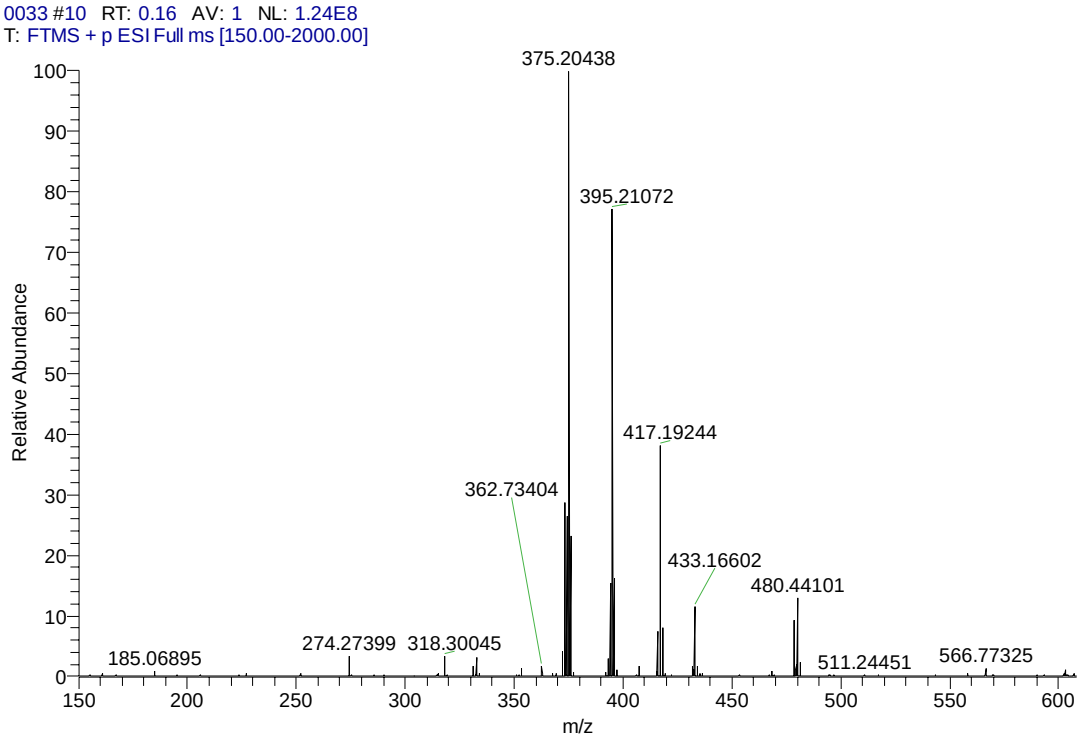
HRMS for **4c**

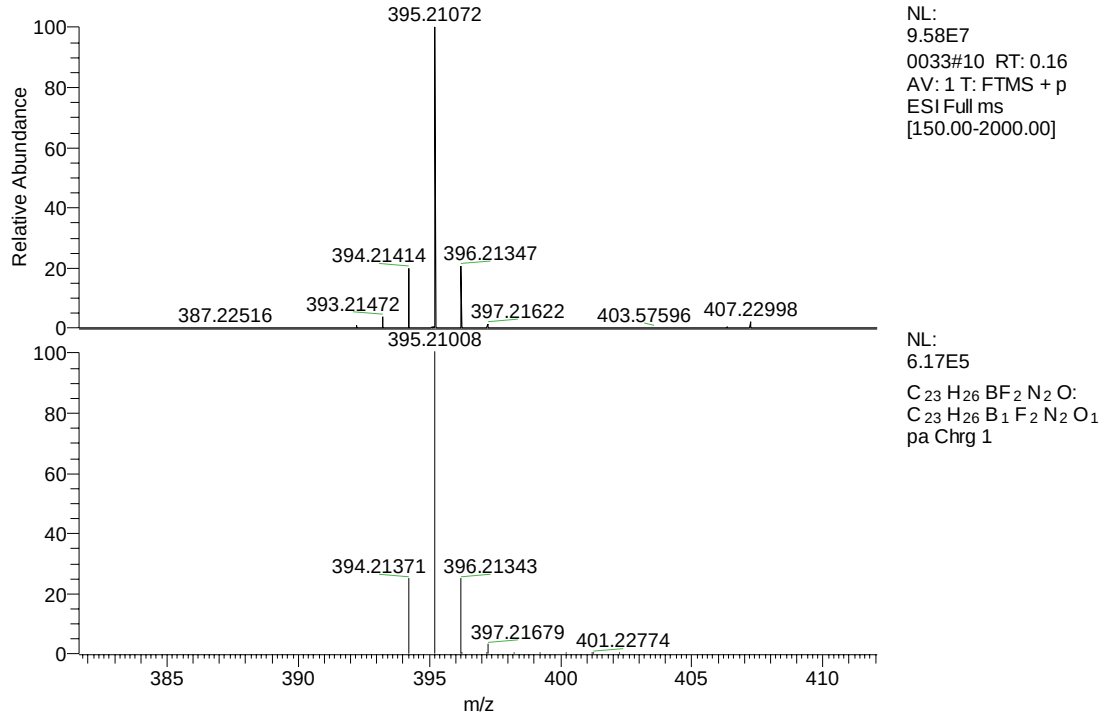

0031 #9 RT: 0.16 AV: 1 NL: 3.05E7
T: FTMS + p ESI Full ms [150.00-2000.00]
365.02289
345.01685
391.05942
274.27402
318.30029
433.04639
454.08649
512.50366
566.78516
185.07253
227.08115
Relative Abundance
m/z
365.02289
367.01971
364.02637
362.74069
359.03168
369.01691
371.13071
375.04660
NL:
3.05E7
0031#9 RT: 0.16 AV: 1 T:
FTMS + p ESI Full ms
[150.00-2000.00]
365.02258
367.01963
364.02621
368.02299
370.02004
373.02764
NL:
3.83E5
C16 H10 BCl2 F2 N2 O:
C16 H10 B1 Cl2 F2 N2 O1
pa Chrg 1

HRMS for **4d**

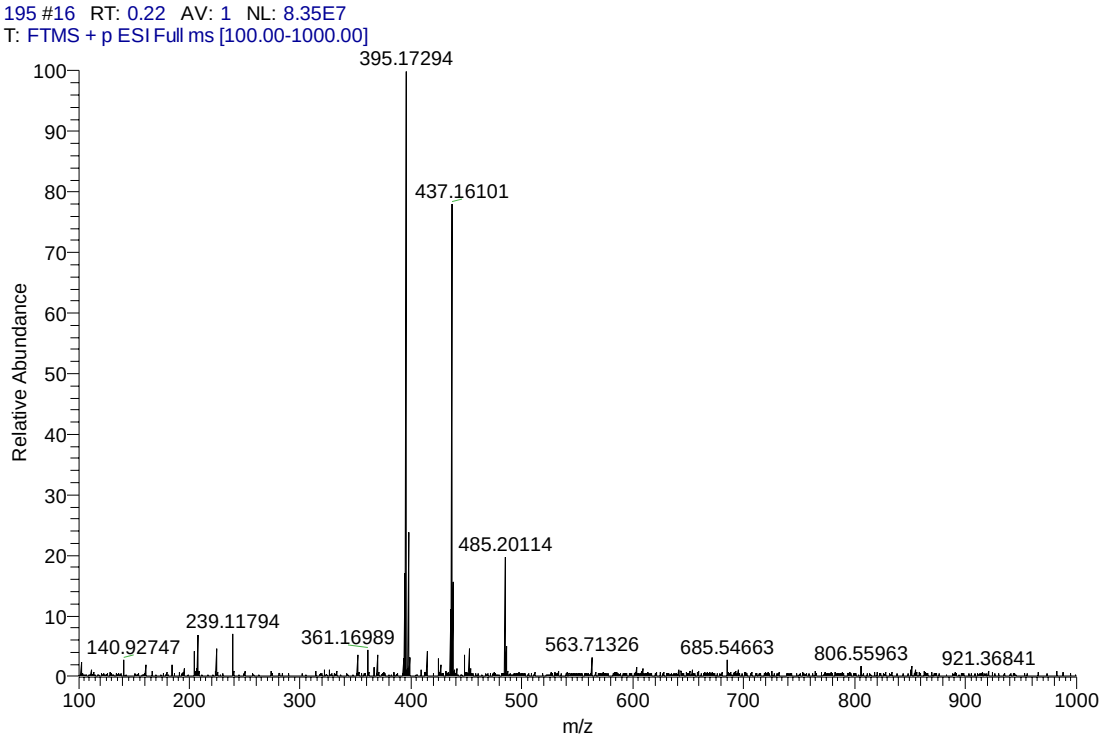

0032 #17 RT: 0.30 AV: 1 NL: 1.12E6
T: FTMS + p ESI Full ms [150.00-2000.00]
375.14511
333.15717
391.11899
164.10664
227.08127
274.27408
318.30051
415.21130
196.11186
460.14258
495.33658
543.26147
Relative Abundance
m/z
353.16345
352.16714
354.16681
345.12570
351.16882
355.17276
359.17331
362.75598
353.16313
352.16676
354.16648
355.16984
358.17744
NL:
3.50E5
0032#17 RT: 0.30
AV: 1 T: FTMS + p
ESI Full ms
[150.00-2000.00]
NL:
6.38E5
C20 H20 BF2 N2 O:
C20 H20 B1 F2 N2 O1
pa Chrg 1

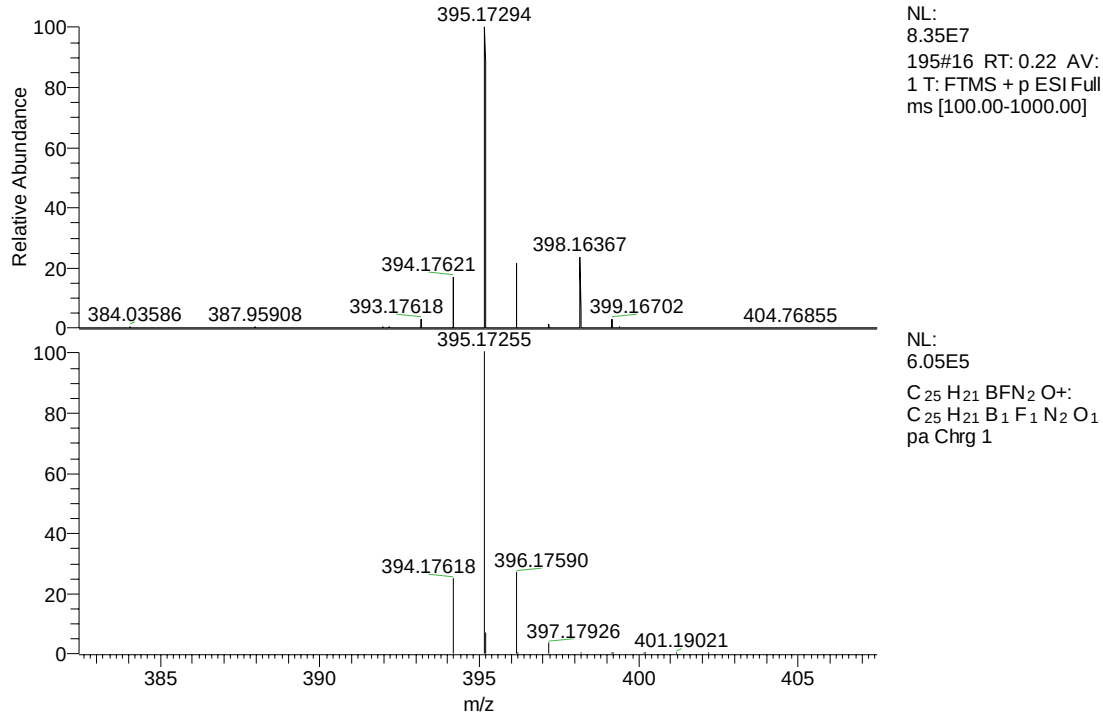
HRMS for **4e**


0033 #10 RT: 0.16 AV: 1 NL: 1.24E8
T: FTMS + p ESI Full ms [150.00-2000.00]
375.20438
395.21072
417.19244
362.73404
433.16602
480.44101
274.27399
318.30045
185.06895
511.24451
566.77325
Relative Abundance
m/z

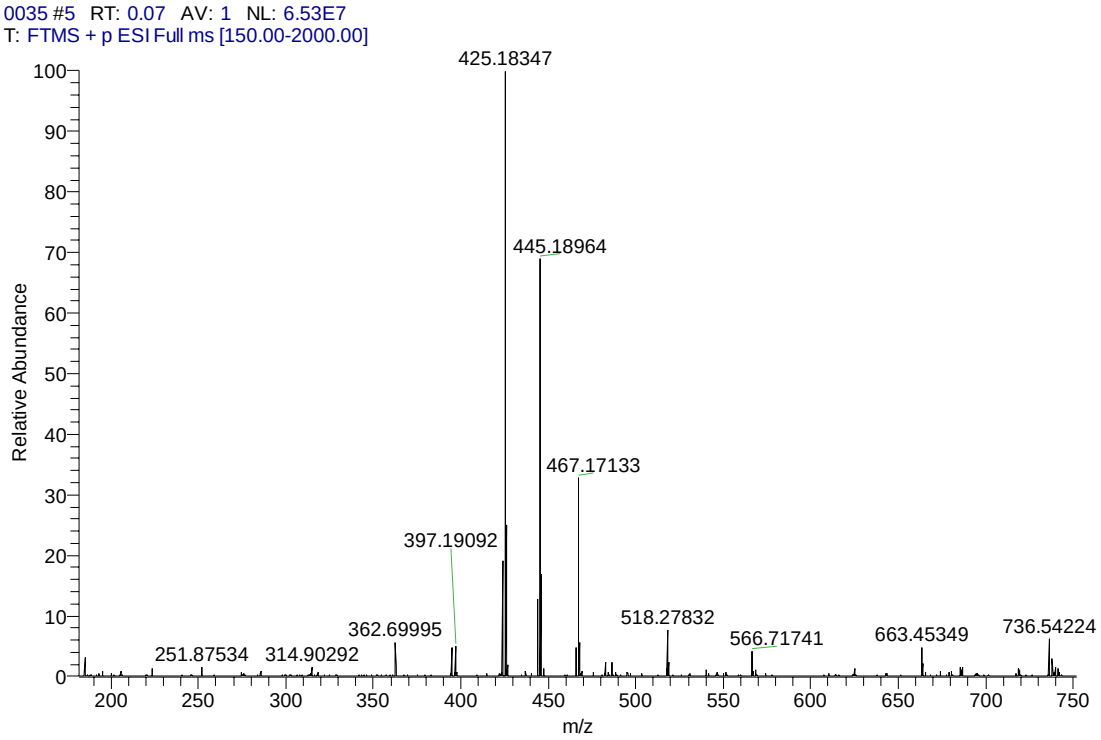

395.21072
394.21414
396.21347
387.22516
393.21472
397.21622
403.57596
407.22998
NL:
9.58E7
0033#10 RT: 0.16
AV: 1 T: FTMS + p
ESI Full ms
[150.00-2000.00]
395.21008
394.21371
396.21343
397.21679
401.22774
NL:
6.17E5
C 23 H 26 BF 2 N 2 O:
C 23 H 26 B 1 F 2 N 2 O 1
pa Chrg 1
Relative Abundance
m/z

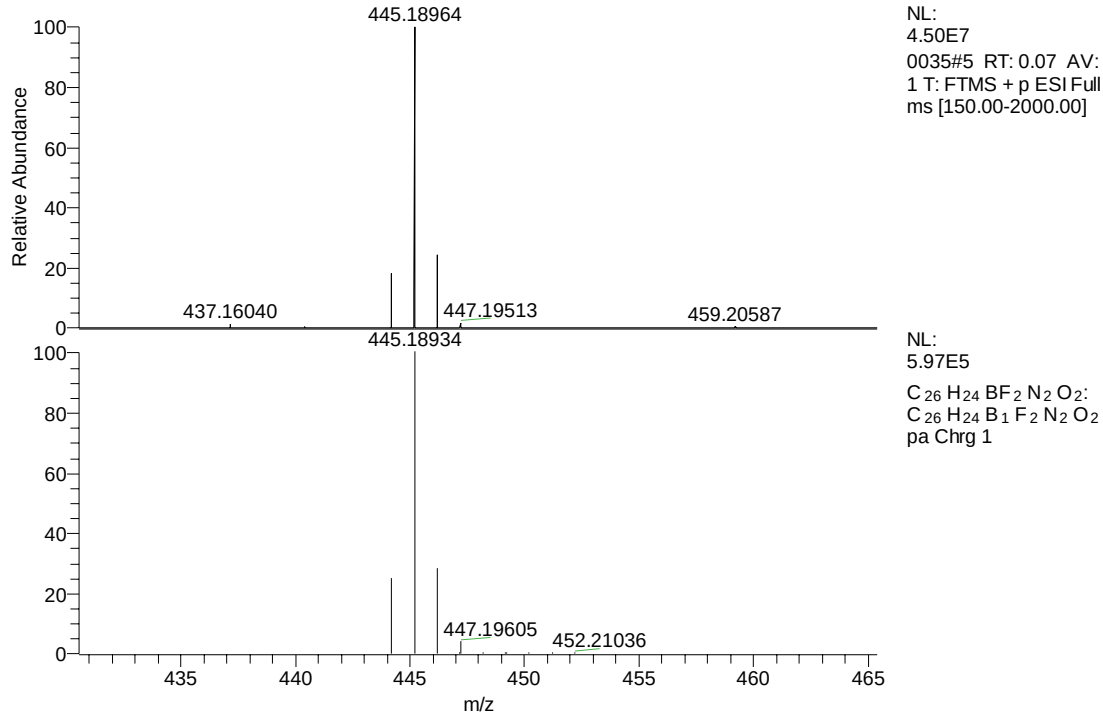
HRMS for **4f**


195 #16 RT: 0.22 AV: 1 NL: 8.35E7
T: FTMS + p ESI Full ms [100.00-1000.00]
395.17294
437.16101
485.20114
239.11794
140.92747
361.16989
563.71326
685.54663
806.55963
921.36841
Relative Abundance
m/z

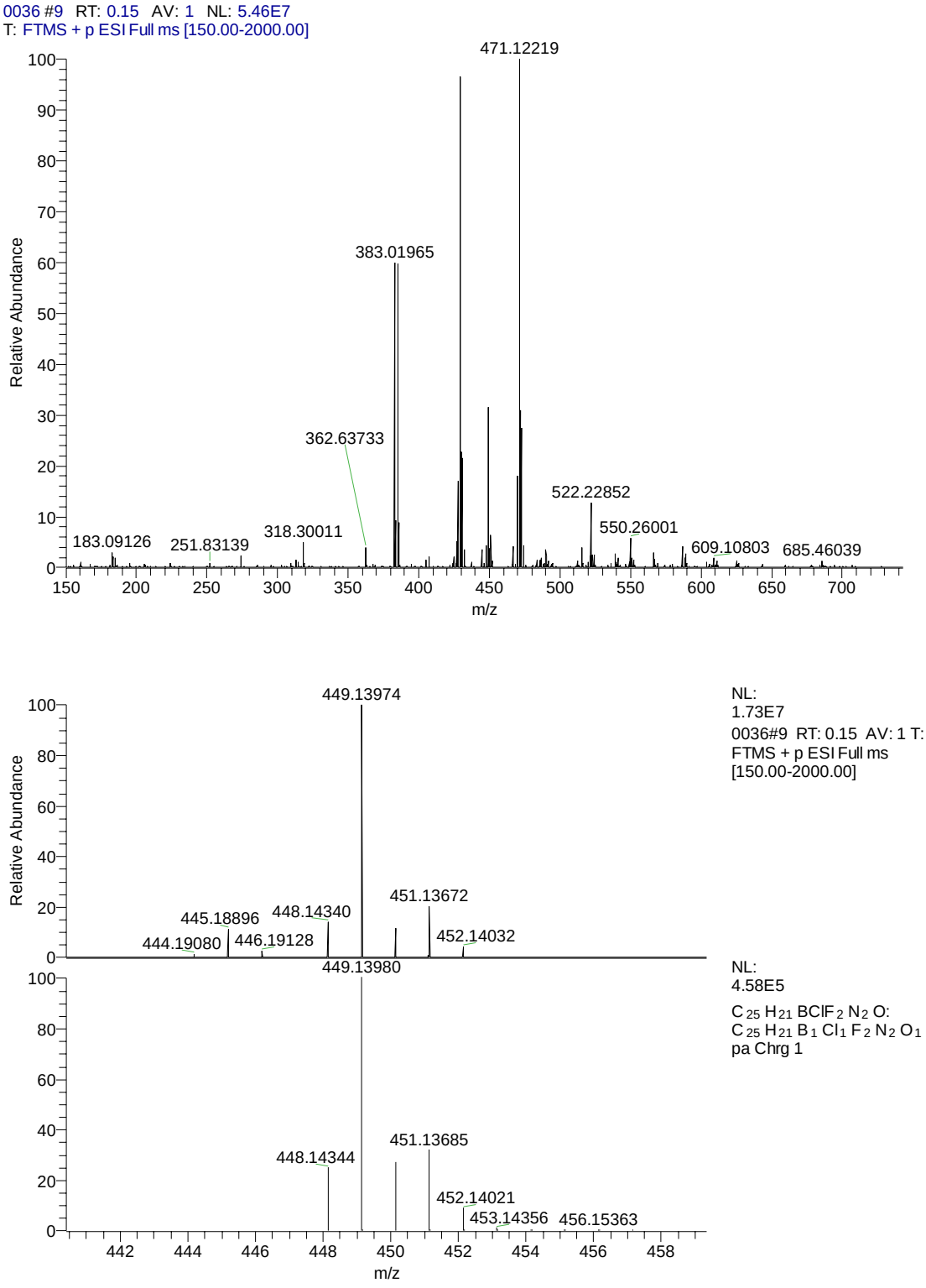

395.17294
398.16367
394.17621
384.03586
387.95908
393.17618
399.16702
404.76855
NL:
8.35E7
195#16 RT: 0.22 AV: 1 T: FTMS + p ESI Full ms [100.00-1000.00]
395.17255
394.17618
396.17590
397.17926
401.19021
NL:
6.05E5
C25 H21 BFN2 O+:
C25 H21 B1 F1 N2 O1 pa Chrg 1
Relative Abundance
m/z

HRMS for **4g**

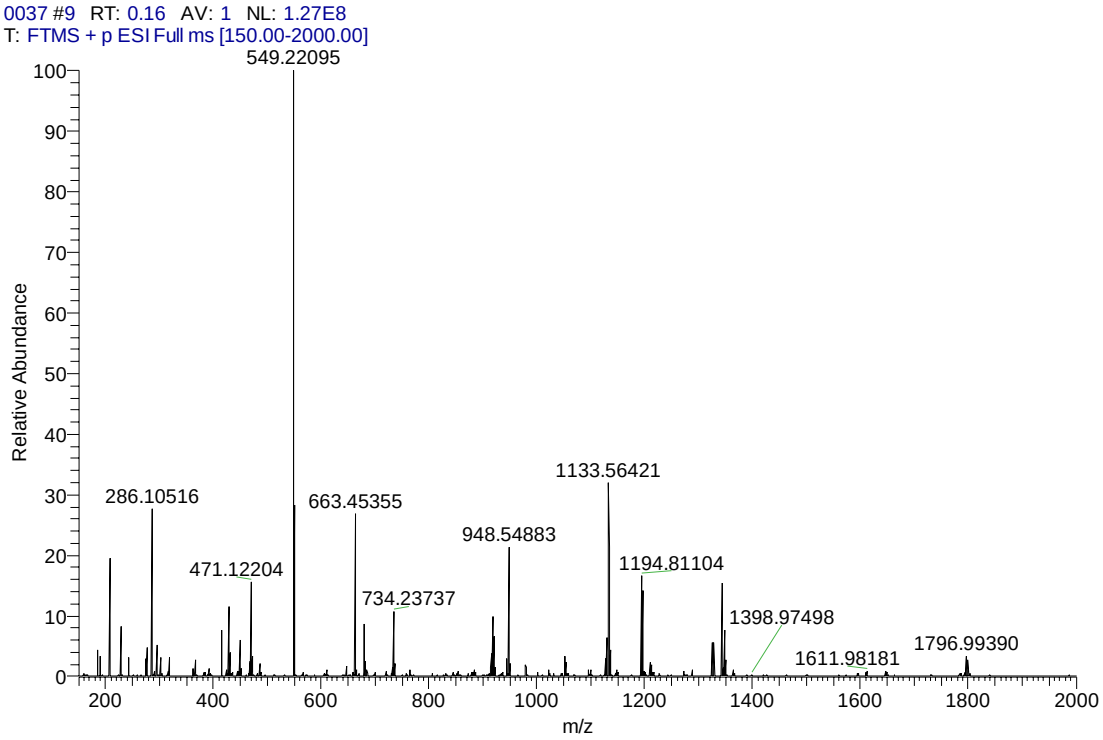

0035 #5 RT: 0.07 AV: 1 NL: 6.53E7
T: FTMS + p ESI Full ms [150.00-2000.00]
425.18347
445.18964
467.17133
397.19092
362.69995
518.27832
566.71741
663.45349
736.54224
251.87534
314.90292
Relative Abundance
m/z

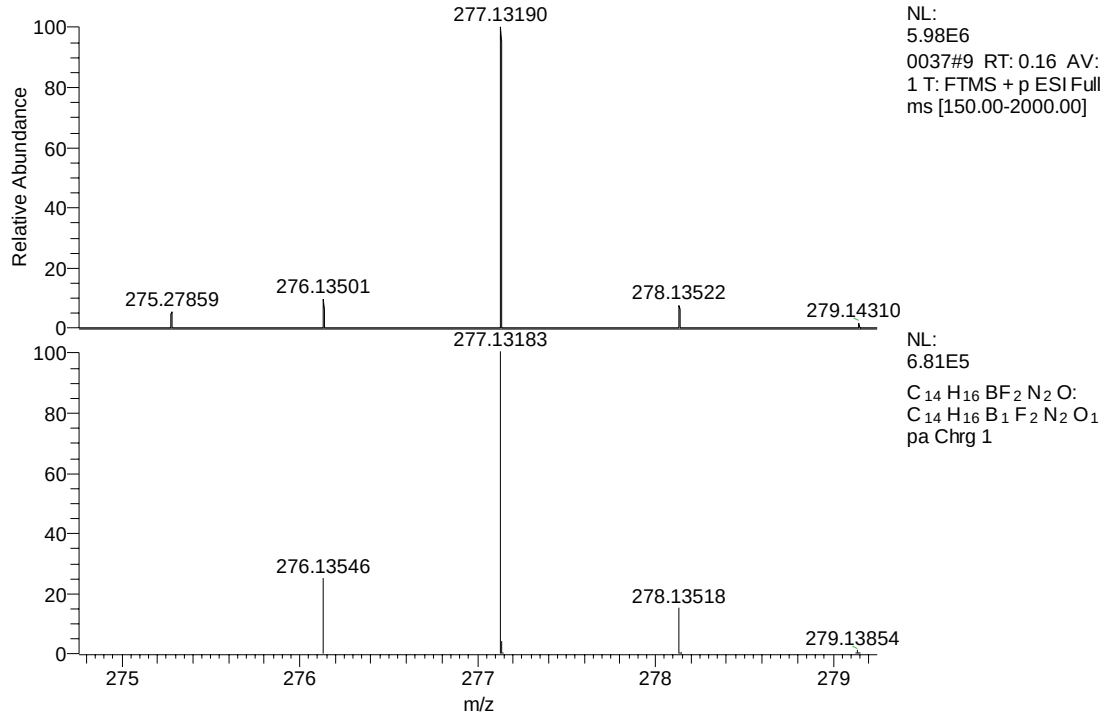

445.18964
437.16040
447.19513
459.20587
NL:
4.50E7
0035#5 RT: 0.07 AV: 1 T: FTMS + p ESI Full ms [150.00-2000.00]
445.18934
447.19605
452.21036
NL:
5.97E5
C26 H24 BF2 N2 O2:
C26 H24 B1 F2 N2 O2 pa Chrg 1
Relative Abundance
m/z

HRMS for **4h**

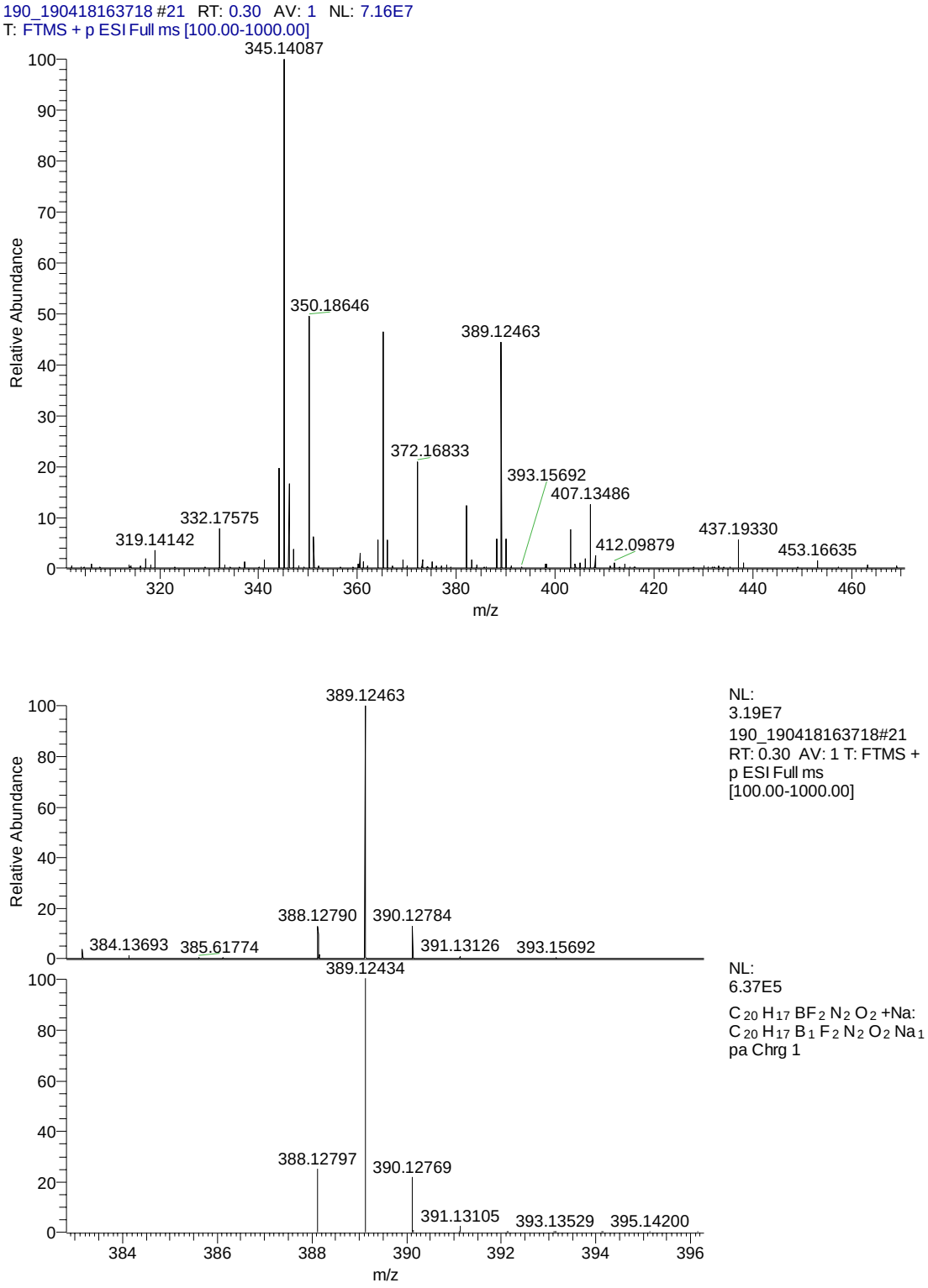

0036 #9 RT: 0.15 AV: 1 NL: 5.46E7
T: FTMS + p ESI Full ms [150.00-2000.00]
471.12219
383.01965
362.63733
522.22852
550.26001
318.30011
183.09126
251.83139
609.10803
685.46039
Relative Abundance
m/z
449.13974
451.13672
445.18896
448.14340
444.19080
446.19128
452.14032
NL:
1.73E7
0036#9 RT: 0.15 AV: 1 T:
FTMS + p ESI Full ms
[150.00-2000.00]
449.13980
451.13685
448.14344
452.14021
453.14356
456.15363
NL:
4.58E5
C 25 H 21 BClF 2 N 2 O:
C 25 H 21 B 1 Cl 1 F 2 N 2 O 1
pa Chrg 1

HRMS for **4i**

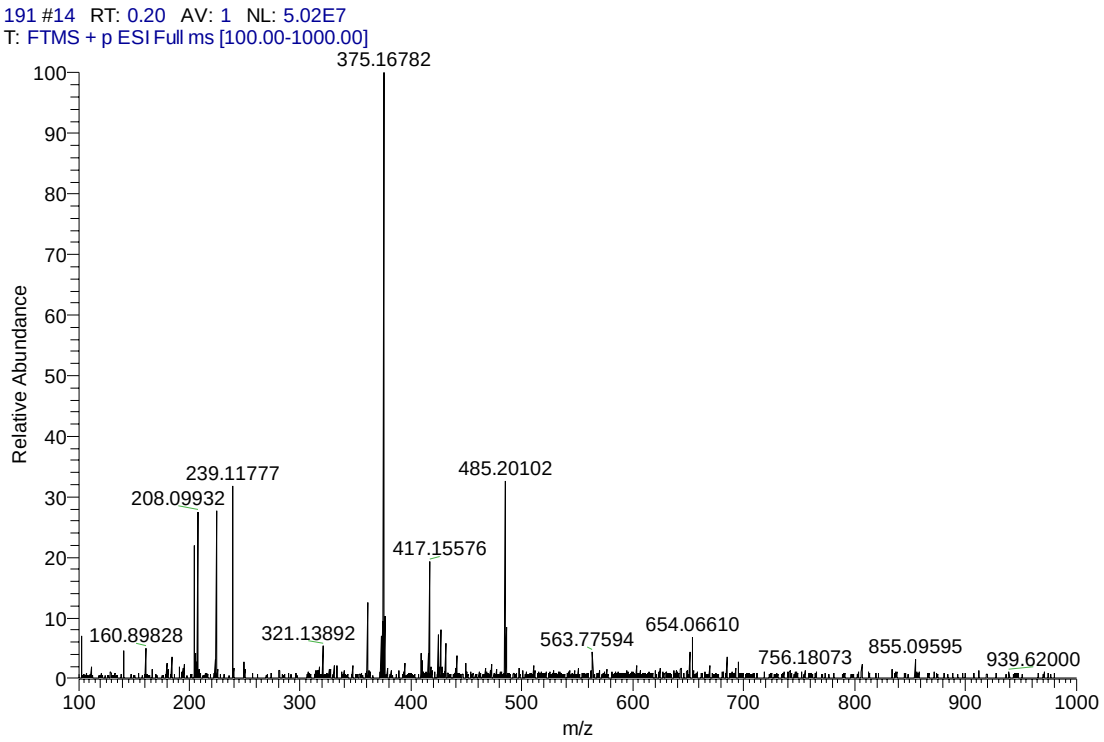

0037 #9 RT: 0.16 AV: 1 NL: 1.27E8
T: FTMS + p ESI Full ms [150.00-2000.00]
549.22095
286.10516
663.45355
1133.56421
948.54883
471.12204
1194.81104
734.23737
1398.97498
1796.99390
1611.98181
Relative Abundance
m/z

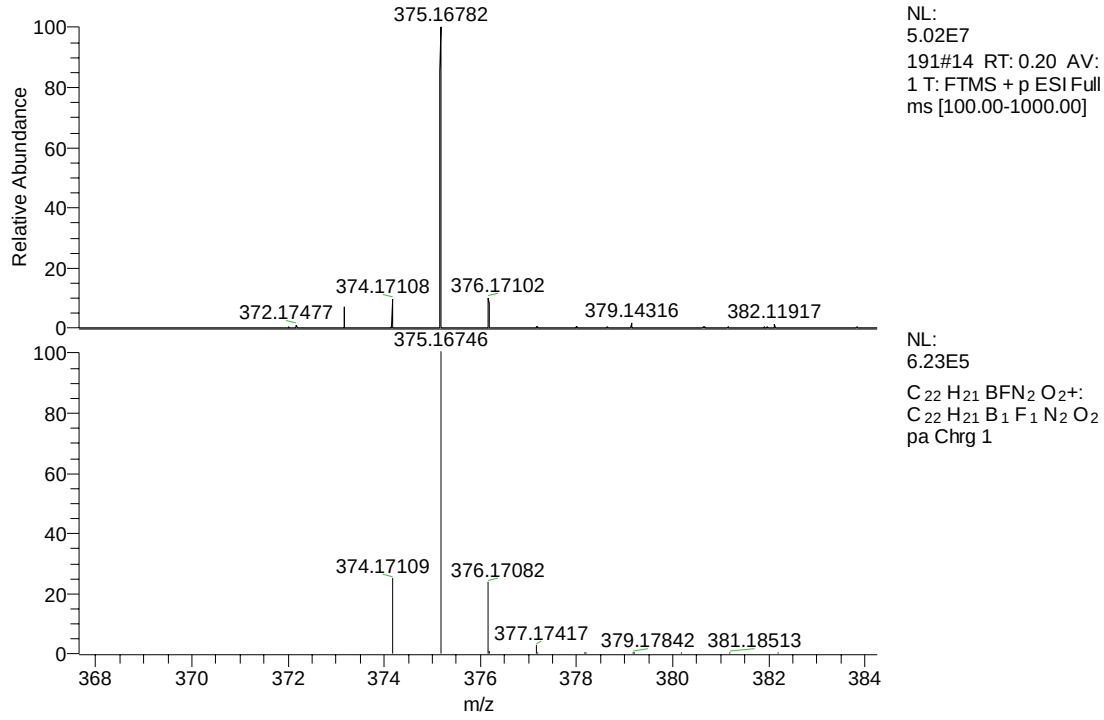

277.13190
NL:
5.98E6
0037#9 RT: 0.16 AV:
1 T: FTMS + p ESI Full
ms [150.00-2000.00]
275.27859
276.13501
278.13522
279.14310
277.13183
NL:
6.81E5
C 14 H 16 BF 2 N 2 O:
C 14 H 16 B 1 F 2 N 2 O 1
pa Chrg 1
276.13546
278.13518
279.13854
Relative Abundance
m/z

HRMS for **5a**

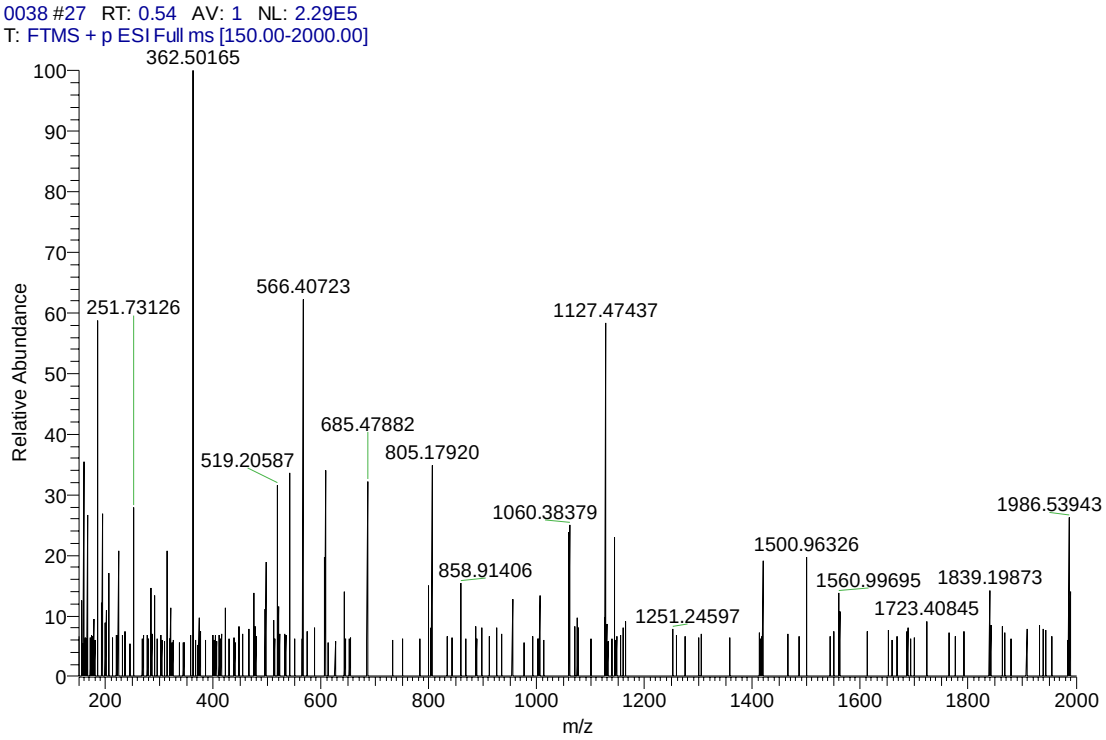

190_190418163718 #21 RT: 0.30 AV: 1 NL: 7.16E7
T: FTMS + p ESI Full ms [100.00-1000.00]
345.14087
350.18646
389.12463
372.16833
393.15692
407.13486
332.17575
319.14142
437.19330
412.09879
453.16635
Relative Abundance
m/z
389.12463
388.12790
390.12784
384.13693
385.61774
391.13126
393.15692
NL:
3.19E7
190_190418163718#21
RT: 0.30 AV: 1 T: FTMS +
p ESI Full ms
[100.00-1000.00]
389.12434
388.12797
390.12769
391.13105
393.13529
395.14200
NL:
6.37E5
C20 H17 BF2 N2 O2 +Na:
C20 H17 B1 F2 N2 O2 Na1
pa Chrg 1

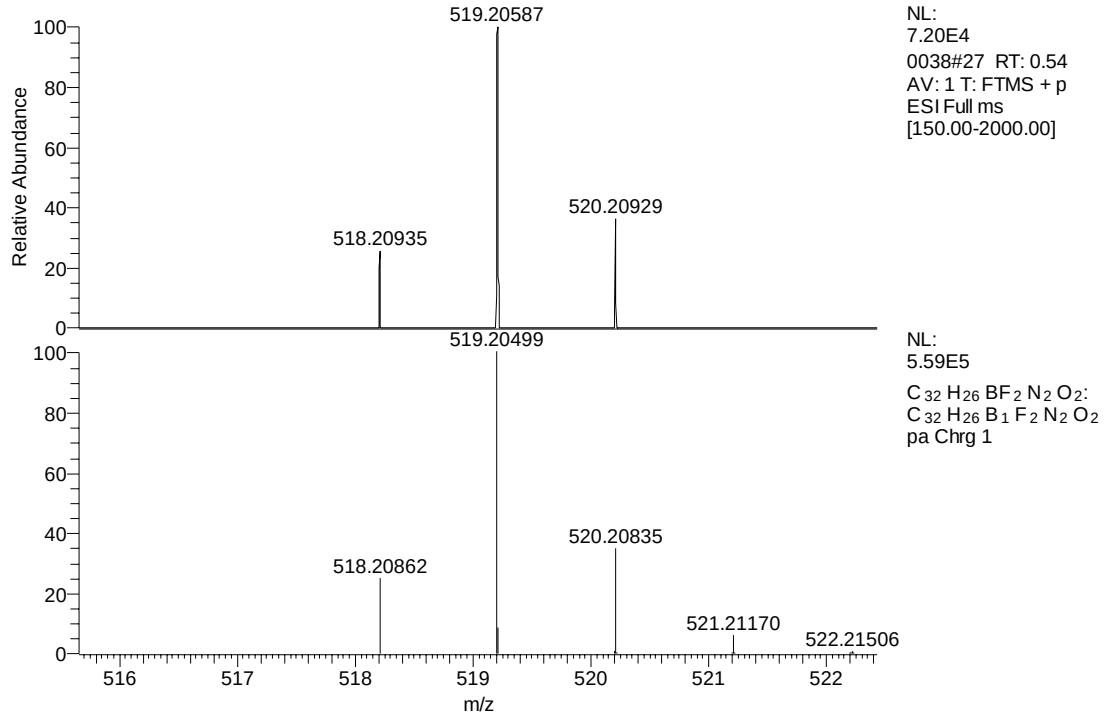
HRMS for **5b**


191 #14 RT: 0.20 AV: 1 NL: 5.02E7
T: FTMS + p ESI Full ms [100.00-1000.00]
375.16782
239.11777
208.09932
485.20102
417.15576
160.89828
321.13892
563.77594
654.06610
756.18073
855.09595
939.62000
Relative Abundance
m/z

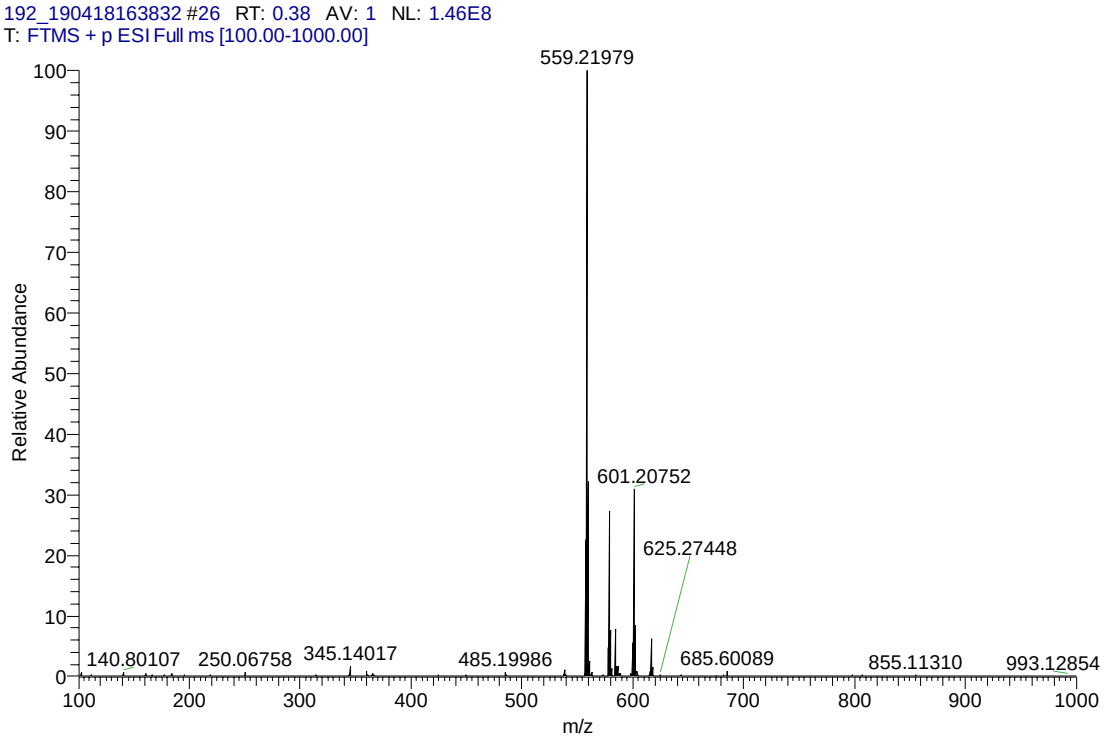

375.16782
374.17108
376.17102
372.17477
379.14316
382.11917
NL:
5.02E7
191#14 RT: 0.20 AV: 1 T: FTMS + p ESI Full ms [100.00-1000.00]
375.16746
374.17109
376.17082
377.17417
379.17842
381.18513
NL:
6.23E5
C22 H21 BFN2 O2+: C22 H21 B1 F1 N2 O2 pa Chrg 1
Relative Abundance
m/z

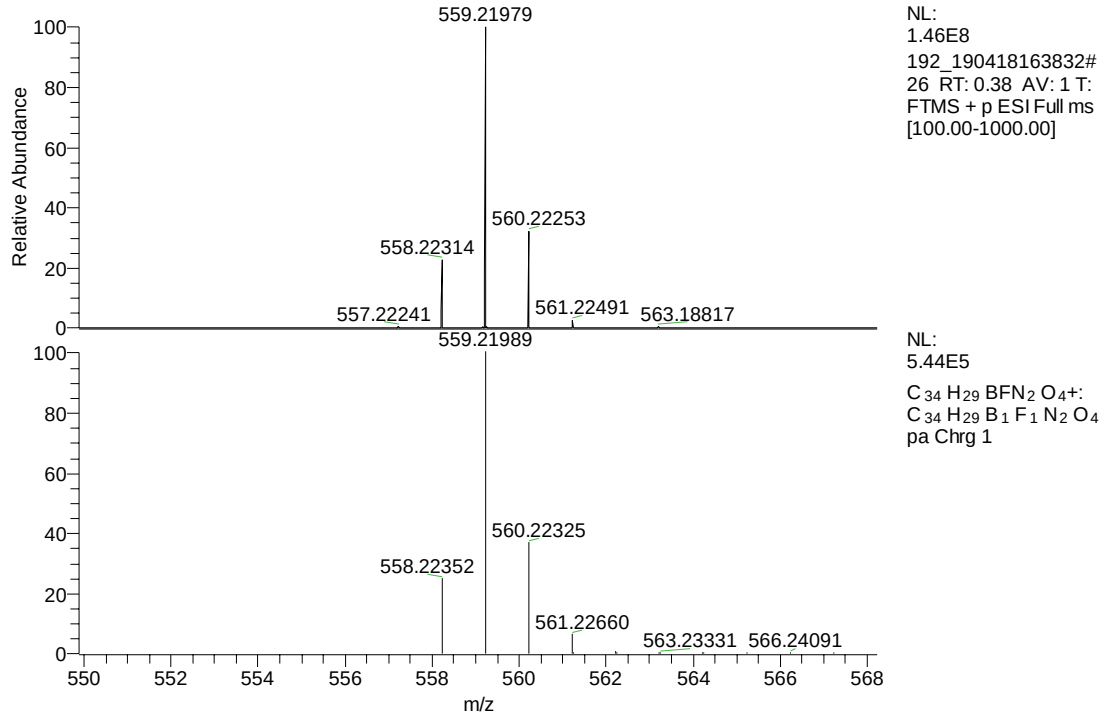
HRMS for **5c**


0038 #27 RT: 0.54 AV: 1 NL: 2.29E5
T: FTMS + p ESI Full ms [150.00-2000.00]
362.50165
566.40723
251.73126
1127.47437
685.47882
805.17920
519.20587
1060.38379
1986.53943
1500.96326
858.91406
1560.99695
1839.19873
1723.40845
1251.24597
Relative Abundance
m/z

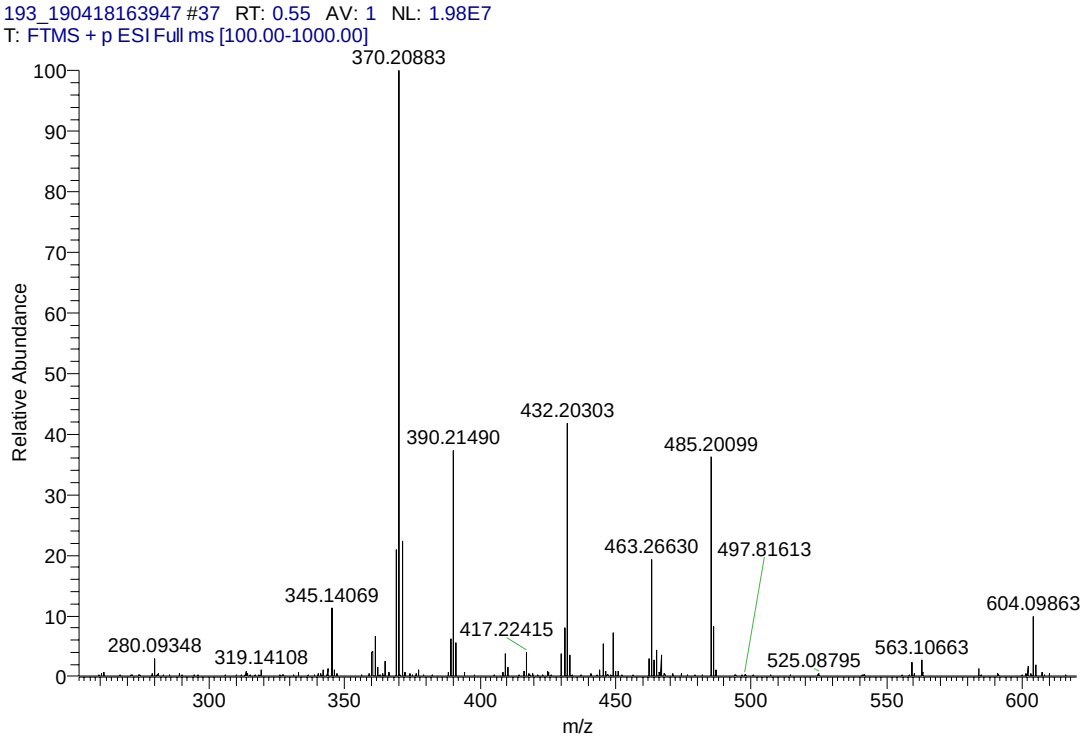

519.20587
520.20929
518.20935
NL:
7.20E4
0038#27 RT: 0.54
AV: 1 T: FTMS + p
ESI Full ms
[150.00-2000.00]
519.20499
520.20835
518.20862
521.21170
522.21506
NL:
5.59E5
C32 H26 BF2 N2 O2:
C32 H26 B1 F2 N2 O2
pa Chrg 1
Relative Abundance
m/z

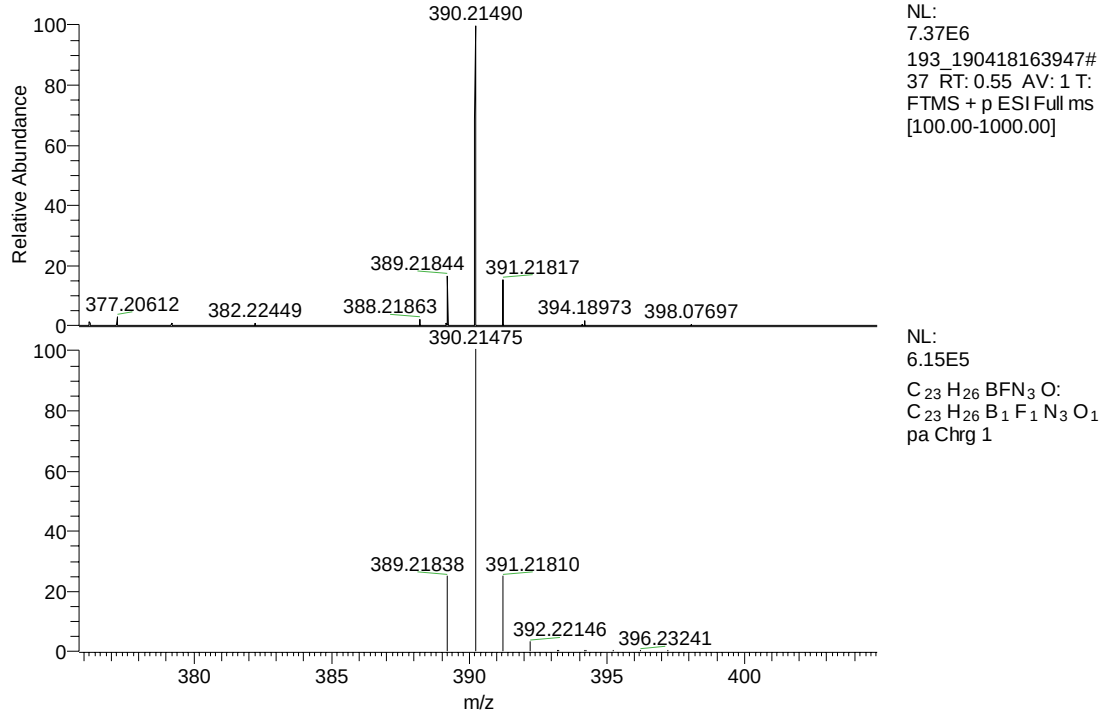
HRMS for **5d**


192_190418163832 #26 RT: 0.38 AV: 1 NL: 1.46E8
T: FTMS + p ESI Full ms [100.00-1000.00]
559.21979
601.20752
625.27448
140.80107
250.06758
345.14017
485.19986
685.60089
855.11310
993.12854
Relative Abundance
m/z


559.21979
560.22253
558.22314
557.22241
561.22491
563.18817
NL:
1.46E8
192_190418163832#
26 RT: 0.38 AV: 1 T:
FTMS + p ESI Full ms
[100.00-1000.00]
559.21989
560.22325
558.22352
561.22660
563.23331
566.24091
NL:
5.44E5
C34 H29 BFN2 O4+:
C34 H29 B1 F1 N2 O4
pa Chrg 1
Relative Abundance
m/z

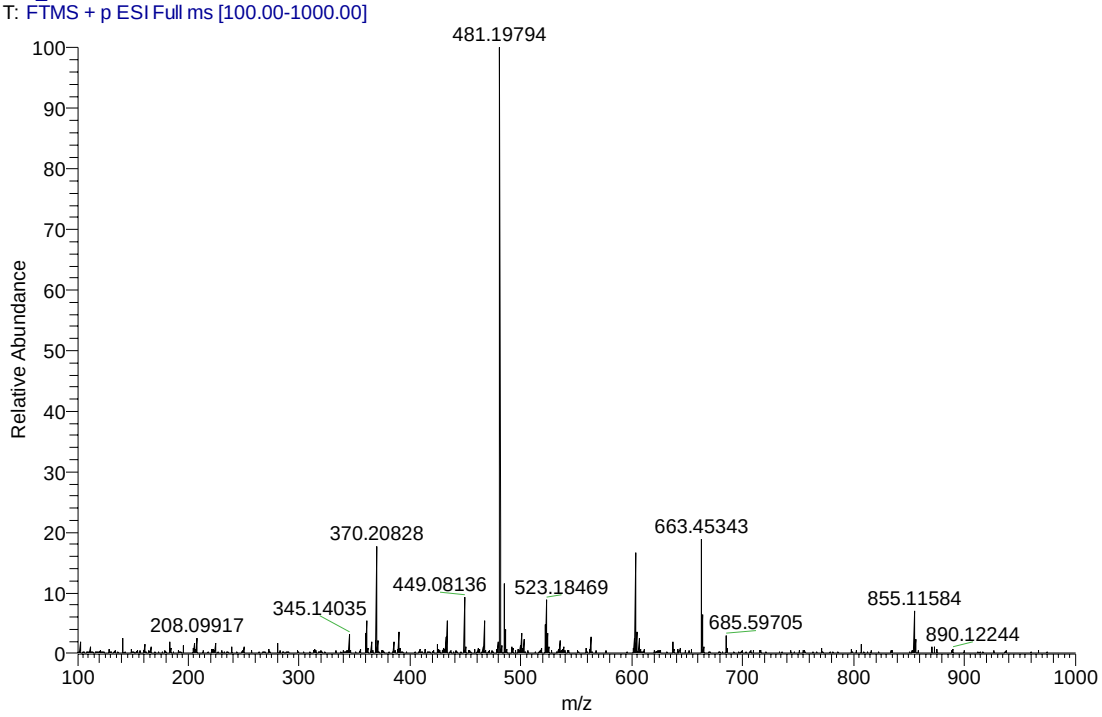
HRMS for **6**

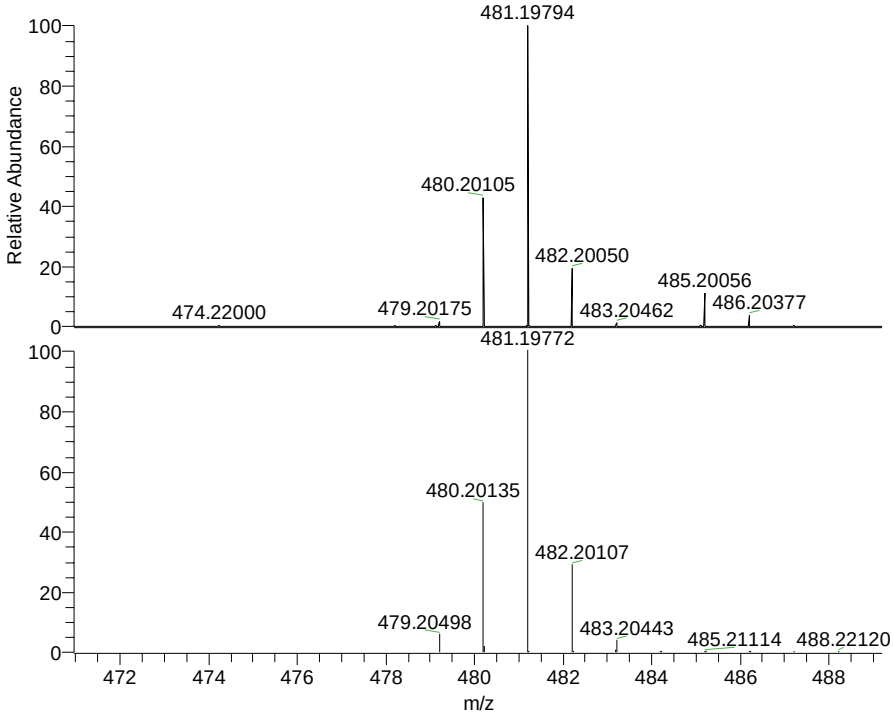

193_190418163947 #37 RT: 0.55 AV: 1 NL: 1.98E7
T: FTMS + p ESI Full ms [100.00-1000.00]
370.20883
390.21490
432.20303
485.20099
463.26630
497.81613
345.14069
417.22415
604.09863
280.09348
319.14108
525.08795
563.10663
Relative Abundance
m/z


390.21490
389.21844
391.21817
377.20612
382.22449
388.21863
394.18973
398.07697
NL:
7.37E6
193_190418163947#
37 RT: 0.55 AV: 1 T:
FTMS + p ESI Full ms
[100.00-1000.00]
390.21475
389.21838
391.21810
392.22146
396.23241
NL:
6.15E5
C 23 H 26 BFN 3 O:
C 23 H 26 B 1 F 1 N 3 O 1
pa Chrg 1
Relative Abundance
m/z

HRMS for **7**

194_190418164057 #35 RT: 0.52 AV: 1 NL: 1.87E7
T: FTMS + p ESI Full ms [100.00-1000.00]





NL:
1.87E7
194_190418164057#
35 RT: 0.52 AV: 1 T:
FTMS + p ESI Full
ms [100.00-1000.00]

NL:
4.72E5
$C_{27}H_{22}B_2F_3N_4$+:
$C_{27}H_{22}B_2F_3N_4$
pa Chrg 1

References

1. (a) C. Yu, L. Jiao, H. Yin, J. Zhou, W. Pang, Y. Wu, Z. Wang, G. Yang and E. Hao, *Eur. J. Org. Chem*., 2011, 5460; (b) X. Zhou, C. Yu, Z. Feng, Y. Yu, J. Wang, E. Hao, Y. Wei, X. Mu and L. Jiao, *Org. Lett*., 2015, **17**, 4632.

2. (a) F. M. Menger and H. Lu. *Chem. Commun.,* 2006, **42**, 3235. (b) Y. S. Hon, C. F. Lee, R. J. Chen and P. H. Szu, *Tetrahedron,* 2001, **57**, 5991. (c) C. Mukai, J. W. Cho, L. J. Kim, M. Kido and M. Hanaoka, *Tetrahedron,* 1991, **47**, 3007. (d) B. Wang, P. Li, F. Yu, P. Song, X. Sun, S. Yang, Z. Lou and K. Han, *Chem. Commun.,* 2013, **49**, 1014.

3. N. Adarsh, R. R. Avirah, and D. Ramaiah, *Org. Lett.*, 2010, **12**, 5720.