Supporting information

Design, synthesis and properties of artificial nucleic acids from (R)-4-amino-butane-1, 3-diol

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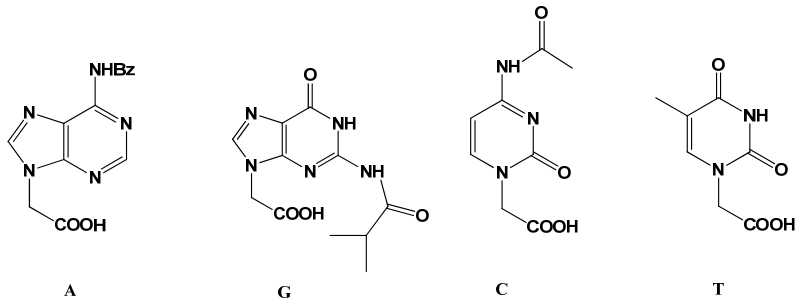
S1. Synthesis of acetate-nucleobases and acyclic nucleotide analogues.



Scheme S1 Acetate-nucleobases in our work. (A, G, C and T)

Acetate-nucleobases (**A**, **G** and **C**, **T** is commercially available) are synthesized according to previous reported methods with modifications. [1] NMR data were consistent to those in literature reports.

(N^6-benzoyladenin-9-yl) acetic acid (A)

^{1}H-NMR (400 MHz, DMSO-d_6) δ = 11.20 (s, 1 H), 8.74 (s, 1 H), 8.46 (s, 1 H), 8.06 (d, 2 H, *J* = 7.3 Hz), 7.64 (m, 1 H), 7.54-7.65 (m, 2 H), 5.11 (s, 2 H).

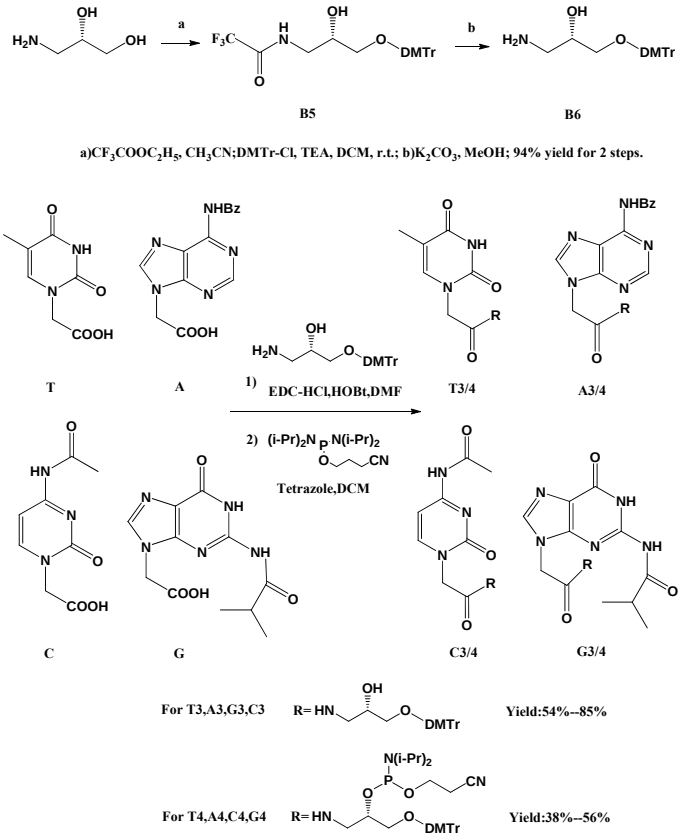
2-(4-acetamido-2-oxopyrimidin-1(2H)-yl) acetic acid (C)

^{1}H-NMR (400 MHz, DMSO-d_6) δ = 10.87 (s, 1 H), 8.04 (d, 1 H, *J* = 7.2 Hz), 7.17 (d, 1 H, *J* = 7.2 Hz), 4.54 (s, 2 H), 2.11 (s, 3 H). ^{13}C-NMR (100 MHz, DMSO-d6) δ = 170.9, 169.3, 162.8, 155.2, 150.7, 95.0, 50.54, 24.3.

2-(2-isobutyramido-6-oxo-1H-purin-9(6H)-yl) acetic acid (G)

^{1}H-NMR (400 MHz, DMSO-d6) δ = 12.10 (s, 1 H), 11.69 (s, 1 H), 7.99 (s, 1 H), 4.90 (s, 2 H), 2.76 (m, 1 H), 1.10 (d, 6 H, J = 7Hz); C-NMR (100 MHz, DMSO-d_6) δ = 180.2, 169.0, 154.8, 148.1, 140.3, 119.5, 44.5 34.7, 27.7, 18.9.

S2. (S)-3-Amino-1, 2-propanediol nucleic acid modified duplexes [#]



Scheme S2. Synthesis of backbone and monomers of (S)-3-amino-1, 2-propanediol nucleic acid

Table S1. Sequences of (S)-3-Amino-1, 2-propanediol nuclei acid ((S)-AmpNA) modified duplex.[#]

Entry	Sequence[$]	Calculated Mw	Measured Mw
AmpNA-mmp 1	3'-**c**ACA**c**CTT**g**CC**a**TC**g**-2'	4545.9	4547.2
AmpNA-mmp 2	3'-**cacaccttgccatcg**-2'	4696.0	4697.6
AmpNA-mmp 3	**c**ACACCTTGCCATCG	4485.8	4487.0
AmpNA-mmp 4	CAC**a**CCTTGCCATCG	4485.8	4487.0
AmpNA-mmp 5	CACACCT**t**GCCATCG	4485.8	4487.0
AmpNA-mmp 6	CACACCTTGCC**a**TCG	4485.8	4487.0
AmpNA-mmp 7	CACACCTTGCCATC**g**	4485.8	4487.0

[$] underlined lower case letters represent (S)-3-Amino-1,2-propanediol nuclei acid modified nucleotides and upper case letters represent DNA nucleotides.

[#]Part of data came from published thesis of master student from our laboratory: Meng Su, "Functionalization and Reconstrunction of Oligonucleotides", Master Thesis, 2012, Peking University.

S3. Solid synthesis and evaluation of (R)-Am-BuNA modified oligonucleotides.

DNA synthesis, cleavage and purification

DNA oligonucleotides were synthesized on an Applied Biosystems Incorporated 394 synthesizer. The synthesis was carried out on 1 μmol scale. The coupling time and concentration of phosphoramidite monomers for the acyclic nucleotides were the same as those for the natural bases. With a refurbished ABI 394, we set 90s coupling timeand 0.1M concentration for all monomers. Trityl detection showed the same level of incorporation efficiency for acyclic nucleosides as that of natural DNA oligonucleotides with the average step yield over 97%.

After synthesis, fresh concentrated ammonium hydroxide was added to CPGs. The CPGs were shaken for 24 hours at room temperature and then concentrated. The residue was dissolved by small amount of water and was then purified with Waters 320 HPLC on an Eclipse XDB-C18 column (5 μM, 9.4×250 mm). Conditions: solvent A, 0.05M TEAA buffer; solvent B, acetonitrile. Started at 0% B; liner gradient 2% B/min, flow rate: 2 mL/min. 80% aqueous acetic acid (500 μL) was added to dry oligonucleotides to remove trityl group. The solution was shaken for 30 min at room temperature, and was then concentrated and purified by HPLC. HPLC conditions: started at 0% B; liner gradient 2% B/min, flow rate: 2 mL/min. PAD detector wavelength: 260 nm.

Thermal denaturation studies for acyclic-modified oligonucleotides.

The oligonucleotides were mixed in corresponding buffers and ion concentrations. Oligonucleotide solutions were hybridized by first heating at 90 ℃ for 5 min and then slowly cooled down to room temperature. The melting profiles started with a denaturing run from 25 ℃ to 85 ℃ at a rate of 1℃ /min. The absorbance at 260 nm was monitored at 0.5 ℃ intervals on a Beckman Series 800 UV spectrometer (at 295 nm for denaturation of quadruplex). The melting temperatures of the oligonucleotides were determined as the peak of the first derivations of the corresponding melting curves.

Enzymatic stability of acyclic-modified oligonucleotides with FBS and SVPDE

Enzymatic stability of the acyclic-modified single-stranded DNA and thrombin-binding DNA aptamer was tested in the presence of fetal bovine serum (FBS) and snake venom phosphodiesterase (SVPDE). The reactions were performed with the oligonucleotide concentrations of 5 μM (SVPDE) and 10 μM (FBS) oligonucleotide at 37 ℃. To the above oligonucleotide solution, proper amount of enzymes was added for oligonucleotide degradation. Aliquots (10 μL) were taken at intervals, quenched by the addition of equal volume of 10 mM EDTA aqua on ice bath and kept at -80 ℃ for further PAGE analysis. Every sample was added 4 μL loading buffer (6-fold) before PAGE assay. The mixture was subjected to the gel electrophoresis using 20% native polyacrylamide gel with 1×TBE buffer at 150 V for 40min**.**

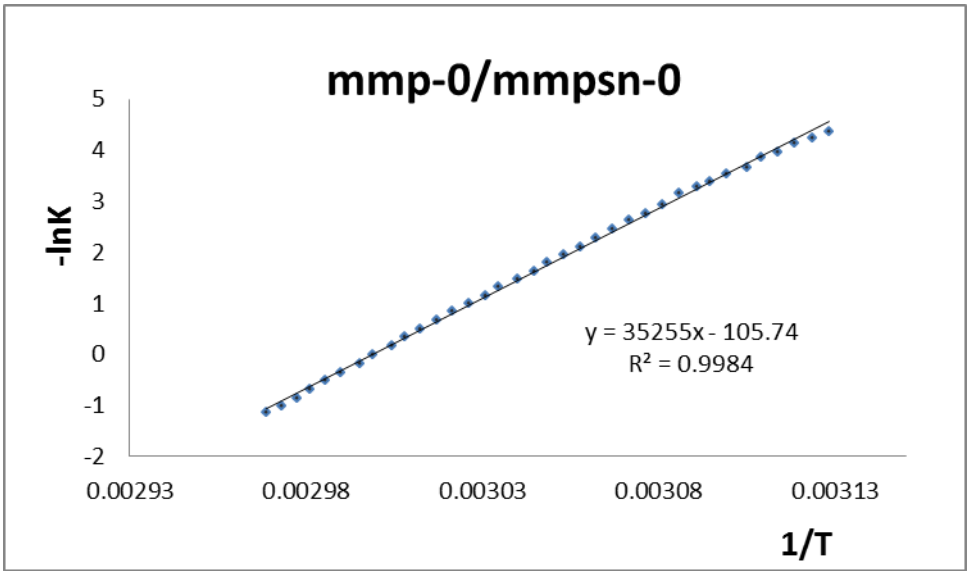
CD spectra measurement

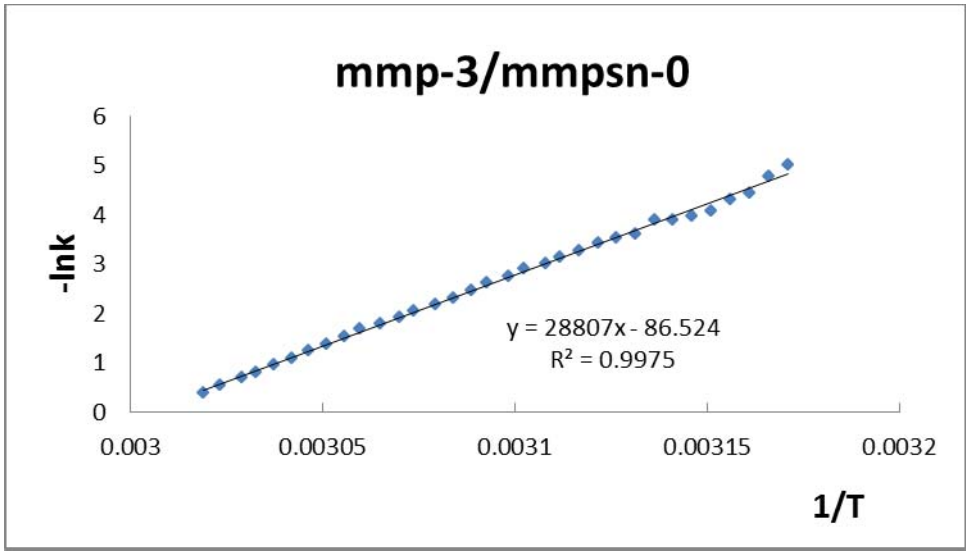
The samples of oligonucleotides in corresponding buffers and ion concentrations were first annealed. Then CD spectra of the samples were measured at room temperature (298 K) in 0.1cm cuvettes using a Jasco J-810 spectropolarimeter. The wavelength was scanned from 220 to 320 nm with a scanning speed of 200 nm/min for 3 times. The obtained curves were smoothed by the built-in software.

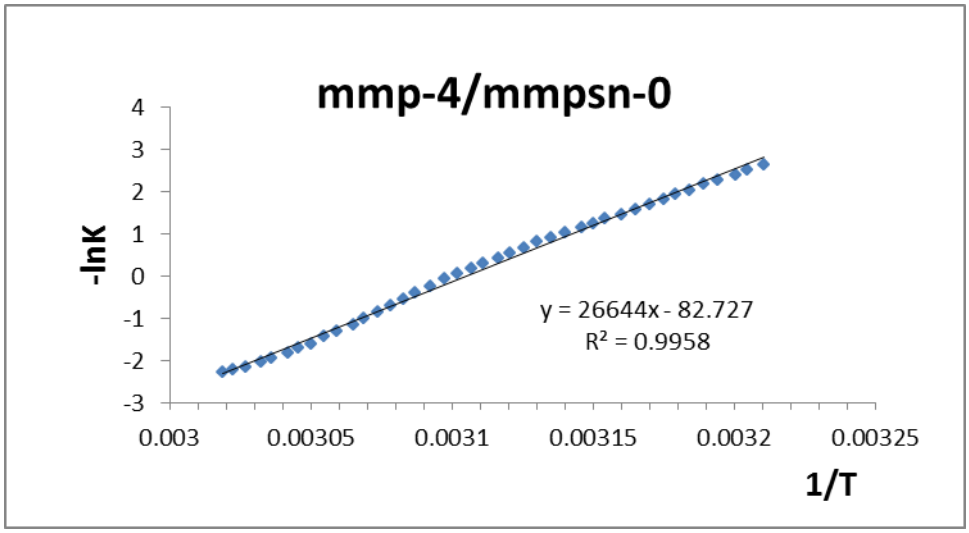
Methods for the calculation of thermodynamic parameters of duplex or quadruplex formation

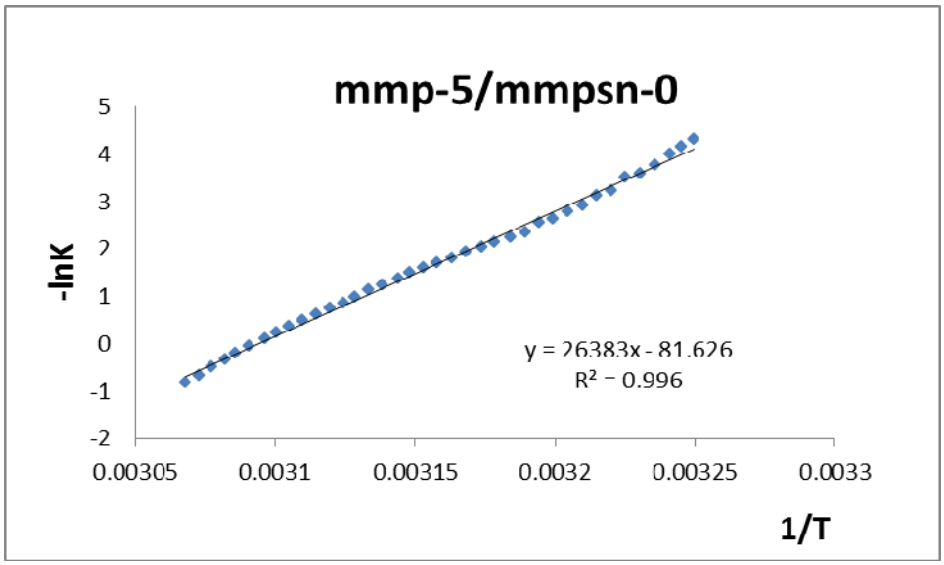
In melting processes of duplexes and quadruplexes, we supposed the existence of folded and unfolded states. The equilibrium constant, K, can be determined by the ratio of two folded and unfolded states ($K=\theta/(1-\theta)$). Supposed that θ referred to the percentage of duplex in all oligonucleotides, then $K=(A_{max}-A_n)/(A_n-A_{min})$. According to Gibbs fundamental equation: $\Delta G=-RT\ln(K)=\Delta H-T\Delta S$, a linear regression with 1/T as x and ln(K) as y was conducted to obtain the slope as $-(\Delta H/R)$ and vertical intercept as $(\Delta S/R)$. Accordingly, ΔH and ΔS can be obtained through the melting profiles. All the parameters were constructed by fitting melting curves in a temperature range of Tm ± 10°C

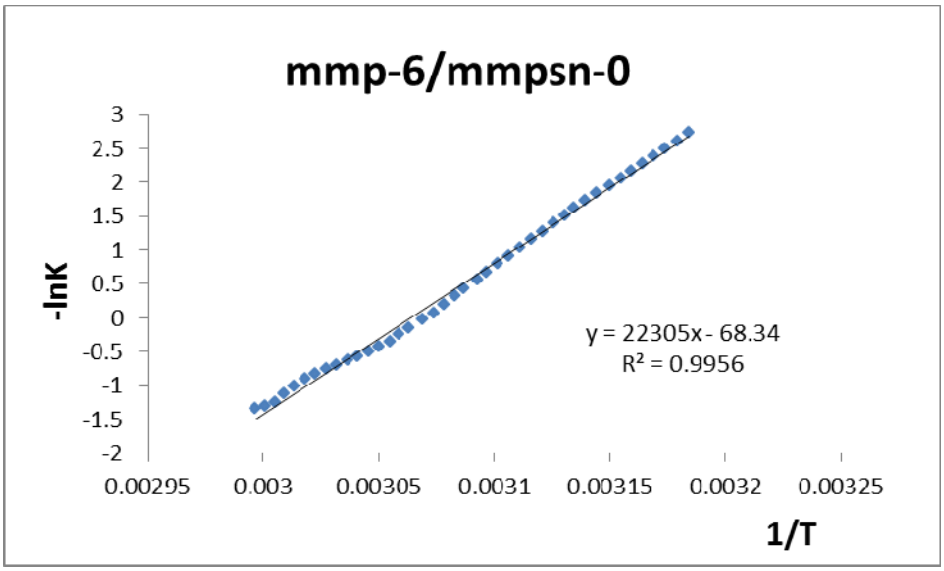
S4. Van′t Hoff plot of (R)-AM-BuNA modified oligonucleotides.

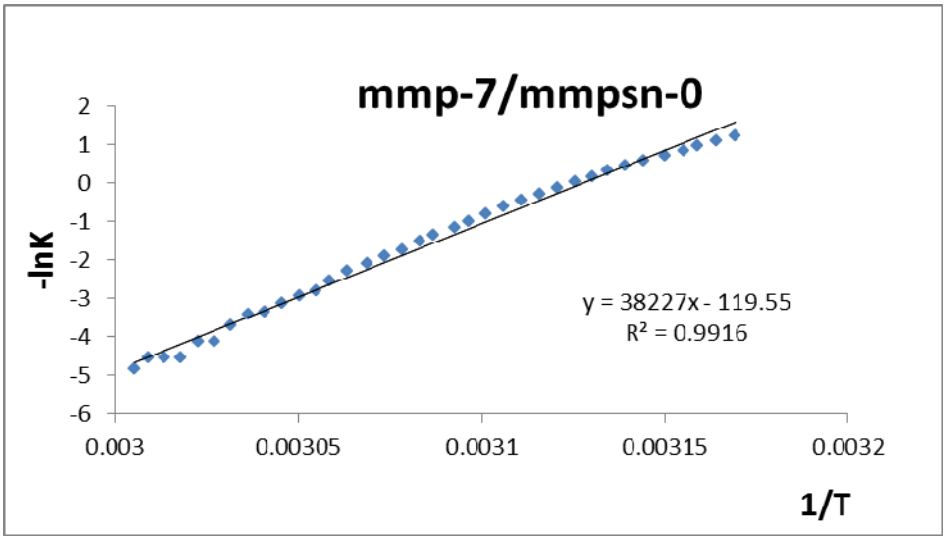


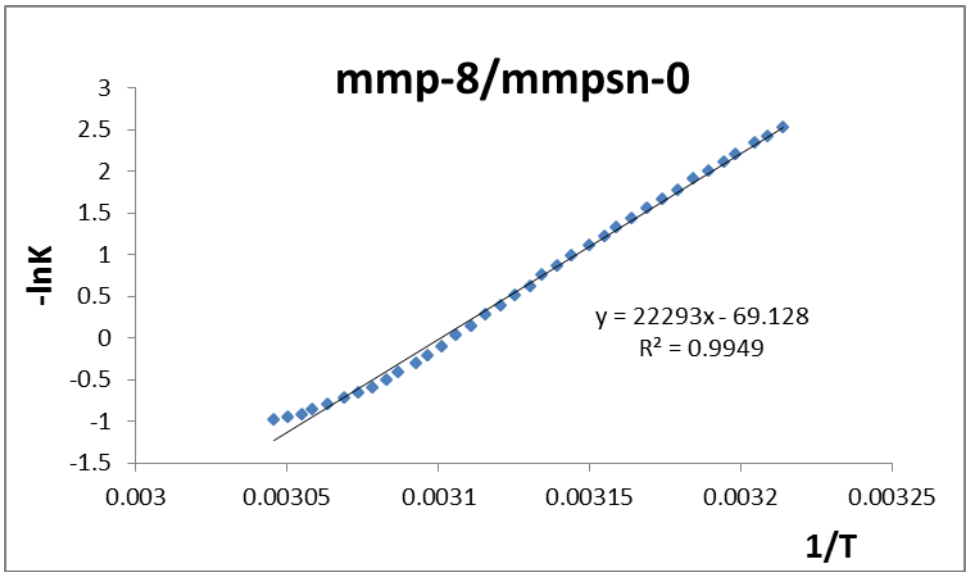


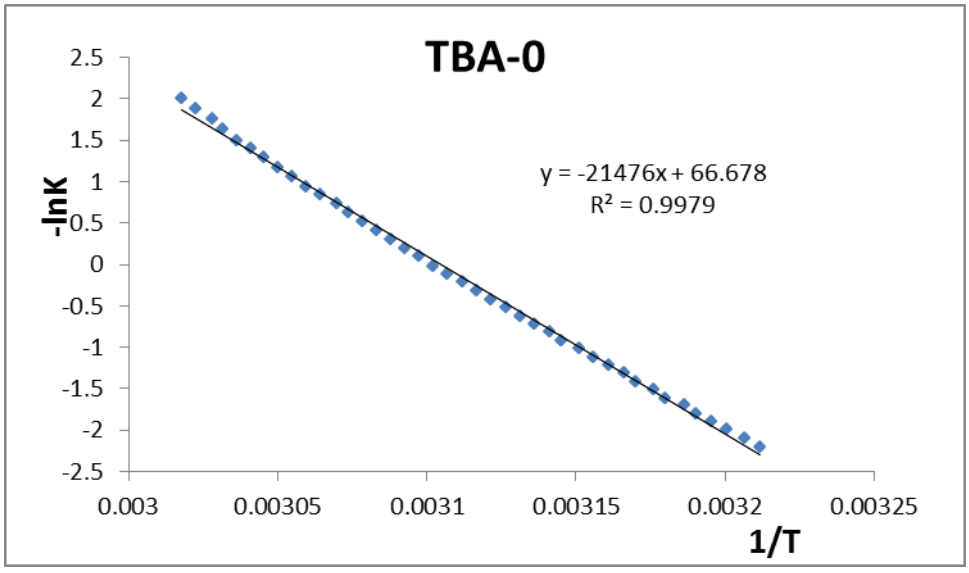


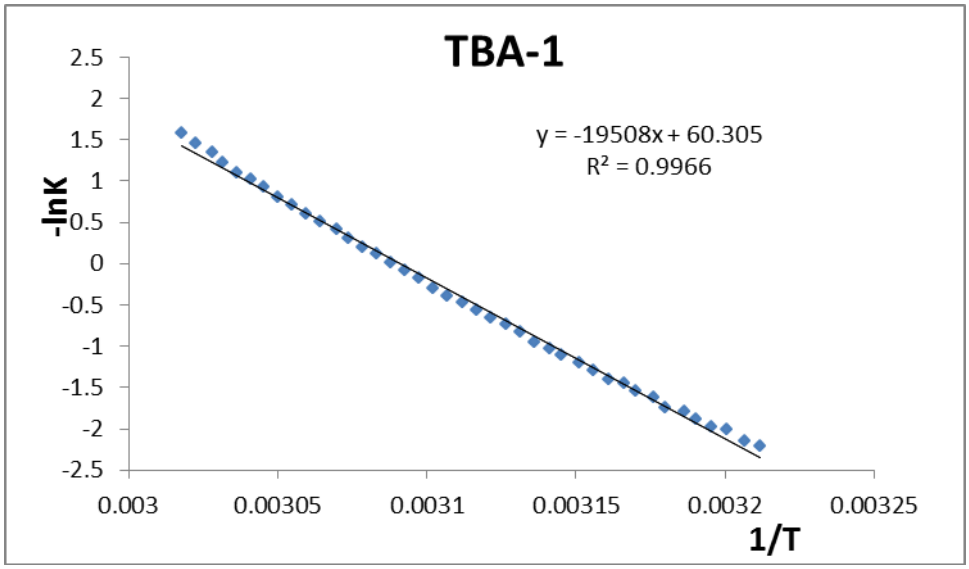


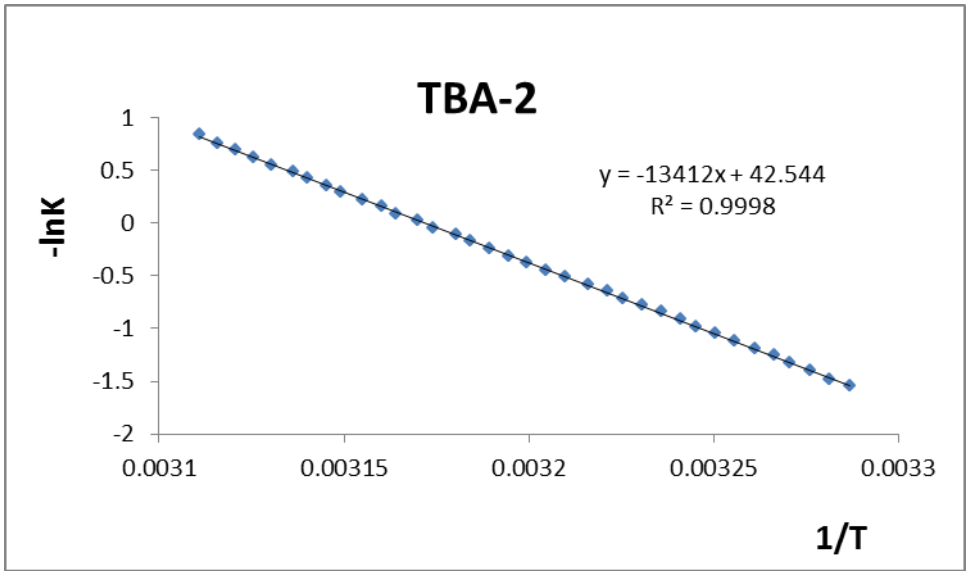




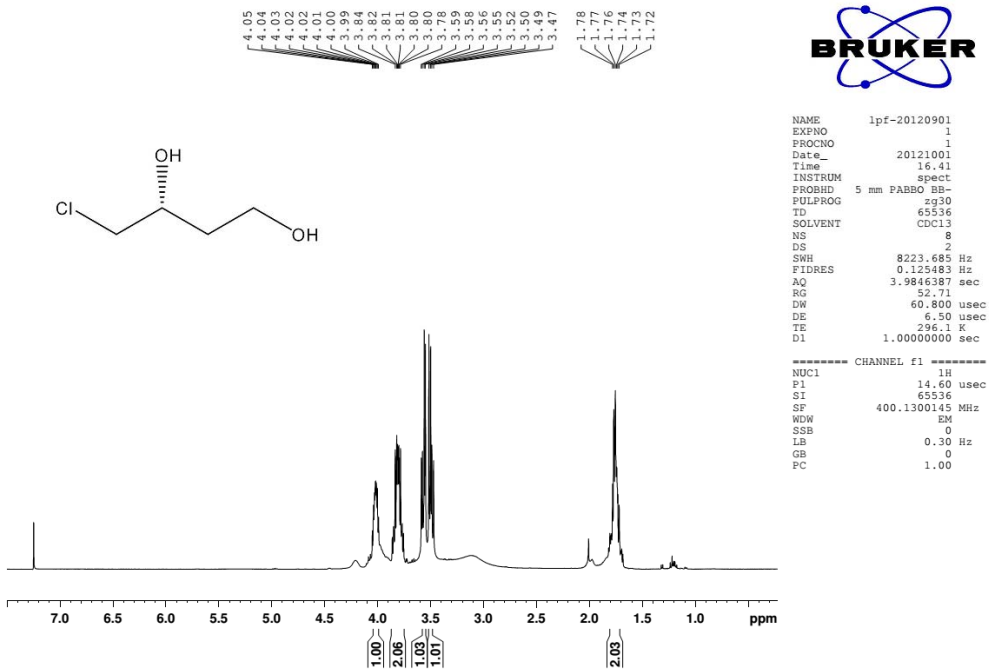


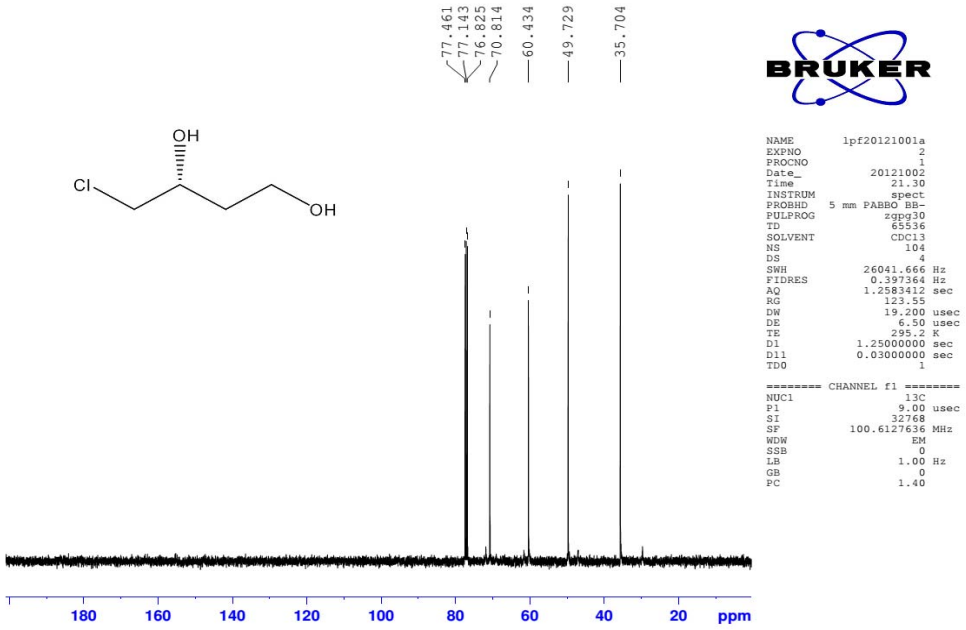


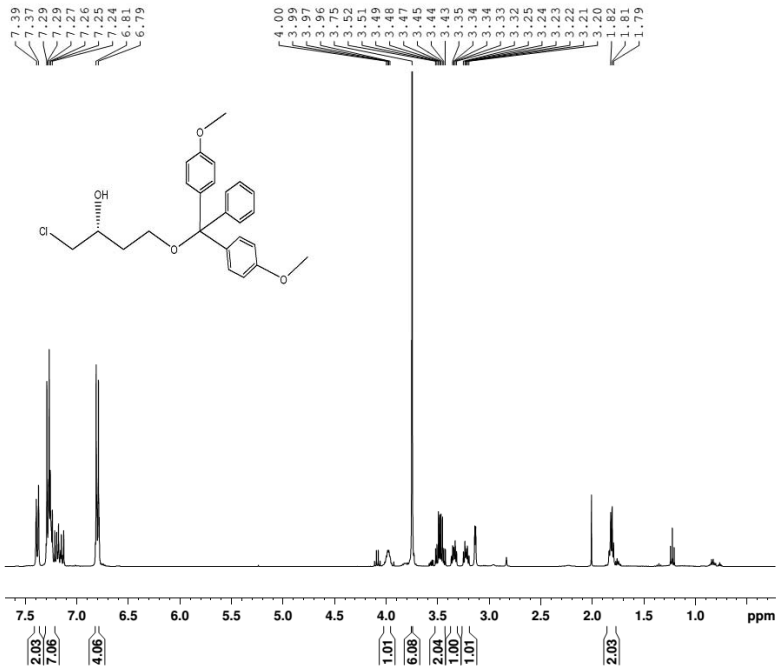




S5. NMR spectra and ESI-MS of compounds in our work.





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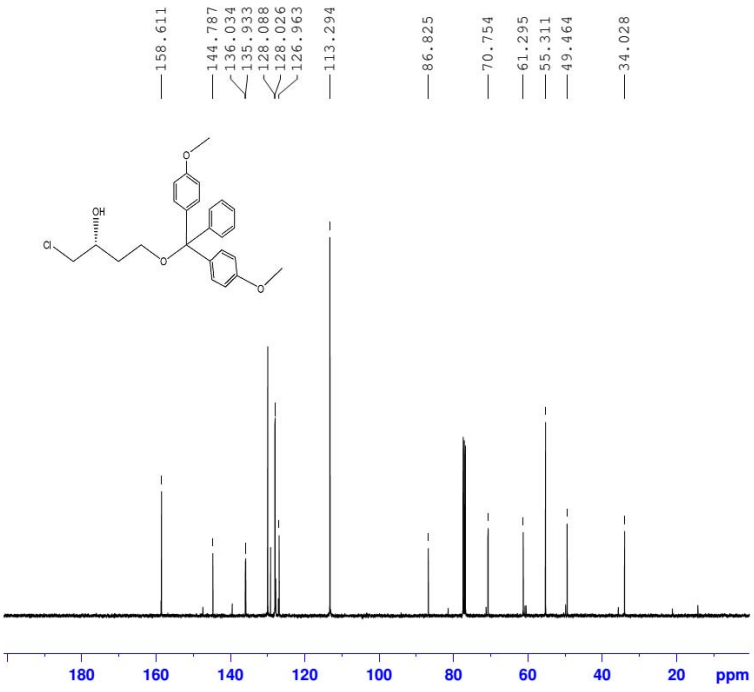


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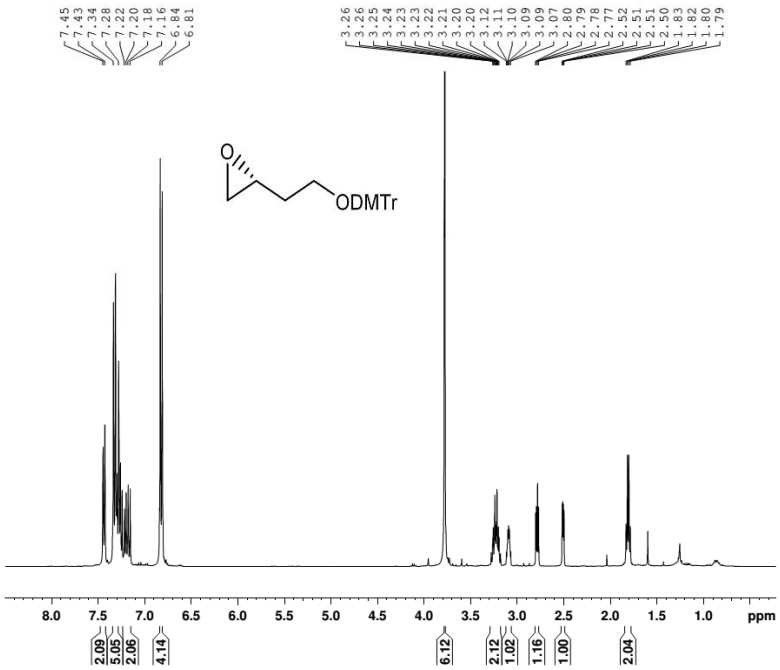

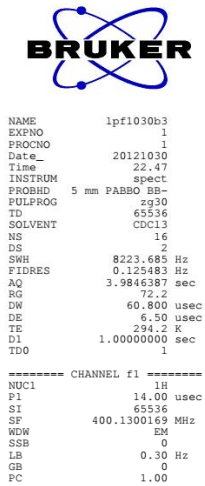


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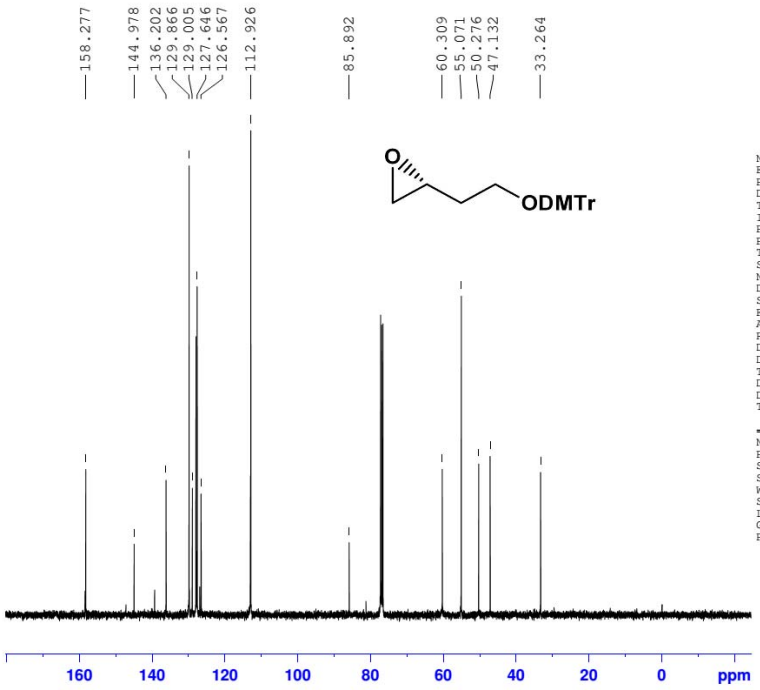


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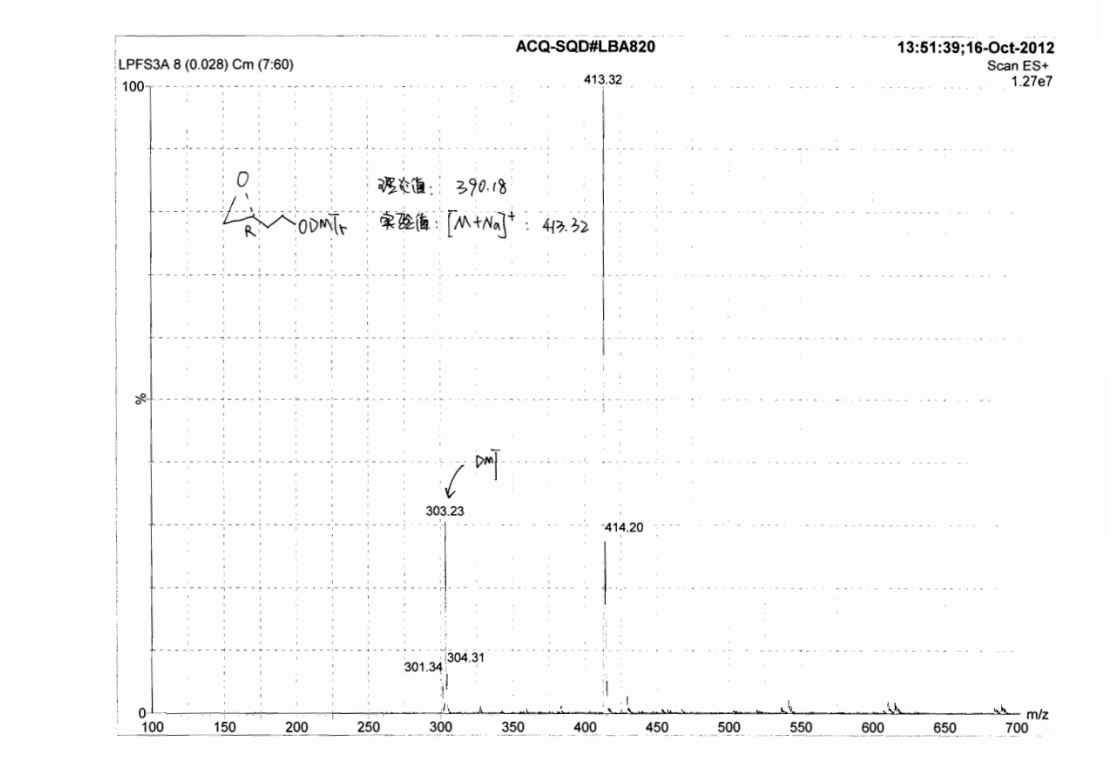

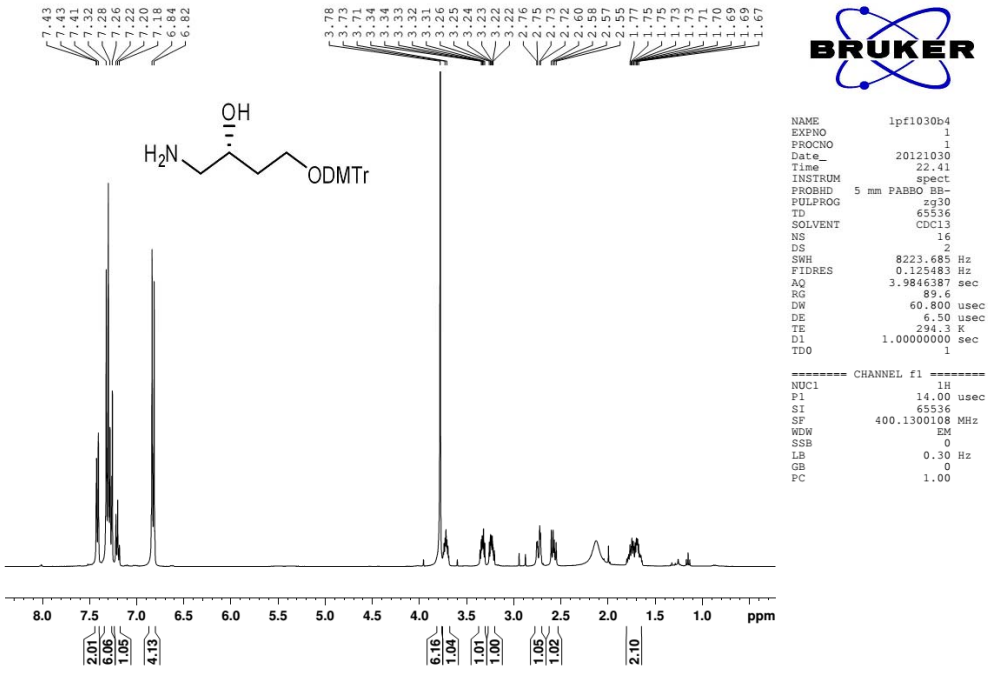


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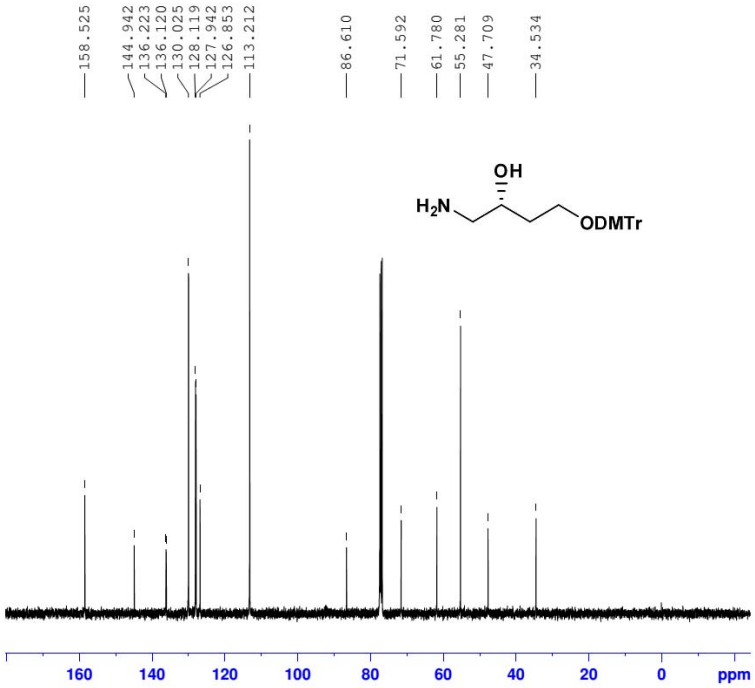


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Acquisition Date 10/25/2012 4:19:27 PM

Operator bpfxsh@bjmu.edu.cn; Tel:010-82801437

Instrument FT_MS _Bruker APEX IV (7.0 T)

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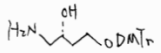

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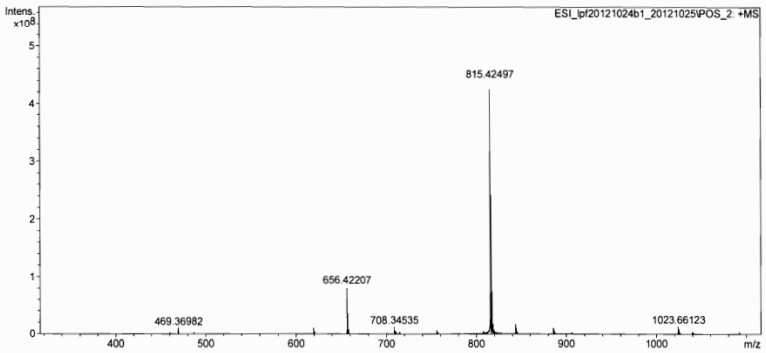

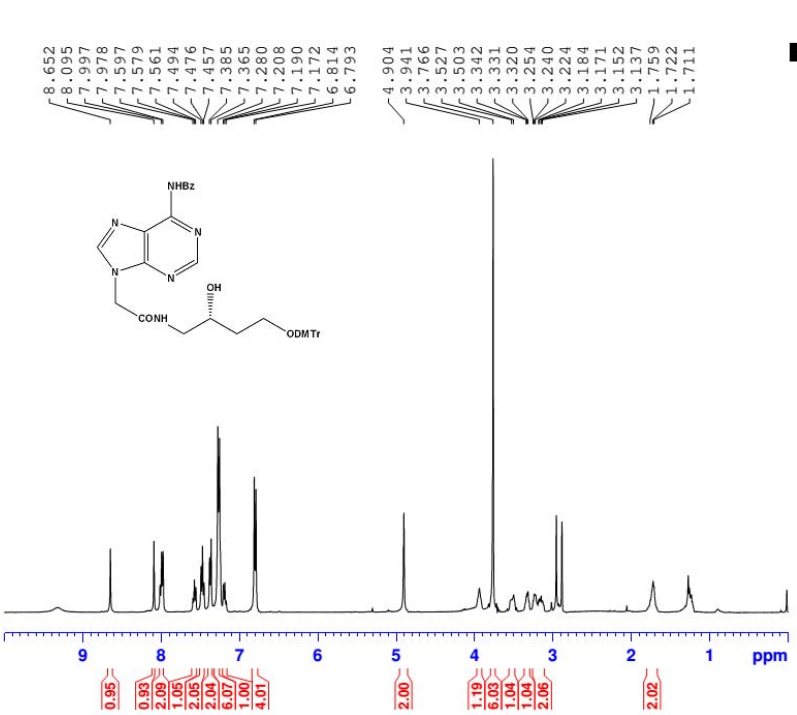

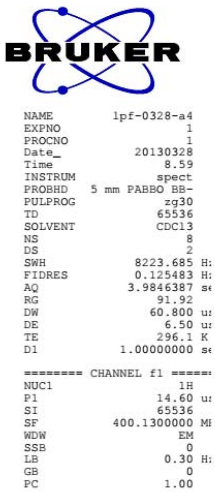


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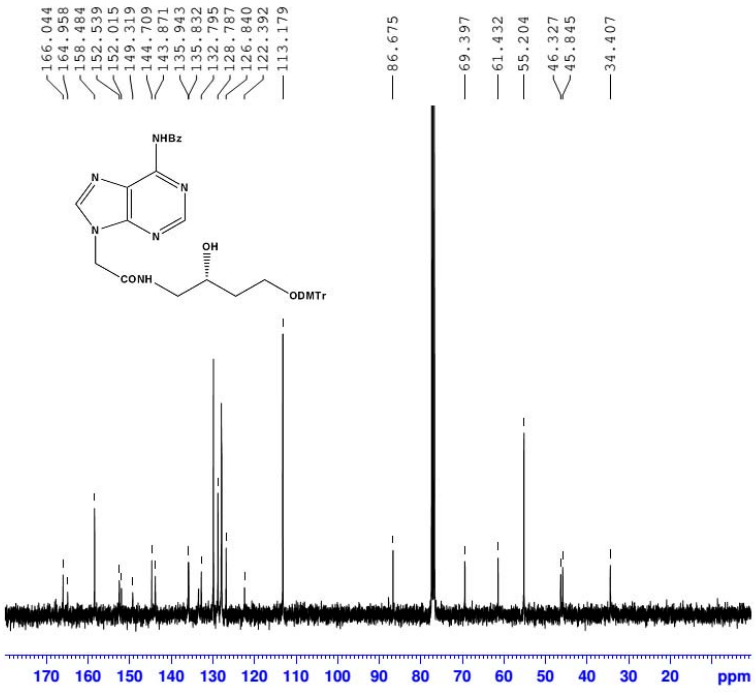


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PCPD2                60.00 usec
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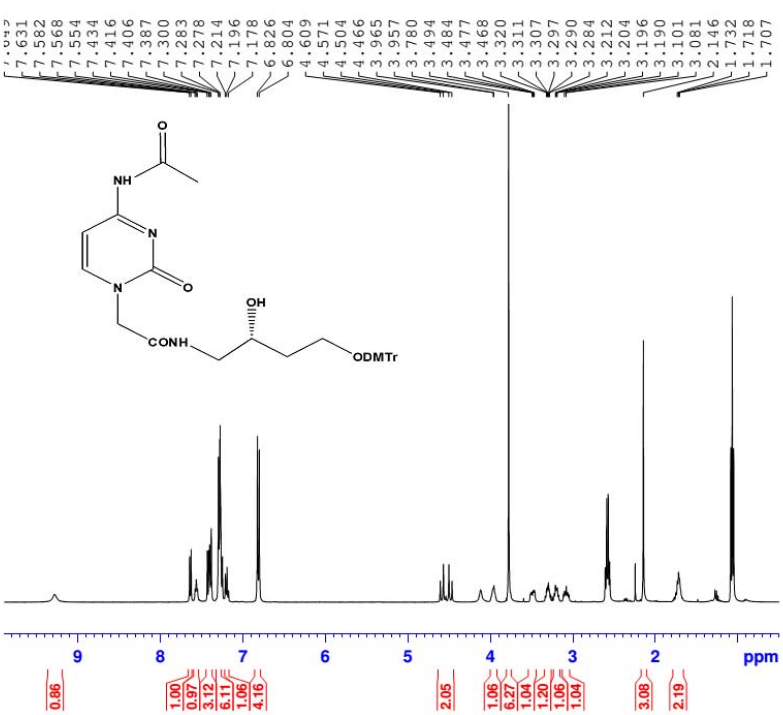
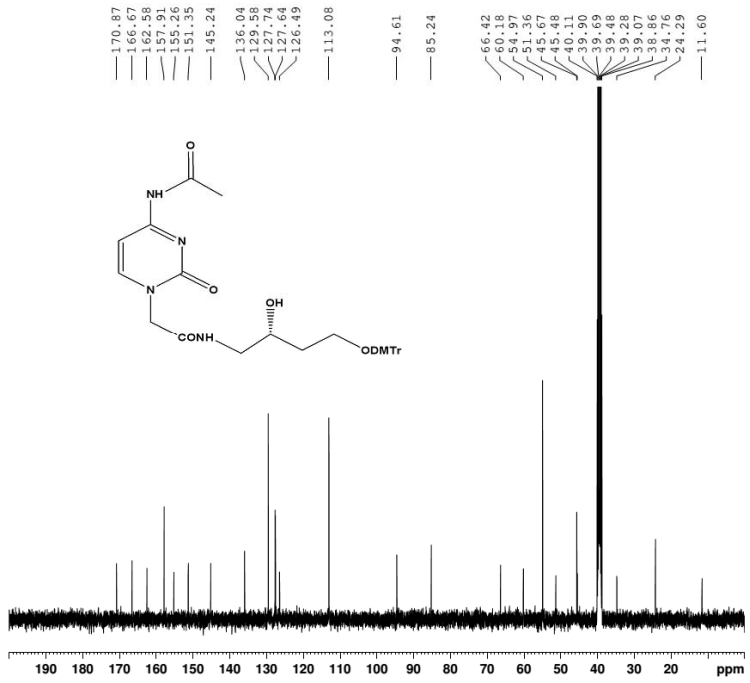
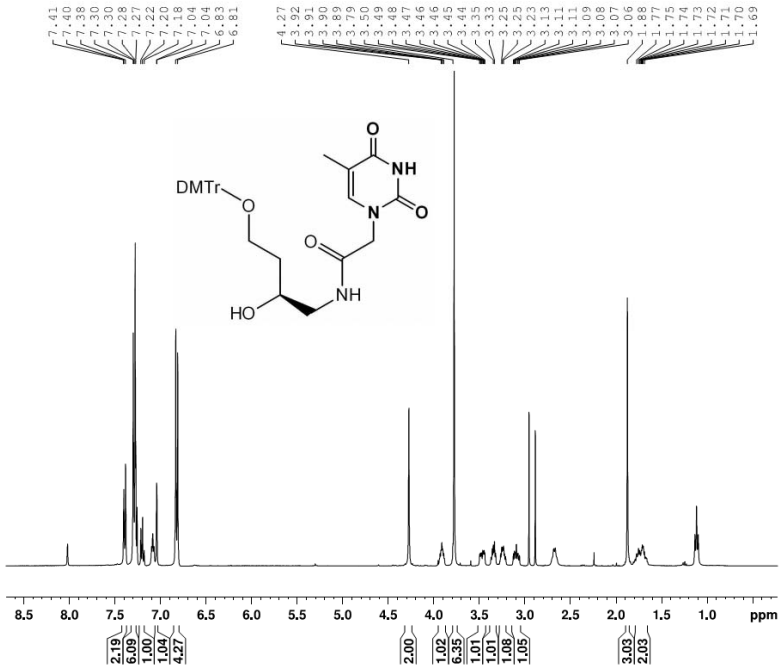


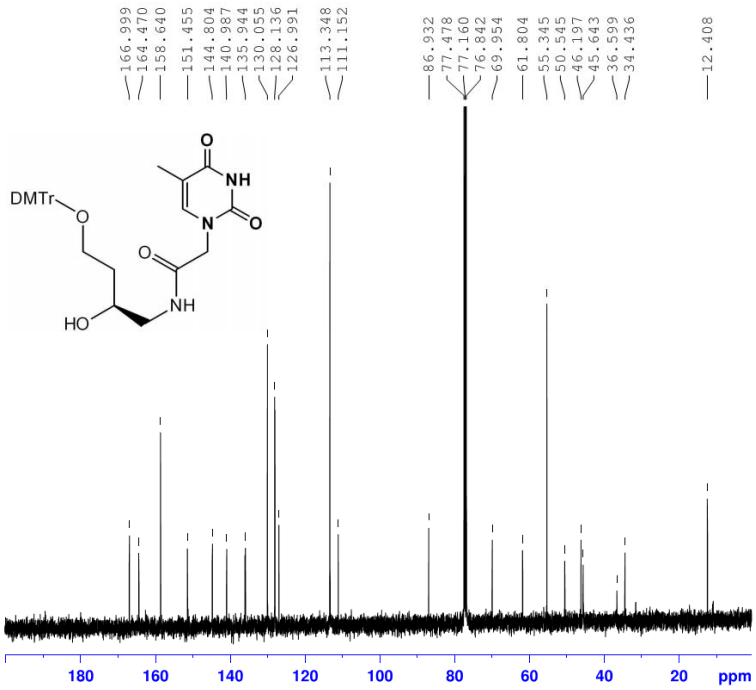
```
NAME          lpf-07-c4
EXPNO                 1
PROCNO                1
Date_          20130406
Time              13.59
INSTRUM           spect
PROBHD   5 mm PABBO BB-
PULPROG            zg30
TD                65536
SOLVENT           CDCl3
NS                    8
DS                    2
SWH            8223.685 Hz
FIDRES        0.125483 Hz
AQ            3.9846387 sec
RG               133.41
DW               60.800 usec
DE                6.50 usec
TE               295.6 K
D1            1.00000000 sec

======== CHANNEL f1 ========
NUC1                 1H
P1               14.60 usec
SI                65536
SF          400.1300000 MHz
WDW                  EM
SSB                   0
LB                 0.30 Hz
GB                    0
PC                 1.00
```



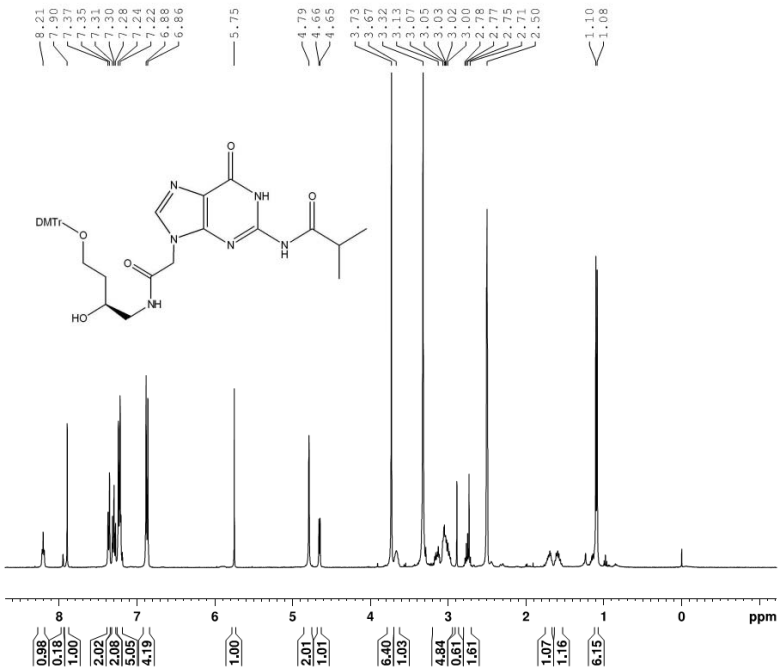
```
NAME        lpf-0307-c4
EXPNO                 2
PROCNO                1
Date_          20130407
Time              13.30
INSTRUM           spect
PROBHD   5 mm PABBO BB-
PULPROG         zgpg30
TD                65536
SOLVENT            DMSO
NS                  430
DS                    4
SWH           26041.666 Hz
FIDRES        0.397364 Hz
AQ            1.2583412 sec
RG               205.82
DW               19.200 usec
DE                6.50 usec
TE               296.8 K
D1            1.25000000 sec
D11           0.03000000 sec
TD0                   1

======== CHANNEL f1 ========
NUC1                13C
P1                9.00 usec
SI                32768
SF          100.6128193 MHz
WDW                  EM
SSB                   0
LB                 1.00 Hz
GB                    0
PC                 1.40
```



```
NAME            lpf-0218-t4
EXPNO                     1
PROCNO                    1
Date_              20130218
Time                  18.06
INSTRUM               spect
PROBHD   5 mm PABBO BB-
PULPROG                zg30
TD                    65536
SOLVENT               CDCl3
NS                       16
DS                        2
SWH                8223.685 Hz
FIDRES             0.125483 Hz
AQ                 3.9846387 sec
RG                    112.54
DW                    60.800 usec
DE                     6.50 usec
TE                   298.4 K
D1                 1.00000000 sec
TD0                       1

======== CHANNEL f1 ========
NUC1                      1H
P1                     14.00 usec
SI                     65536
SF              400.1300056 MHz
WDW                      EM
SSB                       0
LB                     0.30 Hz
GB                        0
PC                     1.00
```

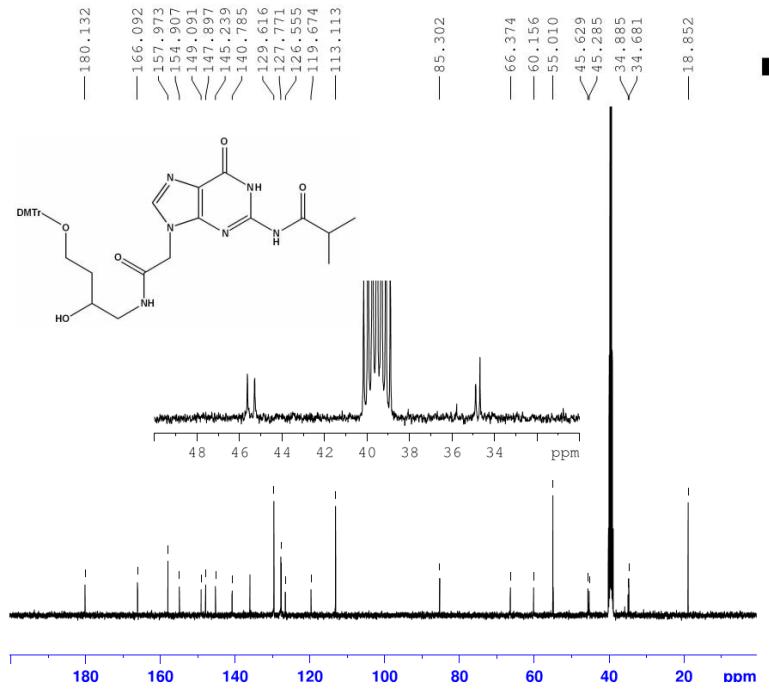


```
NAME         lpf-0218-t4-01
EXPNO                     1
PROCNO                    1
Date_              20130218
Time                  18.17
INSTRUM               spect
PROBHD   5 mm PABBO BB-
PULPROG             zgpg30
TD                    65536
SOLVENT               CDCl3
NS                      248
DS                        4
SWH               26041.666 Hz
FIDRES             0.397364 Hz
AQ                 1.2583412 sec
RG                    205.82
DW                    19.200 usec
DE                     6.50 usec
TE                   299.5 K
D1                 1.25000000 sec
D11                0.03000000 sec
TD0                       1

======== CHANNEL f1 ========
NUC1                     13C
P1                      9.00 usec
SI                     32768
SF             100.6127568 MHz
WDW                      EM
SSB                       0
LB                     1.00 Hz
GB                        0
PC                     1.40
```



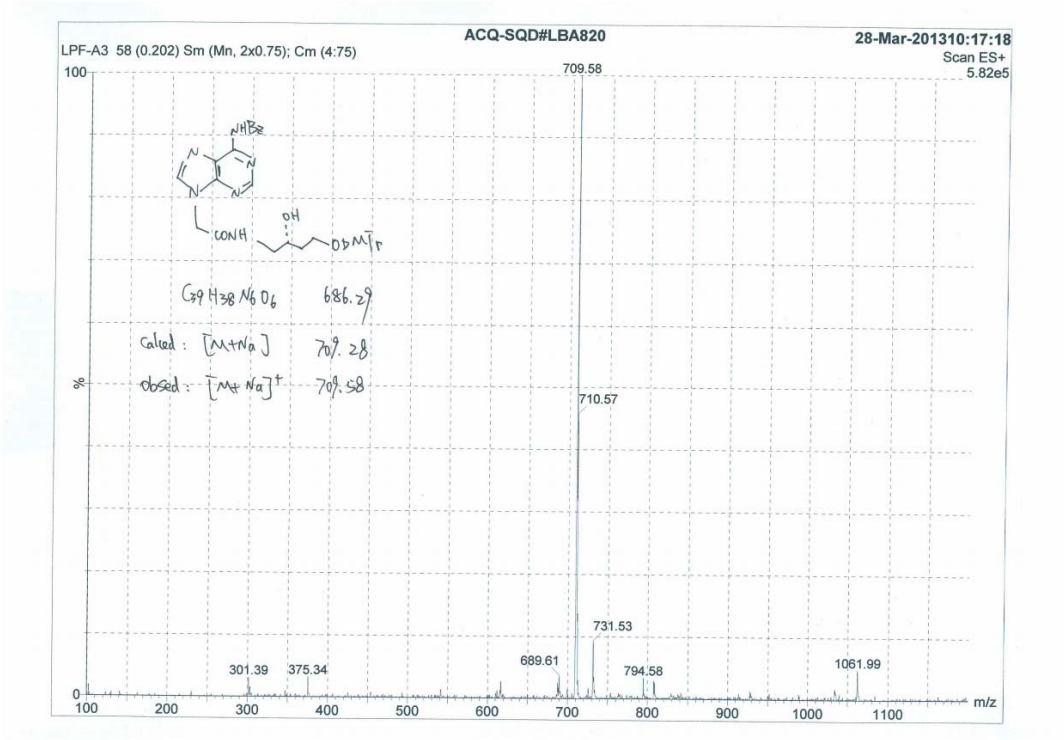
BRUKER

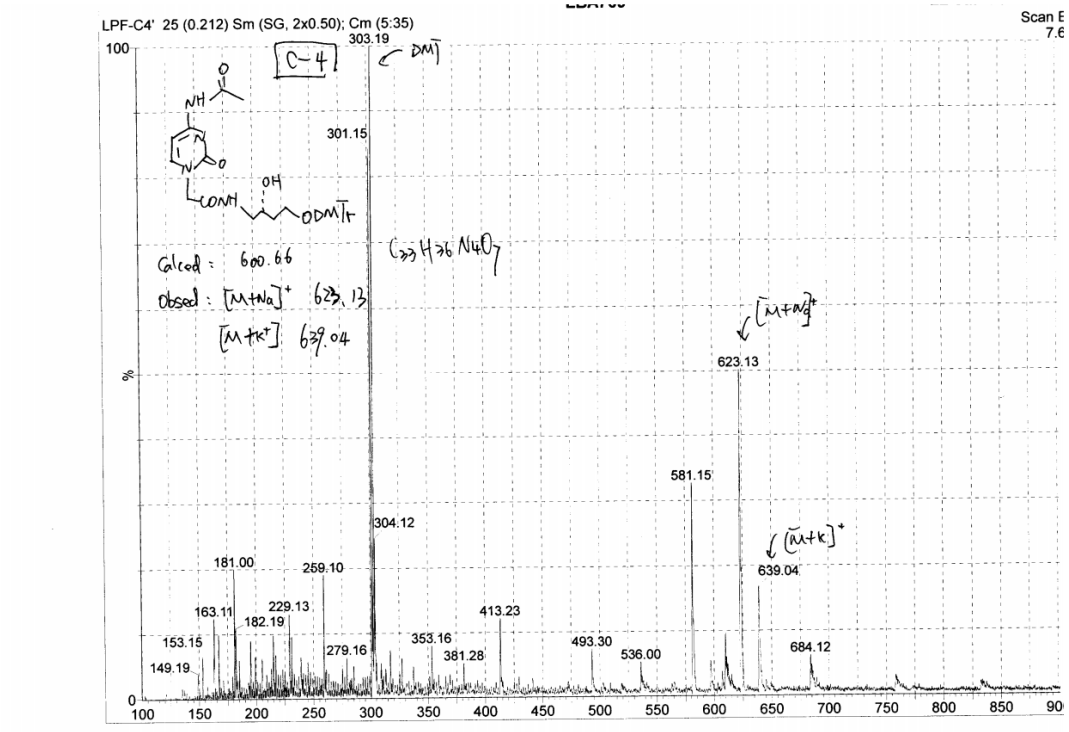
NAME	lpf-g4
EXPNO	1
PROCNO	1
Date_	20130126
Time	10.26
INSTRUM	spect
PROBHD	5 mm PABBO BB-
PULPROG	zg30
TD	65536
SOLVENT	DMSO
NS	8
DS	2
SWH	8223.685 Hz
FIDRES	0.125483 Hz
AQ	3.9846387 sec
RG	133.41
DW	60.800 usec
DE	6.50 usec
TE	299.5 K
D1	1.00000000 sec
======== CHANNEL f1 ========	
NUC1	1H
P1	14.60 usec
SI	65536
SF	400.1300022 MHz
WDW	EM
SSB	0
LB	0.30 Hz
GB	0
PC	1.00

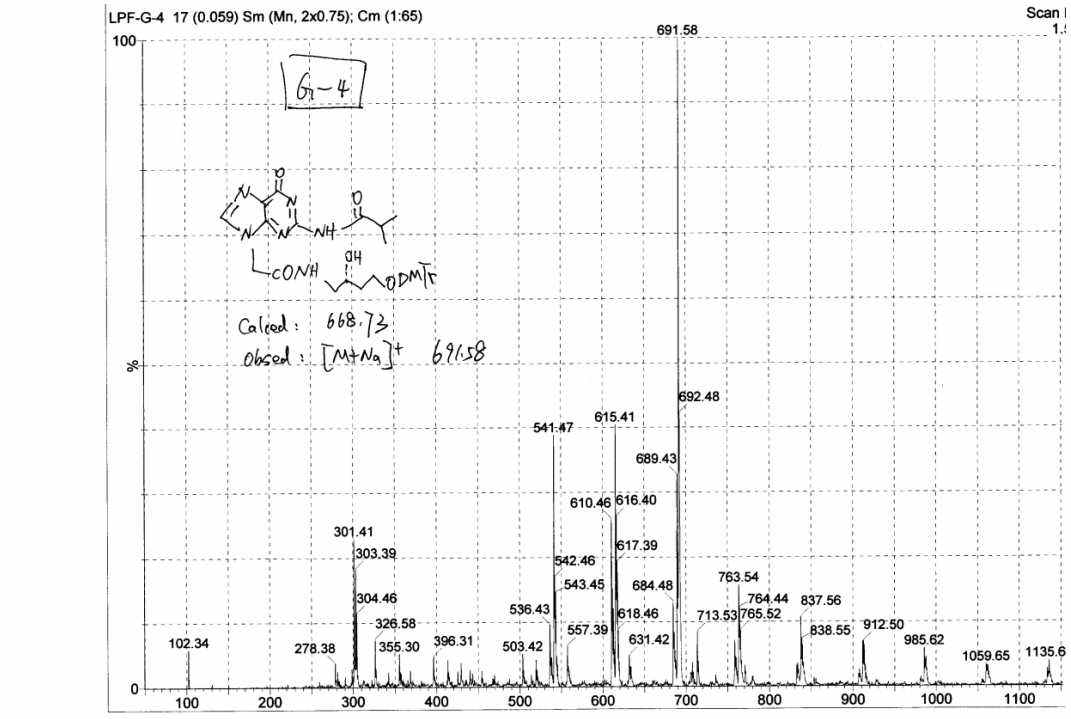


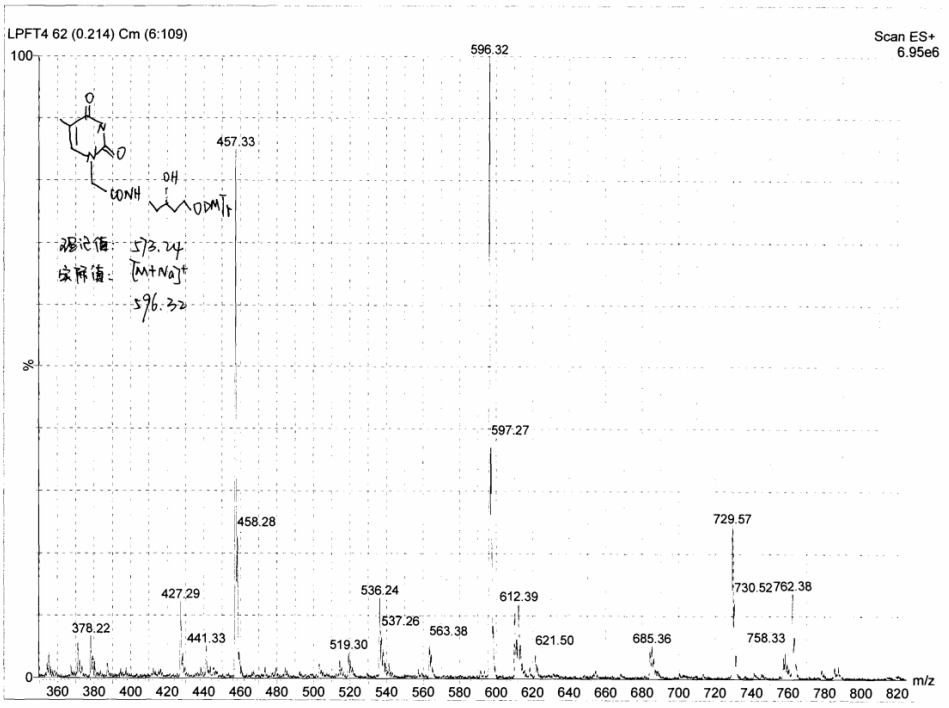
BRUKER

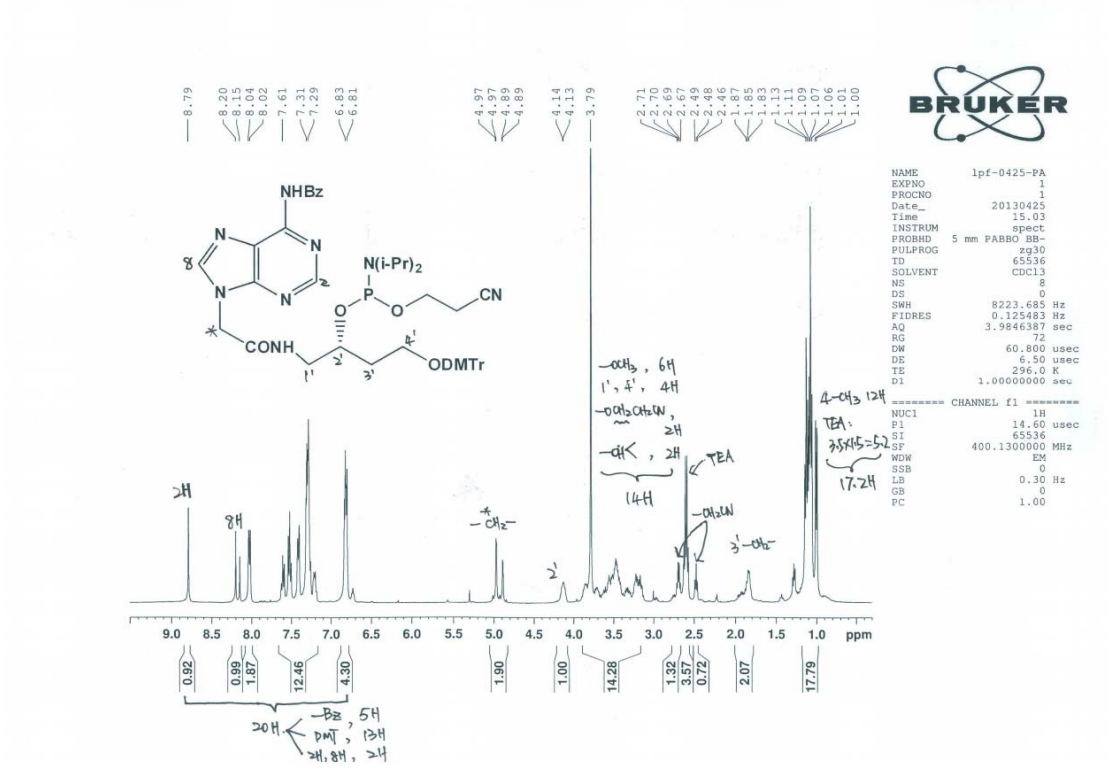
NAME	lpf-0219-G4
EXPNO	2
PROCNO	1
Date_	20130219
Time	20.45
INSTRUM	spect
PROBHD	5 mm PABBO BB-
PULPROG	zgpg30
TD	65536
SOLVENT	DMSO
NS	368
DS	4
SWH	28409.092 Hz
FIDRES	0.433488 Hz
AQ	1.1534836 sec
RG	183.47
DW	17.600 usec
DE	6.50 usec
TE	296.9 K
D1	1.20000005 sec
D11	0.03000000 sec
======== CHANNEL f1 ========	
NUC1	13C
P1	9.00 usec
SI	32768
SF	100.6128148 MHz
WDW	EM
SSB	0
LB	1.00 Hz
GB	0
PC	1.40

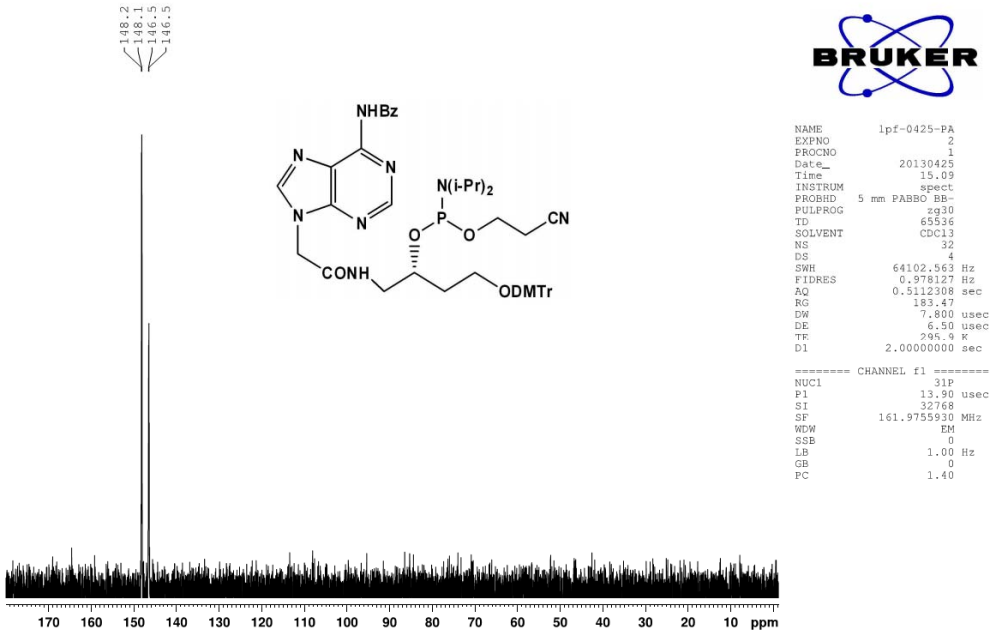

ACQ-SQD#LBA820
28-Mar-201310:17:18
LPF-A3 58 (0.202) Sm (Mn, 2x0.75); Cm (4:75)
Scan ES+
5.82e5
709.58
710.57
731.53
689.61
794.58
1061.99
301.39
375.34
NHBz
OH
CONH
ODMTr
C39H38N6O6 686.29
Calcd: [M+Na] 709.28
Obsed: [M+Na]+ 709.58
%
m/z

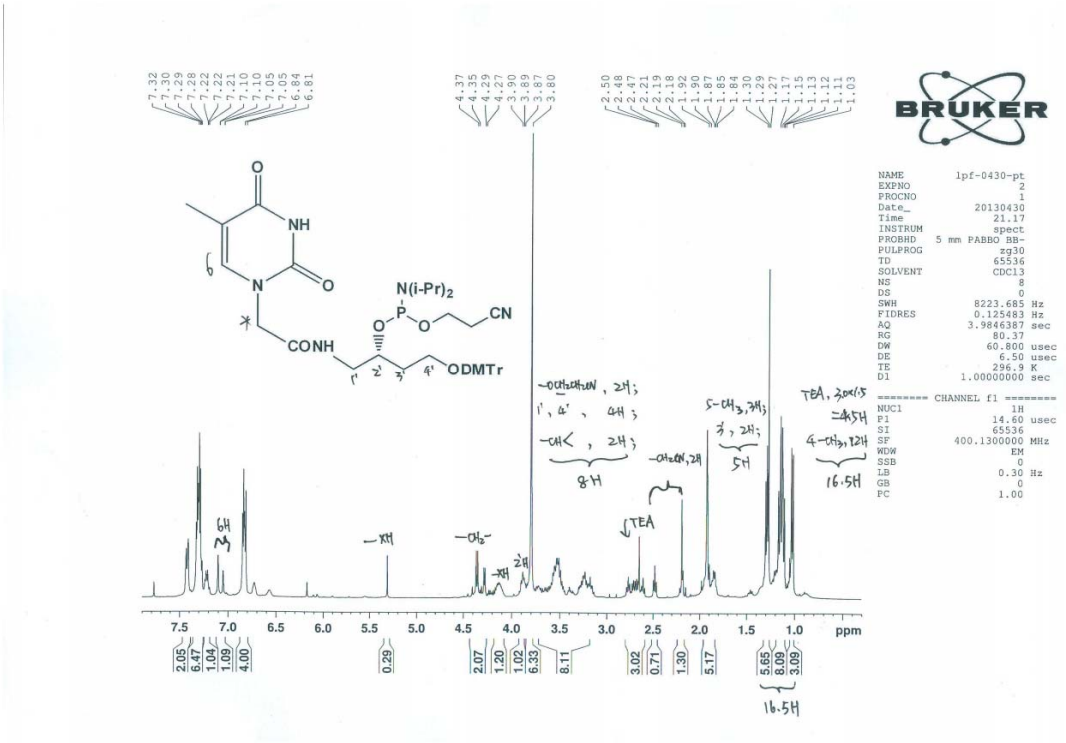

LPF-C4' 25 (0.212) Sm (SG, 2x0.50); Cm (5:35)
C-4
303.19
DMT
301.15
623.13
581.15
304.12
639.04
181.00
259.10
229.13
163.11
182.19
153.15
279.16
149.19
353.16
381.28
413.23
493.30
536.00
684.12
NH
O
OH
CONH
ODMTr
Calcd: 600.66
Obsed: [M+Na]+ 623.13
[M+K]+ 639.04
C33H36N4O7
[M+Na]+
[M+K]+
%

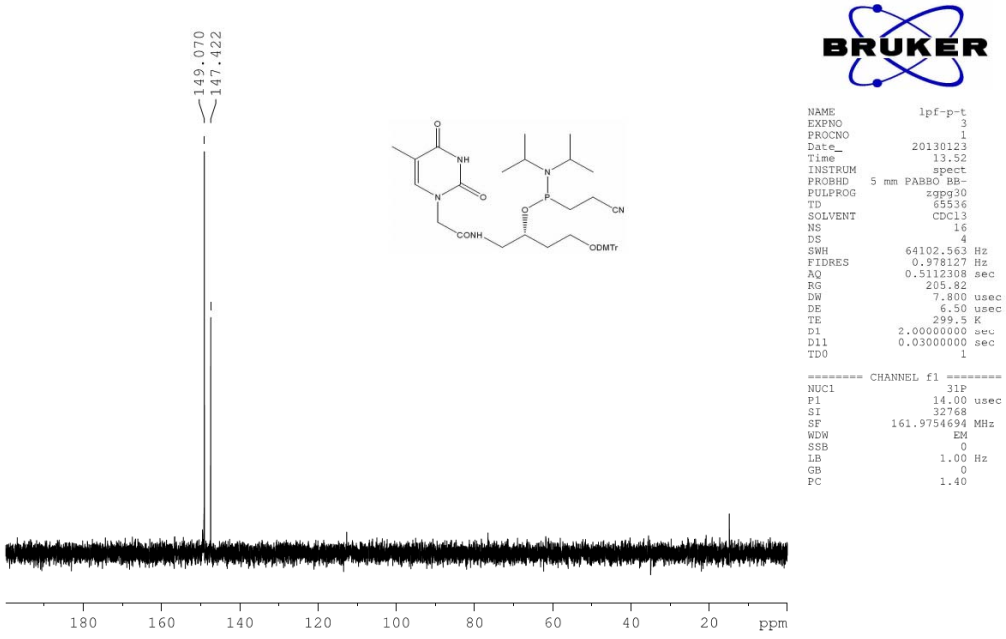

LPF-G-4 17 (0.059) Sm (Mn, 2x0.75); Cm (1:65)
Scan
G-4
Calcod: 668.73
Obsed: [M+Na]+ 691.58
691.58
692.48
615.41
541.47
689.43
610.46
616.40
301.41
303.39
617.39
542.46
543.45
684.48
763.54
304.46
764.44
837.56
536.43
618.46
713.53
765.52
326.58
838.55
912.50
557.39
631.42
985.62
102.34
278.38
355.30
396.31
503.42
1059.65
1135.6
%
100
200
300
400
500
600
700
800
900
1000
1100

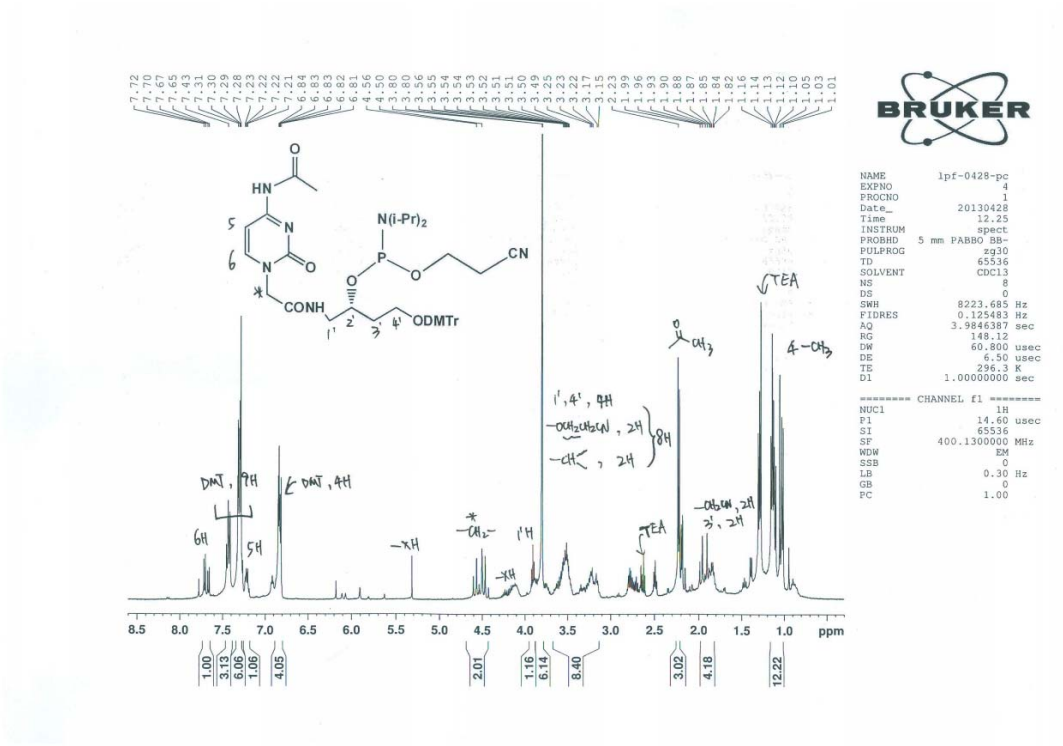

LPFT4 62 (0.214) Cm (6:109)
Scan ES+
6.95e6
596.32
457.33
597.27
458.28
729.57
427.29
536.24
730.52
762.38
612.39
537.26
563.38
378.22
441.33
519.30
621.50
685.36
758.33
%
m/z
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
760
780
800
820

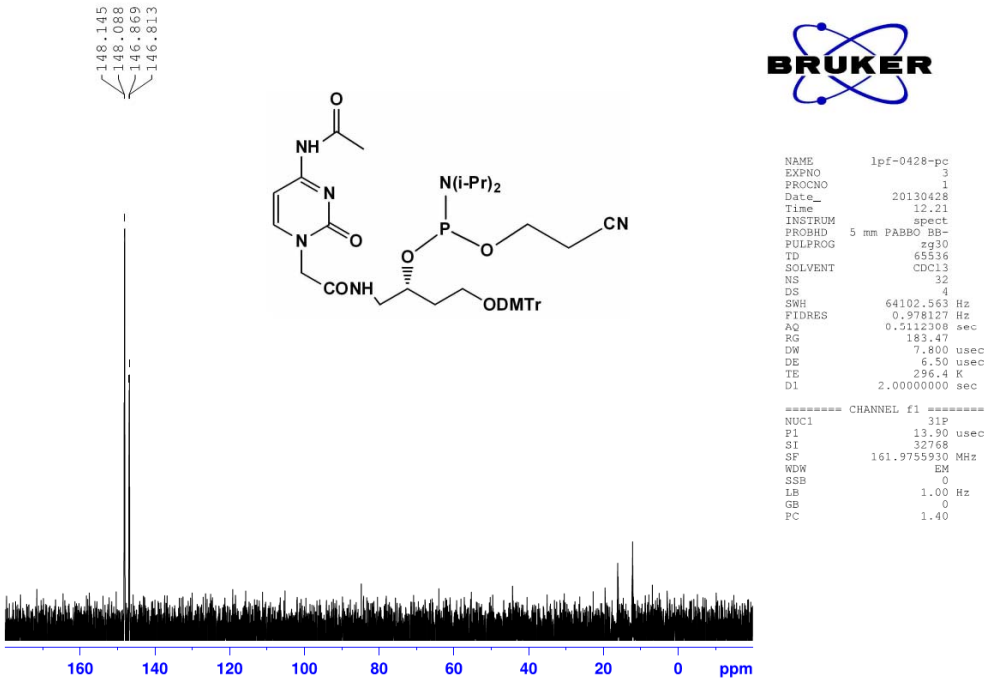

8.79
8.20
8.15
8.04
8.02
7.61
7.31
7.29
6.83
6.81
4.97
4.97
4.89
4.89
4.14
4.13
3.79
2.71
2.70
2.69
2.67
2.49
2.48
2.46
2.07
1.85
1.83
1.13
1.11
1.09
1.07
1.06
1.01
1.00
NHBz
N(i-Pr)2
CN
CONH
ODMTr
NAME 1pf-0425-PA
EXPNO 1
PROCNO 1
Date_ 20130425
Time 15.03
INSTRUM spect
PROBHD 5 mm PABBO BB-
PULPROG zg30
TD 65536
SOLVENT CDCl3
NS 8
DS 0
SWH 8223.685 Hz
FIDRES 0.125483 Hz
AQ 3.9846387 sec
RG 72
DW 60.800 usec
DE 6.50 usec
TE 296.0 K
D1 1.00000000 sec
======== CHANNEL f1 ========
NUC1 1H
P1 14.60 usec
SI 65536
SF 400.1300000 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 ppm
0.92
0.99
1.87
12.46
4.30
1.90
1.00
14.28
1.32
3.57
0.72
2.07
17.79

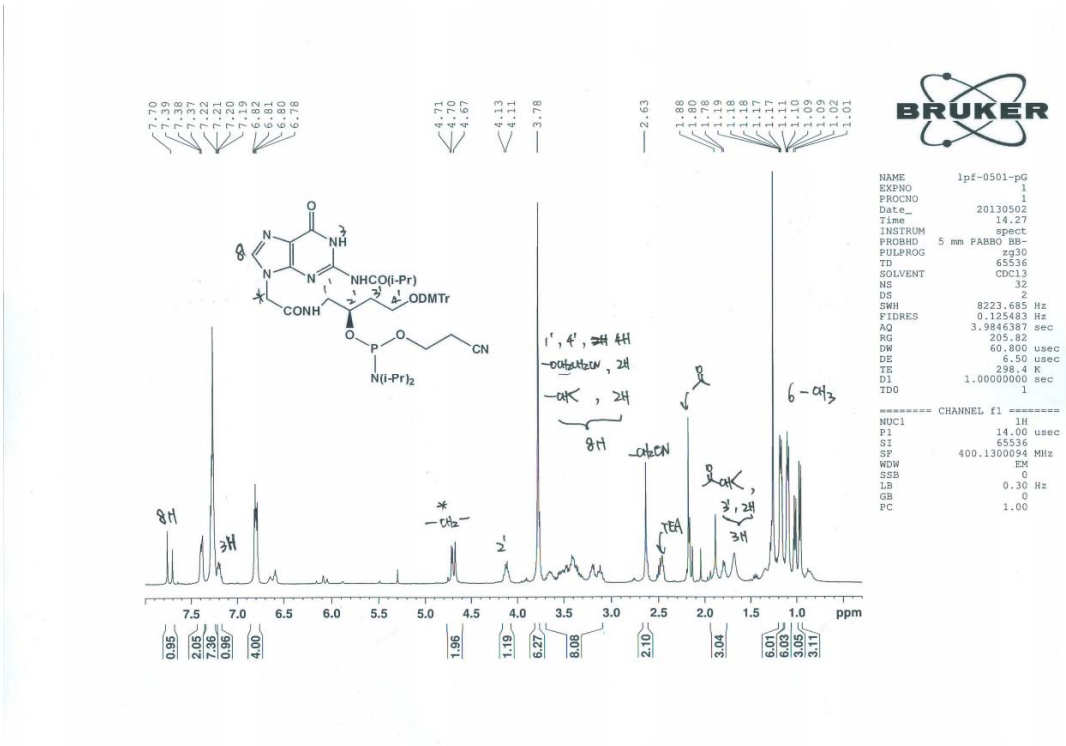

148.2
148.1
146.5
146.5
NHBz
N(i-Pr)2
CN
CONH
ODMTr
NAME 1pf-0425-PA
EXPNO 2
PROCNO 1
Date_ 20130425
Time 15.09
INSTRUM spect
PROBHD 5 mm PABBO BB-
PULPROG zg30
TD 65536
SOLVENT CDCl3
NS 32
DS 4
SWH 64102.563 Hz
FIDRES 0.978127 Hz
AQ 0.5112308 sec
RG 183.47
DW 7.800 usec
DE 6.50 usec
TE 295.9 K
D1 2.00000000 sec
======== CHANNEL f1 ========
NUC1 31P
P1 13.90 usec
SI 32768
SF 161.9755930 MHz
WDW EM
SSB 0
LB 1.00 Hz
GB 0
PC 1.40
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

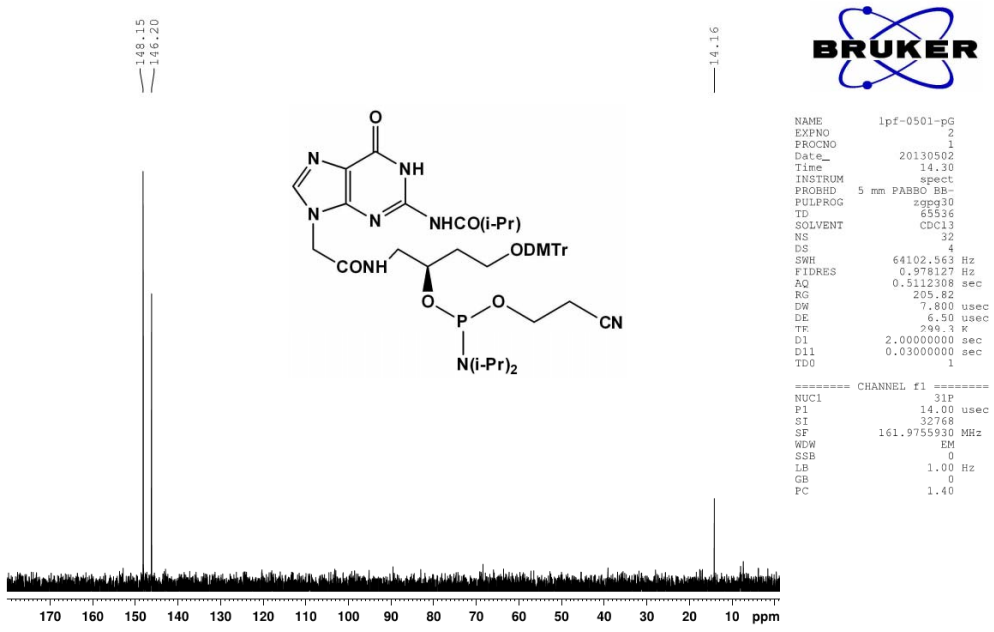

BRUKER
NAME 1pf-0430-pt
EXPNO 2
PROCNO 1
Date_ 20130430
Time 21.17
INSTRUM spect
PROBHD 5 mm PABBO BB-
PULPROG zg30
TD 65536
SOLVENT CDC13
NS 8
DS 0
SWH 8223.685 Hz
FIDRES 0.125483 Hz
AQ 3.9846387 sec
RG 80.37
DW 60.800 usec
DE 6.50 usec
TE 296.9 K
D1 1.00000000 sec
======== CHANNEL f1 ========
NUC1 1H
P1 14.60 usec
SI 65536
SF 400.1300000 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00
N(i-Pr)2
CN
CONH
ODMTr
TEA
8H
5H
16.5H
ppm

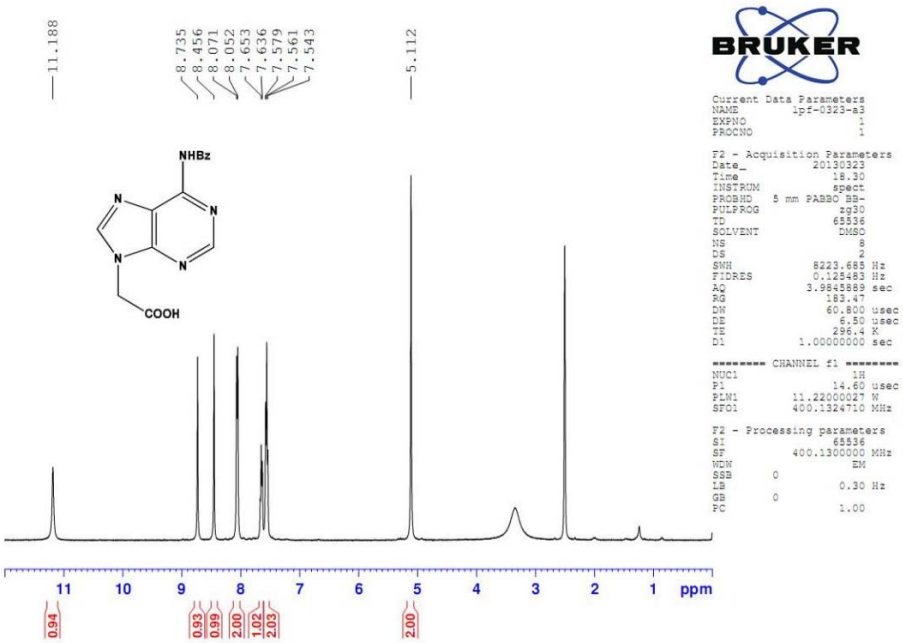

149.070
147.422
BRUKER
NAME lpf-p-t
EXPNO 3
PROCNO 1
Date_ 20130123
Time 13.52
INSTRUM spect
PROBHD 5 mm PABBO BB-
PULPROG zgpg30
TD 65536
SOLVENT CDC13
NS 16
DS 4
SWH 64102.563 Hz
FIDRES 0.978127 Hz
AQ 0.5112308 sec
RG 205.82
DW 7.800 usec
DE 6.50 usec
TE 299.5 K
D1 2.00000000 sec
D11 0.03000000 sec
TD0 1
======== CHANNEL f1 ========
NUC1 31P
P1 14.00 usec
SI 32768
SF 161.9754694 MHz
WDW EM
SSB 0
LB 1.00 Hz
GB 0
PC 1.40
CONH
ODMTr
ppm


BRUKER
NAME lpf-0428-pc
EXPNO 4
PROCNO 1
Date_ 20130428
Time 12.25
INSTRUM spect
PROBHD 5 mm PABBO BB-
PULPROG zg30
TD 65536
SOLVENT CDC13
NS 8
DS 0
SWH 8223.685 Hz
FIDRES 0.125483 Hz
AQ 3.9846387 sec
RG 148.12
DW 60.800 usec
DE 6.50 usec
TE 296.3 K
D1 1.00000000 sec
CHANNEL f1
NUC1 1H
P1 14.60 usec
SI 65536
SF 400.1300000 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00
N(i-Pr)2
CN
CONH
ODMTr
TEA
ppm


BRUKER
NAME lpf-0428-pc
EXPNO 3
PROCNO 1
Date_ 20130428
Time 12.21
INSTRUM spect
PROBHD 5 mm PABBO BB-
PULPROG zg30
TD 65536
SOLVENT CDC13
NS 32
DS 4
SWH 64102.563 Hz
FIDRES 0.978127 Hz
AQ 0.5112308 sec
RG 183.47
DW 7.800 usec
DE 6.50 usec
TE 296.4 K
D1 2.00000000 sec
CHANNEL f1
NUC1 31P
P1 13.90 usec
SI 32768
SF 161.9755930 MHz
WDW EM
SSB 0
LB 1.00 Hz
GB 0
PC 1.40
N(i-Pr)2
CN
CONH
ODMTr
ppm

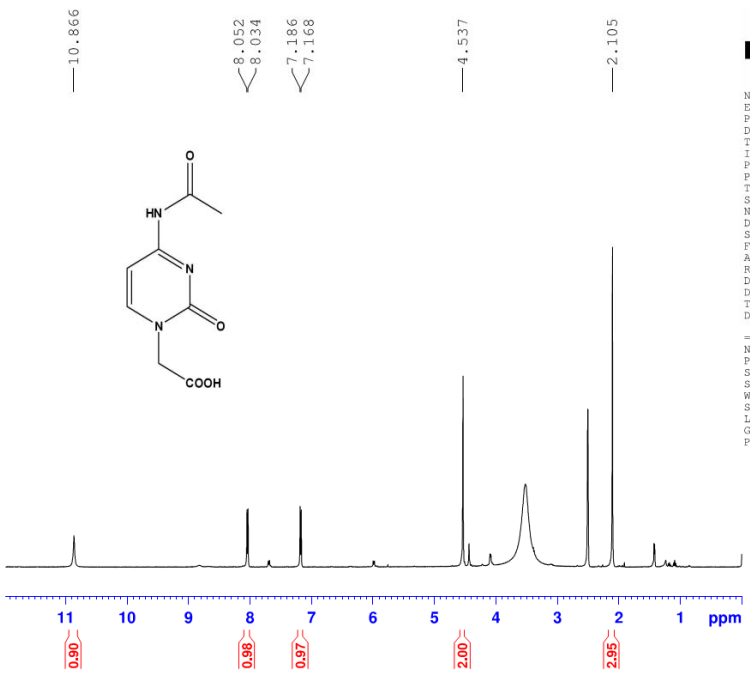

7.70
7.39
7.38
7.37
7.22
7.21
7.20
7.19
6.82
6.81
6.80
6.78
4.71
4.70
4.67
4.13
4.11
3.78
2.63
1.88
1.80
1.78
1.19
1.18
1.18
1.17
1.17
1.11
1.10
1.09
1.09
1.02
1.01
BRUKER
NHCO(i-Pr)
ODMTr
CONH
CN
N(i-Pr)2
NAME 1pf-0501-pG
EXPNO 1
PROCNO 1
Date_ 20130502
Time 14.27
INSTRUM spect
PROBHD 5 mm PABBO BB-
PULPROG zg30
TD 65536
SOLVENT CDC13
NS 32
DS 2
SWH 8223.685 Hz
FIDRES 0.125483 Hz
AQ 3.9846387 sec
RG 205.82
DW 60.800 usec
DE 6.50 usec
TE 298.4 K
D1 1.00000000 sec
TD0 1
======== CHANNEL f1 ========
NUC1 1H
P1 14.00 usec
SI 65536
SF 400.1300094 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00
7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 ppm
0.95 2.05 7.36 0.96 4.00 1.96 1.19 6.27 8.08 2.10 3.04 6.01 6.03 3.05 3.11


148.15
146.20
14.16
BRUKER
NHCO(i-Pr)
ODMTr
CONH
CN
N(i-Pr)2
NAME 1pf-0501-pG
EXPNO 2
PROCNO 1
Date_ 20130502
Time 14.30
INSTRUM spect
PROBHD 5 mm PABBO BB-
PULPROG zgpg30
TD 65536
SOLVENT CDC13
NS 32
DS 4
SWH 64102.563 Hz
FIDRES 0.978127 Hz
AQ 0.5112308 sec
RG 205.82
DW 7.800 usec
DE 6.50 usec
TE 299.3 K
D1 2.00000000 sec
D11 0.03000000 sec
TD0 1
======== CHANNEL f1 ========
NUC1 31P
P1 14.00 usec
SI 32768
SF 161.9755930 MHz
WDW EM
SSB 0
LB 1.00 Hz
GB 0
PC 1.40
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm



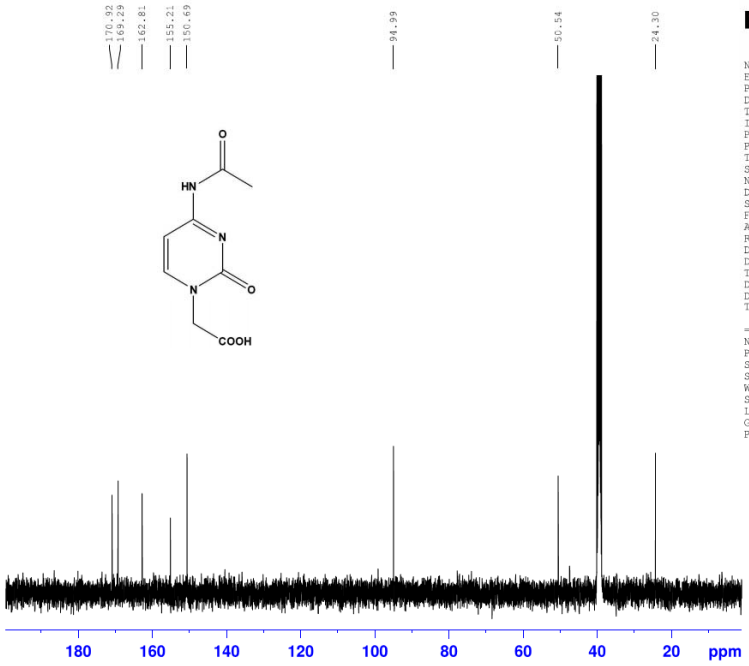
BRUKER

```
Current Data Parameters
NAME                 1pf-0323-a3
EXPNO                          1
PROCNO                         1

F2 - Acquisition Parameters
Date_               20130323
Time                   18.30
INSTRUM                spect
PROBHD     5 mm PABBO BB-
PULPROG                zg30
TD                    65536
SOLVENT                DMSO
NS                         8
DS                         2
SWH                8223.685 Hz
FIDRES            0.125483 Hz
AQ                 3.9845889 sec
RG                     183.47
DW                   60.800 usec
DE                    6.50 usec
TE                   296.4 K
D1                1.00000000 sec

======== CHANNEL f1 ========
NUC1                       1H
P1                    14.60 usec
PLW1           11.22000027 W
SFO1           400.1324710 MHz

F2 - Processing parameters
SI                        65536
SF             400.1300000 MHz
WDW                       EM
SSB          0
LB                     0.30 Hz
GB           0
PC                     1.00
```

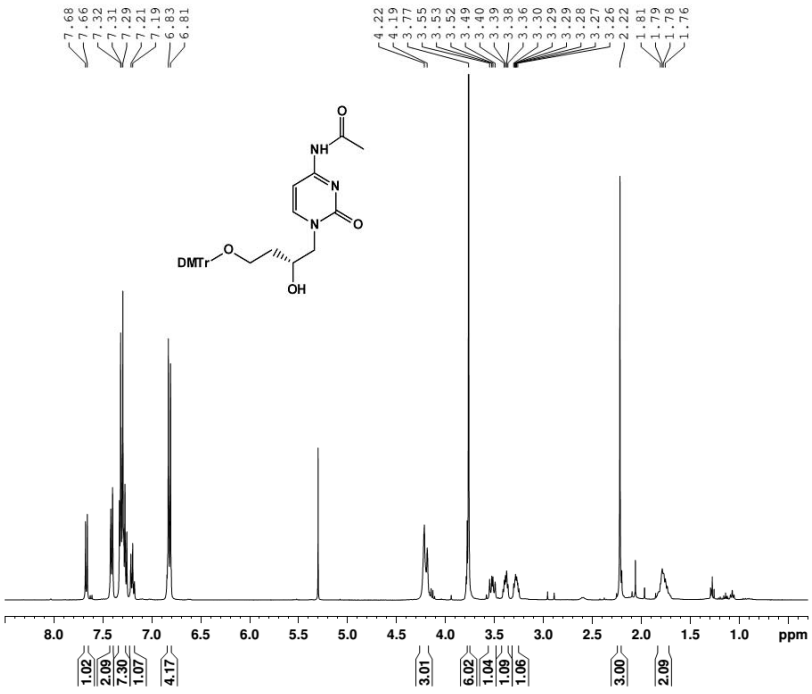


BRUKER

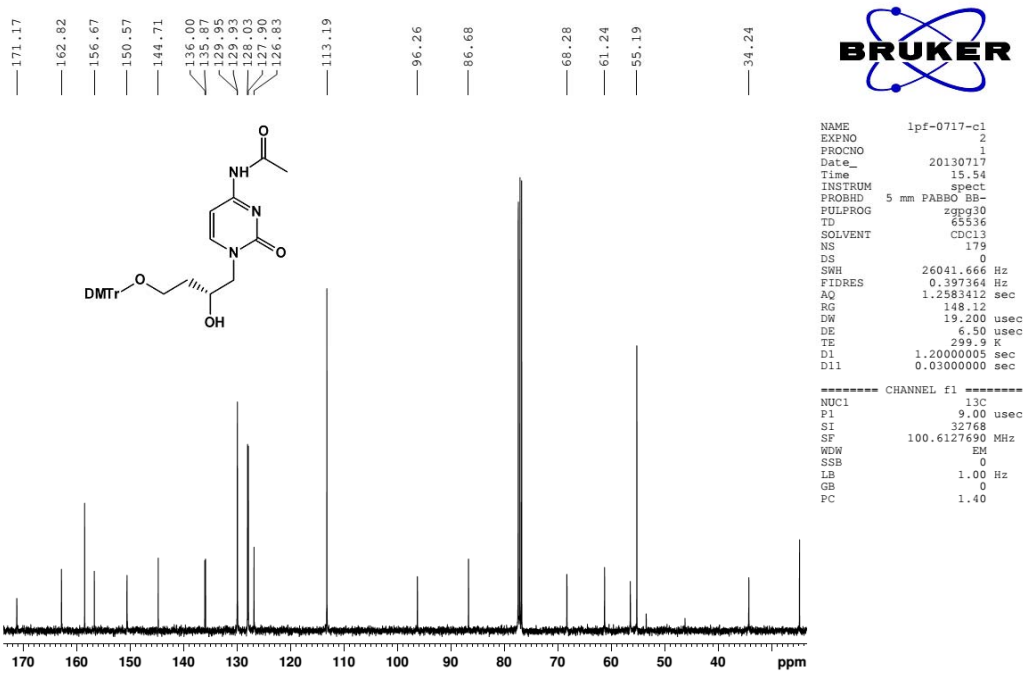
```
NAME                 1pf-0315-c2-1
EXPNO                          1
PROCNO                         1
Date_               20130315
Time                   10.43
INSTRUM                spect
PROBHD     5 mm PABBO BB-
PULPROG                zg30
TD                    65536
SOLVENT                DMSO
NS                         8
DS                         2
SWH                8223.685 Hz
FIDRES            0.125483 Hz
AQ                 3.9846387 sec
RG                     183.47
DW                   60.800 usec
DE                    6.50 usec
TE                   296.5 K
D1                1.00000000 sec

======== CHANNEL f1 ========
NUC1                       1H
P1                    14.60 usec
SI                        65536
SF             400.1300000 MHz
WDW                       EM
SSB                        0
LB                     0.30 Hz
GB                         0
PC                     1.00
```

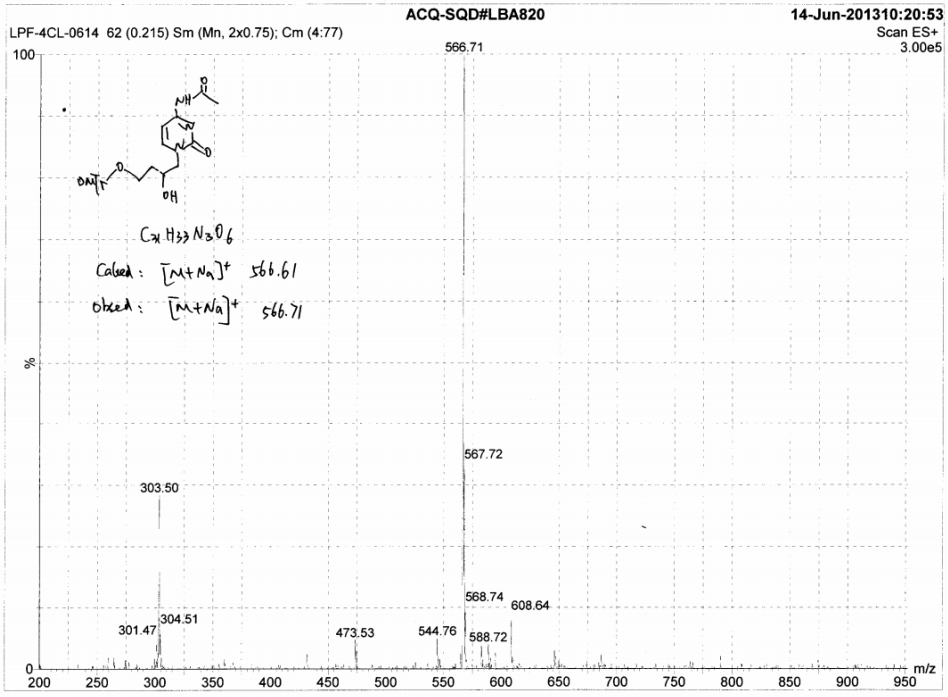


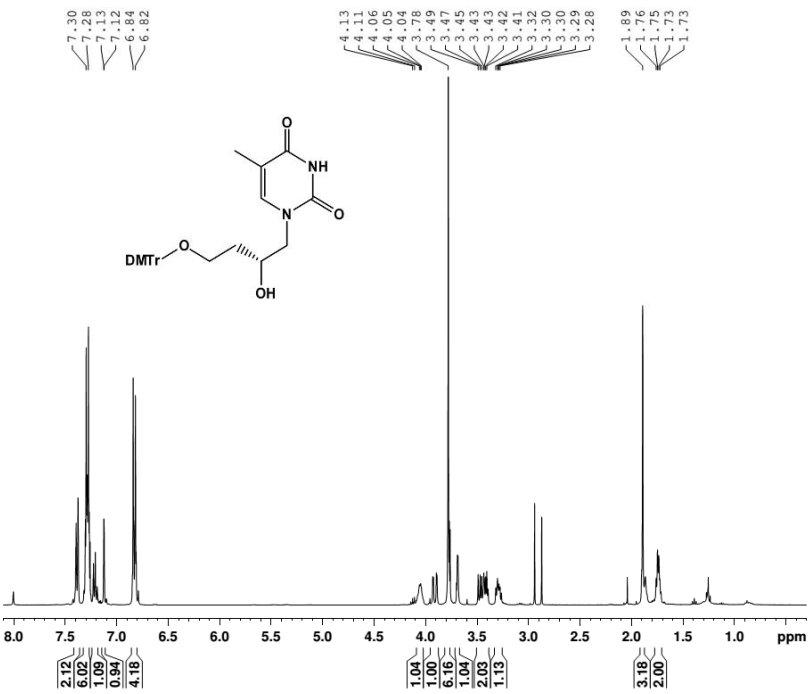

```
NAME            1pf-0315-c2-2
EXPNO                       2
PROCNO                      1
Date_            20130315
Time                 22.23
INSTRUM              spect
PROBHD    5 mm PABBO BB-
PULPROG             zgpg30
TD                   65536
SOLVENT                DMSO
NS                      502
DS                        4
SWH              26041.666 Hz
FIDRES           0.397364 Hz
AQ               1.2583412 sec
RG                  205.82
DW                19.200 usec
DE                 6.50 usec
TE                 298.7 K
D1             1.25000000 sec
D11            0.03000000 sec
TD0                       1

======== CHANNEL f1 ========
NUC1                   13C
P1                  9.00 usec
SI                    32768
SF           100.6128193 MHz
WDW                    EM
SSB                     0
LB                 1.00 Hz
GB                      0
PC                 1.40
```

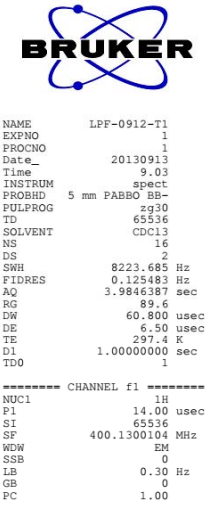



```
NAME            1pf-0717-c1
EXPNO                       1
PROCNO                      1
Date_            20130717
Time                 15.51
INSTRUM              spect
PROBHD    5 mm PABBO BB-
PULPROG              zg30
TD                   65536
SOLVENT              CDCl3
NS                       8
DS                       0
SWH               8223.685 Hz
FIDRES           0.125483 Hz
AQ               3.9846387 sec
RG                   64.88
DW                60.800 usec
DE                 6.50 usec
TE                 299.1 K
D1             1.00000000 sec

======== CHANNEL f1 ========
NUC1                   1H
P1                 14.60 usec
SI                    65536
SF           400.1300000 MHz
WDW                    EM
SSB                     0
LB                 0.30 Hz
GB                      0
PC                 1.00
```

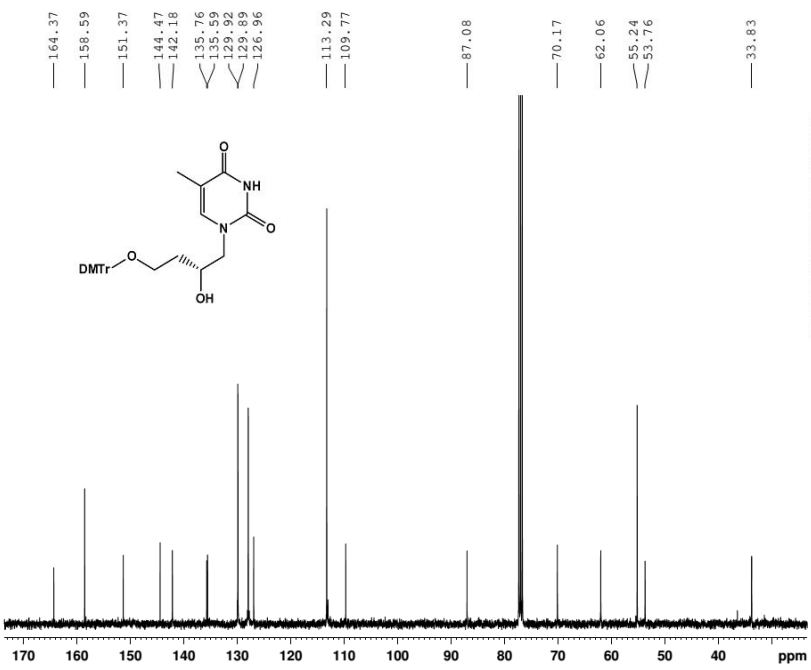

171.17
162.82
156.67
150.57
144.71
136.00
135.87
129.95
129.93
128.03
127.90
126.83
113.19
96.26
86.68
68.28
61.24
55.19
34.24
BRUKER
NAME 1pf-0717-c1
EXPNO 2
PROCNO 1
Date_ 20130717
Time 15.54
INSTRUM spect
PROBHD 5 mm PABBO BB-
PULPROG zgpg30
TD 65536
SOLVENT CDCl3
NS 179
DS 0
SWH 26041.666 Hz
FIDRES 0.397364 Hz
AQ 1.2583412 sec
RG 148.12
DW 19.200 usec
DE 6.50 usec
TE 299.9 K
D1 1.20000005 sec
D11 0.03000000 sec
======== CHANNEL f1 ========
NUC1 13C
P1 9.00 usec
SI 32768
SF 100.6127690 MHz
WDW EM
SSB 0
LB 1.00 Hz
GB 0
PC 1.40
DMTr
OH
170 160 150 140 130 120 110 100 90 80 70 60 50 40 ppm


ACQ-SQD#LBA820
14-Jun-201310:20:53
LPF-4CL-0614 62 (0.215) Sm (Mn, 2x0.75); Cm (4:77)
Scan ES+
3.00e5
566.71
100
%
0
C34 H33 N3 O6
Calcd: [M+Na]+ 566.61
Obsed: [M+Na]+ 566.71
567.72
303.50
568.74
608.64
304.51
301.47
473.53
544.76
588.72
200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 m/z

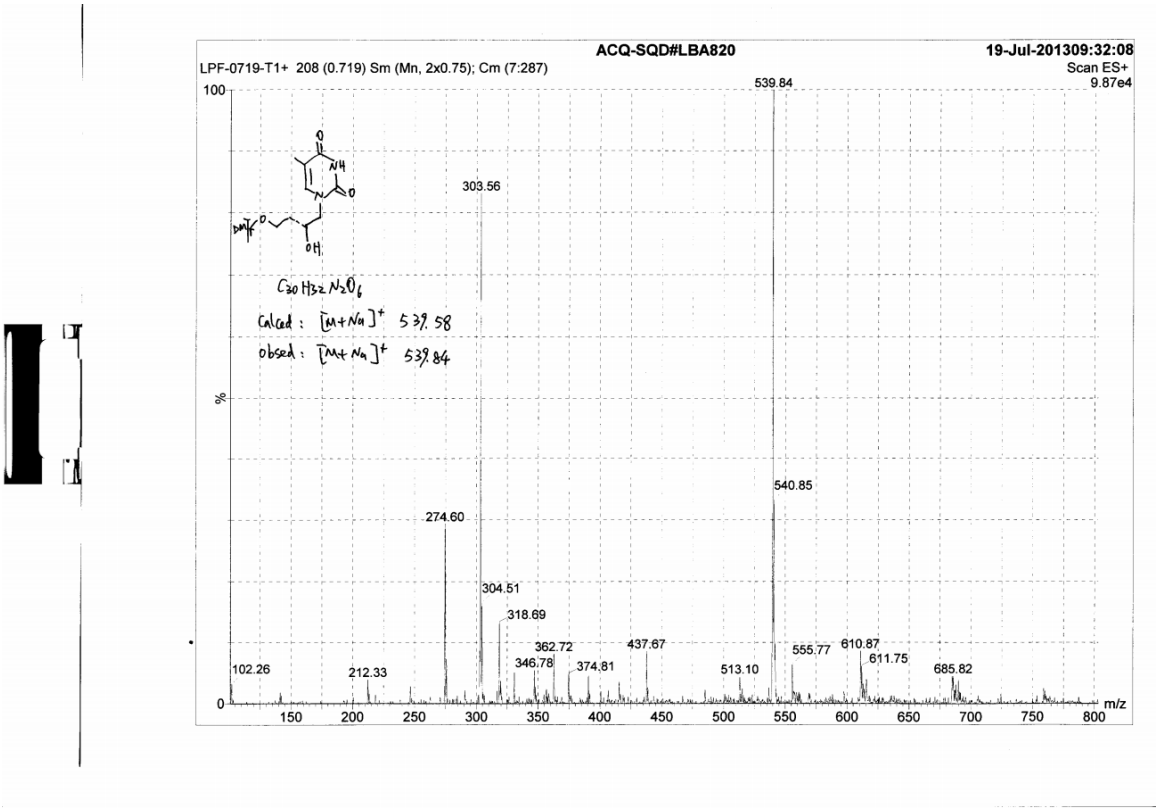


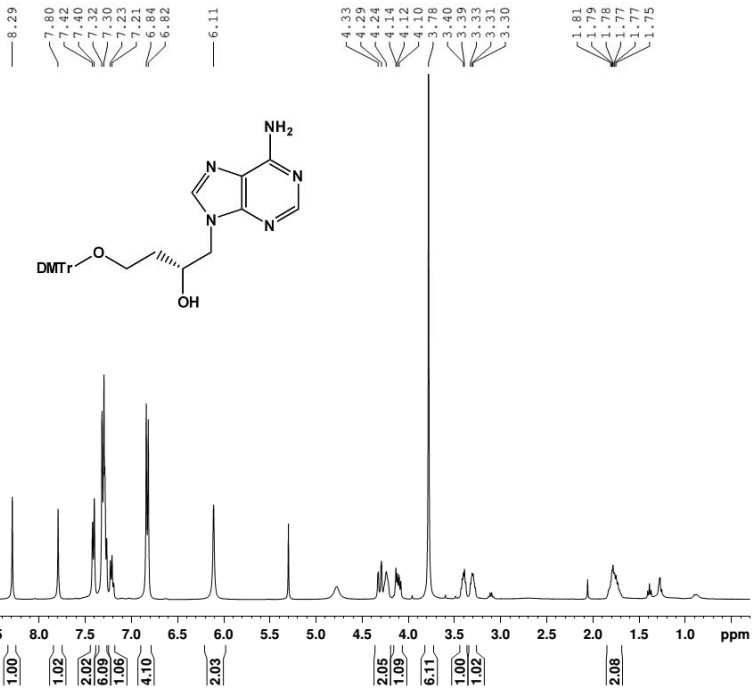



```
NAME          LPF-0912-T1
EXPNO                   1
PROCNO                  1
Date_            20130913
Time                9.03
INSTRUM             spect
PROBHD   5 mm PABBO BB-
PULPROG             zg30
TD                 65536
SOLVENT            CDCl3
NS                    16
DS                     2
SWH             8223.685 Hz
FIDRES          0.125483 Hz
AQ              3.9846387 sec
RG                  89.6
DW                60.800 usec
DE                 6.50 usec
TE                297.4 K
D1             1.00000000 sec
TD0                    1

======== CHANNEL f1 ========
NUC1                  1H
P1                14.00 usec
SI                 65536
SF          400.1300104 MHz
WDW                   EM
SSB                    0
LB                0.30 Hz
GB                     0
PC                 1.00
```

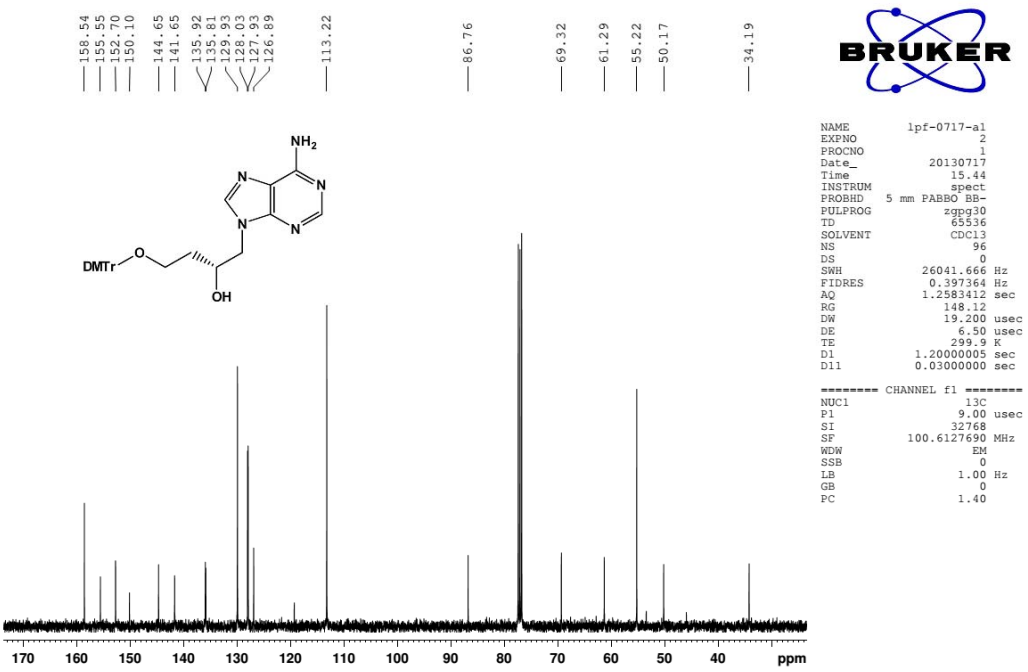


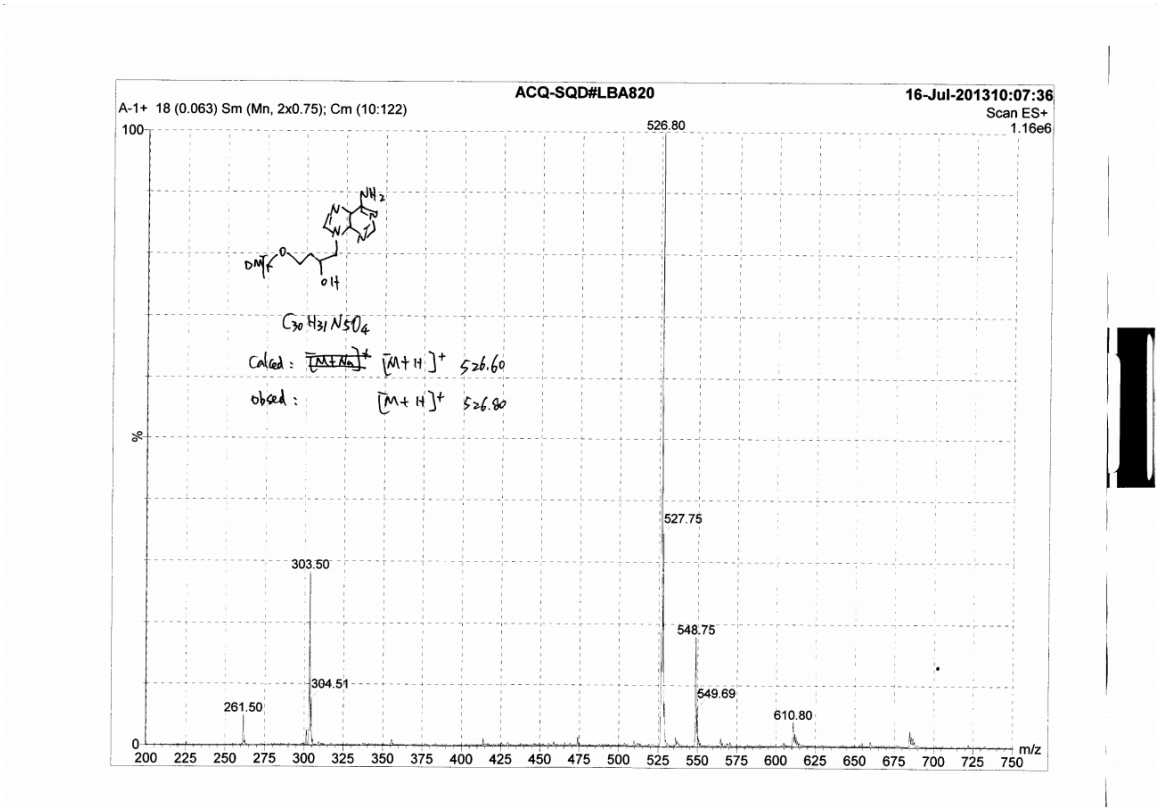

```
NAME          LPF-0912-T1
EXPNO                   2
PROCNO                  1
Date_            20130913
Time                9.04
INSTRUM             spect
PROBHD   5 mm PABBO BB-
PULPROG          zgpg30
TD                 65536
SOLVENT            CDCl3
NS                   302
DS                     4
SWH            26041.666 Hz
FIDRES          0.397364 Hz
AQ              1.2583412 sec
RG                 205.82
DW                19.200 usec
DE                 6.50 usec
TE                298.0 K
D1             1.25000000 sec
D11            0.03000000 sec
TD0                    1

======== CHANNEL f1 ========
NUC1                  13C
P1                 9.00 usec
SI                 32768
SF          100.6127690 MHz
WDW                   EM
SSB                    0
LB                1.00 Hz
GB                     0
PC                 1.40
```

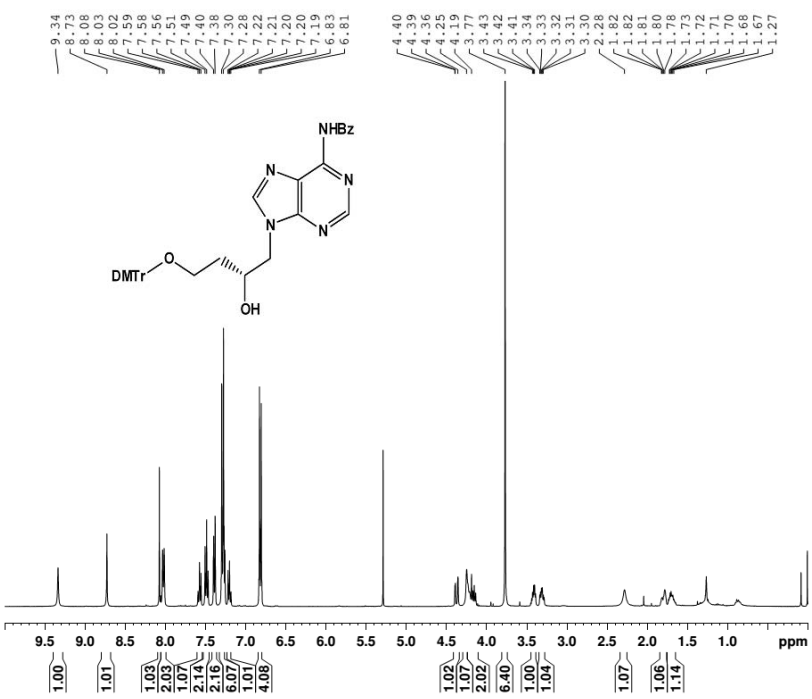


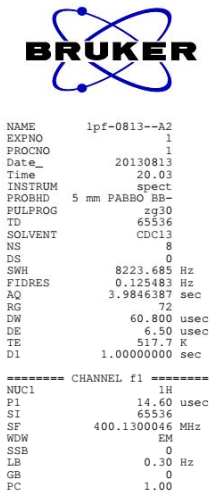


NAME	lpf-0717-a1
EXPNO	1
PROCNO	1
Date_	20130717
Time	15.40
INSTRUM	spect
PROBHD	5 mm PABBO BB-
PULPROG	zg30
TD	65536
SOLVENT	CDCl3
NS	8
DS	0
SWH	8223.685 Hz
FIDRES	0.125483 Hz
AQ	3.9846387 sec
RG	72
DW	60.800 usec
DE	6.50 usec
TE	298.9 K
D1	1.00000000 sec
======== CHANNEL f1 ========	
NUC1	1H
P1	14.60 usec
SI	65536
SF	400.1300000 MHz
WDW	EM
SSB	0
LB	0.30 Hz
GB	0
PC	1.00

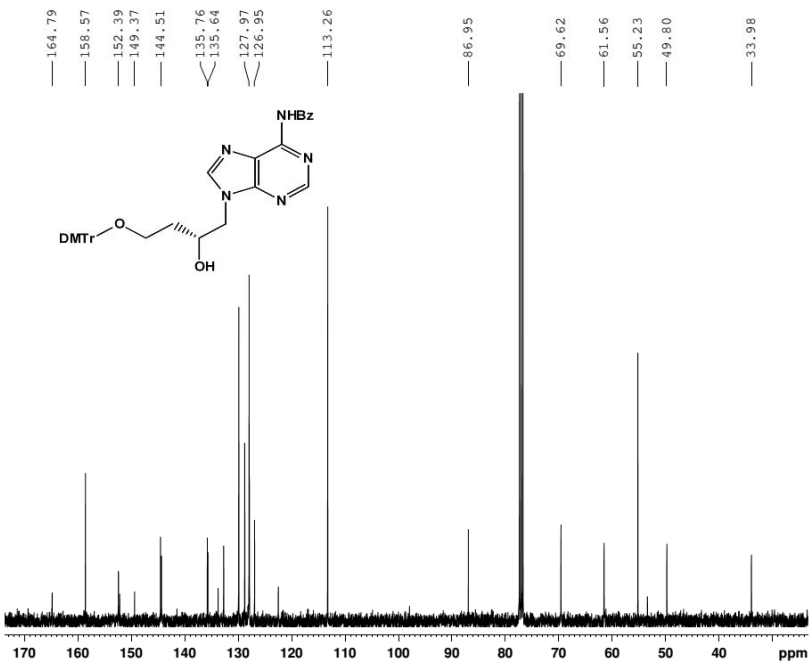

158.54
155.55
152.70
150.10
144.65
141.65
135.92
135.81
129.93
128.03
127.93
126.89
113.22
86.76
69.32
61.29
55.22
50.17
34.19
BRUKER
NH2
N
N
N
N
DMTr
O
OH
NAME 1pf-0717-a1
EXPNO 2
PROCNO 1
Date_ 20130717
Time 15.44
INSTRUM spect
PROBHD 5 mm PABBO BB-
PULPROG zgpg30
TD 65536
SOLVENT CDCl3
NS 96
DS 0
SWH 26041.666 Hz
FIDRES 0.397364 Hz
AQ 1.2583412 sec
RG 148.12
DW 19.200 usec
DE 6.50 usec
TE 299.9 K
D1 1.20000005 sec
D11 0.03000000 sec
======== CHANNEL f1 ========
NUC1 13C
P1 9.00 usec
SI 32768
SF 100.6127690 MHz
WDW EM
SSB 0
LB 1.00 Hz
GB 0
PC 1.40
170 160 150 140 130 120 110 100 90 80 70 60 50 40 ppm


ACQ-SQD#LBA820
16-Jul-201310:07:36
A-1+ 18 (0.063) Sm (Mn, 2x0.75); Cm (10:122)
Scan ES+
1.16e6
100
%
0
526.80
527.75
303.50
548.75
304.51
549.69
261.50
610.80
200 225 250 275 300 325 350 375 400 425 450 475 500 525 550 575 600 625 650 675 700 725 750 m/z
C30H31N5O4
Calcd: [M+Na]+ [M+H]+ 526.60
obsrd: [M+H]+ 526.80



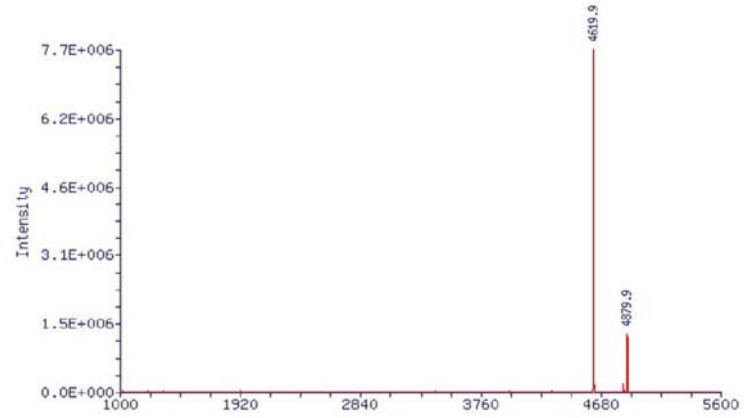



```
NAME          1pf-0813--A2
EXPNO                    1
PROCNO                   1
Date_             20130813
Time                 20.03
INSTRUM              spect
PROBHD   5 mm PABBO BB-
PULPROG              zg30
TD                  65536
SOLVENT             CDCl3
NS                       8
DS                       0
SWH              8223.685 Hz
FIDRES           0.125483 Hz
AQ               3.9846387 sec
RG                      72
DW                 60.800 usec
DE                  6.50 usec
TE                 517.7 K
D1              1.00000000 sec

======== CHANNEL f1 ========
NUC1                    1H
P1                  14.60 usec
SI                   65536
SF           400.1300046 MHz
WDW                     EM
SSB                      0
LB                  0.30 Hz
GB                       0
PC                    1.00
```

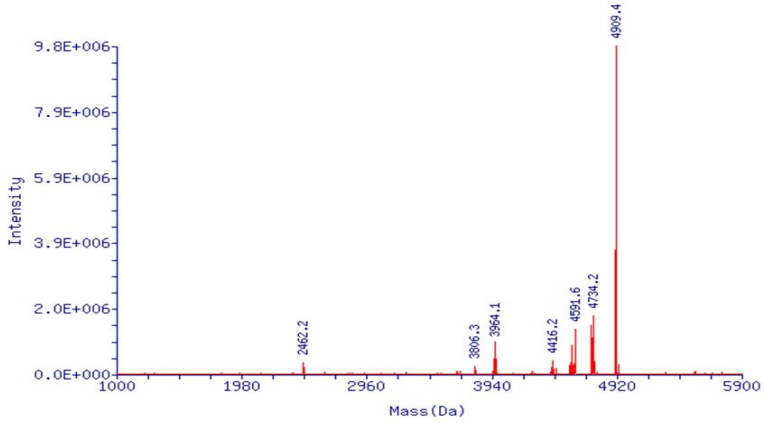



```
NAME          1pf-0813--A2
EXPNO                    2
PROCNO                   1
Date_             20130813
Time                 20.07
INSTRUM              spect
PROBHD   5 mm PABBO BB-
PULPROG           zgpg30
TD                  65536
SOLVENT             CDCl3
NS                     100
DS                       0
SWH             26041.666 Hz
FIDRES           0.397364 Hz
AQ               1.2583412 sec
RG                  148.12
DW                 19.200 usec
DE                  6.50 usec
TE                 518.0 K
D1              1.20000005 sec
D11             0.03000000 sec

======== CHANNEL f1 ========
NUC1                    13C
P1                  9.00 usec
SI                   32768
SF           100.6127690 MHz
WDW                     EM
SSB                      0
LB                  1.00 Hz
GB                       0
PC                    1.40
```

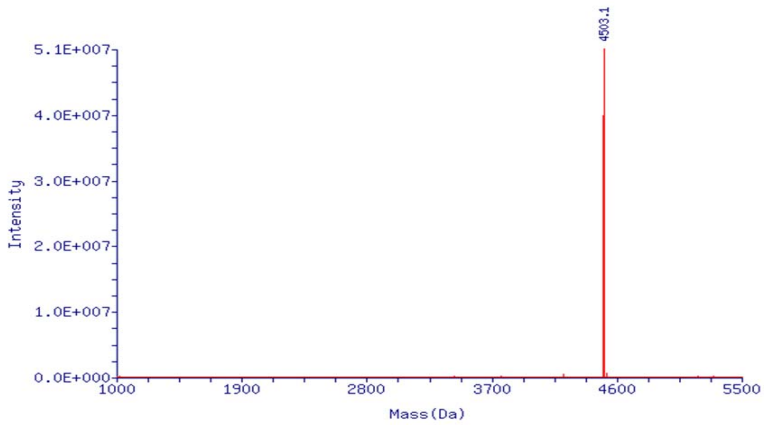
S6. SI-MS of oligonucleotides in our work.



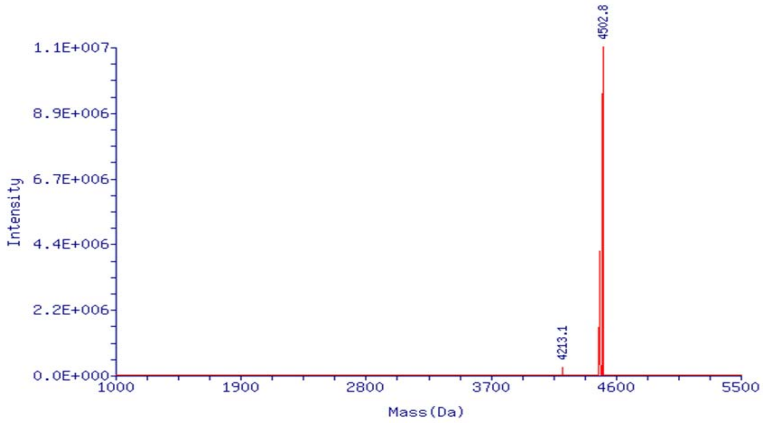
mmp-1



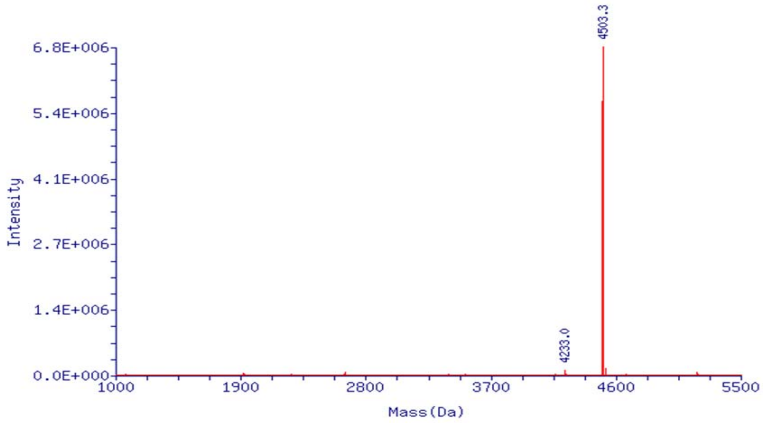
mmp-2



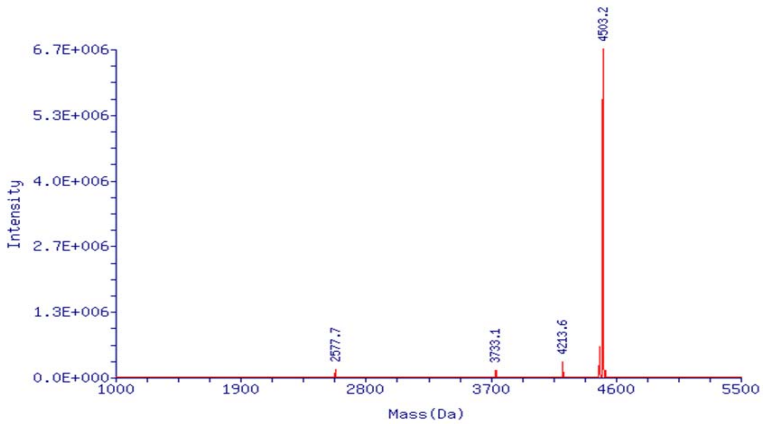
mmp-3



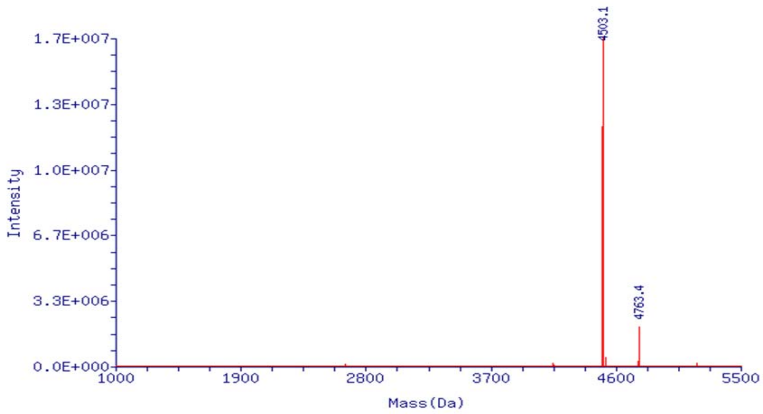
mmp-4



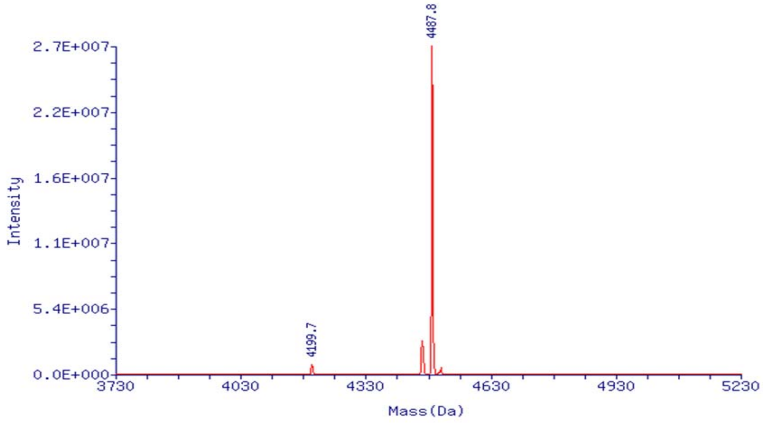
mmp-5



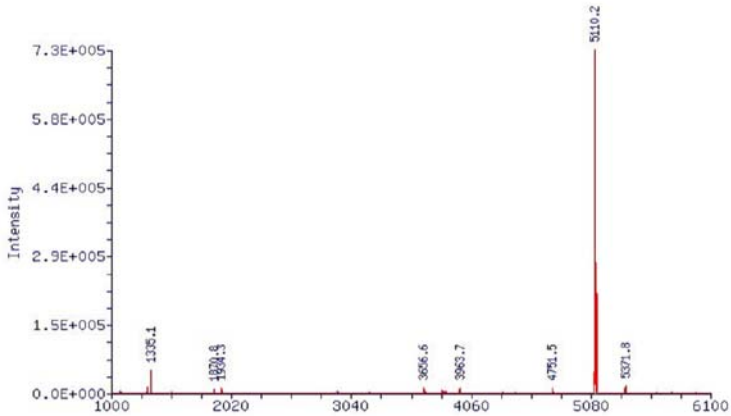
mmp--6



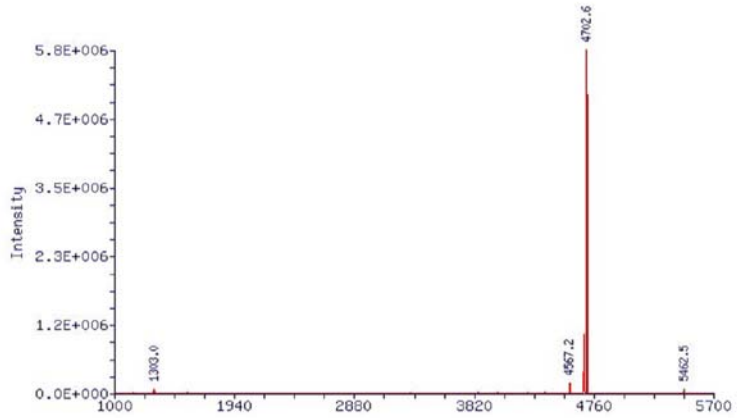
mmp-7



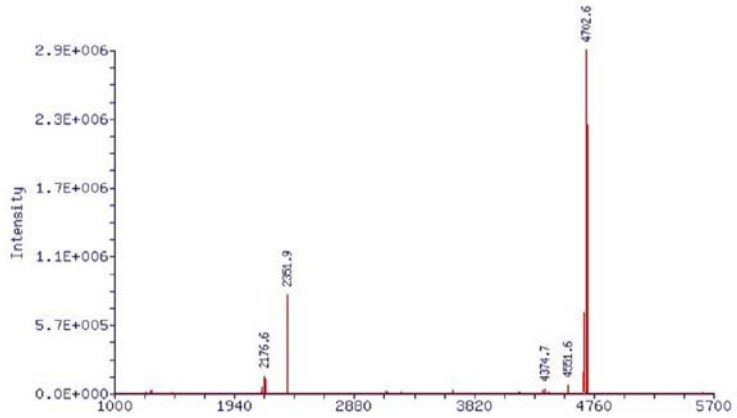
mmp-8



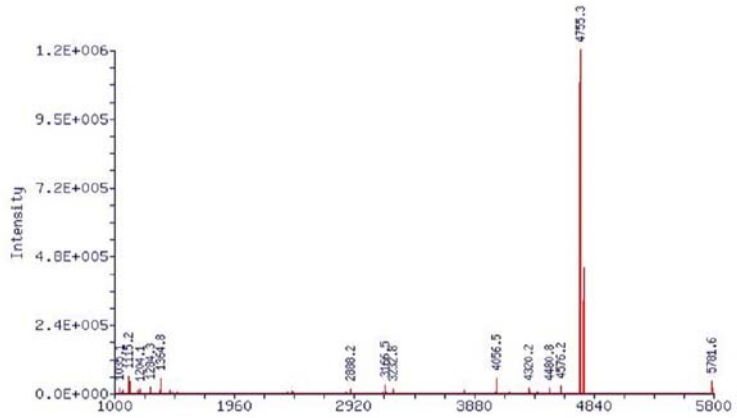
mmpsn-2



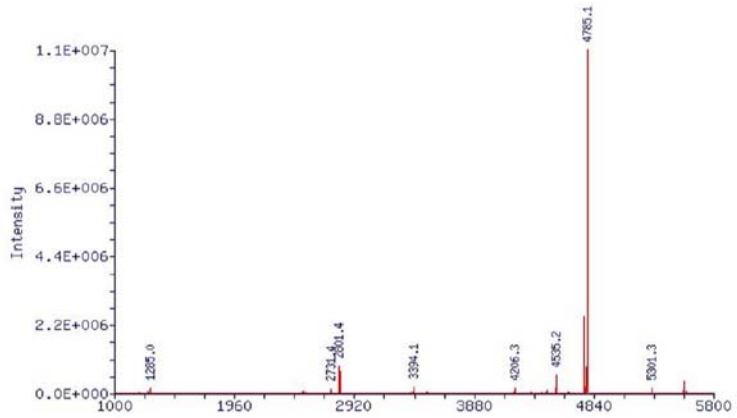
mmpsn-4



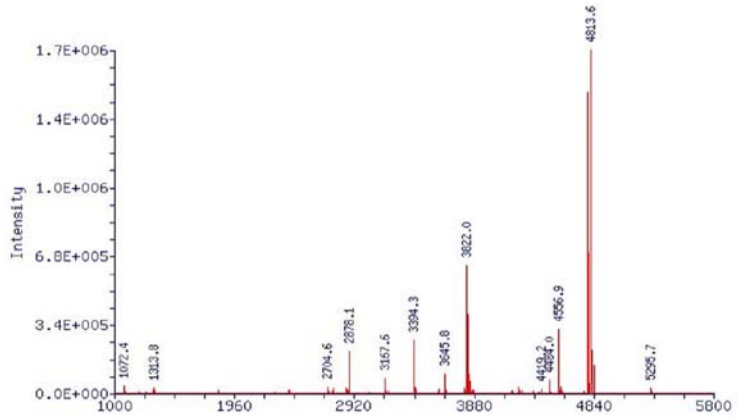
mmpsn-5



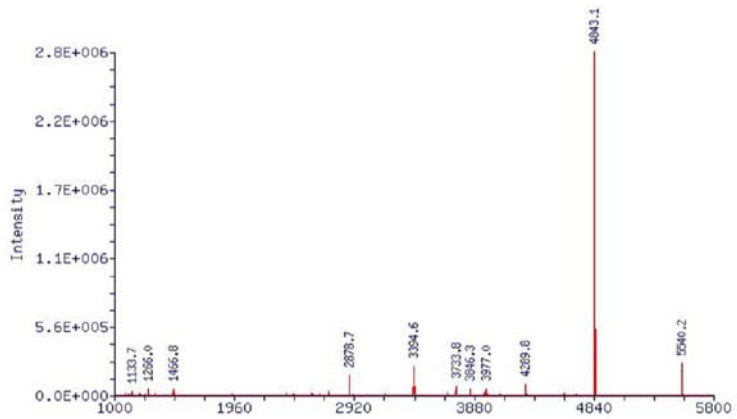
TBA-1



TBA-2



TBA-3



TBA-4

1. (a)Liu, Z.-C.; Shin, D.-S.; Lee, K.-T.; Jun, B.-H.; Kim, Y.-K.; Lee, Y.-S.,. *Tetrahedron,* 2005, *61*, 7967-7973;(b)Dueholm, K. L.; Egholm, M.; Behrens, C.; Christensen, L.; Hansen, H. F.; Vulpius, T.; Petersen, K. H.; Berg, R. H.; Nielsen, P. E.; Buchardt, O., *J. Org. Chem.* 1994, *59*, 5767-5773;(c)Geen, G. R.; Grinter, T. J.; Kincey, P. M.; Jarvest, R. L., *Tetrahedron* **1990,** *46*, 6903-6914. (d)Will, D. W.; Breipohl, G.; Langner, D.; Knolle, J.; Uhlmann, E., *Tetrahedron* **1995,** *51*, 12069-12082.