

Supporting Information

A Novel Bridged Nucleoside Bearing a Conformationally Switchable Sugar Moiety in Response to Redox Changes

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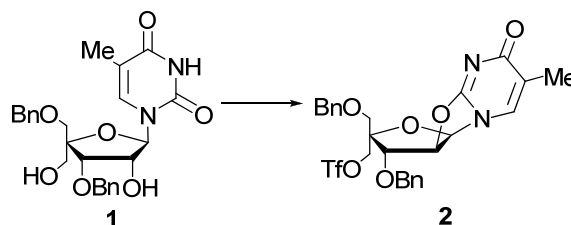
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1. General Methods

Melting points are uncorrected. All moisture-sensitive reactions were carried out in well-dried glassware under a N₂ atmosphere. Dichloromethane, DMF and pyridine were distilled from CaH₂. ¹H-NMR (500, 400, 300 and 270 MHz) and ¹³C-NMR (126, 75.5 and 67.8 MHz) were recorded on JEOL JNM-LA-500, JNM-ECS-400, JNM-AL-300 or JNM-EX-270 spectrometers. Chemical shift are reported in parts per million downfield from internal tetramethylsilane (0.00 ppm) and residual solvent for ¹H-NMR or chloroform-*d*₁ (77.0 ppm), methanol- *d*₄ (49.0 ppm) for ¹³C-NMR. IR spectra were recorded on a JASCO FT/IR-200 or JASCO FT/IR-4200 spectrometers. Optical rotations were recorded on a JASCO DIP-370 instrument. Mass spectra were measured on FINNIGAN LCQ Deca XP MAX, JEOL JMS-600, JMS-700 or JMS-D300 mass spectrometers. For column chromatography, silica gel PSQ-100B, FL-100D was used. For flash column chromatography, silica gel FL-60D was used.

2. Synthesis of new compounds

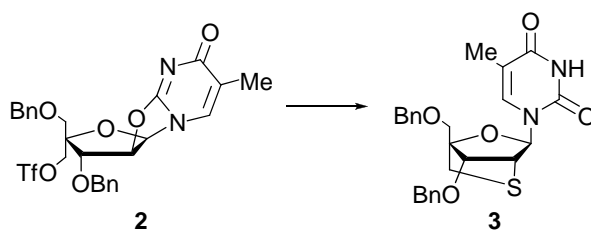
Compound 2



Under a N₂ atmosphere, to a solution of compound **1** (187 mg, 0.399 mmol), *N,N*-dimethyl-4-aminopyridine (73.2 mg, 0.599 mmol) and triethylamine (0.279 mL, 2.00 mmol) in dichloromethane (8.0 mL) at -78 °C was added trifluoromethanesulfonyl chloride (0.127 mL, 1.20 mmol) and resulting mixture was stirred at -78 °C for 1 h. After addition of trifluoromethanesulfonyl chloride (0.030 mL, 0.279 mmol) to the reaction mixture, the mixture was stirred at -78 °C for 1 h. Furthermore trifluoromethanesulfonyl chloride (0.030 mL, 0.279 mmol) was added to the mixture and the mixture was stirred at -78 °C for 1 h. After being acidified by addition of aqueous diluted sulfuric acid at 0 °C, the reaction mixture was diluted with dichloromethane, washed with water, saturated aqueous NaHCO₃ and brine, dried over Na₂SO₄, and concentrated. The crude was purified by column chromatography (AcOEt) to give compound **2** (167 mg, 0.287 mmol, 72%) as a white foam.

mp 120–123 °C. $[\alpha]_D^{26}$ -11.2 (c 1.0, CH₂Cl₂). IR ν_{\max} (KBr): 1636 cm⁻¹. ¹H-NMR (270 MHz, CDCl₃) : δ 1.98 (3 H, s), 3.21 (1 H, d, J = 6 Hz), 3.38 (1 H, d, J = 6 Hz), 4.32–4.44 (3 H, m), 4.53–4.82 (4 H, m), 5.26 (1 H, d, J = 6 Hz), 6.20 (1 H, d, J = 6 Hz), 7.13–7.35 (11 H, m). ¹³C-NMR (67.8 MHz, CDCl₃) : δ 14.0, 69.0, 73.3, 73.7, 74.7, 83.8, 86.2, 87.6, 89.7, 118.3 (q, J = 319 Hz), 119.2, 127.6, 127.7, 128.0, 128.0, 128.2, 128.3, 128.4, 128.5, 128.6, 128.6, 130.1, 135.2, 136.2, 158.9, 171.7. MS (FAB) m/z 583 (M+H⁺), HRMS (FAB): Calcd for C₂₆H₂₆F₃N₂O₈S (M+H⁺): 583.1362. Found: 583.1346.

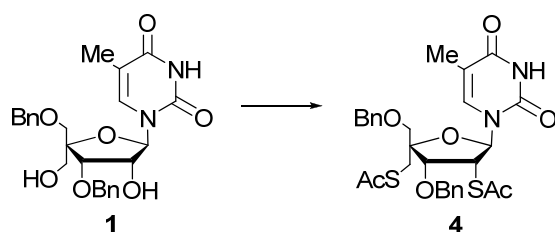
Compound 3



Under a N₂ atmosphere, to a solution of compound **2** (20.0 mg, 0.034 mmol) in *N*-methylpyrrolidone (0.7 mL) was added potassium thioacetate (11.6 mg, 0.101 mmol) and resulting mixture was stirred at room temperature for 1 h. After addition of potassium thioacetate (7.7 mg, 0.067 mmol) to the reaction mixture, the mixture was stirred at 70 °C for 3.5 h and 120 °C for 15 h. After addition of the reaction mixture into brine, the mixture was extracted by dichloromethane and dried over Na₂SO₄, and concentrated. The obtained crude was purified by column chromatography (*n*-hexane/AcOEt = 2/1) to give compound **3** (11.9 mg, 0.026 mmol, 75%) as a yellow foam.

mp 62–65 °C. $[\alpha]_D^{22}$ 98.1 (c 1.0, CH₂Cl₂). IR ν_{\max} (KBr): 1687 cm⁻¹. ¹H-NMR (300 MHz, CDCl₃) : δ 1.44 (3 H, d, J = 1 Hz), 2.79 (1 H, d, J = 10 Hz), 3.02 (1 H, d, J = 10 Hz), 3.72 (1 H, d, J = 2 Hz), 3.78 (1 H, d, J = 11 Hz), 3.87 (1 H, d, J = 11 Hz), 4.20 (1 H, d, J = 2 Hz), 4.47 (1 H, d, J = 11 Hz), 4.59 (2 H, s), 4.63 (1 H, d, J = 11 Hz), 5.85 (1 H, s), 7.26–7.36 (10 H, m), 7.77 (1 H, d, J = 1 Hz), 8.29 (1 H, brs). ¹³C-NMR (75.5 MHz, CDCl₃) : δ 11.8, 35.6, 49.5, 66.9, 71.7, 73.7, 76.4, 88.5, 90.6, 109.3, 127.7, 127.8, 127.9, 128.0, 128.3, 128.5, 135.3, 136.8, 137.1, 150.2, 164.3. MS (FAB) m/z 467 (M+H⁺). HRMS (FAB): Calcd for C₂₅H₂₇N₂O₅S (M+H⁺): 467.1641. Found: 467.1635.

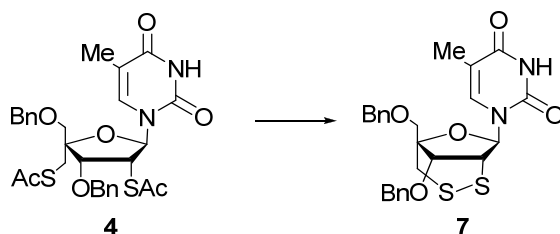
Compound 6



Under a N_2 atmosphere, to a solution of compound **1** (2.00 g, 4.27 mmol), *N,N*-dimethyl-4-aminopyridine (782 mg, 6.41 mmol) and triethylamine (2.98 mL, 21.3 mmol) in dichloromethane (80 mL) at -78 °C was added trifluoromethanesulfonyl chloride (1.36 mL, 12.8 mmol) and resulting mixture was stirred at -78 °C for 2 h. After being acidified by addition of aqueous diluted sulfuric acid at 0 °C, the reaction mixture was diluted with dichloromethane, washed with water, saturated aqueous $NaHCO_3$ and brine, dried over Na_2SO_4 , and concentrated to give a crude mixture (2.77 g) as a pale yellow solid. To a solution of the crude in 1,4-dioxane (80 mL) was added 1M aqueous sodium hydroxide solution (12.8 mL, 12.8 mmol) and the resulting mixture was stirred at room temperature for 75 min. After being acidified by addition of aqueous diluted sulfuric acid at 0 °C, the reaction mixture was diluted with dichloromethane, washed with water, saturated aqueous $NaHCO_3$ and brine, dried over Na_2SO_4 , and concentrated to give a crude mixture (2.80 g) as a pale yellow solid. Under a N_2 atmosphere, trifluoromethanesulfonic anhydride (1.44 mL, 8.54 mmol) was added to a stirred solution of the crude, *N,N*-dimethyl-4-aminopyridine (2.09 g, 17.1 mmol) and pyridine (3.45 mL, 42.7 mmol) in dichloromethane (120 mL) at 0 °C and the mixture was stirred for 1.5 h. After being acidified by addition of aqueous diluted sulfuric acid at 0 °C, the reaction mixture was diluted with dichloromethane, washed with water, saturated aqueous $NaHCO_3$ and brine, dried over Na_2SO_4 , and concentrated to give a crude mixture (3.68 g) as a brown solid. To a solution of the obtained crude in *N,N*-dimethylformamide (80 mL) was added potassium thioacetate (1.46 g, 12.8 mmol) and the resulting mixture was stirred at room temperature for 90 min. After addition of water, the reaction mixture was diluted with diethylether, washed with water and brine, dried over $MgSO_4$, and concentrated. The crude was roughly purified by column chromatography (*n*-hexane/ $AcOEt$ = 3/2) and purified further by column chromatography ($CHCl_3$ / $AcOEt$ = 20/1) to give compound **4** (994 mg, 1.70 mmol, 40%) as a brown foam.

mp 52–54 °C. $[\alpha]_{\text{D}}^{25}$ -23.0 (c 1.0, CH₂Cl₂). IR ν_{max} (KBr): 1694 cm⁻¹. ¹H-NMR (270 MHz, CDCl₃): δ 1.51 (3 H, d, J = 1 Hz), 2.33 (3 H, s), 2.35 (3 H, s), 3.14 (1 H, d, J = 14 Hz), 3.30 (1 H, d, J = 14 Hz), 3.55 (1 H, d, J = 10 Hz), 3.73 (1 H, d, J = 10 Hz), 4.26 (1 H, d, J = 6 Hz), 4.54–4.76 (4 H, m), 4.78 (1 H, d, J = 11 Hz), 6.26 (1 H, d, J = 10 Hz), 7.33–7.41 (10 H, m), 7.50 (1 H, d, J = 1 Hz), 8.07 (1 H, brs). ¹³C-NMR (67.8 MHz, CDCl₃): δ 12.0, 30.4, 30.5, 31.4, 50.4, 73.3, 73.7, 75.2, 81.2, 86.6, 87.8, 111.4, 127.4, 128.0, 128.1, 128.2, 128.5, 128.7, 135.7, 136.6, 137.1, 150.6, 163.5, 193.9, 195.3. MS (FAB) m/z 585 (M+H⁺). HRMS (FAB): Calcd for C₂₉H₃₃N₂O₇S₂ (M+H⁺): 585.1729. Found: 585.1733.

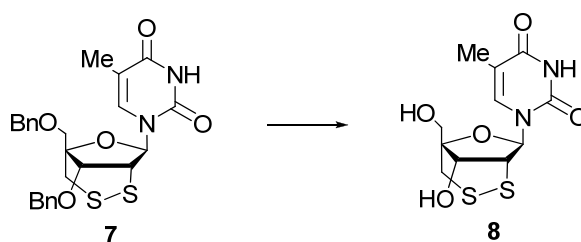
Compound 7



To a solution of compound **4** (100 mg, 0.171 mmol) in methanol (17 mL) was added 28% aqueous ammonia solution (1.00 mL, 16.5 mmol) and resulting mixture was stirred at room temperature for 20 h. The reaction mixture was concentrated and was diluted with dichloromethane, washed with water and brine, dried over Na₂SO₄, and concentrated to give compound **7** (85.0 mg, 0.170 mmol, quant.) as a white foam.

mp 82–85 °C. $[\alpha]_{\text{D}}^{26}$ +38.6 (c 1.0, CH₂Cl₂). IR ν_{max} (KBr): 1685 cm⁻¹. ¹H-NMR (270 MHz, CDCl₃): δ 1.47 (3 H, d, J = 1 Hz), 2.15 (1 H, d, J = 14 Hz), 3.51 (1 H, d, J = 11 Hz), 3.58 (1 H, d, J = 14 Hz), 3.64 (1 H, d, J = 11 Hz), 3.64 (1 H, d, J = 6 Hz), 4.26 (1 H, d, J = 6 Hz), 4.42 (1 H, d, J = 12 Hz), 4.52 (1 H, d, J = 12 Hz), 4.57 (1 H, d, J = 12 Hz), 4.72 (1 H, d, J = 12 Hz), 6.64 (1 H, s), 7.21–7.38 (10 H, m), 7.91 (1 H, d, J = 1 Hz), 8.36 (1 H, brs). ¹³C-NMR (67.8 MHz, CDCl₃): δ 12.1, 32.9, 49.9, 70.2, 71.0, 71.4, 73.6, 84.5, 89.5, 109.9, 127.7, 127.8, 128.0, 128.1, 128.4, 128.6, 135.4, 136.8, 136.9, 149.9, 163.8. MS (FAB) m/z 499 (M+H⁺). HRMS (FAB): Calcd for C₂₅H₂₈N₂O₅S₂ (M+H⁺): 499.1361. Found: 499.1357.

Compound 8



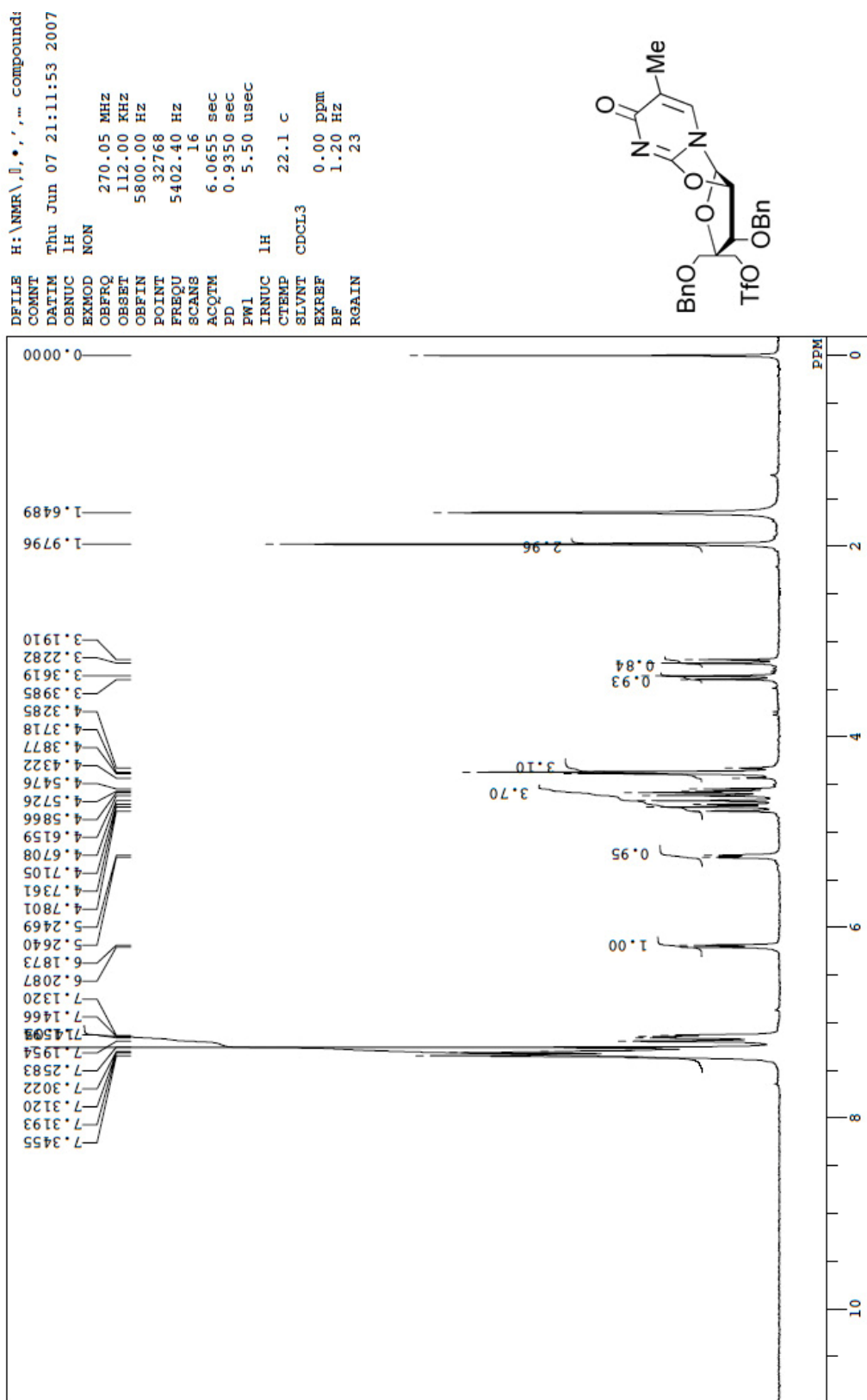
Under a N₂ atmosphere, to a solution of compound **7** (764 mg, 1.53 mmol) in dichloromethane (6.0 mL) at -78 °C was added 1M boron trichloride in dichloromethane solution (30.0 mL, 30.0 mmol) and resulting mixture was stirred at -60 °C for 68 h. After addition of methanol at -60 °C, the reaction mixture was concentrated. The crude was purified by column chromatography (CHCl₃/MeOH = 10/1 to 2/1) to give compound **8** (347 mg, 1.09 mmol, 71%) as a pale brown solid.

The crystal of compound **8** for X-ray crystallographic analysis was obtained by recrystallization from methanol.

mp 210–212 °C (MeOH). [α]_D²⁴ -67.5 (c 1.0, MeOH). IR ν_{\max} (KBr): 1681, 3134 cm⁻¹. ¹H-NMR (300 MHz, CD₃OD) : δ 1.87 (3 H, d, J = 1 Hz), 2.26 (1 H, d, J = 13 Hz), 3.43 (1 H, d, J = 13 Hz), 3.59 (1 H, d, J = 12 Hz), 3.60 (1 H, d, J = 6 Hz), 3.65 (1 H, d, J = 12 Hz), 4.37 (1 H, d, J = 6 Hz), 6.59 (1 H, s), 8.27 (1 H, d, J = 1 Hz). ¹³C-NMR (67.8 MHz, CD₃OD) : δ 12.6, 32.8, 54.1, 63.6, 65.1, 86.1, 90.0, 110.5, 137.8, 152.1, 166.6. MS (FAB) m/z 319 (M+H⁺). Anal. Calcd for C₁₁H₁₄N₂O₅S₂·H₂O: C, 39.28; H, 4.79; N, 8.33; S, 19.06. Found: C, 39.27; H, 4.73; N, 8.27; S, 18.70.

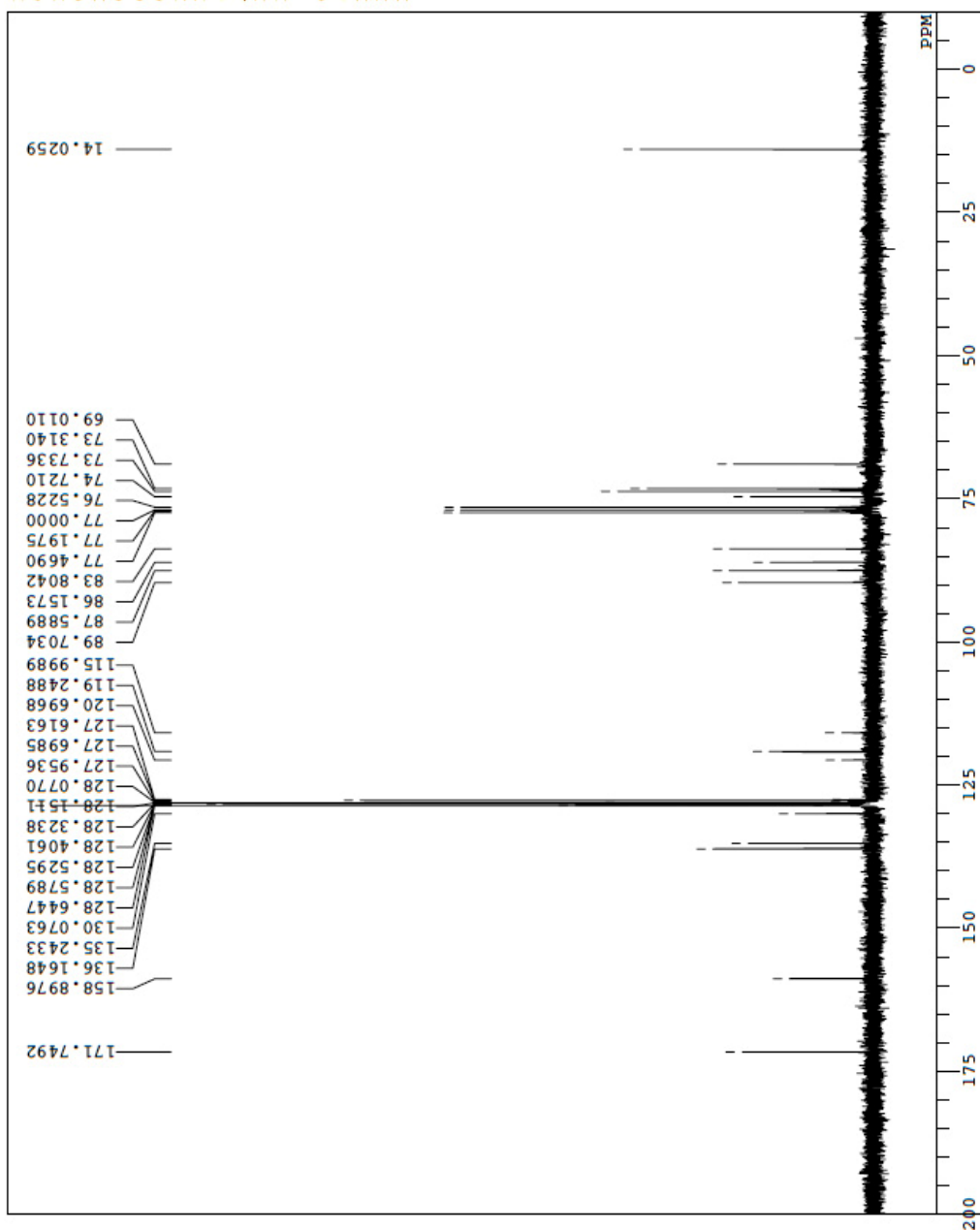
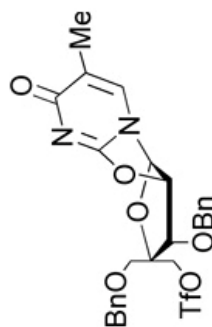
3. ¹H- and ¹³C-NMR spectra of new compounds

Compound 2 (¹H-NMR)

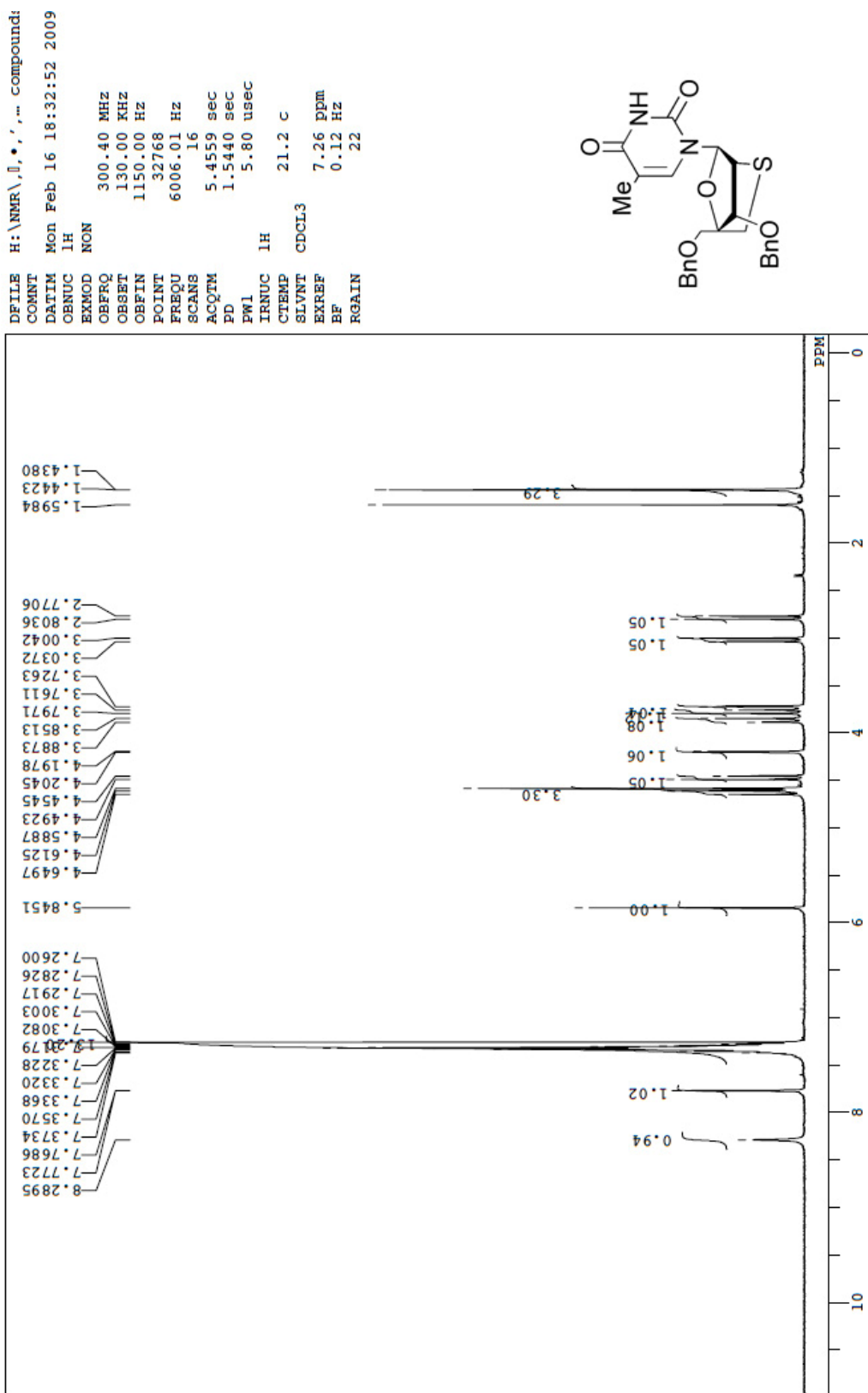


Compound 2 (¹³C-NMR)

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POINT 32768
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BF 0.12 Hz
RGAIN 26

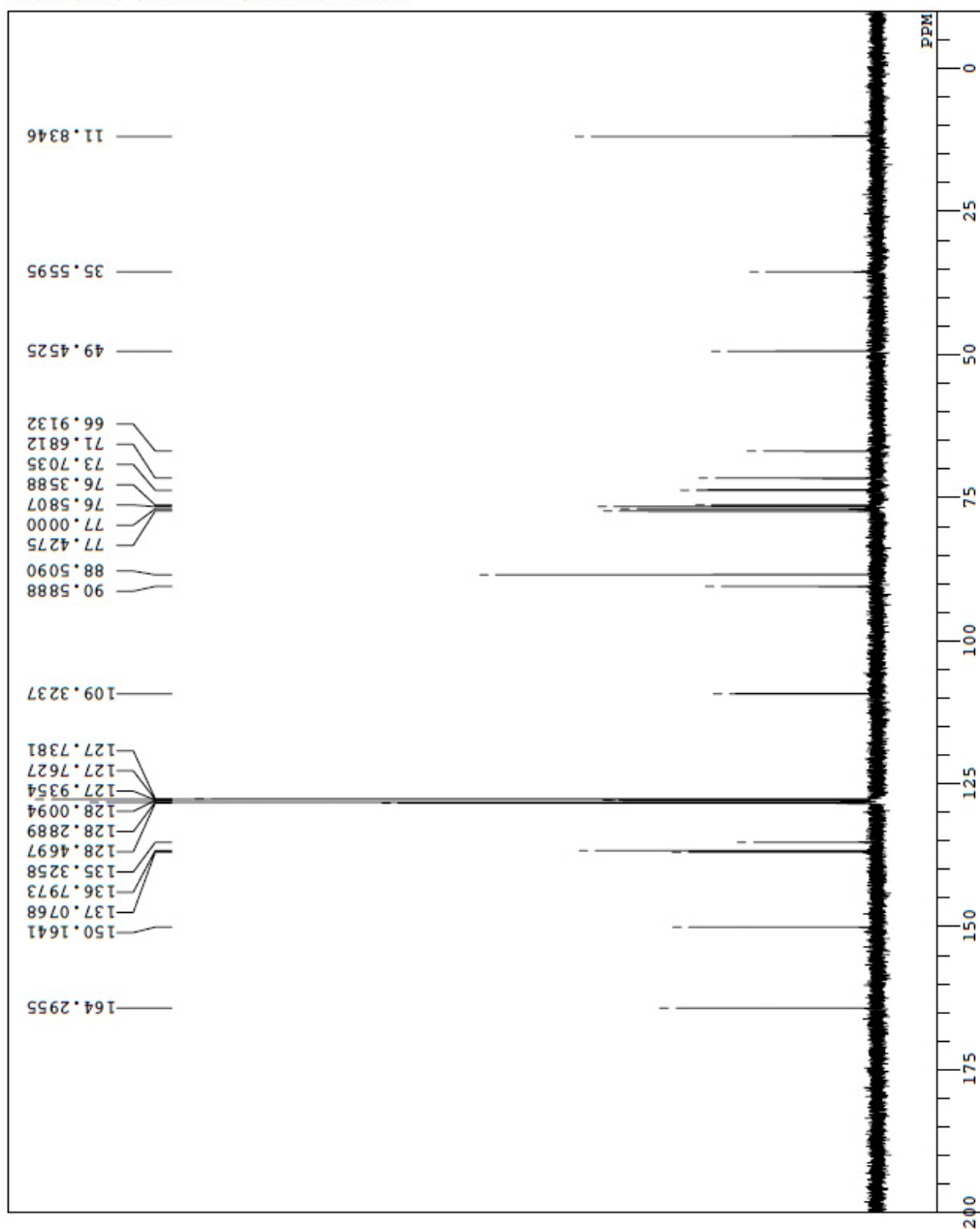
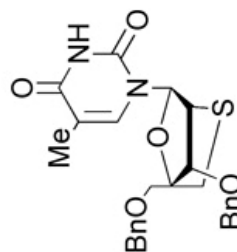


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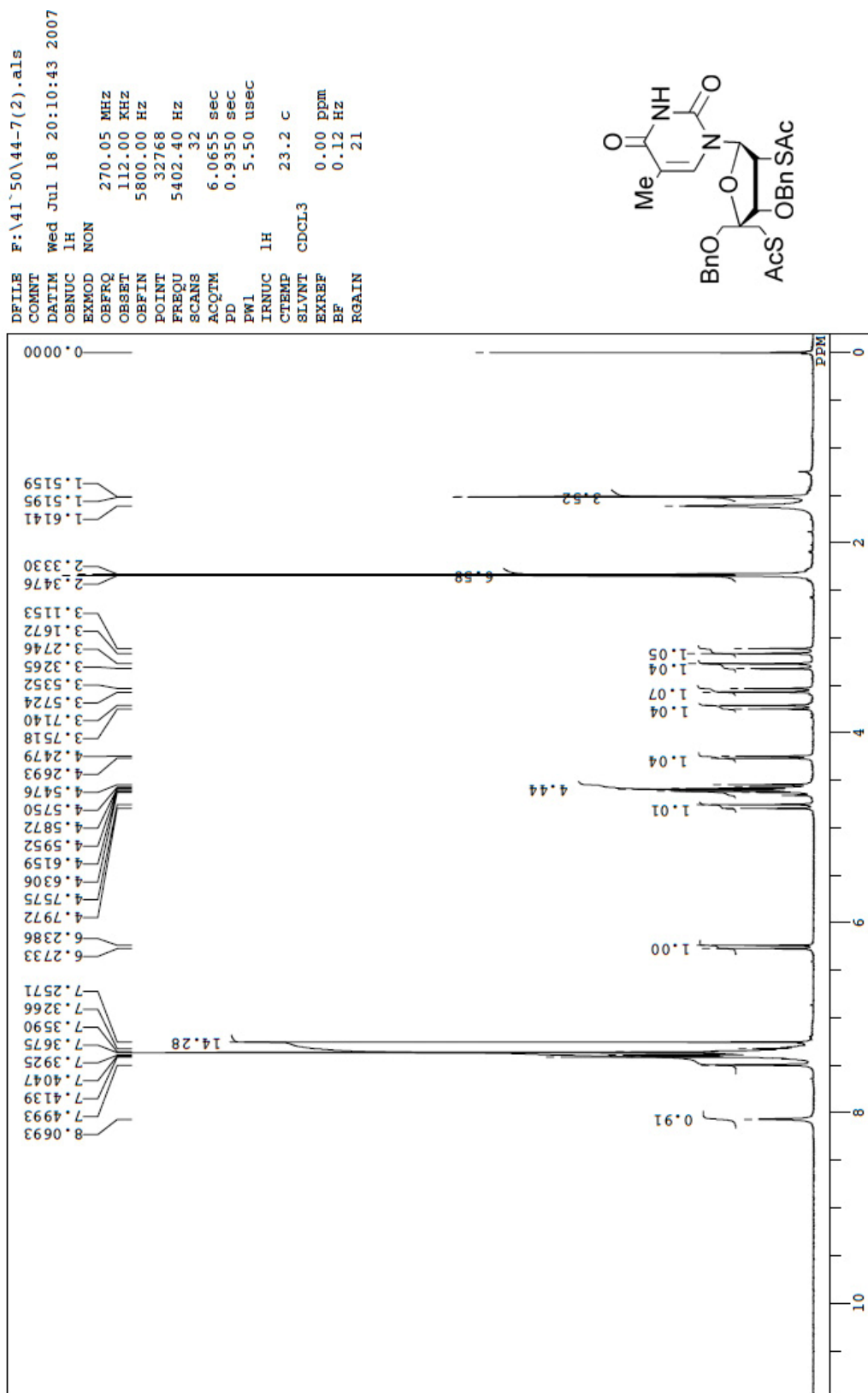


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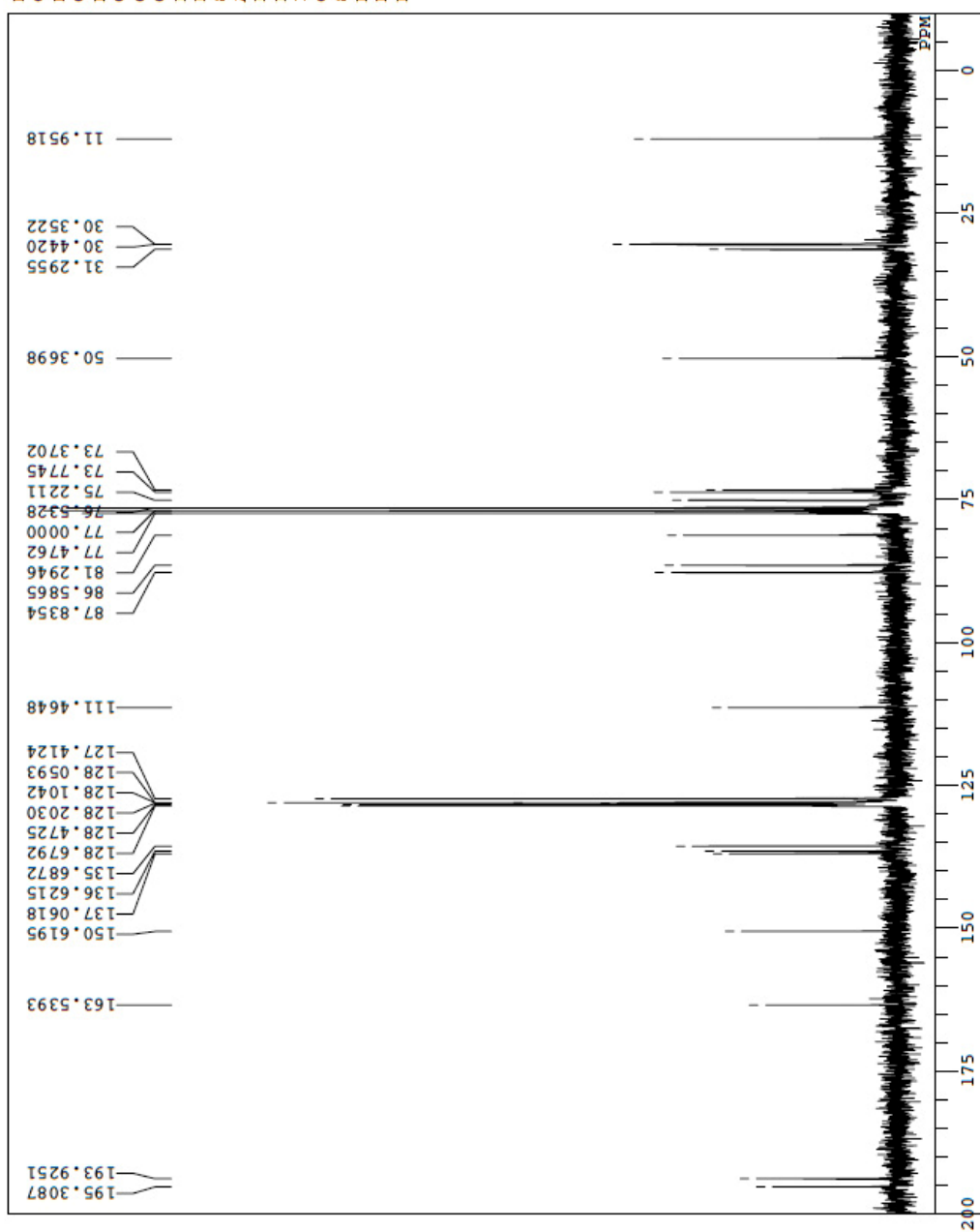
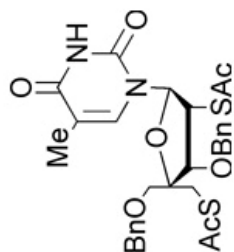


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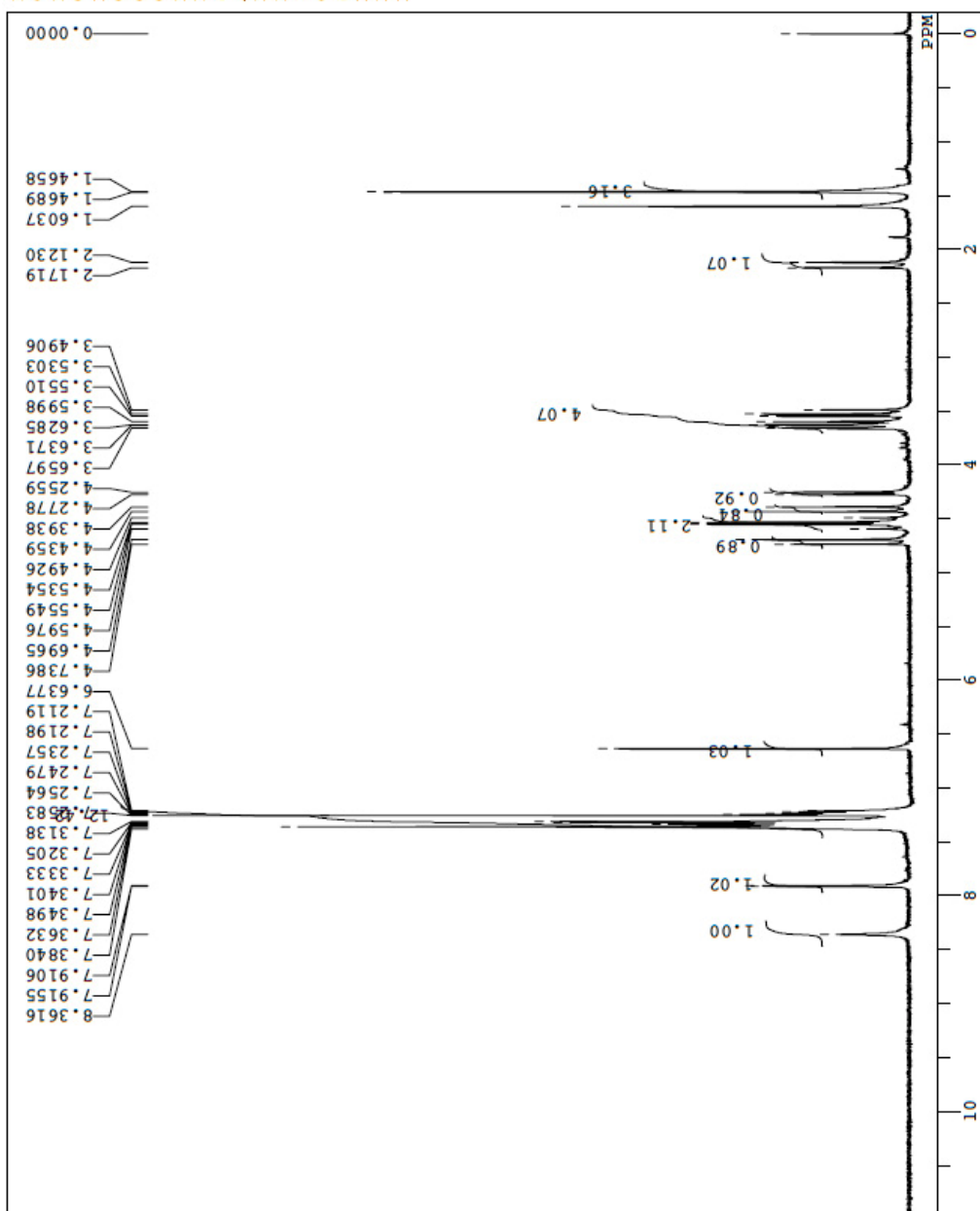
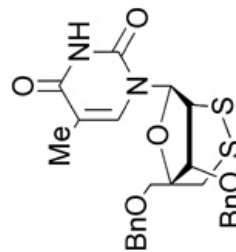
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RGAIN 26



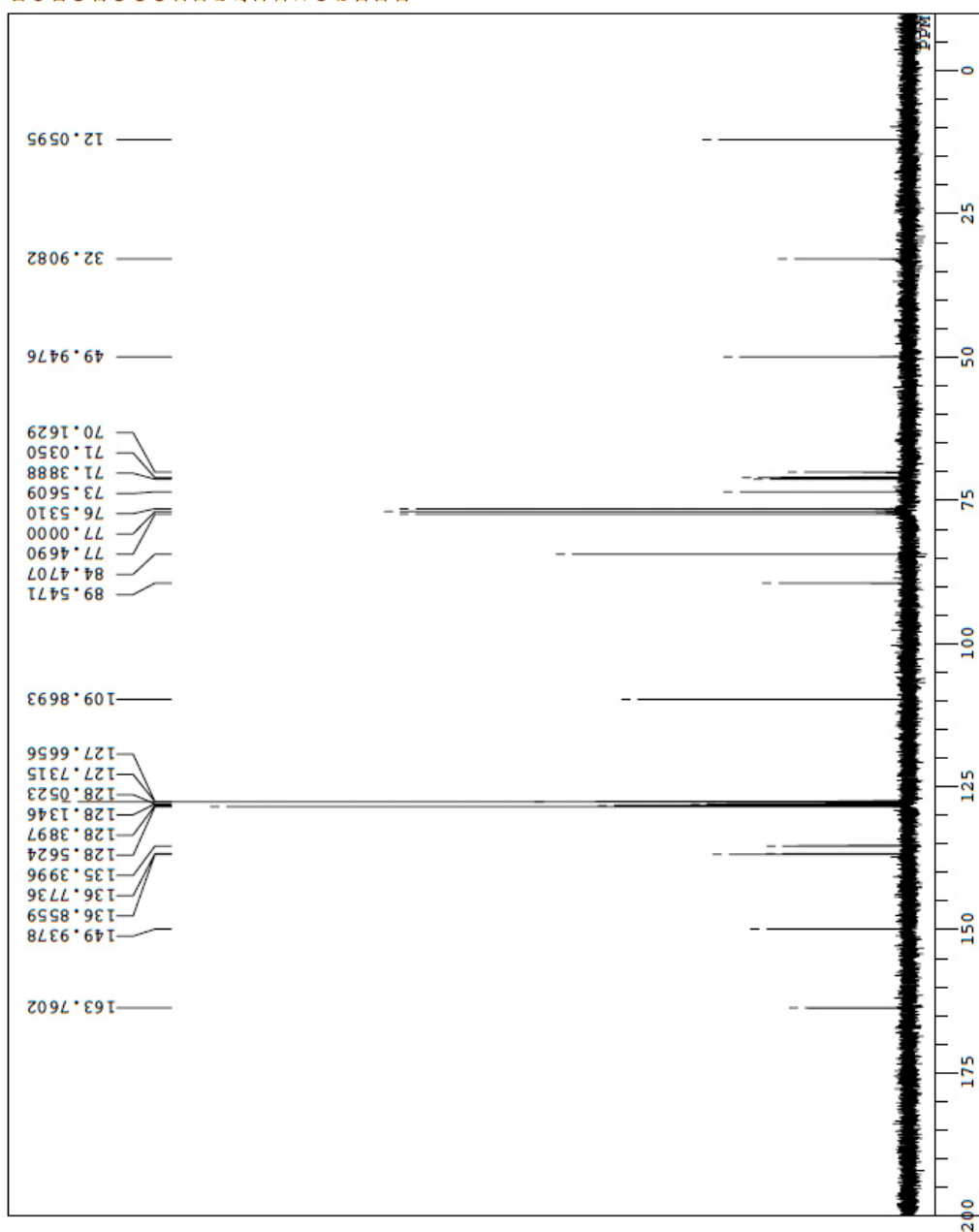
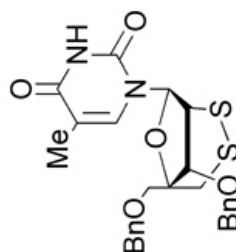
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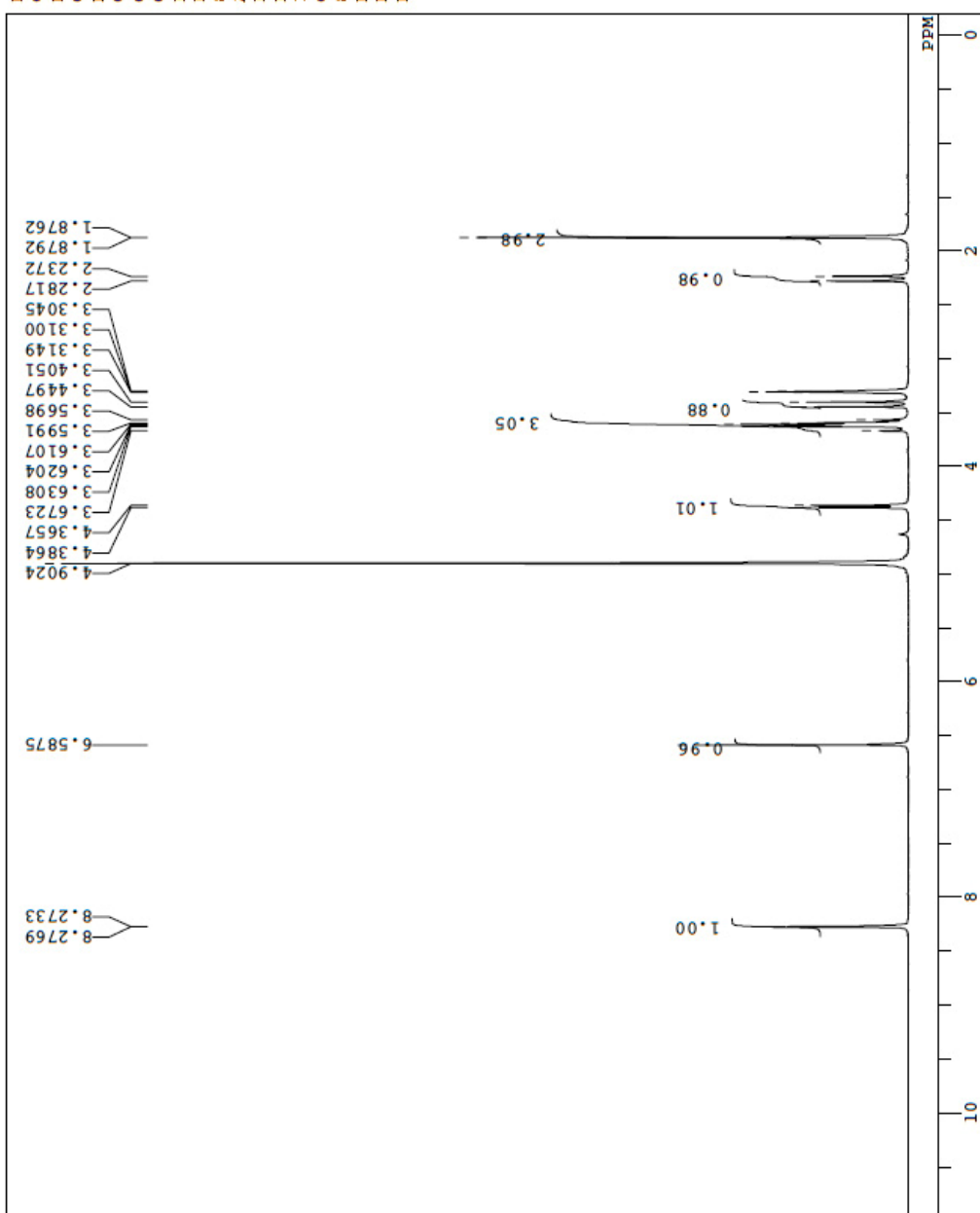
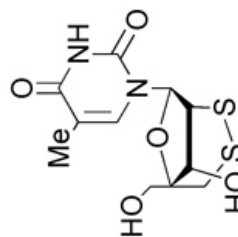
Compound 7 (¹³C-NMR)

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RGAIN 26



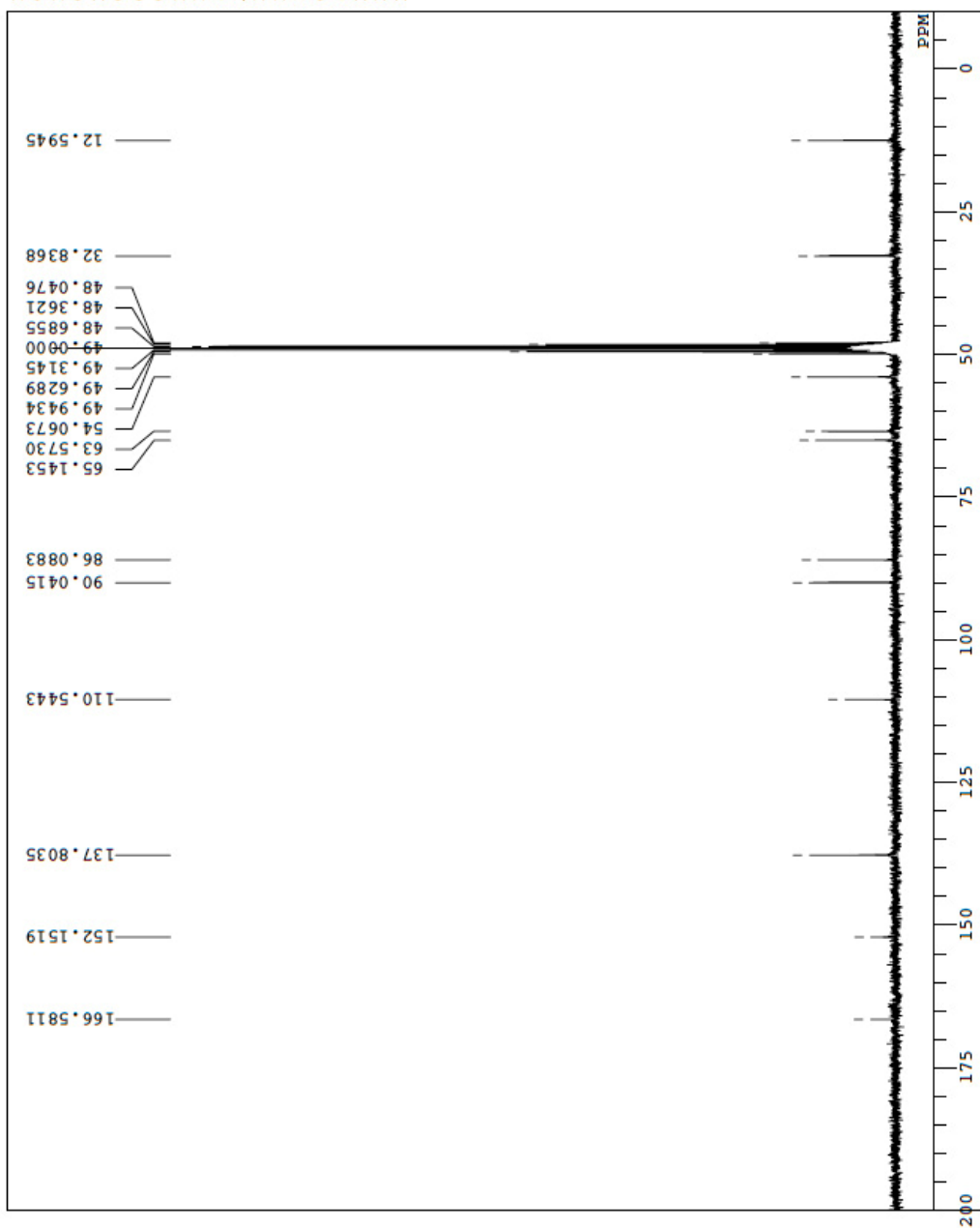
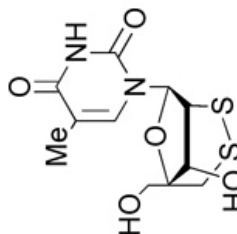
Compound 8 (¹H-NMR)

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OBFIN 1150.00 Hz
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FREQU 6006.01 Hz
SCANS 19
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PD 1.5440 sec
PW1 5.80 usec
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CTEMP 19.3 C
SLVNT CD3OD
EXREF 3.31 ppm
BF 0.12 Hz
RGAIN 17



Compound **8** (^{13}C -NMR)

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CBEFIN 5200.00 Hz
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PD 1.0000 sec
PWL 4.00 usec
IRNUC 1H
CTEMP 20.8 C
SOLVT CD3OD
EXREF 49.00 ppm
BF 1.20 Hz
RGAIN 26



4. Reactions of monomer **8** using reducing and oxidating reagents

4-A (reductant: DTT, oxidant: H₂O₂)

To the solution of compound **8** (2.0 mg, 6.3 μmol) in CD₃OD/deuterated PBS buffer =9/1 (0.6 mL) was added 0.32 M dithiothreitol solution 20 μL in CD₃OD/deuterated PBS buffer =9/1 (6.3 μmol) and the reaction mixture was kept static in a NMR tube for 1 h. After confirming the progress of the reaction by ¹H-NMR spectroscopy, 0.21% H₂O₂ 20 μL in CD₃OD/deuterated PBS buffer =9/1 (6.3 μmol) was added to the reaction mixture and the mixture was kept static in a NMR tube for 1 h. The progress of the reaction was also confirmed.

4-B (reductant: NaBH₄, oxidant: H₂O₂)

To the solution of compound **8** (2.0 mg, 6.3 μmol) in CD₃OD/deuterated PBS buffer =9/1 (0.6 mL) was added 0.63 M NaBH₄ solution 10 μL in CD₃OD/deuterated PBS buffer (pH 7.4) = 9/1 (6.3 μmol) and the reaction mixture was kept static in a NMR tube for 1 h. After confirming the progress of the reaction by ¹H-NMR spectroscopy, 0.42% H₂O₂ 40 μL in CD₃OD/deuterated PBS buffer =9/1 (25.2 μmol) was added to the reaction mixture and the mixture was kept static in a NMR tube for 1 h. The progress of the reaction was also confirmed.

4-C (reductant: TCEP, oxidant: H₂O₂)

To the solution of compound **8** (2.0 mg, 6.3 μmol) in CD₃OD/deuterated PBS buffer (pH 7.4) = 9/1 (0.6 mL) was added tris(2-carboxyethyl)phosphine hydrochloride (1.8 mg, 6.3 μmol) and the reaction mixture was kept static in a NMR tube for 1 h. After confirming the progress of the reaction by ¹H-NMR spectroscopy, 0.42% H₂O₂ 10 μL in CD₃OD/deuterated PBS buffer =9/1 (6.3 μmol) was added to the reaction mixture and the mixture was kept static in a NMR tube for 12 h. The progress of the reaction was also confirmed.

4-D (reductant: DTT, oxidant: I₂)

To the solution of compound **8** (2.0 mg, 6.3 μmol) in CD₃OD/deuterated PBS buffer (pH 7.4) = 9/1 (0.6 mL) was added 0.63 M dithiothreitol solution 10 μL in CD₃OD/deuterated PBS buffer =9/1 (6.3 μmol) and the reaction mixture was kept static in a NMR tube for 1 h. After confirming the progress of the reaction by ¹H-NMR spectroscopy, 0.63 M iodine solution 10 μL in CD₃OD/deuterated PBS buffer (pH 7.4) = 9/1 (6.3 μmol) was added to the reaction mixture and the mixture was kept static in a NMR tube for 1 h. The progress of the reaction was also confirmed.

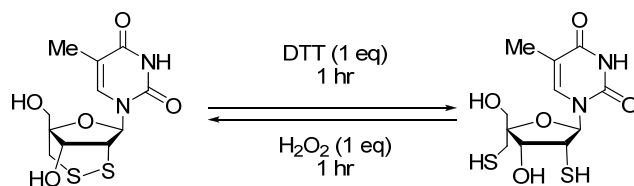
4-E (reductant: DTT, oxidant: DTDP)

To the solution of compound **8** (2.0 mg, 6.3 μmol) in CD₃OD/deuterated PBS buffer (pH 7.4) = 9/1 (0.6 mL) was added 0.63 M dithiothreitol solution 10 μL in CD₃OD/deuterated PBS buffer (pH 7.4) = 9/1 (6.3 μmol) and the reaction mixture was kept static in a NMR tube for 1 h. After confirming the progress of the reaction by ¹H-NMR spectroscopy, 2,2'-dithiodipyridine (1.4 mg, 6.3 μmol) was added to the reaction mixture and the mixture was kept static in a NMR tube for 1 h. The progress of the reaction was also confirmed.

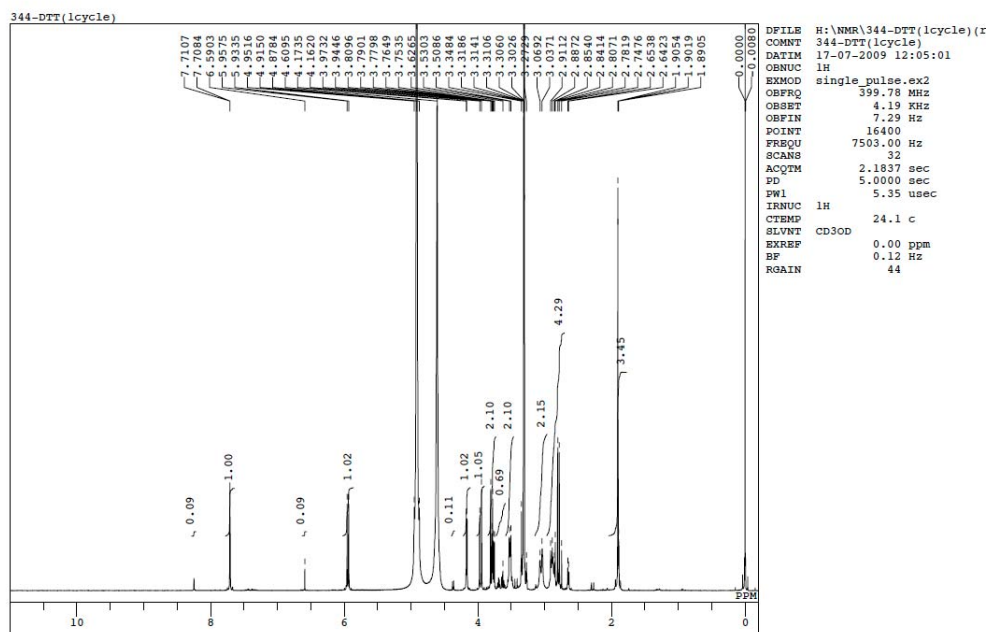
4-F (reductant: 2-mercaptoethanol, oxidant: H₂O₂)

To the solution of compound **8** (2.0 mg, 6.3 μmol) in CD₃OD/deuterated PBS buffer (pH 7.4) = 9/1 (0.6 mL) was added 2-mercaptoethanol (4.4 μL, 63 μmol) and the reaction mixture was kept static in a NMR tube for 12 h. After confirming the progress of the reaction by ¹H-NMR spectroscopy, 0.84% H₂O₂ 25 μL in CD₃OD/deuterated PBS buffer =9/1 (31.5 μmol) was added to the reaction mixture and the mixture was kept static in a NMR tube for xx h. The progress of the reaction was also confirmed.

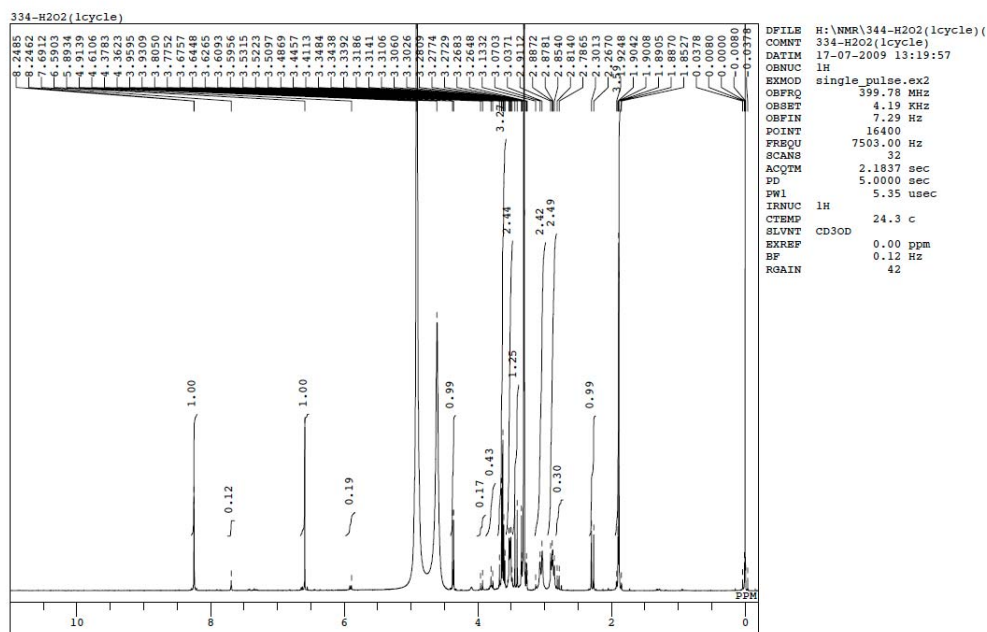
4-A



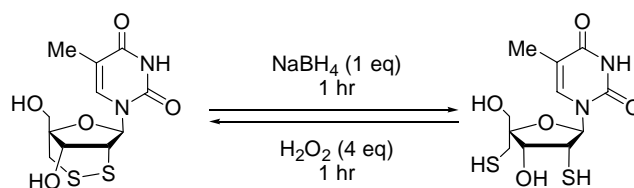
1 hr after addition of dithiothreitol (DTT)



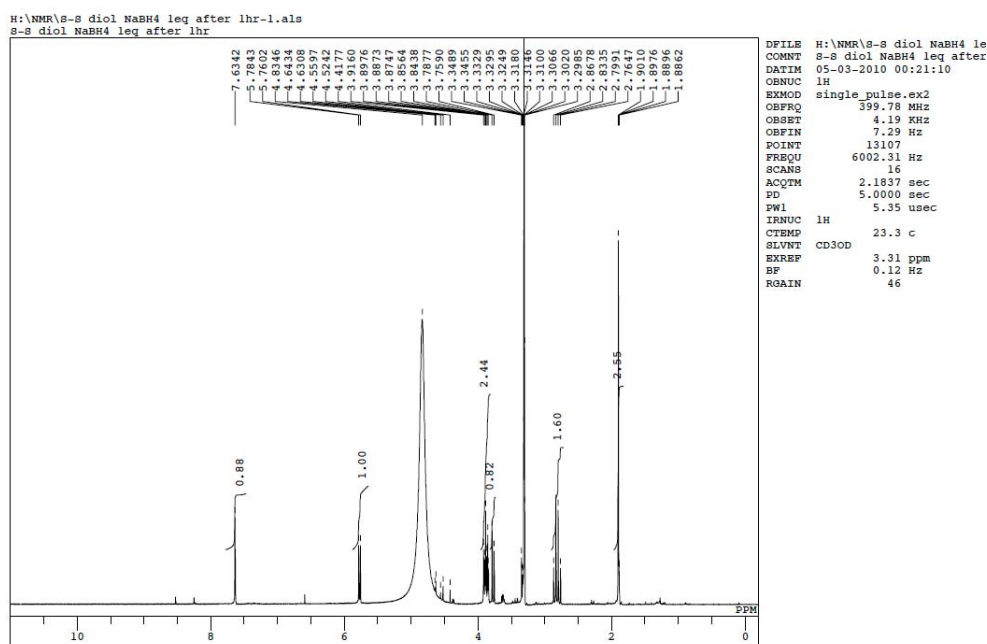
1 hr after addition of H₂O₂



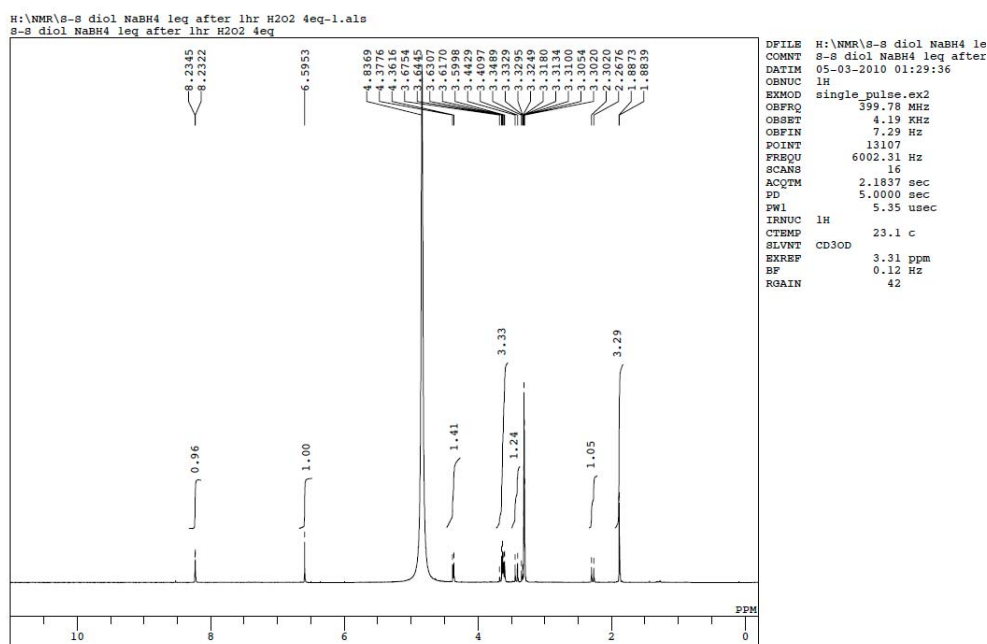
4-B



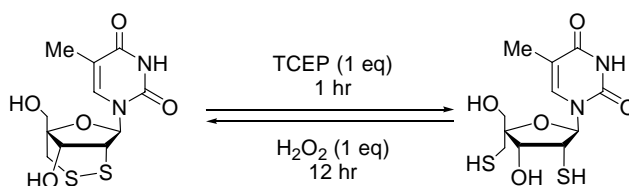
1 hr after addition of NaBH₄



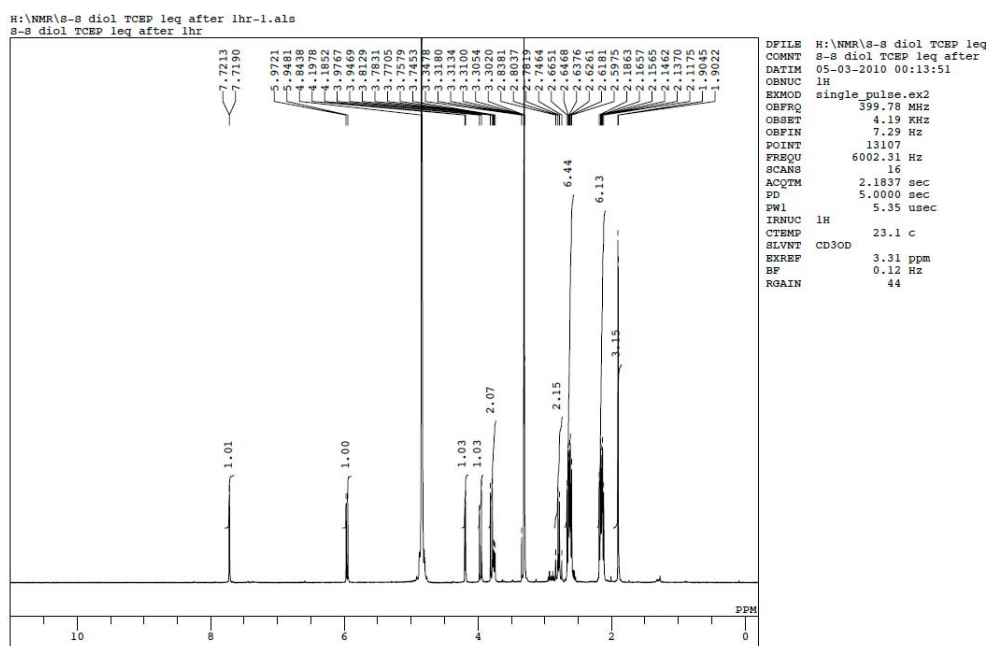
1 hr after addition of H₂O₂



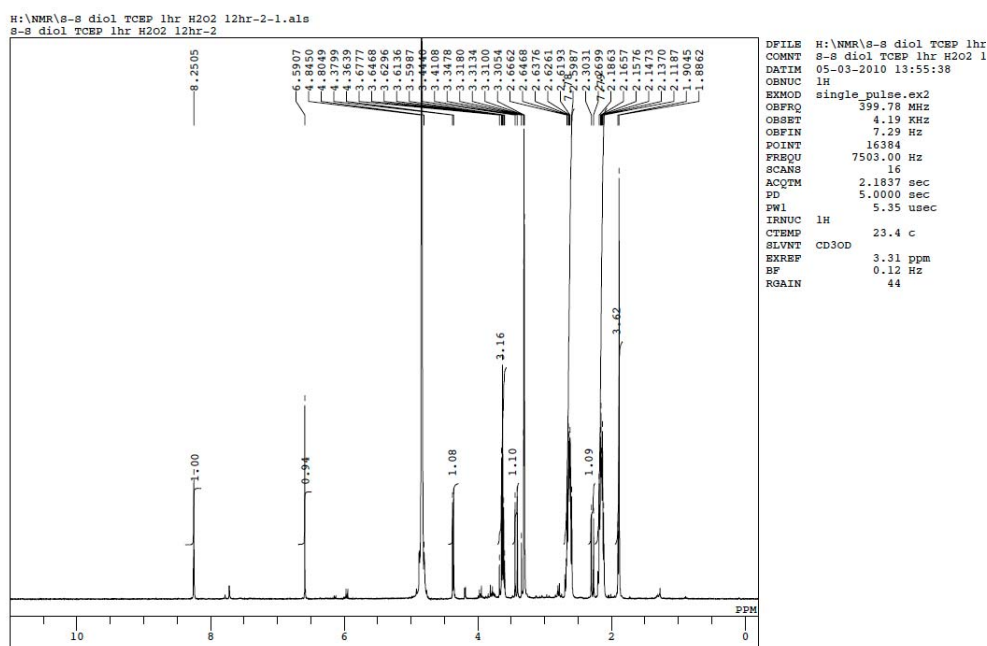
4-C



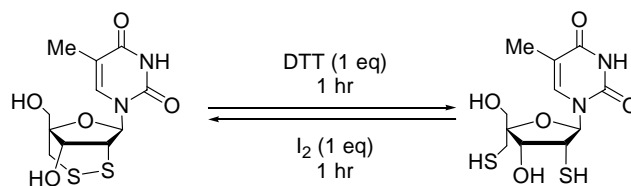
1 hr after addition of tris(2-carboxyethyl)phosphine hydrochloride (TCEP)



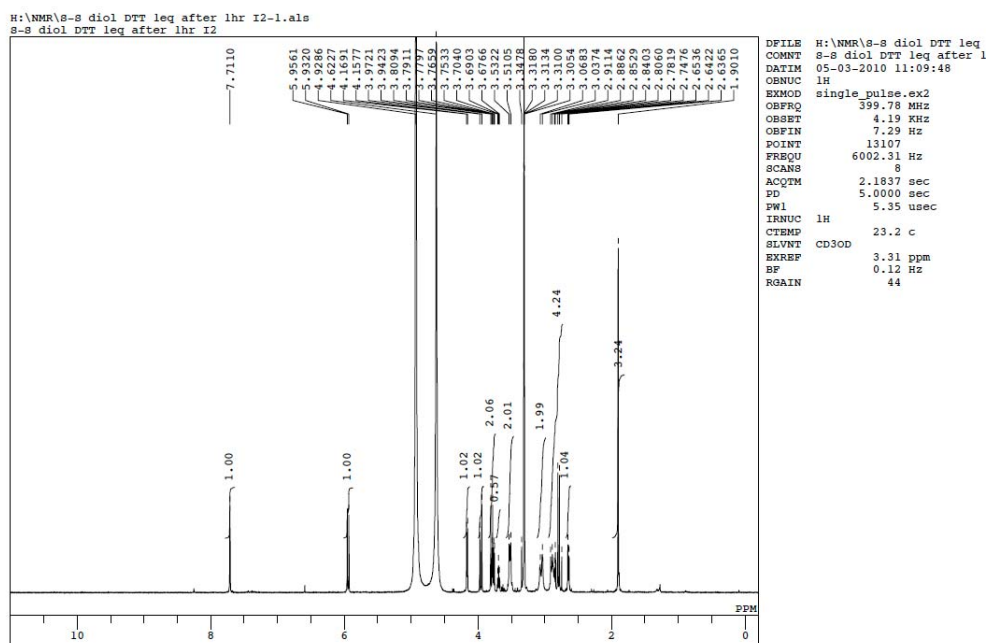
12 hr after addition of H₂O₂



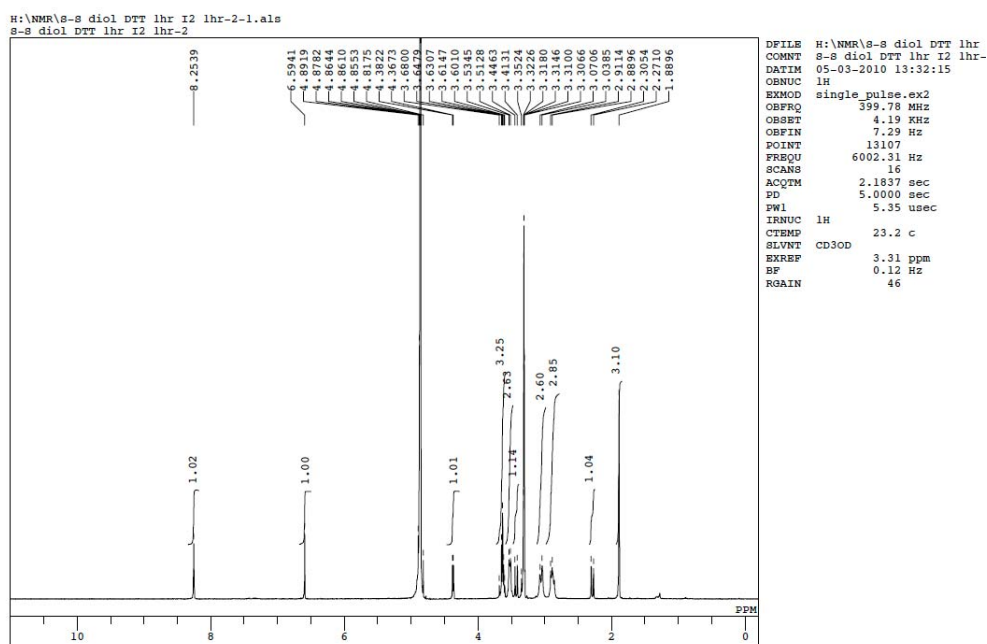
4-D



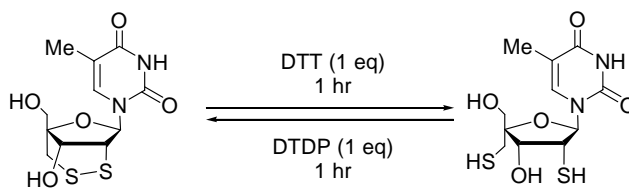
1 hr after addition of dithiothreitol (DTT)



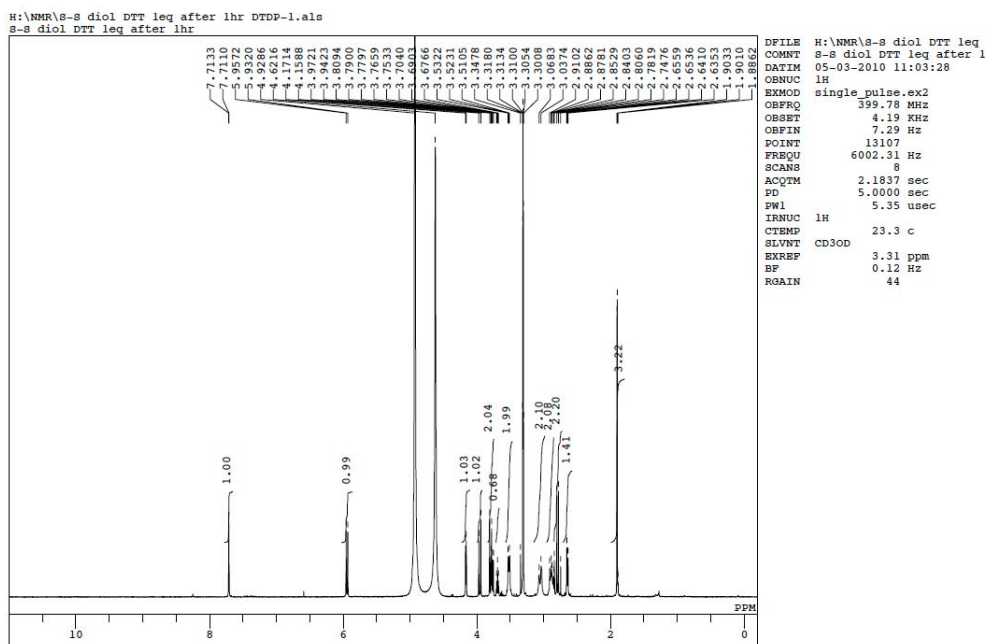
1 hr after addition of I₂



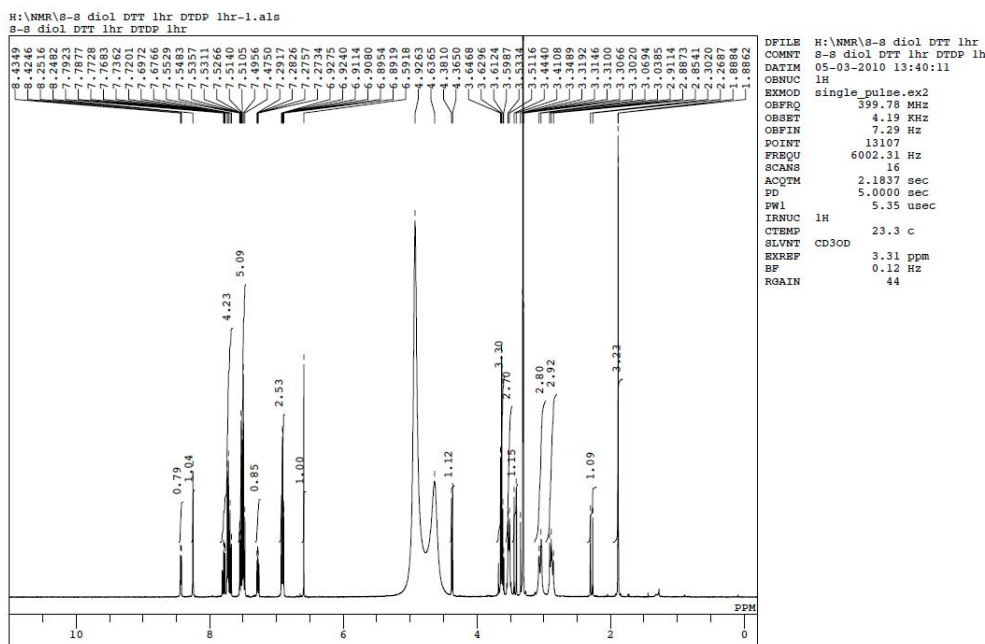
4-E



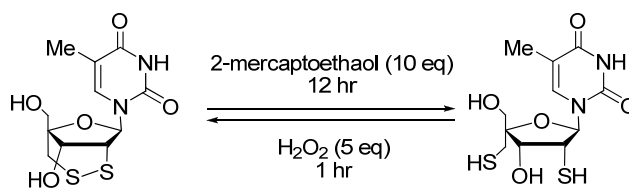
1 hr after addition of dithiothreitol (DTT)



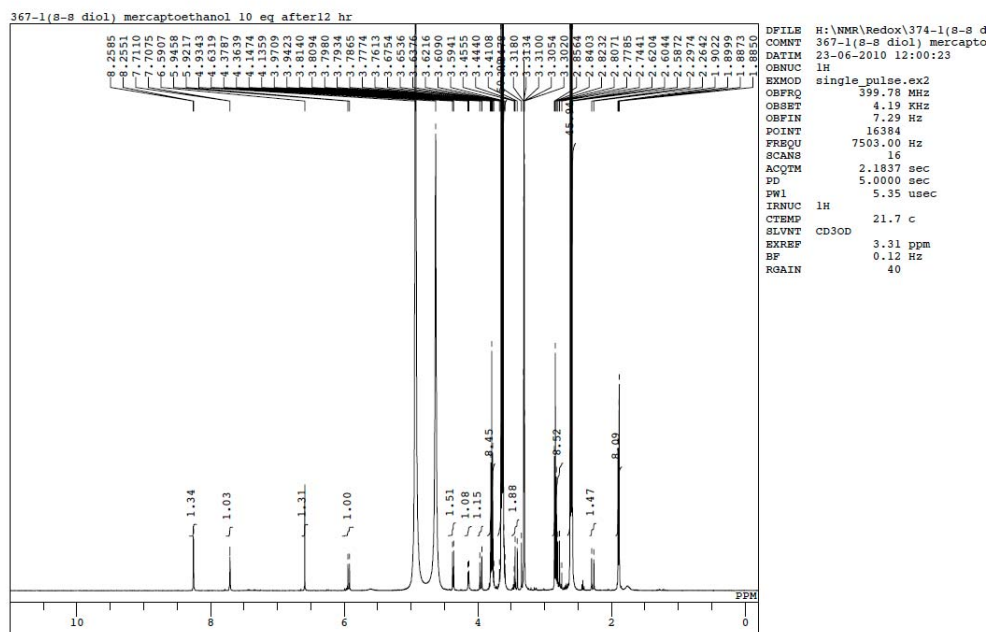
1 hr after addition of 2,2'-dithiodipyridine (DTDP)



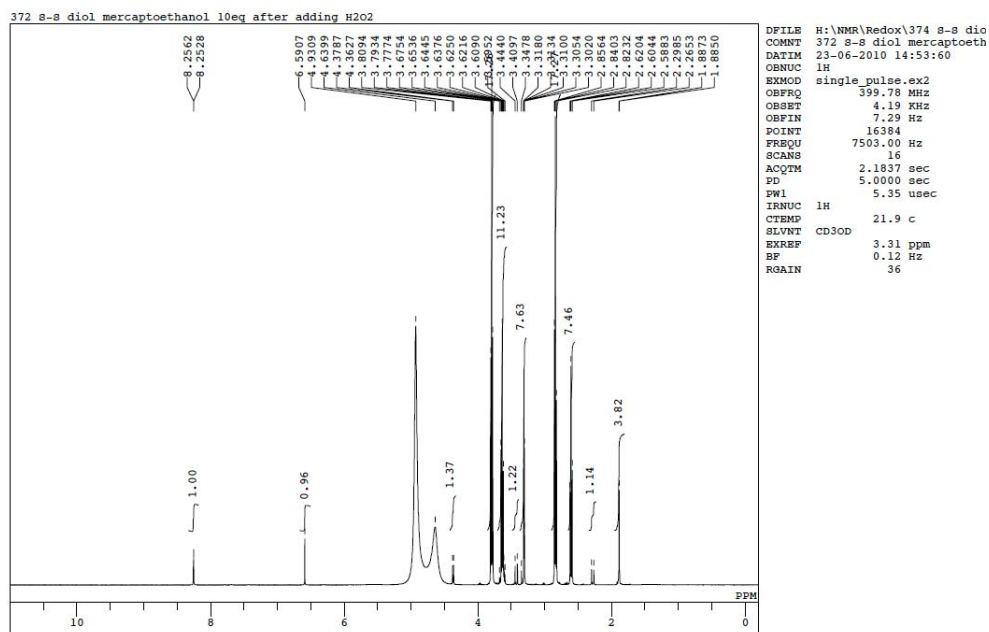
4-F



12 hr after addition of 2-mercaptoethanol



1 hr after addition of H₂O₂



5. Mass spectrum of BNA monomer **8**, **9** and **8-D**, **9-D**

Methods

All ESI-Mass spectra were measured using Thermo LCQ Deca XP MAX and positive mode was used. All samples were diluted to 100 μ M.

8

Compound **8** (3.2 mg, 10 μ mol) was dissolved in methanol (1.0 mL) and the solution was diluted by 100 times using 0.1% trifluoroacetic acid in H₂O/MeCN (10/1) solution.

9

To a solution of compound **8** (3.2 mg, 10 μ mol) in methanol (1.0 mL) was added dithiothreitol (15.4 mg, 100 μ mol) and the reaction mixture was kept standing in an eppendorf tube for an hour. The reaction mixture was diluted by 100 times using 0.1% trifluoroacetic acid in H₂O/MeOH (10/1) solution.

8-D

After coevaporation of **8** with deuterated methanol for 2 times, **8** (3.2 mg, 10 μ mol) was dissolved in deuterated methanol (1.0 mL) and the solution was diluted by 100 times using 0.1% trifluoroacetic acid in D₂O solution.

9-D

After coevaporation of **8** with deuterated methanol for 2 times, to a solution of **8** (3.2 mg, 10 μ mol) in deuterated methanol (1.0 mL) was added dithiothreitol (7.7 mg, 50 μ mol) and the reaction mixture was kept standing in an eppendorf tube for an hour. The reaction mixture was diluted by 100 times using 0.1% trifluoroacetic acid in D₂O solution.

8

S-S diol 0.1 % TFA in H2O-MeCN 10-1 e...

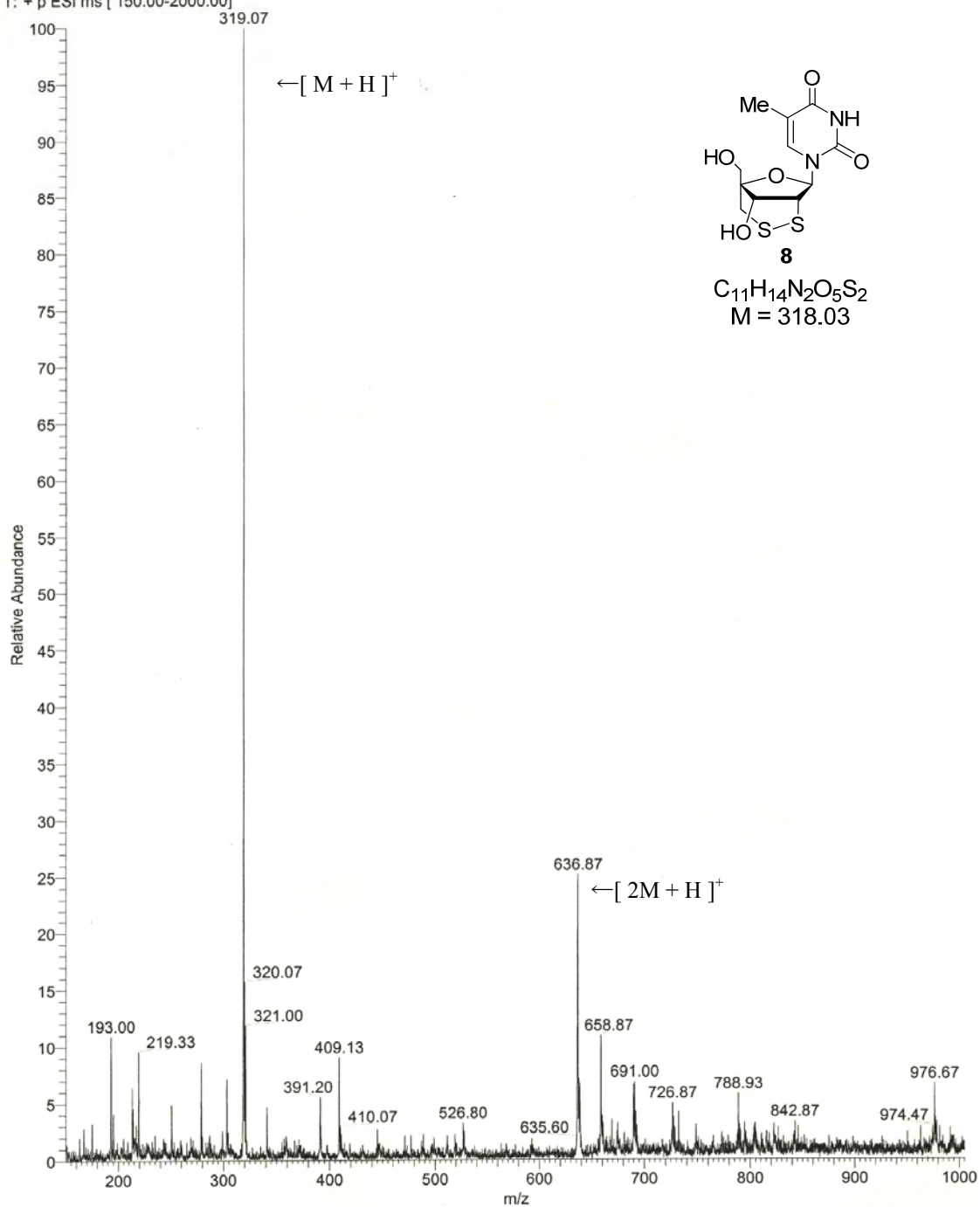
07/01/2010 02:09:24 PM

S-S diol 0.1 % TFA in H2O eppen positiv

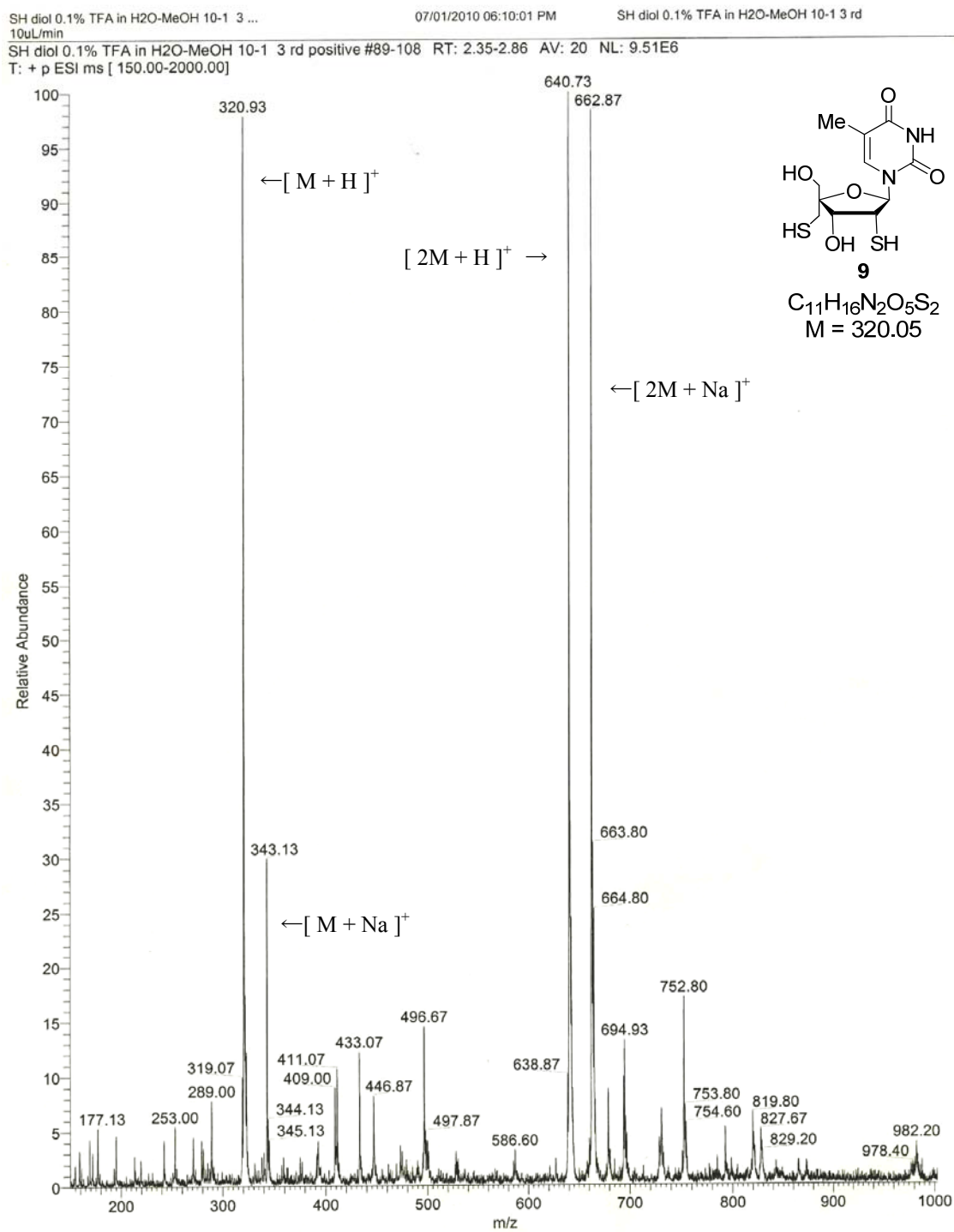
10uL/min

S-S diol 0.1 % TFA in H2O-MeCN 10-1 eppen positive #39-64 RT: 1.02-1.68 AV: 26 NL: 5.68E6

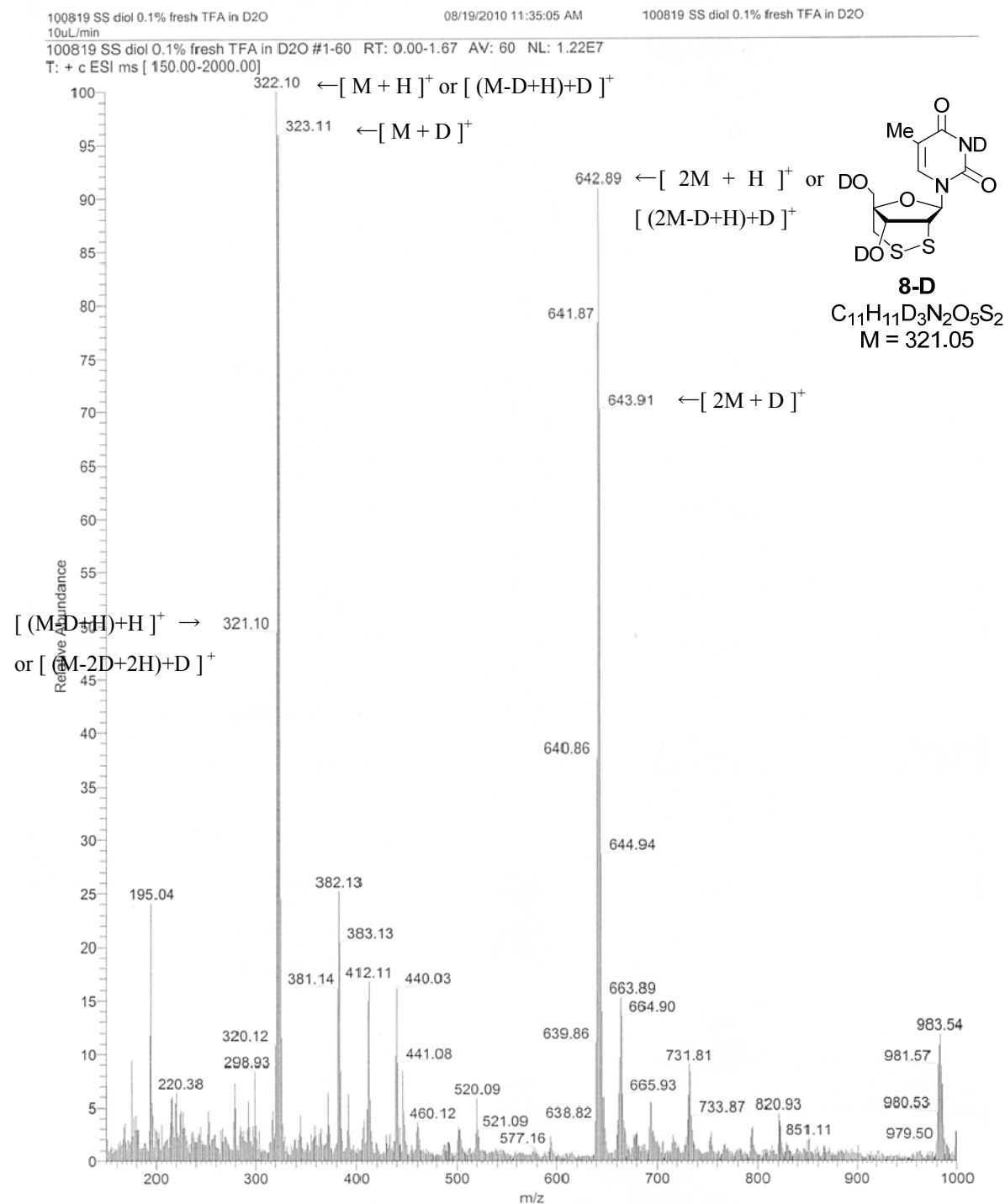
T: + p ESI ms [150.00-2000.00]



9

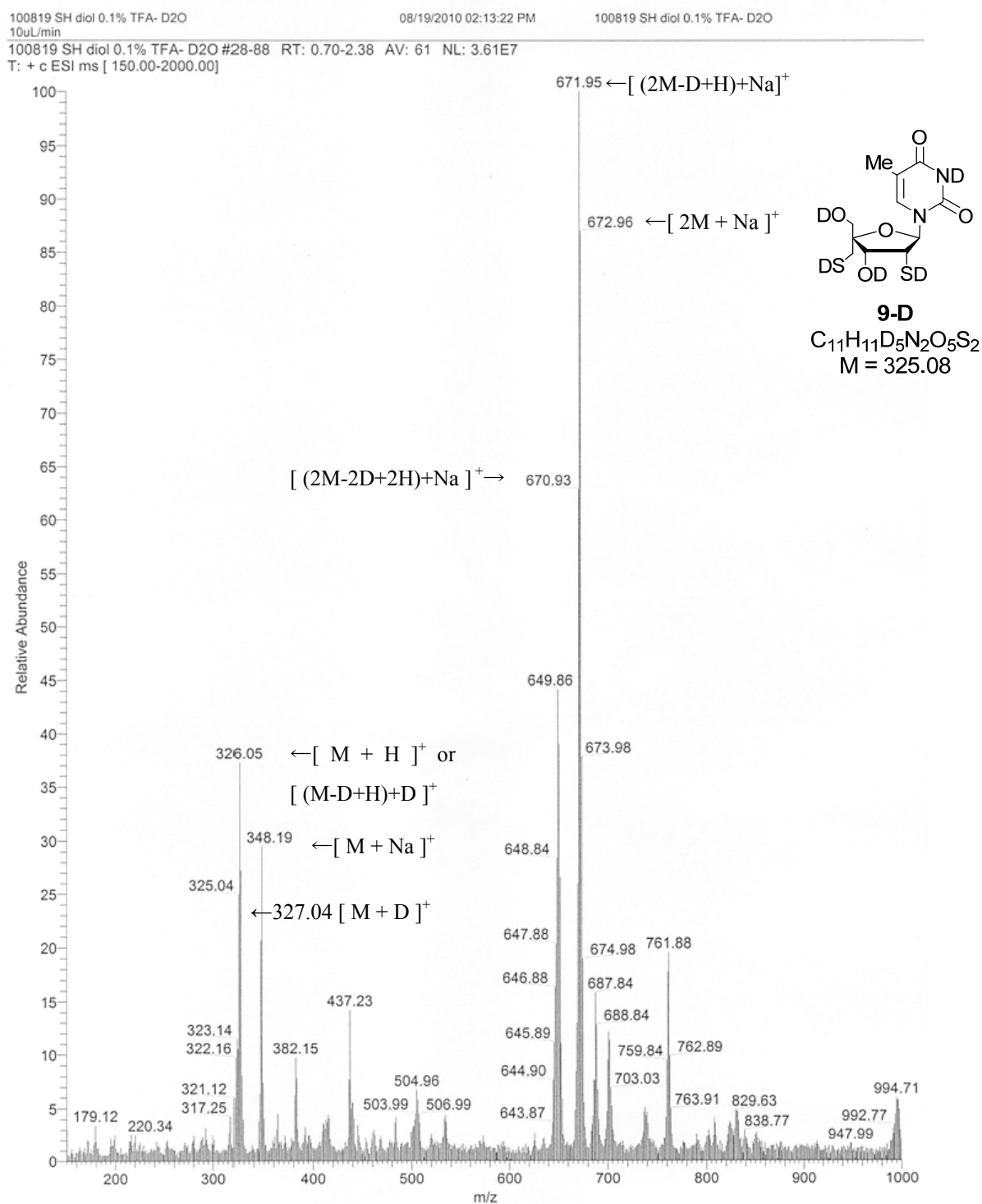


8-D



Signals m/z 323 and 644 was observed, which values are good agreement with $[M+D]^+$, and $[2M+D]^+$ for **8-D**. The signals m/z 322 and 643 observed are derived from the **8-D** + proton ($[M+H]^+$) or the compound what one deuterium of **8-D** was replaced to hydrogen + deuterion ($[(M-D+H)+D]^+$), and $[2M+H]^+$ or $[(2M-D+H)+D]^+$.

9-D



Signals m/z 327, 348 and 673 appeared, which were identical to $[M+D]^+$, $[M+Na]^+$ and $[2M+Na]^+$ for **9-D**, respectively. Moreover, the observed signal m/z 326, which is identical to $[M+H]^+$ or $[(M-D+H)+D]^+$, m/z 671, which is to $[(2M-2D+2H)+Na]^+$, m/z 672, which is to $[(2M-D+H)+Na]^+$.

6. The selected sugar parameters obtained by X-ray crystallographic analysis

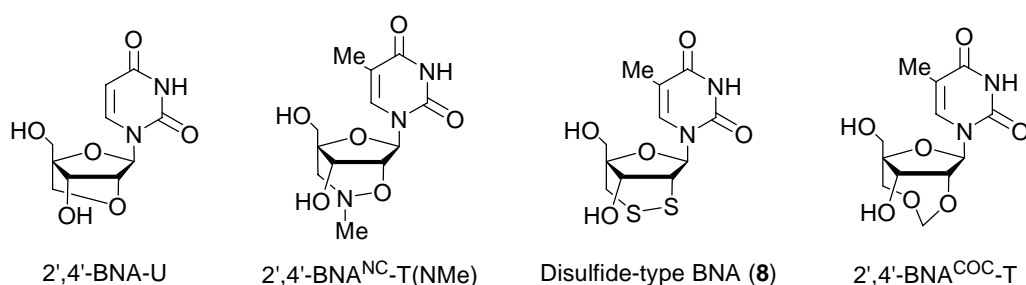


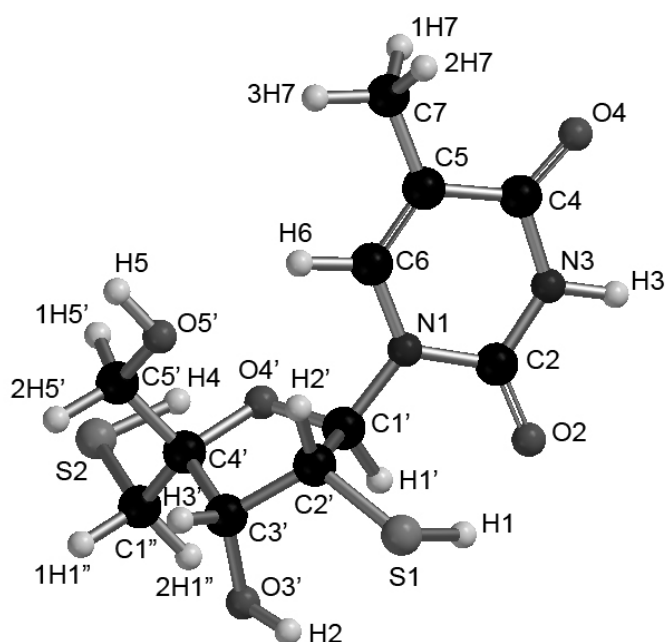
Fig. S1 Structure of 2',4'-BNA analogues.

Table S1 Obtained sugar parameters by X-ray crystallographic analysis

Nucleosides	P	ν_{\max}	δ
A-form duplex ¹⁾	14°	38°	83°
2',4'-BNA-U ²⁾	17.4°	56.6°	66.2°
2',4'-BNA ^{NC} -T(NMe) ³⁾	23.1°	48.6°	75.0°
Disulfide-type BNA (8)	17.8°	42.1°	77.7°
2',4'-BNA ^{COC} -T ⁴⁾	16.9°	38.0°	77.7°

- 1) S. Arnott, D. W. L. Hukins and S. D. Dover, *Biochem. Biophys. Res. Commun.*, 1972, **48**, 1392.
- 2) S. Obika, D. Nanbu, Y. Hari, K. Morio, Y. In, T. Ishida and T. Imanishi, *Tetrahedron Lett.*, 1997, **38**, 8735-8738.
- 3) S. M. A. Rahman, S. Seki, S. Obika, H. Yoshikawa, K. Miyashita and T. Imanishi, *J. Am. Chem. Soc.*, 2008, **130**, 4886-4896.
- 4) Y. Hari, S. Obika, R. Ohnishi, K. Eguchi, T. Osaki, H. Ohishi and T. Imanishi, *Bioorg. Med. Chem.*, 2006, **14**, 1029-1038.

7. Parameters of optimized monomer 9



- torsion angles

$$v_0 = C4'-O4'-C1'-C2' = -24.0^\circ$$

$$v_1 = O4'-C1'-C2'-C3' = -38.0^\circ$$

$$v_2 = C1'-C2'-C3'-C4' = -36.7^\circ$$

$$v_3 = C2'-C3'-C4'-O4' = 23.7^\circ$$

$$v_4 = C3'-C4'-O4'-C1' = -0.1^\circ$$

$$\delta = O3'-C3'-C4'-C5' = 147.6^\circ$$

- pseudorotation phase angle $P = 161.5^\circ$

- maximum torsion angle $v_{\max} = 38.7^\circ$

Fig. S2 Optimized structures, endocyclic sugar torsion angles v_0 - v_4 , maximum torsion angle v_{\max} and pseudorotation phase angle P . The values of P and v_{\max} are calculated as follows: $\tan P = (v_4 + v_1 - v_3 - v_0) / (2 \cdot v_2 \cdot (\sin 36^\circ + \sin 72^\circ))$; $v_{\max} = v_2 / \cos P$. The calculation was carried out using Spartan '06 for Windows (Wavefunction Inc.) and optimized using Geometry Optimization (HF/6-31G*).