Supplementary Information

Synthesis, gene silencing activity, thermal stability, and serum stability of siRNA containing four (*S*)-5′-*C*-aminopropyl-2′-*O*-methylnucleosides (A, adenosine; U, uridine; G, guanosine; and C, cytidine)

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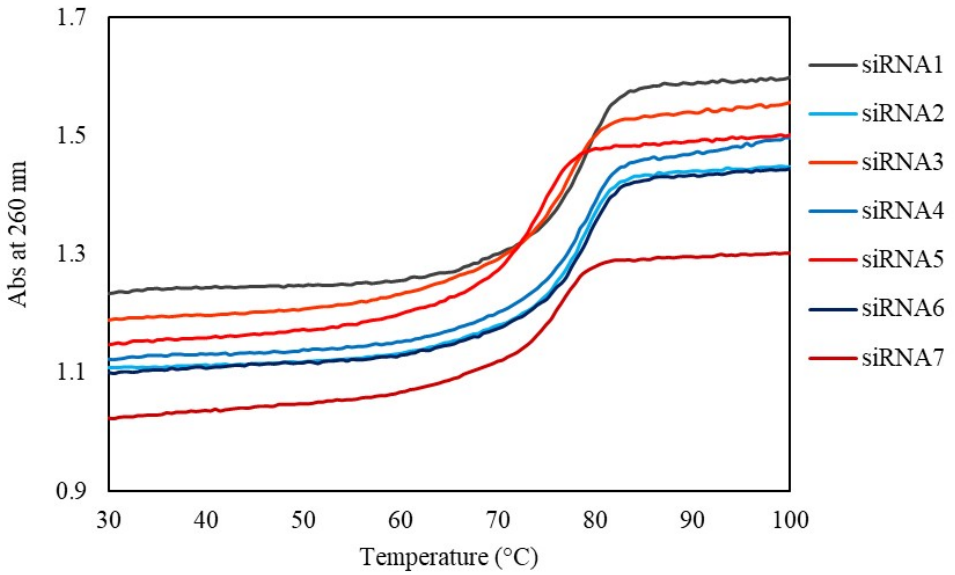


Figure S1. UV melting profiles of the unmodified and modified siRNAs in a buffer containing 10 mM sodium phosphate (pH 7.0) and 100 mM NaCl.

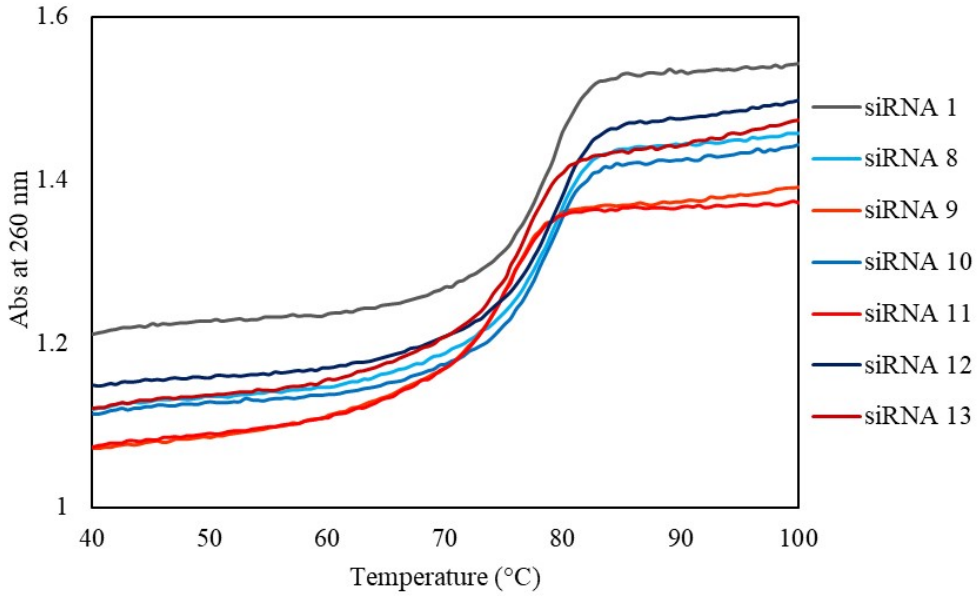


Figure S2. UV melting profiles of the unmodified and modified siRNAs in a buffer containing 10 mM sodium phosphate (pH 7.0) and 100 mM NaCl.

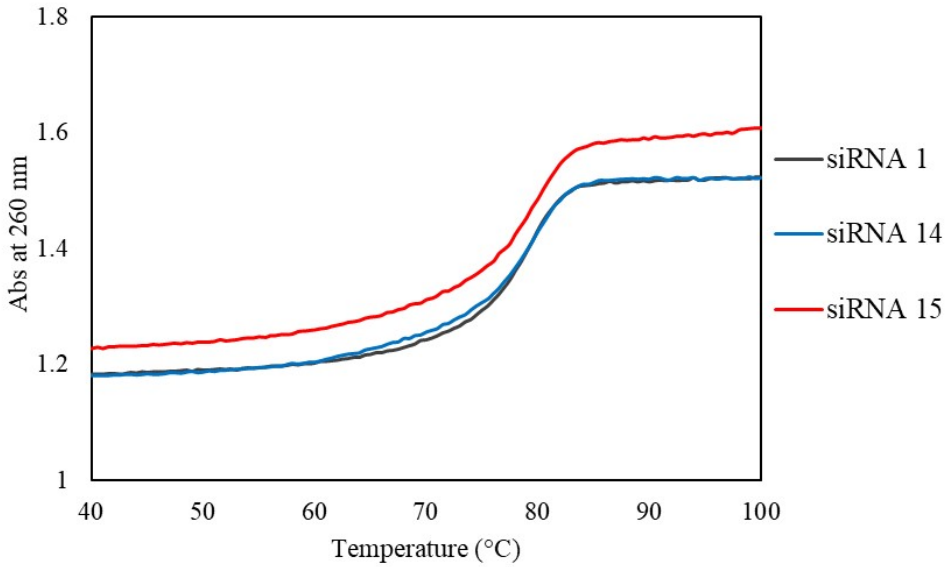


Figure S3. UV melting profiles of the unmodified and modified siRNAs in a buffer containing 10 mM sodium phosphate (pH 7.0) and 100 mM NaCl.

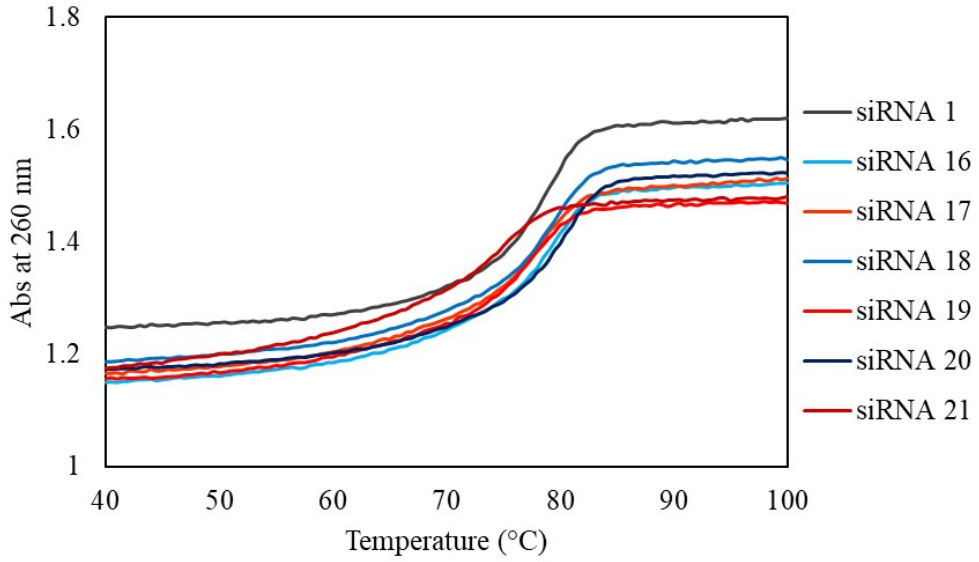


Figure S4. UV melting profiles of the unmodified and modified siRNAs in a buffer containing 10 mM sodium phosphate (pH 7.0) and 100 mM NaCl.

Table S1. Sequences of siRNAs **1**–**7** and their ability to suppress gene expression.

Abbreviation of siRNA	Abbreviation of ssRNA	sequence [a]	upper: 1 nM lower: 0.1 nM
Control	Buffer	-	100 ± 6.1
		Sense (Passenger) strand	
siRNA 1	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	21.1 ± 2.5
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'	59.0 ± 1.4
		Antiense (Guide) strand	
siRNA 2	RNA 2	5'-GGCCUUUCACUACUCCUA**CUU**-3'	19.4 ± 2.0
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'	56.1 ± 1.5
siRNA 3	RNA 3	5'-GGCCUUUCACUACUCCUA**CUU**-3'	16.9 ± 1.7
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'	58.7 ± 3.1
siRNA 4	RNA 4	5'-GGCCUUUCACUACUC**CUA**CUU-3'	20.0 ± 0.79
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'	58.1 ± 5.3
siRNA 5	RNA 5	5'-GGCCUUUCACUACUC**CUA**CUU-3'	60.4 ± 4.0
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'	28.5 ± 1.7
siRNA 6	RNA 6	5'-GGCCUUUCACUA**CUC**CUACUU-3'	20.8 ± 2.5
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'	56.4 ± 2.8
siRNA 7	RNA 7	5'-GGCCUUUCACUA**CUC**CUACUU-3'	21.6 ± 2.5
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'	57.9 ± 4.0

[a]Blue letters, and red letters denote 2′-*O*-methylnucleosides, and (*S*)-5′-*C*-aminopropyl-2′-*O*-methylnucleosides, respectively.

Table S2. Sequences of siRNAs **1**, **8**–**13** and their ability to suppress gene expression.

Abbreviation of siRNA	Abbreviation of ssRNA	sequence [a]	upper: 1 nM lower: 0.1 nM
Control	Buffer	-	100 ± 12.7
		Sense (Passenger) strand	
siRNA 1	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	21.8 ± 5.6
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'	62.5 ± 1.6
		Antiense (Guide) strand	
siRNA 8	RNA 9	5'-GGCCUUUCA**CUA**CUCCUACUU-3'	27.5 ± 3.7
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'	65.8 ± 3.6
siRNA 9	RNA 10	5'-GGCCUUUCA**CUA**CUCCUACUU-3'	63.1 ± 6.4
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'	90.3 ± 5.0
siRNA 10	RNA 11	5'-GGCCUU**UCA**CUACUCCUACUU-3'	32.6 ± 2.3
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'	78.8 ± 6.8
siRNA 11	RNA 12	5'-GGCCUU**UCA**CUACUCCUACUU-3'	91.4 ± 6.5
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'	46.9 ± 1.5
siRNA 12	RNA 13	5'-GGC**CUU**UCACUACUCCUACUU-3'	22.2 ± 2.5
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'	65.0 ± 1.5
siRNA 13	RNA 14	5'-GGC**CUU**UCACUACUCCUACUU-3'	18.5 ±1.1
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'	73.8 ± 3.8

[a]Blue letters, and red letters denote 2′-*O*-methylnucleosides, and (*S*)-5′-*C*-aminopropyl-2′-*O*-methylnucleosides, respectively.

Table S3. Sequences of siRNAs **1**, **14**, **15** and their ability to suppress gene expression.

Abbreviation of siRNA	Abbreviation of ssRNA	sequence [a]	upper: 1 nM lower: 0.1 nM
Control	Buffer	-	100 ± 2.8
		Sense (Passenger) strand	
siRNA 1	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	21.1 ± 1.6
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'	59.9 ± 3.7
		Antiense (Guide) strand	
siRNA 14	RNA 15	5'-**GGC**CUUUCACUACUCCUACUU-3'	15.5 ± 1.4
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'	47.0 ± 2.3
siRNA 15	RNA 16	5'-**GGC**CUUUCACUACUCCUACUU-3'	17.2 ± 1.3
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'	48.5 ± 5.0

[a]Blue letters, and red letters denote 2′-*O*-methylnucleosides, and (*S*)-5′-*C*-aminopropyl-2′-*O*-methylnucleosides, respectively.

Table S4. Sequences of siRNAs **1**, **16**–**21** and their ability to suppress gene expression.

Abbreviation of siRNA	Abbreviation of ssRNA	sequence [a]	upper: 10 nM lower: 1 nM
Control	Buffer	-	100 ± 9.5
		Sense (Passenger) strand	
siRNA 1	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	11.8 ± 0.86
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'	24.7 ± 2.3
		Antiense (Guide) strand	
siRNA 16	RNA 17	5'-**GGC**CUUUCACUACUCCUA**CUU**-3'	9.7 ± 0.53
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'	24.9 ± 1.2
siRNA 17	RNA 18	5'-**GGC**CUUUCACUACUCCUA**CUU**-3'	11.1 ± 0.34
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'	31.0 ± 0.90
siRNA 18	RNA 19	5'-**GGCC**UUUCACUACUCCU**ACUU**-3'	14.0 ± 1.5
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'	26.1 ± 0.62
siRNA 19	RNA 20	5'-**GGCC**UUUCACUACUCCU**ACUU**-3'	34.3 ± 3.1
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'	17.6 ± 2.5
siRNA 20	RNA 21	5'-**GGCCU**UUCACUACUCC**UACUU**-3'	9.7 ± 0.59
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'	22.7 ± 0.68
siRNA 21	RNA 22	5'-**GGCCU**UUCACUACUCC**UACUU**-3'	23.9 ± 1.2
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'	54.3 ± 2.4

[a]Blue letters, and red letters denote 2′-*O*-methylnucleosides, and (*S*)-5′-*C*-aminopropyl-2′-*O*-methylnucleosides, respectively.

Table S5. Sequences of siRNAs **1**, **22**–**29** and their ability to suppress gene expression.

Abbreviation of siRNA	Abbreviation of ssRNA	sequence [a]	upper: 10 nM lower: 1 nM
Control	Buffer	-	100 ± 6.0
		Sense (Passenger) strand	
siRNA 1	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	25.7 ± 2.5
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'	37.9 ± 1.3
		Antiense (Guide) strand	
siRNA 22	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	57.7 ± 0.98
	RNA 23	3'-UUCCGGAAAGUGAUGAGGAU**G**-5'	93.6 ± 7.3
siRNA 23	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	99.1 ± 3.9
	RNA 24	3'-UUCCGGAAAGUGAUGAGGAU**G**-5'	95.3 ± 5.4
siRNA 24	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	54.1 ± 1.9
	RNA 25	3'-UUCCGGAAAGUGAUGAGGA**U**G-5'	83.3 ± 4.7
siRNA 25	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	86.7 ± 4.6
	RNA 26	3'-UUCCGGAAAGUGAUGAGGA**U**G-5'	96.7 ± 3.3
siRNA 26	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	23.7 ± 2.0
	RNA 27	3'-UUCCGGAAAGUGAUGAGG**A**UG-5'	38.7 ± 3.0
siRNA 27	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	64.3 ± 6.6
	RNA 28	3'-UUCCGGAAAGUGAUGAGG**A**UG-5'	82.0 ± 0.90
siRNA 28	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	22.9 ± 1.4
	RNA 29	3'-UUCCGGAAAGUGAUGAG**G**AUG-5'	43.9 ± 3.2
siRNA 29	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	47.5 ± 0.90
	RNA 30	3'-UUCCGGAAAGUGAUGAG**G**AUG-5'	68.1 ± 5.1

[a]Blue letters, and red letters denote 2′-*O*-methylnucleosides, and (*S*)-5′-*C*-aminopropyl-2′-*O*-methylnucleosides, respectively.

Table S6. Sequences of siRNAs **1**, **30**–**37** and their ability to suppress gene expression.

Abbreviation of siRNA	Abbreviation of ssRNA	sequence [a]	upper: 10 nM lower: 1 nM
Control	Buffer	-	100 ± 7.9
		Sense (Passenger) strand	
siRNA 1	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	17.3 ± 1.0
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'	41.3 ± 3.8
		Antiense (Guide) strand	
siRNA 30	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	18.1 ± 1.3
	RNA 31	3'-UUCCGGAAAGUGAUGA**G**GAUG-5'	30.3 ± 0.64
siRNA 31	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	43.6 ± 3.5
	RNA 32	3'-UUCCGGAAAGUGAUGA**G**GAUG-5'	60.2 ± 6.3
siRNA 32	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	20.6 ± 1.2
	RNA 33	3'-UUCCGGAAAGUGAUG**A**GGAUG-5'	33.4 ± 2.8
siRNA 33	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	34.5 ± 3.4
	RNA 34	3'-UUCCGGAAAGUGAUG**A**GGAUG-5'	64.1 ± 1.2
siRNA 34	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	23.9 ± 1.5
	RNA 35	3'-UUCCGGAAAGUGAU**G**AGGAUG-5'	43.7 ± 2.4
siRNA 35	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	23.9 ± 1.0
	RNA 36	3'-UUCCGGAAAGUGAU**G**AGGAUG-5'	39.8 ± 1.4
siRNA 36	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	23.8 ± 1.9
	RNA 37	3'-UUCCGGAAAGUGA**U**GAGGAUG-5'	44.4 ± 2.6
siRNA 37	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	38.1 ± 2.4
	RNA 38	3'-UUCCGGAAAGUGA**U**GAGGAUG-5'	60.8 ± 3.8

[a]Blue letters, and red letters denote 2′-*O*-methylnucleosides, and (*S*)-5′-*C*-aminopropyl-2′-*O*-methylnucleosides, respectively.

Table S7. Sequences of ssRNAs, siRNAs, and T_m values of siRNAs.

Abbreviation of siRNA	Abbreviation of ssRNA	Passenger strand (5'-3') [a] Guide strand (3'-5')	T_m (°C) [b]	ΔT_m (°C) [c]
siRNA 1	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	78.0	-
	RNA 8	3'-UUCCGGAAAGUGAUGAGGAUG-5'		
siRNA 22	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	78.0	-
	RNA 23	3'-UUCCGGAAAGUGAUGAGGAU**G**-5'		
siRNA 23	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	77.8	-0.2
	RNA 24	3'-UUCCGGAAAGUGAUGAGGAU**G**-5'		
siRNA 24	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	77.7	-
	RNA 25	3'-UUCCGGAAAGUGAUGAGGA**U**G-5'		
siRNA 25	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	78.0	0.3
	RNA 26	3'-UUCCGGAAAGUGAUGAGGA**U**G-5'		
siRNA 26	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	78.1	-
	RNA 27	3'-UUCCGGAAAGUGAUGAGG**A**UG-5'		
siRNA 27	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	78.0	-0.1
	RNA 28	3'-UUCCGGAAAGUGAUGAGG**A**UG-5'		

[a]Blue and red letters denote 2′-*O*-methylnucleosides and (*S*)-5′-*C*-aminopropyl-2′-*O*-methylnucleosides, respectively.

[b]The T_m values were determined using 3 μM dsRNA in a buffer containing 10 mM sodium phosphate (pH of 7.0) and 100 mM NaCl.

[c]ΔT_m represents [T_m (siRNA$_{(S)\text{-}5'\text{-}C\text{-aminopropyl-}2'\text{-}O\text{-methyl}}$) − T_m (siRNA$_{2'\text{-}O\text{-methyl}}$)].

Table S8. Sequences of ssRNAs, siRNAs, and T_m values of siRNAs.

Abbreviation of siRNA	Abbreviation of ssRNA	Passenger strand (5'-3') [a] Guide strand (3'-5')	T_m (°C) [b]	ΔT_m (°C) [c]
siRNA 28	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	78.3	-
	RNA 29	3'-UUCCGGAAAGUGAUGAGGGAUG-5'		
siRNA 29	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	77.7	-0.6
	RNA 30	3'-UUCCGGAAAGUGAUGAGGGAUG-5'		
siRNA 30	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	77.7	-
	RNA 31	3'-UUCCGGAAAGUGAUGAGGGAUG-5'		
siRNA 31	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	77.5	-0.2
	RNA 32	3'-UUCCGGAAAGUGAUGAGGGAUG-5'		
siRNA 32	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	77.4	-
	RNA 33	3'-UUCCGGAAAGUGAUGAGGAUG-5'		
siRNA 33	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	77.6	0.2
	RNA 34	3'-UUCCGGAAAGUGAUGAGGAUG-5'		

[a]Blue and red letters denote 2′-*O*-methylnucleosides and (*S*)-5′-*C*-aminopropyl-2′-*O*-methylnucleosides, respectively.

[b]The T_m values were determined using 3 μM dsRNA in a buffer containing 10 mM sodium phosphate (pH of 7.0) and 100 mM NaCl.

[c]ΔT_m represents [T_m (siRNA$_{(S)\text{-}5'\text{-}C\text{-aminopropyl-}2'\text{-}O\text{-methyl}}$) − T_m (siRNA$_{2'\text{-}O\text{-methyl}}$)].

Table S9. Sequences of ssRNAs, siRNAs, and T_m values of siRNAs.

Abbreviation of siRNA	Abbreviation of ssRNA	Passenger strand (5'-3') [a] Guide strand (3'-5')	T_m (°C) [b]	ΔT_m (°C) [c]
siRNA 34	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	77.9	-
	RNA 35	3'-UUCCGGAAAGUGAU**G**AGGAUG-5'		
siRNA 35	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	78.4	0.5
	RNA 36	3'-UUCCGGAAAGUGAU**G**AGGAUG-5'		
siRNA 36	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	77.8	-
	RNA 37	3'-UUCCGGAAAGUGA**U**GAGGAUG-5'		
siRNA 37	RNA 1	5′-GGCCUUUCACUACUCCUACUU-3′	77.3	-0.5
	RNA 38	3'-UUCCGGAAAGUGA**U**GAGGAUG-5'		

[a]Blue and red letters denote 2′-*O*-methylnucleosides and (*S*)-5′-*C*-aminopropyl-2′-*O*-methylnucleosides, respectively.

[b]The T_m values were determined using 3 μM dsRNA in a buffer containing 10 mM sodium phosphate (pH of 7.0) and 100 mM NaCl.

[c]ΔT_m represents [T_m (siRNA$_{(S)\text{-}5'\text{-}C\text{-aminopropyl-}2'\text{-}O\text{-methyl}}$) − T_m (siRNA$_{2'\text{-}O\text{-methyl}}$)].

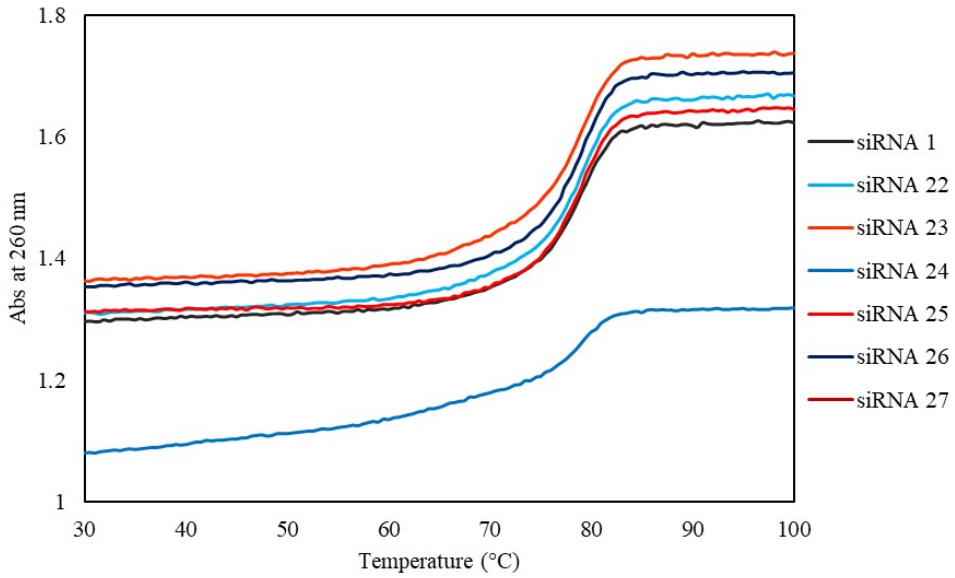


Figure S5. UV melting profiles of the unmodified and modified siRNAs in a buffer containing 10 mM sodium phosphate (pH 7.0) and 100 mM NaCl.

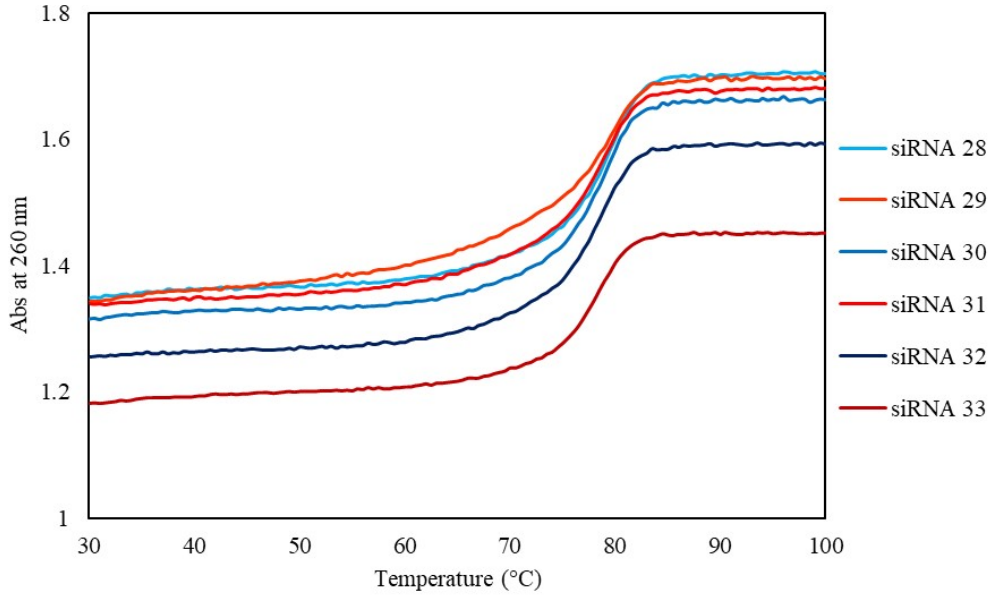


Figure S6. UV melting profiles of the unmodified and modified siRNAs in a buffer containing 10 mM sodium phosphate (pH 7.0) and 100 mM NaCl.

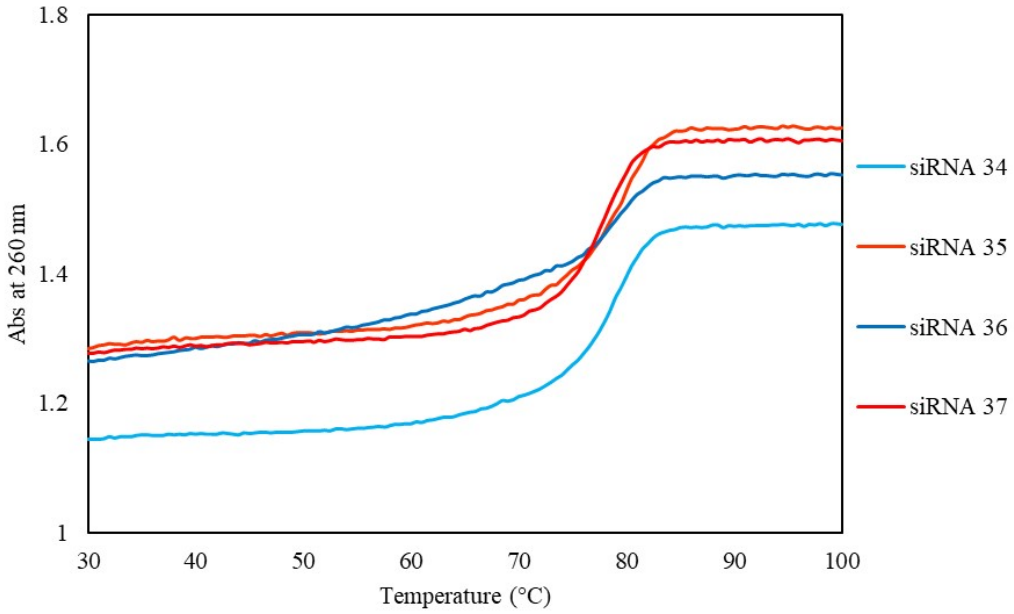
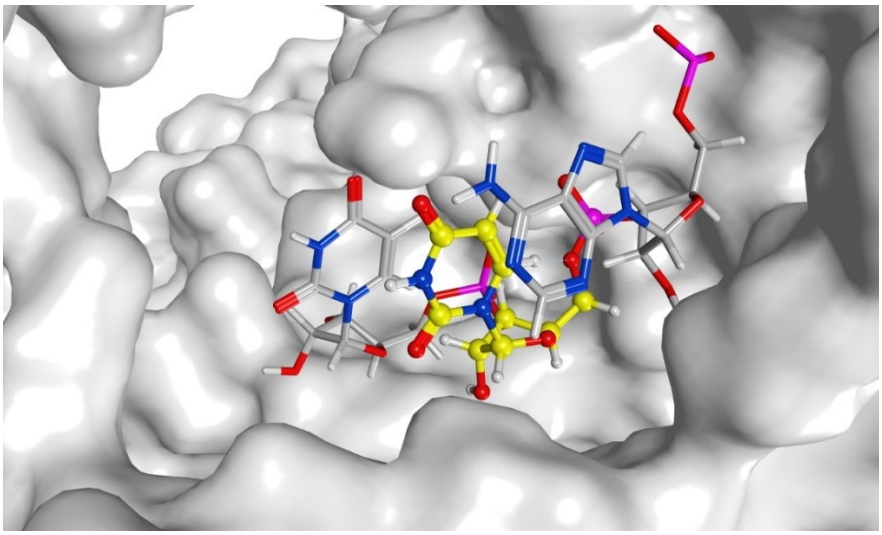


Figure S7. UV melting profiles of the unmodified and modified siRNAs in a buffer containing 10 mM sodium phosphate (pH 7.0) and 100 mM NaCl.

(A)



(B)

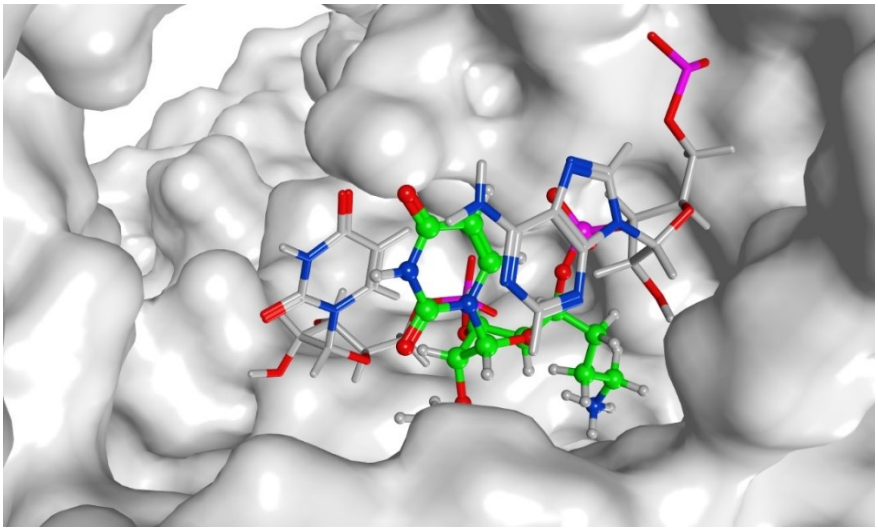


Figure S8. Models of the complex of Argonaute-2 and guide strand positions 6–8 of siRNA based on the crystal structure with a guide and passenger strand duplex (PDB ID code: 4W5O)[1]. (A) unmodified siRNA, (B) modeling structure obtained on substitution with (*S*)-5′-*C*-aminopropyl-2′-*O*-methyl modification at guide strand position 7. As shown, the guide strand position 7 colored yellow (A) and green (B).

Molecular Modeling Method

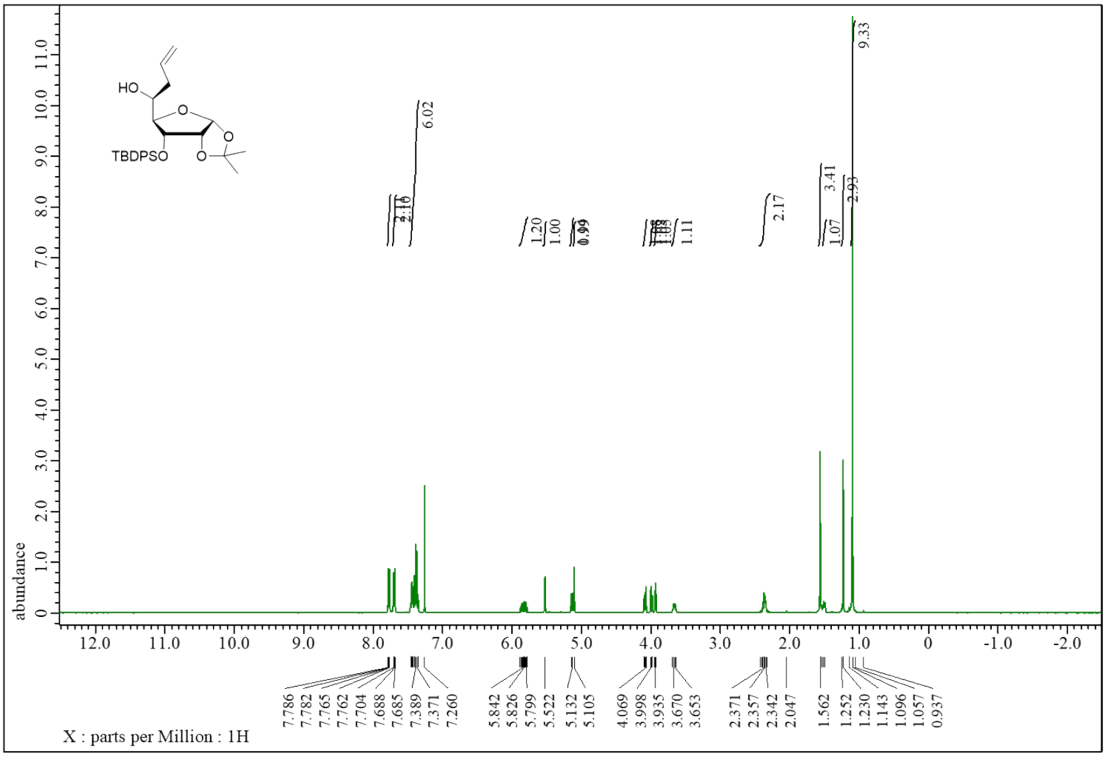
The model of the complex between human Argonaute-2 and the seed region pairing of an siRNA were retrieved from the Protein Data Bank (ID code: 4W5O)[1]. The missing loops in the crystal structure of human Argonaute-2 and an siRNA were built with the MOE (Molecular Operating Environment) program using the "Loop modeler." Subsequently, the (*S*)-5-*C*-aminopropyl-2-*O*-methyl modification was built with the MOE program using the structure-editing tool "Builder." All modeling structures were energy-minimized by MOE using the Amber 14 force field.

Reference.

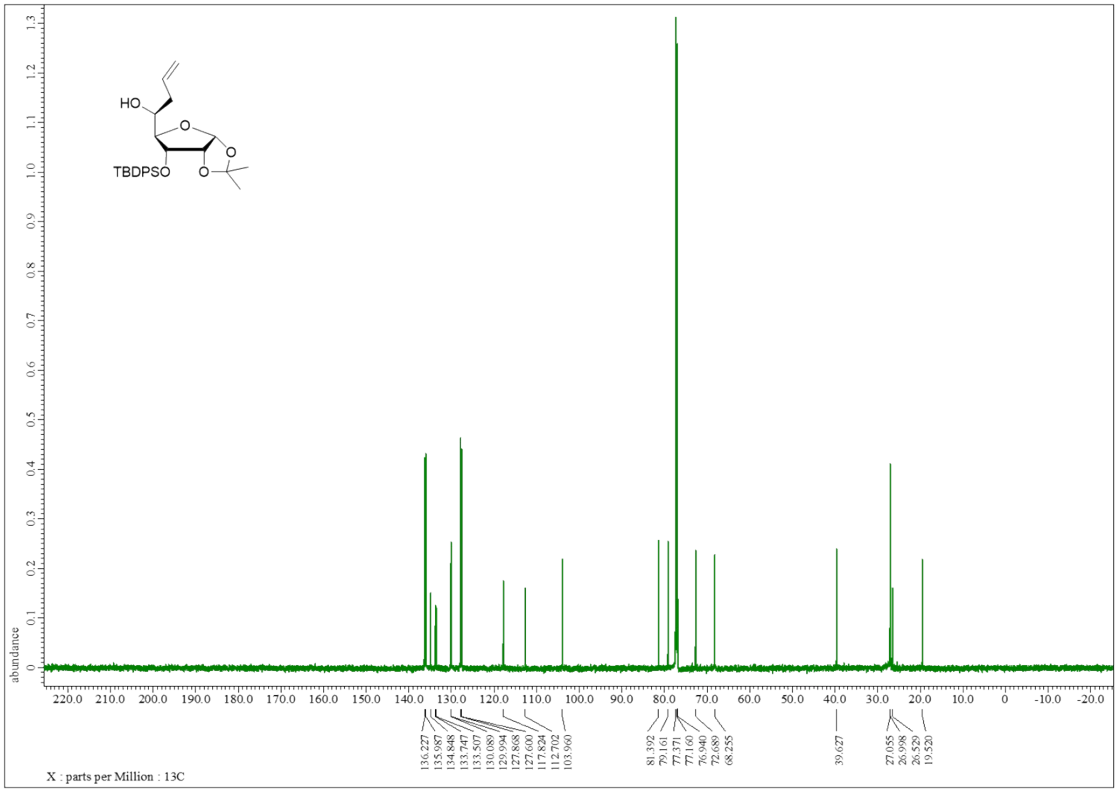
1. N. T. Schirle, J. Sheu-Gruttadauria, I. J. MacRae. Structural basis for microRNA targeting. *Science*, 2014, **346**, 608–613.

NMR spectra (^{1}H, ^{13}C, ^{31}P and NOESY)

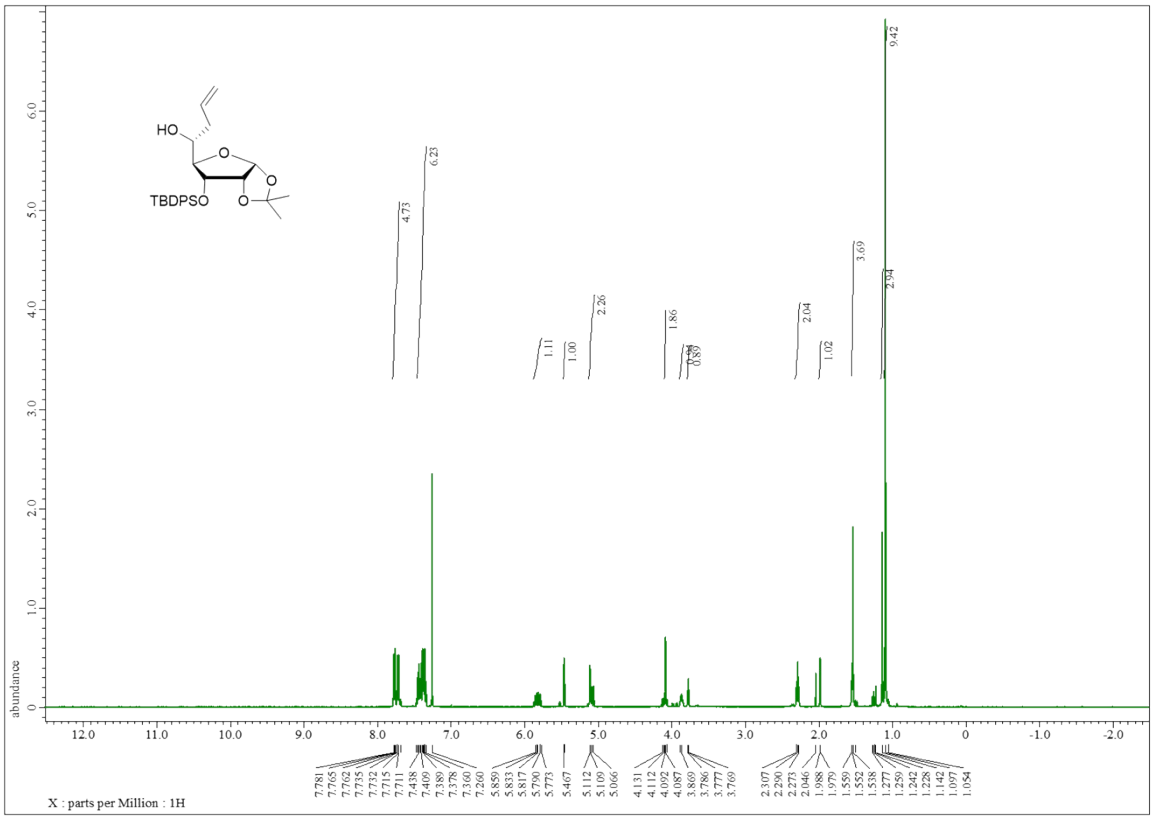
^{1}H NMR spectrum of compound **6**



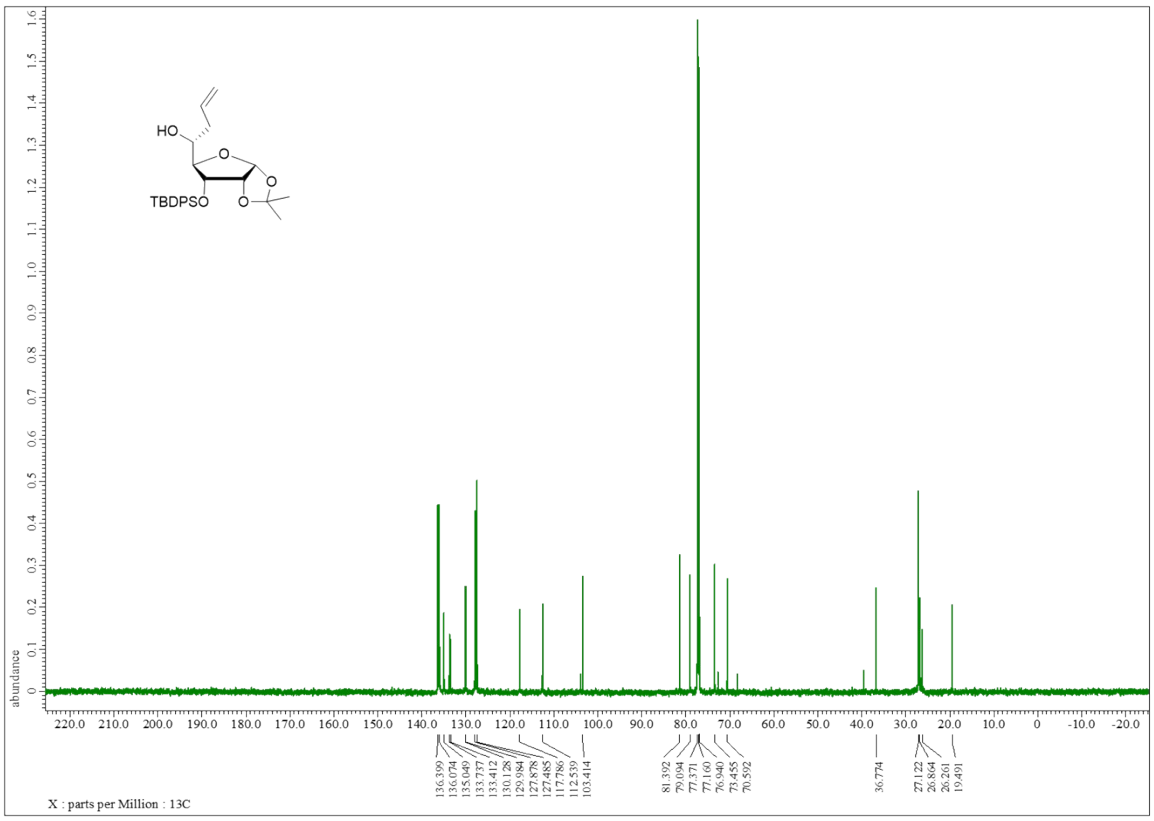
^{13}C{^{1}H}NMR spectrum of compound **6**



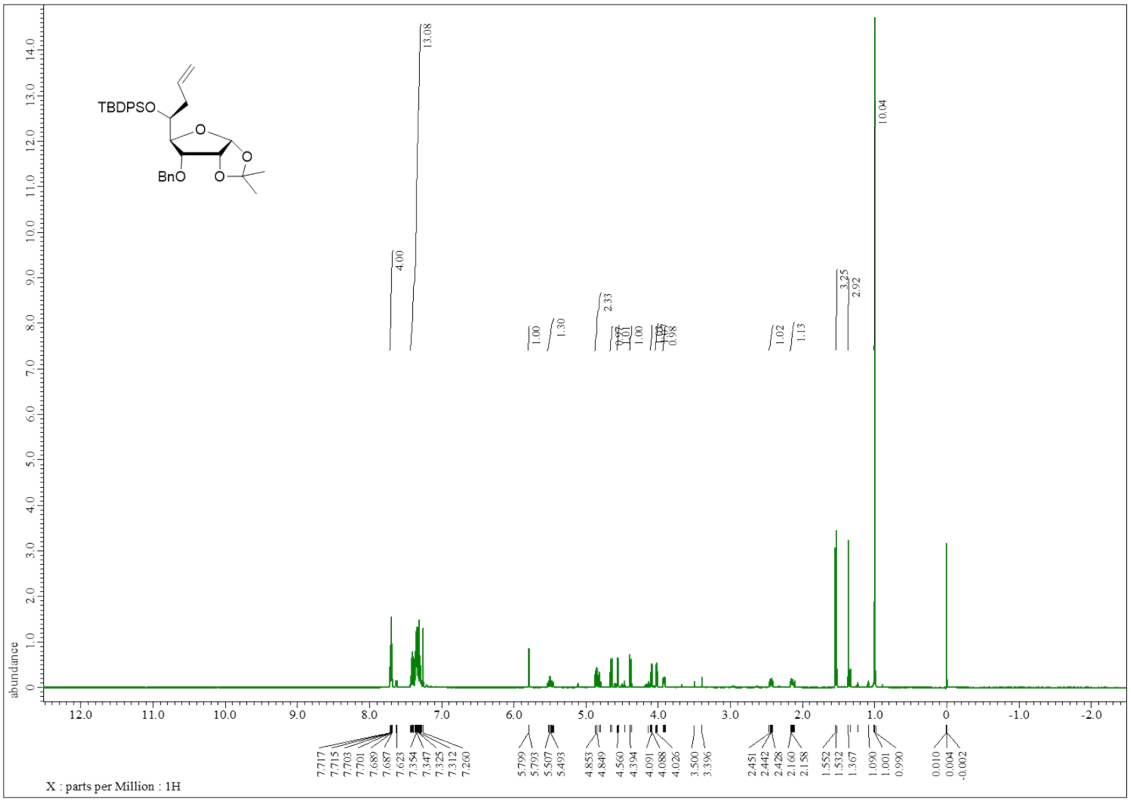
^{1}H NMR spectrum of compound **7**



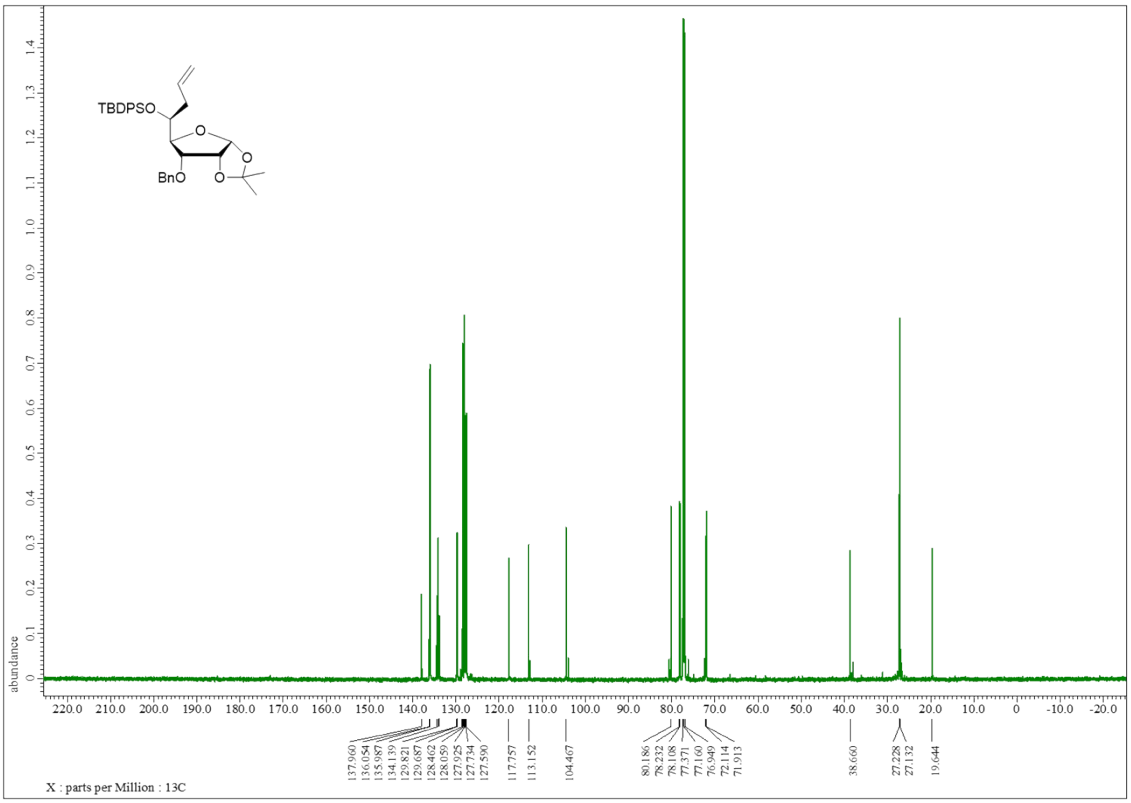
^{13}C{^{1}H}NMR spectrum of compound **7**



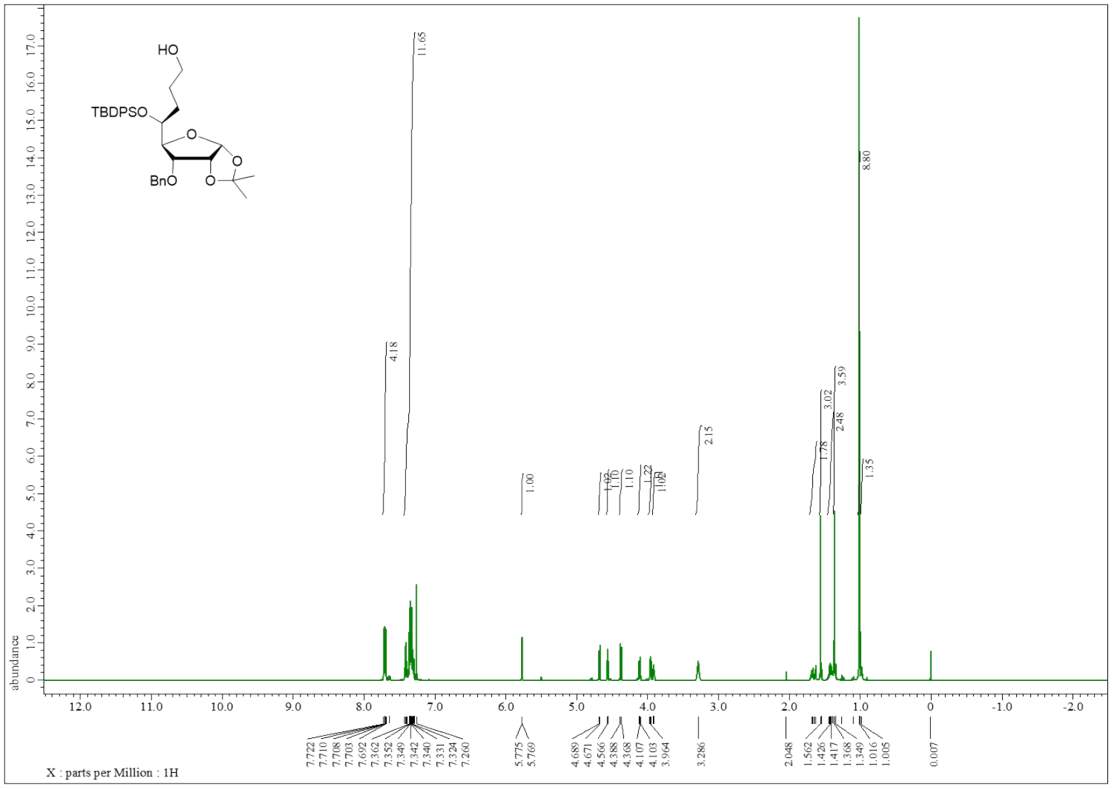
^{1}H NMR spectrum of compound **8**



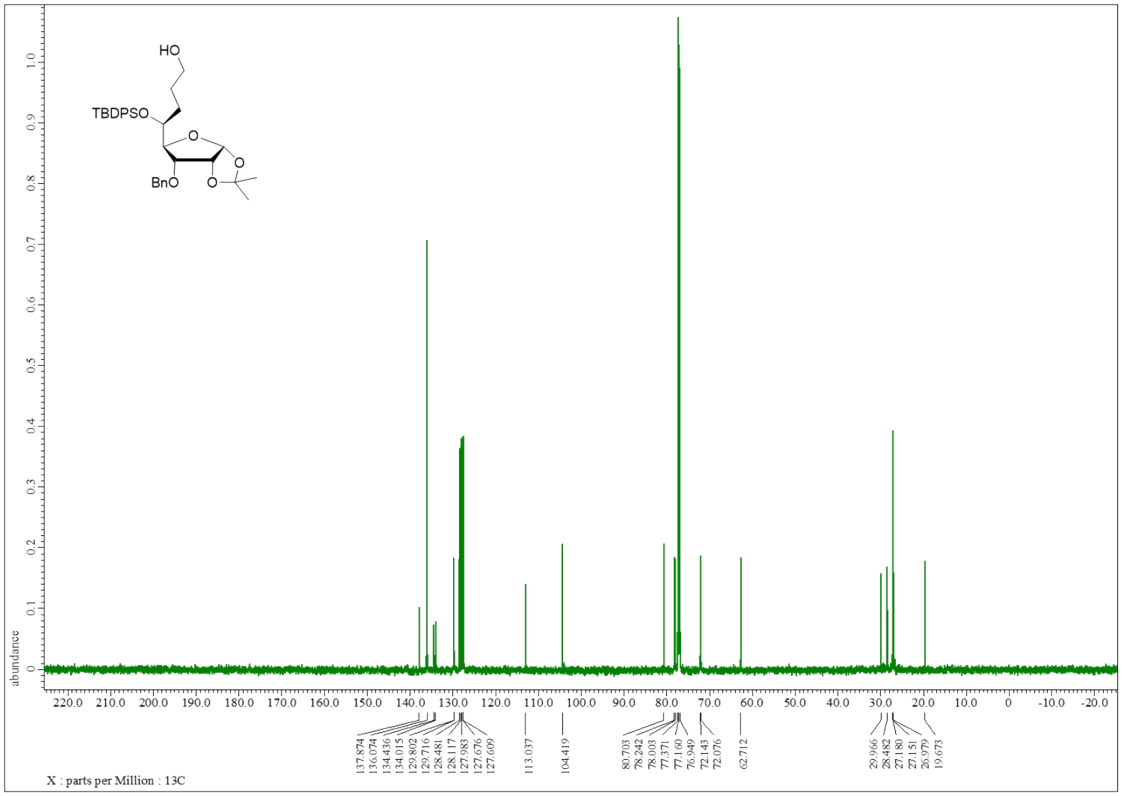
^{13}C{^{1}H}NMR spectrum of compound **8**



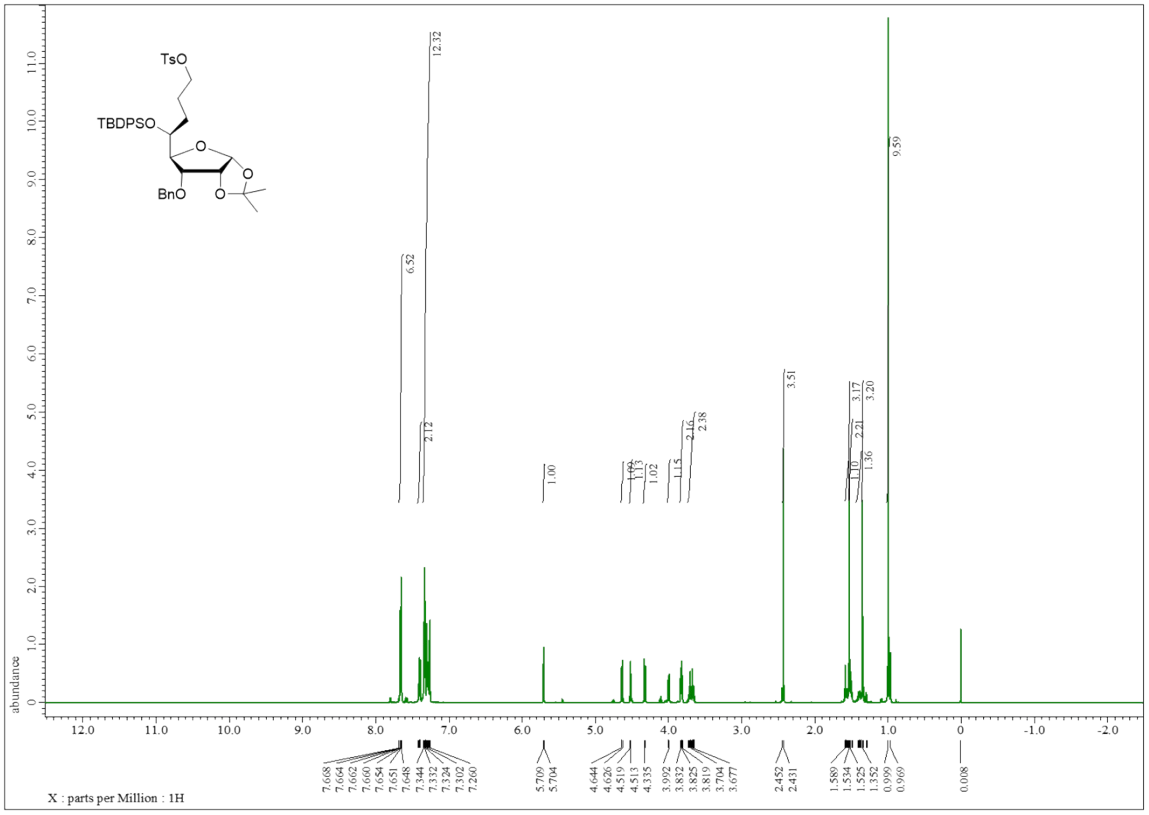
^{1}H NMR spectrum of compound **9**



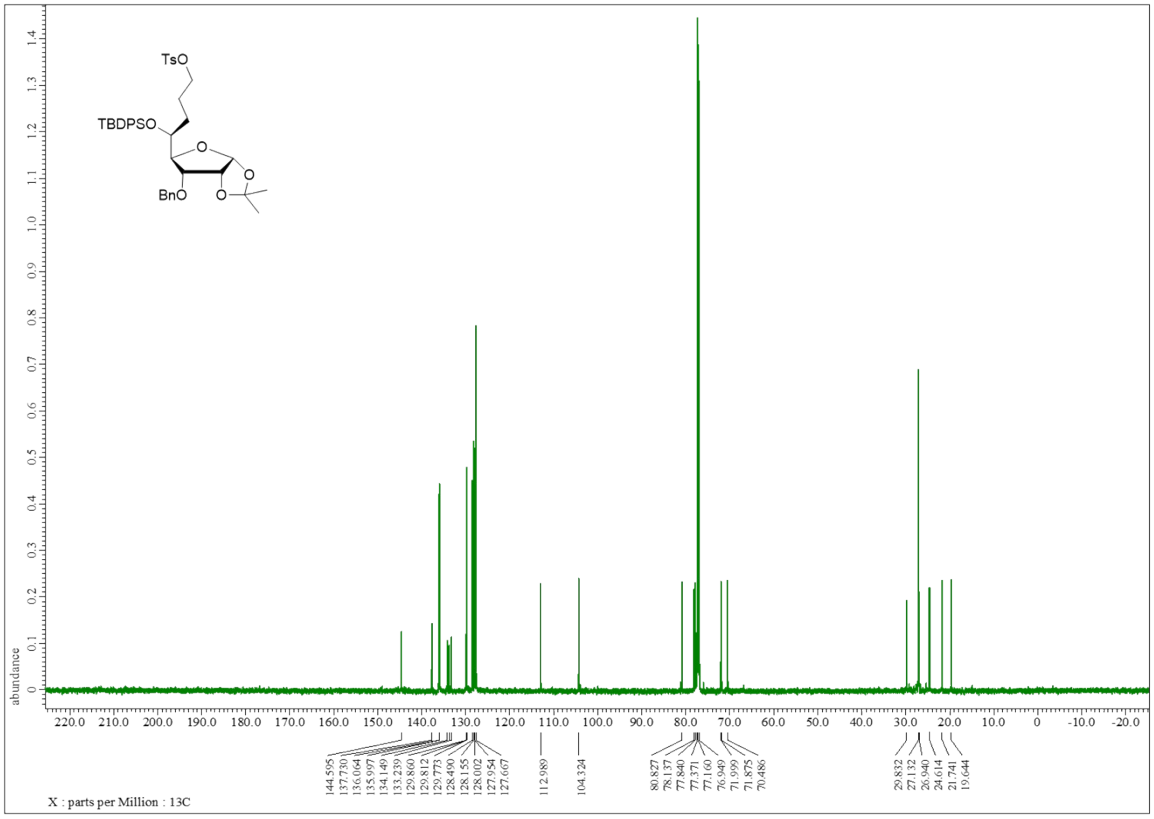
^{13}C{^{1}H}NMR spectrum of compound **9**



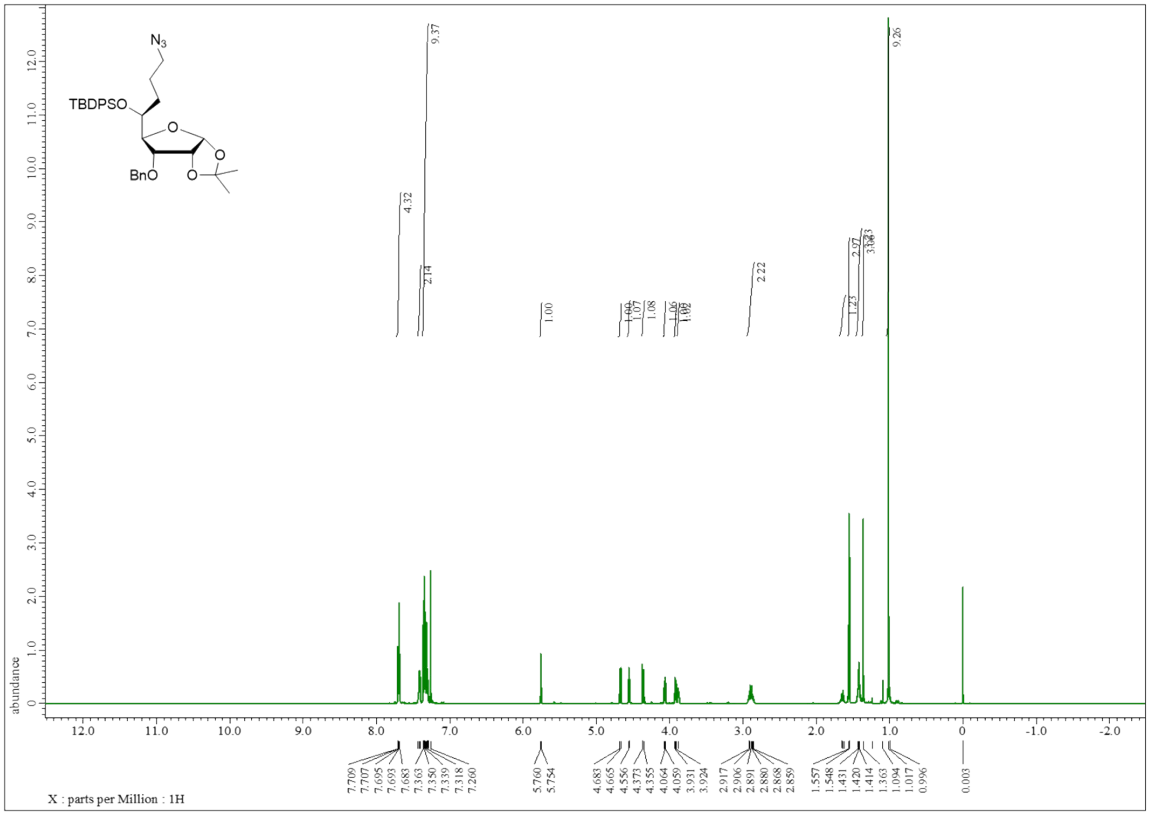
^{1}H NMR spectrum of compound **10**



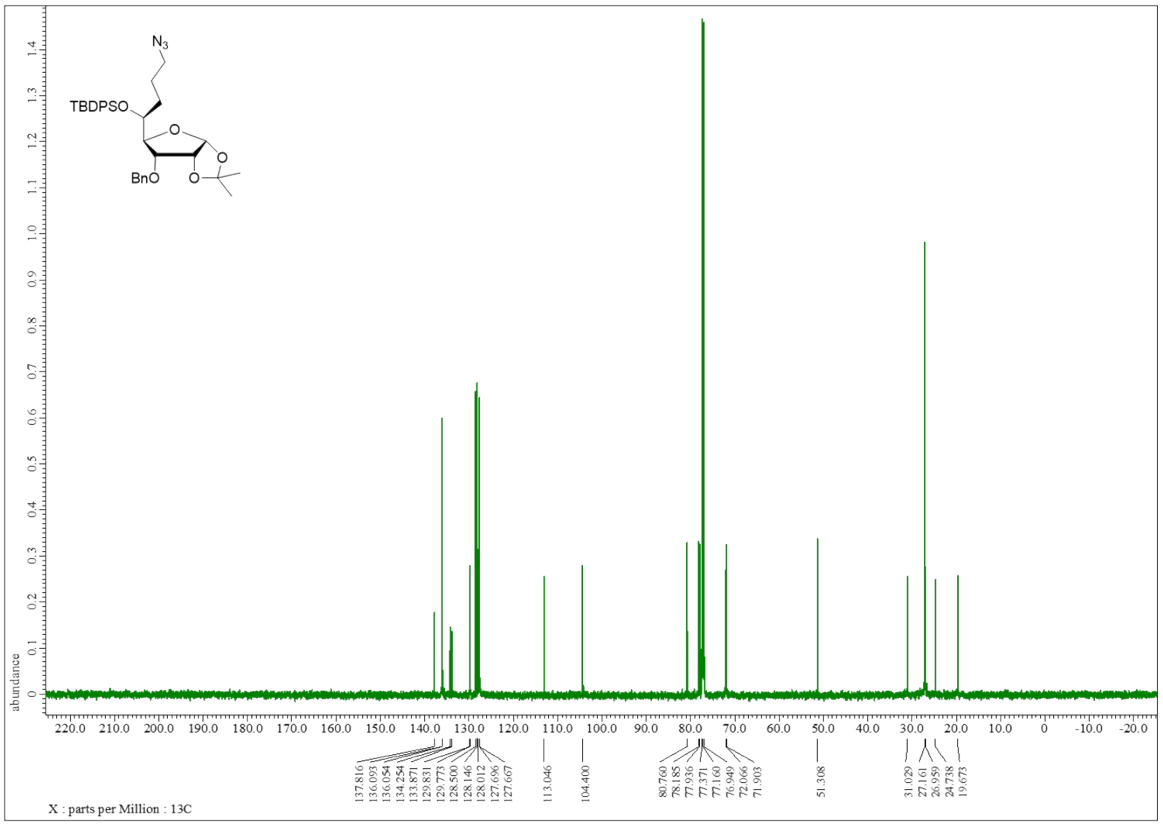
^{13}C{^{1}H}NMR spectrum of compound **10**



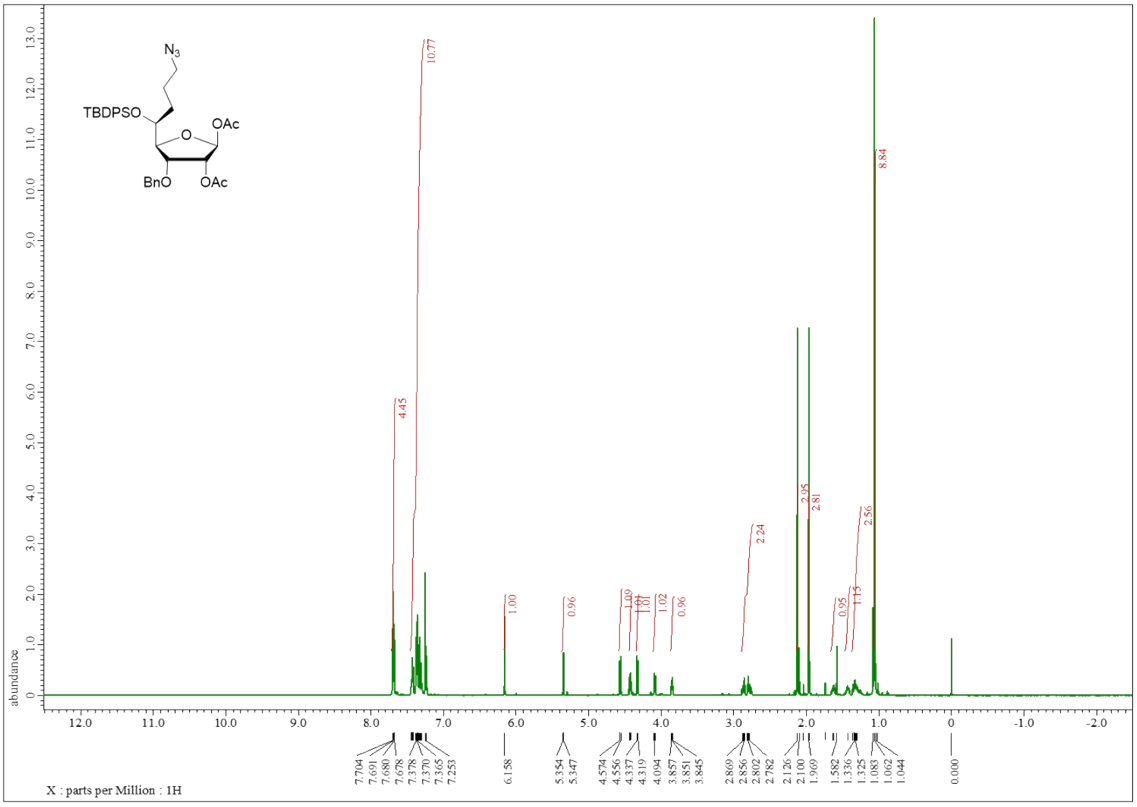
^{1}H NMR spectrum of compound **11**



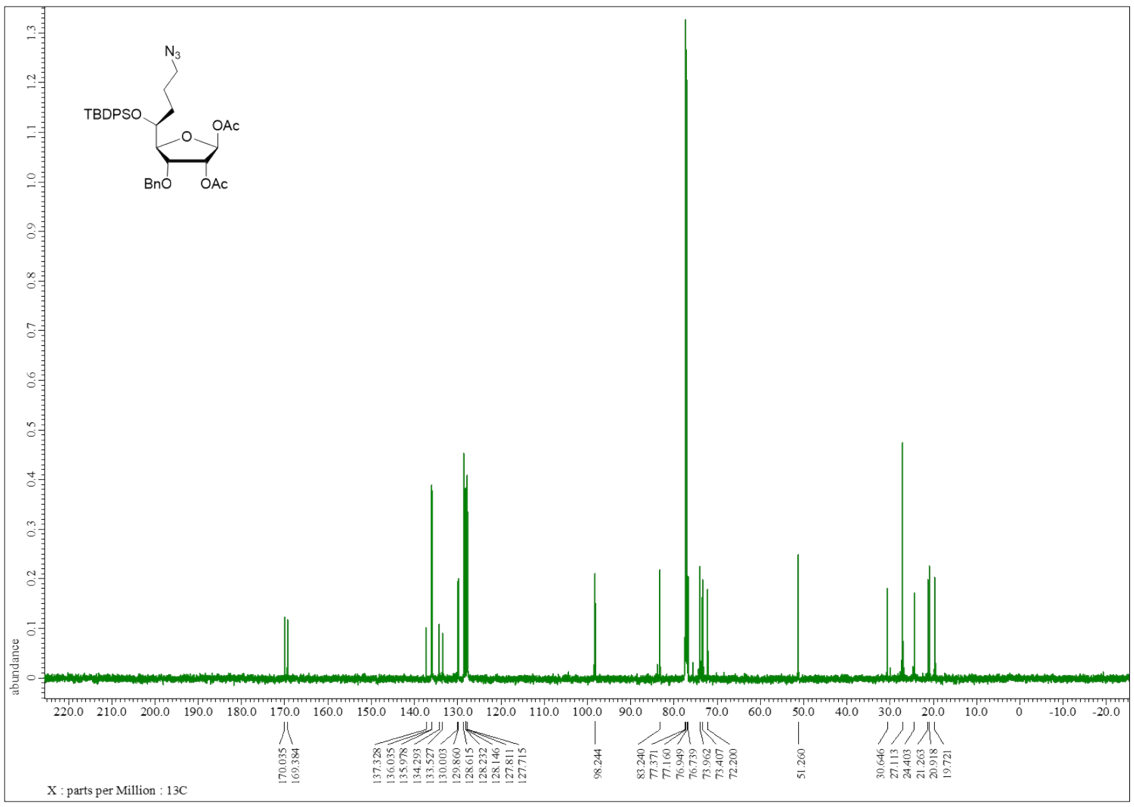
^{13}C{^{1}H}NMR spectrum of compound **11**



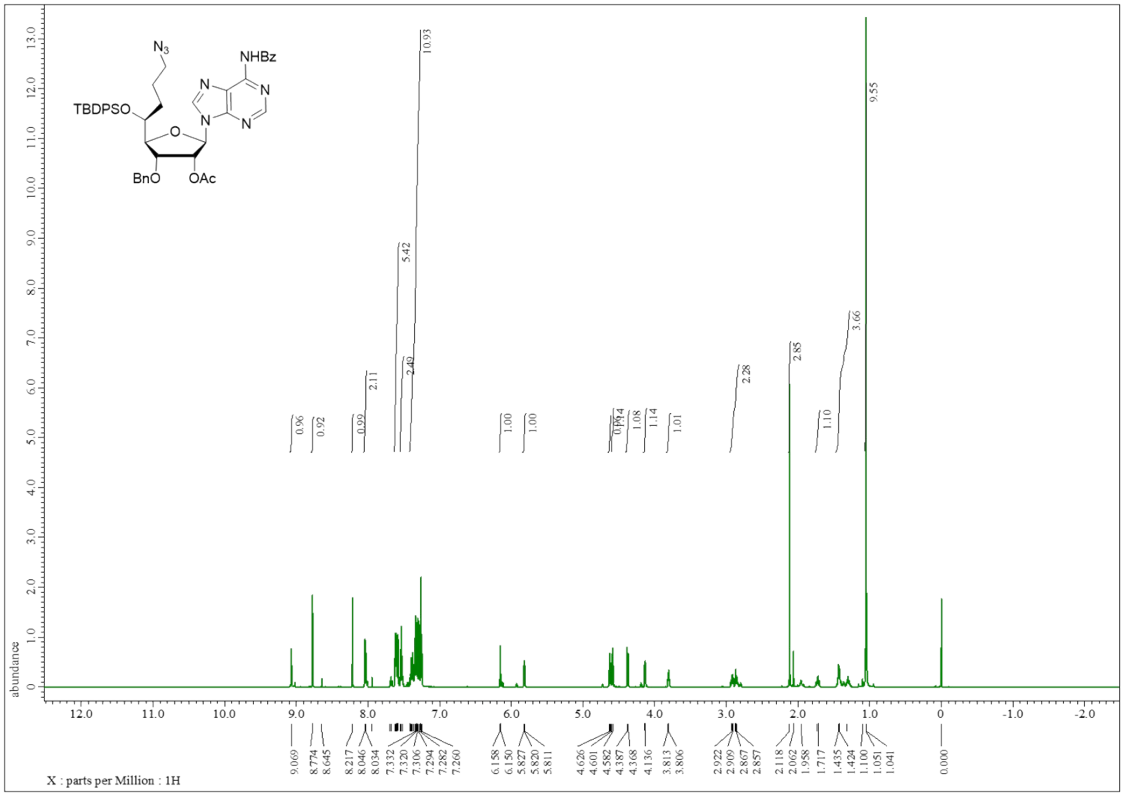
^{1}H NMR spectrum of compound **12** (β-anomer)



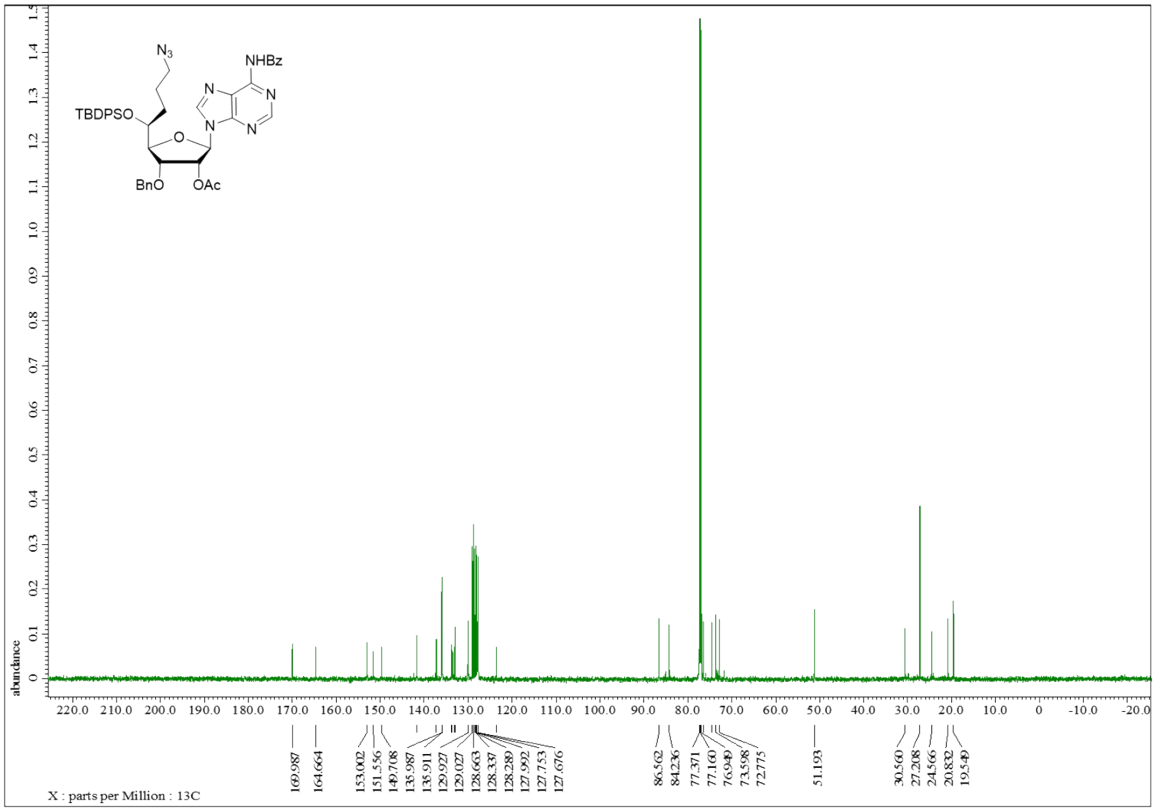
^{13}C{^{1}H}NMR spectrum of compound **12** (β-anomer)



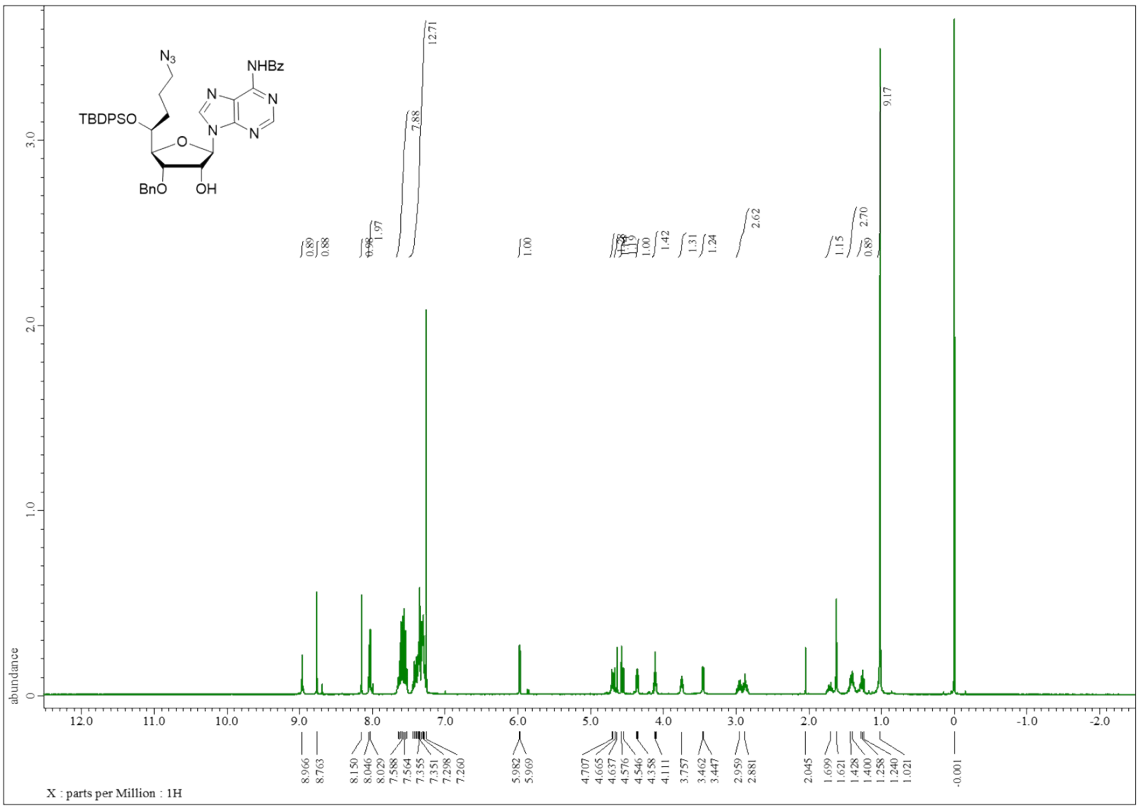
^{1}H NMR spectrum of compound **13**



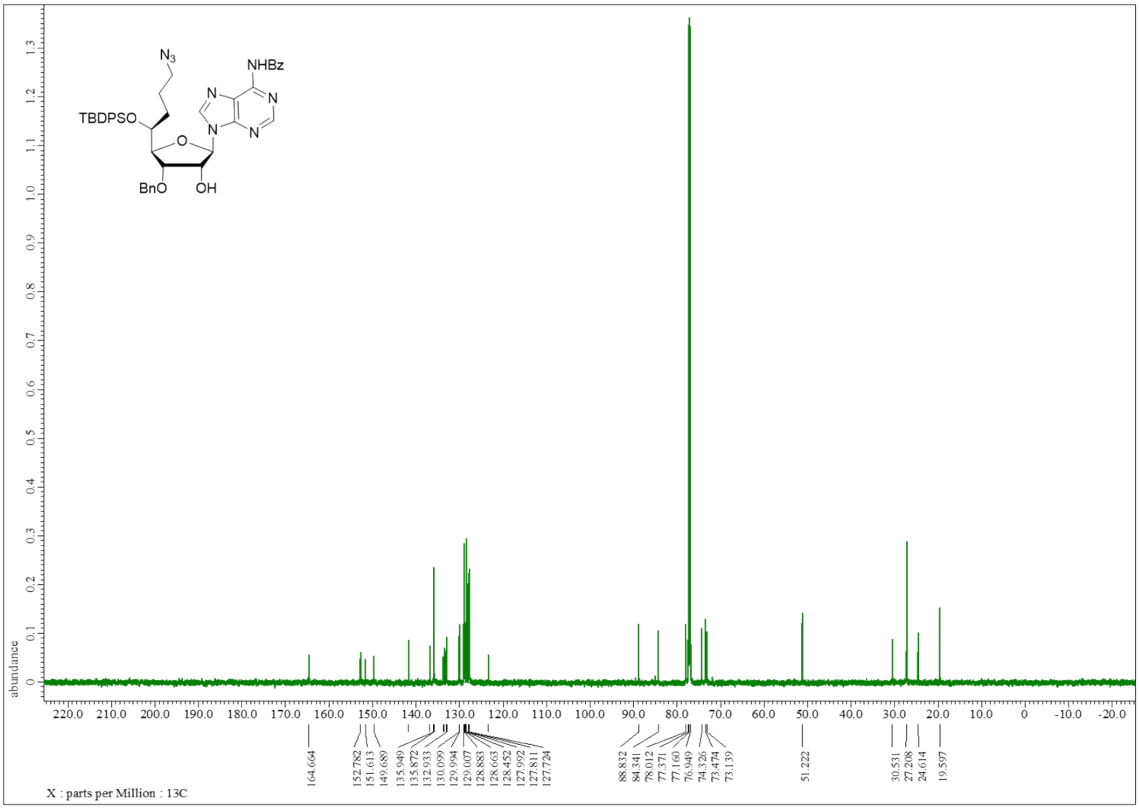
^{13}C{^{1}H}NMR spectrum of compound **13**



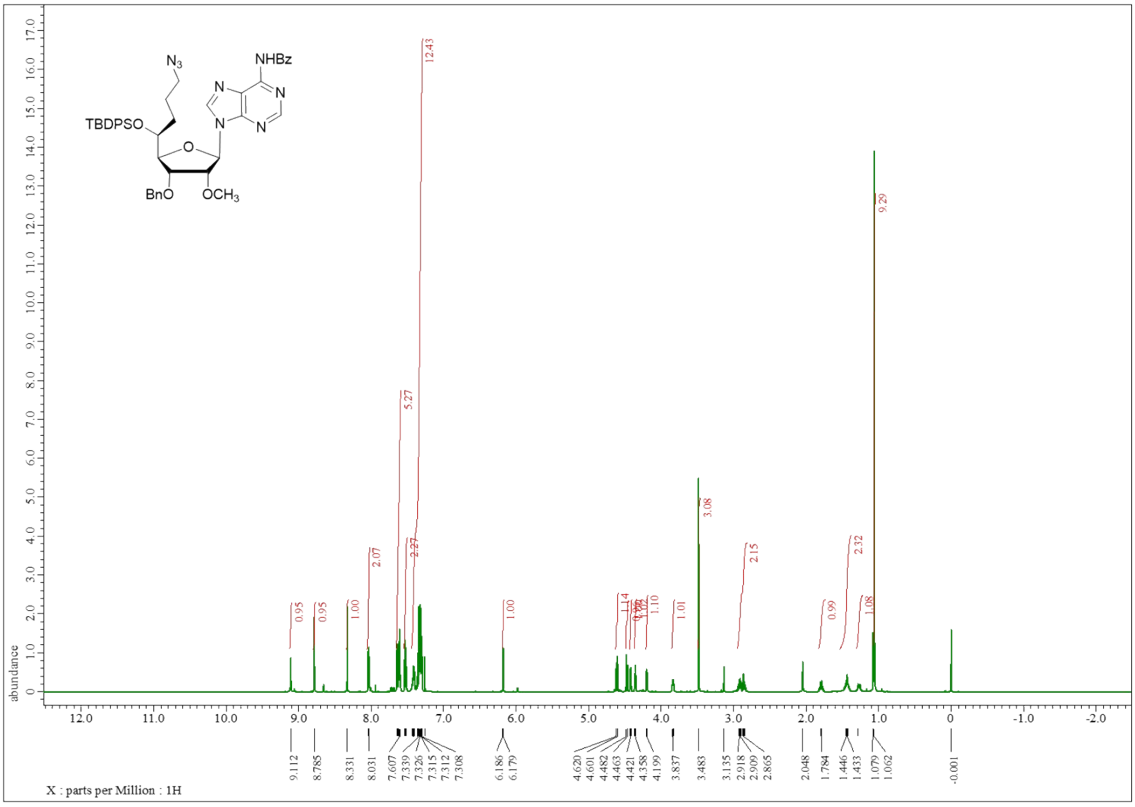
^{1}HNMR spectrum of compound **14**



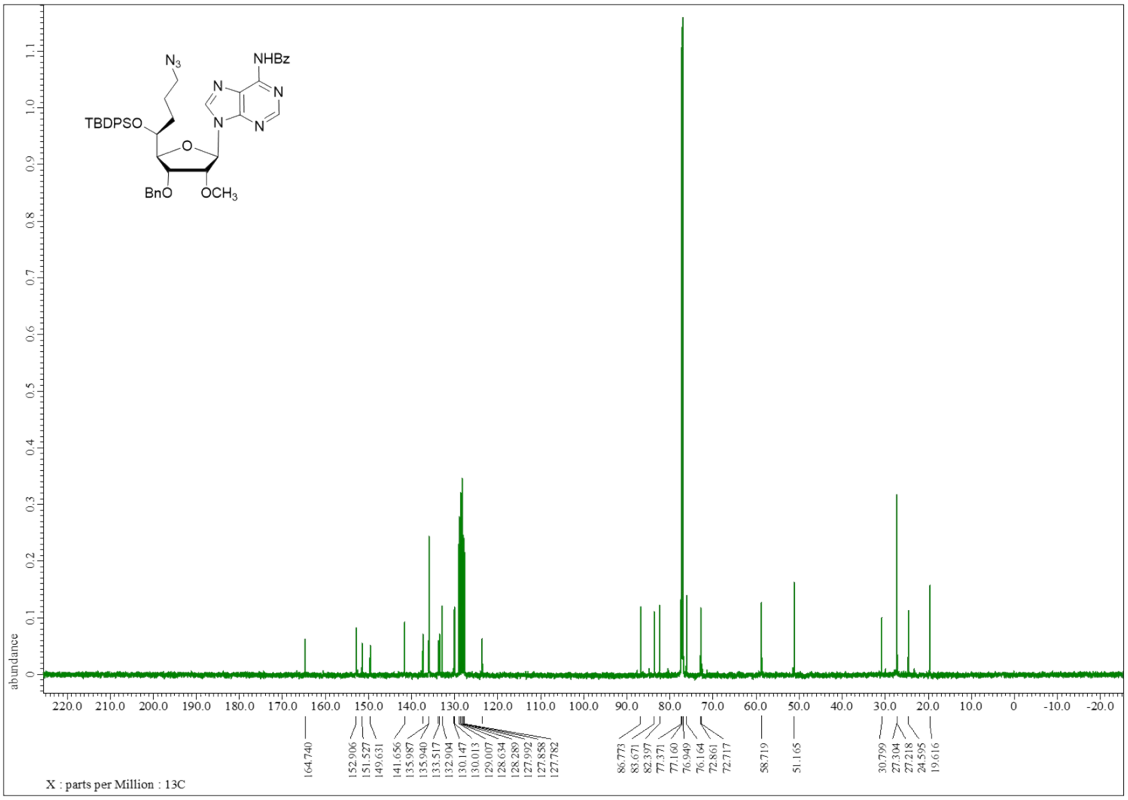
^{13}C{^{1}H}NMR spectrum of compound **14**



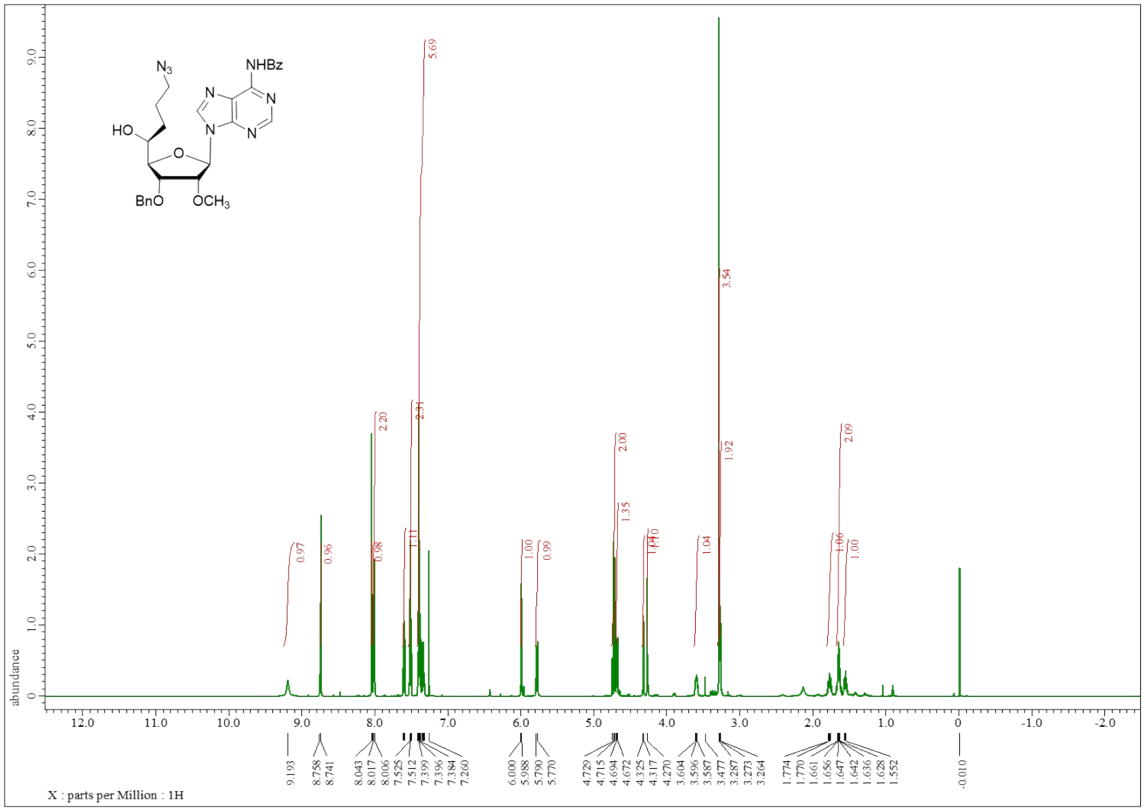
^{1}HNMR spectrum of compound **15**



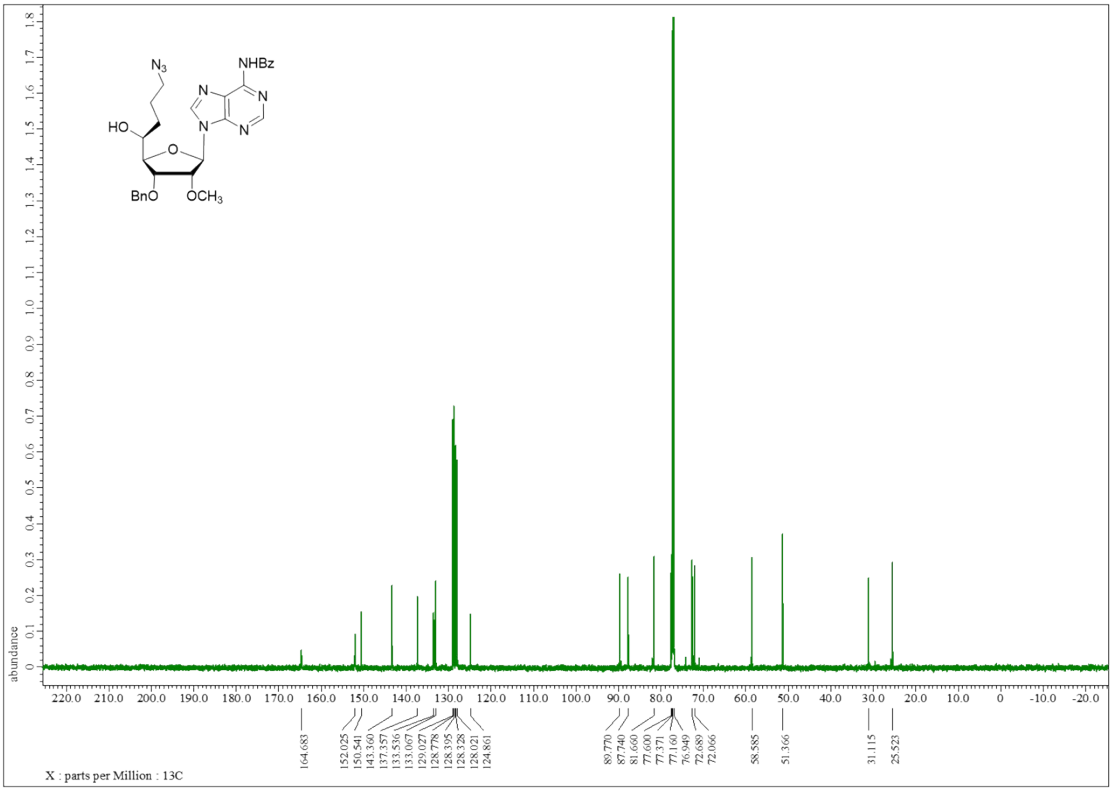
^{13}C{^{1}H}NMR spectrum of compound **15**



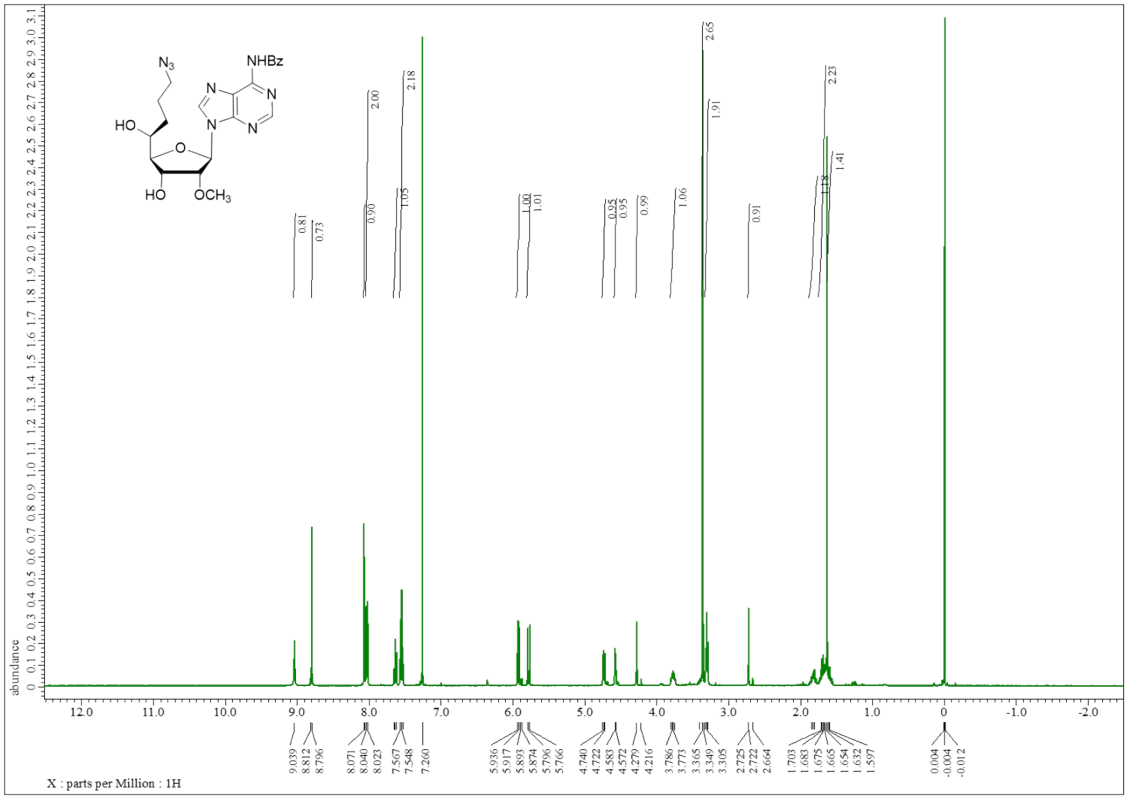
^{1}H NMR spectrum of compound **16**



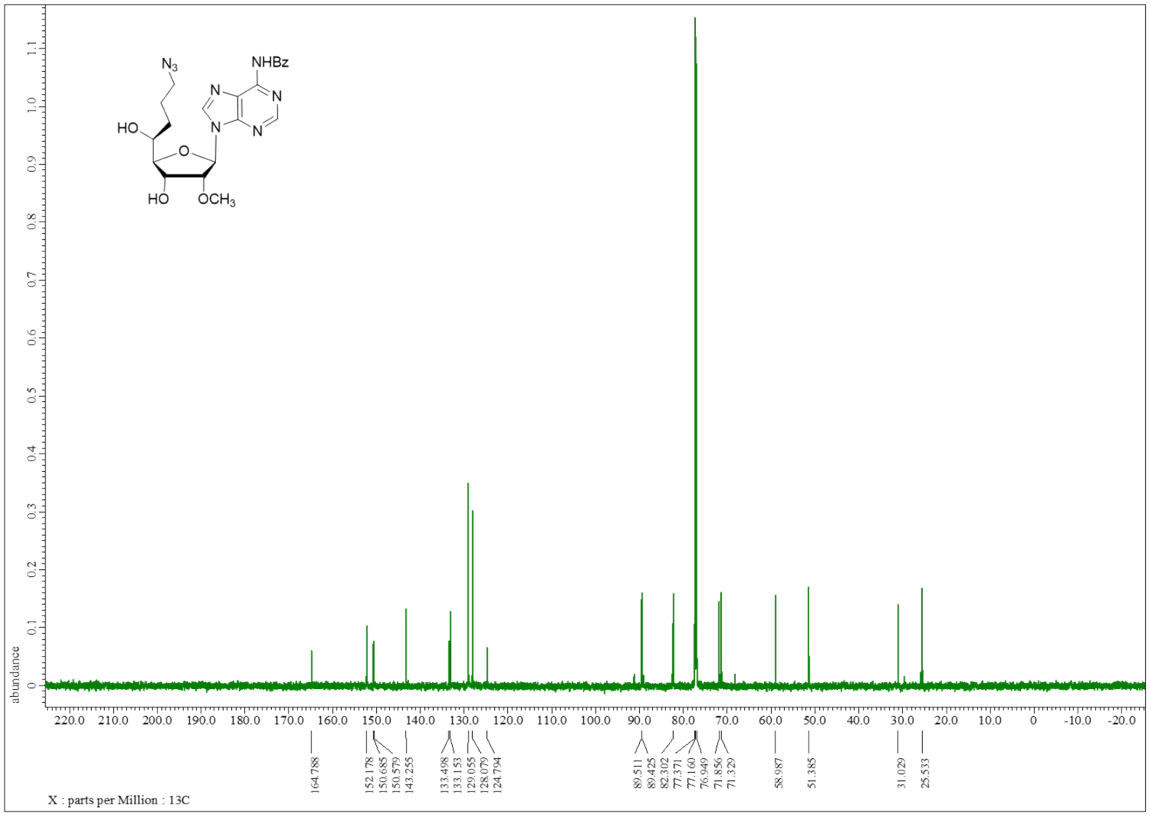
^{13}C{^{1}H}NMR spectrum of compound **16**



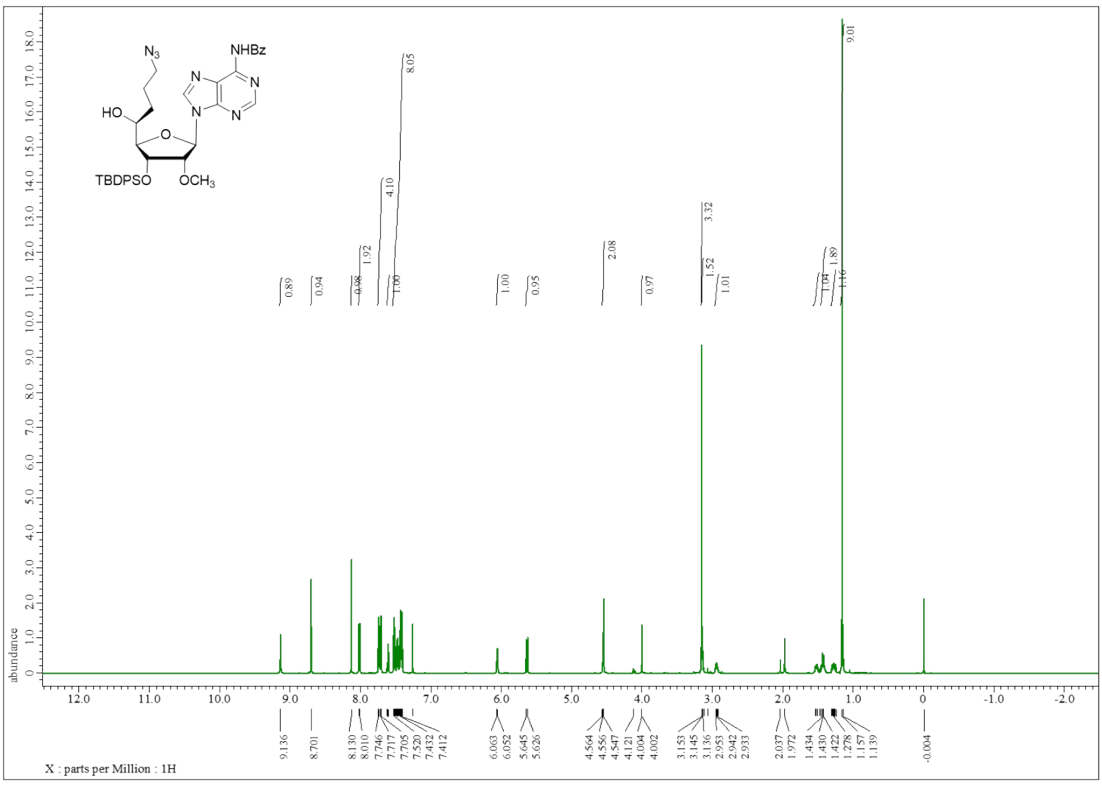
^{1}H NMR spectrum of compound **17**



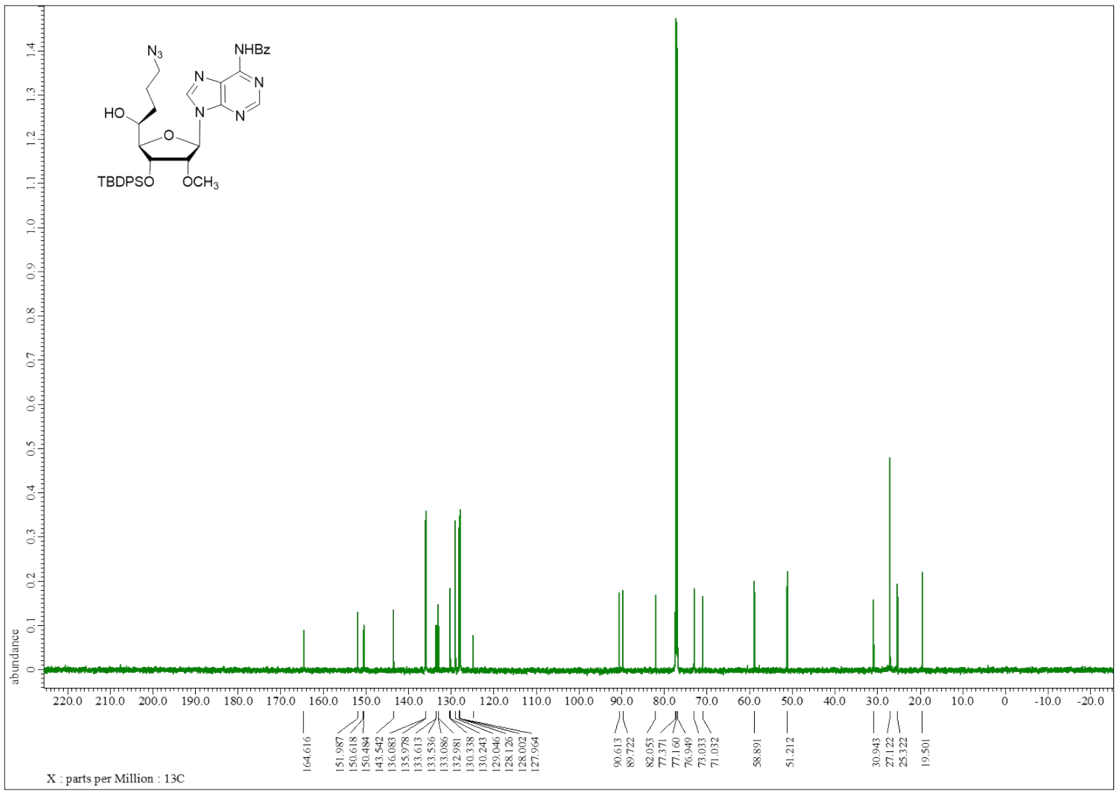
^{13}C{^{1}H}NMR spectrum of compound **17**



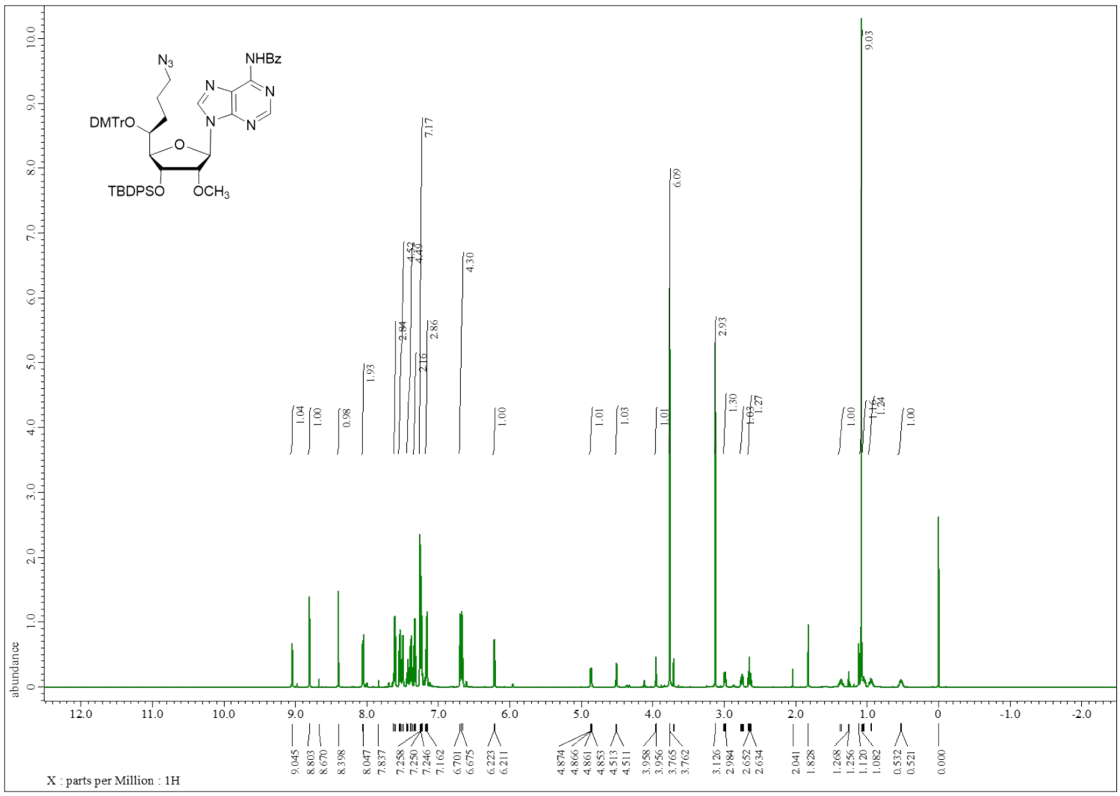
^{1}H NMR spectrum of compound **18**



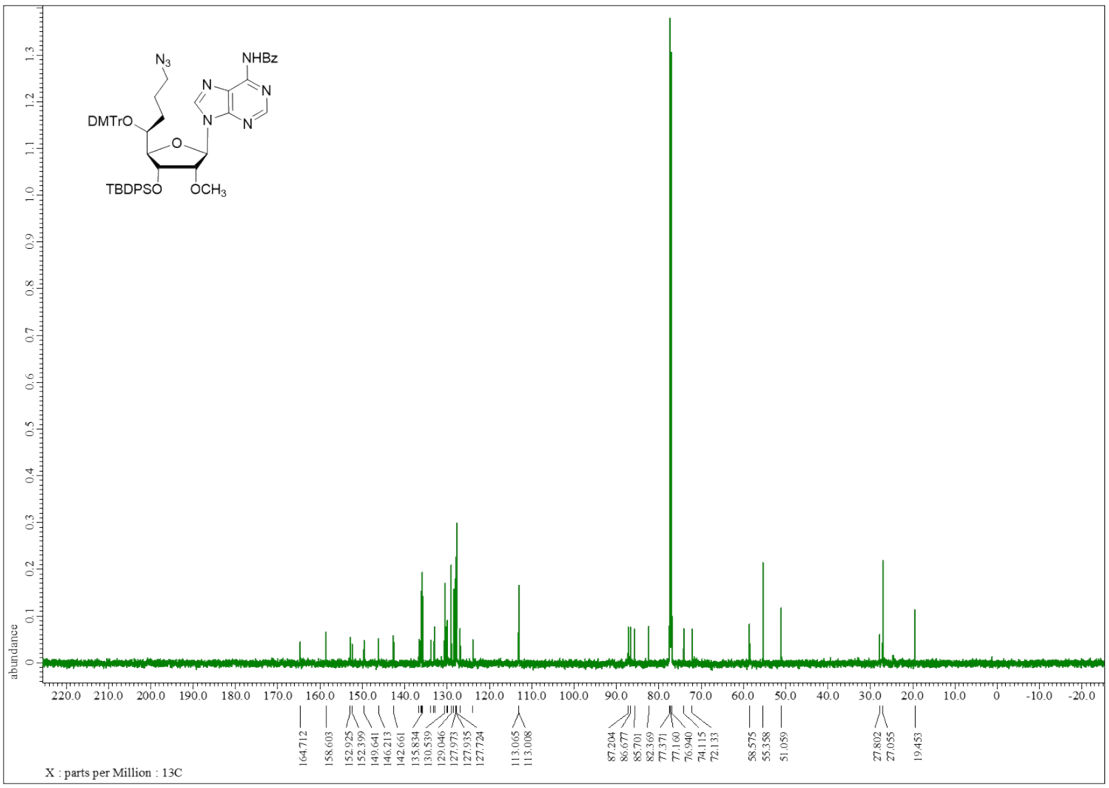
^{13}C{^{1}H}NMR spectrum of compound **18**



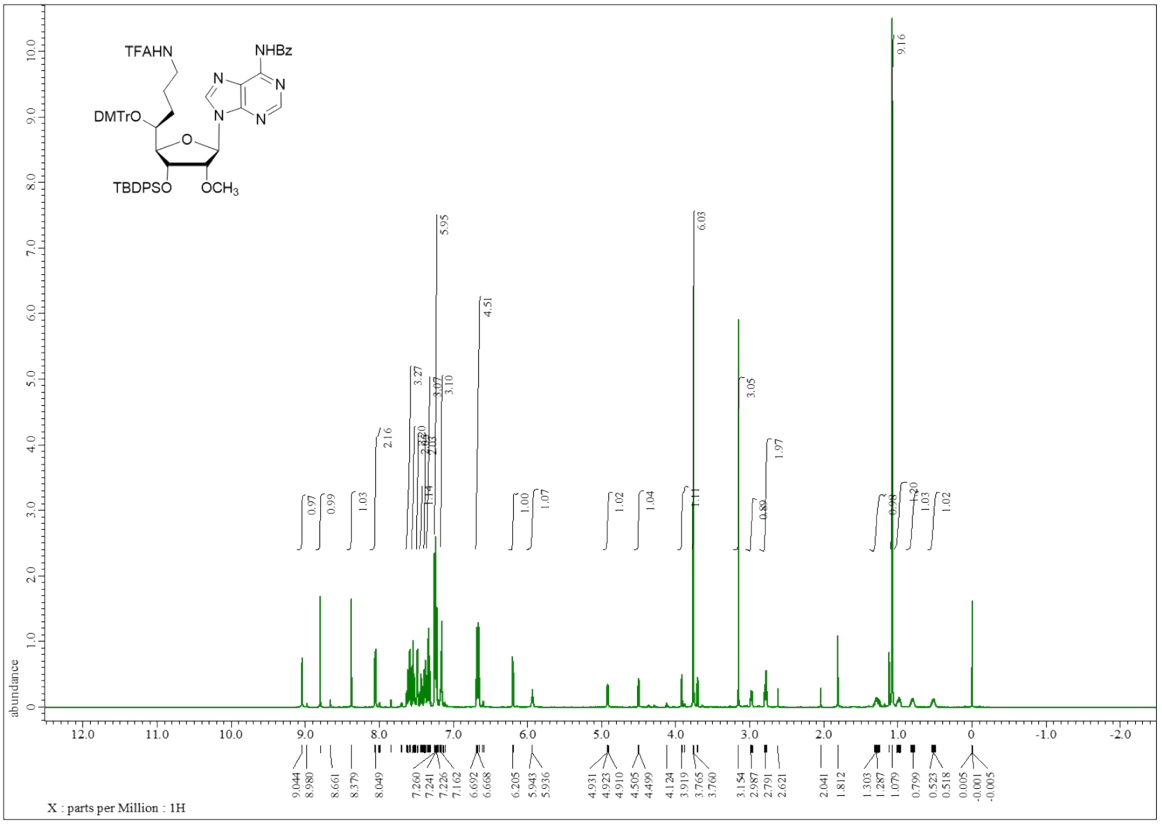
^{1}H NMR spectrum of compound **19**



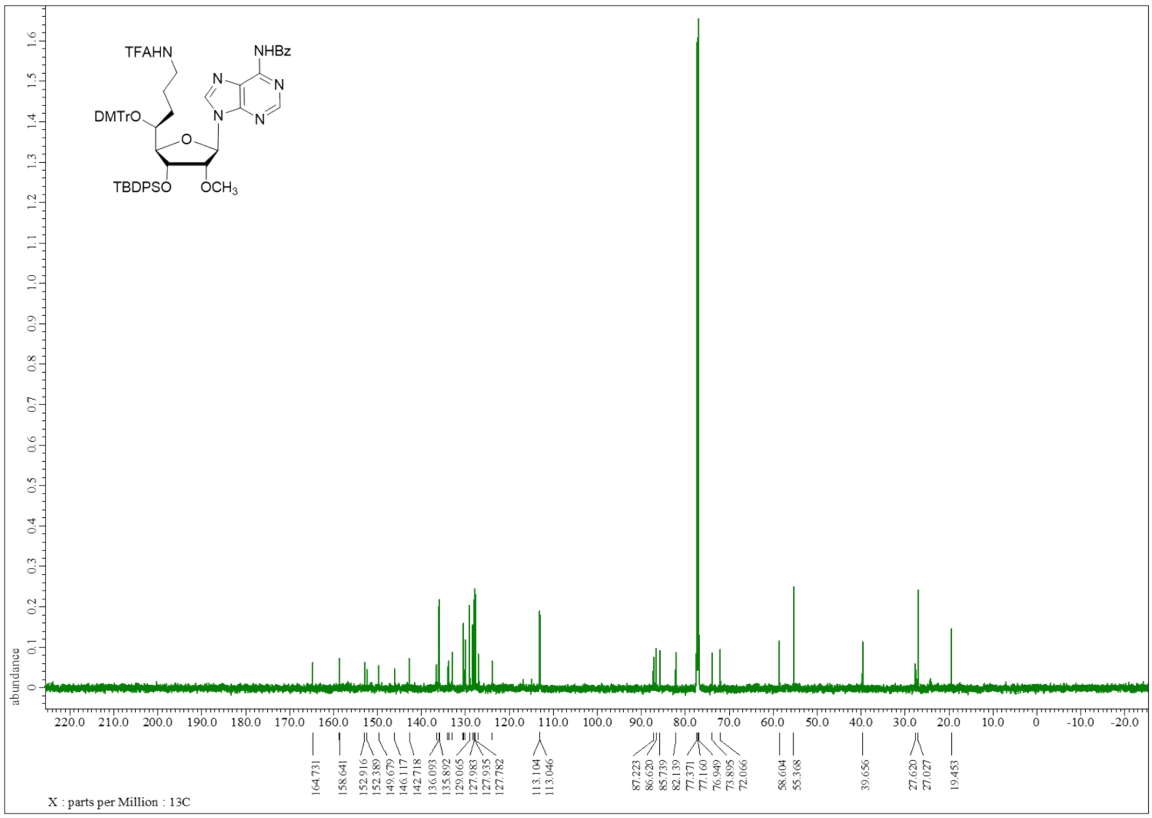
^{113}C{^{1}H}NMR spectrum of compound **19**



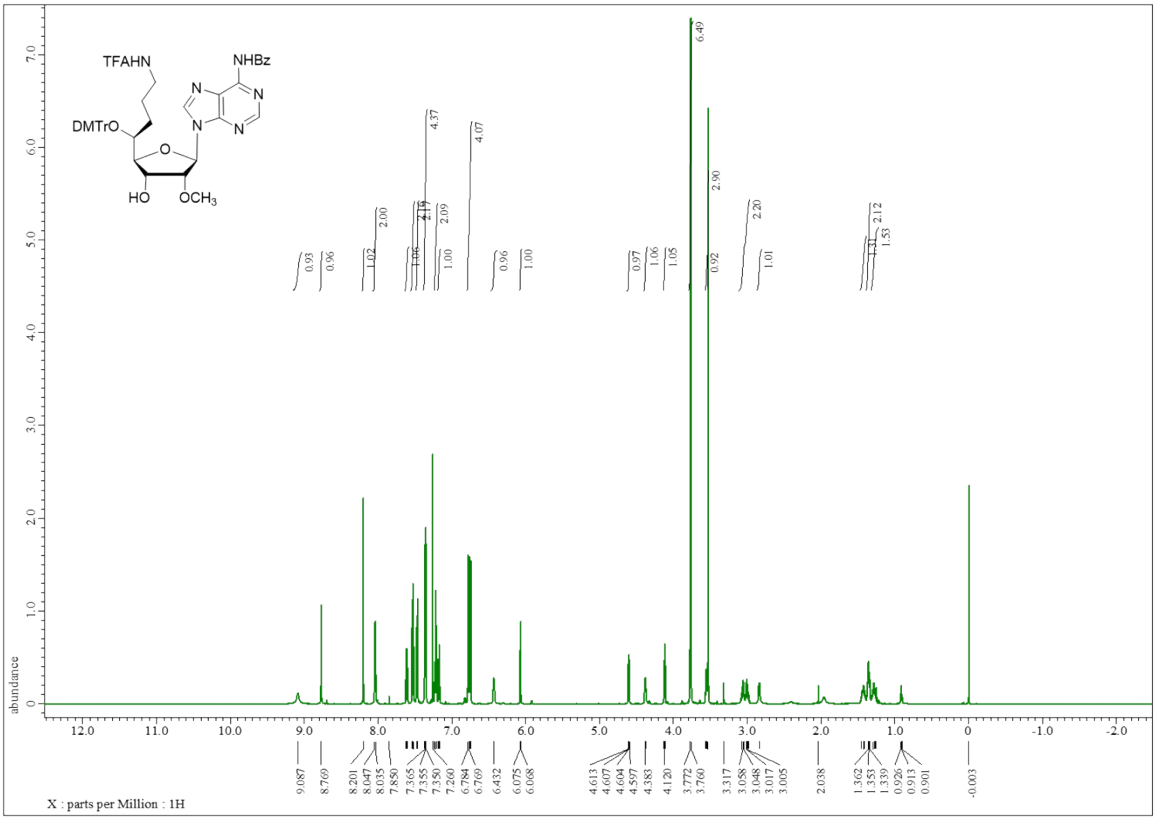
^{1}H NMR spectrum of compound **20**



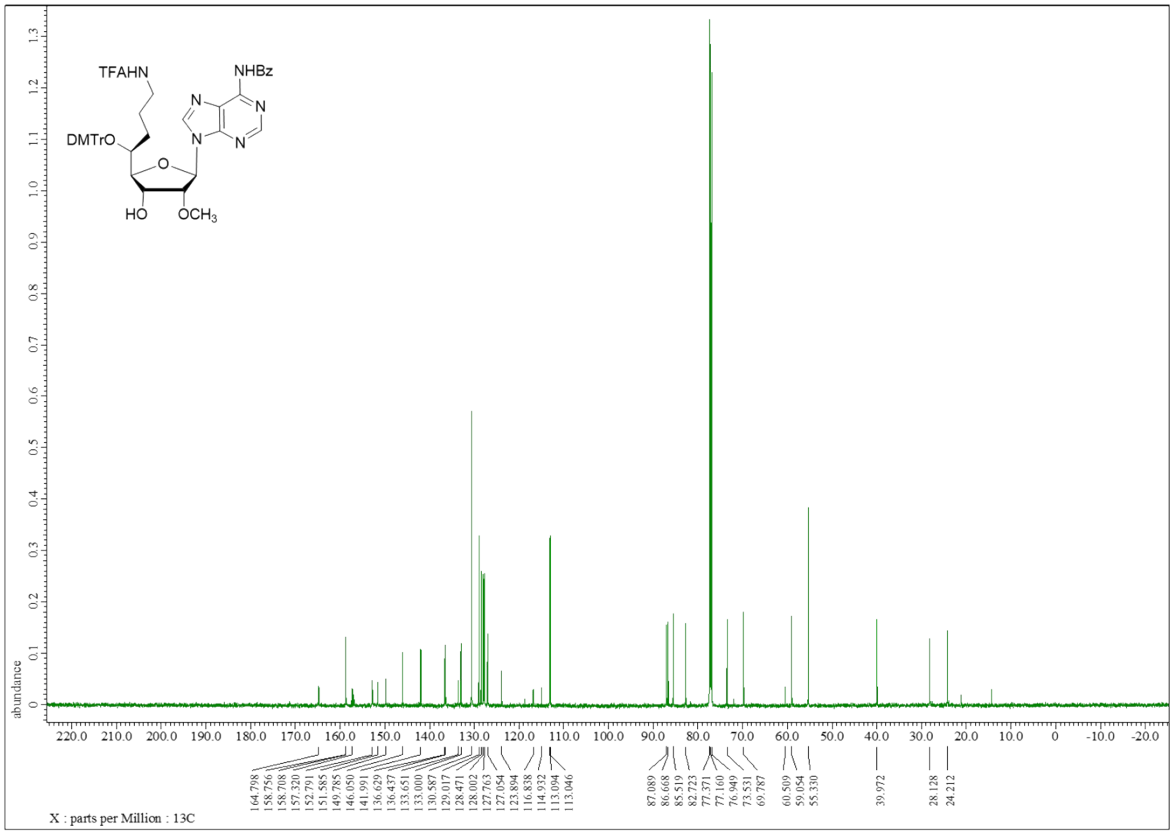
^{13}C{^{1}H}NMR spectrum of compound **20**



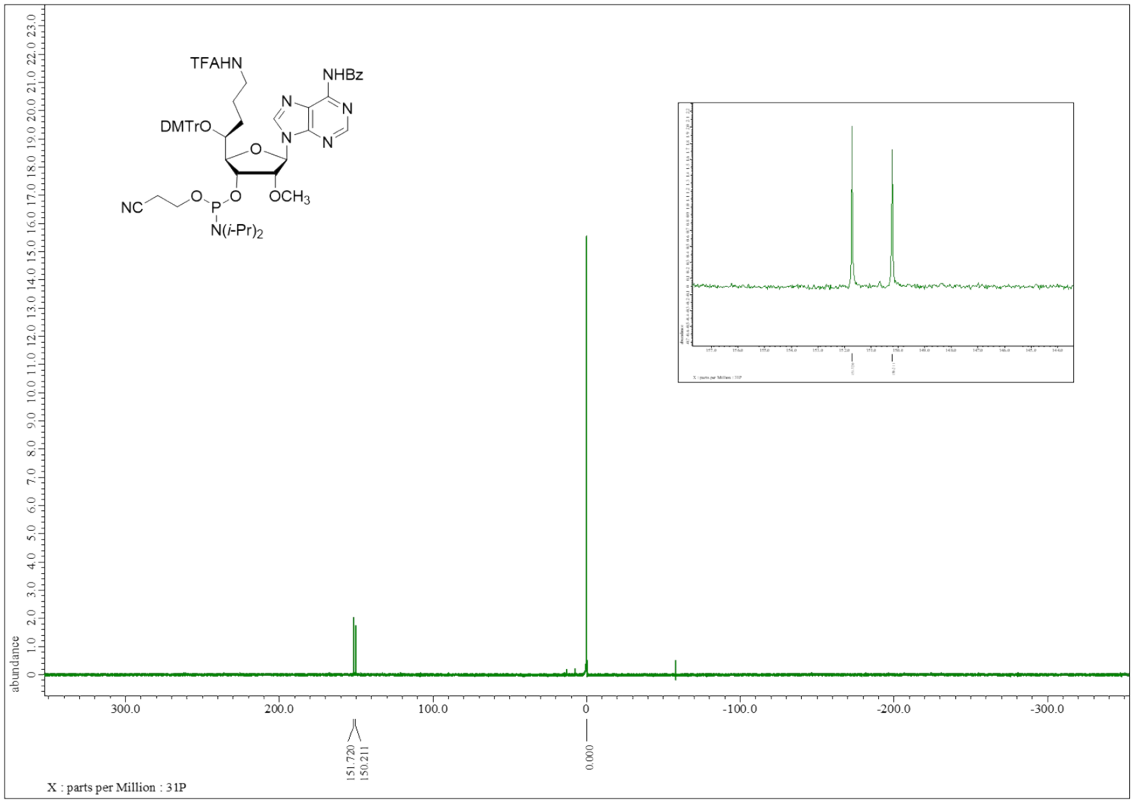
^{1}H NMR spectrum of compound **21**



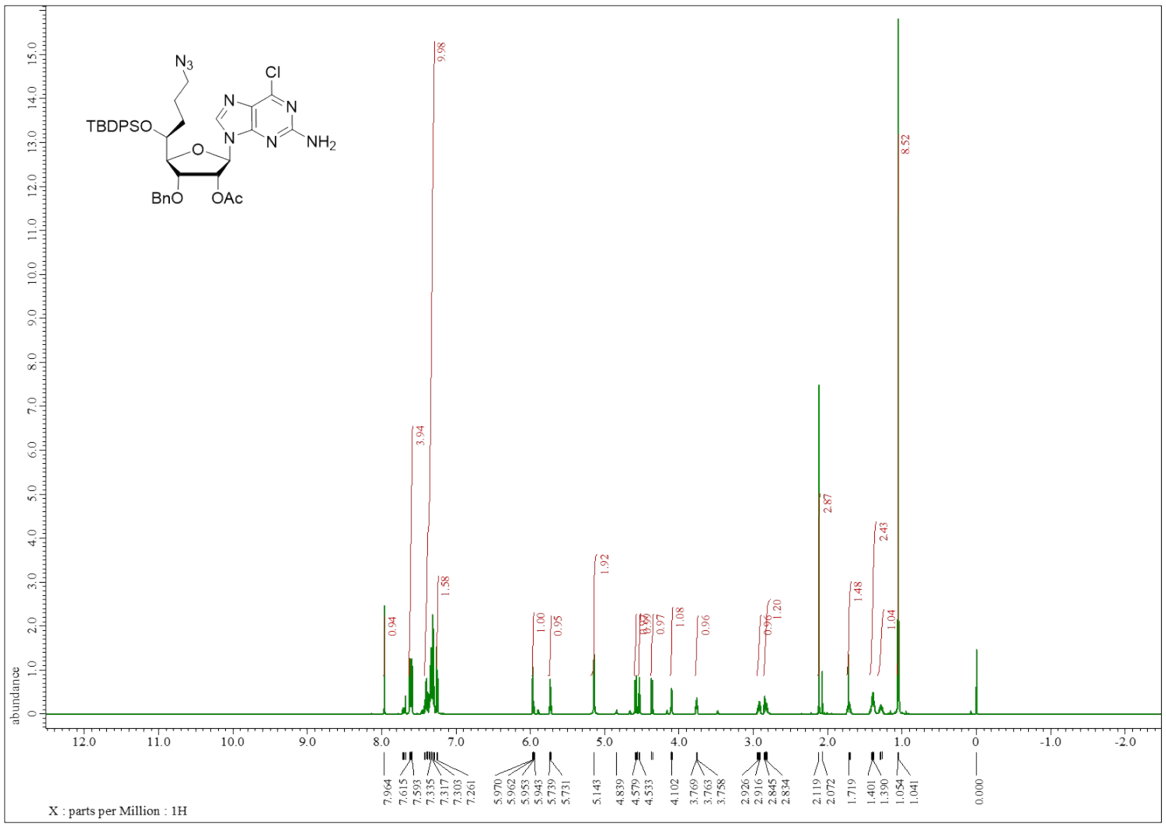
^{13}C{^{1}H}NMR spectrum of compound **21**



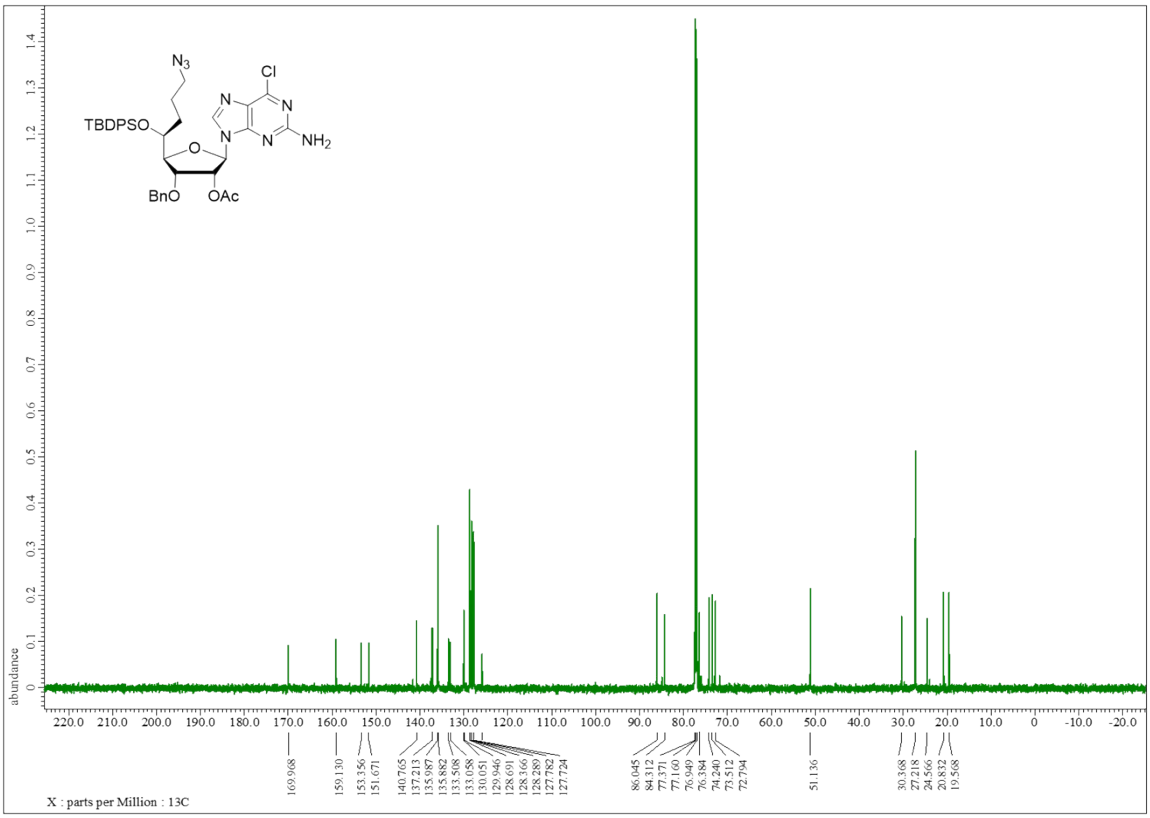
^{31}P NMR spectrum of compound **22**



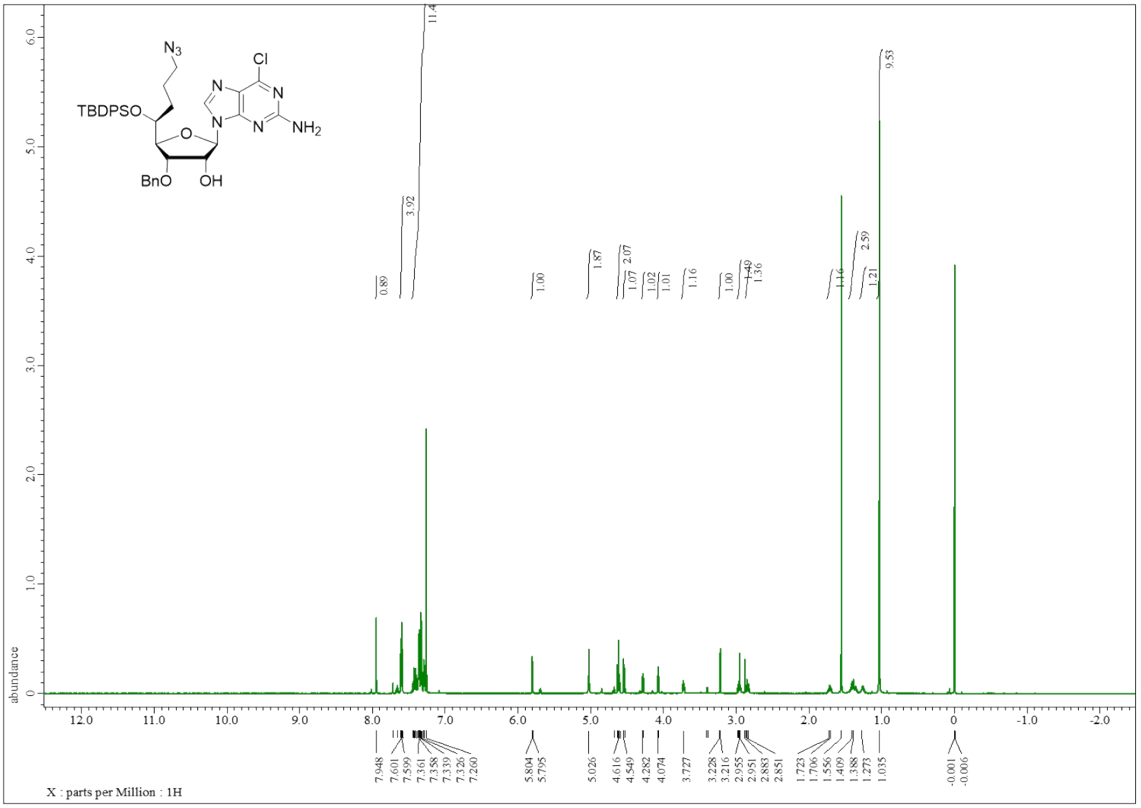
^{1}H NMR spectrum of compound **23**



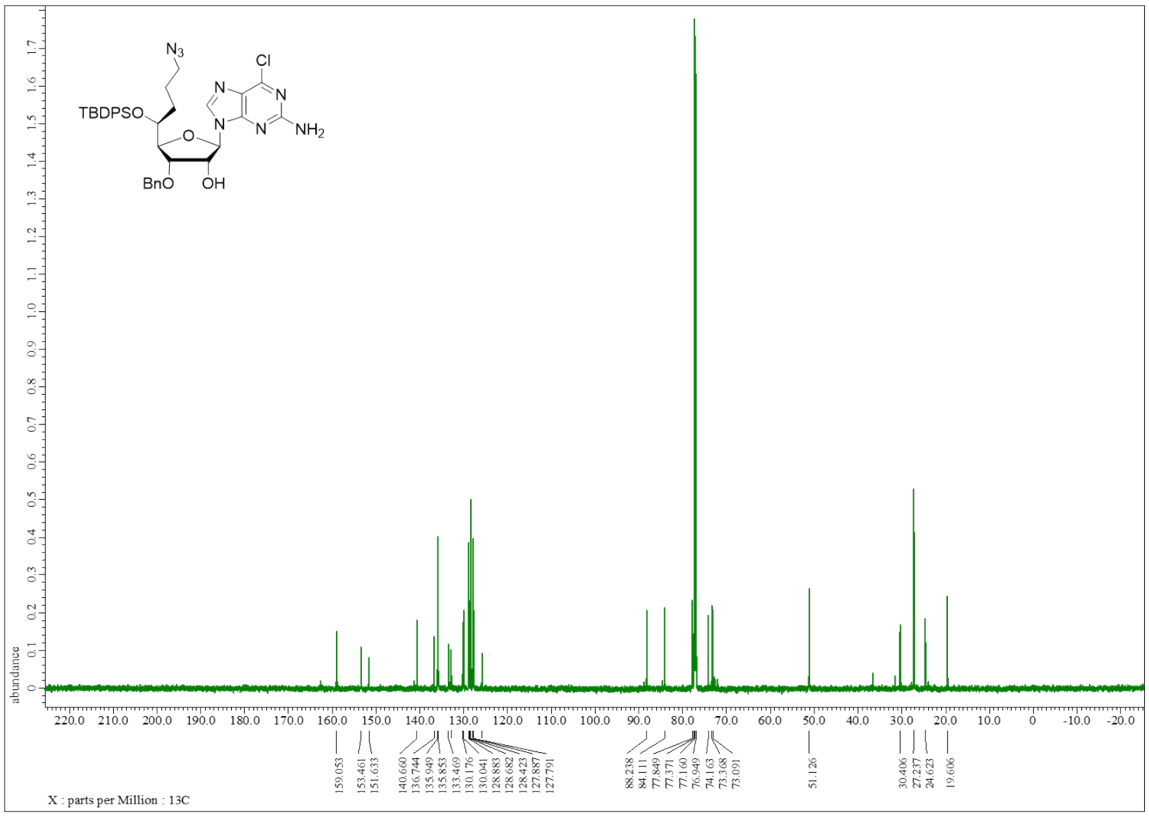
^{13}C{^{1}H}NMR spectrum of compound **23**



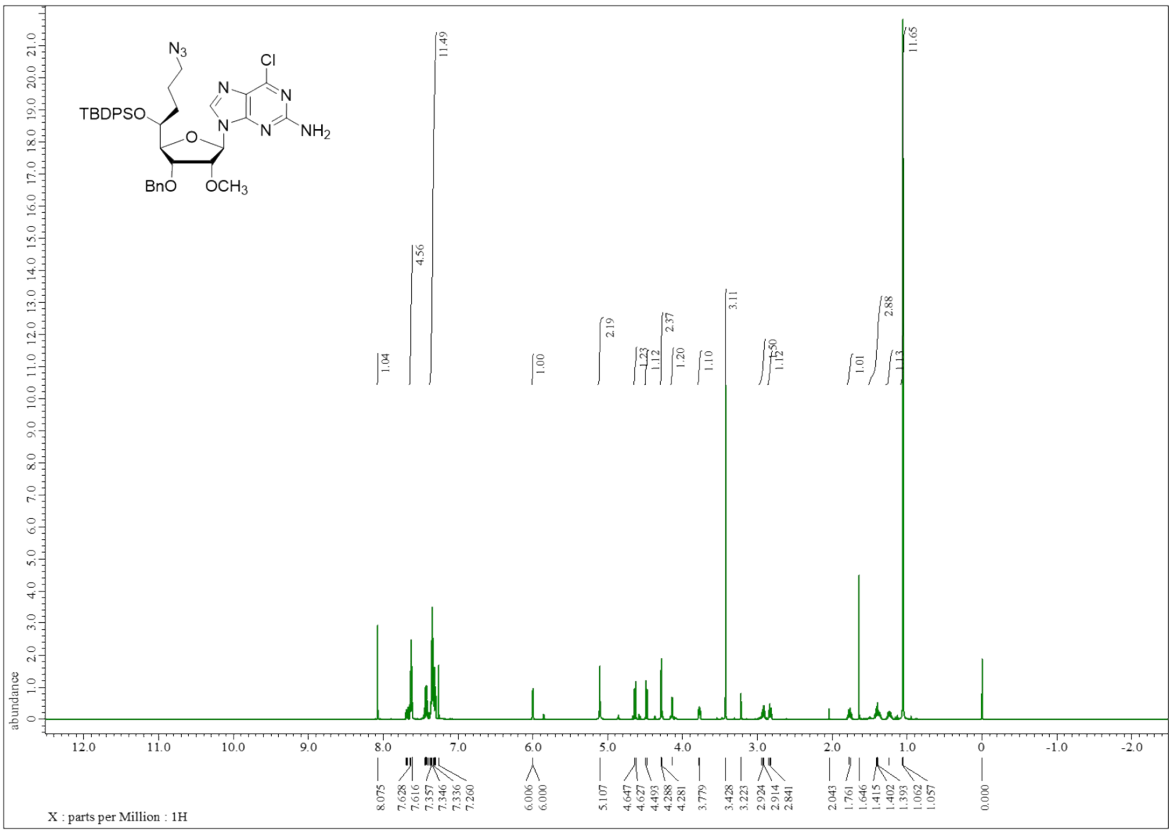
^{1}H NMR spectrum of compound **24**



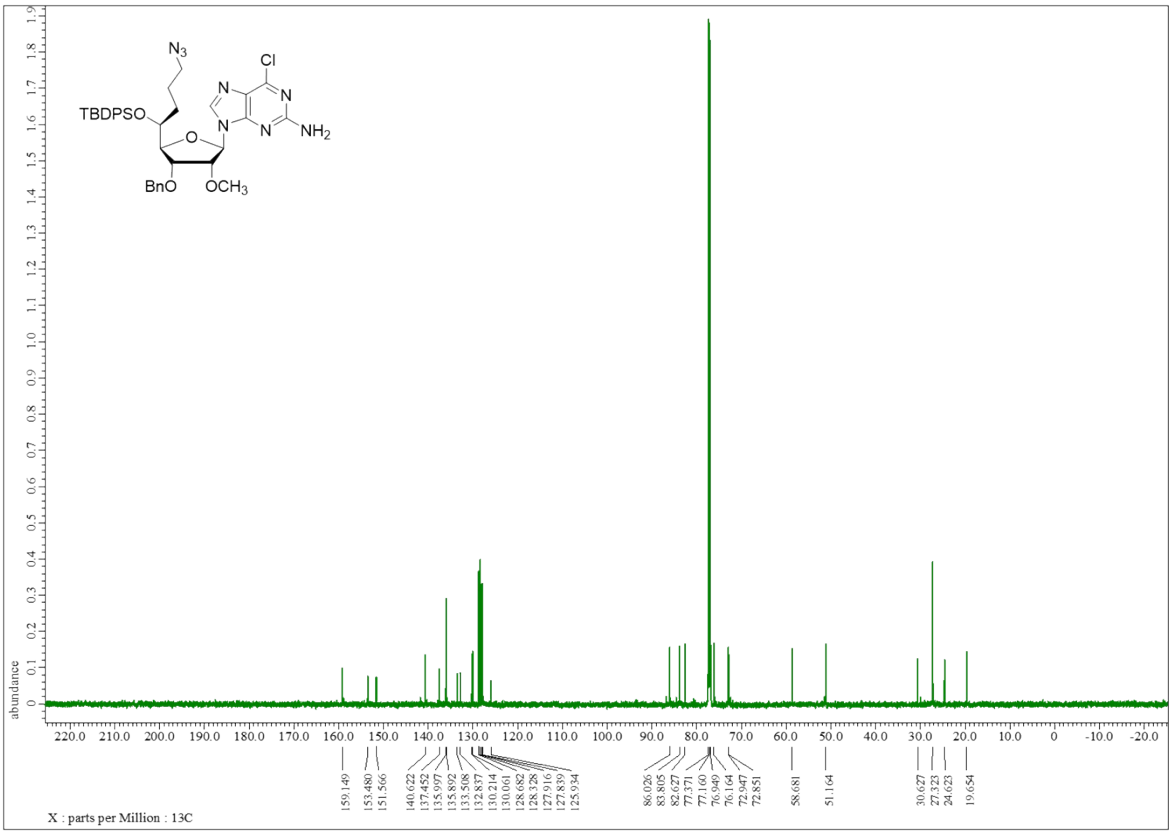
^{13}C{^{1}H}NMR spectrum of compound **24**



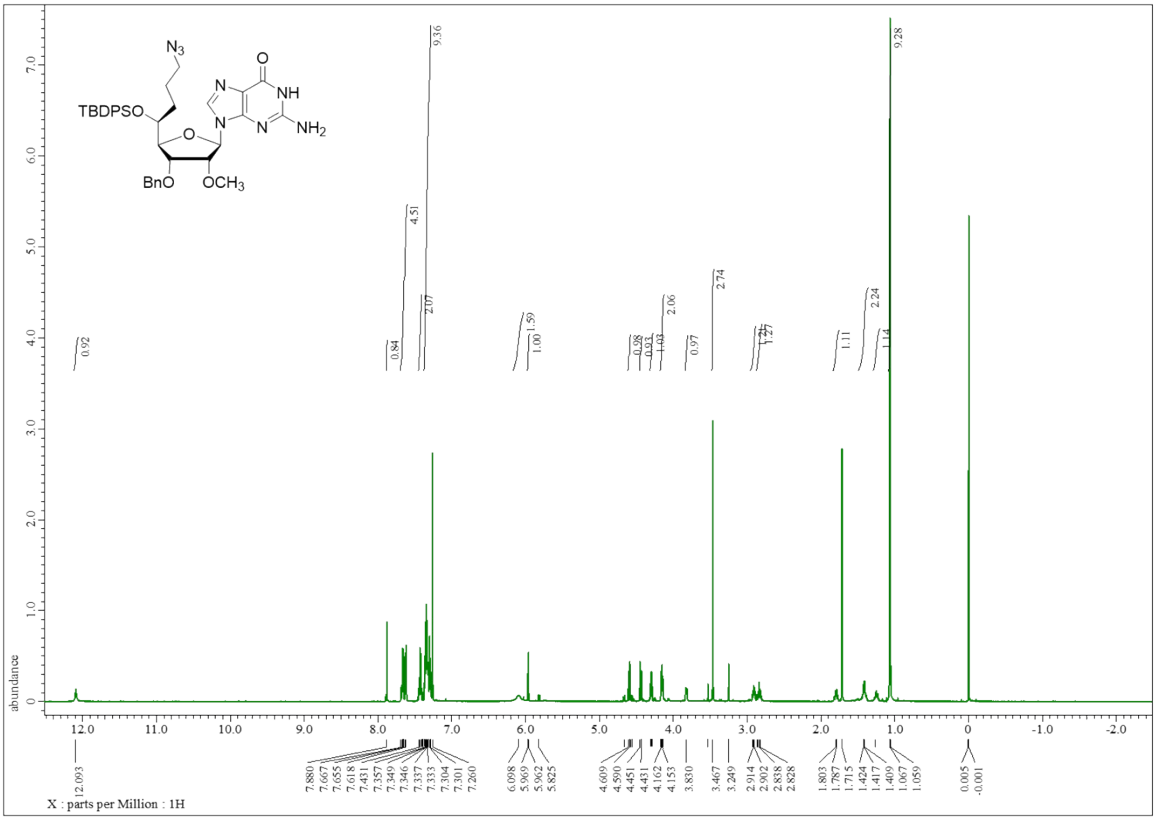
^{1}H NMR spectrum of compound **25**



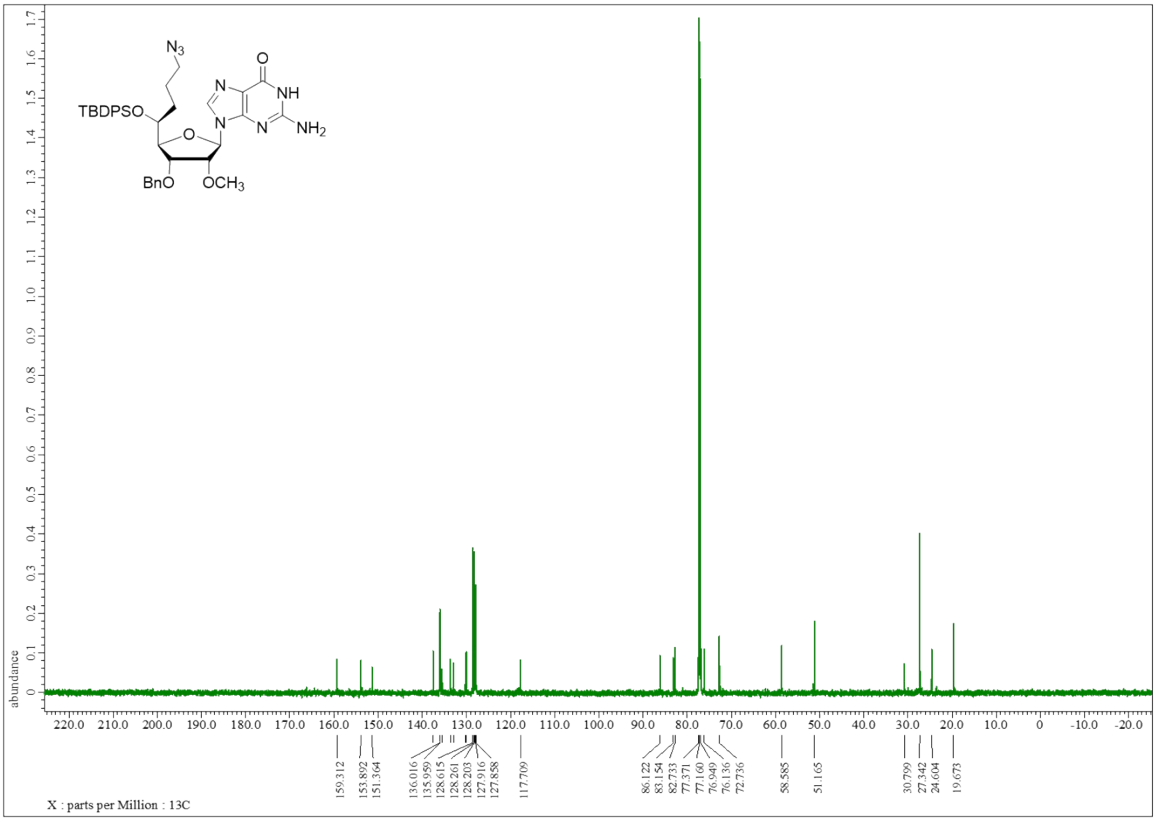
^{113}C{^{1}H}NMR spectrum of compound **25**



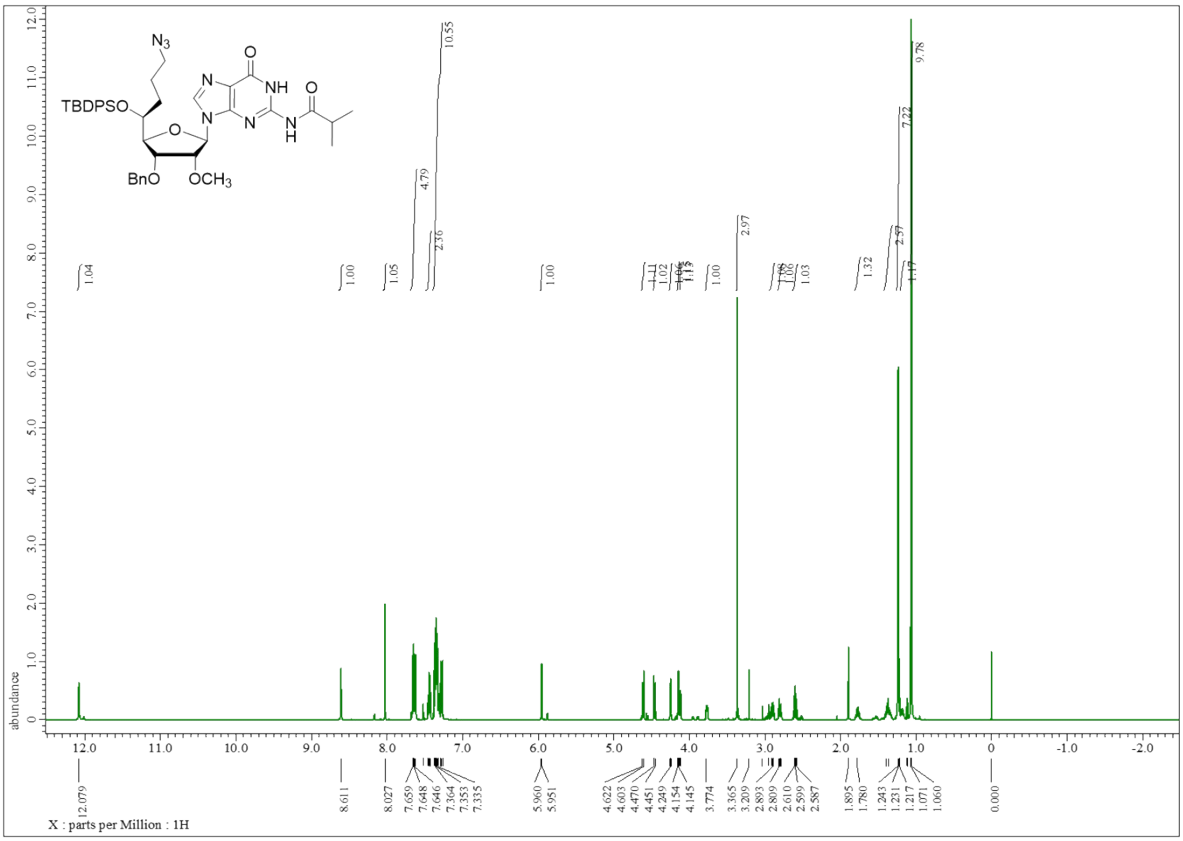
^{1}H NMR spectrum of compound **26**



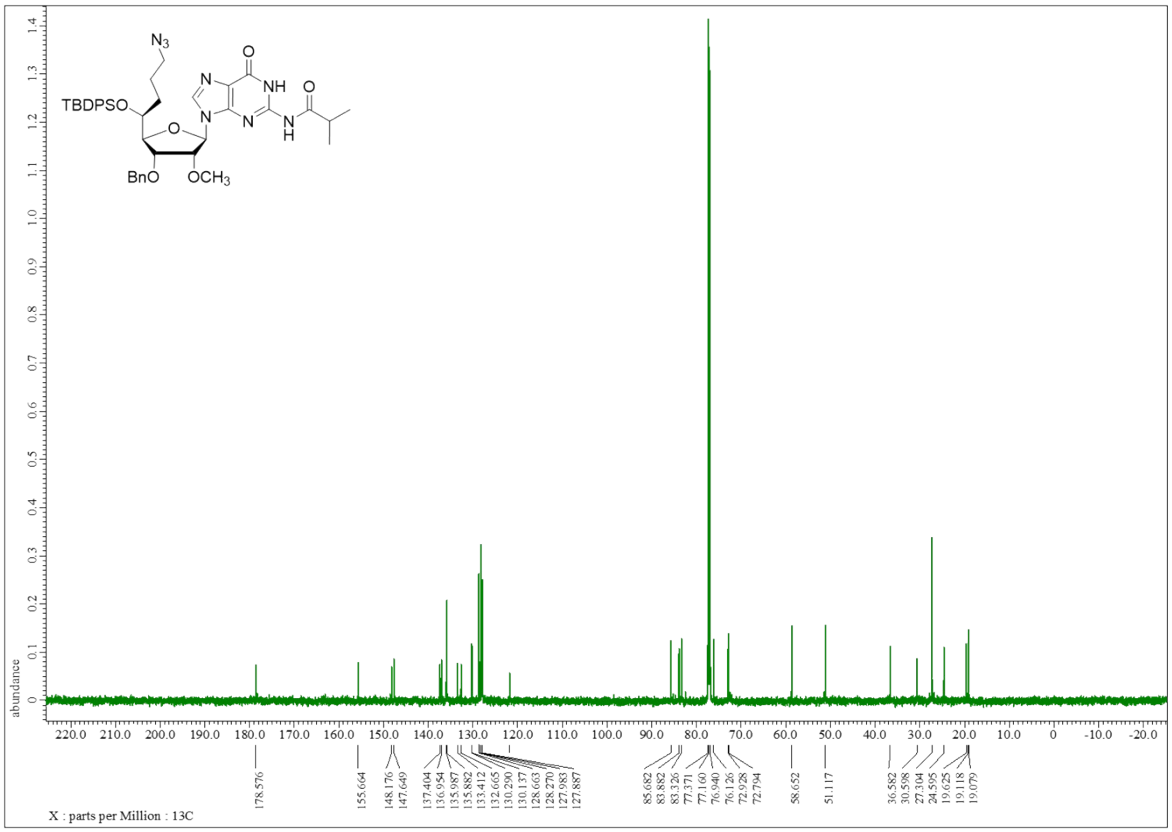
^{13}C{^{1}H}NMR spectrum of compound **26**



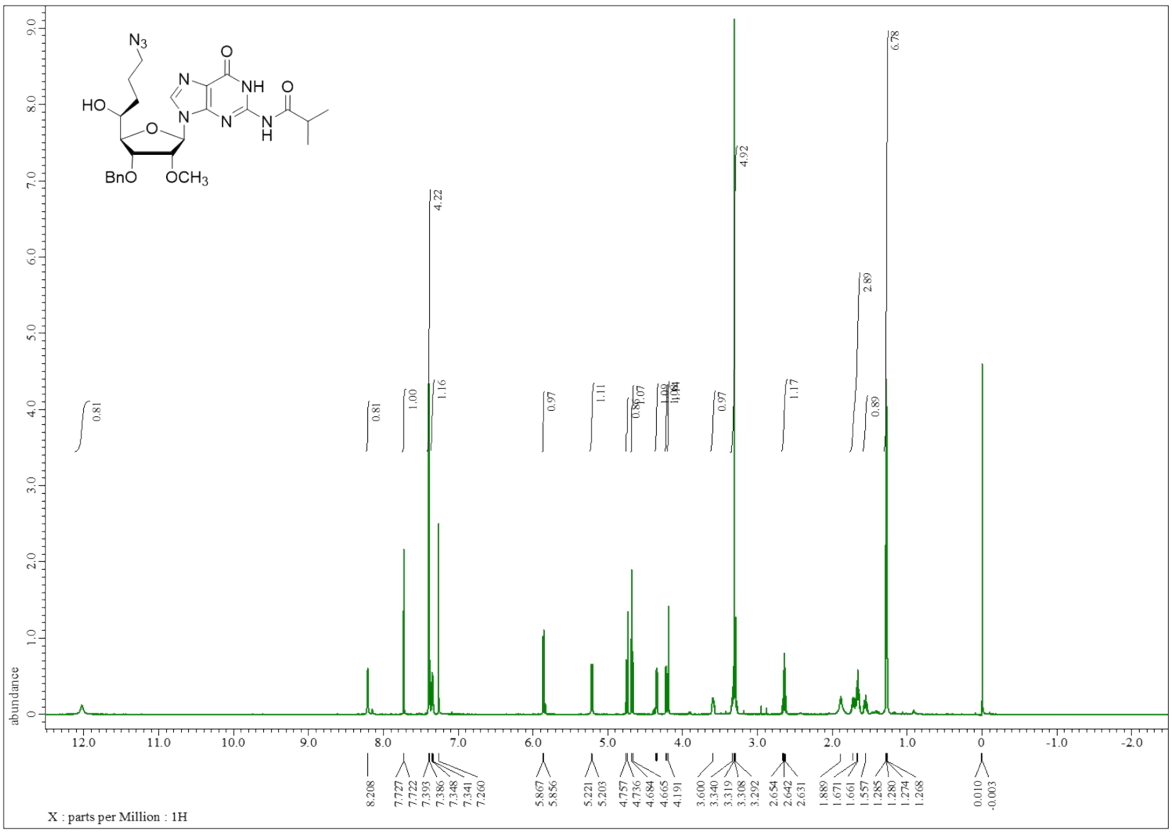
^{1}H NMR spectrum of compound **27**



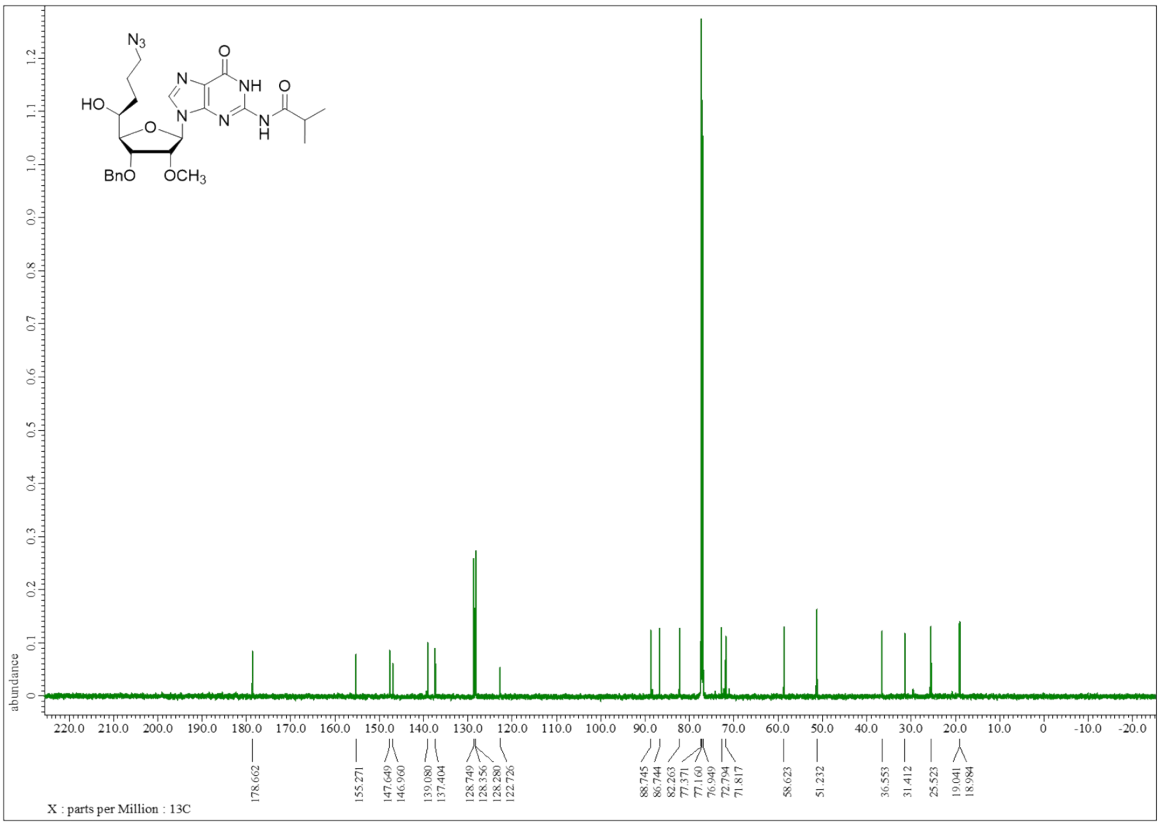
^{13}C{^{1}H}NMR spectrum of compound **27**



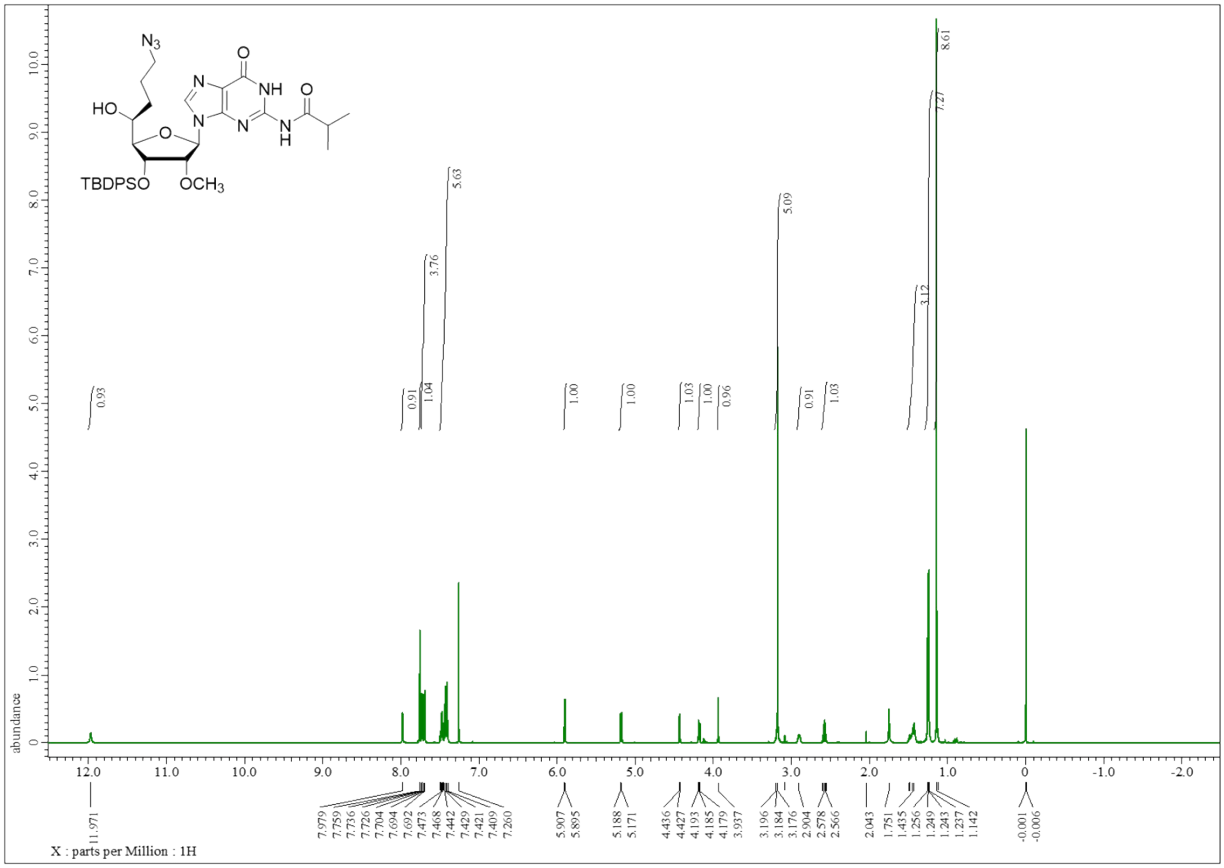
^{1}H NMR spectrum of compound **28**



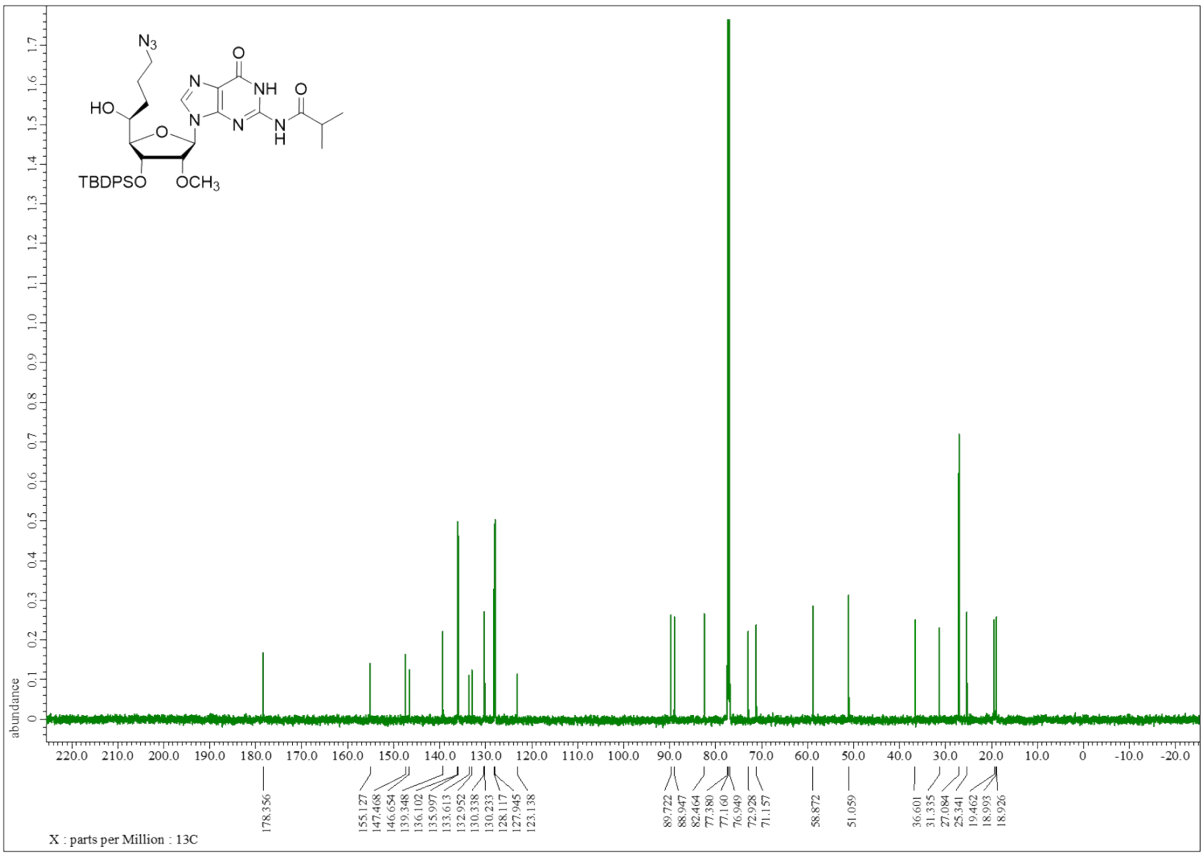
^{13}C{^{1}H}NMR spectrum of compound **28**



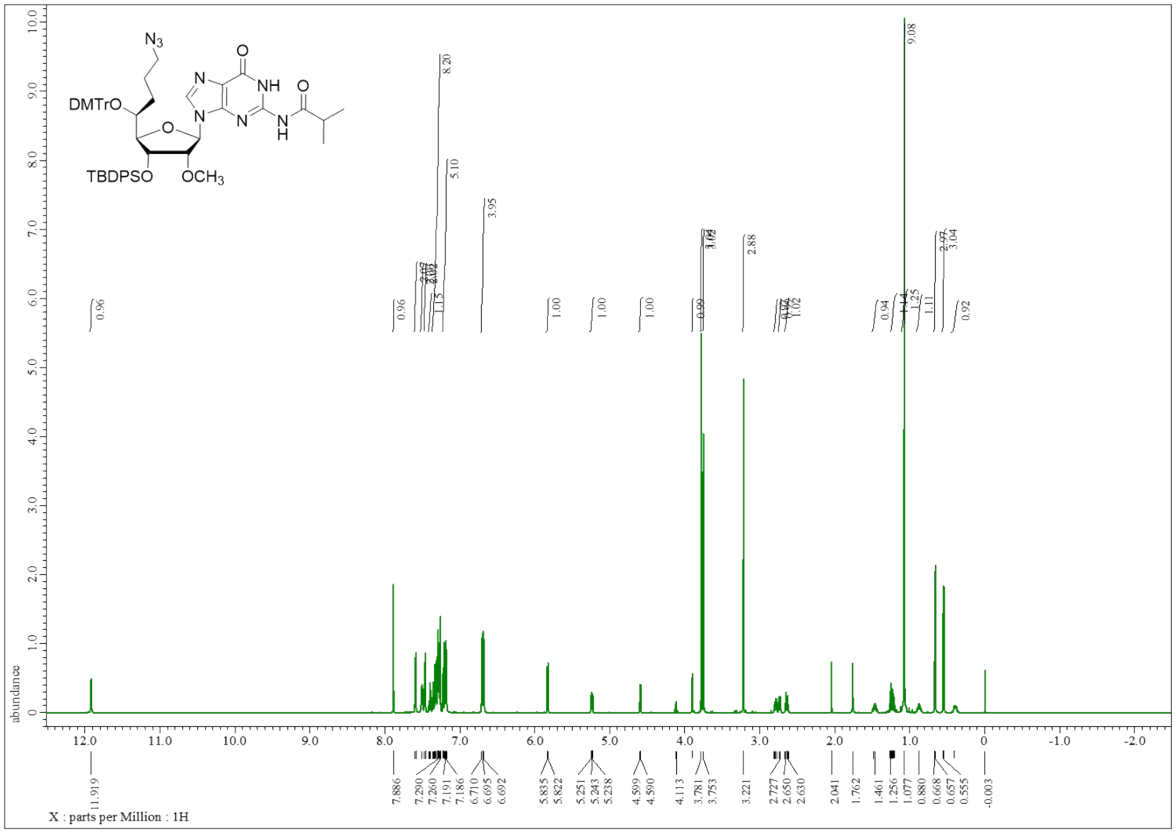
^{1}H NMR spectrum of compound **29**



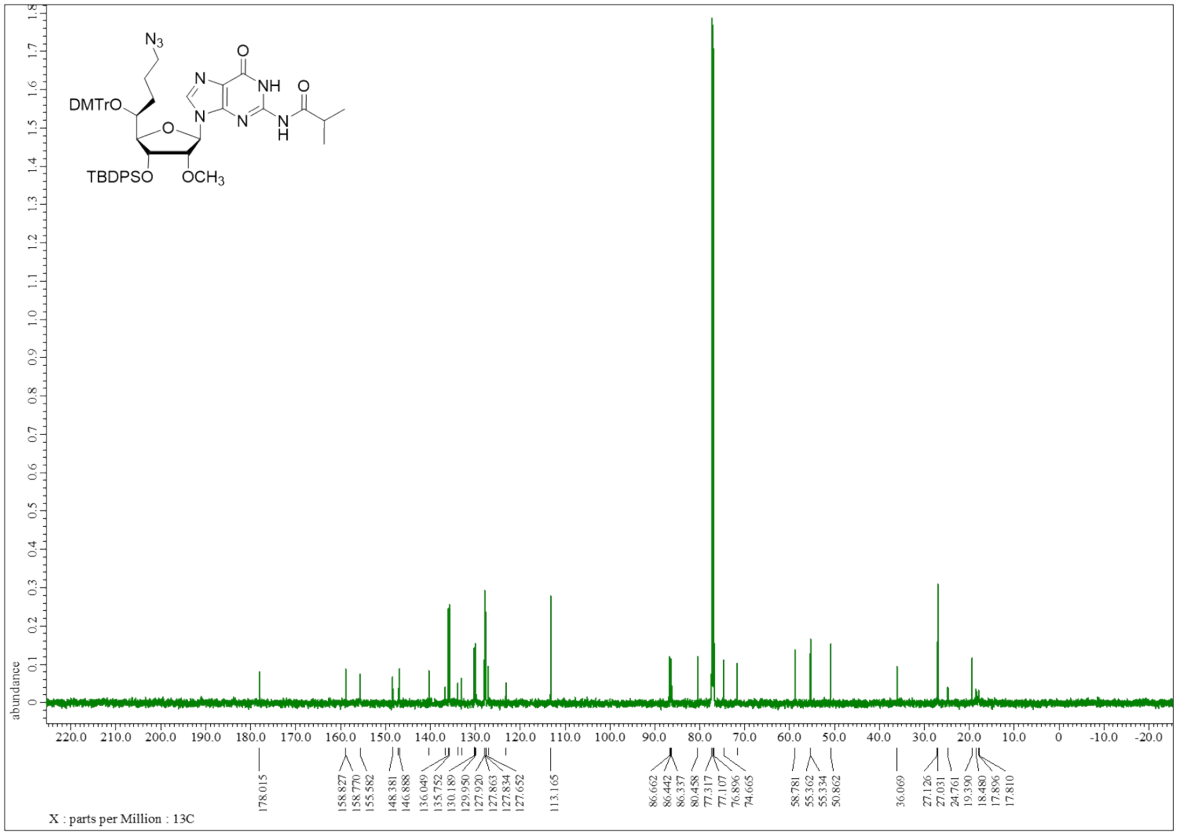
^{13}C{^{1}H}NMR spectrum of compound **29**



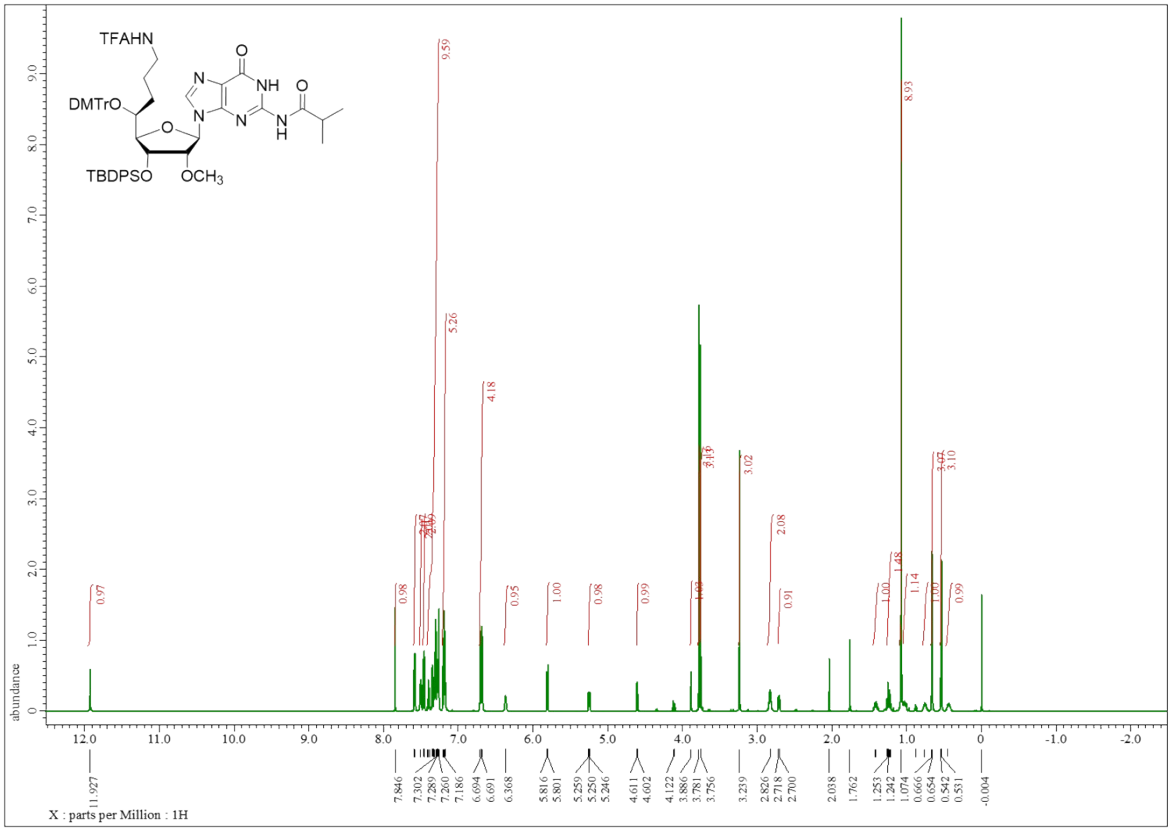
^{1}H NMR spectrum of compound **30**



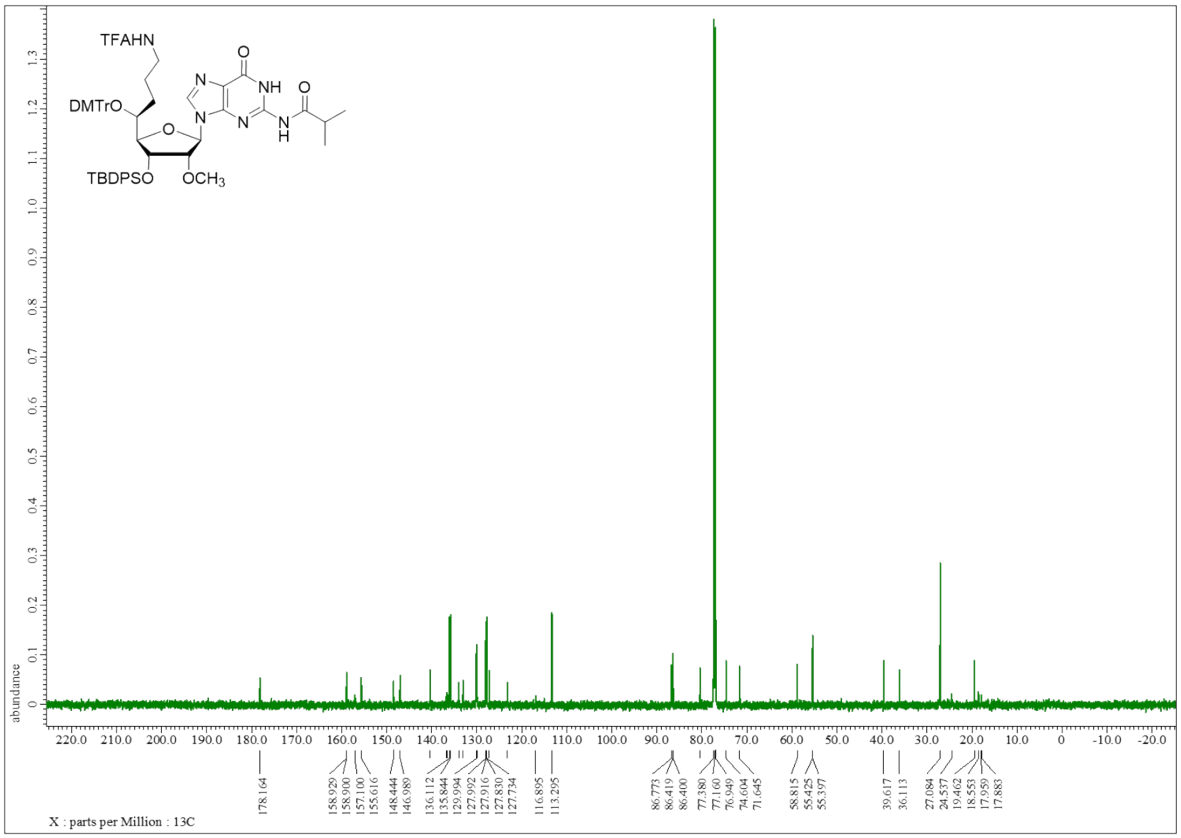
^{13}C{^{1}H}NMR spectrum of compound **30**



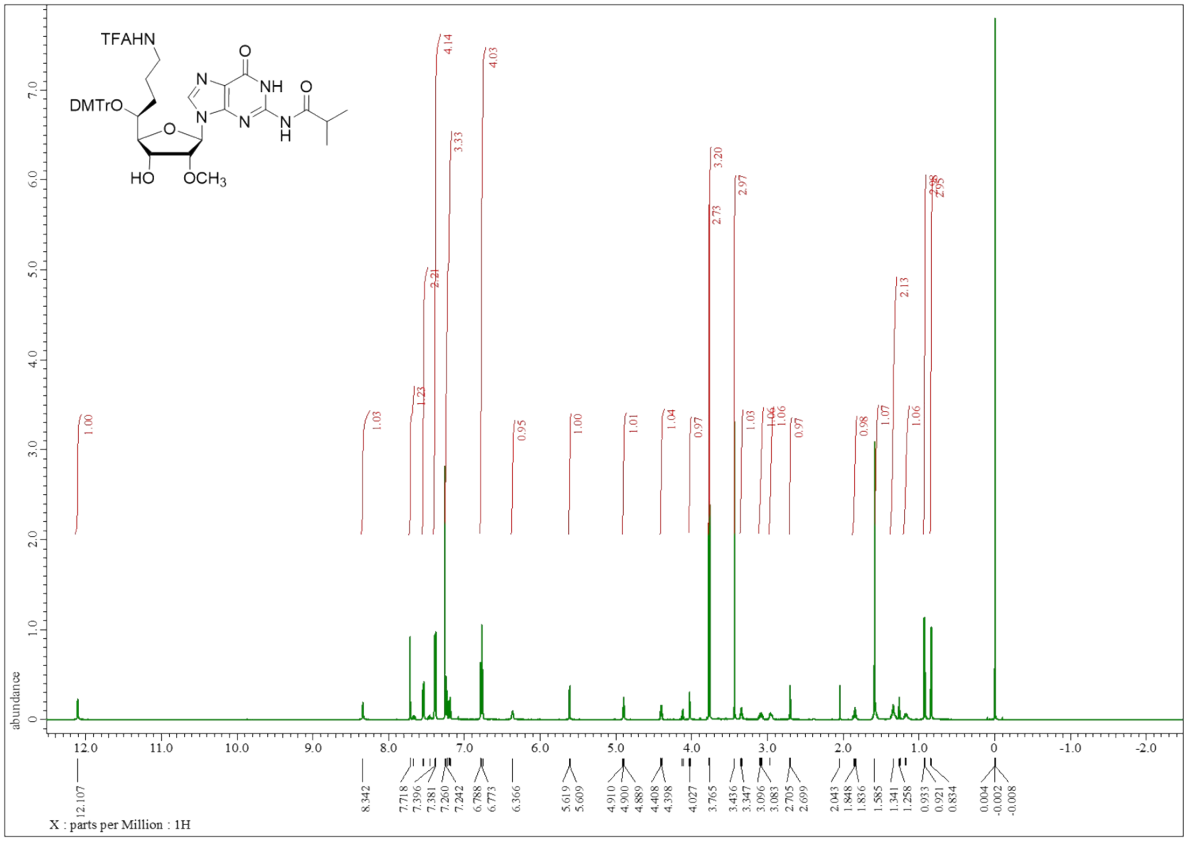
^{1}H NMR spectrum of compound **31**



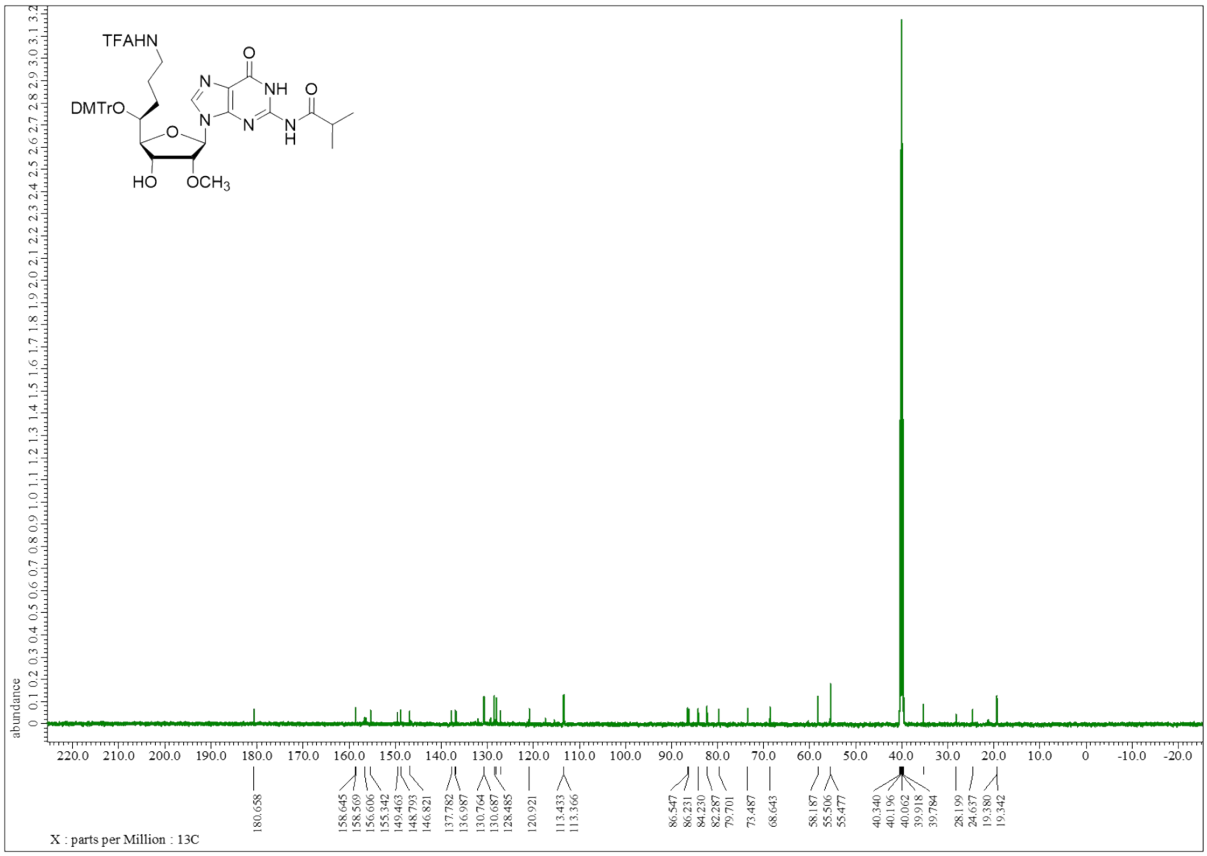
^{13}C{^{1}H}NMR spectrum of compound **31**



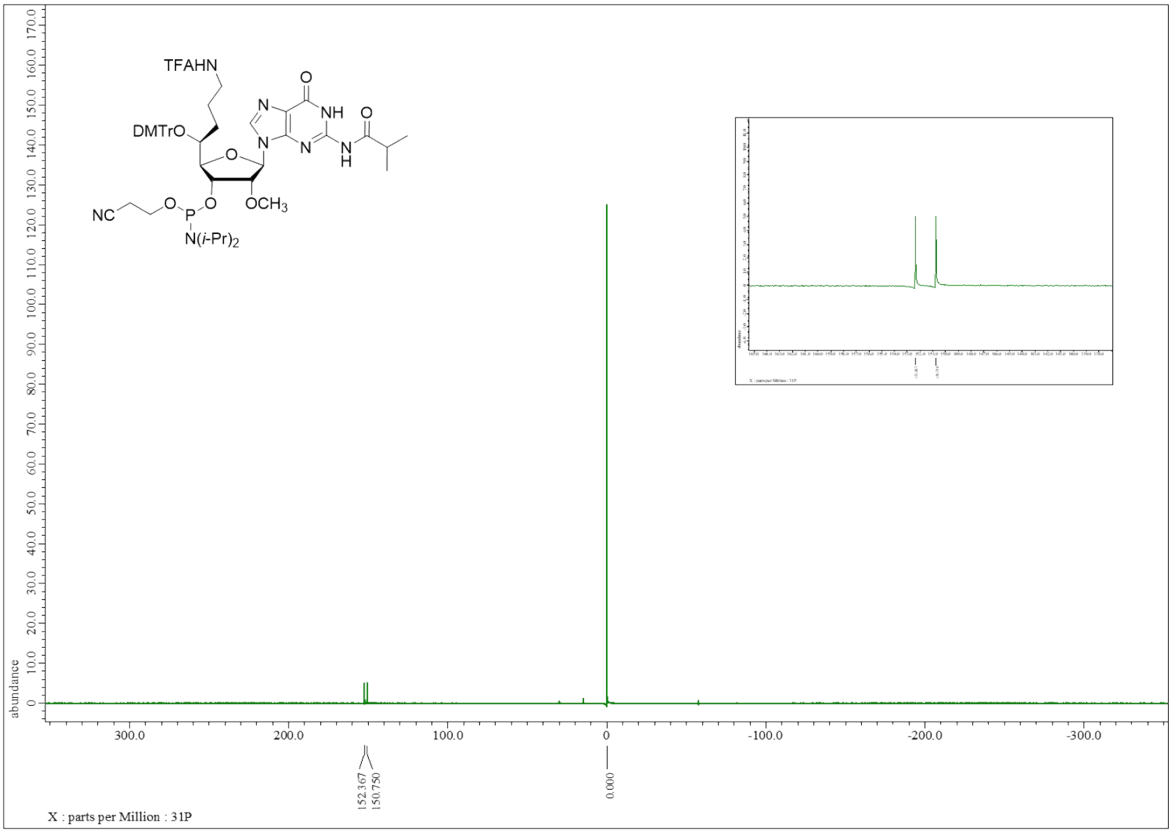
^{1}H NMR spectrum of compound **32**



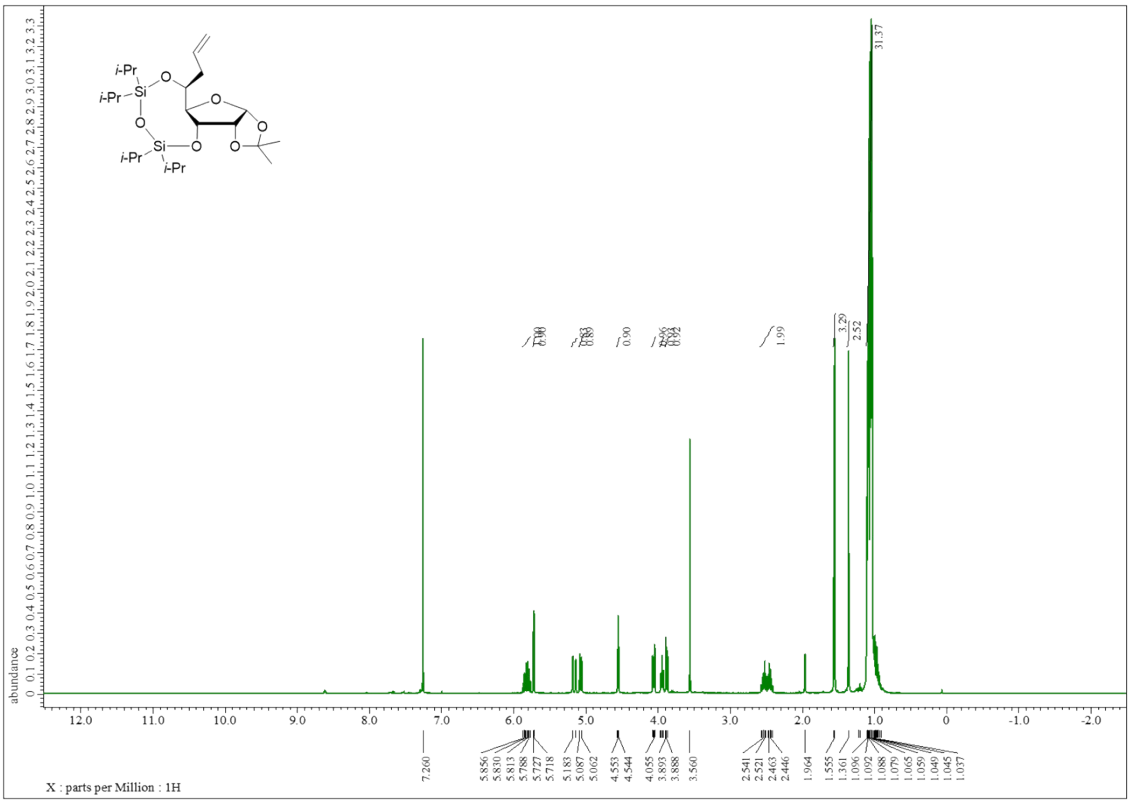
^{13}C{^{1}H}NMR spectrum of compound **32**



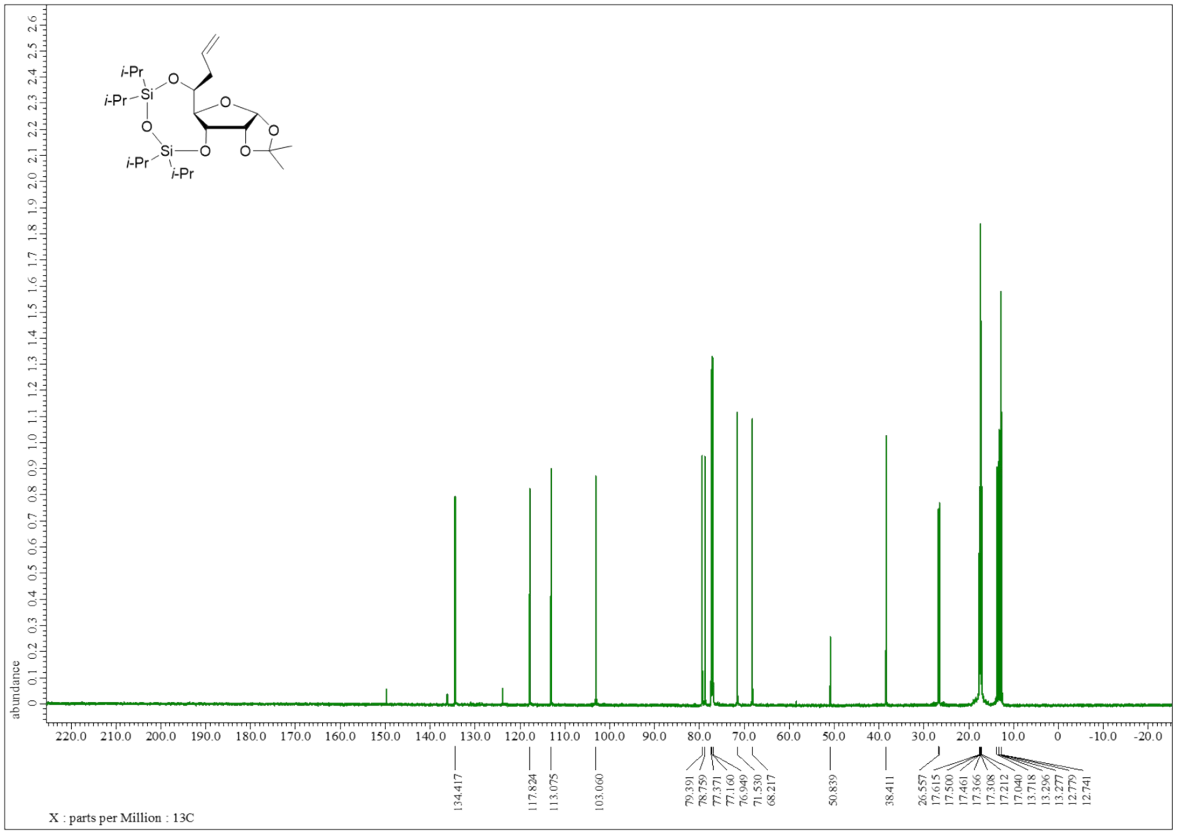
^{31}P NMR spectrum of compound **33**



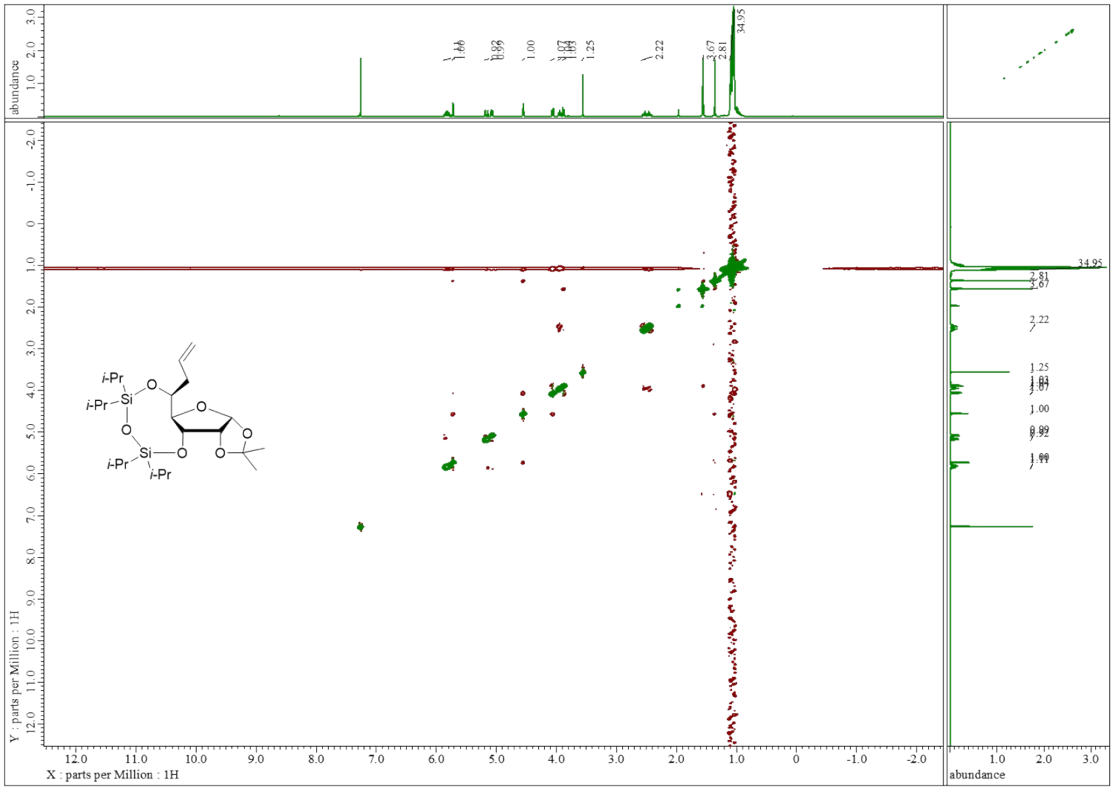
^{1}H NMR spectrum of compound **34**

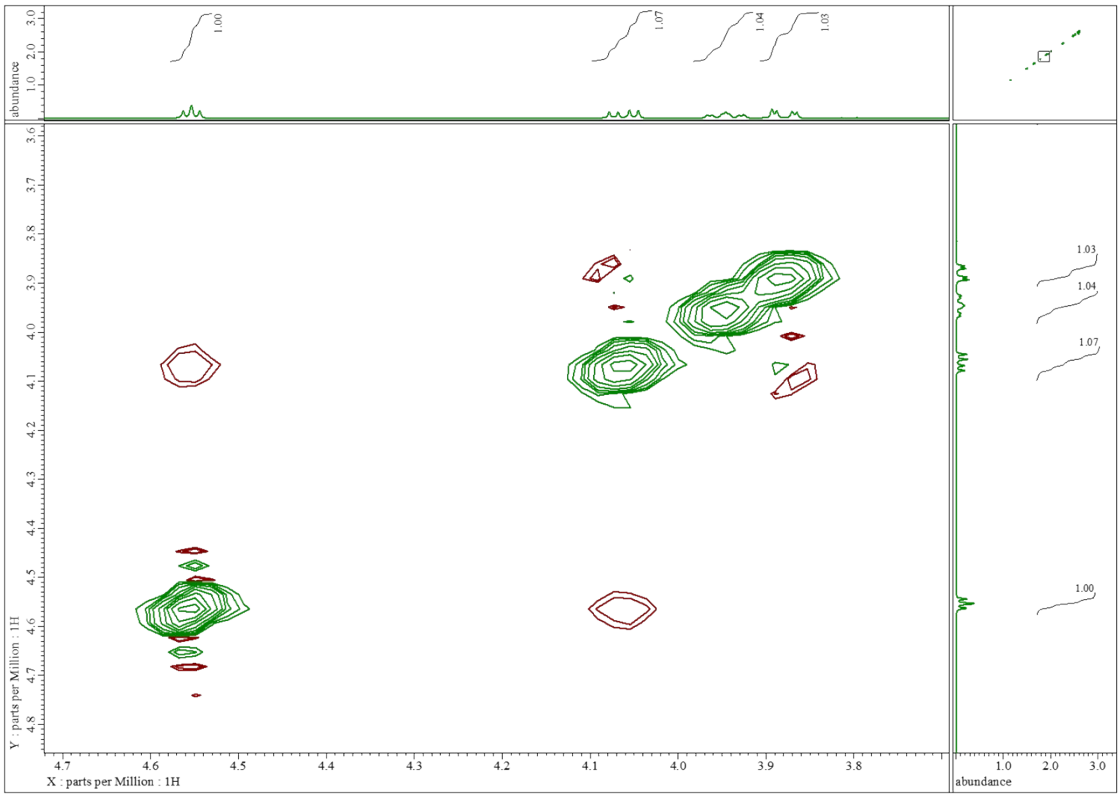


^{13}C{^{1}H}NMR spectrum of compound **34**

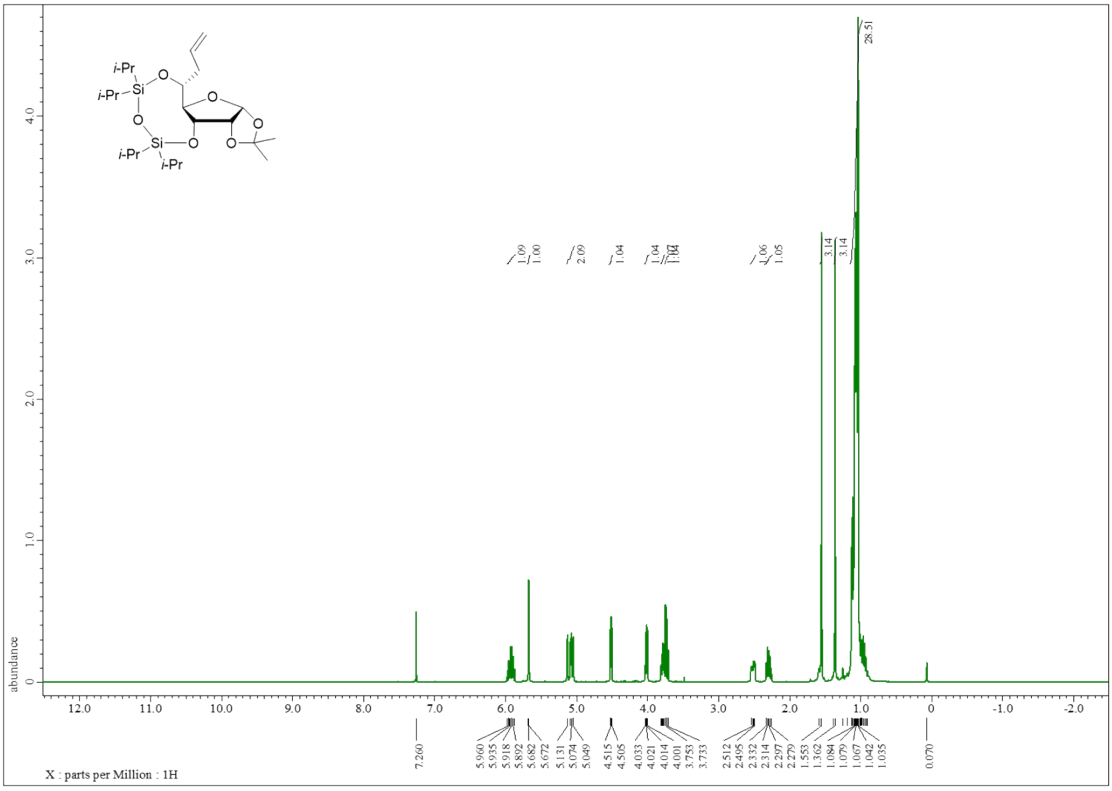


NOESY spectrum of compound **34**

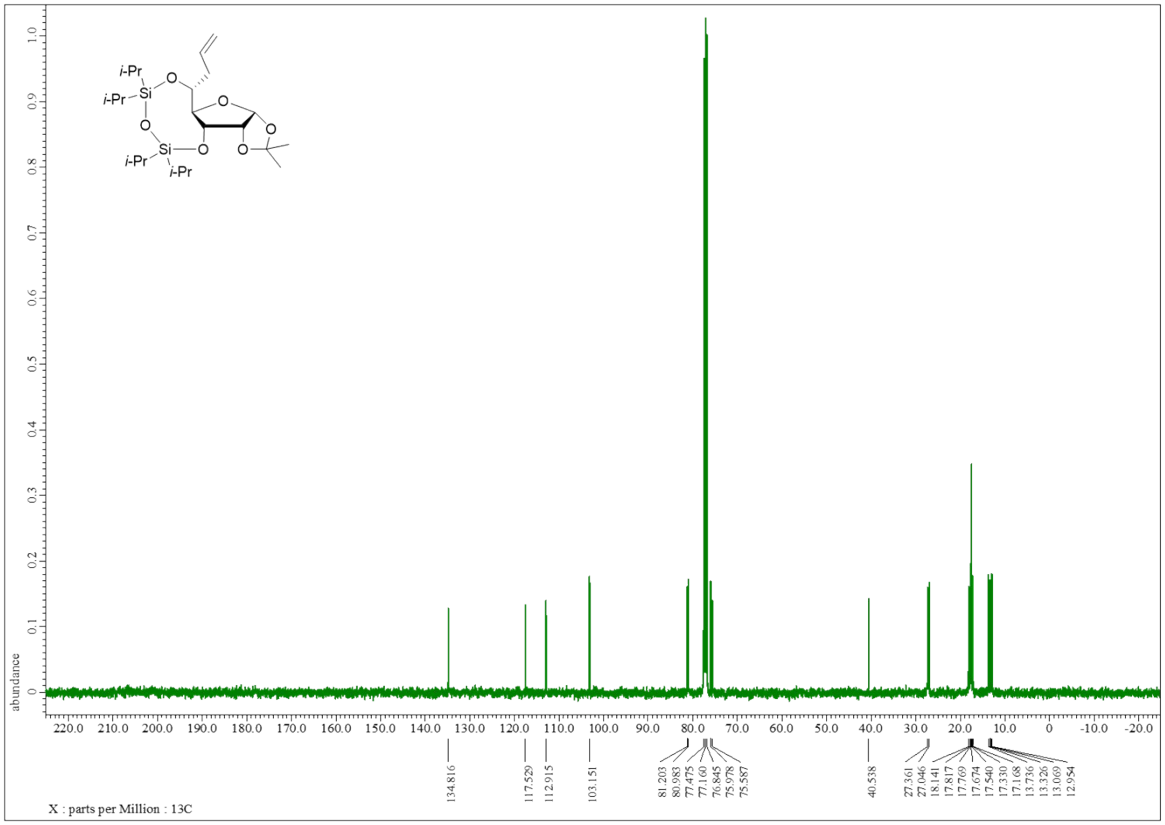




^{1}H NMR spectrum of compound **35**



^{13}C{^{1}H}NMR spectrum of compound **35**



NOESY spectrum of compound **35**