Linear Relationship between Deformability and Thermal Stability of 2´-*O*-Modified RNA Hetero Duplexes

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Supporting Information

Contents

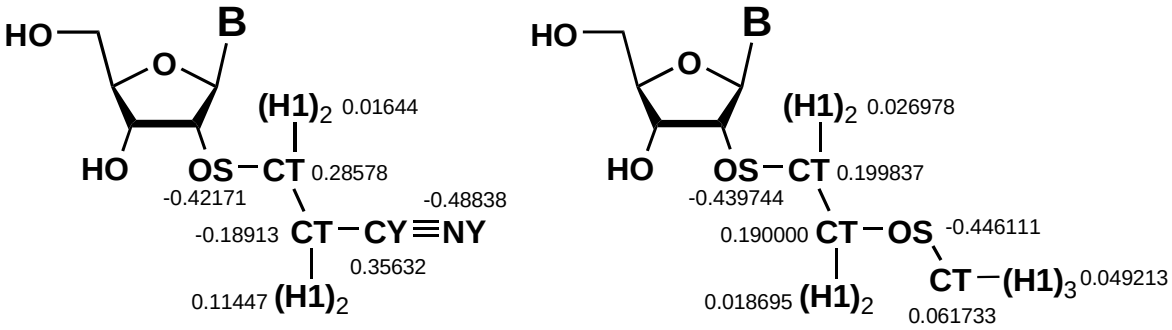

Figure S1. Resp charge distributions and atom types of the 2´-*O*-cyanoethyl and 2´-*O*-methoxyethyl groups.

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MASS
CY 12.01         0.360              nitrile C (Howard et al.JCC,16,243,1995)
NY 14.01         0.530              nitrile N (Howard et al.JCC,16,243,1995)

BOND
CT-CY  400.0    1.458       Howard et al JCC.16,243,1995
CY-NY  600.0    1.150       Howard et al JCC,16,243,1995

ANGLE
CT-CT-CY    63.0      110.00    Junmei et al, 1999
CT-CY-NY    80.0      180.00    Junmei et al, 1999
H1-CT-CY    50.0      110.00    Junmei et al, 1999

DIHE
CT-CT-CY-NY   3    0.00          0.0             1.         Junmei et al, 1999 same as X-CT-CY-X
H1-CT-CY-NY   3    0.00          0.0             1.         Junmei et al, 1999 same as X-CT-CY-X

IMPROPER
N*-NC-C -O          10.5          180.0         2.0         General improper torsional angle (2 general atom types)
CA-H -N2-H           1.0          180.0         2.0         General improper torsional angle (2 general atom types)
CA-CM-CM-HA          1.1          180.0         2.0         General improper torsional angle (2 general atom types)
CM-H4-CM-N*          1.1          180.0         2.0         General improper torsional angle (2 general atom types)

NONBON
  NY          1.8240  0.1700            N in nitrile
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Figure S2. Force field parameters for the 2´-*O*-cyanoethyl group. The others (2´-OMe and 2´-OMOE) did not need additional force field parameters.

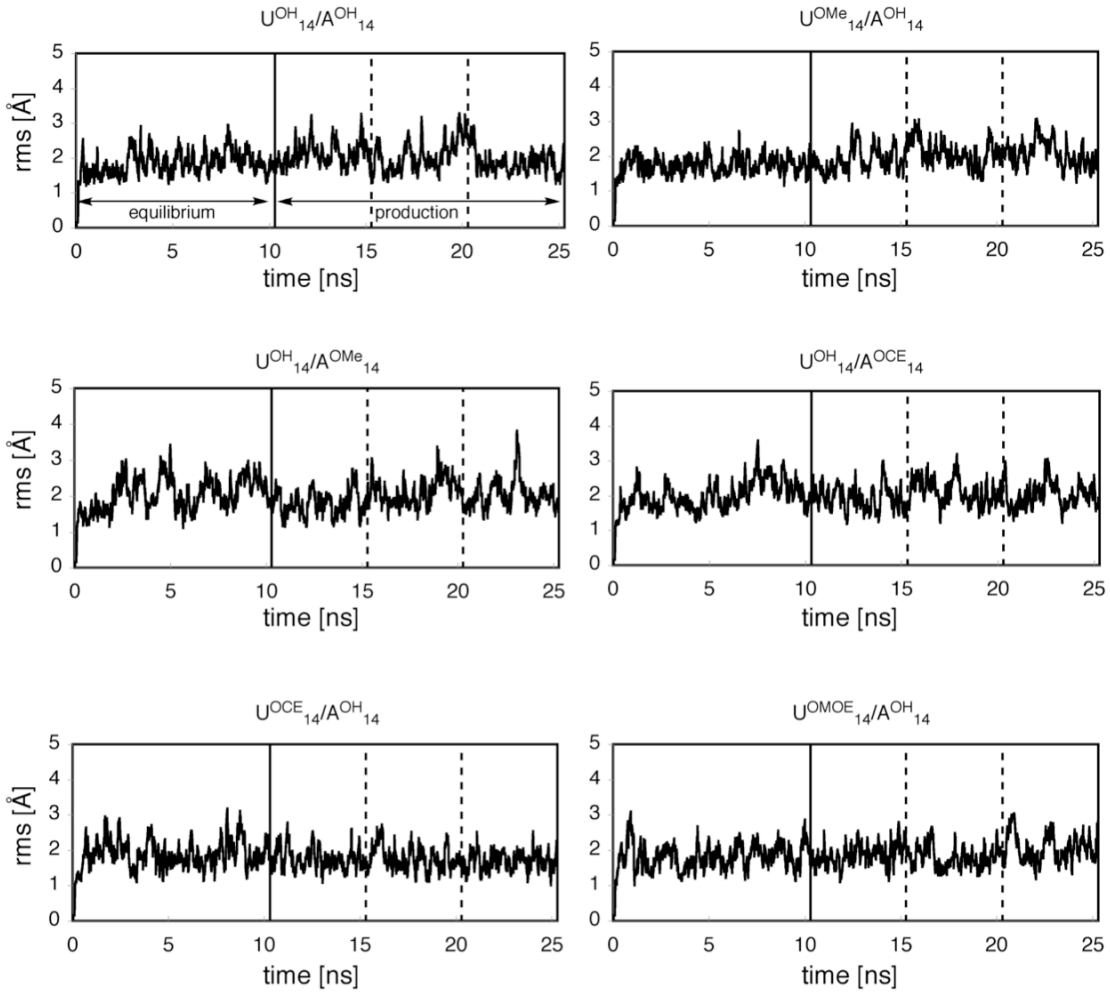

Figure S3. Rms deviations for all atoms except for 2´-*O*-modified groups and H atoms in modified or unmodified U_{14}/A_{14} duplex during MD simulations. The vertical dashed lines denoted each data collection area.

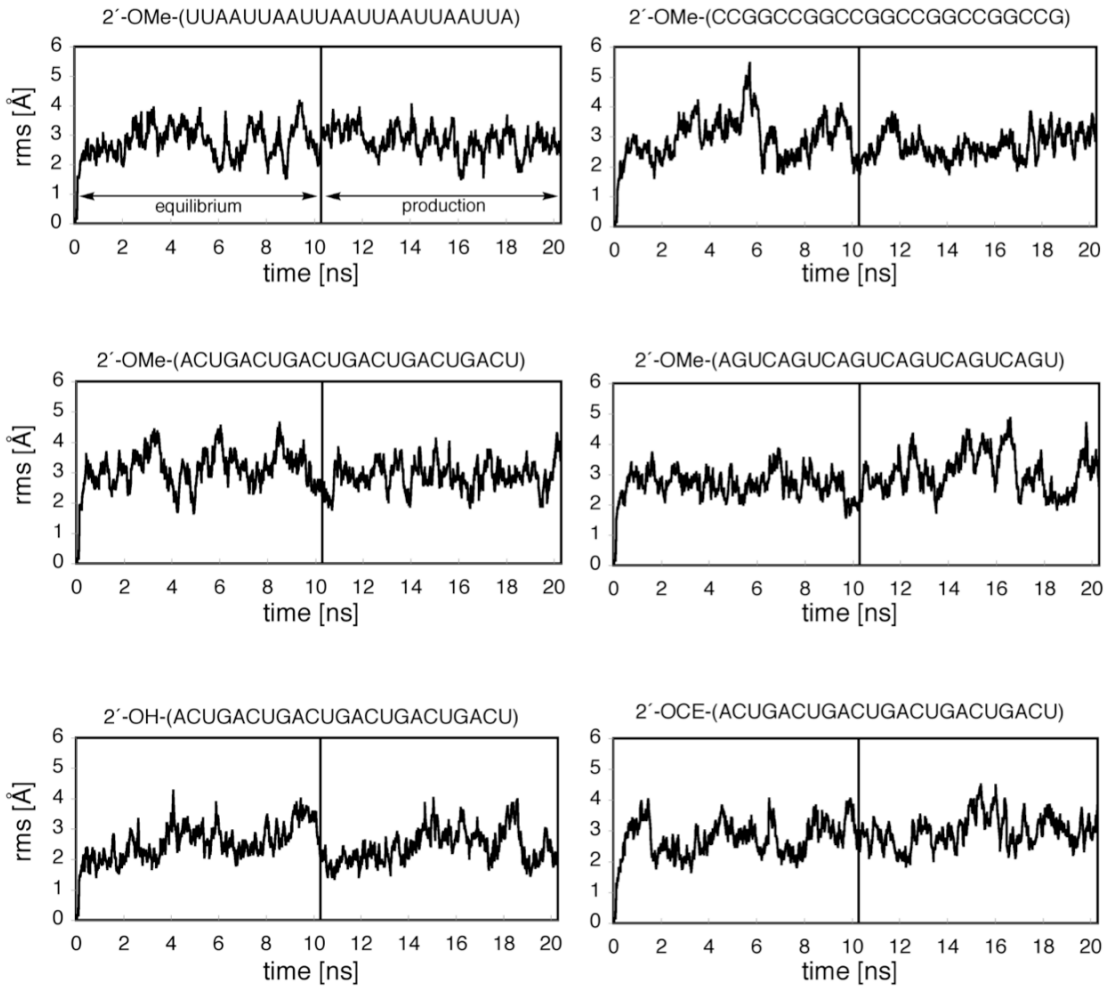

Figure S4. Rms deviations for all atoms except for 2´-*O*-modified groups and H atoms in modified or unmodified duplex (mixed sequence) during MD simulations.

TABLE S1: Detailed Data of Base-pair Step Deformability

duplex	f_{twist} [kcal·mol^{-1}·deg^{-2}]	f_{roll} [kcal·mol^{-1}·deg^{-2}]	f_{tilt} [kcal·mol^{-1}·deg^{-2}]	f_{rise} [kcal·mol^{-1}·Å^{-2}]	f_{shift} [kcal·mol^{-1}·Å^{-2}]	f_{slide} [kcal·mol^{-1}·Å^{-2}]
U^{OH}_{14}/A^{OH}_{14}	0.0512 ± 0.0033	0.0198 ± 0.0006	0.0294 ± 0.0009	8.08 ± 0.15	1.54 ± 0.06	3.09 ± 0.32
U^{OMe}_{14}/A^{OH}_{14}	0.0668 ± 0.0014	0.0214 ± 0.0003	0.0351 ± 0.0007	9.59 ± 0.25	2.06 ± 0.04	4.48 ± 0.07
U^{OCE}_{14}/A^{OH}_{14}	0.0697 ± 0.0013	0.0220 ± 0.0003	0.0368 ± 0.0001	9.93 ± 0.12	2.43 ± 0.03	4.78 ± 0.02
$U^{OMOE}_{14}/A^{OH}_{14}$	0.0694 ± 0.0013	0.0214 ± 0.0003	0.0360 ± 0.0004	9.73 ± 0.04	2.27 ± 0.07	4.85 ± 0.11
U^{OH}_{14}/A^{OMe}_{14}	0.0557 ± 0.0026	0.0205 ± 0.0006	0.0314 ± 0.0001	7.87 ± 0.19	1.68 ± 0.08	3.91 ± 0.11
U^{OH}_{14}/A^{OCE}_{14}	0.0609 ± 0.0004	0.0206 ± 0.0005	0.0337 ± 0.0003	8.46 ± 0.03	1.90 ± 0.04	4.22 ± 0.09

TABLE S2: Detailed Data of Rotation, Translation, and Product Deformability

duplex	F_{rot} [10^3(cal·mol^{-1}·deg^{-2})^3]	F_{trans} [(kcal·mol^{-1}·Å^{-2})^3]	F_{prod} [(kcal·mol^{-1}·deg^{-1}·Å^{-1})^6]	T_m [°C]
U^{OH}_{14}/A^{OH}_{14}	30.0 ± 3.7	38.3 ± 3.7	0.00116 ± 0.00024	24
U^{OMe}_{14}/A^{OH}_{14}	50.1 ± 1.0	88.8 ± 5.3	0.00445 ± 0.00026	36
U^{OCE}_{14}/A^{OH}_{14}	56.5 ± 2.1	115.1 ± 2.8	0.00651 ± 0.00034	43
$U^{OMOE}_{14}/A^{OH}_{14}$	53.6 ± 1.7	107.1 ± 4.4	0.00573 ± 0.00026	40
U^{OH}_{14}/A^{OMe}_{14}	35.9 ± 2.4	51.6 ± 0.5	0.00185 ± 0.00012	24
U^{OH}_{14}/A^{OCE}_{14}	42.3 ± 0.8	67.7 ± 0.8	0.00286 ± 0.00009	27

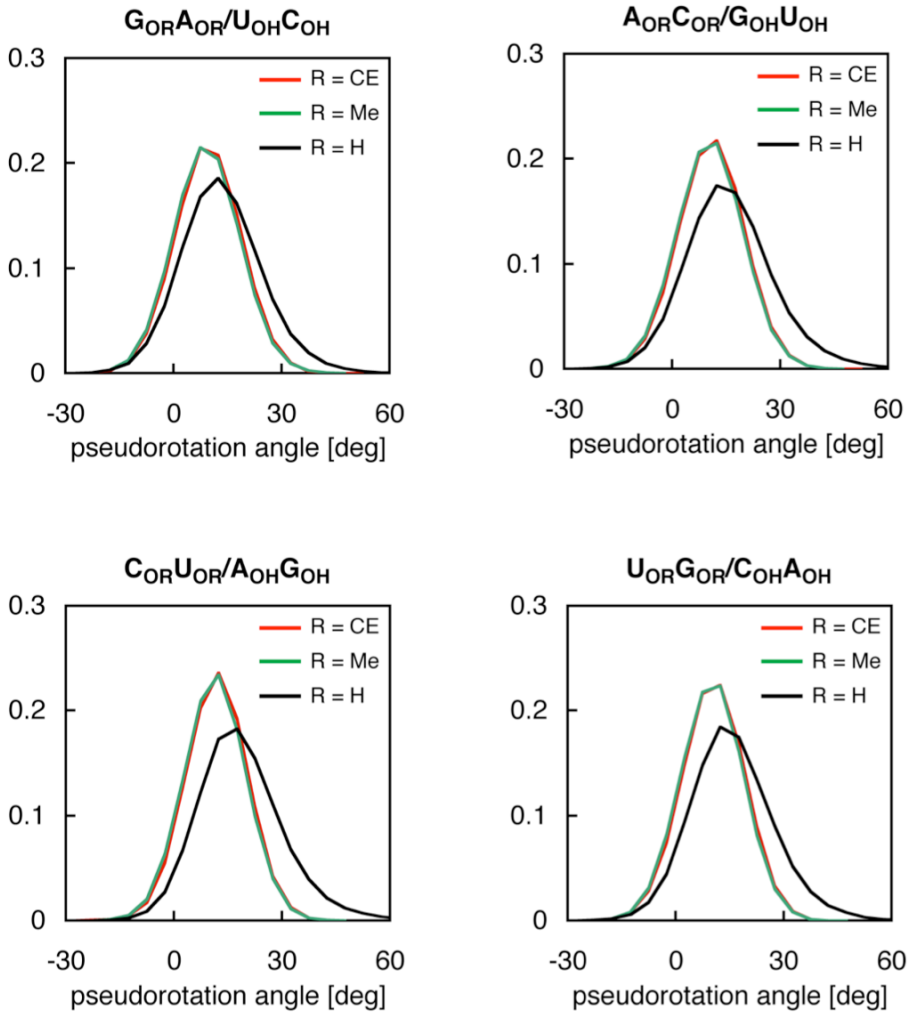

Figure S5. Histograms of pseudorotation angle of each base-pair step.

TABLE S3: Deformability of sugar puckering.

base-step	f_{sugar} [cal·mol^{-1}·deg^{-2}]		
	2′-OH	2′-OMe	2′-OCE
GA	0.0047	0.0073	0.0074
AC	0.0040	0.0072	0.0073
CU	0.0043	0.0083	0.0083
UG	0.0045	0.0081	0.0081

TABLE S4: Detailed Data of Base-pair Step Deformability

	base-step	f_{twist} [kcal·mol^{-1}·deg^{-2}]	f_{roll} [kcal·mol^{-1}·deg^{-2}]	f_{tilt} [kcal·mol^{-1}·deg^{-2}]	f_{rise} [kcal·mol^{-1}·Å^{-2}]	f_{shift} [kcal·mol^{-1}·Å^{-2}]	f_{slide} [kcal·mol^{-1}·Å^{-2}]	F_{rot} [(kcal·mol^{-1}·deg^{-2})^3]	F_{trans} [(kcal·mol^{-1}·Å^{-2})^3]	F_{prod} [(kcal·mol^{-1}·deg^{-1}·Å^{-1})^6]
2′-OH	GA	0.066	0.023	0.041	9.79	1.48	3.65	0.0000627	53.0	0.00334
	AC	0.059	0.025	0.028	11.97	1.09	3.09	0.0000414	40.4	0.00169
	CU	0.058	0.022	0.035	8.17	1.32	3.98	0.0000450	43.0	0.00195
	UG	0.060	0.018	0.029	4.95	1.67	4.65	0.0000312	38.1	0.00119
2′-OMe	AU	0.066	0.022	0.027	11.55	1.26	3.66	0.0000397	53.3	0.00213
	UU	0.070	0.021	0.036	9.31	2.34	4.10	0.0000542	89.7	0.00485
	UA	0.067	0.017	0.028	4.94	2.66	5.60	0.0000317	73.8	0.00236
	AA	0.058	0.022	0.033	7.95	1.76	4.15	0.0000424	60.7	0.00286
	GC	0.067	0.032	0.040	14.70	2.58	3.81	0.0000851	144.6	0.01233
	CC	0.064	0.026	0.050	10.31	2.21	6.32	0.0000820	144.3	0.01181
	CG	0.069	0.020	0.037	4.63	1.13	4.90	0.0000507	25.6	0.00130
	GG	0.064	0.026	0.050	10.13	2.16	6.15	0.0000819	134.7	0.01107
	GA	0.056	0.022	0.041	9.19	1.87	4.41	0.0000529	76.2	0.00428
	AC	0.049	0.026	0.031	12.20	1.38	3.12	0.0000402	52.5	0.00215
	CU	0.069	0.024	0.037	8.66	1.74	4.97	0.0000605	75.1	0.00454
	UG	0.071	0.020	0.033	5.50	1.87	5.58	0.0000453	57.4	0.00259
	UC	0.069	0.022	0.042	9.63	1.98	3.94	0.0000655	75.3	0.00494
	GU	0.063	0.026	0.032	12.32	1.58	3.16	0.0000537	61.6	0.00332
	AG	0.068	0.022	0.039	8.45	1.36	4.61	0.0000585	52.9	0.00309
	CA	0.067	0.018	0.031	5.30	1.83	5.25	0.0000386	51.8	0.00204
2′-OCE	GA	0.070	0.023	0.042	9.57	1.84	4.52	0.0000668	79.9	0.00530
	AC	0.059	0.027	0.031	12.49	1.47	2.97	0.0000489	54.6	0.00268
	CU	0.070	0.023	0.038	8.86	2.07	5.20	0.0000617	95.0	0.00587
	UG	0.071	0.017	0.034	5.41	2.05	5.37	0.0000416	59.7	0.00249

Table S5: Relationship between Deformability and T_m Value.

duplex	F_{total} [(kcal·mol^{-1}·deg^{-1}·Å^{-1})^6]	T_m(exp.) [°C]	T_m(calc.) [°C]	ΔT_m [c] [°C]
$(CU)^{OH}_7/(AG)^{OH}_7$	0.0337	68.1	68.2 [a]	0.1
$(CU)^{OH}_7/(AG)^{OMe}_7$	0.0614	73.9	74.0 [a]	0.1
$(CU)^{OMe}_7/(AG)^{OH}_7$	0.0473	71.3	71.0 [a]	-0.3
$(GACU)^{OH}_3/(AGUC)^{OH}_3$	0.0233	59.1	58.6 [b]	-0.5
$(GACU)^{OMe}_3/(AGUC)^{OH}_3$	0.0381	63.6	64.5 [b]	0.9
$(GACU)^{OCE}_3/(AGUC)^{OH}_3$	0.0466	68.4	67.9 [b]	-0.5

[a] $T_m = 210 \times F_{total} + 61.1$ [b] $T_m = 402 \times F_{total} + 49.2$ [c] $\Delta T_m = T_m$ (calc.) - T_m (exp.).

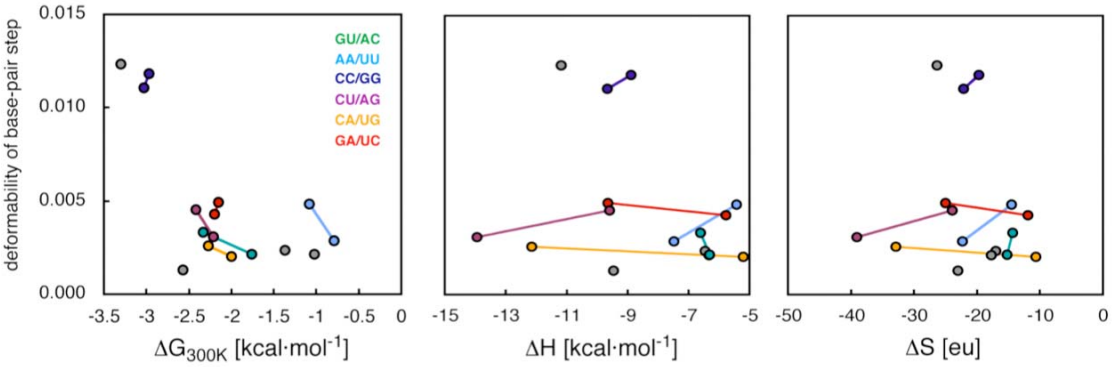

Figure S6. Relationship between the deformability and nearest neighbor parameters.[1]

References

1) Kierzek, E.; Mathews, D. H.; Ciesielska, A.; Turner, D. H.; Kierzek, R. *Nucleic Acids Res*. **2006**, *34*, 3609-3614.