Electronic Supplementary Material (ESI) for Nanoscale.

Supplementary Information

Metal-Ion Responsive Reversible Assembly of DNA Origami Dimers: G-Quadruplex Induced Intermolecular Interaction

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Materials and methods

Materials

All chemicals were purchased from Sigma and used as received without further purification. All chemically synthesized DNA strands were purchased from Integrated DNA Technologies, Inc. (www.Idtdna.com). The unmodified staple strands were ordered in a 96-well plate format, suspended in ultrapure water without purification. All modified strands were purified with PAGE. The DNA origami purification column (100kDa MWCO centrifuge filter) was purchased from Pall, Inc.

Experimental Section

Assembly/disassembly of DNA origami nanostructures

M13mp18 viral DNA and all of the staple strands were mixed together at a 1:5 ratio, in a 1× TAE buffer solution containing 40 mM Tris-HCl, 20 mM of acetic acid, 2 mM of EDTA, and 11.5 mM of magnesium acetate. The mixture was slowly cooled from 90℃ to 15℃ with PCR over 12h. The final concentration of M13mp18 DNA in the solution was 20 nM. The DNA origami was then purified to remove excess DNA strands, using 100kDa MWCO centrifuge filters.

Formation of DNA origami dimer: The prepared DNA origami monomers were mixed at a molar ratio of 1:1 in a 1×TAE buffer containing 11.5 mM of magnesium acetate. Then, the mixture was annealed from 53℃ to 15℃ over varied time course from 2h to 12h to form the corresponding DNA origami dimers (Figure S1). The separation of the origami dimer was accomplished by adding varied concentration of potassium chloride or sodium chloride in the solution of DNA origami dimer and incubating at a temperature ranging from 53℃ to 15℃ over 12 h time course. A 100kDa MWCO centrifuge filter was used to exchange the reaction buffer.

AFM imaging

The AFM images of the DNA origami dimer and monomer were obtained through spotting the sample (3 μl) onto freshly cleaved muscovite mica (Ted Pella, Inc.) for 15 s. Afer the fixation of targeted structure of DNA origami on mica surface, doubly distilled H_2O (20-30ul) was placed quickly on the mica to remove the buffer salts, the drop was wicked off, and the sample was dried with compressed air. Atomic force imaging was done by utilizing Nanoscope III (Digital Instruments) tapping in air, with ultra-sharp 14 series (NSC 14) tips that had been purchased from NANOANDMORE.

Agarose Gel Electrophoresis

The samples were loaded into 0.8% agarose gel that contained 5 mM $Mg(CH_3COO)_2$, 20 mM KCl or NaCl in a 1×TAE buffer solution under 55V at room temperature. The gel was stained with ethidium bromide for DNA visualization.

Supporting Figures

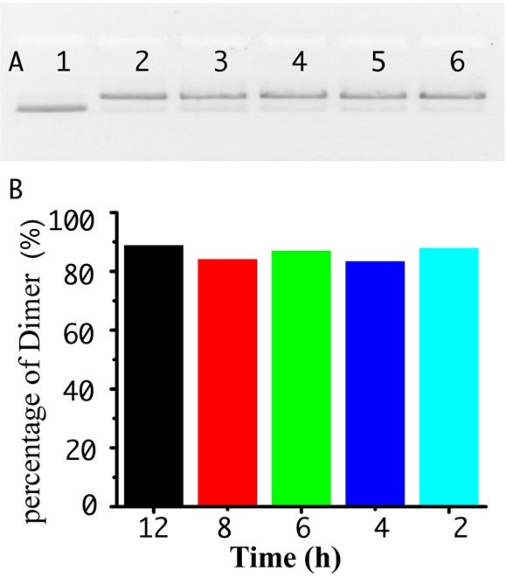


Figure S1. (A) Agarose gel electrophoresis image of assembly of DNA origami dimer with varied annealing period (design corresponding to Figure 1A). Lane 1: DNA origami monomer. Lane 2 to lane 6: corresponding to the annealing period from 12 h, 8 h, 6h, 4h to 2 h respectively. (B) The quantification of band intensity in an agarose gel image (shown in Figure S1A). There is no time-dependence in the formaiton of DNA origami dimer.

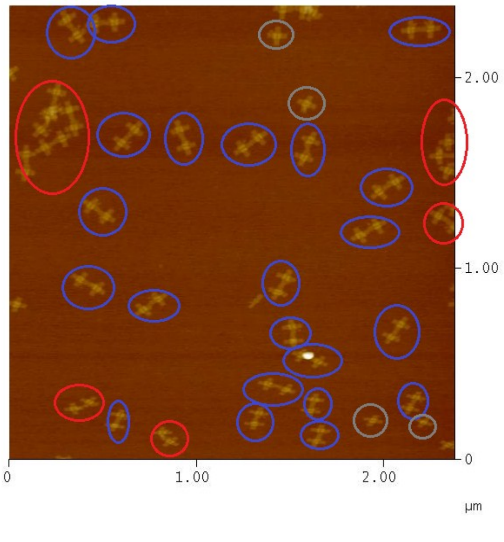


Figure S2. An example of an AFM image used to calculate the yield of a DNA origami dimer with the design shown in Figure 1. The blue circles represent a DNA origami dimer; the grey circles represent DNA origami monomer; and the red circles represent the non-counted DNA origami aggregations. The final yield is the average yield of each image.

The following equation was used to calculate the yield of the DNA origami dimer:

$$\%\,Yield = \frac{Number\ of\ DNA\ origami\ dimers\ x\ 2}{total\ number\ of\ DNA\ origami}\ X\ 100$$

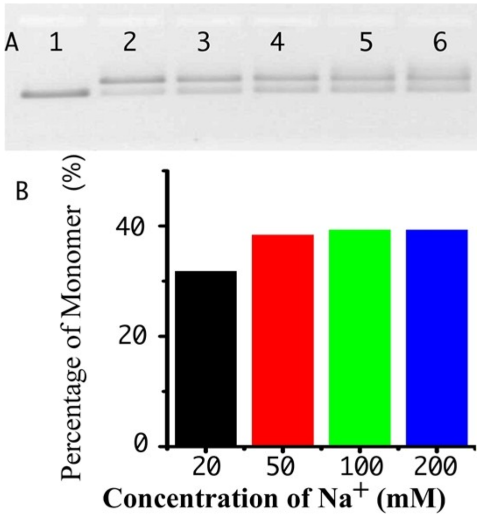


Figure S3. (A) Agarose gel electrophoresis image of dissociation of a DNA origami dimer with different concentrations of Sodium (design corresponding to Figure 1A). Lane 1: DNA origami monomer. Lane 2: DNA origami dimer before Na^+ treatment. Lane 3 to Lane 6 : DNA origami dimer treated with varied concentrations of Na^+, 20 mM, 50 mM, 100 mM, 200 mM, respectively. (B) The quantification of band intensity in an agarose gel image (shown in Figure S3A).

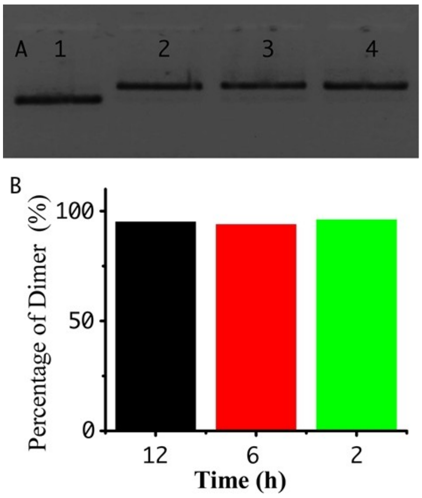


Figure S4. (A) Agarose gel electrophoresis image of assembly of DNA origami dimer with varied annealing period (design corresponding to Figure 4A). Lane 1: DNA origami monomer. Lane 2 to lane 4: corresponding to the annealing period from 12 h, 6h, to 2 h respectively. (B) The quantification of band intensity in an agarose gel image (shown in Figure S4A). There is no time-dependence in the formaiton of DNA origami dimer.

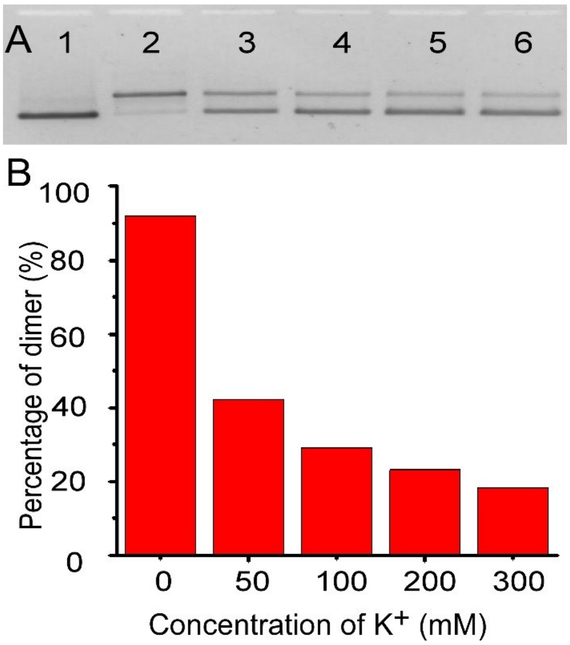


Figure S5. (A) Agarose gel electrophoresis image of dissociation of a DNA origami dimer with different concentrations of potassium (design corresponding to Figure 4A). Lane 1: DNA origami monomer. Lane 2: DNA origami dimer before K^+ treatment. Lane 3 to Lane 6 : DNA origami dimer treated with varied concentrations of K^+, 50 mM, 100 mM, 200 mM, 300 mM, respectively. (B) The quantification of band intensity in an agarose gel image (shown in Figure S2A).

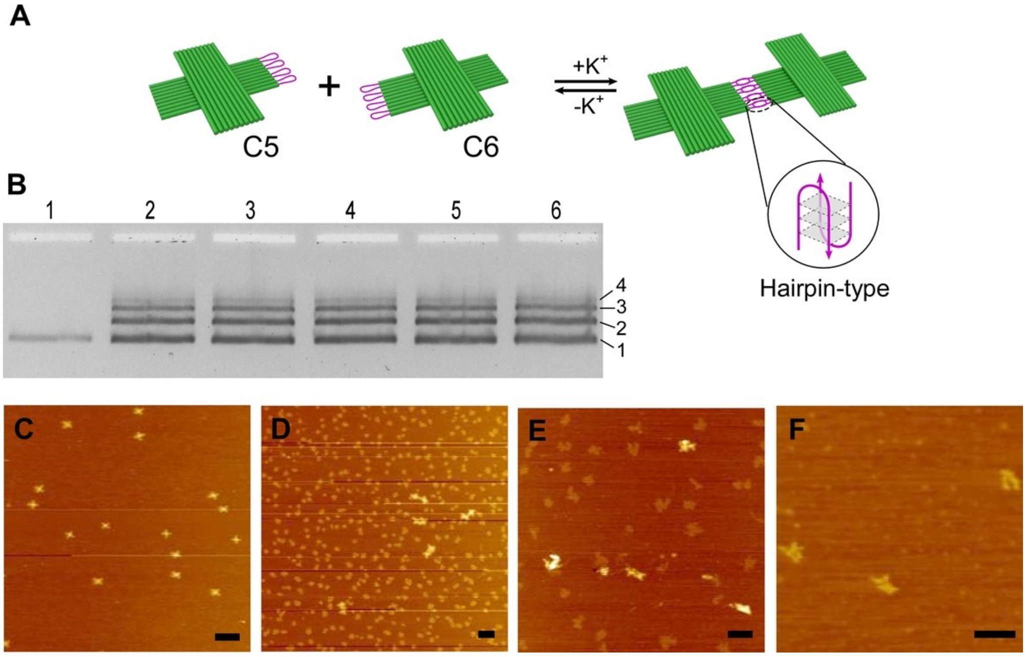
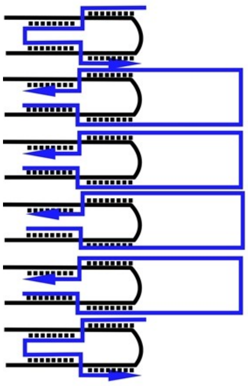


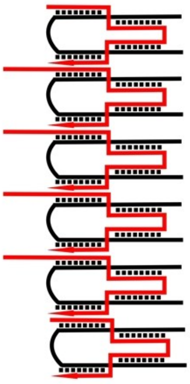
Figure S6. (A) Schematic drawings of a DNA origami assembly/disassembly driven by intermolecular G-quadruplex. (B) Agarose gel electrophoresis image of a DNA origami dimer with different concentrations of potassium. Lane 1: DNA origami monomer. Lane 2 to Lane 6: mixture of DNA origami with varied K^+ concentrations, 0 mM, 50 mM, 100 mM, 200 mM, and 300 mM, respectively. (C)-(F) AFM images corresponding to Band 1 through Band 4, respectively. Scale bar, 200nm.

The Stikcy-ends design and sequences of DNA origami:

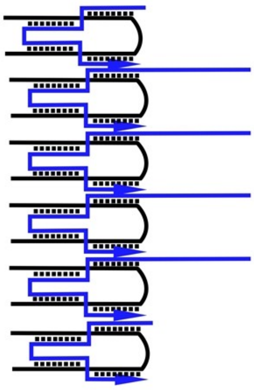
C1



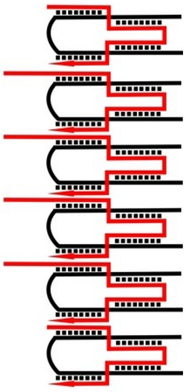
C2



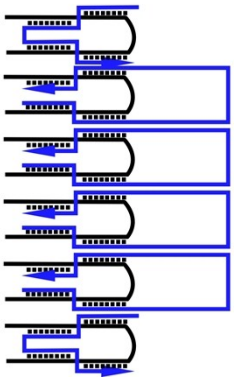
C3



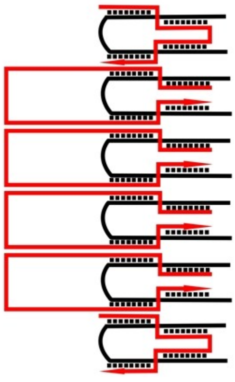
C4



C5



C6



RC-M1	AGCTAATGCAGAACGCGCCTGTTTTAATATCC
RC-M2	CATCCTAATTTGAAGCCTTAAATCTTTTATCC
RC-M3	TGAATCTTGAGAGATAACCCACAAAACAATGA
RC-M4	AATAGCAATAGATGGGCGCATCGTACCGTATC
RC-M5	GGCCTCAGCTTGCATGCCTGCAGGGAATTCGT
RC-M6	AATCATGGTGGTTTTTCTTTTCACCCGCCTGG
RC-M7	CCCTGAGAGAGTTGCAGCAAGCGGGTATTGGG
RC-M8	CGCCAGGGTCATAGCTGTTTCCTGGACGGCCA
RC-M9	GTGCCAAGGAAGATCGACATCCAGATAGGTTA
RC-M10	CGTTGGTGTAGCTATCTTACCGAATTGAGCGC
RC-M11	TAATATCAACCTTCGCTAACGAGCCCGACTTG
RC-M12	CGGGAGGTTTTACGAGCATGTAGAACATGTTC
RC-M13	CTGTCCAGACGACGACAATAAACAAACCAATC
RC-M14	AATAATCGCGTTTTAGCGAACCTCGTCTTTCC
RC-M15	AGAGCCTACAAAGTCAGAGGGTAAGCCCTTTT
RC-M16	TAAGAAAAGATTGACCGTAATGGGCCAGCTTT
RC-M17	CCGGCACCCACGACGTTGTAAAACTGTGAAAT
RC-M18	TGTTATCCGGGAGAGGCGGTTTGCTCCACGCT
RC-M19	GGTTTGCCCCAGCAGGCGAAAATCAATCGGCC
RC-M20	AACGCGCGGCTCACAATTCCACACCCAGGGTT
RC-M21	TTCCCAGTGCTTCTGGTGCCGGAAGTGGGAAC
RC-M22	AAACGGCGGTAAGCAGATAGCCGAAACTGAAC
RC-M23	ACCCTGAAATTTGCCAGTTACAAATTCTAAGA
RC-M24	ACGCGAGGGCTGTCTTTCCTTATCAAGTAATT
RC-M25	GTACCGACAAAAGGTAATTCCAAG
RC-M26	AACGGGTAGAAGGCTTATCCGGTAATAAACAG
RC-M28	GTCGGATTCTCCACCAGGCA

RC-M30	AGCCGGAAGCCAGCTGCATTAATGCTGTTTGATGGTGTCTTCCTGTAGCCAGCTTTAATCGATG
RC-M31	GCAAAATTCGGGAAACCTGTCGTGCATAAAGTGTAAAGCGATGTGCT
RC-M32	GCAAGGCGTTCGCCATTCAGGCTGCGCAACTG
RC-M33	GGAAGCGCTTTATCCCAATCCAAAAAGCAAAT
RC-M34	CAGATATATTAAACCATACGGAAATTACCCAAAAGAACTGGCATGATTA
RC-M35	AGGCATTTTCGAGCCAGTACTCATCG
RC-M36	AGAACAAGTACCGCGCCCAATAGCTAAGAAAC
RC-M39	CCTAATGAACTGCCCGCTTTCCAGCCCTTATA
RC-M40	AATCAAAAGAATAGCCCTTTAAATATGCATTCTACTA
RC-M41	GAGATAGGGTTGTCAGGATTAGAGAGTACCTATTCATT
RC-M42	TTGCGCTCGTGAGCTAACTCACATGATAGCCC
RC-M43	TATTACGCGGCGATCGGTGCGGGCGAGGATTT
RC-M44	CAGCCTTTGTTTAACGTCAAAAATTTTCAATT
RC-M45	GGAATCATCAAGCCGTTTTTATTTGTTATATA
RC-M46	TCGCCATATTTAACAACGTTGCGGGGTTTTAAGCCCAA
RC-M47	CCAACAGTGTGTGCCCGTATAAACAGTTAACCAGAGC
RC-M48	ACTATATGCTCCGGCTTAGGTTGGTCATCGTA
RC-M51	TAAAACATCTTTAATGCGCGAACTTAATTGCG
RC-M52	CTATTAGTCGCCATTAAAAATACCATAGATTA
RC-M53	GAGCCGTCTAGACTTTACAAACAATTCGACAA
RC-M54	AATCGCGCAAAAGAAGTTAGTTAGCTTAAACAGCTTGATACGCCCACGC
RC-M55	TTTTTAACTAAATGCTGATGCAAAATTGAGAA
RC-M56	CAAGACAAAAATCATAGGTCTGAGACAAACAT
RC-M59	CACCAGCAGGCACAGATTTAATTTCTCAATCATAAGGGAAC
RC-M60	TGCTGGTAATATCCAGAACAATATAAGCGTAA
RC-M61	GAATACGTGAAGATAAAACAGAGGATCTAAAA
RC-M62	TATCTTTAAAATCCTTTGCCCGAACCGCGACCTGC
RC-M63	CGAAACAAAGTAATAACGGA
RC-M64	TTCGCCTGCAAAATTAATTACATTAATAGTGA
RC-M65	ATTTATCAAGAACGCGAGAAAACTAGTATAAAGCCAATAAAGAATACAC
RC-M66	ATATGCGTTATACAAATTCTTACCTTTTCAAA
RC-M67	TATATTTTGACGCTGAGAAGAGTCTAACAATT
RC-M69	ATTTGTATCATCGCTTCTGAATTACAGTAACA
RC-M71	TCAGTATTAACCCTTCTGACCTGATACCGCCA
RC-M72	GCCATTGCAACAGGAAAAACGCTCTGGCCAAC
RC-M73	AGAGATAGAACACCGCCTGCAACAAAATCAAC
RC-M74	AGTAGAAAAGTTTGAGTAACATTA
RC-M75	TTTGGATTATACCTGATAAATTGTGTCGAAATCGTTATTA
RC-M76	GTACCTTTATTACCTTTTTAATGCGATAGCT
RC-M77	TAGATTAAAGTTAATTCGATCTTCTTAGTATC
RC-M78	TCATAATTACTAGAAAAAGCCTGTTGACCTAA
RC-M79	ATTTAATGATCCTTGAAAACATAGGAAACAGT
RC-M80	ACATAAATACGTCAGATGAATATATGGAAGGA
RC-M81	ATTGAACCAATATAATCCTGATTGTCATTTTG
RC-M82	CGGAACAATATCTGGTCAGTTGGCGTGCCACG
RC-M83	CTGAGAGCAATAAAAGGGACATTCATGGAAAT
RC-M84	ACCTACATTTTGACGCTCAATCGTCAGTGCGC
RC-M85	CGACCAGTCAGCAGCAAATGAAAATCAAACCC
RC-M86	TCAATCAAAGAAACCACCAGAAGGATGATGGC
RC-M87	AATTCATCAACCATATCAAAATTATAGATTTT
RC-M88	CAGGTTTACAATATATGTGAGTGATTAATTTT
RC-M89	CCCTTAGAGTTTGAAATACCGACCCACCGGAA
RC-M90	AAAAGGGTAAGATTGTATAAGCAAAAATTCGC
RC-M91	AATAACCTTTAGAACCCTCATATAAAAGATTC
RC-M92	GAAAGACTCAATTCTGCGAACGAGAAATGGTC
RC-M93	CATAGTAATGACTATTATAGTCAGGGAAGCCC
RC-M94	TAACAAAGTTAGGAATACCACATTTTACGAGG
RC-M95	GCTGGCTGACCTTCATCAAGAGTAAATCAACG
RC-M96	GTTGAGATCTGCTCATTCAGTGAAGCGCATAG
RC-M97	CTTTACCCGAGCAACACTATCATAATTCATCA
RC-M98	TTGATTCCTCAAATATCGCGTTTTAATCAGGT

RC-M99	AAAAATTTGTTTAGCTATATTTTCTGTAACAG
RC-M100	AAAACAGGGAGAAAGGCCGGAGACGCAAGGAT
RC-M101	GTTAAATTTTTGTTAAATCAGCTCAAGCCCCA
RC-M102	CACCATCACGGTTGATAATCAGAAATTTTTTA
RC-M103	CGCGAGCTAAGCCTTTATTTCAACAGTCAAAT
RC-M104	CTTCAAAGTGGAAGTTTCATTCCAATTTGGGG
RC-M105	TTACCAGAATGACCATAAATCAAAAATTCGAG
RC-M106	GCCCTGACTATTACAGGTAGAAAGACCCTCGT
RC-M107	ACAGATGAACGGTGTACAGACCAGTAAGGCTT
RC-M108	AACAACATGAGAACACCAGAACGAGAAAGAGG
RC-M110	ACGGTGTCCGAACCAGACCGGAAGAGTTCAGA
RC-M112	ATGTACCCATATGATATTCAACCGAATACTTT
RC-M113	ACCAATAGGAACGCCATCAAAAATTCAATCAT
RC-M114	GATAAATTTCGTAAAACTAGCATGAATTCGCGTCTGGCTGTTCCGAAATCG
RC-M115	ATAGTAGTAACATTATGACCCTGTTTCTAGCT
RC-M116	CAAACTCCAACAGTTGAGTGTTGTTCGTAGAAGAACTCAAACTTTGAATGG
RC-M117	GAGGCTTTCTCAAATGCTTTAAAC
RC-M118	TTGGGCTTTACGTTAATAAAACGAAATAGCGA
RC-M119	CGAACTGACCAACTTTGTAGTAAA
RC-M120	GAAAAATCGAGATGGTTCAATATTTATCGGCCT
RC-M123	AACGGTAAAATGCCGGAGAGGGTAAATCGGTT
RC-M124	TTAAATGTGAGCGAGTAACAACTTAAGGAAACCGAGGAAA
RC-M125	CTGGAGCAAACAAGAGCATCAACA
RC-M126	CTGAATCTAAATCATACAGGCAAGTCAGAGCATGAAAGGGGCTGGGGTG
RC-M127	GGTAATAGGCGGAATCGTCATAAATTTAATTGCTCCTTTTCTTAATTG
RC-M128	TCATTGTGTTATACCAGTCAGGACCCAGAGGG
RC-M129	AACGAGGCGCAGACGGAACTTTAA
RC-M130	CTGGCTCAAATTACCTTATGCGATAATGACAA
RC-M132	GCTTAGAGGATAAGAGGTCATTTTTGAAACAT
RC-M134	CTGAGAGTCTACAAAGGCTATCAGACTTGAGC
RC-M135	CATTTGGGATTATCACCGTCACCGGTCATTGC
RC-M136	CTCAGAGCACCGCCACCCTCAGAGATTAAGCA
RC-M137	GAAAGTATTCGGAACCTATTATTCTGCGGATG
RC-M138	CCACAGACACAAACTACAACGCCTGATAGCGT
RC-M139	CAACCATCCGATAGTTGCGCCGACTTTAAGAA
RC-M140	ATAACCGATCATCTTTGACCCCCAGCGATTATACCAAGTTCATGTTACTTAGCCGG
RC-M142	TGCCTATTTAAGAGGCTGAGACTCGAGTTTCG
RC-M144	AAAGGTGAAATTAGAGCCAGCAAAAGCCGCCA
RC-M145	CGCAATAATAACGGAATATTCATT
RC-M146	TAGCACCAAAATATTGTAGTACCGCAATAAGAGAATATAAA
RC-M147	CGCCGCCAGAACCGCCTCCCTCAGATCACCAG
RC-M148	CTAAAGTTCATGTACCGTAACACTCTCAAGAGAAGGATTAGGATTA
RC-M149	TAAAACACTATATTCGGTCGCTGATTTCGAGGAGAATTTCGTAACGAT
RC-M150	GGGAGTTAAACGAAAGAGGCGTCGCTCAACAGTAGGGCTTATCCAATCG
RC-M153	AGACTCCTTTGAGGGAGGGAAGGTTTACCATTAGCAAGGCACCAGAGC
RC-M154	AGTATGTTAGCAAACGTAGAAAATGCGCCAAA
RC-M155	TCACCAATGGCGACATTCAACCGATATTACGC
RC-M156	TCAGACGAAATCAAAATCACCGGACGGAAACG
RC-M157	CCAGGCGGTTTTAACGGGGTCAGTGAGGCAGG
RC-M158	AATGAATTCATTTTCAGGGATAGCGCTCAGTA
RC-M159	TTTTGCGGGAGCCTTTAATTGTATCGTTAGTA
RC-M160	GCCACTACGAAGGCACCAACCTAAAAGGCCGC
RC-M161	TCCAAAAGGATCGTCACCCTCAGCTACGTAAT
RC-M162	ACCACCCTTTCTGTATGGGATTTTAAAAAGGC
RC-M163	GTAATAAGATAAGTGCCGTCGAGATCAGAGCC
RC-M164	CTTTTCATTTGGCCTTGATATTCAGTGTACTG
RC-M165	GACAAAAGGAAACCATCGATAGCATTTGCCAT
RC-M166	AAAGGTGGCAACATATAAAAGAAACACAATCA
RC-M167	ATCAGTAGTTCATATGGTTTACCAACATACAT
RC-M168	TGGATCTTAGCCCCCTTATTAGCGGCACCGTA
RC-M169	ATAAGTATTTTTGATGATACAGGACAAACGAA

RC-M170	ACTTTCAACTCAGAACCGCCACCCGGGTTGAT
RC-M171	ACAGCATCGTTGAAAATCTCCAAAGCTAAACA
RC-M172	GAAGTTTCCATTAAACGGGTAAAAAGCGAAAG
RC-M173	TTTTTCACGGAACGAGGGTAGCAATTCATGAG
RC-M174	CCGCCACCCAGTTTCAGCGGAGTGATAATAAT
RC-M175	TACATGGCAGCCCGGAATAGGTGTCCTCAGAA
RC-M176	TCGGTCATCATTAAAGCCAGAATGAAGCGTCA
RC-M177	ATAGAAAACGACAGAATCAAGTTTCGGCATTT
RC-M27-AS	CCATATTAATTAGACGGGAGAATTACAAAGTTACC
RC-M29-AS	AAGCGCCAATTAAGTTGGGTAACGAACATACG
RC-M37-AS	GATTTTTTACAGAGAGAATAACATAAAAACAG
RC-M38-AS	TTGGGAAGCAGCTGGCTTAAAGCTAGCTATTTTTGAGAGAT
RC-M49-AS	ACCTGAGCAGAGGCGAATTATTCAGAAAATAG
RC-M50-AS	AGAAGTATAATAGATAATACATTTCTCTTCGC
RC-M57-AS	CAAGAAAAATTGCTTTGAATACCAAGTTACAA
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RC-M70-AS	ATTTTAAAGGAATTGAGGAAGGTTTGAGGCGG
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RC-M111-AS	TGCGGGAGGAAAAGGTGGCATCAAACTAAAGT
RC-M121-AS	GAATCCCCTGCAAAAGAAGTTTTGGTTGGGAA
RC-M131-AS	CCAATACTTAAAATGTTTAGACTGGTAGCATT
RC-M133-AS	ATAAAGCCGCAAAGAATTAGCAAACCACCACC
RC-M141-AS	TCACCAGTAGCCCTCATATGATGAAAGACTACC
RC-M143-AS	CCCTCAGACGCCACCAGAACCACCATGCCCCC
RC-M122-AS	GTACCAAAAGCATTAACATCCAATGGTGCTGTAGCTCAACATGTTT
RC-M151-AS	TAGGAACCTTGTCGTCTTTCCAGACGGTTTATCAGCTTGCGGCTTGCA
RC-M152-AS	CACCACCGGCATTGACAGGAGGTTGCCTTGAGTAACATAATTTAGGCAG

Modified DNA sequences corresponding to the design of Figure 1:

Loop GQ1	TAACCTTGCTTCTGTTTTTGGGTTAGGGTTAGGGTTAGGGTTTTAATCGTCGCTATTAA
Loop GQ2	TAGCACGTAAAACATTTTTGGGTTAGGGTTAGGGTTAGGGTTTTAATAAAGAAATTGCG
Loop GQ3	GCGGAATTATCATCTTTTTGGGTTAGGGTTAGGGTTAGGGTTTTATTCCTGATTATCAG
Loop GQ4	TCTAAAGCATCACCTTTTTGGGTTAGGGTTAGGGTTAGGGTTTTGCTGAACCTCAAATA
Blunt RE1	TTTTGTTAAATAAGAATAAAGTGTGATAAATAAGGCTTTT
Blunt RE6	TTTTACATTGGCAGATTCACCTGAAATGGATTATTTTTTT
Loop Complementary G1	CCTAACCCTTTTTTGAGTAATGTGTAGGTTTTTAAATGCAATGCCTTTTT
Loop Complementary G2	CCTAACCCTTTTTATTAGATACATTTCGCTAGATTTAGTTTGACCTTTTT
Loop Complementary G3	CCTAACCCTTTTTATCAAAAAGATTAAGAAAGCAAAGCGGATTGCTTTTT
Loop Complementary G4	CCTAACCCTTTTTATAACGCCAAAAGGAACAACTAATGCAGATACTTTTT
Blunt DE1	TTTTCGTTAATATTTTGTTAATATTTAAATTGTAAATTTT
Blunt DE6	TTTTGGATATTCATTACCCAATCTTCGACAAGAACCTTTT

Modified DNA sequences corresponding to the design of Figure 4:

Linear GQ1	GGGTTAGGGTTAGGGTTAGGGTTTTAAATCGTCGCTATTAAATAACCTTGCTTCTGTTTT
Linear GQ2	GGGTTAGGGTTAGGGTTAGGGTTTTAAATAAAGAAATTGCGTTAGCACGTAAAACAGTTT
Linear GQ3	GGGTTAGGGTTAGGGTTAGGGTTTTTATTCCTGATTATCAGAGCGGAATTATCATCATTT
Linear GQ4	GGGTTAGGGTTAGGGTTAGGGTTTTTGCTGAACCTCAAATAATCTAAAGCATCACCTTTT
Linear Complementary G1	CCTAACCCTTTTTTGAGTAATGTGTAGGTTTTTAAATGCAATGCCTTTTT
Linear Complementary G2	CCTAACCCTTTTTATTAGATACATTTCGCTAGATTTAGTTTGACCTTTTT
Linear Complementary G3	CCTAACCCTTTTTATCAAAAAGATTAAGAAAGCAAAGCGGATTGCTTTTT
Linear Complementary G4	CCTAACCCTTTTTATAACGCCAAAAGGAACAACTAATGCAGATACTTTTT
Blunt DE1	TTTTCGTTAATATTTTGTTAATATTTAAATTGTAAATTTT
Blunt DE6	TTTTGGATATTCATTACCCAATCTTCGACAAGAACCTTTT
Blunt RE1	TTTTGTTAAATAAGAATAAAGTGTGATAAATAAGGCTTTT
Blunt RE6	TTTTACATTGGCAGATTCACCTGAAATGGATTATTTTTTT

Modified DNA sequences corresponding to design in Figure S6 (G3):

Blunt RE1	TTTTGTTAAATAAGAATAAAGTGTGATAAATAAGGCTTTT
Short G LEFT1	ATAACCTTGCTTCTGTTTTTGGGTTAGGGTTTTAAATCGTCGCTATTAA

Short G LEFT2 TTAGCACGTAAAACAGTTTTTGGGTTAGGGTTTTAAATAAAGAAATTGCG
Short G LEFT3 AGCGGAATTATCATCATTTTTGGGTTAGGGTTTTTATTCCTGATTATCAG
Short G LEFT4 ATCTAAAGCATCACCTTTTTTGGGTTAGGGTTTTTTGCTGAACCTCAAATA
Blunt RE6 TTTTACATTGGCAGATTCACCTGAAATGGATTATTTTTTT
Blunt DE1 TTTTCGTTAATATTTTGTTAATATTTAAATTGTAAATTTT
Short G RIGHT1 TTTTAAATGCAATGCCTTTTTGGGTTAGGGTTTTTTGAGTAATGTGTAGGT
Short G RIGHT2 TAGATTTAGTTTGACCTTTTTGGGTTAGGGTTTTTATTAGATACATTTCGC
Short G RIGHT3 AAGCAAAGCGGATTGCTTTTTGGGTTAGGGTTTTTATCAAAAAGATTAAGA
Short G RIGHT4 CAACTAATGCAGATACTTTTTGGGTTAGGGTTTTTATAACGCCAAAAGGAA
Blunt DE6 TTTTGGATATTCATTACCCAATCTTCGACAAGAACCTTTT

Modified DNA sequences corresponding to design in Figure S6 (G9):

Blunt RE1 TTTTGTTAAATAAGAATAAAGTGTGATAAATAAGGCTTTT
Full G LEFT1 ATAACCTTGCTTCTGTTTTGGGGGGGGGTTTTGGGGGGGGGTTTAAATCGTCGCTATTAA
Full G LEFT2 TTAGCACGTAAAACAGTTTGGGGGGGGGTTTTGGGGGGGGGTTTAAATAAAGAAATTGCG
Full G LEFT3 AGCGGAATTATCATCATTTGGGGGGGGGTTTTGGGGGGGGGTTTTATTCCTGATTATCAG
Full G LEFT4 ATCTAAAGCATCACCTTTTGGGGGGGGGTTTTGGGGGGGGGTTTTGCTGAACCTCAAATA
Blunt RE6 TTTTACATTGGCAGATTCACCTGAAATGGATTATTTTTTT
Blunt DE1 TTTTCGTTAATATTTTGTTAATATTTAAATTGTAAATTTT
Full G RIGHT1 TTTTAAATGCAATGCCTTTGGGGGGGGGTTTTGGGGGGGGGTTTTGAGTAATGTGTAGGT
Full G RIGHT2 TAGATTTAGTTTGACCTTTGGGGGGGGGTTTTGGGGGGGGGTTTATTAGATACATTTCGC
Full G RIGHT3 AAGCAAAGCGGATTGCTTTGGGGGGGGGTTTTGGGGGGGGGTTTATCAAAAAGATTAAGA
Full G RIGHT4 CAACTAATGCAGATACTTTGGGGGGGGGTTTTGGGGGGGGGTTTATAACGCCAAAAGGAA
Blunt DE6 TTTTGGATATTCATTACCCAATCTTCGACAAGAACCTTTT