

Electronic supplementary information (ESI)

Enhancing the stability of DNA origami nanostructures: staple strand redesign versus enzymatic ligation[†]

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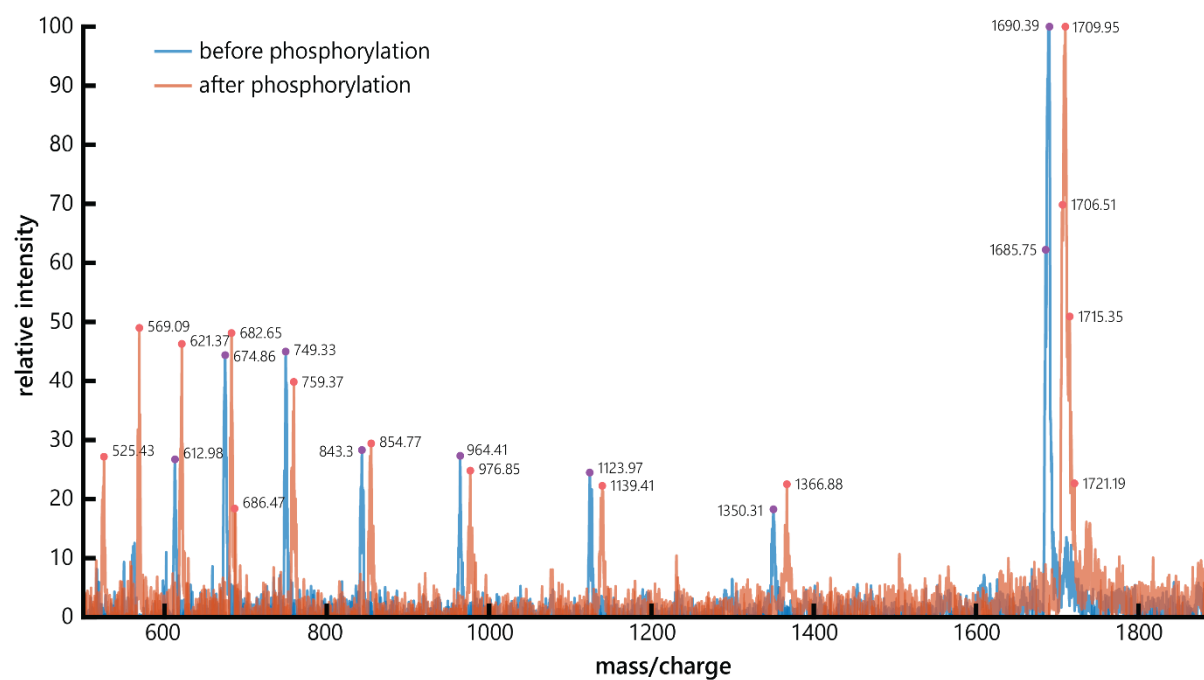


Figure S1: Exemplary mass spectra for staple strand t-11s28e with molecular weights of 6767.49 Da before and 6846.59 Da after phosphorylation. Multiple peaks occur, representing various degrees of deprotonation.

Table S1: Sequences of all staple strands. Oligonucleotides that were omitted in lieu of the elongated bridging staples are highlighted in orange.

Rothemund's notation	Sequence (5' to 3')
<i>Trapezoid staples</i>	
t1s18h	AATACTGCGGAATCGTAGGGGGTAATAGTAAAATGTTTAGACT
t1s28h	TCTTTGATTAGTAATAGTCTGTCCATCACGCAAATTAACCGTT
t1s8h	CAGAAGGAAACCGAGGTTTTTAAGAAAAGTAAGCAGATAGCCG
t1s10g	GACGGGAGAATTAACCTCGGAATAAGTTTATTTCCAGCGCC
t1s12i	TCATATGTGTAATCGTAAACTAGTCATTTTC
t1s14i	GTGAGAAAATGTGTAGGTAAAGATACAACCTT
t1s16i	GGCATCAAATTTGGGGCGCGAGCTAGTTAAAG
t1s18i	TTCGAGCTAAGACTTCAAATATCGGGAACGAG
t1s20g	GAATACCACATTCAACTTAAGAGGAAGCCCGATCAAAGCG
t1s22i	TCGGGAGATATACAGTAACAGTACAAATAATT
t1s24i	CCTGATTAAAGGAGCGGAATTATCTCGGCCTC
t1s26i	GCAAATCACCTCAATCAATATCTGCAGGTCGA
t1s28i	CGACCACTACATTGGCAGATTCACCTGATTGC
t1s2i	CGGGGTTTCCTCAAGAGAAGGATTTTGAATTA
t1s30g	TTGACGAGCACGTATACTGAAATGGATTATTTAATAAAAAG
t1s4i	AGCGTCATGTCTCTGAATTTACCGACTACCTT
t1s6i	TTCATAATCCCCTTATTAGCGTTTTTCTTACC
t1s8i	ATGGTTTATGTCACAATCAATAGATATTAAAC
t2s11g	AGAAAAGCCCCAAAAAGAGTCTGGAGCAAACAATCACCAT
t2s13g	ACAGTCAAAGAGAATCGATGAACGACCCCGGTTGATAATC
t2s15f	ATAGTAGTATGCAATGCCTGAGTAGGCCGGAG
t2s17f	AACCAGACGTTTAGCTATATTTTCTTCTACTA
t2s1g	GATAAGTGCCGTCGAGCTGAAACATGAAAGTATACAGGAG
t2s21g	CCTGATTGCTTTGAATTGCGTAGATTTTCAGGCATCAATA
t2s23g	TGGCAATTTTTTAACGTCAGATGAAAACAATAACGGATTTCG
t2s25f	AAGGAATTACAAAGAAACCACCAGTCAGATGA
t2s27f	GGACATTCACCTCAAATATCAAACACAGTTGA
t2s3g	TTTGATGATTAAGAGGCTGAGACTTGCTCAGTACCAGGCG
t2s5f	CCGGAACCCAGAATGGAAAGCGCAACATGGCT
t2s7f	AAAGACAACATTTTCGGTCATAGCCAAAATCA
t3s10g	GTCAGAGGGTAATTGATGGCAACATATAAAAGCGATTGAG
t3s14e	CAATATGACCCTCATATATTTTAAAGCATTAA
t3s16e	CATCCAATAAATGGTCAATAACCTCGGAAGCA
t3s18g	AACTCCAAGATTGCATCAAAAAGATAATGCAGATACATAA
t3s20g	CGCCAAAAGGAATTACAGTCAGAAGCAAAGCGCAGGTCAG
t3s24e	TAATCCTGATTATCATTTTGCAGGAGAGGAAGG
t3s26e	TTATCTAAAGCATCACCTTGCTGATGGCCAAC
t3s28g	AGAGATAGTTTGACGCTCAATCGTACGTGCTTTCCTCGTT
t3s30g	AGAATCAGAGCGGGAGATGGAAATACCTACATAACCTTTC
t3s4e	TGTACTGGAAATCCTCATTAAGCAGAGCCAC
t3s6e	CACCGGAAAGCGCGTTTTTCATCGGAAGGGCGA
t3s8g	CATTCAACAAACGCAAAGACACCAGAACACCCTGAACAAA
t4s11g	GCAAATATTTAAATTGAGATCTACAAAGGCTACTGATAAA
t4s13g	CGTTCTAGTCAGGTCATTGCCTGACAGGAAGATTGTATAA

t4s15f	CAGGCAAGATAAAAAATTTTGTAGAATATTCAAC
t4s17f	GATTAGAGATTAGATACATTTTCGCAAATCATA
t4s1g	TAGCCCGGAATAGGTGAATGCCCCCTGCCTATGGTCAGTG
t4s21g	GCGCAGAGGCGAATTAATTATTTGCACGTAAATTCTGAAT
t4s23g	GATTATACACAGAAATAAAGAAATACCAAGTTACAAAATC
t4s25f	TAGGAGCATAAAAGTTTGAGTAACATTGTTTG
t4s27f	TGACCTGACAAATGAAAAATCTAAAATATCTT
t4s3g	TTTAACGGTTCGGAACCTATTATTAGGGTTGATATAAGTA
t4s5f	CTCAGAGCATATTACAAAACAAATTAATAAGT
t4s7f	GGAGGGAATTTAGCGTCAGACTGTCCGCCTCC
t5s10g	GATAACCCACAAGAATGTTAGCAAACGTAGAAAATTATTC
t5s14e	TTAATGCCTTATTTCAACGCAAGGGCAAAGAA
t5s16e	TTAGCAAATAGATTTAGTTTGACCAGTACCTT
t5s18g	TAATTGCTTTACCCTGACTATTATGAGGCATAGTAAGAGC
t5s20g	AACACTATCATAACCCATCAAAAATCAGGTCTCCTTTTGA
t5s24e	AATGGAAGCGAACGTTATTAATTTCTAACAAC
t5s26e	TAATAGATCGCTGAGAGCCAGCAGAAGCGTAA
t5s28g	GAATACGTAACAGGAAAAACGCTCCTAAACAGGAGGCCGA
t5s30g	TTAAAGGGATTTTAGATACCGCCAGCCATTGCGGCACAGA
t5s4e	CCTTGAGTCAGACGATTGGCCTTGCGCCACCC
t5s6e	TCAGAACCCAGAATCAAGTTTGCCGGTAAATA
t5s8g	TTGACGGAAATACATACATAAAGGGCGCTAATATCAGAGA
t6s15g	ATAAAGCCTTTGCGGGAGAAGCCTGGAGAGGGTAG
t6s17f	TAAGAGGTCAATTCTGCGAACGAGATTAAGCA
t6s25g	TCAATAGATATTAAATCCTTTGCCGGTTAGAACCT
t6s27f	CAATATTTGCCTGCAACAGTGCCATAGAGCCG
t6s5g	CAGAGCCAGGAGGTTGAGGCAGGTAACAGTGCCCG
t6s7f	ATTAAAGGCCGTAATCAGTAGCGAGCCACCCT
t7s10g	ATAAGAGCAAGAAACATGGCATGATTAAGACTCCGACTTG
t7s14e	ATGACCCTGTAATACTTCAGAGCA
t7s16e	TAAAGCTATATAACAGTTGATTCCCATTTTTTG
t7s18g	CGGATGGCACGAGAATGACCATAATCGTTTACCAGACGAC
t7s20g	GATAAAAACCAAATATTAAACAGTTCAGAAATTAGAGCT
t7s24e	ACAATTCGACAACCTCGTAATACAT
t7s26e	TTGAGGATGGTCAGTATTAACACCTTGAATGG
t7s28g	CTATTAGTATATCCAGAACAATATCAGGAACGGTACGCCA
t7s30g	GAATCCTGAGAAGTGTATCGGCCTTGCTGGTACTTTAATG
t7s4e	GCCGCCAGCATTGACACCACCCTC
t7s6e	AGAGCCGCACCATCGATAGCAGCATGAATTAT
t7s8g	CACCGTCACCTTATTACGCAGTATTGAGTTAAGCCCAATA
t8s17g	TAATTGCTTGGAAGTTTCATTCCAAATCGGTTGTA
t8s27g	CGCGAACTAAAACAGAGGTGAGGCTTAGAAGTATT
t8s7g	AGCCATTTAAACGTCACCAATGAACACCAGAACCA
t9s10h	TATCTTACCGAAGCCCAAACGCAATAATAACGAAAATCACCAG
t9s16e	ACTAAAGTACGGTGTCTGAATATAA
t9s18g	TGCTGTAGATCCCCCTCAAATGCTGCGAGAGGCTTTTGCA
t9s20h	AAAGAAGTTTTTGCCAGCATAAATATTCATTGACTCAACATGTT
t9s26e	ACCACCAGCAGAAGATGATAGCCC

t9s28g	TAAAACATTAGAAGAACTCAAACCTTTTATAATCAGTGAG
t9s30h	GCCACCGAGTAAAAGAACATCACTTGCCTGAGCGCCATTAAAA
t9s6e	CCATTAGCAAGGCCGGGGGAATTA
t9s8g	GAGCCAGCGAATACCCAAAAGAACATGAAATAGCAATAGC
t-10s17h	ACCAACCTAAAAAATCAACGTAACAAATAAATTGGGCTTGAGA
t-10s27h	AACTCACATTATTGAGTGTTGTTCCAGAAACCGTCTATCAGGG
t-10s7h	ACGACAATAAATCCCGACTTGCGGGAGATCCTGAATCTTACCA
t-12s19h	CCTGACGAGAAACACCAGAACGAGTAGGCTGCTCATTCAGTGA
t-12s29h	ACGTGGACTCCAACGTCAAAGGGCGAATTTGGAACAAGAGTCC
t-12s9h	TGCTATTTTGCACCCAGCTACAATTTTGTTTTGAAGCCTTAAA
t-1s10e	AGAGAATAACATAAAAAACAGGGAAGCGCATTA
t-1s12i	AGGGATAGCTCAGAGCCACCACCCCATGTCAA
t-1s14e	ATTTTCTGTCAGCGGAGTGAGAATACCGATAT
t-1s14i	CAACAGTTTATGGGATTTTGCTAATCAAAAGG
t-1s16e	ATTTCGGTCTGCGGGATCGTCACCCGAAATCCG
t-1s16i	GCCGCTTTGCTGAGGCTTGCAGGGGAAAAGGT
t-1s18g	CGACCTGCGGTCAATCATAAGGGAACGGAACAACATTATT
t-1s18i	GCGCAGACTCCATGTTACTTAGCCCGTTTTAA
t-1s20e	ACAGGTAGAAAGATTTCATCAGTTGAGATTTAG
t-1s22i	CGCGTCTGATAGGAACGCCATCAACTTTTACA
t-1s24e	CAGTTTGACGCACTCCAGCCAGCTAAACGACG
t-1s24i	AGGAAGATGGGGACGACGACAGTAATCATATT
t-1s26e	GCCAGTGCGATCCCCGGGTACCGAGTTTTTCT
t-1s26i	CTCTAGAGCAAGCTTGCATGCCTGGTCAGTTG
t-1s28g	TTTCACCAGCCTGGCCCTGAGAGAAAGCCGGCGAACGTGG
t-1s28i	CCTTCACCGTGAGACGGGCAACAGCAGTCACA
t-1s2i	CCTTTTTTTCATTTAACAATTTTCATAGGATTAG
t-1s30e	CGAGAAAGGAAGGGAAGCGTACTATGGTTGCT
t-1s4e	TTATCAAACCGGCTTAGGTTGGGTAAGCCTGT
t-1s4i	TTTAACCTATCATAGGTCTGAGAGTTCCAGTA
t-1s6e	TTAGTATCGCCAACGCTCAACAGTCGGCTGTC
t-1s6i	AGTATAAAATATGCGTTATACAAAGCCATCTT
t-1s8g	TTTCCTTAGCACTCATCGAGAACAATAGCAGCCTTTACAG
t-1s8i	CAAGTACCTCATTTCCAAGAACGGGAAATTCAT
t-2s11	CCTCAGAACCGCCACCCAAGCCCAATAGGAACGTAAATGA
t-2s13g	AGACGTTACCATGTACCGTAACACCCCTCAGAACCGCCAC
t-2s15f	CACGCATAAGAAAGGAACAATAAGTCTTTCC
t-2s17f	ATTGTGTCTCAGCAGCGAAAGACACCATCGCC
t-2s1g	AAAACAAAATTAATTAAATGGAAACAGTACATTAGTGAAT
t-2s21g	GCTCATTTTTTAACCAGCCTTCCTGTAGCCAGGCATCTGC
t-2s23g	GTAACCGTCTTTCATCAACATTAATAATTTTTGTAAATCA
t-2s25f	ACGTTGTATTCCGGCACCGCTTCTGGCGCATC
t-2s27f	CCAGGGTGGCTCGAATTCGTAATCCAGTCACG
t-2s3g	AGAGTCAAAAATCAATATATGTGATGAAACAAACATCAAG
t-2s5f	ACTAGAAATATATAACTATATGTACGCTGAGA
t-2s7f	TCAATAATAGGGCTTAATTGAGAATCATAATT
t-3s10g	AACGTCAAAAATGAAAAGCAAGCCGTTTTTATGAAACCAA
t-3s14e	GTTTTGTCAGGAATTGCGAATAATCCGACAAT

t-3s16e	GACAACAAGCATCGGAACGAGGGTGAGATTTG
t-3s18g	TATCATCGTTGAAAGAGGACAGATGGAAGAAAAATCTACG
t-3s20g	TTAATAAAACGAACTAACCGAACTGACCAACTCCTGATAA
t-3s24e	TGTAGATGGGTGCCGGAACAGGAACGCCAG
t-3s26e	GGTTTTCCATGGTCATAGCTGTTTGAGAGGCG
t-3s28g	GTTTGCGTCACGCTGGTTTGCCCCAAGGGAGCCCCGATT
t-3s30g	TAGAGCTTGACGGGGAGTTGCAGCAAGCGGTCATTGGGCG
t-3s4e	GATTAAGAAATGCTGATGCAAATCAGAATAAA
t-3s6e	CACCGGAATCGCCATATTTAACAAAATTTACG
t-3s8g	AGCATGTATTTTCATCGTAGGAATCAAACGATTTTTTGT
t-4s11g	AGGTTTAGTACCGCCATGAGTTTCGTCACCAGGATCTAAA
t-4s13g	AGCGTAACTACAACTACAACGCCTATCACCGTACTCAGG
t-4s15f	TAGTTGCGAATTTTTTTCACGTTGATCATAGTT
t-4s17f	GTACAACGAGCAACGGCTACAGAGGATACCGA
t-4s1g	GAGCAAAAAGAAGATGAGTGAATAACCTTGCTTATAGCTTA
t-4s21g	GTTAAAATTCGCATTAATGTGAGCGAGTAACACACGTTGG
t-4s23g	GGATAGGTACCCGTCGGATTCTCCTAAACGTTAATATTTT
t-4s25f	AGTTGGGTCAAAGCGCCATTCGCCCCGTAATG
t-4s27f	CGCGCGGGCCTGTGTGAAATTGTTGGCGATTA
t-4s3g	ACATAGCGCTGTAAATCGTCGCTATTCATTTCAATTACCT
t-4s5f	GTTAAATACAATCGCAAGACAAAGCCTTGAAA
t-4s7f	CCCATCCTCGCCAACATGTAATTTAATAAGGC
t-5s10g	TCCCAATCCAAATAAGATTACCGCGCCCAATAAATAATAT
t-5s16e	AACAGCTTGCTTTGAGGACTAAAGCGATTATA
t-5s18g	CCAAGCGCAGGCGCATAGGCTGGCAGAACTGGCTCATTAT
t-5s20g	ACCAGTCAGGACGTTGGAACGGTGTACAGACCGAAACAAA
t-5s26e	TGCTGCAAATCCGCTCACAATTTCCAGCTGCA
t-5s28g	TTAATGAAGTTTGATGGTGGTTCCGAGGTGCCGTAAAGCA
t-5s30g	CTAAATCGGAACCCTAAGCAGGCGAAAATCCTTCGGCCAA
t-5s6e	GTGTGATAAGGCAGAGGCATTTTCAGTCCTGA
t-5s8g	ACAAGAAAGCAAGCAAATCAGATAACAGCCATATTATTTA
t-6s13f	ACAGACAGCCCAAATCTCCAAAAAAAATTTCTTA
t-6s15c	CGAGGTGAGGCTCCAAAAGGAGCC
t-6s17f	ACCCCCAGACTTTTTTCATGAGGAACTTGCTTT
t-6s23f	CGGCGGATTGAATTCAGGCTGCGCAACGGGGGATG
t-6s25c	TGGCGAAATGTTGGGAAGGGCGAT
t-6s27f	TGTCGTGCACACAACATACGAGCCACGCCAGC
t-6s3f	TCCCTTAGAATAACGCGAGAAAACCTTTACCGACC
t-6s5c	GTTTGAAATTCAAATATATTTTAG
t-6s7f	AATAGATAGAGCCAGTAATAAGAGATTTAATG
t-7s10g	GCCAGTTACAAAATAATAGAAGGCTTATCCGGTTATCAAC
t-7s18g	AAAACACTTAATCTTGACAAGAACTTAATCATTGTGAATT
t-7s20g	ACCTTATGCGATTTTATGACCTTCATCAAGAGCATCTTTG
t-7s28g	TTCCAGTCCTTATAAATCAAAGAGAACCATCACCCAAAT
t-7s30g	CAAGTTTTTTGGGGTCGAAATCGGCAAAATCCGGGAAACC
t-7s8g	GCGCCTGTTATTCTAAGAACGCGATTCCAGAGCCTAATTT
t-8s15f	CGGTTTATCAGGTTTCCATTAAACGGGAATACACT
t-8s17c	GGCAAAAGTAAATACGTAATGCC

t-8s25f	TCTTCGCTATTGGAAGCATAAAGTGTATGCCCGCT
t-8s27c	GCGCTCACAAGCCTGGGGTGCCTA
t-8s5f	TTCTGACCTAAAATATAAAGTACCGACTGCAGAAC
t-8s7c	TCAGCTAAAAAAGGTAAAGTAATT
t-9s10g	ACGCTAACGAGCGTCTGGCGTTTTAGCGAACCCAACATGT
t-9s20g	TGGTTTAATTTCAACTCGGATATTCATTACCCACGAAAGA
t-9s30g	CGATGGCCCACTACGTATAGCCCGAGATAGGGATTGCGTT
ts-rem	GCGCTTAATGCGCCGCTACAGGGC
<i>Bridging staples</i>	
t-5s22e	GTGGGAACAAATTTCTATTTTTGAG
t-5s2e	TTAATTAATTTTTTACCATATCAAA
t-5s12e	TGTAGCATTCCTTTTATAAACAGTT
t-7s4e	TTAATTTTCATCTTAGACTTTACAA
t-9s6e	CTGTCCAGACGTATAACGAACGA
t-11s8e	TCAAGATTAGTGTAGCAATACT
t-7s14e	TTTAATTGTATTTCCACCAGAGCC
t-9s16e	ACTACGAAGGCTTAGCACCATTA
t-11s18e	ATAAGGCTTGCAACAAAGTTAC
t-7s24e	CGGTGCGGGCCTTCCAAAAACATT
t-9s26e	ATGAGTGAGCTTTTAAATATGCA
t-11s28e	ACTATTAAAGAGGATAGCGTCC
<i>Merged bridging staples</i>	
t-12s29h-t-11s28e-t11s18h	ACGTGGACTCCAACGTCAAAGGGCGAATTTGGAACAAGAGTCC ACTATTAAAGAGGATAGCGTCCAATACTGCGGAATCGTAGGGG GTAATAGTAAAATGTTTAGACT
t-8s27c-t-9s26e-t9s16e	GCGCTCACAAGCCTGGGGTGCCTAATGAGTGAGCTTTTAAATA TGCAACTAAAGTACGGTGTGCAATATAA
t-6s25c-t-7s24e-t7s14e	TGGCGAAATGTTGGGAAGGGCGATCGGTGCGGGCCTTCCAAAA ACATTATGACCCTGTAATACTTCAGAGCA
t-12s9h-t-11s8e-t11s28h	TGCTATTTTGCACCCAGCTACAATTTGTTTTGAAGCCTTAAA TCAAGATTAGTGTAGCAATACTTCTTTGATTAGTAATAGTCTG TCCATCACGCAAATTAACCGTT
t-8s7c-t-9s6e-t9s26e	TCAGCTAAAAAAGGTAAAGTAATTCTGTCCAGACGTATAACCGA ACGAACCACCAGCAGAAGATGATAGCCC
t-6s5c-t-7s4e-t7s24e	GTTTGAAATTCAAATATATTTTAGTTAATTTTCATCTTAGACTT TACAAACAATTCGACAACCTCGTAATACAT
t-12s19h-t-11s18e-t11s8h	CCTGACGAGAAACACCAGAACGAGTAGGCTGCTCATTAGTGA TCAAGATTAGTGTAGCAATACTCAGAAGGAAACCGAGGTTTTT AAGAAAAGTAAGCAGATAGCCG
t-8s17c-t-9s16e-t9s6e	GGCAAAAGTAAAATACGTAATGCCACTACGAAGGCTTAGCACC ATTACCATTAGCAAGGCCGGGGGAATTA
t-6s15c-t-7s14e-t7s4e	CGAGGTGAGGCTCCAAAAGGAGCCTTTAATTGTATTTCCACCA GAGCCGCCGCCAGCATTGACACCACCCTC