Electronic Supplementary Information

Photo-controlled DNA Nanotubes as Stiffness Tunable Matrices for Controlling Cellular Behavior

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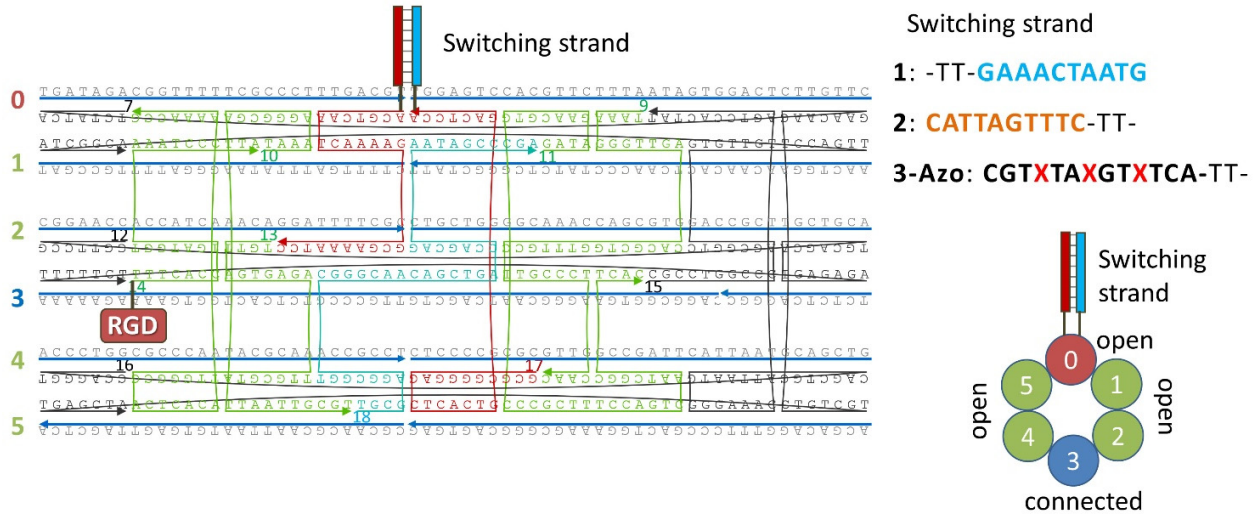

Figure S1. Design of DNA nanotube with switching strands and RGD ligand. DNA helix number (helix 0-5) is indicated in the left side of the design (caDNAno) and the DNA sequences are listed in Table S1 and S2.

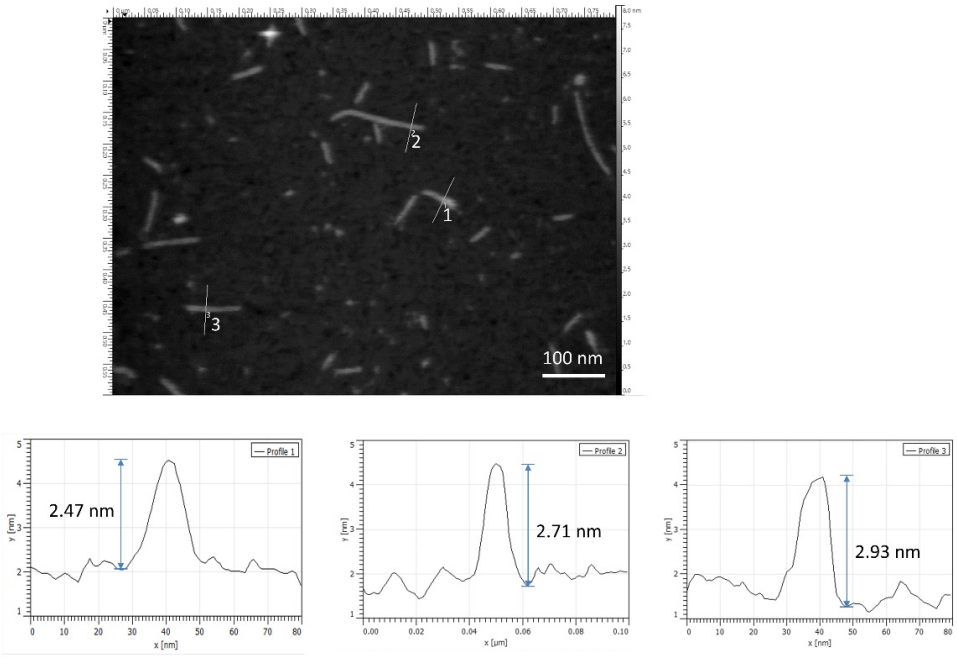

Figure S2. Height measurement of DNA nanotubes without modification. AFM image and the example of height profiles. The height of DNA nanotubes was obtained as 2.67 ± 0.34 nm (SD), which is reasonable for two-layered dsDNA.[1-2]

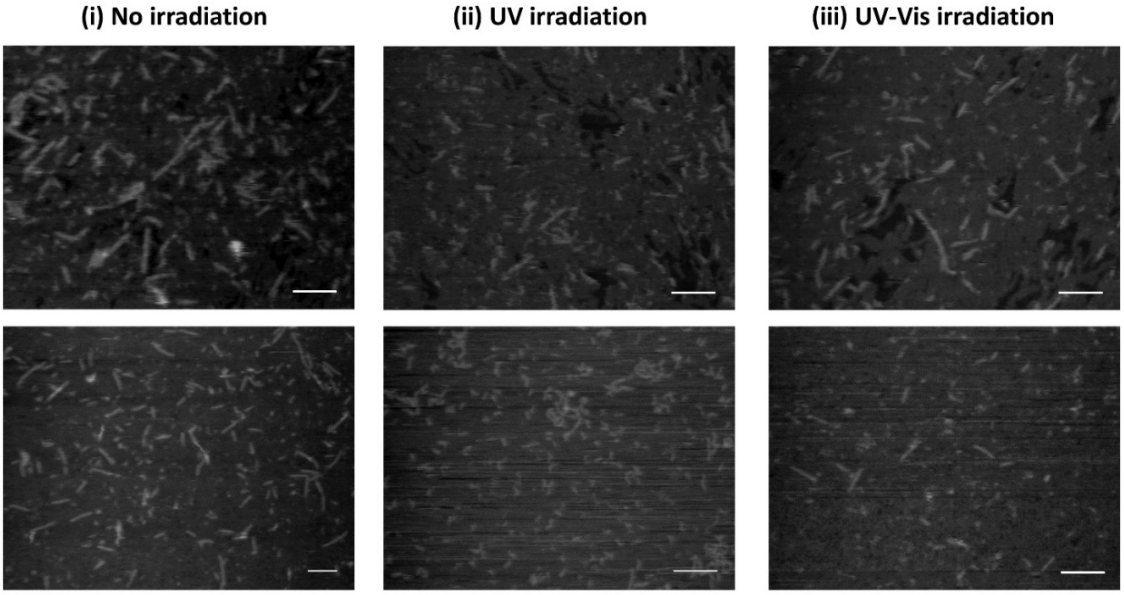

Figure S3. Morphology change of azobenzene-containing DNA nanotubes (Azo-nanotube) with photoirradiation. AFM images of Azo-nanotubes. (i) Initial state of assembled Azo-nanotube. (ii) UV-irradiated Azo-nanotube. (iii) UV-Vis irradiated Azo-nanotube. Scale bars: 100 nm.

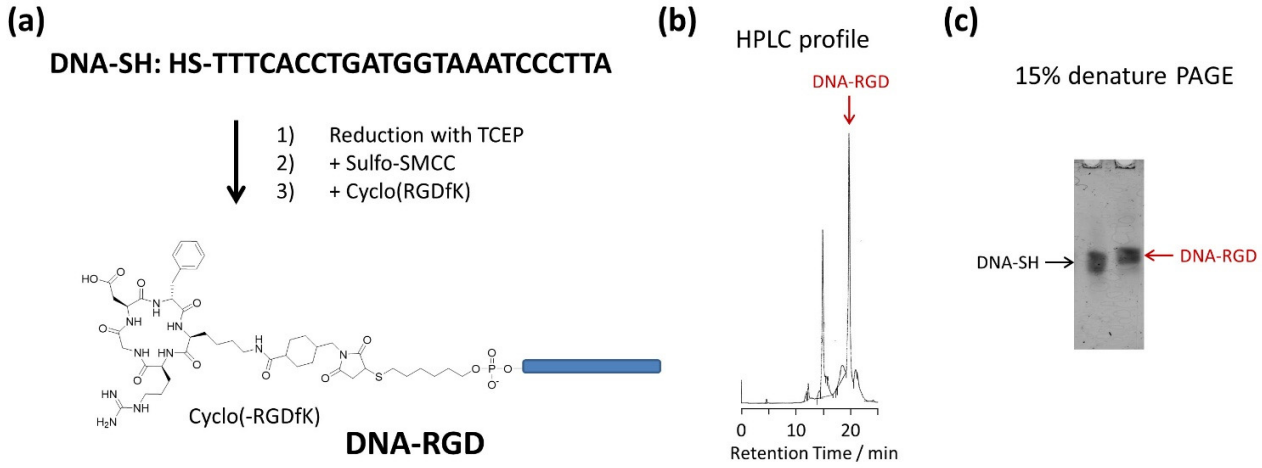

Figure S4. Characterization of the conjugation of RGD to DNA strand. (a) Scheme for the DNA-RGD synthesis. (b) HPLC profile for purification. (c) 15% denaturing PAGE gel (8M urea) of HPLC-purified RGD-conjugated DNA.

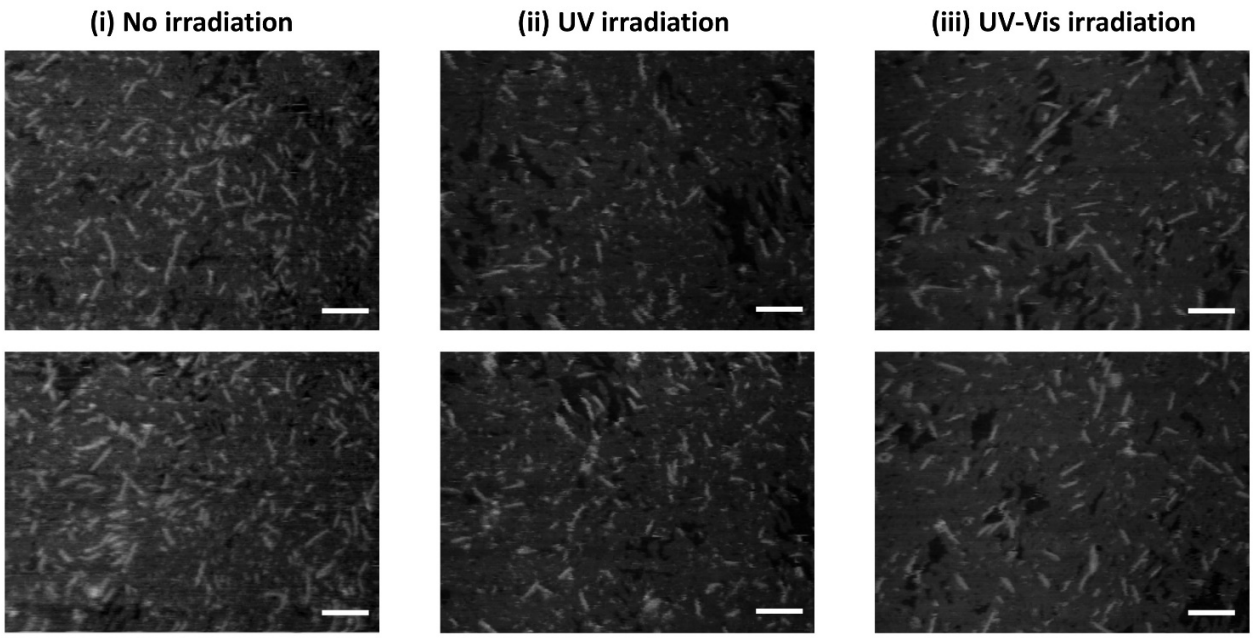

Figure S5. Morphology change of RGD-conjugated Azo-nanotubes with photoirradiation. AFM images of RGD-modified Azo-nanotubes. (i) Initial state of RGD- conjugated Azo-nanotube. (ii) UV-irradiated RGD- conjugated Azo-nanotube. (iii) UV-Vis irradiated RGD- conjugated Azo-nanotube. Scale bars: 100 nm.

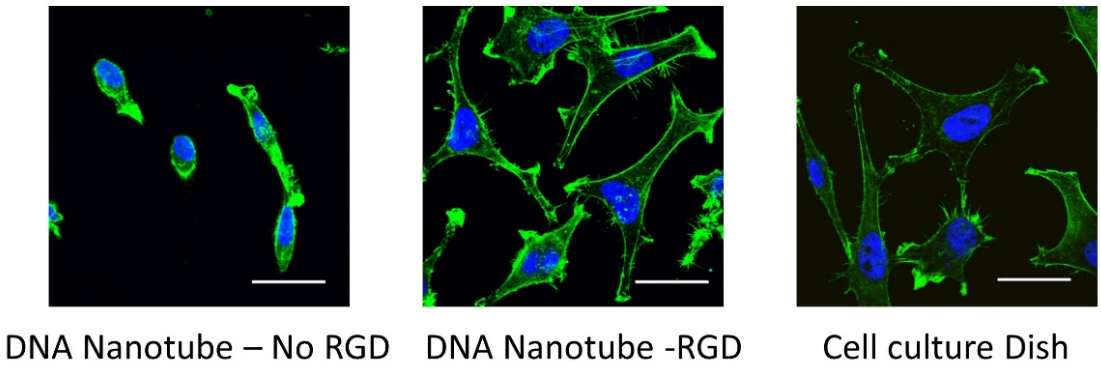

Figure S6. Comparison of cell spreading for different substrates. DNA nanotubes coated glass for cell adhesion and spreading. (a) Confocal images of HeLa cells cultured on three different substrates (DNA nanotube – NO RGD, DNA nanotube – RGD, on cell culture plate). Scale bar 30 μm.

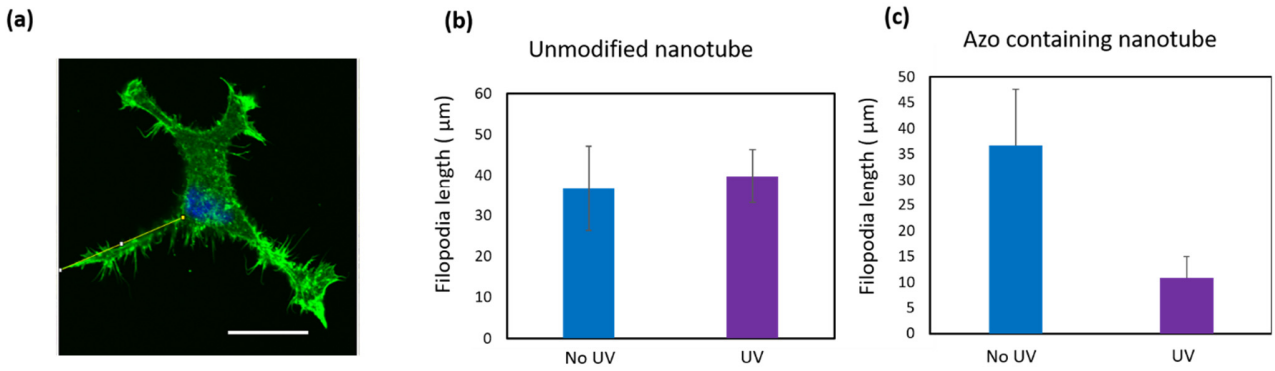

Figure S7. Measurement of the filopodia length. (a) An example image for the measurement of the filopodia length (yellow line in the image). The length of the filopodia from the cell body was manually calculated in each case using image J. Scale bar- 20 µm. (b) Filopodia length of the samples with unmodified nanotubes with no irradiation and with pre-UV irradiation was compared. (c) Filopodia length of non-irradiated samples and pre-UV irradiated samples (UV irradiated on azobenzene nanotubes in solution) was compared.

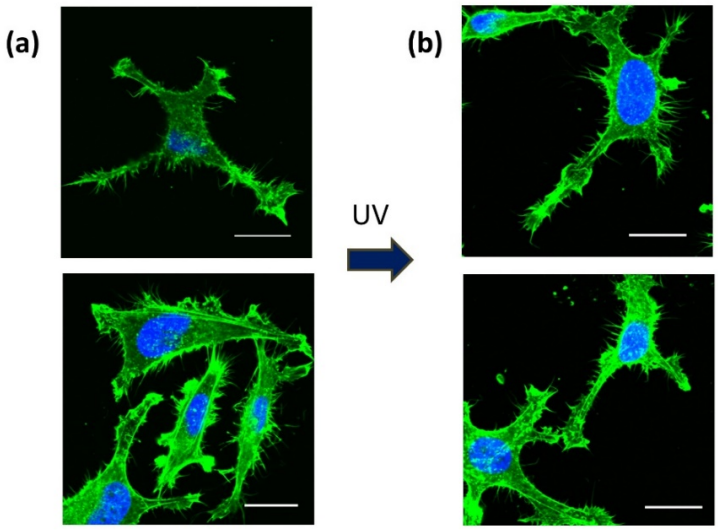

Figure S8. A control experiment to verify that change in morphology is observed only in response to the conformation change of the DNA nanotubes. More than 50 cells were analysed in each case. (a) Representative Images of HeLa cells on control tubes (without any switching strand). (b) Representative Images of HeLa cells on UV irradiated control tubes. Scale bar: 20 µm.

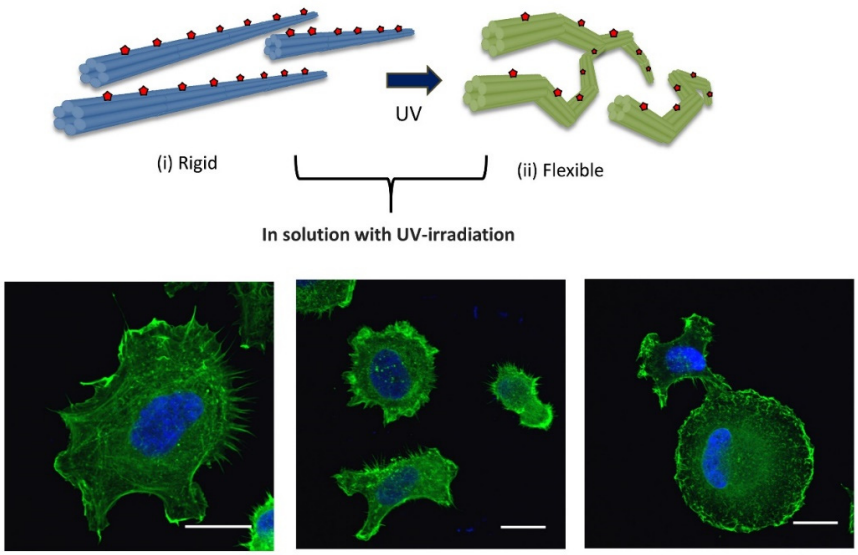

Figure S9. Analysing morphology change of cells seeded RGD-conjugated DNA nanotubes (pre-irradiated with UV). A control experiment to check the morphology on the flexible matrix. Scale bar: 20 μm

Table S1. DNA strands for tube formation.

Tube_01	TGGAGTCCACGTTCTTTAATAGTGGACTCTTGTTC-TGATAGACGGTTTTTCGCCCTTTGACGT
Tube_02	CTTTTGATTTATAAGGGATTTTGCCGAT-AACTGGAACAACACTCAACCCTATCTCGGGCTATT
Tube_03	CTGCTGGGGCAAACCAGCGTGGACCGCTTGCTGCA-CGGAACCACCATCAAACAGGATTTTCGC
Tube_04	CAGGCGGTGAAGGGCAATCAGCTGTTGCCCGTCTCACTGGTGAAAAGAAAAA-TCTCTCAGGGC
Tube_05	CTCCCCGCGCGTTGGCCGATTCATTAATGCAGCTG-ACCCTGGCGCCCAATACGCAAACCGCCT
Tube_06	CGCAACGCAATTAATGTGAGTTAGCTCA-ACGACAGGTTTCCCGACTGGAAAGCGGGCAGTGAG
Tube_07	TCTATCAGAACAAGCTGTCGTTGAGCTA
Tube_08	ACGTCAATCAAAAGGCGAAAATCC
Tube_09	TAAAGGGTTGACACGCTGGTTTGCCTTGCCCTCAAC
Tube_10	TAAAAGGGCGATTAATTGCGT
Tube_11	GATAGAACGTGCCCGCTTTCCAGTCAATCGGCTCAC
Tube_12	GGTTCCGTGCAGCATGAGAGATTTTTCT
Tube_13	TGTTAGTGAGATTGCGTATTGGGCGACTCACAAAAACCG
Tube_14	TTTCACCTGATGGTAAATCCCTTA
Tube_15	CGCCTGGCCCAGCGGTCGTGTTGTTCCAGTTATCGGCA
Tube_16	CCAGGGTCAGCTGCATTAATGGGGAAACAGTCCACTAT
Tube_17	GCGCGGGGAGCTCACTGGACTCCA
Tube_18	TGCGAGGCGGTCGGGCAACAGCTGACCAGCAGAATAGCCCGA

Table S2. DNA strands for tube modification.

Tube_17-switching strand **1**	**GCGCGGGGAGCTCACTGGACTCCA-TT-GAAACTAATG**
Tube_8-switching strand **2**	CGTTAGTTTC-TT-ACGTCAATCAAAAGGCGAAAATCC
Tube_8-switching strand **3-Azo**	CGTXTAXGTXTCA-TT-ACGTCAATCAAAAGGCGAAAATCC
Tube_17-8 connect	GCGCGGGGAGCTCACTGGACTCCA-ACGTCAATCAAAAGGCGAAAATCC
Tube_14-**RGD**	**RGD**-TTTCACCTGATGGTAAATCCCTTA

References

1. T. Wang, D. Schiffels, S. M. Cuesta, D. K. Fygenson, N. C. Seeman, Design and Characterization of 1D Nanotubes and 2D Periodic Arrays Self-Assembled from DNA Multi-Helix Bundles. *J. Am. Chem. Soc.* **2012**, 134, 3, 1606–1616.
2. D. Schiffels, T. Liedl, D. K. Fygenson, Nanoscale structure and Microscale Stiffness of DNA nanotubes, *ACS Nano,* **2013**, 7, 6700–6710.