Self-assembly of cylinders and Möbius strips by DNA origami

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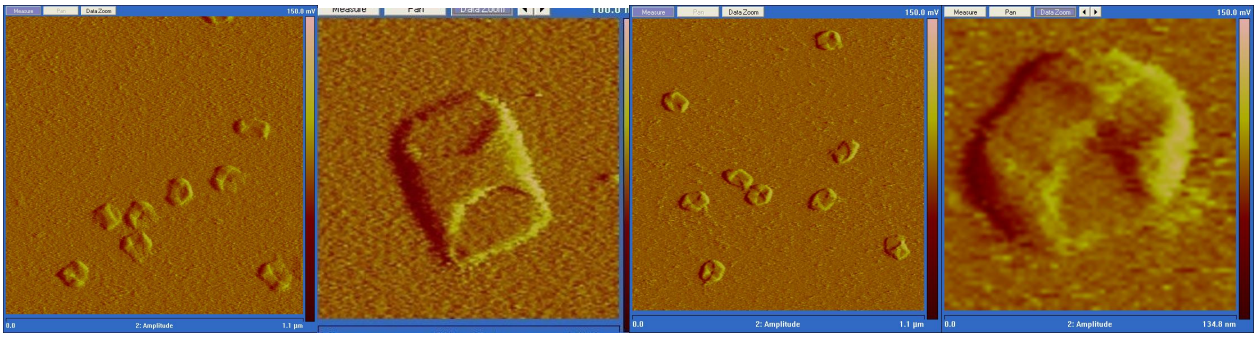
Abstract

We report the self-assembly of two novel DNA complexes. Using the technique of DNA origami [1], we have assembled DNA complexes in the shape of cylinders (Figures 1a,1b) and in the shape of Möbius strips (Figures 1c,1d). We believe this is the first demonstration of Möbius strips at the nanoscale.

Rothemund's origami square, our cylinder and our Möbius strip employ nearly the same set of oligonucleotides. If cut open, both the cylinder and the Möbius strip would form squares of approximately 100 nm a side.

The structures of Rothemund [1] and the origami nanotubes of Douglas et al. [2] were designed to enforce specific angles between adjacent double helices. We nonetheless suspected that the Rothemund square would have sufficient residual flexibility to absorb the stress induced by twisting into a Möbius strip or a cylinder. Our results confirm that this is the case.

Möbius strips are known to be chiral in Euclidean 3-space. They may be clockwise or counterclockwise. Atomic force micrographs suggest that there may be a preference for our DNA self-assembly to produce counterclockwise Möbius strips. If this is so, then DNA self-assembled structures might ultimately be useful as a basis for the creation of asymmetric catalysts for the enantioselective synthesis of chiral compounds.



(a) 1.1 $\mu m \times 1.1$ μm (b) 175.8 $nm \times 175.8$ nm (c) 1.1 $\mu m \times 1.1$ μm (d) 134.8 $nm \times 134.8$ nm

Figure 1: Atomic force microscope scans of cylinders (a,b) and Möbius strips (c,d).

References

[1] P. W. K. Rothemund, Nature 440, 297 - 302, (2006).

[2] S. M. Douglas, J. J. Chou and W. M. Shih, PNAS, April 17, 2007, vol. 104, no. 16, 6644-6648.