Isothermal self-assembly of DNA origamis at room temperature in an unchanging buffer going through multiple folding pathways

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When it comes to DNA origami formation, the large majority of research papers use the same method: the M13 template and the staples of a given shape are mixed together in a magnesium-containing buffer (usually TAE 1x + ~10 mM MgCl2) and submitted to a temperature ramp starting with a denaturing step at high temperature (typically 90 °C) and going down to 20 °C. This temperature ramp allows the system to go through several distinct equilibrium states, each of which stable at a given temperature. But what happens when the primitive system (meaning the M13 template and the staples in the buffer, before annealing) is incubated at a constant temperature? Can the system self-organize to create a flawless origami structure after a certain incubation time? In other words, is it possible to form DNA nanostructures by replacing the thermal annealing with an isothermal annealing? A few isothermal protocols have been developed, but they are based either on the addition of organic denaturing agents [1–4] or on the use conventional saline buffers but at a high temperature [5,6].

In this presentation, I will describe experimental results on a new original method for the isothermal formation of DNA nanostructures at room temperature, that doesn't involve any structural modification of the DNA, nor any environmental modification before, during or after the isothermal folding process. I will demonstrate the versatility of this method by describing the formation of different origami shapes at room temperature (25 °C) and at 30 °C in an unchanging buffer, I will describe the kinetics of the folding process and, as the most significant result, I will show the first in situ observation by AFM of the isothermal folding process at room temperature. This constitutes the first direct characterization and visualization of the folding mechanism(s) [7] of DNA origamis, thus bringing new insights on the matter.

References

[1] R. Jungmann, T. Liedl, T. L. Sobey, W. M. Shih, F. C. Simmel, J. Am. Chem. Soc. 2008, 130, 10062–10063.
[2] A. Kopielski, A. Schneider, A. Csáki, W. Fritzsche, Nanoscale 2015, 7, 2102–2106.
[3] I. Gállego, M. A. Grover, N. V. Hud, Angew. Chem. Int. Ed. 2015, 54, 6765–6769.
[4] Z. Zhang, J. Song, F. Besenbacher, M. Dong, K. V. Gothelf, Angew. Chem. Int. Ed. 2013, 52, 9219–9223.
[5] J.-P. Sobczak, T. G. Martin, T. Gerling, H. Dietz, Science 2012, 338, 1458–1461.
[6] J. Song, Z. Zhang, S. Zhang, L. Liu, Q. Li, E. Xie, K. V. Gothelf, F. Besenbacher, M. Dong, Small 2013, 9, 2954–2959.
[7] C. Rossi-Gendron et al., Nature Nanotechnology, under review