Catalytic DNA reactions on nanogels

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DNA nanotechnology [1-3] has shown that the self-assembly properties of nucleic acids open many possibilities to design molecular devices, including motors and logic circuits.This paper focuses on DNA molecular circuits, constituted by sets of partially or fully hybridized DNA strands, interacting through strand displacement reactions. Several theoretical and experimental works [4] have shown the possibility to cascade strand displacement reactions in order to perform DNA-based computations. One of the difficulties of these systems is the fact that interactions time constants are diffusion limited. This translates, for usual concentrations in the nanomolar range, to time scales of several hours.
Tethering DNA circuits to structured platforms, such as DNA origamis, is a possible solution to this issue [5]. It has been shown that constraining the distances between different strands to a few nanometers decreases the time responses by two orders of magnitude (as compared to bulk reactions). The drawback of this approach is the difficulty to scale-up this type of platforms.
Here, we consider an alternative solution, by tethering DNA strands to a nanogel. We describe an original way to synthetize polyacrylamide nanogels that also bind DNA strands. We show that simple catalytic reactions take place on these floppy structures.

[1] Zhang, D.Y.; Winfree, E. Control of DNA Strand Displacement Kinetics Using Toehold Exchange. J. Am. Chem. Soc. (2009) 131, 17303-17314.
[2] Zhang, D. Y.;, Turberfield, A. J.; , Yurke, B.; Winfree, E. Engineering Entropy-Driven Reactions and Networks Catalyzed by DNA. Science (2007) 318, 1121-1125.
[3] Yin, P.; Choi, H.M.; Calvert, C.R.; Pierce, N.A. Programming Biomolecular Self-Assembly Pathways. Nature (2008) 451, 318-322.
[4] Qian, L.; Winfree, E. Scaling Up Digital Circuit Computation with DNA Strand Displacement Cascades. Science (2011) 332, 1196-1201.
[5] Mendoza, O.; Houladi, S.; Aimé, J.P. and Elezgaray, J., Signal replication in a DNA nanostructure, J. Chem. Phys. (2017) 146, 025102.