Self-assembly of higher ordered structures in DNA nanotube systems

Martin Glaser[1,2] , Jörg Schnauß[1,2] , Teresa Tschirner[1,2], B U Sebastian Schmidt[1], Maximilian Moebius-Winkler[2], Josef A Käs[1], and David M Smith[2]

[1]Faculty of Physics and Earth Sciences, Institute of Experimental Physics I, Leipzig University, Linnéstr. 5, 04103 Leipzig, Germany.
[2]Fraunhofer Institute for Cell Therapy and Immunology IZI, DNA Nanodevices Group, Perlickstraße 1, 04103 Leipzig, Germany.

Self-assembly of molecular and macromolecular building blocks into organized patterns is a complex process found in diverse systems over a wide range of size and time scales. The formation of star- or aster-like configurations, for example, is a common characteristic in solutions of polymers or other molecules containing multi-scaled, hierarchical assembly processes. To date, however, it has not been possible to systematically parameterize the structural properties of the constituent components in order to study their influence on assembled states.
Here, we overcome this limitation by using mechanically programmable DNA nanotubes as our basic building blocks [1]. A small set of DNA oligonucleotides can be chosen to hybridize into micron-length DNA nanotubes with a well-defined circumference and stiffness. The self-assembly of these nanotubes to higher ordered structures is driven by depletion forces. This system allowed us to investigate self-assembly effects while maintaining a complete decoupling of density, self-association or bundling strength, and stiffness of the nanotubes.
Our findings show diverse ranges of emerging structures including heterogeneous networks, aster-like structures, and densely bundled needle-like superstructures, which compare directly to configurations found in many other systems.

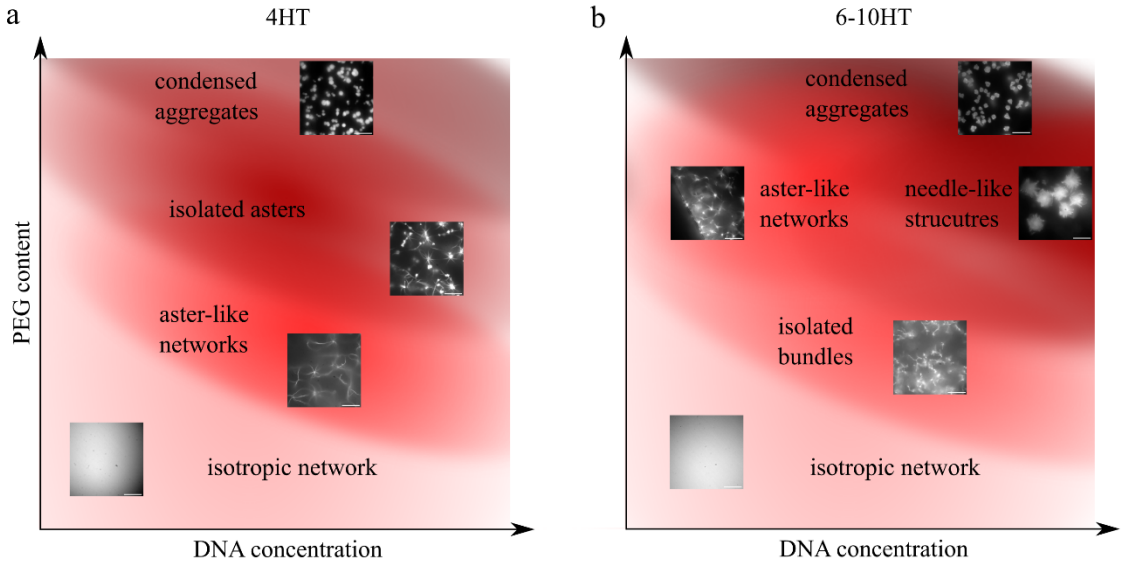

Fig. 1. Suggested diagram for observed self-assembled states of different DNA nanotubes, as a function of the attraction strength (depletion forces) and DNA concentration. (a): Flexible nanotubes (4HT). (b): Semiflexible and stiffer nanotubes (6-10HT) [2].

[1] Yin, et al. Science 321.5890 (2008): 824-826.
[2] Glaser et al. submitted to New J. Phys. (2016).