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Polymer brush coatings for DNA: fundamental polymer physics and nanofabrication applications

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Recombinant DNA technology allows for the production of precisely defined self-assembling protein-based polymers. So far, the major applications for such protein-based polymers have been self-assembling hydrogels and micellar structures with biomedical application. Inspired by minimal models for the self-assembly of rod-shaped viruses such as the tobacco mosaic virus, I have developed protein-polymers that co-assemble with DNA into rod-shaped virus-like particles, and protein-polymers that provide brush coatings around single DNA molecules. In this presentation I will focus on the latter, showing that on the one hand brush coated DNA is a rich model system for exploring the physics of bottle-brush polymers, while on the other hand brush coatings of DNA can also play an important practical role in nanofabrication. A key problem in the physics of bottle-brush polymers that I will address is the scale-dependence of bottle-brush elasticity. For long-wavelength thermal deformations probed by AFM imaging I will demonstrate that there is significant stiffening due to the brush coating, while for short wavelength thermal deformations probed by force spectroscopy, we find that stiffening due to the brush coating disappears completely. DNA brush coatings can also play an important practical role in nanofabrication by acting as a compatibilizer between chemically different building blocks. I will explore the example of DNA origami in combination with gold nanoparticles: while Mg^{2+} ions and high concentrations of monovalent salts are crucial for the stability of DNA origami, such solution conditions are typically incompatible with the colloidal stability of gold nanoparticles. I will show how DNA brush coatings can dramatically enhance the yield of formation of isolated DNA-gold nanoparticle composite nanostructures.