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Identifying the configuration of surface-bound DNA by tracking the Brownian motion of magnetic nanoparticles

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Magnetic nanoparticles play a pivotal role in developing cost-effective and sensitive point-of-care medical diagnostic systems [1]. Surface-functionalization of the particles with DNA offers great flexibility, covering a wide range of possible applications from magnetic biosensing to the controlled assembly of specifically designed colloidal structures [2]. The effectiveness of these functions is highly dependent on the structural configuration of the DNA on the particle surface [2].
This work presents an experimentally facile approach for determining the DNA configuration bound to a spherical nanoparticle based solely on the optical tracking of the particle's 2D Brownian motion in a quiescent liquid [3]. We attached differently sized fragments (maximum 2000 base pairs) of double-stranded DNA to commercially available superparamagnetic nanoparticles with a nominal diameter of 300 nm. Using an optimized multiparticle tracking procedure, we quantified their diffusivities in a low-salt concentration medium. We find that the distribution of diffusion coefficients for all tracked particles is significantly narrowing and shifting toward lower magnitudes for larger DNA fragments attached to the particles. It implies a substantial increase in the effective sizes of the particle-DNA complexes. Comparing with the size distribution of naked particles and a hedgehog model for the particle-bound DNA configuration, our observations conclusively point toward a brushed state for longer DNA strands.
The results highlight a comparably simple method for gathering vital structural information on nanoparticles and the complexes they form with attached biomolecular components, even for particle sizes that fall below the optical resolution limit. All that is needed is an optical microscope and a computer workstation for the tracking analysis. Harnessing their magnetic properties, the DNA-functionalized particles are further addressable via magnetic fields for usage in diagnostic Lab-on-a-chip devices.

References

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