

3D DNA-origami as a molecular dynamometer

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DNA origami hybrid nanostructures have raised large interest because of the programmable control over their shape and size, precise spatial addressability, mechanical flexibility, and biocompatibility^[1,2]. The complexity of the achievable structures offers the possibility to create smart DNA scaffolds and dynamic structures^[3]. The nucleic acids architecture allows the precise positioning of nano-objects such as gold nanoparticles (AuNPs) which are particularly interesting for their optical properties and easiness of functionalization. AuNPs have been already used in sensing applications exploiting the well known dependence of their optical properties on the inter-particles distance^[4].

In this work we discuss an hybrid system which combines the plasmon ruler concept and the mechanical properties of DNA structures to design a molecular dynamometer. The structure of choice for our origami design was a tetrahedron^[5], made of four-dsDNA 90 nm long struts linked by flexible hinges at the vertices (Fig 1a). Two gold NPs are positioned at the centre of two opposite tetrahedron faces linked through three binding sites (Fig 1b). A 120 nucleotides single-stranded DNA (actuator) connects two of the six struts crossing one empty face. After the addition of a specific ssDNA target that hybridizes the actuator, a tensile force will be exerted on the 3D structure. The actuator shortening upon hybridization will reduce the distance between struts inducing an approach of the two NPs detectable through the plasmon resonance shift using dark-field spectromicroscopy (Fig 2).

The proposed sensing tool could be applied for precise detection of specific DNA target sequences or, alternatively, for the analysis of the tensile forces variation due to external stimuli inside biological systems.

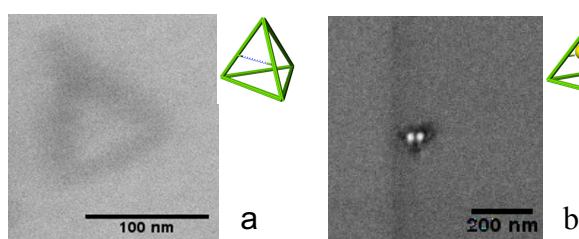


Fig 1: SEM pictures of DNA origami tetrahedron with (a) without (b) gold NPs; the designed distance between the NPs is 10 nm

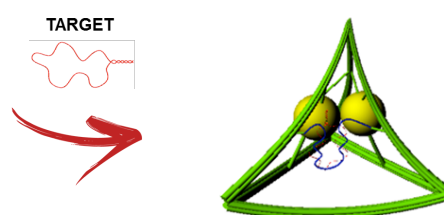


Fig 2: Representation of the actuation with ssDNA target that reduces the distance between gold NPs

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