Graphene Energy Transfer and DNA Nanotechnology for single-molecule studies of heterostructures and structural biology.

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Graphene constitutes a broadband energy acceptor, avoiding labeling, photobleaching and complicated photophysics. Graphene quenches fluorescence of fluorophores in a range of 0-40 nm, following a d^{-4} distance dependence, with the highest sensitivity around d_0 = 18 nm, which is the distance of the 50% energy transfer efficiency.[1,2] Due to Graphane Energy Transfer (GET) a single dye molecule shows a reduced fluorescence intensity and a proportionally shortened fluorescence lifetime as a function of its distance to graphene. This information can be used to determine the position of the dye molecule to graphene with a moderate number of photons and to sensitively report on distance changes in real-time.[2,3] In our first realization, we used DNA origami nanopositioners [4] to place a fluorophore and other molecular components at a defined distance from graphene. With this approach, using single-molecule fluorescence microscopy techniques and several different assays we demonstrated among others: switching dynamics of a DNA pointer between two binding sites with high time resolution, dynamics of a flexible DNA tether influenced by viscosity or target binding, 3D superresolution imaging with isotropic nanoscale resolution, a biosensing assay with single DNA molecule detection in a novel unquenching assay format.[3] Our recently developed tools to connect DNA and graphene enable single base-pair resolution.[5] We use this approach to visualize structural properties of DNA which precede direct interactions with biomolecules and DNA-protein interactions. We also explore optoelectronic properties of multilayer graphene and graphene/hBN heterostructures to tune the range of distance at which our platforms operate.

References

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