# Methods to Characterize the Oligonucleotide Functionalization of Quantum Dots*

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Currently, DNA nanotechnology offers the most programmable, scalable and accurate route for the self-assembly of matter with nanometer precision into 1, 2 or 3-dimensional structures. Since the controlled assembly of quantum dots (QDs) is of high interest in the field of photonics and other optoelectronic applications, a more detailed view on the functionalization of QDs with oligonucleotides should be achieved. In our work we present four different methods to characterize the functionalization of thiol-capped CdTe QDs with oligonucleotides by using AFM, optical spectroscopy and gel electrophoresis. The latter two methods make use of the specific interactions between single-stranded oligonucleotides and are quick and easy to accomplish. The functionalized QDs were crosslinked by the use of a complementary oligonucleotide that resulted in an energy transfer-driven reduction of the emission intensity. In a second experiment, a quencher-functionalized oligonucleotide was attached to the QD surface via a complementary capture strand. We used PL lifetime measurements to prove that the emission quenching of this QD-quencher complex ensues a static mechanism. In a different experiment, the hybridization of dye-functionalized oligonucleotides to modified QDs was shown by gel electrophoresis. To provide additional quantitative information about the oligonucleotide functionalization, QDs were dissolved by EDTA. The specific absorption of the oligonucleotide in the supernatant allows to calculate the average number of oligonucleotides per QD. Since these methods are based on the emission and absorption characteristics of QDs, they are not limited to the CdTe QDs used here but can also be established for other semiconductor materials. The obtained results will, therefore, be beneficial for further investigations of functionalized semiconductor nanomaterials and their self-assembly onto DNA origami structures.

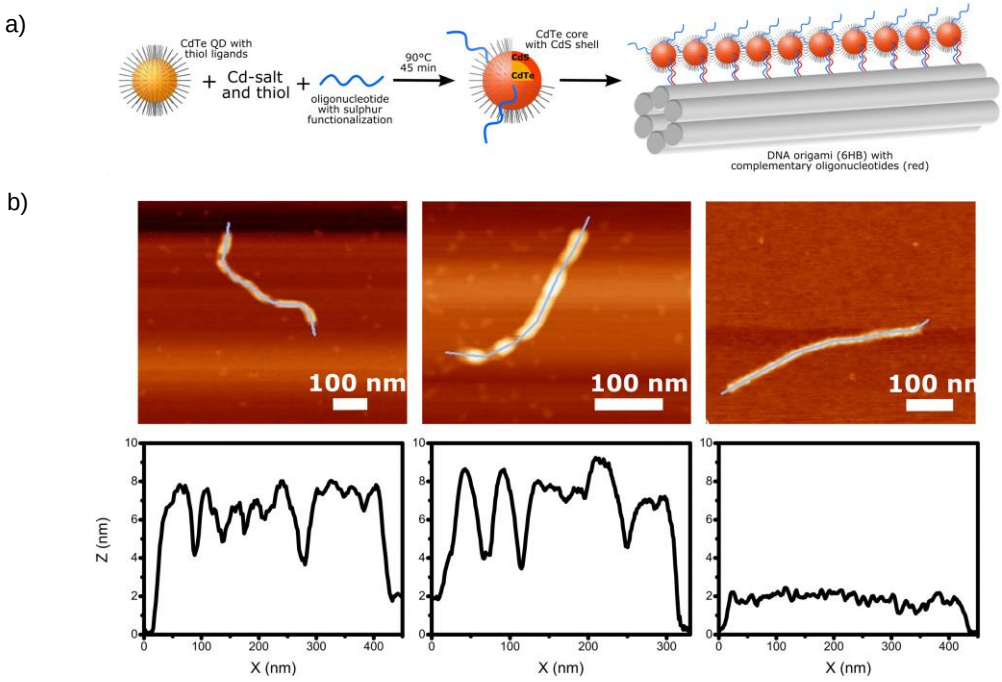


**Fig. 1** (a) Functionalized CdTe QDs, were attached to six-helix bundles (6HB) with ten equally spaced capture strands. (b) AFM images and corresponding height profiles of 6HBs containing 3.2 nm sized QDs (left and middle) and of a non-functionalized 6HB (right).

* This work is published in Small. (doi: 10.1002/smll.201601525)