DNA Based Emerging Technologies for Biological Applications

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Abstract:
Structural DNA nanotechnology explores various nanoscale structural and functional properties of DNA to manipulate matter at nanoscale for diverse applications[1]. Three dimensional architectures based on DNA polyhedra have raised particular interest in biomedical applications[2]. DNA polyhedra possess an internal void bounded by a well-defined three-dimensionally structured surface[3]. The internal void can house cargo, and the designer DNA scaffold can facilitate molecular display to program biological targeting. While the delivery of designer DNA particles bearing surface ligands has been achieved[4], the successful demonstration of their full potential of targeted delivery when housing an internal payload remains an outstanding challenge. I will present the first successful delivery of quantum dots (QDs) as the internal payload of DNA icosahedra. A long-standing challenge for QDs has been the inability to achieve their monofunctionalization in bulk[5]. We resolve this by encapsulating QDs within molecularly identical icosahedral DNA particles in bulk where the DNA shell is mono-functionalized with different endocytic ligands. We demonstrate the monofunctionalization and successful specific, endocytic uptake of QDs, using multiple endocytic ligands like folic acid, Galectin-3 (Gal3[6]) and Shiga toxin B-subunit (STxB[7]). Single particle tracking of Gal3/STxB-bearing, QD-loaded icosahedra reveal new observations of compartment dynamics along the endocytic pathways. QD-loaded DNA polyhedra bearing ligands of unique stoichiometry represent a new class of high-precision molecular imaging tools for quantitative approaches to complex biological phenomena arising from receptor clustering. Our results highlight the emerging potential of DNA devices in cell biology and biomedical applications that could enable probing and programming various biological systems as well as developing next generation tools for targeted delivery of molecular payloads within living systems.

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