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From Quantum Dots to Fluorescent Organic Nanoparticles: bright nanotools for biosensing

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The in situ and real-time detection of analytes in complex biological media demands robust, sensitive, and stable biosensors capable of signal amplification. Luminescent nanoparticles (LNPs) are promising candidates, offering exceptional brightness and photostability compared to traditional dyes.[1] These LNPs fall into two main categories: intrinsically luminescent, such as Quantum Dots (QDs), or doped NPs, where dyes are encapsulated within a matrix. For imaging and sensing applications, LNPs aim to achieve excellent brightness, enhanced photostability, and strong colloidal stability in water, outperforming conventional organic dyes. Classical FRET nanosensors typically involve a donor LNP conjugated with bioreceptors that bind to a ligand labeled with an acceptor dye. While bioreceptors optimization has advanced detection limits and dynamic ranges, the roles of dye type and spatial configuration in these systems remained underexplored. In this talk, we will compare organic fluorophores (e.g., Cy5, Texas Red) and QDs as FRET donors or acceptors, identifying key molecular parameters that enhance sensor performance to provide guidelines for FRET-based assays and diagnostics.[2-3] Additionally, Fluorescent Organic Nanoparticles (dFONs) will be introduced as metal-free alternatives to QDs, with comparable brightness per volume. Obtained via nanoprecipitation of hydrophobic dyes, dFONs remain underutilized as biosensors due to limited functionalization strategies.[4] We demonstrate an innovative maleimide-thiol surface functionalization approach, enabling applications such as intracellular thiol sensing in the µM range[5] and biotinylation for biomarker development. These advancements position dFONs as versatile, ultra-bright, and metal-free tools for next-generation diagnostics.

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