Exciton dynamics in quantum dots: from curiosity to potential applications

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The interactions between quantum dots (QDs) and molecules adsorbed on their surface can be utilized for applications as varied as photocatalysis and drug delivery. Photosensitization of molecular catalysts (MCs) for processes like hydrogen evolution and CO_2 reduction can be achieved by photoinduced electron transfer (PET) from the QD to the MC, especially when the surface of the QD is negatively charged while the MC is positively charged. Back electron transfer (BET) severely hinders the performance of such photocatalytic assemblies. Elucidation of dynamics of these electron transfer processes, in timescales ranging from femtoseconds to milliseconds, is crucial. $Cu(PAP)_2$, a MC for HER in aqueous medium, is effectively photosensitized in aqueous medium by $CuInS_2$ (CIS) QDs [1]. Deposition of a ZnS shell on the QDs suppresses PET, but improves the photocatalytic performance significantly, due to a greater extent of suppression of BET [2]. In a different experiment, a non-heme iron MC, ($[Fe(AAP)_2Cl_2]Cl$) (Fe Cat), has been photosensitized by the same QDs for photocatalytic CO_2 reduction to CO in water, with 440 nm irradiation [3]. On a different note, the QDs have been functionalized with folic acid for obtain a model drug delivery vehicle for doxorubicin (DOX), which quenches the photoluminescence of the QDs through the same mechanism of PET [4]. So, release of DOX is marked by the recovery of the QD photoluminescence. Using fluorescence lifetime imaging microscopy, the potential of such a drug delivery vehicle is ascertained.

References

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