Bright fluorescent polymer nanoparticles based on dyes: design, energy transfer and bioimaging applications

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Fluorescent organic nanoparticles (NPs) appear as an attractive alternative to inorganic NPs, such as quantum dots, because of their potential biodegradability, low toxicity and high capacity to encapsulate active molecules.[1] For successful applications in biosensing and bioimaging, they should be small, ultra-bright and biocompatible, as well as they should undergo efficient Förster resonance energy transfer (FRET). The small size of NPs was achieved through an original methodology based on nanoprecipitation of polymers bearing 1-2 charged groups per polymer chain.[2,3] For encapsulation, we designed cationic dyes (rhodamines and cyanines) containing large fluorinated counterions that prevent dye pi-stacking and thus aggregation caused self-quenching (Figure 1).[2,4] In case of neutral dyes, such as perylene diimides, we employed bulky side groups.[5] As a result, PLGA and PMMA NPs of 15-50 nm size were obtained, where the size was tuned by the polymer structure. Our smallest NPs of 15 nm size encapsulating >100 rhodamine dyes were ~10-fold brighter than quantum dots-585 recorded at the same conditions. Dependent on the dye design and the polymer nature, our NPs showed either stable emission or complete ON/OFF switching. This switching behavior is an indication of strong coupling of the dyes by ultra-fast exciton diffusion, so that >100 dyes behave like a single emitter. This high collective behavior was successfully applied to obtain giant light-harvesting nano-antenna that amplifies up to 1000-fold emission of single FRET acceptor dyes. Other applications include super-resolution imaging, photo-switching[6] and long-term multi-color cellular imaging. Dye-loaded polymer NPs are promising nano-tools for single-molecule detection, biosensing and bioimaging.

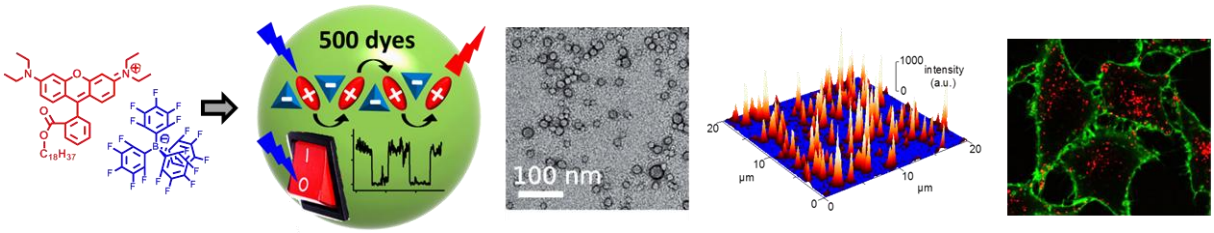

Figure 1. Dye-loaded polymer NPs using cationic dyes with hydrophobic counterions.

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