Smart and bright fluorescent molecules and nanoparticles: when chemistry meets biology

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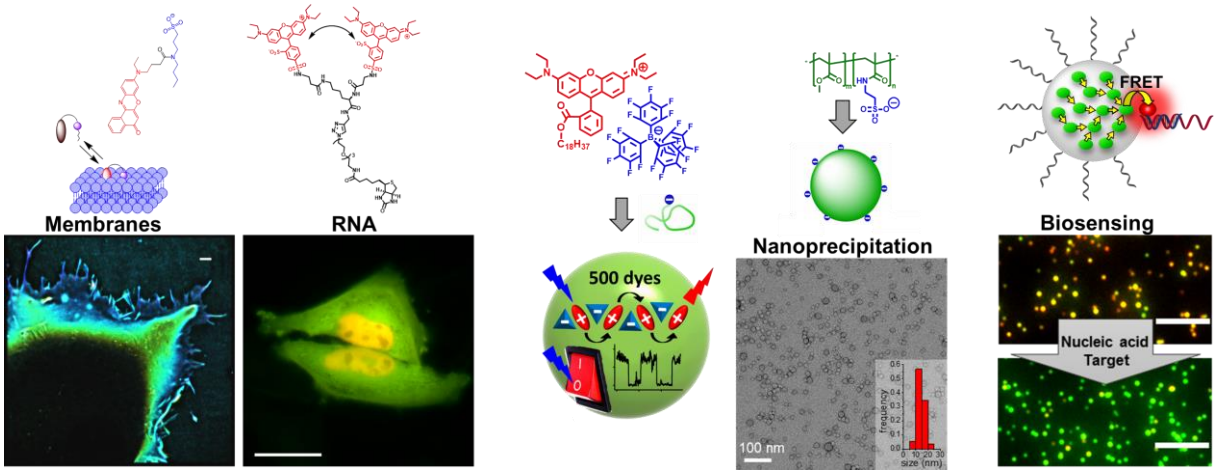
Fluorescent molecules and nanomaterials become essential tools for biological research and medical diagnostics. Of particular interest are environment-sensitive fluorescent molecular probes that change their color (solvatochromic dyes) or intensity (fluorogenic dyes) in response to cellular targets.[1] Probes based on solvatochromic dyes enable super-resolution imaging of plasma membrane organization,[2] polarity mapping of organelles in live cells and monitoring their response to stress.[3] On the other hand, fluorogenic probes exploiting folding/unfolding in dye dimers allow background free imaging of target G protein coupled receptors[4] and intracellular RNA.[5]



To go beyond the limits of brightness of organic dyes, we focused on fluorescent dye-loaded organic nanoparticles.[6] Small size of polymeric NPs prepared by nanoprecipitation was achieved by introducing charged groups into the polymer.[7] To prevent aggregation-caused quenching of loaded dyes, bulky hydrophobic counterions were proposed as dye insulators.[8] So far, we have already developed polymeric nanoparticles with size ranging from 7 till 100 nm and >100-fold higher brightness than semiconductor quantum dots.[8-9] Small size (<25 nm) was found essential for their entry into live cells by electroporation[10] and for free diffusion inside cytosol.[7] At high loading, encapsulated dyes communicated by ultrafast energy transfer generating giant light-harvesting nanoantennas, allowing detection of single molecules at sunlight-like excitation.[9] By functionalizing these light-harvesting NPs with DNA, we obtained FRET-based color switching nanoprobes for detection of target nucleic acids with single-molecule sensitivity,[11] compatible with a smartphone[12] and opening a route to cancer diagnostics based on microRNA biomarkers.[13]

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