ABSTRACT

Conjugated polymer nanoparticles (CPNs), as a promising class of fluorescent probes, have been successfully applied in biomedical fields. In this dissertation, we are focusing on the development of brighter red-emitted CPNs through resonance energy transfer and the investigation of photophysical properties with single particle spectroscopy, with an eye towards the development of nanoparticles with properties suitable for super-resolution imaging (e.g., photoswitching or saturable nanoparticles). The first type is blended PFBT/MEH-PPV CPNs. Steady-state and time-resolved fluorescence spectroscopies showed efficient energy transfer from donor to acceptor, yielding bright and red-shifted emission. Energy transfer dynamics is investigated in order to probe the complex energy transport occurring in similar systems such as nanostructured bulk heterojunction photovoltaic devices. We compared the fluorescence decay kinetics and steady-state quenching efficiencies with a multiple energy transfer model and prior dye-doped CPNs results. The analysis indicates that the high energy transfer efficiency is largely due to multi-step energy transfer (i.e., exciton diffusion), while the fluorescence lifetime heterogeneity appears to be strongly influenced by acceptor polymer polydispersity as well as nanoscale inhomogeneity. Single particle spectroscopy indicates blended CPNs emit ~109 photons prior to irreversible photobleaching, and have ~107 photons/s saturated emission rates at very low excitation intensities, which is promising for saturation-based superrresolution imaging. Bulk photobleaching spectra show photo-activation behavior of donor emission. The second type is near-infrared (NIR) dye doped CPNs through doping dye molecules into polymer matrix. Highly efficient energy transfer is observed from polymer to NIR dye. The single particle imaging indicates that the NIR-emitting CPNs are highly photostable, and the NIR dye does not adversely affect the photostability. Energy transfer dynamics at single particle level is studied with single particle fluorescence spectra, and the results show particle-to-particle variability in energy transfer efficiency, consistent with a Poisson distribution of dye molecules in the particles.