X-MAC

EXCITONIC ENERGY TRANSFERRING MACROCRYSTALS OF QUANTUM DOTS

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Project context and objectives:

Nonradiative energy transfer is a physical process where excitation energy flows from an excited donor emitter to an acceptor emitter via dipole-dipole interactions. In our design, quantum dots (QDs) of different sizes werepreferred as the exciton donor-acceptor pair. High donor quantum yield (QY), spectral overlap between donor emission and acceptor absorption enable and increase nonradiative energy transfer between donor and acceptor emitters.

Within the framework of this seed project, we aimed to benefit nonradiative energy transfer to enhance emission in a macro scale solid emitter. The design is based on embedding QDs into salt macrocrystals. Water-soluble TGA-capped CdTe semiconductor macrocrystals of different sizes are selected as QD emitters due to their compatibility with polar solvents, high quantum yield and size-tunability. Added KCl molecules formed an ionic lattice surrounding QDs.This medium acts as a shield against environmental effects for QDs and enables production of photo-stable, macro-dimensional, formable structure.

To realize NRET in these structures, QDs of different sizes are required. First, QDs whose emission peaks range from 518 to 628 nm were synthesized. Subsequently, donor and acceptor emitters were determined and blended with saturated aqueous solutions of KCl saltsat specific concentrations. Third, the blend of initial solutionswas crystallized under standard conditions. Next, produced QD embedded macrocrystals were powdered. Finally, specific amount of powdered macrocrystals were carefully encapsulated with silicone on thin glass substrate and cured. The manufactured thin film materials were optically excited and carefully tested by measuring their emission intensities and lifetimes.

Our scientific objective is to demonstrate nonraditive energy transfer between embedded and shielded QDs within these macro crystals, to investigate Förster resonance energy transfer (FRET) processes and to enhance FRET with careful optimizations.

Brief description of the main results:

Dresden and Bilkent groups have synthesized thiol-capped aqueous colloidal quantum dots of different sizes.Using evaporator, the density of QDs solutions were increased. Next, QDs were incorporated into MCs with crystallization by determining initial concentrations. QDs embedded macrocrystal were encapsulatedwith silicone resin on the glass substrates. Prepared samples were tested usingtime-resolved fluorescence spectroscopy by Bilkent Group.

Time resolved fluorescence measurements provide information for emitter lifetimes. It is seen that donor lifetimes were shortened with the presence of acceptor molecules as a result of FRET. Additionally, acceptor emission was enhanced.

Potential impact and challenges:

FRET enhanced macrodimensional photo-stable and formable solid emitterswere obtained. FRET efficiency is improved up to 51.8 %. As a consequence of FRET, emission intensity of acceptor QDs was observed to strengthen. With their photo-stability, higher quantum yield, processability and compatibility with today’s fabrication techniques for emitters and light emitting devices, designed structures promises improvement in lighting and optics.