Semiconductor Nanocrystals for Biomedical Imaging, Health, and Sustainability

Colloidal semiconductor nanocrystal quantum dots are tiny crystals whose color depends upon the size of the crystal. This presentation will describe how it was possible to leverage this size-dependent nanocrystal color and to couple the nanocrystals with biological molecules, revealing for the first time how this new type of fluorescent probe could become a powerful tool for bioimaging. Water-soluble nanocrystals required for biological applications were achieved by extending the chemistry of the core-shell systems through a third silica layer that made the core-shell water soluble 2(Science, 281, 2013, (1998)). Further, the silica surface layer was modified with different groups to control specific interactions with biological samples, all while maintaining a large quantum yield that is required for the probes to be bright. The nanocrystals had narrow, tunable, symmetric emission spectra, and the resulting biological quantum dots enabled color-coded identification of multiple cell structures for many biomedical applications. Following the initial discovery, it was important for these materials to be made available to as many biomedical researchers as possible. This was achieved through the founding of Quantum Dot Corporation (QDC). This biotechnology company used quantum dot synthesis and know-how to enable color-coded identification of multiple cell structures. The Qdot innovations became commercially available in 2002. With more than 200 Qdot-based products sold in more than 160 countries, today they are benefiting millions of people worldwide. They are deployed for many biomedical diagnostic needs, especially for the analysis of tumors in pathology laboratories and also for optimizing biological processes for sustainable crops and for diagnosing plant and animal disease. These applications reduce the use of fertilizer, pesticides and water, and improve plant and animal breeding. Current human applications include clinical treatment and public health protection, such as disease detection and surveillance, newborn screening, and food safety assays. This talk will also feature some discussion of the future challenges in improving the science of making precision nanocrystals and the many prospects for further technology applications that may benefit humanity.