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Friday, January 21, 2022 | **ZOOM** | 10:00 AM (ET)

Title | Induction Period of Colloidal Semiconductor Quantum Dots

Abstract | Photoluminescent (PL) colloidal semiconductor quantum dots (QDs) have received a worldwide interest in the past forty years. Significant efforts have been made to improve their syntheses and applications. However, the QD synthesis has been performed as an empirical art, lacking of fundamental understanding, especially regarding the pre-nucleation stage also called the induction period (IP). Colloidal semiconductor magic-sized clusters (MSCs) have been reported as a side product during the QD production. Meanwhile, the growth relationship between QDs and MSCs has been addressed only in a limited fashion, with no consensus reached in the literature. Here, I will present our latest advances towards the fundamental understanding of the prenucleation stage. Based on our experimental results, we propose that there are two individual pathways in the prenucleation stage of the QDs. Pathway 1 can be depicted by the self-assembly of metal (M) and chalcogenide (E) precursors which results in the formation of binary II-VI ME MSCs. The LaMer model of the classical nucleation theory (CNT) can be used to describe Pathway 2, which leads to QDs via monomers and fragments. The two pathways are inter-connected via a special intermediate, called the precursor compound (PC) of MSCs. MSCs exhibit characteristic optical absorption at specific wavelengths, and their counterpart PCs do not absorb at these and longer wavelengths. MSCs and their PCs are quasi isomers and able to transform reversibly from each other via intramolecular reorganization. Following this two-pathway model (Yu), I will introduce our latest advances on the PC-enabled pathway (with monomer substitution or addition) for transformations among various MSCs, as well as on the PC-enabled synthesis of various nano-species, which include PL CdSe helical nanostructures and ultrasmall CdS QDs with enhanced particle yield. Hopefully, this presentation brings a deeper understanding into the prenucleation stage of QDs. With the two-pathway model (Yu) proposed for the growth of binary ME MSCs and corresponding quantum dots (QDs), the synthesis of colloidal nanocrystals could move one step forward to transform from an empirical art to science.

Keywords: Quantum Dots (QDs), Magic-Size Clusters (MSCs), Precursor Compounds (PCs), Induction Period (IP), Two-Pathway Model

Reference

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Bio | Prof. Kui Yu joined Sichuan University in 2014 with a Yangtze River Scholarship chair position, awarded from the Ministry of Education, P. R. China. Since 2002, she started her independent research career, focusing on the research field of colloidal photo-luminescent semiconductor quantum dots (QDs). Dr. Yu earned her Ph.D. from Department of Chemistry, McGill University (Canada), and went to Sandia National Laboratories (USA) as a post-doc fellow and a limited term employee. Dr. Yu joined National Research Council Canada (NRC) in Ottawa in 2002 as an Assistant Research Officer and became Associate and then Senior Research Officer till 2014. Dr. Yu serves as Associate Editor for ACS Applied Materials & Interfaces.

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