Lead Sulfide Quantum Dot Ligand Density Quantification Towards Controlled Assembly of Nanocrystal Solids

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Abstract: Lead sulfide (PbS) quantum dots (QDs) have garnered attention as light absorbing materials for photodetectors and solar cells. Large extinction coefficients and size tunable direct band gaps are a few of the properties that make QDs attractive for optoelectronic applications. While synthetic procedures have progressed to allow for synthetic control over size, size distribution, and to some extent capping ligand, the procedures for reliably purifying QDs have fallen behind. Frequently, QDs are purified using a precipitation and redissolution method that relies on differences in solubility to precipitate the dots which are then separated from synthetic impurities by subsequent centrifugation and decantation. This procedure, however, can lead to an irreversible aggregation and a loss of quantum confinement thereby ruining the sample. Recently gel permeation chromatography, an anhydrous form of size exclusion chromatography, has been developed as a reproducible way to purify quantum dot samples removing synthetic impurities as well as weakly associated ligands. GPC provides a consistent starting material to which post-synthetic modifications can be made which are required for the majority of applications. Here we utilize GPC purification to study the relationship between PbS QD size and ligand density at the surface. For many optoelectronic applications, QDs are deposited as films and better understanding of the ligand coverage will help to improve these deposition and ligand exchange processes.