Monodisperse Polymer-Ligated Nanocrystals: from Synthesis to Dimension-dependent Physical Properties

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Despite recent progress in synthesis and utility of semiconducting nanoparticles (NPs) due to their intriguing optoelectronic properties, the compositional instability of some of them remains a great challenge for their practical applications. Herein, we report a unique strategy via capitalizing on a set of star-like block copolymers as nanoreactors for in situ crafting of uniform semiconducting NPs with readily tailored sizes, surface chemistry, optoelectronic properties, and more importantly, an array of markedly enhanced stabilities. The diameter of the resulting NPs can be conveniently tuned by regulating the molecular weight of the inner hydrophilic blocks of star-like block copolymers. The intimate and permanent tethering of the outer blocks of star-like block copolymers on the surface of semiconducting NPs imparts their effective dispersion in both the solution and dry state. Intriguingly, judiciously alternating the compositions and chain lengths of the outer blocks of the star-like block copolymers renders controllable, remarkably improved stability and additional functionality of semiconducting NPs. On the other hand, the incorporation of conjugated polymer connected outside semiconducting NPs manifested efficient separation of photogenerated charge carriers at their interfaces due to the appropriate electronic band alignment between conjugated polymer and semiconducting NPs. As a result, the polymer-ligated semiconducting NPs with both enhanced stability and efficient charge carriers separation can be utilized in novel application that previously hindered by their intrinsic instability, for instance, photo-induced polymerization. In principle, our star-like block copolymer nanoreactor strategy can be easily extended to synthesize functional NPs other than semiconductors for investigation into their dimension-dependent physical properties and self-assembly as well as various applications.