Enhancing Photoexcitation Energy Transfer in a Novel Graphene-Colloidal Quantum Dot Interface

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Currently, the capabilities of optoelectronic devices such as solar cells and photosensors are limited by inefficient light absorption and slow charge transport. Graphene-colloidal quantum dot interfaces (GCIs), nanostructured hybrids of colloidal quantum dots and graphene, provide promising solutions to these problems. However, the rate of transfer of photoexcitation energy from quantum dots to graphene requires enhancement. In this study, we optimized GCIs by determining the effect of species, ligand length, and size of quantum dots on photoexcitation energy transfer rates. First, through ab initio model calculations, we found that GCI performance can be enhanced by (1) using PbS quantum dots instead of widely used CdSe; (2) replacing bulky oleic acid ligands on the quantum dots with short halides (“atomic ligand exchange”); and (3) using quantum dots with an optimal diameter of ~7.55 nm. Next, we performed a proof of concept by designing and fabricating a novel PbS-based GCI. We employed an atomic ligand exchange process that was safer and simpler than those used previously in GCIs. Following ligand exchange, we observed an increase in energy transfer rate by an unprecedented factor of ~5.6. Our findings are an important step toward the deployment of GCIs as components of efficient optoelectronic devices.