Protein-Templated Synthesis and Assembly of Visible-Light-Driven Semiconductor Nano-Architectures for Efficient Hydrogen Production

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Abstract

Bacteriophages have emerged as useful biotemplates for material synthesis due to their unique recognition ability for inorganic components. Bacteriophages are assembled from protein subunits into precise 3D nano-scale structures and can be replicated in large quantities. Furthermore, bacteriophages are amenable to express foreign protein insets through genetic engineering such that the bio-templates possess the ability to recognize and direct the growth of desired inorganic nanostructures. P22 virus is a lysogenic bacteriophage and its viral capsid has been widely investigated in virus assembly. In this work, both the coat and scaffolding proteins of P22 have been genetically engineered with special binding peptides for the synthesis of visible-light-driven semiconductor nano-architectures for potential clean-energy applications. A variety of sulfide nanostructures with controlled size, phase structure, and three-dimensional architecture have been synthesized using the engineered coat protein templates. With increasing reaction time, sulfide nanostructures are observed to develop from monodisperse quantum dots to hollow spheres. Similarly, using genetically engineered scaffolding proteins of P22, both CdS and TiO_2 nanostructures have been grown inside the shell cavity.