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Dimensional-Controlled Functional Gold Nanoparticles and Zinc Oxide Nanorods for Solar Water Splitting

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Abstract : Semiconductor photocatalyst is known as one of the key roles in developing clean and sustainable energy. However, most of the semiconductor only possesses photoactivity within the UV light region, and hence, decreases the overall photocatalyst efficiency. Generally, the overall effectiveness of the photocatalyst activity is determined by three critical steps: (i) light absorption efficiency and photoexcitation electron-hole pair generation, (ii) separation and migration of charge carriers to the surface of the photocatalyst, and (iii) surface reaction of the carriers with its environment. Much effort has been invested on optimizing hierarchical nanostructures of semiconductors for efficient photoactivity due to the fact that the visible light absorption capability and occurrence of the chemical reactions mostly depend on the dimension of photocatalysts. In this work, we incorporated zero-dimensional (0D) gold nanoparticles (AuNPs) and one dimensional (1D) Zinc Oxide (ZnO) nanorods (NRs) onto strontium titanate (STO) for efficient visible light absorption, charge transfer, and separation. We demonstrate that the electrical and optical properties of the photocatalyst can be tuned by controlling the dimensional structures of AuNPs and ZnO NRs. We found that smaller AuNPs sizes exhibited higher photoactivity because of Fermi level shifting toward the conductive band of STO, STO band gap narrowing and broadening of absorption spectrum to the visible light region. For ZnO NRs, it was found that the average ZnO NRs c-axis length must achieve of certain length to induce multiphoton absorption as a result of light reflection and trapping behavior in the free space between adjacent ZnO NRs hence broadening the absorption spectrum of ZnO from UV to visible light region. This work opens up a new way of broadening the absorption spectrum by incorporating controllable nanostructures of semiconductors, which is important in optimizing the solar water splitting process.

Keywords : gold nanoparticles, photoelectrochemical, PEC, semiconductor photocatalyst, zinc oxide nanorods
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