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Synthesis of spatially separated aluminum oxide-titanium dioxide yolk-shell hollow spheres as efficient photocatalyst for water oxidation

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Solar chemical fuel (H_2 and O_2) produced by mimicking the nature photosystem reaction is desirable as it is clean energy. The central determinant is the synthesis of water oxidation photocatalyst as it requires to fulfill the four-hole complex chemistry. Fe_2O_3 is a suitable candidate as it is abundant and harvest the visible portion of the solar spectrum. However, photogenerated electron-hole recombination phenomenon and light penetration depth about the minority charges collection length are the issues which need to address. For the first time, controlled pseudobrookite phase as the yolk and titanium oxide as the shell of hollow spheres were synthesized for the photocatalytic water oxidation. Simple and facile sacrificial hard template strategy was utilized. Firstly, the distribution of TiO_2 in the hollow spheres was controlled by loading aqueous solution of 2, 3, and 5 mol/L $TiCl_4$ precursor respectively onto carbonaceous template followed by annealing. To prove the Al^{3+} ions radial penetration into the hydrophobic core of carbonaceous template, we optimized the ethanol to water ratio. The designed photocatalysts exhibited excellent light harvesting due to the geometry of hollow sphere; charge separation by a thin shell-yolk hetero-junction, a void cavity to access reaction solvent to reactive sites and the hetero-junction of Al-O-Ti in the hollow structure. These findings suggest that our designed Al_2O_3-TiO_2 yolk-shell hollow spheres are beneficial for the photocatalytic water oxidation.

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