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Harnessing Sunlight for Clean Water: Scalable Approach for Silver-Loaded Titanium Dioxide Nanoparticles

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Abstract : Water pollution is a critical global challenge that demands scalable and effective solutions for water decontamination. In this captivating research, we unveil a groundbreaking strategy for harnessing solar energy to synthesize silver (Ag) clusters on stable titanium dioxide (TiO_2) nanoparticles dispersed in water, without the need for traditional stabilization agents. These Ag-loaded TiO_2 nanoparticles exhibit exceptional photocatalytic activity, surpassing that of pristine TiO_2 nanoparticles, offering a promising solution for highly efficient water decontamination under sunlight irradiation. To the best knowledge, we have developed a unique method to stabilize TiO_2 P25 nanoparticles in water without the use of stabilization agents. This breakthrough allows us to create an ideal platform for the solar-driven synthesis of Ag clusters. Under sunlight irradiation, the stable dispersion of TiO_2 P25 nanoparticles acts as a highly efficient photocatalyst, generating electron-hole pairs. The photogenerated electrons effectively reduce silver ions derived from a silver precursor, resulting in the formation of Ag clusters. The Ag clusters loaded on TiO_2 P25 nanoparticles exhibit remarkable photocatalytic activity for water decontamination under sunlight irradiation. Acting as active sites, these Ag clusters facilitate the generation of reactive oxygen species (ROS) upon exposure to sunlight. These ROS play a pivotal role in rapidly degrading organic pollutants, enabling efficient water decontamination. To confirm the success of our approach, we characterized the synthesized Ag-loaded TiO_2 P25 nanoparticles using cutting-edge analytical techniques, such as transmission electron microscopy (TEM), scanning electron microscopy (SEM), X-ray diffraction (XRD), and spectroscopic methods. These characterizations unequivocally confirm the successful synthesis of Ag clusters on stable TiO_2 P25 nanoparticles without traditional stabilization agents. Comparative studies were conducted to evaluate the superior photocatalytic performance of Ag-loaded TiO_2 P25 nanoparticles compared to pristine TiO_2 P25 nanoparticles. The Ag clusters loaded on TiO_2 P25 nanoparticles exhibit significantly enhanced photocatalytic activity, benefiting from the synergistic effect between the Ag clusters and TiO_2 nanoparticles, which promotes ROS generation for efficient water decontamination. Our scalable strategy for synthesizing Ag clusters on stable TiO_2 P25 nanoparticles without stabilization agents presents a game-changing solution for highly efficient water decontamination under sunlight irradiation. The use of commercially available TiO_2 P25 nanoparticles streamlines the synthesis process and enables practical scalability. The outstanding photocatalytic performance of Ag-loaded TiO_2 P25 nanoparticles opens up new avenues for their application in large-scale water treatment and remediation processes, addressing the urgent need for sustainable water decontamination solutions.

Keywords : water pollution, solar energy, silver clusters, TiO_2 nanoparticles, photocatalytic activity
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