A X-ray spectroscopy study for the investigation of the mechanism of the plasmon-induced photocatalytic activity of Au nanoparticle-decorated hollow mesoporous TiO_2

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Abstract

The Au nanoparticle-decorated hollow mesoporous TiO_2 (Au-NDHMTs) with 0.0, 0.1, 0.25, 0.5, and 1.0 wt% Au loading contents were successfully synthesized via a hydrothermal route. The photocatalytic performance of Au-NDHMTs is found that can be enhanced by controlling its particle size. With the aid of XAS spectra, the univalent Au ions, lattice distortion, and variation in Ti 3*d* orbital orientation were observed. Furthermore, the increasing in the Ti 3*d* t_{2g} unoccupied state infers to the significant effect of Au incorporation on the symmetry of TiO_6 octahedral. An *in-situ* XAS measurement was first conducted to investigate the correlation between electronic structure and photocatalytic performance in the Au-NDHMTs system. In addition, the UV-visible absorption spectra and I-V measurements were performed to examine localized surface plasmon resonance (LSPR) effect and photoelectrocatalytic (PEC) ability. These results show an LSPR effect triggered by the Au nanoparticles that provides a conductive path to the excited charge carriers. The charge transfer from Au 5*d* to Ti 3*d* orbitals under solar illumination generated an enhanced photocurrent. The photocurrent density of Au-NDHMTs shows an increase with Au content with a maximum for 0.5 wt% Au, whereas in the case of 1% Au the photocurrent profile was similar to 0% Au. A comparison of the XAS and PEC performances implies that the lattice distortion and the corresponding symmetry changes together with the size of Au particle substantially influenced the rate of hot electron charge transfer. In detail, the variation of PEC activity of Au-NDHMTs sample with 0.5 wt% Au loading has the highest activity. This work improve photocatalytic efficiency by making chemically stable innovative structures with enhanced surface area, which is very important for the environmental and energy applications.

Keywords - Au Nanoparticle-Decorated, TiO_2, X-ray Spectroscopy