Improvement of Photocatalytic Efficiency by Adding Ag Nanoparticles and Reduced Graphene Oxide to TiO_2

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1. Introduction

Titanium dioxide (TiO_2) is the commonly used photocatalyst. However, because only a small ultraviolet portion of solar spectrum can excite the electron-hole pairs resulting from the large band gap (3.2 eV) [1] and the recombination rate is high, its efficiency is restrained. To overcome this drawback, we added silver nanoparticles and reduced graphene oxide (RGO) to construct the ternary plasmonic catalyst to improve the catalytic performance of TiO_2 nanopowder (P25). We prepared three different geometries of Ag nanostructures including sphere, decahedron and prism because the plasmon resonance properties of Ag could be controlled by the morphology of Ag nanoparticle, which shows characteristic strong localized surface plasmon resonance (LSPR) leading to an increase in light absorption [2]. The incorporated RGO inhibited the charge recombination and enhanced the electron-hole separation. In this study, Ag nanodecahedrons/P25/RGO and Ag nanoprisms/P25/RGO hybrid photocatalysts possessed remarkable photocatalytic activity, which displayed over 8 times higher photocatalytic efficiency than the P25 photocatalyst.

2. Results and discussions

The morphologies of Ag/P25/RGO ternary hybrid system with 0.432 wt% Ag and 5 wt% RGO were examined by bright field TEM images and are shown in Figure 1(a), (b) and (c) for the three different geometries of Ag nanoparticles. While the size of P25 was about 25 nm, it was bigger than Ag nanospheres (~20 nm), compatible with Ag nanodecahedrons (30–50 nm) and smaller than Ag nanoprisms (60–100 nm). RGO could be identified from the fine lines in the image as the contrast was enhanced by the wrinkle or the edge. Figure 1(d) shows methylene blue (MB) decolorization of binary and ternary systems with various Ag nanostructures. In this case, MB as the target pollutant was mixed with nanocomposites catalysts in the reactor under a commercially florescent lamp (10 W) irradiation. Under our experimental conditions, the degradation rates of the ternary hybrid photocatalysts with RGO were higher than those of binary hybrid photocatalysts without RGO for every Ag nanostructure. In our ternary systems, Ag(d)/P25/RGO and Ag(p)/P25/RGO with 0.432 wt% of Ag and 5 wt% of RGO exhibited the highest reaction rate, which photodegraded more than 80% of MB under visible-light irradiation for 1 h and displayed the highest photocatalytic efficiency.

3. Conclusions

In summary, the Ag nanostructures could enhance the absorbance of co-catalysts in both UV light and visible light ranges. The addition of RGO could enhance the electron-hole separation to improve the efficiency of catalyst. In our study, the hybrid nanocomposite demonstrated excellent photocatalytic response under visible light irradiation as compared to the commercial P25 powder. Specifically, the Ag/P25/RGO hybrid plasmonic photocatalyst with 0.432 wt% of Ag and 5 wt% of RGO remarkably enhanced the photocatalytic efficiency.

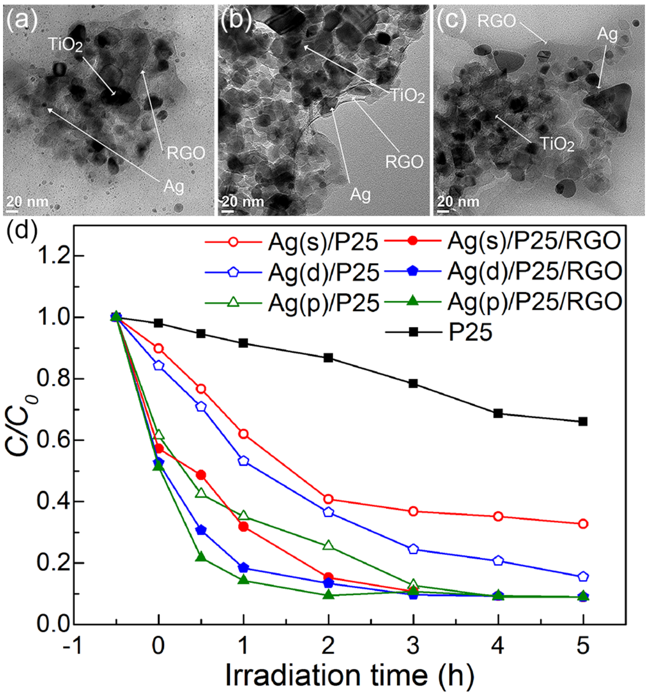

Figure 1. TEM images of ternary systems of (a) Ag(s)/P25/RGO, (b) Ag(d)/P25/RGO, and (c) Ag(p)/P25/RGO with 0.432 wt% Ag and 5wt% RGO compositions. (d) MB decolorization of binary and ternary systems with various Ag nanostructures.

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References

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