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One-step synthesis of composite semiconductor AgBr/$Ag_5P_3O_{10}$ heterojunctions and their photocatalytic activity, kinetic analysis, photocatalytic mechanism under visible light radiation

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HIGHLIGHTS

- AgBr/$Ag_5P_3O_{10}$ heterojunctions showed higher activity than that of $Ag_5P_3O_{10}$.
- The high activity could be attributed to AgBr for modifying $Ag_5P_3O_{10}$.
- More ·OH radicals may be significant reason to improve $Ag_5P_3O_{10}$ activity.

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ABSTRACT

A composite semiconductor AgBr/$Ag_5P_3O_{10}$ heterojunction has been synthesized by a simple one-step ion-exchange process in Br ionic liquids. All the as-obtained AgBr/$Ag_5P_3O_{10}$ heterojunctions were characterized by X-ray powder diffraction (XRD), scanning electronic microscopy (SEM), transmission electronic microscopy (TEM), Brunauer–Emmett–Teller (BET), UV–vis absorption spectroscopy (UV–vis), photoluminescence (PL), and surface photovoltage (SPS) techniques. The as-prepared AgBr/$Ag_5P_3O_{10}$ heterojunctions intensively absorb in the visible light region. The effects of different conditions on the photocatalytic properties were investigated systematically. The AgBr/$Ag_5P_3O_{10}$ heterojunctions exhibited an enhanced photocatalytic activity than the individual $Ag_5P_3O_{10}$ did in the degradation of methylene blue (MB) under visible-light irradiation. Much more ·OH radicals were found in the AgBr/$Ag_5P_3O_{10}$ system in comparison with those in $Ag_5P_3O_{10}$ alone by analyzing the formed ·OH radicals under visible light radiation. The SPS measurement shows that the SPS amplitude of AgBr/$Ag_5P_3O_{10}$ heterojunctions was higher than that of $Ag_5P_3O_{10}$, which indicates the higher charge separation efficiency of AgBr/$Ag_5P_3O_{10}$ heterojunctions. Based on the above experimental results, the kinetic data and the photocatalytic mechanism of the AgBr/$Ag_5P_3O_{10}$ heterojunctions were discussed in detail.

1. Introduction

Photocatalytic technique has attracted much attention in solving environmental contaminated problems because of low cost, high activity and pollution-free [1–3]. A lot of unique semiconductors, such as TiO_2, ZnO, and WO_3, show good photolytic performance [4–10]. Besides, composite semiconductor heterojunction photocatalysts have also been applied to the degradation of pollutants to further boost the photocatalytic activity [11–18]. The effective separation of photogenerated electrons and holes in the composite semiconductor heterostructures can significantly augment the photocatalytic activity under light radiation. The energy band positions of two semiconductors in heterojunctions differ, thus the photogenerated electrons in the semiconductor surface migrate to the low energy band, which facilitates the effective separation of photogenerated electrons and holes, leading to the full oxidation of the photogenerated holes.

In our experiments, we found that $Ag_5P_3O_{10}$ exhibited obvious photocatalytic activity in the degradation of MB. In order to further enhance its photoactivity, we prepared AgBr/$Ag_5P_3O_{10}$ heterojunctions in the Br ionic liquid by a one-step synthesis, and their

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