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Enhanced photodegradation of Rhodamine B by coupling direct solid-state Z-scheme N-$K_2Ti_4O_9$/g-C_3N_4 heterojunction with high adsorption capacity of UiO-66

Fang Wang, Yong Tao Zhang, Yanli Xu, Xing Wang, Sunfeng Li, Hanbiao Yang, Xueting Liu*, Fengyu Wei*

School of Chemistry and Chemical Engineering, Hefei University of Technology, Anhui Key Laboratory of Controllable Chemical Reaction & Material Chemical Engineering, Hefei 230009, China

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ABSTRACT

N-$K_2Ti_4O_9$/g-C_3N_4/UiO-66 ternary composites were successfully synthesized by a solvothermal method, and were characterized by powder X-ray diffraction, UV–vis diffuse reflectance spectroscopy, the valence band X-ray photoelectron spectroscopy, field emission transmission electron microscopy, photoluminescence emission spectra and N_2 adsorption-desorption. Photocatalytic activities of N-$K_2Ti_4O_9$, g-C_3N_4, UiO-66, N-$K_2Ti_4O_9$/g-C_3N_4 binary composites and the ternary composites were investigated by the degradation of Rhodamine B (RhB) under visible light irradiation. The results show that the ternary composites exhibit higher photocatalytic activity as compared with the binary composites and the pure materials. The synergistically enhanced photocatalytic activity of the ternary composites is due to coupling direct solid-state Z-scheme N-$K_2Ti_4O_9$/g-C_3N_4 heterojunction with high adsorption capacity of UiO-66 for RhB.

Contents

1. Introduction

In recent years, water pollution has seriously threatened the human survival, and commercially used dyes usually account for a

* Corresponding author.
E-mail addresses: wmlxt@163.com, weifyliuj@163.com (F. Wei).

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large portion of the water pollutants [1], so the treatment of dye-containing wastewater is one of the most crucial problems to be solved [2–4]. The use of solar energy and semiconductor catalysts for photocatalytic degradation of organic dyes in water has been intensively investigated as an emerging renewable technology [5–8].

Potassium titanate ($K_2Ti_4O_9$) has attracted enormous interest due to its nontoxicity, low cost, physical and chemical stability, availability, and unique electronic and optical properties [9–11]. However, as its band-gap is at ca. 3.2–3.4 eV [12], $K_2Ti_4O_9$ can only be excited under ultraviolet light. Therefore, the key point in the photocatalytic degradation of dye molecules is how to reduce the band-gap and widen the practical applications of $K_2Ti_4O_9$ related materials, in which doping of N element into $K_2Ti_4O_9$ (entitled "N-$K_2Ti_4O_9$") is a common method to enhance its visible light response [13,14].

Graphitic carbon nitride (g-C_3N_4) with layered structure similar to graphene has been reported to be a promising candidate for photocatalysis owing to its unique structure [15]. The two-dimensional planar structure with π-conjugated system benefits the transport of charge carriers, and the narrow bandgap energy of about 2.70 eV endows the polymeric semiconductor with visible-light absorbing ability up to ca. 460 nm.

Lately, numerous researches have been focused on metal-organic frameworks (MOFs) materials, which are made up of metal clusters linked to each other by organic ligands [16–20]. Due to

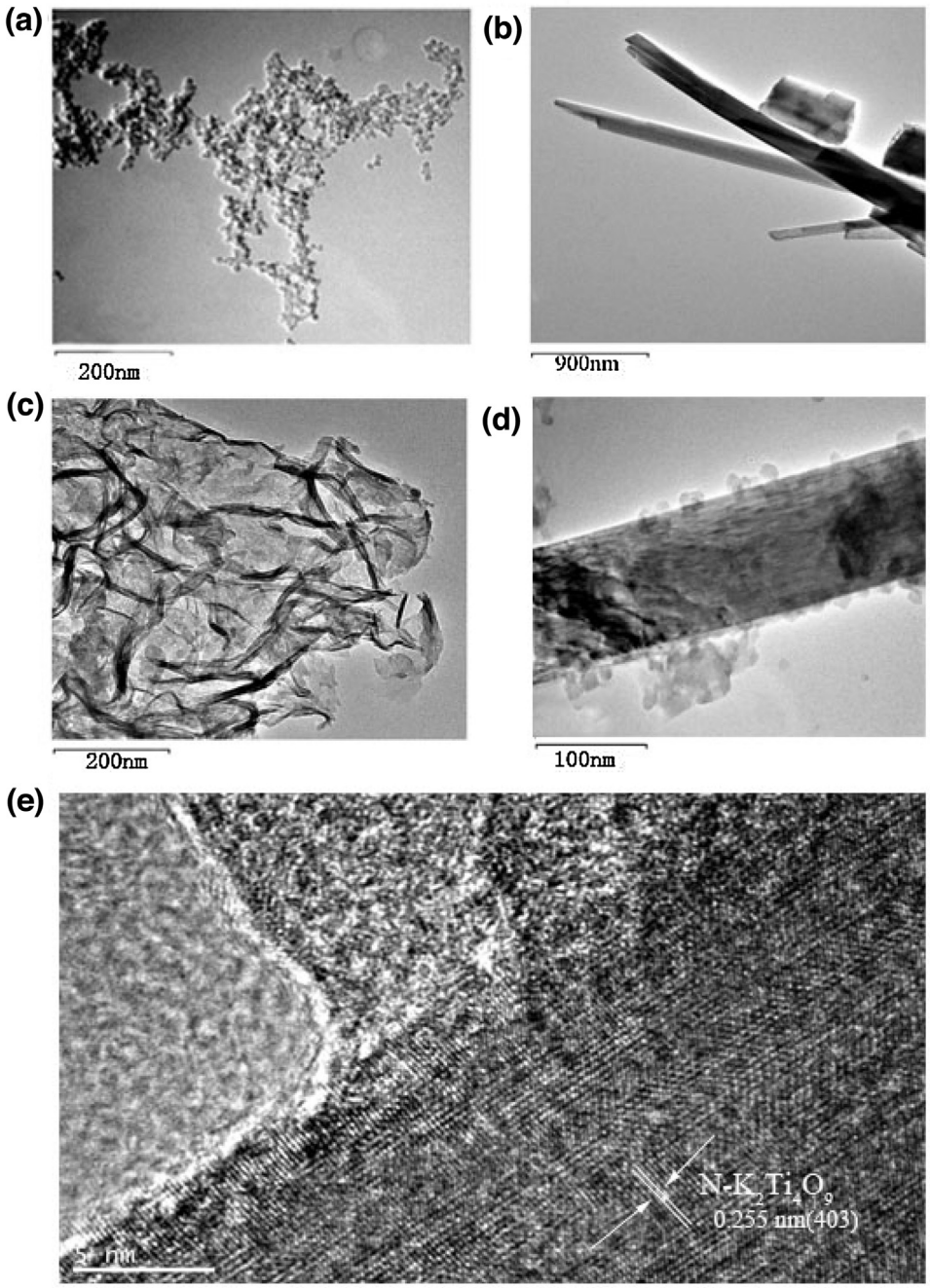

Fig. 1. TEM images of (a) UiO-66, (b) N-$K_2Ti_4O_9$, (c) g-C_3N_4, (d) N-$K_2Ti_4O_9$/g-C_3N_4/UiO-66(3:2); and (e) HRTEM image of N-$K_2Ti_4O_9$/g-C_3N_4/UiO-66(3:2).