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Hydrothermal Synthesis of Anatase TiO_2 Nanoflowers on a Nanobelt Framework for Photocatalytic Applications

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Anatase titanium dioxide (TiO_2) nanoflowers were fabricated on rutile TiO_2 nanobelts through a simple hydrothermal synthesis. The architecture of the composite nanostructures was composed of a rutile nanobelt framework with anatase nanoflowers. The novel TiO_2 composite nanostructures exhibit higher photocatalytic activity for organic pollutants relative to TiO_2 nanobelts and commercially available nanoparticles (P25). This enhanced photocatalytic activity is primarily a result of complex crystal nanostructures that enhance the carrier transport along the nanobelt framework. The results indicate that this novel TiO_2 nanostructure has superior photocatalytic properties, which demonstrates its potential as a new photocatalyst material.

Key words: TiO_2, nanoflower, hydrothermal synthesis, photocatalyst

INTRODUCTION

Titanium dioxide (TiO_2) is the most widely used photocatalyst due to its unique physical and chemical properties, environmental friendliness, and facile fabrication.[1–3] The application of TiO_2 is strongly dependent on its morphology, crystalline structure, and phase dimension.[4,5] The morphology and size properties of TiO_2 nanostructures determine their intrinsic properties, such as carrier transport and charge separation.[6–9] Hence, the characteristics of TiO_2 can be controlled by precise design of its nanostructure. Typically, a rough surface and good crystallization are essential for obtaining large specific surface areas with good carrier transport properties.[10] Structural control has been shown for nanoflower, nanoparticle, nanotube, and nanowire TiO_2, and these shapes along with rough surfaces and ordered structures have been shown to exhibit ideal behavior in photocatalytic applications.[11–13] The structures of TiO_2 that are commonly utilized tend to be on the nanoscale and show improvement with further decreases in size; this makes reuse of these materials difficult and often results in other concerns regarding nanosized particles. To solve these problems, use of nanobelt architectures that are several tens of nanometers in width and have adjustable lengths has been examined.[10] Additionally, these nanobelts have characteristic high charge mobilities and fewer localized states near the band edges and in the bandgap due to the existence of fewer unpassivated surface states in the nanobelts, which reduces electron–hole recombination rates and therefore can enhance photocatalytic efficiencies.[13,14] While rutile nanobelts show good photocatalytic ability, they do not perform as well as other anatase nanostructures, such as nanoflower structures and nanosheet structures. One way to enhance the photocatalytic ability while maintaining the ability to reuse these materials may come from the development of new composite architectures.

In this study, we take advantage of the film layer petals composing anatase nanoflowers and the ability to isolate and reuse rutile nanobelts by proposing the growth of nanostructures on nanobelts and reporting on the resulting composite structures. A novel composite nanostructure is obtained by assembling flower-like nanostructures onto a TiO_2

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