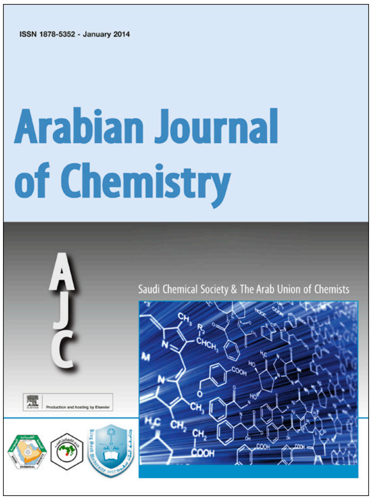

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Synthesis of highly water-dispersible N-doped anatase titania based on low temperature solvent-thermal method

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Abstract In this paper, the high-concentration aqueous dispersion N-doped anatase TiO_2 is prepared based on low temperature non-aqueous solvent-thermal method by using TCl_4 and NH_4Cl as titanium source and nitrogen source respectively. From TEM image, we can learn that the particle is composed of spindle-shaped particles with the size from 8 to 15 nm. According to the XRD and XPS spectra of N-doped TiO_2, it can be seen that, during the synthesis process, N atoms permeate into the TiO_2 lattice, and the impurity level can be formed within the band gap of TiO_2. The impurity level can extend to absorb UV and the visible light. As for N-doped TiO_2 nanoparticle of XPS spectrum, ethanol is used as solvent to form carbonaceous species on the surface of TiO_2. The carbonaceous species in visible light can excite electrons towards the TiO_2 conduction band , so as to increase the number of electrons in the conduction band under visible light to improve the catalytic activity of TiO_2 which possesses the feature of high catalytic activity under UV-visible light.

KEYWORDS TiO_2 nanoparticle; Highly aqueous dispersion; Visible light photocatalytic activity.

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1. Introduction

Semiconductor-based photocatalysts are a class of advanced materials because of important applications to cleaning environmental pollution and producing new energy, such as degradation of organic pollutants and H_2 evolution from water-splitting under UV or visible-light irradiation. Due to its non-toxic and inexpensive, Titanium dioxide (TiO_2), as a semiconductor-based photocatalysts, has aroused extensive attention (Kumar et al., 2012; Wang et al., 2012; Katoh et al., 2010; Dette et al., 2014; Periyat et al., 2009; Sun et al., 2012; Sukor et al., 2017; Hassan et al., 2017). TiO_2 has a wide band gap with 3.0-3.2 eV, which makes it has strong absorption capacity in the UV range and little absorption capacity in the visible range. This property restricts catalytic activity in the visible light range. At the same time, in order to obtain excellent photocatalysis properties, TiO_2 materials are usually made into products with nano scale. TiO_2 nanoparticles have high specific surface area and own strong surface energy, which makes it agglomerate in water easily and arouse photocatalysis activity to decrease greatly. These aforementioned shortcomings have often prevented TiO_2 materials from further being applied to different fields.

To enhance the catalytic activity of TiO_2 under visible light, doping of TiO_2 with different elements, including wildly being explored both metallic and nonmetallic elements. Doping will help bring impurity level in the band gap, and then the impurity level can create splitting of energy levels of TiO_2. In this way, absorption under visible light can be improved. At the same time, doping also helps form crystal defects, which can reduce the rate of electron-hole recombination, thereby improving the efficiency of photocatalytic reaction. Kubacka’s group prepared N,W-codoped TiO_2 using ammonium tungsten oxide as nitrogen source and tungsten source, Triton X-100 as surfactant and hexanol as cosurfactant, and then maintaining calcine under 500 ℃. The N,W-codoped TiO_2 has high photocatalytic activity, but it can’t disperse in water (Periyat et al., 2009; Halim et al., 2017; Rahman et al., 2017). Elaine's group uses tungstic acid and melamine borate as dopants to prepare C, W co-doped TiO_2 under the 400 ℃ calcination, and the result shows that W atoms can diffuse into the TiO_2 lattice, which instead increases in visible-light activity of TiO_2. However, high-temperature calcination would lead TiO_2 to agglomerate. The agglomeration of TiO_2 greatly decreases the dispersion in aqueous solution (Elaine et al., 2012; Basheer et al., 2017; Ismail and Hanafiah, 2017). Di Li’s group had used high-temperature treatment device for atomizing to prepare F,N-codoped TiO_2 (Li et al., 2005; Aziz and Hanafiah, 2017) . This F, N-codoped TiO_2 has some capacity for absorbing visible light, but the dispersibility in water is poor. Sakthivel’s group synthesized N doped TiO_2 using thiourea as N source. The band gap of obtained TiO_2 can decrease to 2.91 eV, but it would agglomerate after calcination at 400-600 ℃. In this way, the dispersibility becomes worse (Sakthivel et al., 2004; Khan et al., 2017). Doping can more or less improve the photocatalysis activity of TiO_2 under visible light. However, high temperature calcination in these methods often lead the obtained TiO_2 can hardly disperse in water (Elaine et al., 2012; Jobbagy et al., 2008; Kiraz et al., 2011; Sakthivel et al., 2004; Tachikawa et al., 2004; Chen et al., 2007; Serpone, 2006; Li et al., 2005; Shamsudin et al., 2017; Ghafar et al., 2017).

To improve the dispersible property of TiO_2 nanomaterials in water, surface modification with organic chelating ligands, such as oleic acid, oleate, and dopamine is a common method. Surface modification can reduce the

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