Nanoparticle of TiO$_2$ photocatalyst prepared on lignin structure

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Abstract

For improving the activity of TiO$_2$ as a photocatalyst, preparation of TiO$_2$ nanoparticle in the lignin structure as a support solid has been studied, which was accompanied by characterization and photoactivity test. The preparation was carried out by impregnating titania tetra isopropoxide (TTiP) solution in the ethanol and water into lignin powder, followed by calcination. In the preparation, TTiP concentration and calcination temperature have been varied to obtain an optimal condition. Characterizations by means of XRD and DRUV spectrophotometers, and TEM microscope have been conducted. Photocatalytic activity of TiO$_2$-lignin has been preliminary examined for Hg(II) photoreduction. The results of the research show that increasing TTiP concentration has increased TiO$_2$ loaded in TiO$_2$-lignin, but gives no different effect on TiO$_2$ crystallinity degree. In contrast, the elevation of calcination temperature has raised the degree of TiO$_2$ crystallinity in TiO$_2$-lignin, but yields same TiO$_2$ loaded in TiO$_2$-lignin. The optimal condition of the preparation for 0.10 gram of lignin is reached when 50 mL of 0.5 mol/L TTiP, with 12 h of the impregnation time, and 300°C of calcination temperature were applied. The TEM image and DRUV absorption spectra of TiO$_2$-lignin obtained from optimal condition infer that TiO$_2$ with uniform nanoparticle has been formed in TiO$_2$-lignin with higher band gap energy as a character of a photocatalyst. From the photoreduction experiment, it is found that the TiO$_2$-lignin prepared by optimal condition shows stronger activity in Hg(II) photoreduction than TiO$_2$ powder does. The influence of TiO$_2$ loaded and crystallinity degree in TiO$_2$-lignin on the photocatalytic activity for Hg(II) photoreduction is suggested to be examined.

Keywords: TiO$_2$, lignin, photocatalyst, nanoparticle

Introduction

Titania (TiO$_2$) has semiconductor structure that is characterized by conduction band filled with electrons and vacation empty band, separated by a gap as big as 3.2 eV, called as band gap energy. When TiO$_2$ is irradiated with UV light, one electron from the conduction band is exited into vacation band while leaves a hole or positive radical. This radical acts as a strong oxidizing agent (Hoffmann, et al, 1995) that has been examined to improve some hazardous organic pollutants including phenol (Wahyuni and Mudasir, 2005), and pesticides (Konstantinoue et al. 2001). On the other hand, electron released by TiO$_2$ can induce a reduction reaction, that has been explored for photocatalyzing reduction of toxic heavy metal ions such as Cu(II) (Wahyuni et al, 2009), Cr(IV) (Wahyuni, et al, 2011) and Hg(II) (Wahyuni and Mudasir, 2008). Because TiO$_2$ can act to increase the reaction rate and effectiveness, this oxide is also called as a photocatalyst. Photocatalytic degradation and reduction by using suspension of micro-powders TiO$_2$ has frequently been addressed because of its simplicity and easiness. But, in practical application, the suspended particles tend to aggregate, especially when they are present at high concentrations, leading to the less effective reduction. In addition, for recovery purpose, TiO$_2$ suspension is difficult to be separated appearing cost problem especially in the larger scale. This has created a number of attempts to anchor TiO$_2$ on solid supports, including zeolites (Xu and Langford, 1996) and cation exchanger resin (Wahyuni et al, 2010). It has been reported that TiO$_2$ prepared on those solids are formed as nanoparticles (1-10 nm of the size), resulting in higher band gap energy and stronger photocatalytic activity. The formation of nanoparticles is a result of the confinement of TiO$_2$ particle growth by zeolites and resins structures that have active sites and pores/voids/cages sized of 1-10 nm (Borelli, et al, 1987). Natural zeolites are abundantly deposited in nature, utilize them as solid supports must be low cost and potentially applicable in the fields. However, since the minerals come from unrenewable sources, exploring them intensively will arise environmental problems. On the hand, resins can be synthesized from plants that are renewable.