



Original Research Paper

Adsorption and photocatalysis of nanocrystalline TiO₂ particles prepared by sol–gel method for methylene blue degradationKyung-Jun Hwang^a, Jae-Wook Lee^{a,*}, Wang-Geun Shim^b, Hee Dong Jang^c, Se-Il Lee^d, Seung-Joon Yoo^{d,*}^a Department of Chemical and Biochemical Engineering, Chosun University, Gwangju 501-759, Republic of Korea^b School of Applied Chemical Engineering, Chonnam National University, Gwangju 500-757, Republic of Korea^c Korea Institute of Geoscience and Mineral Resources, Daejeon 305-350, Republic of Korea^d Department of Environmental and Chemical Engineering, Seonam University, Namwon 590-711, Republic of Korea

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ABSTRACT

Titanium dioxide (TiO₂) powders were synthesized by using TiO₂ colloidal sol prepared from titanium-tetraisopropoxide (TTIP) and used as a starting material by applying the sol–gel method. The effect of aging times and temperatures on physical and chemical properties of TiO₂ sol particles was systematically investigated. The results showed that the crystallinity and average particle size of TiO₂ can be successfully controlled by adjusting the aging time and temperature. The samples after calcination of TiO₂ powders were characterized by X-ray diffractometry (XRD), scanning electron microscopy (SEM), and nitrogen adsorption measurements. In addition, the photocatalytic activity of synthesized TiO₂ powders was evaluated by studying the degradation of 10 ppm aqueous methylene blue dye under 32 W high pressure mercury vapor lamp with 100 mg of TiO₂ powders. The highest photocatalytic activity was observed in TiO₂ powder synthesized at 90 °C for 0 h attributed to the presence of anatase and rutile phases in an 80:20 ratio.

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1. Introduction

Methylene blue (MB) is the most commonly employed basic dye that finds enormous applications in dyeing and printing industry. To date, various physical, chemical, and biological methods have been employed for the treatment of colored waste water but the search for a cost effective methodology still eludes the scientific community [1–3]. In this context, photocatalysis stands out to be one probable methodology that can be effectively exploited for the complete mineralization of various dye pollutants present in natural environment. Of late, photocatalysis has been successfully employed for environmental remediation, production of hydrogen by photo splitting of water, odor control, and in self-cleaning glasses [4]. A good photocatalyst should absorb photon whose energy is equal to or more than the band gap thereby transferring an electron from the valence band into the conduction band and subsequently generating electron–hole pair. These electrons and holes react with oxygen and water, producing superoxide anion radicals, and hydroxyl radicals which act as stronger

reducing and oxidizing species, respectively, thereby resulting in degradation of several organic as well as inorganic compounds [5].

Till now, TiO₂ is one of the most efficient photocatalysts for environmental remediation because of its biological and chemical inertness, cost effective, and strong oxidizing power of its photo generated hole. It has been known that the crystal structure of TiO₂ changes with temperature and it exists in three structural polymorphs viz., anatase, brookite, and rutile [6]. There has been much report on the synthesis of TiO₂ for the control of crystal structure and morphology. However, the systematic control of physical and chemical properties of TiO₂ was not studied well.

Therefore, in the present work, we systematically studied the effect of synthesis conditions on the photocatalytic activity of TiO₂. For that purpose, the TiO₂ samples with different crystalline properties (crystalline size and crystalline phase), particle size and surface area have been synthesized by adjusting the aging temperature and aging time in sol–gel process.

In particular, TiO₂ colloidal sol was prepared through the aging process accompanied by hydrolysis/polycondensation using titanium-tetraisopropoxide (TTIP) as a starting material to adjust the physical and chemical properties of TiO₂ powder. The adsorption and photocatalytic activity of synthesized TiO₂ powders was evaluated by examining the degradation of 10 ppm aqueous methylene blue dye under 32 W high pressure mercury vapor lamp with 100 mg of TiO₂ powders.

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