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Original Research Paper

Decolorization of beads-milled TiO_2 nanoparticles suspension in an organic solvent

I Made Joni [a,b], Takashi Ogi [a], Agus Purwanto [c], Kikuo Okuyama [a,*], Terunobu Saitoh [d], Kazutaka Takeuchi [d]

[a] Department of Chemical Engineering, Graduate School of Engineering, Hiroshima University, 1-4-1 Kagamiyama, Higashi Hiroshima, Hiroshima 739-8527, Japan
[b] Department of Physics, Faculty of Mathematics and Natural Science, Padjadjaran University, Jl. Raya Bandung-Sumedang KM 21, Jatinangor 45363, Indonesia
[c] Department of Chemical Engineering, Faculty of Engineering, Sebelas Maret University, Jl. Ir. Sutami 36 A, Surakarta, Central Java 57126, Indonesia
[d] Material Processing Research Department 3, Canon Inc., 70-1, Yanagi-cho, Saiwai-ku, Kawasaki-shi, Kanagawa 212-8602, Japan

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ABSTRACT

In this paper, a new method is proposed for the decolorization of a yellow-hued suspension of rutile TiO_2 nanoparticles in an organic solvent (diethylene glycol dimethylether). The presence of color has always been undesirable in a suspension of nanoparticles filler used for industrial needs, particularly for optical applications.

A colorless suspension was achieved by irradiating well-dispersed TiO_2 nanoparticles in an organic solvent with UV-light (λ = 254 nm) for 5 h. TiO_2 nanoparticles of 1 and 5 wt.% were dispersed using a beads mill method. Trimethoxytrifluor(propyl) silane was used as a dispersant to achieve stability. The effect of the UV-light irradiation on the TiO_2 nanosuspension was investigated by means of a Fourier transform nuclear magnetic resonance analyzer (FT-NMR). The dispersant was partially desorbed due to the interaction of UV light and the TiO_2/dispersant complex. Thus, an enhanced transparency and the absence of color were obtained for well-dispersed TiO_2 nanoparticles in an organic solvent.

1. Introduction

Titanium dioxide (TiO_2) nanoparticles are known as useful filler for some composite materials — in particular, photosensitive materials such as photoanodes [1] and photocatalysts [2]. Due to a high refractive index [3], titanium dioxide (TiO_2) is used as nanocomposite filler in optical applications. The optical properties of TiO_2 nanocomposites depend on the content, size and size-distribution, and dispersion stability of the fillers. The dispersion of nanoparticles using a beads mill process was successfully achieved only after surface modification of the particles, as shown in our previous study [4,5]. Dispersion stability of nanoparticles in liquids is an important issue on various material properties and its applications [5–7]. The attractive forces between nanoparticles in a liquid suspension are sufficiently strong that nanoparticles tend to agglomerate in most monomers [8–12]. Our previous study successfully dispersed TiO_2 nanoparticles with a primary size of 15 nm in an organic solvent using a beads mill method and a dispersing agent to modify the surface of TiO_2 [4]. However, the color of well-dispersed TiO_2 nanoparticles in an organic solvent, i.e., diethylene glycol dimethyl ether (diglyme), was yellow. This suspension did not meet the application requirement as an alternative to glass, where a colorless and transparent performance is required. Therefore, for nanocomposite optical applications, a method that will produce a colorless dispersion of TiO_2 nanoparticles in an organic solvent becomes important. In the present study, a fluorinated compound (trimethoxytrifluor(propyl) silane) ($CF_3CH_2CH_2Si(OCH_3)_3$) was applied as a dispersing agent and ultraviolet (UV) irradiation was applied to obtain a color degradation of dispersed TiO_2 nanoparticles in an organic solvent — a method that has never been investigated.

TiO_2 particles tend to absorb UV light due to a high intrinsic band gap (3.0 eV for rutile). UV light excites the electrons from the valence and conduction bands of TiO_2, leaving holes in the valence band. These electrons and holes can initiate a redox reaction with the molecular species adsorbed onto the surfaces of TiO_2 particles. Anpo and Takeuchi [13] reported that UV-light irradiation of a TiO_2 catalyst generates electron–hole pairs, which can be represented as a localized electron (Ti^{3+}) and a hole (O^-(lattice)) and/or OH radicals. Some of these electron–hole pairs disappeared after recombination on bulk TiO_2, while other electrons and holes diffused to the surface of the TiO_2 to react with various hydrocarbons (i.e., hydrogenolysis and the formation of oxygen-containing organic compounds). Thus, due to the photocatalytic activities of the TiO_2 particles, it is reasonable to apply UV irradiation to a solution to obtain the color degradation of dispersed TiO_2 nanoparticles in an organic solvent.

A Fourier transform nuclear magnetic resonance analyzer (FT-NMR) was used to measure the effect of UV irradiation exposure on the adsorbed dispersant on TiO_2 particles. Furthermore, the

* Corresponding author. Tel.: +81 82 424 7716; fax: +81 82 424 5494.
E-mail address: Okuyama@hiroshima-u.ac.jp (K. Okuyama).

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