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Comparison of ZrO_2, TiO_2, and α-Fe_2O_3 nanotube arrays on Cr(VI) photoreduction fabricated by anodization of Zr, Ti, and Fe foils

Abstract

This paper presents the fabrication of self-organized ZrO_2, TiO_2, and α-Fe_2O_3 nanotube arrays by anodization of Zr, Ti, and Fe foils, respectively in fluoride-containing EG electrolyte at 40 V for 20 min. The as-anodized nanotubes were annealed in a tube furnace at 400 °C for 3 h to induce the crystallization of the oxide film. Morphology, crystal structure, surface properties, and optical properties of the anodic ZrO_2 nanotubes (ZNTs), TiO_2 nanotubes (TNTs), and α-Fe_2O_3 nanotubes (FNTs) were characterized by Field-Emission Scanning Electron Microscopy (FESEM), Transmission Electron Microscopy (TEM), X-ray Diffraction (XRD), Fourier-Transform Infrared (FTIR) spectroscopy, Photoluminescence (PL) spectroscopy, and UV-visible Near-Infrared Diffuse Reflectance Spectra (UV-vis NIR DRS) spectroscopy, respectively. Based on the FESEM and TEM micrographs, ZNTs possessed the longest nanotubes (i.e. 9.6 μm) compared with TNTs and FNTs under the same anodization condition. The aspect ratio of the nanotubes can be arranged in the order of ZNTs > FNTs > TNTs. The surface of the annealed ZNTs, FNTs, and TNTs was enriched with-OH groups to facilitate the Cr(VI) adsorption. According to the UV-vis NIR DRS spectra, strong visible light absorption was observed on the FNTs due to their low band gap. Whereas, the TNTs predominantly absorbs the UV light at λ_{max} = 360 nm. Rapid Cr(VI) removal was observed on FNTs, i.e. 100% after 2 h activated by sunlight with negligible Cr(VI) removal for ZNTs and TNTs. When exposed to UVC (λ = 254 nm), only 39% versus 37% Cr(VI) removal efficiencies were obtained on TNTs and ZNTs after 3 h suggesting sluggish electron transfer due to rapid charge carriers recombination as evident in the PL spectra.

Keywords

Anodization; Hematite; Nanotubes; Photoreduction; Titania; Zirconia