Hierarchically Interconnected TiO_2 Nanoisland Photocatalytic Membranes with High Porosity for Wastewater Treatment

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Abstract:

Herein, we introduce the preparation of highly porous TiO_2 nanoislands (hp-TiO_2) *via* an one-step, sol-gel process using epoxy-containing polymer as a template. The soft copolymer template is synthesized *via* one-pot free-radical polymerization, which contains polyethylene glycol (PEG) and epoxy side group, simultaneously. In order to design the appropriate soft template, the ratio between the PEG chain and epoxy functional group is changed. A hydrophilic Ti precursor partially coordinated on the PEG chain while the epoxy side chain induces the crosslinking between the copolymer backbone during the sol-gel process. The hierarchically porous architecture of hp-TiO_2 is coated on the porous Al_2O_3 substrate through a spin-coating process, followed by the mild calcination to get rid of the polymeric template. The formation of hp-TiO_2 film generated the highly water-permeable interstitial voids while maintaining its interconnectivity due to the crosslinking between the polymeric template. Moreover, even though the one-pot synthesis process was introduced, the layer-by-layer morphology is well-developed without any significant cracks or severe damage on the film. The top layer consists of a uniform, mesoporous thin layer and the bottom TiO_2 particles seems to be ellipsoidal morphology. It is noteworthy that the top layer covered the bottom surface with an excellent interconnectivity, which would be important for the anti-fouling property by preventing the desorption of TiO_2 particles. The flux decline for 3 h was only 10% while achieving an organic removal efficiency of more than 91.5% under UV irradiation, which is much higher than that obtained from porous TiO_2 (p-TiO_2) yielding 53.6%.

Keywords: Photocatalytic membrane, water treatment, copolymer, titanium oxide, crosslinking