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TiO_2-C hybrid aerogel photocatalysts for methylene blue degradation

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Abstract

TiO_2-C hybrid aerogels were prepared by one-pot sol-gel process in ethanol, followed by supercritical drying and carbonization, using $TiCl_4$ as TiO_2 precursor, resorcinol-furfural as carbon precorsors, ethyl acetoacetate (EA) as a chelating agent and propylene epoxide (PO) as a gel initiator. Ce doping was performed by adding cerous nitrate into the solutions that form gels to modify the photocatalytic properties. Microstructures of samples were characterized by XRD, SEM, TEM, UV-Vis, Raman spectroscopy, nitrogen adsorption, mercury porosimetry, XPS and IR spectroscopy and the photocatalytic properties for methylene blue degradation were tested under UV and Vis light irradiation. Results showed that the porous textures of the hybrid aerogels were related to $TiCl_4$/ resorcinol-furfural mass ratio, the molar ratios of EA/Ti and PO/Ti. The samples had large specific surface areas, high adsorption capacities for methylene blue, uniform distribution of TiO_2 nanoparticles as anatase in the amorphous carbon structure. The presence of the amorphous carbon inhibited both the growth of TiO_2 nanoparticles and their conversion from anatase to rutile phase. The adsorption of methylene blue followed the pseudo-second-order kinetics model and its degradation followed the first-order kinetics model. The maximum photocatalytic activity for methylene degradation was up to 4.23 times that of P25 for the TiO_2-C hybrid aerogels carbonized at 800 ^oC. A partial reduction of Ti^{4+} to Ti^{3+} was found for the samples carbonized at 900 ^oC, which improved significantly the catalytic activity under visible light. Methylene blue can be degradated under visible light within 60 min with the Ce-doped TiO_2-C hybrid aerogels or the undoped one carbonized at 900 ^oC. Adsorption coupled with photo excitement, reduced recombination rate of e/h pair, band gap narrowing by interaction of carbon with TiO_2, partial reduction of Ti^{4+} to Ti^{3+} during carbonization or Ce-doping, and the increased light utilization via scattering by macropores are responsible for the improved catalytic performance as compared with P25 photocatalyst from Degussa.