Chemical Engineering Journal 200–202 (2012) 18–24

Contents lists available at SciVerse ScienceDirect

Chemical Engineering Journal

journal homepage: www.elsevier.com/locate/cej

Preparation of oxygen-vacant TiO_{2-x} and activated carbon fiber composite using a single-step thermal plasma method for low-concentration elemental mercury removal

Hsing-Cheng Hsi [a,*], Cheng-Yen Tsai [b]

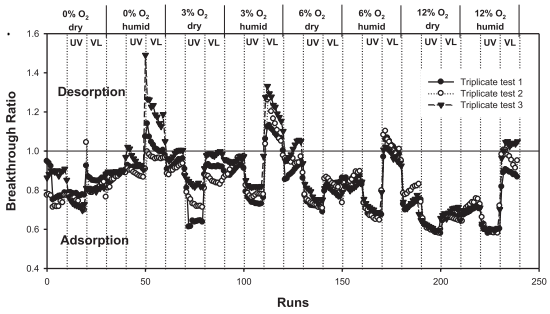
[a] Institute of Environmental Engineering and Management, National Taipei University of Technology, No. 1, Sec. 3, Chung-Hsiao E. Rd., Taipei 106, Taiwan
[b] Graduate Institute of Engineering Science and Technology, National Kaohsiung First University of Science and Technology, No. 2, Jhuoyue Rd., Nanzih, Kaohsiung 811, Taiwan

HIGHLIGHTS

- TiO_{2-x}/ACF composites were developed via a N_2/Ar/He thermal plasma system.
- TiO_{2-x} had a size within 10–40 nm and a mixture of anatase and rutile phases.
- TiO_{2-x}/ACF composites had a greater Hg removal under UV than VL irradiation.
- Presence of O_2 enhanced the Hg removal of TiO_{2-x}/ACF.
- Moisture reduced Hg removal performance of TiO_{2-x}/ACF.

GRAPHICAL ABSTRACT

TiO_{2-x}/ACF composites were synthesized using N_2/He/Ar thermal plasma. Hg^0 removal by the TiO_{2-x}/ACF was enhanced by light radiation and O_2 but reduced by competitive adsorption from moisture.



ARTICLE INFO

Article history:
Received 29 January 2012
Received in revised form 9 May 2012
Accepted 6 June 2012
Available online 17 June 2012

Keywords:
Oxygen vacancy
Photocatalyst
Carbon fiber
Mercury
Thermal plasma

ABSTRACT

Oxygen-vacant TiO_2 (TiO_{2-x}) nanoparticles and TiO_{2-x}/activated carbon fiber (ACF) composites were developed via a N_2/Ar/He thermal plasma system. The TiO_{2-x} nanoparticles and TiO_{2-x}/ACF composites were characterized with TEM, XRD, UV–Vis, ESEM and N_2 adsorption isotherms. The removal effectiveness of TiO_{2-x}/ACF for gaseous Hg^0 at ppb concentration level and various conditions was subsequently evaluated. The experimental results indicated that the formed TiO_{2-x} nanoparticles had a size within 10–40 nm and a mixture of anatase and rutile phases. The TiO_{2-x} formed at 7% N_2 concentration had an evident red-shift in wavelength absorption. The ESEM and N_2 adsorption results suggested that the synthesized TiO_{2-x} nanoparticles unevenly deposited on the ACF surface causing a decrease in total and micropore surface areas/volumes. Hg breakthrough tests revealed that TiO_{2-x}/ACF composites had a greater Hg removal under UV or visible-light irradiation than those obtained in the dark condition. The presence of O_2 up to 12% greatly enhanced the Hg removal, implying the positive effects of catalytic oxidation. However, moisture reduced Hg removal performance, especially when visible-light irradiation was applied. These results revealed the competitive adsorption between Hg species and H_2O and the physisorption nature of Hg species on the light-induced hydrophilic TiO_{2-x}/ACF surface.

* Corresponding author. Tel.: +886 2 27712171x4126; fax: +886 2 87732954.
E-mail address: hchsi@ntut.edu.tw (H.-C. Hsi).

1385-8947/$ - see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.cej.2012.06.021