



Comparative photocatalytic degradation of estrone in water by ZnO and TiO₂ under artificial UVA and solar irradiation

Jie Han^{a,*}, Yangsi Liu^a, Naresh Singhal^b, Lianzhou Wang^c, Wei Gao^{a,*}

^a Department of Chemical & Materials Engineering, The University of Auckland, Auckland, New Zealand

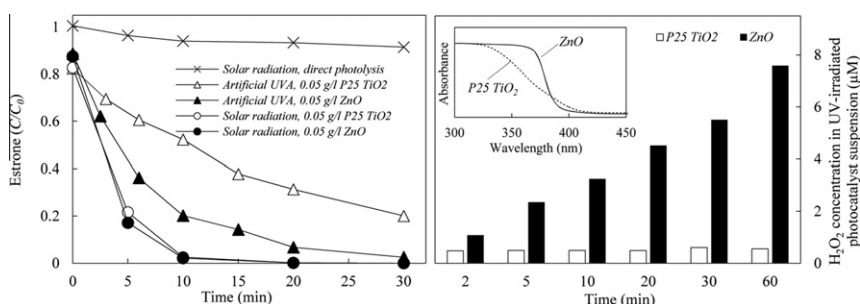
^b Department of Civil & Environmental Engineering, The University of Auckland, Auckland, New Zealand

^c ARC Centre of Excellence for Functional Nanomaterials, School of Chemical Engineering, The University of Queensland, St. Lucia, Brisbane, Australia

HIGHLIGHTS

- ▶ Rapid degradation of estrone by ZnO under artificial UVA or solar irradiation.
- ▶ Markedly faster estrone degradation by ZnO than P25 TiO₂ under UVA irradiation.
- ▶ Higher UV absorbance on ZnO than P25 TiO₂ in the 320–385 nm region.
- ▶ Higher concentrations of H₂O₂ generated in UV-irradiated ZnO suspension.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:

Received 23 May 2012

Received in revised form 14 September 2012

Accepted 17 September 2012

Available online 5 October 2012

Keywords:

Estrone
Photocatalysis
Zinc oxide
Titanium dioxide
Photocatalytic activity

ABSTRACT

Zinc oxide (ZnO) was studied as a photocatalyst under artificial ultraviolet (UV) and solar irradiation for degradation of estrone, a ubiquitous micropollutant widely detected in treated effluent from sewage treatment facilities. Despite its lower specific surface area and larger agglomerate size in water, ZnO enabled significantly more rapid estrone degradation in water under artificial UVA irradiation compared to the benchmark photocatalyst, Aeroxide[®] titanium dioxide P25 (P25 TiO₂). Dissolution of ZnO photocatalyst, predominantly driven by its aqueous solubility, occurred during the photocatalytic degradation process which could be mitigated by pH adjustment. Solar irradiation was found to be a highly effective UV source for estrone photocatalytic degradation using either ZnO or P25 TiO₂. Previous comparative studies on ZnO and TiO₂ photocatalysts were reviewed, and the origin of the superior performance of ZnO under artificial UVA irradiation was investigated. Diffuse reflectance spectroscopy measurements showed that ZnO exhibited markedly higher UV absorbance than P25 TiO₂ within the wavelength range of 320–385 nm, which supports the observation that ZnO showed evidently better performance than P25 TiO₂ for estrone degradation under weak artificial UVA irradiation. Furthermore, a detailed mechanism was proposed on the role of intrinsic defects during ZnO optical excitation and charge transfer process, and its potential effect on ZnO surface redox reactions. The mechanism was supported by the observation that higher levels of hydrogen peroxide were generated in UV-irradiated ZnO suspension in the absence of added electron donors, suggesting that the photocatalytic activity of ZnO may be enhanced by an effective charge separation mechanism induced by its intrinsic defects.

© 2012 Elsevier B.V. All rights reserved.

1. Introduction

Endocrine-disrupting compounds (EDCs) comprise a class of trace organic contaminants in water that can interfere with the normal functioning of endocrine systems in human and wildlife.

* Corresponding authors. Tel.: +64 9 373 7599x88667; fax: +64 9 373 7463 (J. Han), tel.: +64 9 373 7599x88175 (W. Gao).

E-mail addresses: jie.han@auckland.ac.nz (J. Han), w.gao@auckland.ac.nz (W. Gao).