



Photodegradation of estrogenic endocrine disrupting steroidal hormones in aqueous systems: Progress and future challenges



Kireesan Sornalingam^a, Andrew McDonagh^b, John L. Zhou^{a,*}

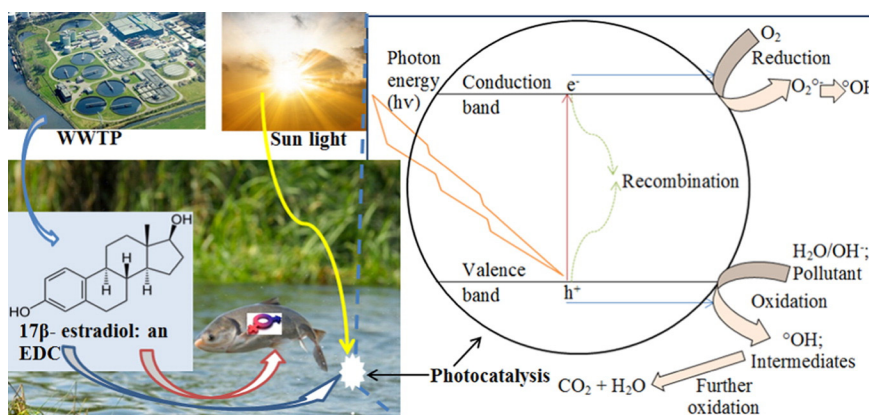
^a School of Civil and Environmental Engineering, University of Technology Sydney, NSW 2007, Australia

^b School of Mathematical and Physical Sciences, Faculty of Science, University of Technology Sydney, NSW 2007, Australia

HIGHLIGHTS

- Photodegradation of E1, E2, E3 and EE2 follows 1st or pseudo 1st order kinetics.
- Fastest removal rates occur at pH 7–8, for a range relevant to natural environment.
- The optimum TiO₂ loadings are often between 0.05 and 1 g l⁻¹.
- Estrogenicity persists if the intermediates possess the phenolic moiety.
- Both positive and negative impacts from DOM on photodegradation are reported.

GRAPHICAL ABSTRACT



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ABSTRACT

This article reviews different photodegradation technologies used for the removal of four endocrine disrupting chemicals (EDCs): estrone (E1), 17 β -estradiol (E2), estriol (E3) and 17 α -ethinylestradiol (EE2). The degradation efficiency is greater under UV than visible light; and increases with light intensity up to when mass transfer becomes the rate limiting step. Substantial rates are observed in the environmentally relevant range of pH 7–8, though higher rates are obtained for pH above the pK_a (~10.4) of the EDCs. The effects of dissolved organic matter (DOM) on EDC photodegradation are complex with both positive and negative impacts being reported. TiO₂ remains the best catalyst due to its superior activity, chemical and photo stability, cheap commercial availability, capacity to function at ambient conditions and low toxicity. The optimum TiO₂ loading is 0.05–1 g l⁻¹, while higher loadings have negative impact on EDC removal. The suspended catalysts prove to be more efficient in photocatalysis compared to the immobilised catalysts, while the latter are considered more suitable for commercial scale applications. Photodegradation mostly follows 1st or pseudo 1st order kinetics. Photodegradation typically eradicates or moderates estrogenic activity, though some intermediates are found to exhibit higher estrogenicity than the parent EDCs; the persistence of estrogenic activity is mainly attributed to the presence of the phenolic moiety in intermediates.

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* Corresponding author.

E-mail address: junliang.zhou@uts.edu.au (J.L. Zhou).

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1. Introduction

Endocrine disrupting chemicals (EDCs) can cause adverse health effects in reproductive, neurological and immune systems WHO (2015); NIEHS. Endocrine disruptors, 2015. The effect of EDCs on wildlife and

humans has been widely reported. EDCs are usually present in the environment at trace concentrations but can still cause significant damage (Snyder et al., 2003). They enter the environment mainly from sewage treatment plant (STP) effluents (Laganà et al., 2004) although other sources include direct discharge, leakage from septic tanks and run-off

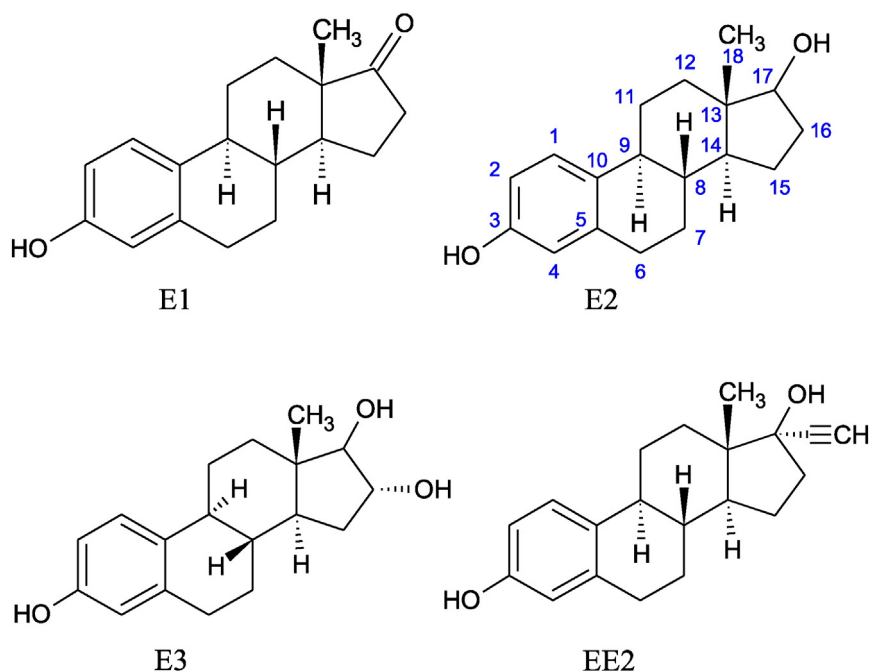


Fig. 1. Chemical structures of estrogenic steroidal hormones. The atomic numbering scheme is shown in the structure of E2.

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