Triclosan degradation by electro-Fenton process using electrolytic unit with titanium electrodes

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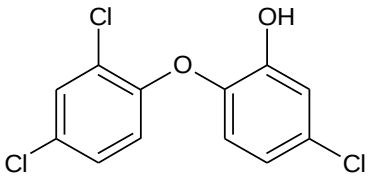
Abstract
The paper focuses on the degradation of a widely used antibacterial agent triclosan (5-chloro-2-(2,4-dichlorophenoxy)phenol by electro-Fenton process. Direct and indirect type of oxidation has been investigated. The continuous system consisting of an electrolytic unit (undivided reactor cell with coated iridium oxide titanium electrodes used both as the cathode and the anode), peristaltic pump which was used for pumping the aqueous triclosan solution through the system. Triclosan concentration of 10 mg/L was used for the purpose of the experiments. Different concentrations of Fe^{2+}, H_2O_2 (if added) as Fenton reagents, different concentrations of Na_2SO_4 as a supporting electrolyte, different flow rates and current values were used to examine what impact it has on the degradation. The main reactive oxygen species responsible for the degradation are ·OH radicals generated in the process.

Keywords
Degradation, Electro-Fenton, sorption, triclosan.

INTRODUCTION

In last few decades there has been increase in concern regarding the emerging pollutants such as pharmaceuticals, pesticides, personal care products (PCPs) etc. Among these pollutants is also triclosan (TCS), 5-chloro-2-(2,4-dichlorophenoxy)phenol (Fig.1) – a broad spectrum antimicrobial agent widely used in PCPs such as toothpastes, soaps, shampoos, cosmetics (Bedoux, 2012). Triclosan is ordinarily detected in aquatic environments (Bester, 2003) and although the removing efficiency of TCS in wastewater treatment plants (WWTPs) is quite high, a small percentage of the compound is discharged to the rivers where it could affect the aquatic biota because of its toxicity for water organisms such as algae, phytoplankton, daphnia, invertebrates, fish (Orvos, 2002).



(1)

Fig.1 Chemical structure of triclosan

There are several ways for degradation of organic pollutants so-called advanced oxidation processes (AOPs). These processes are all characterized by generation of $^{\bullet}OH$ radicals as the main oxidizing species which are very strong agents capable of degrading broad spectrum of organic molecules. Among many oxidation processes in respect to the topic of this paper we should name Fenton based processes which are used in recent years in many different ways. We could distinguish Fenton reactions as follows: classical Fenton reaction uses H_2O_2 and Fe^{2+} to generate $^{\bullet}OH$ radicals (Fenton, 1894), Fenton-like process (H_2O_2 and Fe^{3+}), photo-Fenton ($H_2O_2/Fe^{2+}(Fe^{3+})$/UV) and so-called

electro-Fenton which is the focus of this paper. By electro-Fenton reaction the hydrogen peroxide is generated from the saturated oxygen solution on the electrodes (Brillas, 2009).

MATERIALS AND METHODS

Electrolytic equipment

Electrolytic unit was purchased from Adept Water Technologies, Denmark and consisted of undivided reactor cell of volume about 70 cm^3 with iridium oxide coated titanium electrodes (both used as the cathode and the anode). Peristaltic pump with pump tubing and PTFE tubing as the connecting part in the circulation system were used. 1 L of 10 mg/L aqueous TCS solution was used in the continuous system.

Analysis

Triclosan was quantified by Agilent Technologies HPLC 1100/1200 series equipped with a Zorbax Eclipse XDB - C18 column (4.6 x 150 mm, 5 μm) and a DAD detector. The analysis was carried out at 214 and 220 nm simultaneously; the mobile phase was a mixture of acetonitrile and water (65:35, v/v) at a flow rate of 1 ml/min. Soluble and total soluble iron were measured by the 1,10-phenantroline method.

RESULTS AND DISCUSSION

Degradation of 10 mg/L aqueous TCS solution by Electro-Fenton reaction in a continuous system with iridium oxide coated titanium electrodes has been conducted. Different concentration of a Fenton reagent Fe^{2+}, different concentrations of Na_2SO_4 as a supporting electrolyte, various flow rates (50 and 100 ml/min) and current values were changed. Triclosan degradation process has been influenced by the sorption effect of TCS to plastic materials in the system. An effort to overcome the sorption has been made by change of the setup but without any significant effect. Sorption varies with the flow rate and for the setup which was used for the experiments it was around 18 - 26 %. Degradation rate after sorption deduction was behind 17 and 26 % within 60 minutes. Ways for improvement of the process are the future goals to increase the degradation percentage in short time and make it efficient and cheap. The sorption phenomenon might be very interesting for further investigation in continuous systems for degradation of TCS and other emerging pollutants. Electro-Fenton is an alternative way to already used modified classical Fenton reaction and could work as a powerful method for the effective elimination of TCS and many other contaminants in the wastewaters.

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