Chapter 14
Advanced Oxidation Processes for Mineralization of Amoxicillin in Aqueous Solutions

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ABSTRACT

This chapter presents the study of kinetics and mechanisms of transformation of EC (antibiotics) by advanced oxidation processes (AOPs): Fenton (H2O2/Fe(II)), UV photolysis (UV/H2O2/TiO2), and combined methods. The application of AOPs is based on the formation of reactive species such as hydroxyl radical, superoxide radical, hydroperoxyl radical (HO2•), and peroxyradical (ROO•) and takes place by electron transfer reaction, proton extraction by the production of organic radicals (R•) and electrophilic addition to the double bond or aromatic ring. The main objective of this research includes the optimization of the physico-chemical parameters that influence the oxidation process of amoxicillin (AMX). The effect of EC degradation/mineralization was determined according to the concentrations of hydrogen peroxide and catalyst (Fe(II), TiO2), UV intensity, environmental pH, and others. EC transformation rates and speed constants of HO• bimolecular reactions with different emerging contaminants using AOPs have been determined by homogeneous and heterogeneous catalysis.

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INTRODUCTION

The development of various industrial fields and other important sectors of the world economy provoked increased water consumption which led to the degradation of its quality. In the anthropogenesis impacts, contamination of natural water by pharmaceutical waste effluents plays an essential role. Under the action of different external factors, there comes to pass degradation of toxicants and formation of new substances including the more toxic ones.

According to the studied references, it was concluded that catalytic and photocatalytic processes can be some potential methods for removal of AMX in optimal conditions at low concentrations but this process must be adapted to the real substrate concentrations.

In this context, the main purpose of this study is to establish the physico-chemical parameters of catalytic and photocatalytic oxidation of solutions containing AMX: pH value, reaction time, catalyst and oxidant concentration, as well as substrate concentration. After establishing the optimal conditions, it has released the degradation/mineralization of the AMX antibiotic with the range of initial concentrations from 100 up to 300 mg/L which represents the real concentrations in the residual effluents.

BACKGROUND

In recent years, the pollution by emerging contaminants was paid attention by the academic community around the world because on the one hand, the discharged pharmaceutical pollutants are toxic and on the other hand, they are found in a considerable diversity, which makes the treatment process difficult (Verma, M. et al., 2020, De Carvalha, J.F. et al., 2020, Pieri, A. et al., 2020, Mocanu, L. et al., 2020). Concern about the emerging contaminants, such as pharmaceutical compounds (PCs), has increased due to their negative impact on the ecosystems, as effluents from the pharmaceutical industries are discharged into the sewers of domestic wastewater, natural water flows (rivers, lakes, and ponds), in soil, etc. (Kay, P. et al., 2017, Lester, Y. et al., 2013, Tran, N. et al., 2018, Meng, L. et al., 2017). It was found that some bacteria and genes acquired resistance to antibiotics (Hansen, E. et al., 2020, Pérez-Rodríguez, F. et al., 2019). Lethal effects on aquatic organisms, interference with the natural decomposition of organic matter, and a decrease in the diversity of microbial communities in various environments have been observed (Felis, E. et al., 2019).

Antibiotic resistance affects the entire European Region, driven by the overuse, underuse, and misuse of antibiotics (WHO, 2015). Their presence in water bodies poses a threat to human health (Chen, B. et al., 2018). According to the data made available to the World Health Organization (WHO), 10% of the drugs used by patients in the Republic of Moldova are antibiotics. At the same time, WHO standards provide for the consumption of any type of antibiotics by six percent per country. As a result, since April 2017, these drugs can only be purchased with a prescription. This law came after the alarms sounded about the uncontrolled use of antibiotics, starting in 2013. A 2014 study showed that Moldavian people most often used the antibiotics ampicillin, amoxicillin, cephalothin, cefamandole etc. (WHO, 2014).

According to the survey on healthcare-associated infections and antimicrobial use in hospitals of the Republic of Moldova, conducted in 2018 under the auspices of the Ministry of Health, Labour and Social Protection, 42.7 percent of patients receive antibiotic treatment. The study was conducted on a sample of 67 hospitals, 546 wards, including 10594 patients. Thus, it has been calculated that the highest prevalence of infections in intensive care units is 20%. Most often, antibiotics are prescribed to patients