

Ciprofloxacin degradation by photolysis and advanced oxidation processes

Arlene B. S. Nossol¹ (PG), Oswaldo G. Junior¹ (PG), Valdislaine M. da Silva¹ (PG), Antonio E. H. Machado¹ (PQ), Carla Sirtori² (PQ), Camila R. Lemos³ (IC), Adriane M. de Freitas³ (PQ), Alam G. Trovó¹ (PQ)*

* alamtrovo@iqufu.ufu.br

¹ Universidade Federal de Uberlândia, Instituto de Química, Av. João Naves de Ávila, 2121, Uberlândia- MG.

² Universidade Federal do Rio Grande do Sul, Av. Bento Gonçalves, 9500, Porto Alegre, Rio Grande do Sul, Brasil.

³ Universidade Tecnológica Federal do Paraná, Rua Deputado Heitor de Alencar Furtado, 5000, Curitiba, Paraná, Brasil.

Keywords: *Vibrio fischeri*, antibiotics, photo-Fenton, radiation.

Abstract

Ciprofloxacin degradation and toxicity changes were evaluated by different processes using UVA or UVC radiation.

Introduction

Ciprofloxacin (CIP) is an antibiotic widely used in human and veterinary treatment and aquaculture applications¹. Studies have detected and quantified CIP in different types of water compartments, due its inefficient removal by conventional processes employed in the sewage treatment plants². So, it is important to evaluate alternatives of treatment for this contaminant. In this context, the degradation of CIP by UV, H₂O₂/UV, Fe²⁺/H₂O₂, Fe³⁺/H₂O₂/UV and Fe²⁺/H₂O₂/UV using two types of radiation sources were evaluated and compared, being the acute toxicity of the by-products monitored by bioassays with *Vibrio fischeri*.

Results and Discussion

All experiments were performed at lab-scale, exposing 500 mL of a 3.3 mg L⁻¹ CIP solution to the radiation furnished by two dark light lamps (UVA radiation) or germicide lamps (UVC radiation), with the same power (8 W). The lamps were positioned in parallel (separated by a distance of 3.5 cm) and at 1 cm of the open dark-glass vessel (4.3 cm deep and 188.7 cm² of surface area). The concentrations of iron and H₂O₂ used were respectively 0.5 and 32 mg L⁻¹. The pHs used were respectively 2.5-2.8 and 7 to the experiments in the presence and absence of iron. Samples of 10 mL were collected during 30 min. The results obtained by HPLC analysis (Fig. 1) demonstrate that the type of radiation influences strongly the rate of CIP degradation. A higher rate of photolytic CIP degradation was obtained using UVC since 100% of degradation was reached in 20 min of irradiation, while using UVA it was necessary 30 min to achieve only 50%. A similar behaviour was observed in the treatment using the photo-Fenton process, being pronounced when Fe³⁺ was used as iron source. This occurs because UVC radiation involves high-energy photons capable to promote

the direct photolysis of CIP, resulting in synergistic effect when combined with Fenton reactions. On the other hand, using Fe²⁺, there was no difference on the rate of CIP degradation by photo-Fenton treatment using UVA or UVC, due the Fenton (Fe²⁺/H₂O₂) contribution (Fig. 1). Comparing the same radiation source, UVC, it can be observed that the combination of H₂O₂/UVC enhanced the rate of CIP degradation, when compared to direct UVC irradiation, since 100% of CIP degradation was obtained after 15 and 20 min, respectively. A more pronounced enhancement was obtained combining Fe³⁺, H₂O₂ and UVC, reaching 100% of CIP degradation after 10 minutes. The use of Fe²⁺ permitted to reduce the time to only 5 minutes.

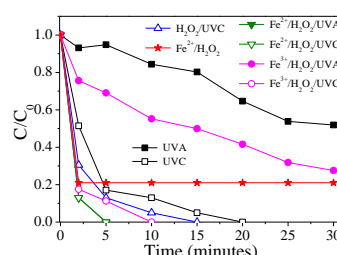


Figure 1. CIP degradation by different processes.

The bioassay using the bacteria *Vibrio fischeri* showed the formation of non-toxic by-products in all processes evaluated.

Conclusions

The type of radiation source influenced strongly the rate of CIP degradation. Among the processes evaluated, the best result was achieved by the photo-Fenton treatment using Fe²⁺ (Fe²⁺/H₂O₂/UV) since the total CIP degradation occurred after only 5 minutes of treatment. In all processes evaluated it was not observed the formation of toxic products.

Acknowledgments

FAPEMIG, CAPES, CNPq and RQ-MG.

¹Chang, P.; Jiang, W.; Li, Z.; Kuo, C.; Wu, Q.; Jean, J. and Lv, G. *J. Hazard. Mat.* **2016**, 303, 55.

²Vasconcelos, T. G.; Henriques, D. M.; König, A.; Martins, A. F. and Kümmerer, K. *Chemosphere*. **2009**, 76, 487.