Plasma-based degradation of cefixime in synthetic and real wastewater in a continuous-flow dielectric barrier discharge reactor

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Abstract: We report the degradation of cefixime in simulated wastewater (SW) and real wastewater (RW) sampled from a tertiary WWTP effluent. The treatment was carried out in a continuous-flow dielectric barrier discharge reactor powered by a high-voltage alternating current power supply. A maximum degradation of 92% in SW and 19% in RW was obtained. Findings reveal the presence of bicarbonate to have influenced the degradation in the RW.

1. Introduction

Cephalosporins, a class of semi-synthetic beta (β)-lactam antibiotics, are widely employed in treating humans and animals [1]. Over the past decade, cefixime, a third-generation cephalosporin, has become the standard therapy for respiratory and urinary tract infections in several countries [2]. However, oral absorption of cefixime in humans is around 40-50%, and excretion through urine is around 16-26% [3]. Mirzaei et al. [4] measured cefixime concentrations of 272–777 ng/L and 50 – 422 ng/L in the influent and effluent, respectively, of different wastewater treatment plants (WWTPs) in Tehran.

Here, we compare the degradation efficiency of cefixime in simulated wastewater and in a tertiary WWTP effluent using plasma technology.

2. Methods

A continuous-flow dielectric barrier discharge (DBD) reactor was used for the study. Herein, a high-voltage (HV) electrode made of a multi-pin stainless steel rod was inserted in a glass tube surrounded by conductive copper tape as the outer electrode. The DBD plasma was generated with oxygen gas using a HV alternating current power supply at a voltage range of 10-12 kV and a frequency of 5-7 kHz. The oxygen gas was introduced at a flow rate of 1 L/min with a cefixime solution of 1 L (5 – 15 mg/L initial concentration) circulated by a peristaltic pump at a flow rate of 500 mL/min. The voltage and current variations during plasma discharge were recorded with a digital oscilloscope and used to calculate the dissipated power. Samples were taken every 5 min over a total duration of 30 min. The samples were analyzed on a UV-1600PC spectrophotometer from VWR.

3. Results and Discussion

The degradation efficiency of cefixime in deionized water (DI) and in tertiary WWTP effluent (RW) were compared as shown in Figure 1. After 25 min, 19% of cefixime was removed in RW compared to 92% after 30 min in DI. The rate constants differ as well, i.e., 0.085 min^{-1} in DI while 0.003 min^{-1} in RW. Next to that, cefixime degradation was also studied in diluted real wastewater (DRW) and in simulated wastewater (SW), being DI spiked with relevant inorganic ions in mg/L (chloride, 56.26; sulphate, 95.52; nitrite, 1.42; and bicarbonate, 234). The RW has a pH and conductivity value of 7.53 and 548 µS/cm, respectively.

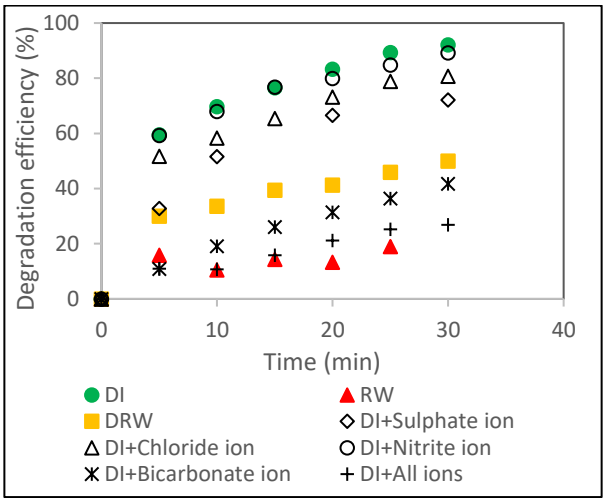

Fig. 1: Comparison of cefixime degradation (initial concentration: 5 mg/L) (%) in different water matrices (synthetic and (diluted) real wastewater) during DBD treatment with an applied voltage of 11 kV and a frequency of 5 kHz.

Results given in Figure 1 show that the complex matrix of wastewater inhibits cefixime degradation, with bicarbonate having a much more important effect than nitrite, chloride and sulphate. The combined effect of the four inorganic ions decreased the cefixime degradation efficiency up to a level comparable to that in RW.

4. Conclusion

This study highlights the large impact of (inorganic) matrix constituents on the degradation of cefixime in wastewater. Among the ions investigated, particularly bicarbonate is found to have an inhibitory effect on cefixime degradation.

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References

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