IDENTIFICATION OF OZONATION TRANSFORMATION PRODUCTS OF FUROSEMIDE USING LC-HR-MS/MS

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Pharmaceuticals are detected at ng L^{-1} to μg L^{-1} levels in the aquatic environment, indicating that they are not removed efficiently through the conventional wastewater treatment processes [1, 2]. Although ozonation is a promising tertiary treatment technique for the elimination of micropollutants, its increased direct and indirect reactivity may lead to the formation of transformation products which can be more toxic than their parent compounds.

In this study, the degradation of the diuretic drug furosemide and the formation of its ozonation transformation products (TPs) were investigated in ultrapure water samples. The effect of pH at three different pH values (5.0, 7.0 and 9.0), the role of natural organic matter (NOM; 0.05, 0.5 and 5.0 mg L^{-1} humic acid), as well as the formation and stability of the detected TPs as the ozone dose increases (0.75, 1.0, 2.0, 5.0 and 7 mg L^{-1}) were also studied. Moreover, the effect of t-BuOH addition, a known hydroxyl radical scavenger, was tested in order to elucidate the oxidation mechanism. Ozonation experiments were conducted in sealed bottles by mixing a predefined amount of an ozone-saturated solution, with an aqueous solution of furosemide, in order to obtain the desirable initial aqueous ozone concentration. Post-acquisition suspect and non-target treatment of the data, obtained by LC-QTOFMS analysis, based on accurate mass measurements, isotopic and retention time fitting and fragmentation pattern, led to the structure elucidation of transformation products. 2-amino-4-chloro-5-sulfamoylbenzoic acid ($C_7H_7ClN_2O_4S$), which had been previously identified in a photodegradation study [3], was detected in both positive and negative ionization mode and its structure was confirmed *via* analysis of a reference standard, reaching level 1 of identification confidence [4]. In addition, more TPs formed, either by the cleavage of furosemide structure or by its oxidation, were tentatively identified in the treated samples and seemed to be stable in high ozone doses. A direct ozonation reaction pathway was proposed, since all identified by-products were detected even in the samples containing t-BuOH.

Keywords: ozonation, furosemide, pharmaceuticals, emerging pollutants, structure elucidation, transformation products

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