Photocatalytic degradation of wastewater containing the pesticide bentazone in a fountain photocatalytic reactor

C. Berberidou*, V. Kitsiou, D. Lambropoulou, A. Kouras, I. Poulios

Laboratory of Physical Chemistry, Department of Chemistry, Aristotle University of Thessaloniki, Thessaloniki, Greece

*** Correspondence: cberber@chem.auth.gr**

Introduction and Objectives

The introduction of pesticides in agricultural activity has led to widespread contamination of the environment with these bio-recalcitrant organic compounds. The United Nations estimate that less than 1% of all pesticides used in agriculture actually reaches the crops. The remaining contaminates the land, the air and particularly the water [1]. These contaminants are in many cases toxic, non-biodegradable and they have the ability to accumulate in the environment with unpredictable consequences [2].

Bentazone is a selective post-emergence herbicide (3-isopropyl-1H-2,1,3-benzothiadiazin-4-(3H)-one-2,2-dioxide, CAS No: 25057-89-0, M_r: 240.28), used to control many broadleaf weeds and sedges. Bentazone has the potential to contaminate both ground and surface water because of its low soil sorption and high water solubility [3].

Homogenous photocatalytic processes have been shown to be potentially advantageous for degradation and mineralization of a wide range of herbicides, herbicides, fungicides and insecticides [4]. Our study investigates the mineralization of simulated wastewater containing bentazone in a novel photocatalytic fountain type reactor in the presence of the photo-Fenton (Fe^{3+}/H_2O_2/UV-A , Vis) or the Ferrioxalate reagent ($[Fe(C_2O_4)_3]^{3-}/H_2O_2$/UV-A, Vis).

Materials and Methods

The simulated wastewater containing 20 mg L^{-1} bentazone (Fig. 1) was made by appropriately diluting the commercial pesticide Basagran® 48 SL (BASF) with tap water. Pilot-scale experiments were carried out in a slurry, fountain-type photocatalytic reactor, able to operate under artificial or solar light, shown in Fig. 2. The total working volume was 15 L and the system was exposed to artificial light, with intensities determined with a radiometer (PMA2100, Solar Light Co., equipped with a UV-A-S/N 8773 and a global detector-S/N 18031). All reagents used were analytical grade. pH was adjusted to 3.0±0.1 with H_2SO_4 prior to photocatalysis.

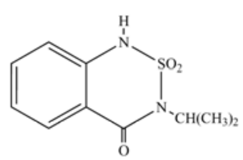

***Figure 1**: Bentazone (3-isopropyl-1H-2,1,3-benzothiadiazin-4-(3H)-one-2,2-dioxide, CAS No: 25057-89-0, M_r: 240.28) is the active compound of Basagran® 48 SL, the commercial pesticide obtained by BASF.*

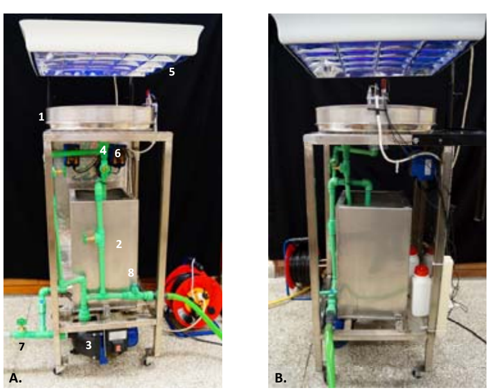

***Figure 2**: A. Front and B. Side view of the pilot fountain-type photocatalytic reactor operating under artificial illumination (UV-A or visible). The simulated wastewater overflows from the top of the photocatalytic tank (PT, 1), falls down to the reservoir (2) and is then recirculated back to the PT with an air pump (3) and through a plastic tube (4). The wastewater is spread on the PT through six orifices, which also provide adequate aeration and agitation of the liquid phase. Illumination is conducted by four parallel lamps emitting UV-A (Philips TLD 18W/08) or visible (OSRAM Biolux L18W/965) irradiation placed on top of the PT (5). Addition of reagents is conducted via two dosing pumps (6). The treated waste may be rejected through a tube and a port placed at the bottom of the reservoir (7) or may be channeled to an Imhoff tank via the pump and tap (8), for catalyst/wastewater separation.*

Results and Discussion

• During photo-Fenton mineralization of the simulated wastewater containing bentazone, increase of the concentration of H_2O_2 from 0-100 mg L^{-1} results to increase of the mineralization reaction constant. Further increase of H_2O_2 to 200 mg L^{-1} has no further beneficial effect on K_{DOC} values (Fig. 3).

•Similarly, Fig. 4 shows the effect of initial Fe^{3+} concentration on the photo-Fenton mineralization of the simulated wastewater. K_{DOC} values increase as Fe^{3+} rises from 0 to 10 mg L^{-1}.

•As shown in Fig. 5, Ferrioxalate , followed by photo-Fenton, in the presence of UV-A, is the most efficient system for the mineralization of the simulated wastewater containing bentazone. Both systems are also effective under visible light for the mineralization of the wastewater, resulting , however, to lower mineralization rates.

•Finally, increase of the irradiation intensity enhances both mineralization rates and K_{DOC} values during photocatalytic mineralization of bentazone in the following systems: Fe^{3+}/H_2O_2/UV-A, Ferrioxalate/H_2O_2/UV-A and Fe^{3+}/H_2O_2/Vis.

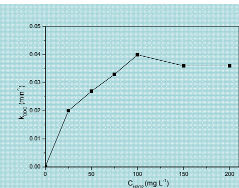

***Figure 3**: Effect of H_2O_2 concentration on the reaction constant, k_{DOC}, during mineralization of the simulated wastewater containing 20 mg L^{-1} BNZ in the presence of the photo-Fenton reagent (7 mg L^{-1} Fe^{3+}, pH: 3.0). Intensity of UV-A irradiation: 3.5 mW cm^{-2}, total volume: 15 L, illuminated volume: 5L.*

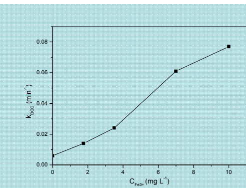

***Figure 4**: Effect of Fe^{3+} concentration on the reaction constant, k_{DOC}, during mineralization of the simulated wastewater containing 20 mg L^{-1} BNZ in the presence of the photo-Fenton reagent (100 mg L^{-1} H_2O_2, pH: 3.0). Intensity of UV-A irradiation: 3.5 mW cm^{-2}, total volume: 15 L, illuminated volume: 5L.*

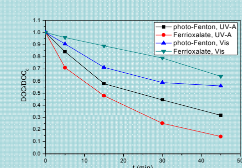

***Figure 5**: Mineralization of simulated wastewater containing 20 mg L^{-1} BNZ in the presence of the photo-Fenton and Ferrioxalate reagents and UV-A or visible irradiation (7 mg L^{-1} Fe^{3+}, 33 mg L^{-1} $C_2O_4^{2-}$, 100 mg L^{-1} H_2O_2), total volume: 15 L, illuminated volume: 5L.*

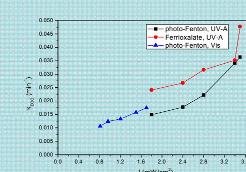

***Figure 6**: Effect of irradiation intensities on the reaction constants, k_{DOC} of the mineralization of simulated wastewater containing 20 mg L^{-1} BNZ in the presence of the photo-Fenton and Ferrioxalate reagents (7 mg L^{-1} Fe^{3+}, 33 mg L^{-1} $C_2O_4^{2-}$, 100 mg L^{-1} H_2O_2), total volume: 15 L, illuminated volume: 5L.*

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Acknowledgements

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