Degradation of Diclofenac in Water Using FeO-Based Catalytic Ozonation in a Modified Flotation Cell

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Abstract : Pharmaceutical residues are a section of emerging contaminants of anthropogenic origin that are present in a myriad of waters with which human beings interact daily and are starting to affect the ecosystem directly. Conventional waste-water treatment systems are not capable of degrading these pharmaceutical effluents because their designs cannot handle the intermediate products and biological effects occurring during its treatment. That is why it is necessary to hybridize conventional waste-water systems with non-conventional processes. In the specific case of an ozonation process, its efficiency highly depends on a perfect dispersion of ozone, long times of interaction of the gas-liquid phases and the size of the ozone bubbles formed through-out the reaction system. In order to increase the efficiency of these parameters, the use of a modified flotation cell has been proposed recently as a reactive system, which is used at an industrial level to facilitate the suspension of particles and spreading gas bubbles through the reactor volume at a high rate. The objective of the present work is the development of a mathematical model that can closely predict the kinetic rates of reactions taking place in the flotation cell at an experimental scale by means of identifying proper reaction mechanisms that take into account the modified chemical and hydrodynamic factors in the FeO-catalyzed Ozonation of Diclofenac aqueous solutions in a flotation cell. The methodology is comprised of three steps: an experimental phase where a modified flotation cell reactor is used to analyze the effects of ozone concentration and loading catalyst over the degradation of Diclofenac aqueous solutions. The performance is evaluated through an index of utilized ozone, which relates the amount of ozone supplied to the system per milligram of degraded pollutant. Next, a theoretical phase where the reaction mechanisms taking place during the experiments must be identified and proposed that details the multiple direct and indirect reactions the system goes through. Finally, a kinetic model is obtained that can mathematically represent the reaction mechanisms with adjustable parameters that can be fitted to the experimental results and give the model a proper physical meaning. The expected results are a robust reaction rate law that can simulate the improved results of Diclofenac mineralization on water using the modified flotation cell reactor. By means of this methodology, the following results were obtained: A robust reaction pathways mechanism showcasing the intermediates, free-radicals and products of the reaction, Optimal values of reaction rate constants that simulated Hatta numbers lower than 3 for the system modeled, degradation percentages of 100%, TOC (Total organic carbon) removal percentage of 69.9 only requiring an optimal value of FeO catalyst of 0.3 g/L. These results showed that a flotation cell could be used as a reactor in ozonation, catalytic ozonation and photocatalytic ozonation processes, since it produces high reaction rate constants and reduces mass transfer limitations ($Ha > 3$) by producing microbubbles and maintaining a good catalyst distribution.

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