

Influence of a Cationic Membrane in a Double Compartment Filter-Press Reactor on the Atenolol Electro-Oxidation

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Abstract : Contaminants of emerging concern are substances widely used, such as pharmaceutical products. These compounds represent risk for both wild and human life since they are not completely removed from wastewater by conventional wastewater treatment plants. In the environment, they can be harm even in low concentration (μ or ng/L), causing bacterial resistance, endocrine disruption, cancer, among other harmful effects. One of the most common taken medicine to treat cardiocirculatory diseases is the Atenolol (ATL), a β -Blocker, which is toxic to aquatic life. In this way, it is necessary to implement a methodology, which is capable to promote the degradation of the ATL, to avoid the environmental detriment. A very promising technology is the advanced electrochemical oxidation (AEO), which mechanisms are based on the electrogeneration of reactive radicals (mediated oxidation) and/or on the direct substance discharge by electron transfer from contaminant to electrode surface (direct oxidation). The hydroxyl ($\text{HO}\cdot$) and sulfate ($\text{SO}_4\cdot^-$) radicals can be generated, depending on the reactional medium. Besides that, at some condition, the peroxydisulfate ($\text{S}_2\text{O}_8^{2-}$) ion is also generated from the $\text{SO}_4\cdot^-$ reaction in pairs. Both radicals, ion, and the direct contaminant discharge can break down the molecule, resulting in the degradation and/or mineralization. However, ATL molecule and byproducts can still remain in the treated solution. On this wise, some efforts can be done to implement the AEO process, being one of them the use of a cationic membrane to separate the cathodic (reduction) from the anodic (oxidation) reactor compartment. The aim of this study is investigate the influence of the implementation of a cationic membrane (Nafion®-117) to separate both cathodic and anodic, AEO reactor compartments. The studied reactor was a filter-press, with bath recirculation mode, flow 60 L/h. The anode was an Nb/BDD2500 and the cathode a stainless steel, both bidimensional, geometric surface area 100 cm^2 . The solution feeding the anodic compartment was prepared with ATL 100 mg/L using Na_2SO_4 4 g/L as support electrolyte. In the cathodic compartment, it was used a solution containing Na_2SO_4 71 g/L. Between both solutions was placed the membrane. The applied currents densities (i_a) of 5, 20 and 40 mA/cm^2 were studied over 240 minutes treatment time. Besides that, the ATL decay was analyzed by ultraviolet spectroscopy (UV/Vis). The mineralization was determined performing total organic carbon (TOC) in TOC-L CPH Shimadzu. In the cases without membrane, the i_a 5, 20 and 40 mA/cm^2 resulted in 55, 87 and 98 % ATL degradation at the end of treatment time, respectively. However, with membrane, the degradation, for the same i_a , was 90, 100 and 100 %, spending 240, 120, 40 min for the maximum degradation, respectively. The mineralization, without membrane, for the same studied i_a , was 40, 55 and 72 %, respectively at 240 min, but with membrane, all tested i_a reached 80 % of mineralization, differing only in the time spent, 240, 150 and 120 min, for the maximum mineralization, respectively. The membrane increased the ATL oxidation, probably due to avoid oxidant ions ($\text{S}_2\text{O}_8^{2-}$) reduction on the cathode surface.

Keywords : contaminants of emerging concern, advanced electrochemical oxidation, atenolol, cationic membrane, double compartment reactor

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