Investigation of β-blocker atenolol degradation and transformation products by hydroxyl and sulfate radicals through Electro-Fenton process

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Abstract

The release of pharmaceuticals into natural environments, including surface water, groundwater, sediments and soil is an important environmental issue due to their potential influence on human health and ecosystems. The removal of PPCPs from water has generated a great interest. As a result, the evaluation of advanced treatment technologies, such as adsorption, membrane filtration, and advanced oxidation processes (AOPs), to address this emerging issues is highly needed, AOPs are used frequently at present. It uses the hydroxyl radical (HO•), which can destruct a broad range of toxic organic pollutants quickly and non-selectively. Among the AOPs, especially Fenton and electro Fenton processes (EF) has been extensively studied and used for the decomposition of a wide range of pharmaceuticals.

This present investigation emphasized persistent pharmaceutical ingredient and *β*-blocker atenolol degradation through electrochemically produced Fe^{2+}/Fe^{3+} activation of oxidants (peroxomonosulfate (PMS), persulfate (PS) and hydrogen peroxide (HP). In this connection, the role of atenolol concentration, initial electrolyte pH, applied potential, oxidant concentrations and co-existing ions on atenolol degradation (removal efficiency) has been examined by electro-Fenton and electro-Fenton *like* process.

Preliminarily experimental results suggest that physiochemical parameters (C_{ATL}, electrolyte pH, applied potentials) under all experimental conditions leads not to considerable atenolol removal efficiency (15 to 25%) by electrochemical process in the absence of oxidants. However, the atenolol removal efficiency has been significantly improved up to 99% by the addition of oxidants under different physiochemical conditions. The impact of different common oxidants such as PMS, PS and HP on atenolol degradation is systematically examined. Moreover, the atenolol degradation mechanism and proposed pathway and possible transformation product analysis by using chromatographic analysis (LC-MS/MS).

In the absence of oxidant agent, only electro-coagulation reactions occur. However, in the presence of oxidants, the $SO_4^{\bullet -}$ and $OH^{\bullet}$ were involving to the degradation reaction and as a result increasing the atenolol removal efficiency.

Key word: *β*-blocker atenolol, electro-Fenton, electro-Fenton *like* process

Conclusion

According to the results, electrochemical degradation of atenolol using PDS, PMS and HP were feasible methods of elimination of beta blocker atenolol, which HP was a most feasible oxidant out of PDS and PMS which showed more than 98% removal efficiency all experimental conditions such as pH, pollutant concentration, applied current and oxidant concentration. It means $OH^{\bullet}$ showed highly reactivity towards ATL compared to $SO_4^{\bullet-}$. $OH^{\bullet}$ played an important role in the electrochemical oxidation process with the physiochemical parameters.

Further, PMS and PDS show most efficient removal under low concentration of pollutant while, HP observed 100 % removal efficiency all pollutant concentration. The sodium co- existence ions on the removal efficiency of atenolol Cl^-, CO_3^{2-} and SO_4^{2-} ions showed significant removal efficiency with PMS and HP while NO_3^- did not show ATL removal with any oxidant.

The degradation product of atenolol with presence of oxidants; PDS, PMS and HP were observed similar spectrum peak diagram for most m/z values. Hence, it is concluded that the same fragmentation pathways and degradation mechanism shown in electro Fenton (H_2O_2)/Fe and Fenton like (PDS/Fe and PMS/Fe) reaction of this research. However, I recommend that the possible research efforts are needed to understand and figure out the reasons for effect of impurities, other ions and inhibition effect of byproducts.