Removal of emerging contaminants in wastewater using biocatalysis assisted by electrochemical process.

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I. Introduction

Ensuring adequate water quality is a fundamental environmental and public health issue[1] as anthropogenic activities introduce several classes of chemical pollutants into water resources[2], including emerging pollutants (EPs). EPs comprise pharmaceuticals, personal care products, endocrine disruptors, pesticides, industrial chemicals, among others. These compounds have attracted considerable attention as they have been detected in the environment in concentrations ranging from ng/L to µg/L. EPs may bioaccumulate along the trophic chain and cause harmful effects to different organisms[3].

Enzymatic biocatalysis is an effective method for the removal of EPs. Specifically, laccase enzymes (E.C. 1.10.3.3.2) oxidize various phenolic compounds, including well known emerging pollutants[4]. Still, a main drawback is that its efficiency in wastewater is affected by unfavorable pH, high salt concentrations, chemical/biological denaturing agents, and temperature. Immobilization has been developed as an alternative to overcome these limitations, and immobilized enzymes have higher stability and greater capacity to withstand denaturing agents[5]. Despite their marked improvements, the performance of immobilized enzymes in real wastewater samples is still hampered by interfering compounds present in the water matrix, such as dissolved organic matter (DOM)[6].

On the other hand, electrochemical treatments offer advantages such as environmental compatibility, versatility, and ease of automation. Nevertheless, they are not effective eliminating EPs found at low concentrations in wastewater[7]. In this work, the specific advantages of electrochemical process and biocatalysis were utilized in the following way: (a) Electrocoagulation (EC) remove macropollutants and other compounds found at high concentration in the wastewater sample and,

(b) the enzymatic biocatalysis removes the target emerging pollutants from an electrochemically-treated wastewater sample yielding a high removal of emerging pollutants to the best of our knowledge.

Herein, we explored the removal of two emerging pollutants, Bisphenol A (BPA) and triclosan (TCS), from municipal wastewater from Mexico City via a biocatalytic process assisted by electrochemical method. BPA and TCS were selected as model analytes because they can be bioaccumulated and have been proven to retain toxicological effects on the aquatic environment[8,9].

II. Methodology

1. Wastewater sampling and characterization

2. Laccases immobilization onto TiO_2 nanoparticles

3. Experimental design and statistical analysis

Description	Electrocoagulation		
	Min. Value	Med. Value	Max. Value
pH	3	4	5
Current density, j(mA/cm²)	0.83	1.67	2.5
Treatment time (min)	10	20	30

4. Electrocoagulation (EC) procedure

For wastewater treatment the pH, current density (j) and treatment time were adjusted to 3, 0.83 mA/cm^2 and 10 min, respectively

5. Biocatalytic treatment

An appropriate amount of TiO_2–Lac nanoparticles was dispersed into the electrochemically treated wastewater under optimal conditions.

6. Determination of BPA and TCS by GC-MS

BPA and TCS concentration was monitored during all process stages (beginning, after EC and at different times of the enzymatic treatment)

III. Results

Figure 1 presents the response surface graphs, showing the interaction and optimal levels of the variables j, pH and time, which are necessary to achieve an optimal wastewater pretreatment by EC in order to enhance the laccase activity when is employed in complex matrices.

Figure 2 shows the evolution of the color during the biocatalysis assisted by EC treatment.

Figure 3 shows the concentration of the BPA and TCS by means of gas chromatography coupled to mass spectrometry in each stage of the biocatalysis assisted by EC treatment.

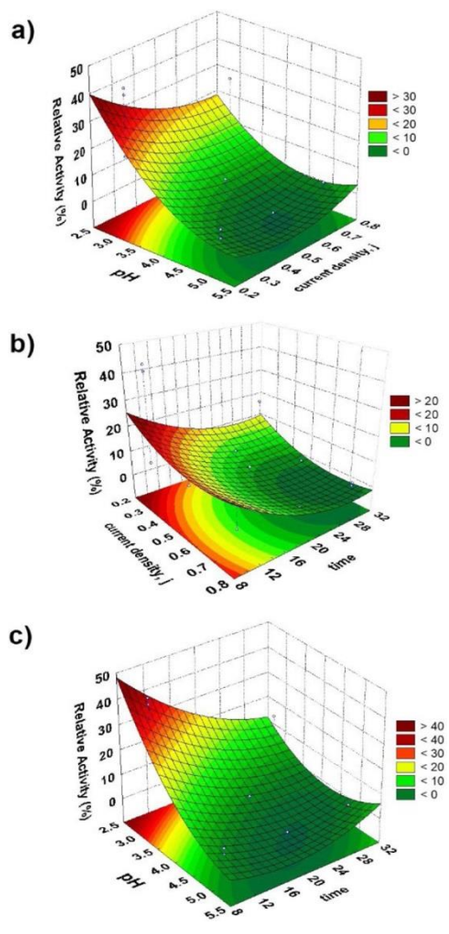

Figure 1. Response surface plots for EC treatment. Relative activity *vs.* (a) pH and *j*, (b) *j* and treatment time, (c) pH and treatment time.

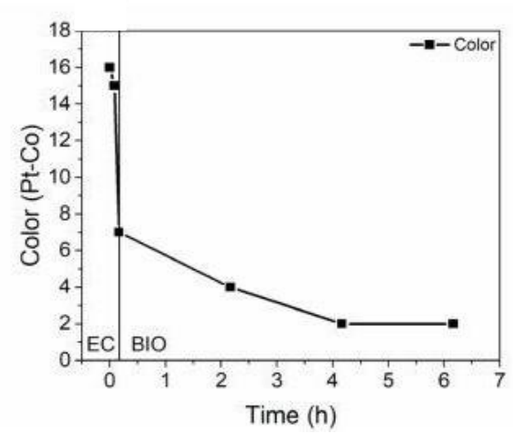

Figure 2. Color removal by the electrocoagulation-assisted biocatalytic process.

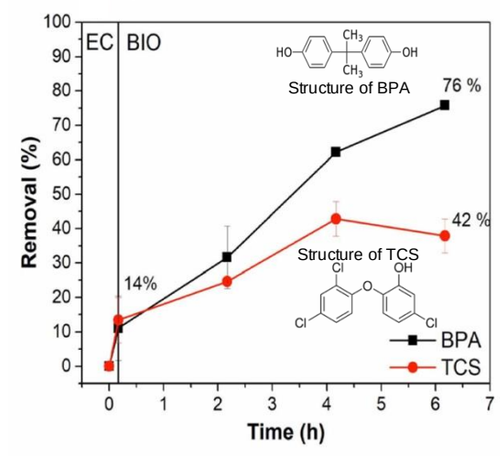

Figure 3. Evolution of BPA and TCS concentrations by the electrocoagulation-assisted biocatalytic process.

IV. Conclusion

BPA and TCS concentrations were determined by GC-MS at each stage of the electrocoagulation-assisted biocatalytic process.

The EC-assisted process reached 42% and 76% removal of TCS and BPA respectively, where EC alone only achieved 14% removal for both emerging contaminants. EC generated an adequate matrix effect, which can be attributed to the formation of sludge that is capable of absorbing both emerging contaminants and other ions within the floc.In the case of the target emerging pollutants, the electrochemical-assisted treatments are preferred, since neither electrochemical nor biocatalytic treatments used independently efficiently eliminated BPA and TCS from wastewater.

V. References

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