Development of an Electrochemical Biosensor for Pesticide Detection in Seawater

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The presence of pesticides, including herbicides, fungicides, and insecticides residues in food, water, and soil has become a significant issue in the field of environmental chemistry. Organophosphorus and carbamate insecticides are particularly concerning due to their toxicity. Such insecticides inhibit acetylcholinesterase (AChE, EC 3.1.1.7) activity, which is necessary for the proper functioning of the central nervous system of both humans and insects.

Analysis of pesticides in seawater samples is a difficult task due to the matrix complexity and low concentrations of the target compounds. Biosensing methods might overcome the drawbacks of the methods available for the determination of pesticides, like colorimetry, capillary electrophoresis (CE) or high-performance liquid chromatography (HPLC). The mentioned methods have produced successful outcomes, but they have limitations such as difficult and time-consuming sample preparation, and can only be utilized in specialized laboratories with costly equipment and trained staff.

Biosensing methods provide advantages such as simplicity, rapidity, specificity, sensitivity, low cost, relatively economical equipment, and user-friendly operation. In this work, we aim at developing an electrochemical biosensor for indirect monitoring of acetylcholinesterase to detect pollutants such as carbendazim or malathion in seawater.

AChE has a very high catalytic activity; each molecule of AChE degrades approximately 25,000 molecules of acetylcholine (ACh) per second into choline and acetic acid. AChE belongs to the family of hydrolases and its active site is characterized by a catalytic coordinated triad of three essential amino acids. However, in the presence of an inhibitor such as carbamates or organophosphorus, a blocking of the triad occurs and the enzyme is inactivated. Keeping in mind the above mentioned, the catalytic activity of the enzyme has been studied by cyclic voltammetry, using *p*-acetoxyphenol as a substrate, which lacks of electrochemical response. As a result of the hydrolysis, an electroactive product (hydroquinone) is obtained, which can be electrochemically detected.

The most important step in the development of an enzyme-based electrochemical sensor is that the enzyme must stay fixed. For that, the enzyme is encapsulated in a sol-gel silica matrix. Through kinetic studies, the activity in the hydrolysis reaction of *p*-acetoxyphenol

was checked. After that, inhibition studies were conducted in the presence of carbendazim and malathion at various concentrations. The results revealed a relationship between the inhibition of enzyme activity and the concentration of added pollutants. This system may pave the way to be utilized in the design of a biosensor-based device that can detect contaminants in the marine environment at an early stage.