Eco-Technologies for Immobilizing Redox Enzymes on Conductive Textiles, for Sustainable Development

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Abstract

Enzyme immobilization on electrically conductive supports is necessary to improve their bioactivity and stability, for use and re-use in applications depending on bio-electrochemical response, such as in bioelectrodes, biosensors, or biofuel cells. However, the immobilization methods used are still facing many challenges in terms of health hazards and high environmental impact. Thus, it is important to find balanced and eco-friendly approaches to achieve efficient immobilization with minimum harmful consequences.

Hence, within the frame of this thesis, the use of eco-technologies such as cold remote plasma, a bio-compatible conductive (PEDOT:PSS) polymer coating, and a bio-based crosslinker "genipin" which has low toxicity, to immobilize glucose oxidase (GOx) enzyme on conductive carbon fiber-based nonwoven textiles was investigated. These carbon-based textiles, regardless of their hydrophobicity, are robust materials to be used as alternative for expensive rigid metals, since they possess good electrical conductivity and good resistance to corrosion in different media.

The results obtained showed that cold remote plasma treatment with nitrogen and oxygen gas mixture was efficient in functionalizing the surface of carbon felts and PEDOT:PSS coated felts. This increased carbon fiber surface energies, and facilitated the immobilization of GOx by physical adsorption with maintained bioactivity and improved reusability. Furthermore, immobilization of GOx using genipin as a crosslinking agent improved remarkably the stability of performance of bio-functionalized carbon felts. This crosslinker showed to be able to directly crosslink the enzymes without a matrix or hydrogel. Finally, the obtained bio-functionalized carbon textiles were primarily evaluated for use in sustainable applications for wastewater treatment such as Bio-Fenton (BF) and enzymatic Bio-Electro-Fenton (BEF). The results showed that bioactivity and bio-electro-activity of immobilized GOx was promising in color removal of Remazol Blue RR reactive dye and its partial degradation from solution in both treatments, which proved the success of the chosen immobilization methods in producing bioactive textiles that can be used as electrodes for power generation and pollution control.

Keywords:

Eco-technology, Carbon felts, PEDOT:PSS, Glucose oxidase immobilization, Cold remote plasma, Genipin