PÔSTER - RESUMO - MATERIAIS E BIOMATERIAIS

FUNCTIONAL BIOCOMPOSITES: INNOVATION IN ELECTROCHEMICAL DEVICES

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The recurrent presence of toxic metal ions, such as $Pb^{2?}$ and $Cd^{2?}$, and organophosphate and carbamate pesticides in surface and groundwater represents both an environmental and analytical challenge, since many of these contaminants occur at low concentrations (μg $L^{?1}$) but exhibit high toxicity and bioaccumulation potential. Conventional treatment technologies frequently rely on chemical coagulants or synthetic adsorbent materials that do not enable in situ monitoring and may generate undesirable byproducts. In this context, biomaterials derived from Moringa oleifera, particularly its cationic coagulating proteins and phenolic compounds, stand out due to their charge-neutralization and pollutant adsorption capabilities. However, the incorporation of these bioactive fractions into electrically conductive polymer matrices capable of simultaneously acting as an adsorptive medium and an active electrochemical interface remains limited and lacks systematic studies correlating chemical composition, nanostructural organization, and functional performance.

The project is currently underway, focusing on the engineering of conductive biocomposites based on Moringa oleifera bioactive fractions (proteins, polysaccharides, and phytochemical extracts) incorporated into polymer matrices reinforced with carbon nanomaterials (carbon nanotubes and graphene) and metal or metal-oxide nanoparticles. The investigation is centered on the hypothesis that Moringa functional groups (amine, hydroxyl, and carboxyl) interact with carbonaceous surfaces and inorganic particles, simultaneously modifying adsorption active sites and charge-transfer mechanisms at the electrode–solution interface. The central scientific contribution of the study lies in elucidating quantitative correlations between chemical composition, nanostructural organization, and electrochemical-adsorptive performance within a single bifunctional system.

Polymeric matrices (PVA, PLA, chitosan, PCL, PEO, PAN, and PANI) are being selected based on their network-forming ability, chemical stability, and compatibility with electrical percolation. Dense films and membranes are produced via casting, while high-surface-area nanofibers are obtained through solution blow spinning (SBS). Processing parameters — including solution viscosity, gas pressure, flow rate, and working distance — are systematically adjusted to control fiber diameter, porosity, and conductive pathway formation.

Structural and morphological characterization is conducted using FTIR, Raman spectroscopy, XRD, SEM, EDS, and AFM, enabling the evaluation of intermolecular interactions, nanomaterial dispersion degree, and conductive network organization. Electrical and electrochemical properties are determined through conductivity measurements, cyclic voltammetry, and electrochemical impedance spectroscopy (EIS), with emphasis on charge transfer resistance (Rct) and electron transport mechanisms. Functional assays are being performed to quantify adsorption capacity (mg g?^{1}), removal efficiency (%), sensitivity (μA μM?^{1}), linear range, and limit of detection (LOD) for Pb^{2}?, Cd^{2}?, organophosphate, and carbamate pesticides.

The central objective of the study is to quantitatively demonstrate the correlation between chemical composition, nanomaterial dispersion degree, percolative network formation, and electrochemical-adsorptive performance. The project's innovation lies in the structural integration of Moringa oleifera coagulating biomolecules into nanostructured conductive polymer matrices, creating a bifunctional architecture in which the same active sites simultaneously participate in adsorption and charge-transfer processes. Results are evaluated using measurable metrics, aiming to demonstrate superior performance compared to non-functionalized polymer matrices, thereby evidencing a synergistic effect between bioactive fractions and conductive nanonetworks.

As an applied outcome, the project consolidates a bifunctional prototype validated under controlled laboratory conditions, capable of performing contaminant removal and electrochemical detection on the same platform. This approach defines a new paradigm of bioactive-conductive hybrid material for decentralized water quality monitoring, with potential for technological scale-up and intellectual property protection based on the functional architecture of the composite.

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Palavras-chave: moringa oleífera; electrochemical sensing; conductive biocomposites; water remediation; nanomaterials; sustainable materials.