Electroactive Materials at the Biointerface: From Neural Electrodes to Drug-Eluting Stents

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Bioelectronic devices increasingly rely on advanced materials that deliver stable electrical performance while remaining mechanically compliant and biologically compatible with living tissues. Conducting polymers have emerged as a unique class of materials that bridge the gap between rigid electronic systems and soft biological environments. Their mixed ionic–electronic conductivity, tunable chemistry, and versatile processing routes make them particularly attractive for biomedical applications.

In this invited lecture, I will present recent advances in bioelectronic interfaces based on conducting polymers, focusing on two main application areas: neural electrodes and functional coatings for metallic implants. In the first part, I will discuss soft, electroconductive neural electrodes incorporating conducting polymers and conductive hydrogels, designed to improve the electrical interface with neural tissue while reducing mechanical mismatch and long-term foreign-body response. I will present electrochemical performance, stability, and selected in vitro results demonstrating their suitability for neural stimulation.

In the second part of the talk, I will introduce conducting polymer-based coatings for biodegradable and permanent metallic stents, with particular emphasis on electrochemically deposited systems that enable controlled drug release. Recent results from national and international research projects will be highlighted, demonstrating how electroactive coatings can integrate electrical functionality with therapeutic performance.

Overall, the lecture will illustrate how conducting polymers can serve as multifunctional platforms for next-generation bioelectronic implants, enabling improved neural interfaces and smart drug-eluting systems, and will outline current challenges and future directions in this rapidly evolving field.