SEMINAR

Materials Science & Engineering

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Advancing Bioelectronics with Electroactive Microbes: From Fundamental Insights to Applications

The increasing demand for silicon-based semiconductors comes at a significant environmental cost, underscoring the need for sustainable solutions. Semiconductor-chip production is not only very resource-intensive, but also produces large amounts of hazardous waste. Biomaterials, with their low carbon footprint and wide range of structures and material properties, are steadily gaining attention as potential alternatives. Electroactive microbes, in particular, capable of transferring electrons to external electrodes, are emerging as promising candidates for use as conductive biomaterials in electronics.

This presentation will focus on the foundational research and practical applications involving both natural and engineered electroactive microbes. By combining synthetic biology with advanced electrochemical approaches, we were able to program microbes to produce an electrical current in response to an endocrine disruptor. By further incorporating a hydrogel encapsulation system into this biosensor, we have reduced the detection time to within 3 minutes. Additionally, I have engineered microbes with multiple electron transfer pathways to detect different heavy metals. By integrating a redox-potential-dependent algorithm, I have successfully converted biological signals into a 2-digit signal output to continuously monitor environmental samples. In the future, I plan to develop engineered electroactive biofilms as conductive biomaterials, focusing on integrated bioelectronics applications in chronic biomedical care and remote environmental monitoring.

BIOGRAPHY

Dr. Xu Zhang, an innovative researcher in the fields of electrochemical analysis and synthetic biology, has dedicated her career to exploring microbial-electrochemical systems and their diverse applications.

As a graduate student at Ghent University in Belgium, she studied natural electroactive biofilms, spanning topics from fundamental mechanisms to bioenergy applications. Beyond the lab, Xu collaborated on the art project ‘Caravel’ for WATER.WAR, where she developed a floating robot powered by microbes and utilized aquatic plants to purify water.

She then moved to Rice University, where she worked with Professor Caroline to deepen her understanding of synthetic biology as a tool for engineering microbes as bioelectronic sensors. Her current focus is developing these microbes as bioelectronic sensors, a cutting-edge area that bridges biology and technology.

Her significant contributions to the field have been recognized and published in high-impact journals such as Nature, Advanced Materials, Bioelectronics, and Biosensors.

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