Abstract: *Energy, Materials, Environment: The Diverse Applications of Electroactive Bacteria Beyond Microbial Fuel Cells*

Electroactive bacteria are known for their capacity to donate or accept electrons from solid electron acceptors and donors. This unique metabolism is perhaps best-known in microbial fuel cell systems, where bacteria such as those of the *Geobacter* genus transfer electrons derived from the oxidation of organic matter to solid electrodes, resulting in electricity production.

However this capacity to couple intracellular metabolic events to the extracellular environment likely evolved in soils and sediments under anaerobic conditions. In the absence of oxygen, metal oxides of iron and manganese instead served as natural extracellular solid electron acceptors, giving these bacteria an important role in mineral cycles and a role to play in the large-scale valorisation of mineral wastes. In addition, many of these bacteria secrete diffusible redox mediators which are potentially lucrative biosourced energy vectors for use in devices such as redox flow batteries and biological supercapacitors. Finally, electroactive micro-organisms are also of interest for environmental depollution applications, both in anodic processes such as organic waste oxidation and cathodic processes including the reduction of nitrates.

This talk will introduce the extracellular respiratory mechanisms of electroactive bacteria before discussing how they can be applied to varied applications in electrochemistry, energy storage and materials synthesis. Our latest research into transforming iron-rich bauxite wastes into valuable nanomaterials will be presented as a case study of particular relevance to Ireland as the site of Europe's largest bauxite processing facility. We also show how this same cellular machinery can be applied in a one-pot route to bioexfoliate graphene oxide derivatives from fluorinated carbon precursors under ambient conditions of pH and temperature.

Finally we introduce the concept of hybrid systems which couple bioelectrodes to other devices, using the example of microbial fuel cell-redox flow battery systems. Combining these systems enables the inherently low current densities of 'free' bioelectricity derived from microbial systems to be nonetheless harnessed for high power devices through energy storage in redox shuttles. Additionally, biosourcing of aqueous-organic redox mediators and other *in situ* redox shuttles utilised by electroactive bacteria is presented as a potential means of replacing organic synthetic protocols currently used to produce these lucrative molecules with bioprocessing routes.

Our results have implications for practical biofuel cell development, sustainable energy storage, iron cycling and the depollution of both solid and aqueous waste in natural environments.

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