Diamond Science Technology Centre

Bioanalytical applications of diamond electrodes

In this project the PhD the student will focus on (but not be restricted to) the use of conducting diamond electrodes for a range of (bio)analytical applications which have significant industrial/applied relevance. The project will also explore the role of the surface chemistry, e.g. sp^2 to sp^3 surface ratio and deliberate surface functionalisation strategies in order to optimise the electrode towards the analyte of interest. For example, during the PhD we aim to explore electrochemical approaches for (1) the detection of single nucleotide polymorphisms (SNPs) in DNA (related to genetic disorders). This will involve the development and characterisation of suitable surface functionalisation strategies which enable redox molecule tagged DNA molecules to be tethered to the surface of a diamond electrode. Localised heating measurements will be employed to “melt” i.e. dissociate the two DNA strands, a process which can be detected electrochemically. The presence of mismatches or SNPs within the DNA will be detected via the time-scale of the melting response. (2) Buffering capacity electrochemical sensors. The ability to measure the buffer capacity of an aqueous solution i.e. ability to resist change in solution pH is especially important for environmental applications where it is important to know how a water source is able to resist changes to make the pH more acidic and consequently harmful to all species living within this environment. All measurements to-date require taking the water from the source and performing an off-site titration, which is far from ideal. Development of in-situ sensors are thus crucial to moving the technology forward. Using multi-functionality electrodes the idea will be one will function as an in-situ pH electrode whilst the other will function as a generator of a defined flux of protons or hydroxide ions. Dependant on the buffer capacity of the electrode, the time taken for the pH of the in-situ sensor to record a change in pH to a defined value will change. These measurements will be accompanied by finite element modelling to help specify the ideal cell design for the electrochemical cell. (c) Chlorine is added to all drinking water supplies as a disinfectant, and it is therefore essential that these (low) levels can be monitored and measured effectively. Measurements currently either employ membrane based electrochemical sensors, where the membrane is prone to clogging, requiring frequent replacement or chemical addition analysis, hence solution must be removed from the source of interest. The aim is to develop an in-situ sensor based on conducting diamond technology (due to the robustness and stability of the diamond electrodes) which is capable of detecting the chlorine at the low levels required. Integration of hydrodynamic flow control may be required, which will require design and fabrication of electrochemical flow cells, using either 3D printing or more conventional fabrication techniques.

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