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BIOLOGICAL, ENVIRONMENTAL AND MEDICAL ANALYTICAL CHEMISTRY

Dr Wong and his research group are particularly interested in the development and applications of (i) electrochemical sensors and/or (ii) electroanalytical techniques to biological, environmental or medical analyses. The following projects offer an opportunity to students with interest in some of these areas. As such, almost all of our research projects are interdisciplinary and they couple electroanalytical chemistry to a diverse area including immunology, biochemistry, neuroscience, medical science, biotechnology, polymer chemistry, environmental science, method validation and quality assurance. Each of these projects will engage students in acquiring hands-on experience in a range of analytical techniques. There is also opportunity to tailor make a project of mutual interest as well.

NEW ELECTROCHEMICAL MICROSENSOR DESIGN FOR BIOLOGICAL, MEDICAL AND PSYCHOLOGICAL DIAGNOSTICS

Dr Wong’s electroanalytical chemistry laboratory is internationally recognised for designing structurally small electrochemical sensors. Indeed, increasing biological, medical and psychological diagnostics are relying on electroanalytical techniques because of their unique capability in performing real-time measurements. In Dr Wong’s laboratory, electrodes with small physical dimensions (≤1 μm in tip diameter) are routinely manufactured by pyrolysing hydrocarbon gases inside and outside pulled capillaries. The carbon produced is then deposited at the tip and on the shank of the capillaries. In recent years, we have perfected the technique to produce a large carbon surface area to obtain amplified detection signal. We are particularly interested in exploiting these electrodes in detecting neurotransmitters in mammalian brain systems. Such a study enables a better understanding of the central neural pathways that stimulate dopamine neurons to burst fire in various neural processes. In this project, we aim at employing sensors with physical dimensions down to 1 μm that are then chemically modified to enhance their sensitivity and selectivity towards detection of dopamine released in targeted regions in the brain. Such a study will aid in identifying the chemical pathways involved in mediating dopamine neuron burst firing and forebrain dopamine release in the central nervous system. This project provides an excellent opportunity for students to gain research experience in both a chemistry laboratory and a medically oriented laboratory.
A VERSATILE MOLECULAR ARCHITECTURE FOR AN ELECTROCHEMICAL IMMUNOSENSOR OR AN ELECTROCHEMICAL DNA BIOSENSOR

In this research area, we are keen to fabricate and characterise biological sensors based on the principles of immunology and DNA hybridisation. In the former, the interactions between an antibody and an antigen are known to be very specific chemical reactions. Such a specific molecular recognition of antigens by antibodies has been exploited in immunoassays to develop highly selective detection methods in many clinical analyses and medical diagnostics as well as for environmental monitoring. Similarly, in the latter, owing to specific recognitions, a DNA probe will only hybridise with its complementary DNA target. Many detection tools used in forensic identifications, medical diagnoses, drug discovery are based on DNA hybridisation. Electrochemical detection is particularly well suited for immunoassays and DNA hybridisation detection owing to its ease and sensitivity. Currently, a lot of work is being focused on the development of rapid, simple, sensitive, automated, and on-site electrochemical immunoassays. In this project, we are interested in fabricating a simple electrochemical immunosensor using a range of chemical and biological reagents. Compared to other methodologies used, our design has a distinct capability in aligning an antibody or a DNA probe in an optimum orientation for interaction with an antigen analyte or a DNA target, respectively. This is a significant factor in maximising the detection sensitivity of the immunosensor. We will also explore the application of nanoparticles or graphene to the development of an immunosensor or a DNA biosensor to further enhance their sensitivity. In immunosensor development, we will apply it to the detection of a real-life analyte (e.g. cortisol, tumour marker), while the DNA biosensor will be used to study the interaction between DNA and selected drugs of medical significance. Graduates with familiarity in analytical techniques are of demand in the current employment market. Note that a background in biology is not required but willingness to acquire new bioanalytical skills will be essential.

PROBING ENVIRONMENTAL CHEMISTRY USING ELECTROANALYTICAL TECHNIQUES ELECTRO- REMEDIATION OF POLLUTED TEXTILE EFFLUENTS

Azo dyes are commonly used in the textile and carpet dyeing industries. Very often, enormous quantities of dye containing wastewaters are being released into effluent streams. Such dyes are harmful to aquatic fauna and flora as well as humans. In this project, electrochemical removal and/or treatment of azo dyes in textile effluents will be explored. This will be achieved using the conducting polymer, polypyrrole, or its derivatives. A distinct advantage of this method is that dye molecules are entrapped in the polymer film for removal, rather than being chemically treated that generates even more harmful products as exhibited by many other treatment methods. Apart from electrochemistry, students will also engage in polymer chemistry, materials chemistry and environmental chemistry in this project.

These projects will provide an opportunity for students to gain experience with a range of analytical techniques, as well as that in method validation and quality assurance. Graduates equipped with all these skills are always of demand in the current employment.