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Real-Time Electrochemical Impedance Spectra Determination and Applications

Electrochemical impedance spectra (EIS) is a very sensitive and widely used method to characterize a material and its surface properties in an electrolyte. It is a diagnostic tool that is used in a variety of applications. Currently, it takes several seconds to multiple minutes to get an accurate EIS measurement over a range of frequencies. This may be adequate in some applications, but there are many applications where rapid EIS could be helpful to allow tracking molecular and cellular changes in real-time.

Prof. Jitendran Muthuswamy at Arizona State University has developed a method for rapid determination of EIS over a broad-band of frequencies of an electrochemical system. This method uses a novel waveforms and systems approach to sample the frequency axis at multiple points and determine the impedance spectra simultaneously. It can be readily integrated into conventional electrochemical workstations or into custom-made hardware and software depending on the user's needs.

One particularly promising application of this EIS method is for assessing changes in local blood flow in the microvasculature in real-time. Blood flow is indicative of local hemorrhage, injury, neuronal activity, etc. Thus, this method could assess changes in blood flow in response to focal stimulation with a deep brain stimulator (DBS), hemorrhage during surgery, monitoring injuries and more. Such changes in blood flow will then be used in closed-loop feedback systems to optimize the dose of stimulation delivered to the tissue and consequently enhance battery life. The above method is an alternative or supplement to the current closed-loop DBS approach that uses electrophysiological responses as feedback to tune the dose of electrical stimulation.

This method could enable new discoveries in many biotechnology applications and provide insight into underlying physiological and biological processes.

Potential Applications

- Biological applications
  - DBS

- Monitoring hemorrhage during surgeries
- Biosensors, diagnostics & implantable devices
- Food-safety monitoring
- Studies of cells of different types and pathogens

- Industrial Applications
  - Fuel cells & energy storage devices
  - Monitoring metal and paint or emulsion corrosion or degradation

Benefits and Advantages

- Rapid – fraction of a second
- Produces an electrochemical impedance spectrogram that can provide a time-frequency distribution of electrochemical impedance values at unprecedented resolutions in both time and frequency
- Enables fundamental discoveries of electrochemical events at the interface of materials and electrolytes
- The speed and resolution of the EIS obtained using this approach can be tailored to the user's needs

For more information about the inventor(s) and their research, please see

Dr. Muthuswamy's departmental webpage