Focus on electrochemistry: bringing electrochemistry to life*

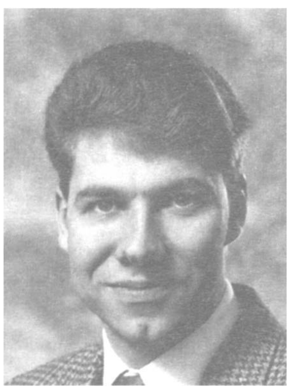
Andrew Abbott
Department of Chemistry, University of Leicester, Leicester, UK LE1 7RH

CHEMICAL SOCIETY REVIEWS

Electrodes have an image problem. The public perception is of Frankenstein and twitching frogs' legs. The work of eminent scientists such as Davy, Faraday, Becquerel, Nernst and Heyrovský has elevated electrochemistry to a science but has done little to raise the general awareness of the subject. To most it is still batteries, potentiometric sensors and boring lectures.

Electrochemistry has, however, come of age. The last twenty years have seen a revolution in the area due mostly to the advent of fast response electronic circuitry. Long gone are the days of equilibrium measurements and pools of mercury. Modern techniques can sweep potentials at greater than 10^6 V s^{-1} and measure currents below 10^{-12} A. Electrodes now come in every shape and size and are constructed from hitherto unimaginable materials. Some industrial processes employ electrodes with surface areas of several square metres while fundamental studies have been carried out with electrodes of nanometre radius. Semiconductors, superconductors and polymers are commonly used and the modification with surface layers to make the electrode specific to a solution species is a routine procedure. The media in which electrochemical investigations are carried out have also changed in recent years. While aqueous strong electrolyte solutions are still commonly used, room temperature molten salts, non-polar solvents, solid state and even supercritical media are finding applications. Several reviews have been published in this journal over the past 10 years highlighting some of these developments.

The renaissance of electrochemistry has come with the general realisation of its ubiquity. In a way chemical processes can be divided into three general types: electron transfer, proton transfer and the rest. The first two make up the majority of solution reactions and are the basis of modern electrochemistry. These processes are not unique to chemistry but span the entire spectrum of physical and biological sciences. Electrochemistry finds applications in such diverse areas as new materials, semiconductor physics, enzyme chemistry, chemical engineering and even neurophysiology. The aim of the articles published in this and subsequent issues is to highlight some of the main areas in which electrochemistry is currently used. It must be stresed, however, that these reviews provide only a flavour of current research.



Andrew Abbott received his BSc from Portsmouth Polytechnic in 1986. He did his PhD at the University of Southampton following which he held postdoctoral research positions at the University of Connecticut and Liverpool University. He is currently a lecturer at the University of Leicester where his main research interest is electrochemistry in novel media including supercritical fluids.

Many of the applications of electrochemistry arise because it is inherently clean, simple and fast. The article on page 147 by Mortimer highlights the new area of electrochromicity, where an electrochemical cell is used to change the oxidation state, and hence the colour, of a layer of material on an electrode surface. Such systems are used for display devices and smart windows which regulate the amount of light and heat entering a room.

A longstanding aim of electrochemical research has been to develop a clean, selective method for carrying out organic synthesis. To date the only large scale industrial electroorganic synthesis process is that producing adiponitrile from acrylonitrile. The article on page 157 by Utley highlights how many general types of organic reactions can be brought about electrochemically. It would seem that the only limitation of electrochemical techniques to organic synthesis is the aversion of organic chemists to electrodes.

Although you may not often think of electrochemistry, your thoughts themselves are electrochemical. The fundamentals of breathing, thinking and moving all have their basis in redox processes, ion transportation and liquid junction potential differences. Electrochemical techniques are therefore unique methods for giving us insight into the fundamentals of biological processes. On pages 169–180, Armstrong *et al.* review the reactions of complex metalloproteins and show how these can be studied using voltammetry.

Electrochemistry forms one of the cornerstones of clean technology initiatives world wide. The article on page 181 by Simonsson highlights some of the areas in which electrochemical techniques can remove pollutants from the environment. It covers such diverse areas as fuel cells for clean energy conversion, soil remediation and electrochemical oxidation of pollutants.

Justifiably electrochemistry has been seen as the science of batteries and as such, rather 'low-tech'. The advent of microelectronics and the profusion of portable devices has made the development of lightweight, cheap and reliable batteries of paramount importance. For example, approximately 50% of the weight and volume of a mobile telephone is the battery and at present prices if you calculate the cost of electricity from alkaline batteries it would work out at over £100 per kilowatt hour. Thus research to improve the energy density and simplicity of batteries is greater now than at any other time in its 200 year history. The article by Owen, which will appear in Issue 4, highlights some of the recent advances in the development of lithium batteries.

The remaining two articles in this series will focus on the materials aspect of electrochemistry. Higgins looks at the way conducting polymers can be functionalised to make them sensitive to species in solution. Such materials form the basis of many modern electrochemical sensors. The final article by Lewerenz continues the theme of semiconductors and investigates how the electrochemical processes occurring at a semiconductor/electrolyte interface can be studied using surface science.

While the articles mentioned here* are broadly electrochemical in nature they cover a wide scientific area and I hope there is something to interest everyone. I hope also that these articles will help to lay to rest the monstrous image that electrochemistry has undeservedly acquired.

---

* Part 1 appears in this issue from pages 147–190. Part 2 will appear in Issue 4.