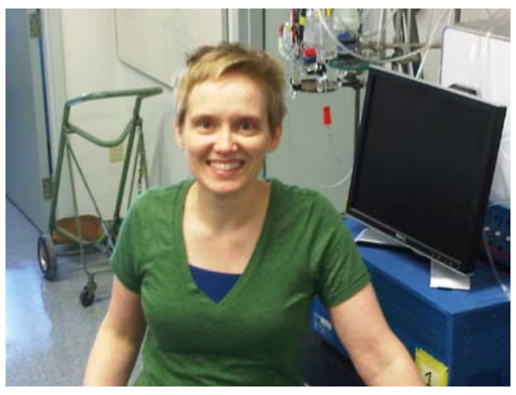
Andreas Research Group



Heather Andreas, Ph.D.

Department of Chemistry, Dalhousie University

6274 Coburg Rd, PO BOX 15000, Halifax, NS B3H 4R2
Office: Rm 316, Lab: Rm 338-340

Phone: 902-494-4505 (office), Fax: 902-494-1310

Heather.Andreas@dal.ca

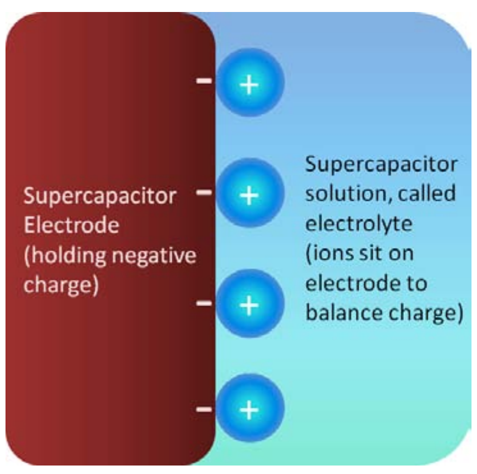
Breaking news: **NSERC Strategic Grant awarded** to Drs. Yu (University of Waterloo), Chen (University of Waterloo), Lian (University of Toronto) and Andreas (Dalhousie) to support an exciting new collaboration studying advanced graphene fibre based wearable supercapacitors.

Graduate Student Positions Available - I am currently accepting applications for graduate students starting September 2016 and 2017. There are open graduate student positions in both the supercapacitor research projects and in the biosensor research (a new research area in my lab).

Research Summary - The research in my lab is based on electrochemistry, and more specifically, the industrial applications of capacitance (storing charge at a surface/solution interface). We focus on two application-based research areas: supercapacitors and biosensors.

Supercapacitors

With rising oil prices and growing environmental awareness, people are becoming more interested in alternative energy systems (such as solar and wind power) and energy storage systems (batteries, fuel cells and supercapacitors). Our research focuses on supercapacitors, where charge is stored in very rapid reactions or on the surface of an electrode with a layer of oppositely-charged ions in solution (see figure).



Supercapacitors have several benefits when compared to other energy storage systems. For instance, they work well for short power bursts (camera flashes or airbag deployment) and they can be charged many, many more times than typical batteries.

Unfortunately, supercapacitors undergo a process called 'self-discharge', where the supercapacitor loses charge when it has been charged but not immediately used. For example, this could be a real problem if you go on vacation and leave your vehicle at the airport – by the time you return home, the supercapacitor may have lost all of its charge, and you would be unable to start your vehicle. Obviously, therefore, self-discharge may be a significant hindrance to the commercialization of supercapacitors.

The present focus of the research in our lab is the identification of the causes of self-discharge. Ideally, if we can identify the causes (and mechanisms) of self-discharge we can find a way of minimizing/preventing self-discharge, making supercapacitors more commercially useful and viable.

Recent Papers: **(students in bold)**

Heather A. Andreas "Self-Discharge in Electrochemical Capacitors: A Perspective Article" *J. Electrochem. Soc.*, **2015**, 162 (5), A1-A7.

Heather A. Andreas, **Jennifer M. Black, Alicia M. Oickle**, "Self-discharge in Manganese Oxide Electrochemical Capacitor Electrodes in Aqueous Electrolytes with Comparisons to Faradaic and Charge Redistribution Models" *Electrochimica Acta*, **2014**, 140, 116-124.

Zachary R. Cormier, Heather A. Andreas, and Peng Zhang "Temperature-Dependent Structure and Electrochemical Behavior of RuO_2/Carbon Nanocomposites" *J. Phys. Chem. C*, **2011**, 115, 19117-19128.

Alicia M. Oickle and Heather A. Andreas, "Examination of electrolyte decomposition and oxygen reduction as self-discharge mechanisms for carbon-based, aqueous electrolyte electrochemical capacitors", *J. Phys. Chem. C*, **2011**, 115, 4283–4288.

Jennifer M. Black and Heather A. Andreas, "Pore shape affects spontaneous charge redistribution in small pores", *J. Phys. Chem. C*, **2010**, 114, 12030-12038.

Alicia M. Oickle, **Sarah Goertzen**, **K. R. Hopper**, **Y. O. Abdalla**, and Heather A. Andreas, "Standardization of the Boehm titration Part II. Method of agitation, effect of filtering and dilute titrant", *Carbon*, **2010**, 48, 3313-3322.

S. Goertzen, **K. D. Theriault**, **Alicia M. Oickle**, **A. C. Tarasuk**, and Heather A. Andreas‡, "Standardization of the Boehm titration. Part I. CO_2 expulsion and endpoint determination", *Carbon*, **2010**, 48, 1252-1261.

Jennifer M. Black and Heather A. Andreas‡, "Prediction of the self-discharge profile of an electrochemical capacitor electrode in the presence of both activation-controlled discharge and charge redistribution", *J. Power Sources*, **2010**, 195, 929-935.

Heather A. Andreas, "Supercapacitors", McGraw-Hill Yearbook of Science & Technology 2010, McGraw-Hill, New York, pg 373-376.

Jennifer M. Black and Heather A. Andreas‡, "Effects of charge redistribution on self-discharge of electrochemical capacitors", *Electrochim. Acta*, **2009**, 54, 3568-3574.

Heather A. Andreas, **K. Lussier**, and **Alicia M. Oickle**, "Effect of Fe-contamination on rate of self-discharge in carbon-based aqueous electrochemical capacitors", *J. Power Sources*, **2009**, 187, 275-283.

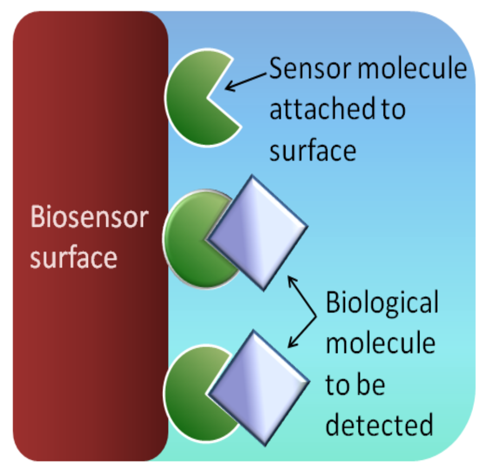
Current students

Mallory Davis
Currently: BSc Honours Project
Starting Graduate School Sept 2016

Adrienne Allison
Currently: BSc Honours Project

Biosensors

The types of biosensors that we study use a flow of electricity through a metal surface to quantify biologically important molecules attached to the surface (see figure). We are interested in the interactions between proteins and the surface. Ideally, these biosensors would be implanted directly into a person's body to measure important biological molecules continuously and allow for an immediate response if the molecule of interest becomes too scarce or too abundant.



Using our knowledge of electrodes and interfaces we examine how proteins adsorb on surfaces, how they react with electrodes and how the electrode chemistry impacts the protein reactions.

One important problem for biosensors is the difficulty in ensuring they quantify only the molecule of interest. Often a response maybe seen with multiple different molecules - this means that the biosensor indicates that the biologically relevant molecule is attached to the surface, when it is in fact an entirely different molecule. This is termed as an issue with selectivity. Selectivity is important since real biological systems contain many different proteins and other molecules and the biosensor needs to be able to selectively quantify only the desired molecule.

Our research examines the parameters and methods that may improve selective quantification. If we can understand the important parameters, we may be able to devise a method to produce a more selective biosensor.

Recent Papers: **(students in bold)**

Michelle A. MacDonald and Heather A. Andreas, "Impact of Electro-chemical Impedance Spectroscopy Experimental Variables on Adsorbed Protein Films, as Illustrated by Bovine Serum Albumin", Electroanalysis, **2015**, 27 (8), 1944-1951.

Michelle A. MacDonald and Heather A. Andreas "Method for equivalent circuit determination for electrochemical impedance spectroscopy data of protein adsorption on solid surfaces", *Electrochimica Acta*, **2014**, 129, 290-299.

Current students

Justin Tom
Currently: PhD Candidate

Gillian Davies
Currently: BSc Research Project