

“Optimization of Platinum Nanoparticles for Proton Exchange Membrane Fuel Cells Using Pulse Electrochemical Deposition”

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Abstract: The high cost of platinum (Pt) is the major barrier hindering the commercialization of hydrogen fuel cells. This research focused on the optimization of various fuel cell production parameters to maximize performance with minimal platinum loading. Precursor solution, solvent concentration, voltage, deposition time, purity of the solution, and type of solvent were varied to maximize the deposited platinum surface area on a fluorine-doped tin oxide electrode. Platinum surface area and efficiency were measured with cyclic voltammetry, while scanning electron microscopy demonstrated physical characteristics. Pt deposition with a new precursor solution, $\text{H}_2\text{Pt}(\text{OH})_6$, was superior to a previous supporting electrolyte of H_2PtCl_6 . Also, 5mM of $\text{H}_2\text{Pt}(\text{OH})_6$ deposited more platinum than 1mM. Decreasing the voltage during deposition was associated with improved Pt loading, with a nadir at $\pm 0.25\text{V}$. Increasing deposition time, as shown in previous studies, increased Pt nucleation sites. Purging impurities from the supporting electrolyte with an inert gas did not provide any benefit. Finally, a new solvent of 20% by volume mixture of 2:1 $\text{HNO}_3/\text{H}_2\text{SO}_4$ yielded more platinum surface area than H_2SO_4 alone. Ultimately, the fuel cell parameters of 5 mM $\text{H}_2\text{Pt}(\text{OH})_6$ in 1.5M H_2SO_4 proved best in performance testing, providing a new and exciting direction for future research.

Mentor: Mr. Jonathan Burke

“Novel Thermogelling Dispersions of Polymer Nanoparticles for Controlled Drug Delivery”

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Abstract: The development of delivery systems for therapeutic proteins is critically important for treating various diseases, but a major problem is that there is not a suitable protein drug carrier that can maintain a sustained release while protecting the protein from degradation in the human body. The purpose of this project is to solve this problem by creating a novel, biocompatible thermogelling dispersion of polymer nanoparticles as a protein drug carrier. Nanoparticles were composed of two biocompatible interpenetrating polymer networks (IPN): thermo-sensitive poly(ethylene glycol) derivative (PEGd) polymers and thermo-insensitive poly(acrylic acid) (PAAc). The physical properties of the nanoparticles were characterized using atomic force microscopy and dynamic light scattering. The aqueous dispersion of nanoparticles exhibited a thermogelling effect, characterized by a drastic increase in viscosity, as the temperature increased from 20 to 37 °C. For controlled drug delivery tests, insulin was mixed with the fluid dispersion at room temperature. At 37 °C, the dispersion formed a gel, which produced a release of insulin with an initial burst followed by a sustained release over a long period of time, as verified by protein assay measurements. Such a steady, continuous release demonstrates that this dispersion has potential as a suitable protein drug carrier.

Mentor: Dr. Liping Tang