Cell-Directed Integration of Mammalian Cells into Lipid/Silica Films

Amanda Horgan

Approach:
- Test the viability of yeast cells undergoing various heat treatments in lipid-silica films.
- Work on reproducible method of integrating macrophage cells.
- Integrate and test viability of rat basophilic leukemia cells.
- Make movies demonstrating viability of macrophage and RBL cells.

Applications:
- Smart prosthetics that can communicate with integrated circuits and nerve cells.
- Advanced physiological sensors with high biocompatibility.
- Portable medical diagnostics devices.
- Platforms for fundamental mammalian cell studies, including host/pathogen interactions, cell signaling, and mechanism of toxicology.
- Development of cell-based sensors that can detect harmful agents, that do not require frequent replenishment of the cell supply.

Results:
- Faced difficulties with autofluorescence and broke down spectra of yeast cell samples.
- After overcoming problems with buffers drying while making movies, succeeded in making movies of both forms of mammalian cells.
- Still having problems with reproducing macrophage integration.

Conclusions:
- With spectral data for yeast, can redo heat tests.
- Movies show cells are alive and functioning in films.
- More work to be done on macrophage integration method.

Diagram:
- Overview of an allergic reaction:
  1. Initial contact with allergen.
  2. Plasma cell released IgE antibodies.
  3. Mast cell.
  4. Subsequent contact with allergen.
  5. Allergic reaction with histamine and other chemicals.
Role of Support for Monometalic & Bimetallic Catalysts In Selective Acetylene Hydrogenation

Research Goal
To discover the relation Between catalyst support and selectivity in acetylene hydrogenation

Approach
- Develop a method for loading catalysts
- Obtain similar particle size on different supports
- Develop reactor for catalyst testing
- Test different catalysts for selectivity in acetylene hydrogenation
- Test effects on selectivity due to varying supports with metallic alloys

Results
- Obtained similar loading on different supports
- Re constructed reactor and plumbing apparatus used in catalyst testing
- Inconclusive findings when testing Catalysts due to variations in gas feed (removal of CO resulted in extremely reactive catalysts which was not predicted)

Ehren Baca
University of New Mexico
Mentor: Hien Pham
PI: Dr. Abhaya Datye
Role of Silica Surface Chemistry on the Stability of Au Nanoparticles

**Goal:** To develop a system to deposit stable gold nanoparticles < 5 nm in size on a functionalized model silica substrate.

**Approach/Method:**
- Study the stability of the Au system
  - Silica wafers functionalized with N-Hydroxysuccinimide (NHS)
  - Changes during synthesis and aging
    - Piranha etched silica wafers increases surface hydroxyls with extended exposure
  - How hydroxyls affect the stability

**Conclusions:**
- NHS is effective at maintaining particle size and distribution
- Partially hydroxylated - Particle size was maintained after ageing
- Hydroxylated - After extended ageing times at moderate temperatures particles grew substantially
- Elevated temperature heating - The extra hydroxyls on the surface lead to an increase in particle size

**Special Thanks to:**

[Image of the process and results]

Si wafers with SiO₂ Layer
750°C for 2 hrs

NHS Functionalization

Wash: 125°C for 5 hrs

Calcine: 125°C for 5 hrs

Au Sol.

1. Wash
2. Reduce 200°C, 2 hrs 3% H₂

Au-Si/SiO₂ Wafers NHS Functionalized

Au Size 4.3 nm

Reduced Sample

Au Size 4.4 nm

Aged in air at 400°C for 2 hours

Au Size 3.7 nm

Aged in air at 400°C for 4 hours

Au Size 5.8 nm

Aged in air at 400°C for 2 hours

Aged in air at 700°C for 2 hours

Au-Si/SiO₂ Wafers Hydroxylated and NHS Functionalized

Au Size 5.0 nm

Au Size 6.0 nm

Au Size 43.0 nm

Au Size 8.0 nm
Goal:
• Control the larger and smaller pores of the bimodal mesoporous silica structures created through microemulsion templating.
• Test the various pore types for their effectiveness at being impregnated with carbon or a carbon/platinum mixture.
• Examine the possible ways to use microemulsion templating for other metal oxides.

Approach:
• Vary surfactants, oil/sol ratio, acidity, and electrolytes added to change the silica particle. Based on the observed changes make decisions about whether the particle is a good candidate for impregnation of carbon or carbon/platinum.
• Impregnate silica particles to see if carbon has high surface area afterwards.

Accomplishments:
• Showed that larger pores and smaller pores may be adjusted on the silica particles.
• Demonstrated the effects of acidity upon the particle formation.
• Created carbon impregnations that could be pyrolyzed at very high temperatures and had high surface area.

A special thanks to:
• Nick Carroll
• Professor Plamen Atanassov
• National Science Foundation
• UNM
• Center for Micro-Engineered Materials
Electrostatic Microvalves Utilizing Conductive Nanoparticles
Chris Hamlin, University of Maine, Mechanical Engineering Freshman

Motivation
• Quake Type valves currently in use in microfluidics
• Very fast, but require separate pressure lines for each valve
• Replacing pneumatic actuation with electrostatic actuation allows for large increase in integration
• *This research: Understand how adding carbon nanotubes to PDMS valve membranes affects mechanical and electrical properties*

Approach
• Develop means to incorporate conductive carbon nanoparticles in a conductive plane encapsulated by PDMS
• Measure effect of curing agents on mechanical properties of PDMS
• Measure effect of CNT loading on electrical conductivity of the membrane
• Measure resistivity change in membrane as a function of membrane displacement over time

Key Results
• Optimized trapping of CNT mats within thin PDMS layers
• Observed time dependent changes of conductivity under membrane strain
• *Observed hysteresis of conductivity*

Conclusions
• Successfully developed a method to repeatably produce integrated PDMS/MWCNT sandwich membranes
• Polymer:hardener ratios do not affect reaction rates or the properties of the cured membranes
• Demonstrated a time dependent logarithmic decay of resistance in strained membranes
• *Time dependent resistance change linked to hysteretic effect of nanotubes in polymer*

Mentor: Chris Apblett, SNL
Effect of ZnO on Pd/ZnO Catalysts in Steam Reforming of Methanol

**Research Goal:**
Examine the effect of ZnO facets and morphology on catalytic activities in Pd/ZnO catalysts

**Payoff:**
Improve Pd/ZnO catalysts by ultimately determining the role of ZnO

**Approach:**
Use different types of ZnO (including Aldrich ZnO, Alfa ZnO, ZnO plates, and etched ZnO) to make Pd/ZnO catalysts via incipient wetness technique

Characterize the catalysts using SEM, TEM, XRD, BET, and methanol steam reforming

**Results:**
- Uniform Pd particles were deposited onto supports
- Pd on etched ZnO showed poor activity
- Pd on faceted ZnO (1010) surfaces have the best activity at 5% loading
- Pd on faceted ZnO (0001) surfaces have good activity only at a high loading
- Selectivity was not greatly affected by type of ZnO support
Growing SiGe Alloy Layer on Tensile-Strained Si

Goal: Create a layer of 20% Germanium, 80% Silicon, 20nm thick on top of a strained silicon without deformations or dislocations

Approach:
- Test sSi on top of Si substrate exposed to high temperatures to verify that it can withstand thermally induced diffusion (XRD, Micro-Raman)
- Use MBE to Grow 4nm of Ge on sSi with periodic thermally induced diffusions to make a layer of 20% Ge, 80% Si, roughly 20nm thick

Results:
- sSi on Si substrate does not relax when exposed to temperatures up to 1100°C
- 3 samples of SiGe were grown with MBE and thermally induced diffusion, characterization pending.

Daniel J Kluskiewicz
Pennsylvania State University
UNM REU 2008
Sang M Han (PI)
Darin Leonhardt (Mentor)
Goal: To Produce a traceable Calibration
For sub nN forces using radiation pressure
From an He-Ne Laser

Method/Approach:
• Radiation Pressure
• Novel amplification force technique
• Walk-off and Fabry-Perot Cavities
• Create maximum reflections to amplify Forces in the cavity

Significance:
• Through calibration new technologies can be manufactured commercially

Results:
• Determined best method (Fabry-Perot)
• Wrote Matlab Program to predict values
• Yielded maximum of 80 reflections
• Began work on MEMS Devices
Model Supports for Studying Aging Phenomena in Fuel Cell Electrocatalysts
Loren Baca, UNM REU 2008

Motivation
• Pt is very expensive, needs to be used more efficiently
• Characterization of fuel cell lifetime is time consuming and costly
• Need to develop accelerated testing protocols and a better understanding of catalyst degradation mechanisms
• **This research:** Our approach of accelerated aging on model supports will be very beneficial in ability to reduce amount of platinum used as a catalyst

Approach
• Simplify system, so we are able to look at just the Pt carbon interface
• Develop a simple model catalyst system that used nano-dispersed Pt particles directly on planar rotating disk electrode supports
• Use RDE to measure electrochemical performance

Key Results
• Began taking measures to synthesize nanoparticle arrays through two different techniques
• Using convective self assembly/Pt vapor deposition, and dip coating
• Began running experiments with the RDE to become more familiar with the system
• Began collecting cyclic voltammetry data on active samples

Conclusions
• Have set a solid foundation to begin running in-depth analysis of electrode samples
• Gathered valuable cyclic voltammetry data of commercial electrodes with various particle sizing and spacing
• Developed much needed techniques for keeping cell/catalyst free of contamination
• **Ready to begin creating samples which will be broken down for studying the effects of sintering**

Mentor: Ron Goeke, SNL
Protocells for Nucleic Acid Delivery into Mammalian and Bacterial Cells

Problem Statement

• Crucial to construct vehicles to bring nucleic acids into cells with regard:
  • Gene therapy
  • Gene silencing
  • Medicine for drug resistant bacteria
• Test the function for nucleic acid delivery:
  – Plasmid DNA: Several kilobase pairs
• E. Coli
  – Model for drug resistant bacteria
• CHO
  – Mammalian cells

E. Coli showing DNA uptake: Green Flourescence

Mammalian Cells showing DNA uptake: Green Flourescence

Alison Stace-Naughton
PI: Dr. Jeff Brinker
Mentor: Juwen Liu
8/08
Evaporation Induced Self-Assembly of Free-Standing Silicon Dioxide Wires with Axially Oriented Nanochannels

**Goal**
To produce free-standing wires with long oriented silica nanochannels that can be used in:
- Molecular Separators
- Catalysis
- Sensors
- Nanofluidics

**Approach**
- Precursors made using sol-gel chemistry and evaporation induced self assembly (EISA)
- Electrospinning
  - Produces free-standing wires
  - Electric field orients nanochannels

**Results/Accomplishments**
- Successfully produced wires by electrospinning.
- Based on TEM images, it is suspected that the wires are oriented. Further analysis is necessary to know for sure.
**Goal:**

- To create a highly specific targeted drug delivery vessel
- To create a highly specific targeted nano-cargo carrier
  - for delivering Au, FeO₂, Quantum Dots, etc. for medical testing and treatment.

**Approach:**

- Use phage display to identify peptides with specific binding affinities
- Modify MS2 bacteriophage via either genetic modification or chemical conjugation of peptides
- Load particle by RNA piggy-backing or chemical conjugation to internal surface.

**Results:**

- We achieved both cell surface binding and internalization of labeled MS2 with the SP94 peptide chemically conjugated to the surface. SP94 targets many lines of hepatocarcinoma, most notably, Hep3B which was used in our experiments.
- Three negative controls were used: Hep 3B with a control peptide and native MS2, and a health Hepatocyte with SP94-MS2. No association was seen.

![Hep 3B (carcinoma) showing a) cell surface binding after 4 hrs and b) internalization overnight](image)
Researching Biomaterial Properties For Engineering Aortic Heart Valve Tissue

**Goal:** Test different biocompatible surface stiffnesses to see which one cells prefer to grow on

**Significance:** Knowledge from experiments will be used in generating a tissue engineered heart valve

**Approach:**
1) Made 4 films with different % weights of DEGDMA
2) Using Promega Cell-titer glo to measure cell attachment and proliferation using VICs
3) Measure film properties to make sure properties are the same, except for stiffness

**Results:**
Able to determine that hydrophobicity/hydrophilicity are same for surfaces

Measure number of cells and determine that more research needs to be done on surfaces and VICs
Structure and Electrochemical Properties of Electrocatalysts for NADH Re-oxidation
Mike Mojica, University of Florida
Mentors: Rosalba Rincon and Dr. Kateryna Artyushkova  PI: Dr. Plamen Atanassov

Research Goal:
Characterize and examine the effectiveness of several azine polymer mediators for biofuel cell applications

Approach:
• Produce azine polymers and analyze the redox potential of NADH+/NAD using cyclic voltammetry.
• Characterize the enzymes using laviron plots and x-ray photoelectron spectroscopy.

Results:
• Methylene Blue may be the most effective azine polymer at reducing the over potential of NADH/NAD+ redox reactions.
• XPS data indicates a new nitrogen group is formed during azine polymerization and sulfur group may be also involved.
MnO$_2$ Supported on C in Zn-Air Batteries

**Goal:**
Develop a method for producing Manganese Dioxide supported on Carbon for use as a catalyst in a Zinc-Air battery with an ionic liquid.

**Approach:**
- Produce MnO$_2$ (from KMnO$_4$) supported on C via spray pyrolysis in a horizontal furnace.
- Wash product to remove K ions
- Characterize with SEM, EDS, BET, TEM, and RDE.

**Results:**
- Nanosized MnO$_2$ was supported on C with minimal K content and will be tested in a Zn-Air battery.

Special thanks to UNM, NSF-REU and CMEM.
Goal

We studied the effectiveness of screen-printed membrane based electrode arrays in multi-channel immunosensors. By integrating the membrane and the electrode into one biosensing unit, we were hoping to improve sensitivity of electrochemical immunoassay. We wanted to determine whether screen-printing directly on the membrane changes the chemical properties of the membrane.

Approach

Using sandwich immunoassay, we first compared the binding capacity of a membrane with screen-printed electrodes to that of an untreated membrane by comparing color intensity and surface plots.

Second, we used an 8-channel biosensing device that could read electric current. We attempted to determine a method for successfully reading current from the screen-printed membrane. Ultimately, we hoped to compare electrochemical calibration curves of both a screen-printed membrane and an untreated membrane with a separate plastic electrode piece.

Accomplishments:

We showed that the binding properties of screen-printed membranes were very similar to untreated membranes for Biodyne A 1.2 μm, Biodyne A 0.45 μm, and UltraBind 0.45 μm.

We found the Vector Lab’s ImmEdge Pen effectively prevents lateral flow in the screen-printed membrane.

We discovered that the Ag/C wires on the screen-printed membranes are easily damaged by minor bending of the membrane. Thus, the electric current is lost between the electrode and the carbon sensor. We propose that in the future screen-printed membranes should be placed on a porous support immediately after printing to prevent damage.