Garcia MRSEC

NSF

Polymers at Engineered Interfaces

SUNY Stony Brook • Polytechnic University • CUNY • North Carolina State University

Research Scholars Program 2006

This program is sponsored in part by the National Science Foundation.

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Polymers at Engineered Interfaces

SUNY Stony Brook • Polytechnic University • CUNY • North Carolina State University

"The program has no set time limits. Research is a lifelong learning experience, and we hope to remain a resource to our students long after 'graduation.'"

The Garcia Center for Polymers at Engineered Interfaces is a collaboration of eleven academic, industrial, and government laboratories. The Center was founded in 1996 and is named after the late Queens College professor, Narcisso Garcia, a pioneer in the integration of education and research. The Garcia Center is funded by the **National Science Foundation** as part of its Materials Research Science and Engineering Center (MRSEC) program. The goal of the MRSEC is to combine the instrumentation and expertise of the participating institutions into coordinated research programs on polymer interface science. The principal focus areas include thin films, coatings, nanocomposites, self-assembled structures, biomaterials, and tissue engineering. These areas address both the fundamental and applied aspects that are relevant to the development of cutting-edge technologies in both engineering and medicine. In the community, the mission of the center is to serve as a valuable resource, providing easy access for technological assistance to educational and industrial institutions. For information on the numerous programs that are available, please see our web site at http://polymer.matscieng.sunysb.edu

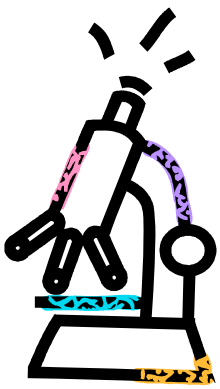
The Research Scholars Program offers the opportunity for high school teachers and students to perform research on the forefronts of polymer science and technology together with GARCIA faculty and staff. Students work as part of focused research teams and are taught to make original contributions of interest to the scientific community. In addition to entering national competitions, the students are encouraged to publish in revered scientific journals and present their results at national conferences.

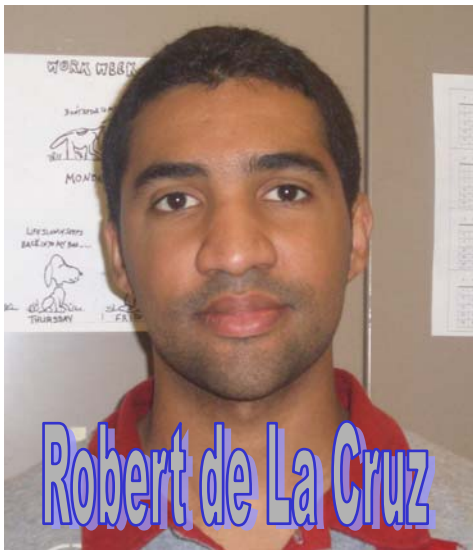
Our goal is to convey to the students the excitement we enjoy daily in research. The program has no set time limits. Research is a lifelong learning experience, and we hope to remain a resource to our students long after "graduation."

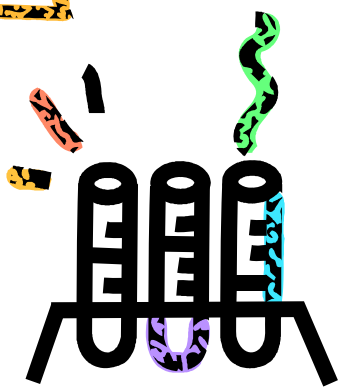
Miriam Rafailovich
Professor, Garcia MRSEC

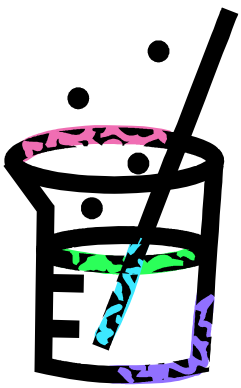
Jonathan Sokolov
Professor, Garcia MRSEC

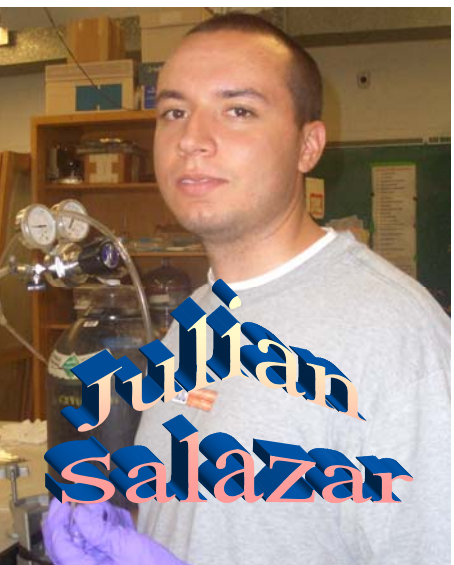
Research Experience for Teachers

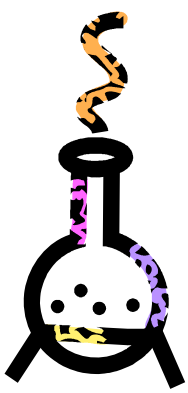


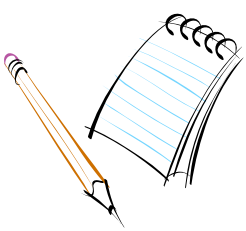












Grads


Xiaolan Ba


Yuan Ji


Jun Jiang


Jaseung Koo


Bingquan Li


IBM
Chunhua Li


Song Li


Ying Liu


PARK
Seongchan Pack


Zhi Pan


Yuan Sun


JAMES!!!
Sijia zhaO


Juan Zhou

Staff


Lourdes Coiano


Mark D'aria

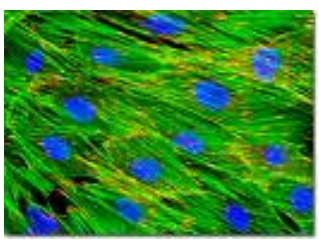

Shouren Ge


Digital Instruments


Vladimir Jurukovski

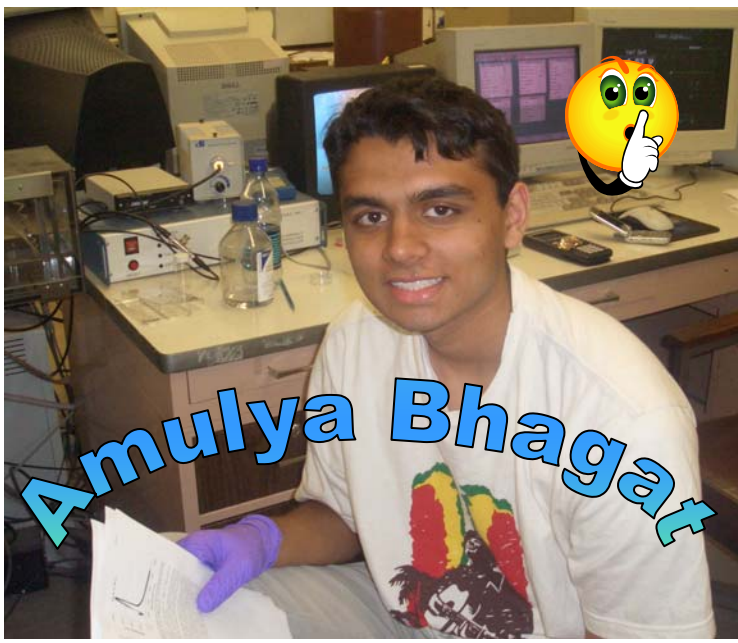

Yantian Wang


Nadine Pernodet




Vladimir Zaitsev

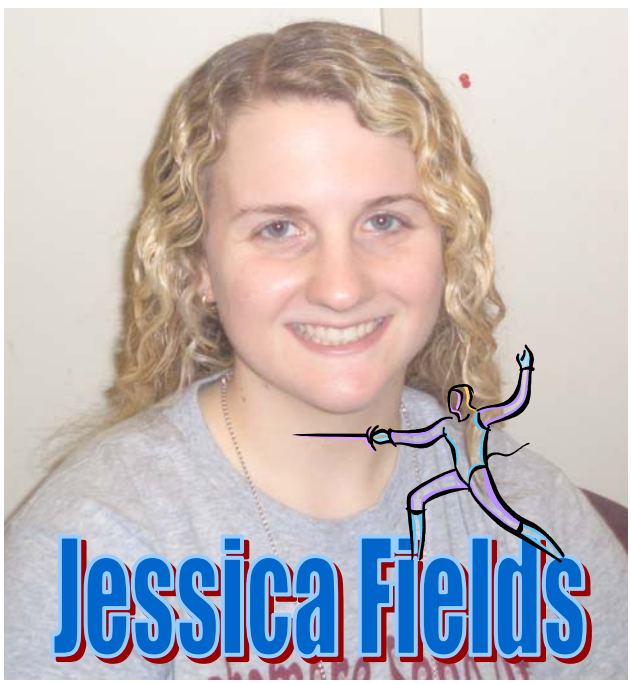
Research Experience for Undergrads




Nicolas Chery


Jennifer Daniels


Kate Dorst


Jessica Fields


Morin Foundation Scholar
Mitchell Fourman


Allyson Ho


Hobbit


John Michael
John Michael
Iraci

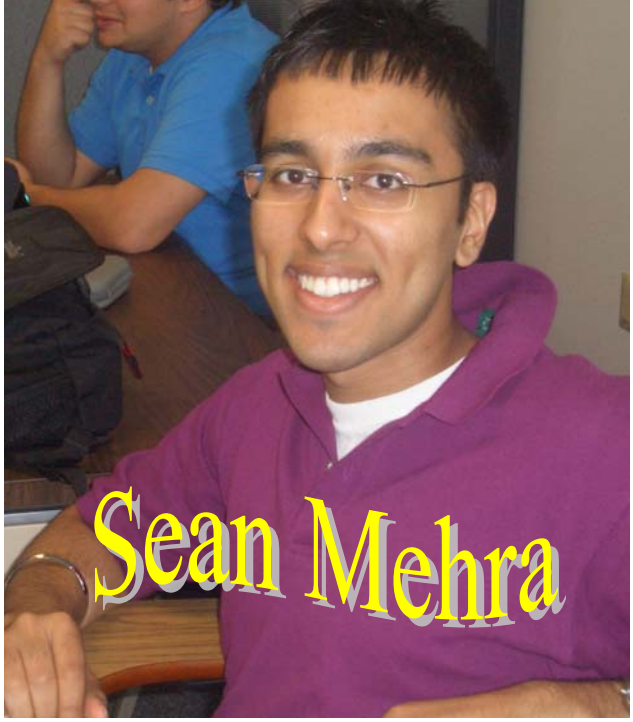
Sean McCormack


Sagar Mehta


Michal Simpser


Vikas Muralis


Jeffrey Reitman


Sean Mehra


Rachel Rosenfeld

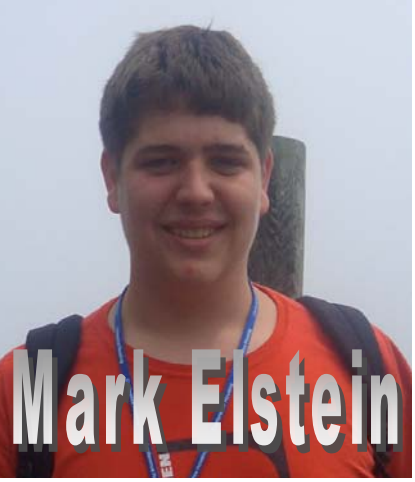

Hilana
Lewkowitz-Shpuntoff

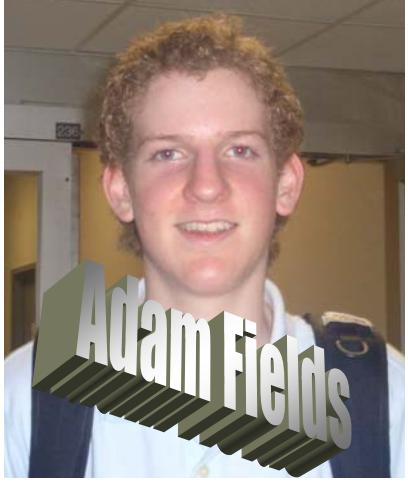

REU
of the
YEAR!!
Lenny Slutsky Rocks


Vandana Sood


Mary
Yang

High School Summer Scholars 2006


Mark Elstein


Adam Fields


Crystalee Forbes

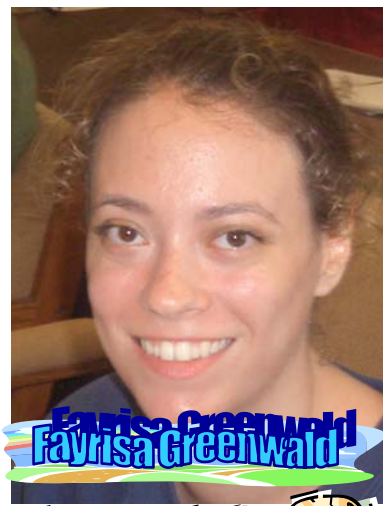

Daniel
Fourman


Alicia Franco


Brian Fromm


David Garczynski


Michael Gebhardt


Fayrisa Greenwald

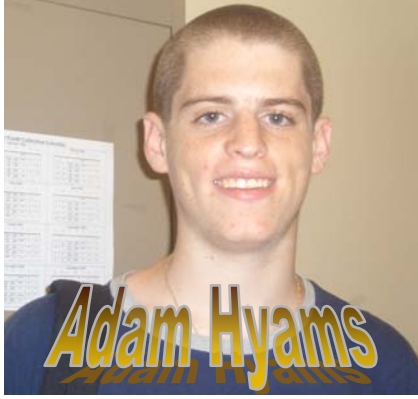

Yehuda Grossman


Yoseph
Gutterman

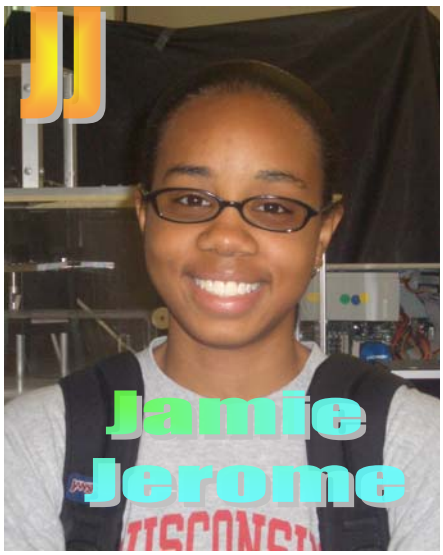

Kristen Hall


Yishu Huang


Victoria Hung


Adam Hyams

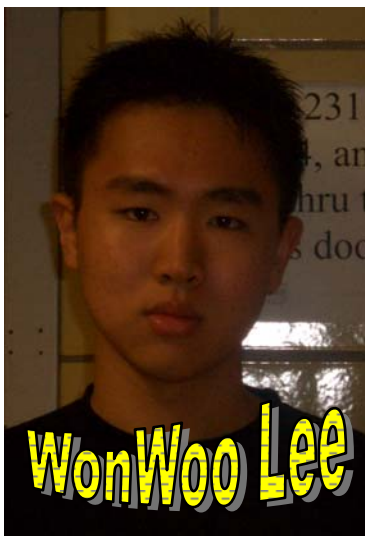

Vijay Jain


JJ
Jamie
Jerome

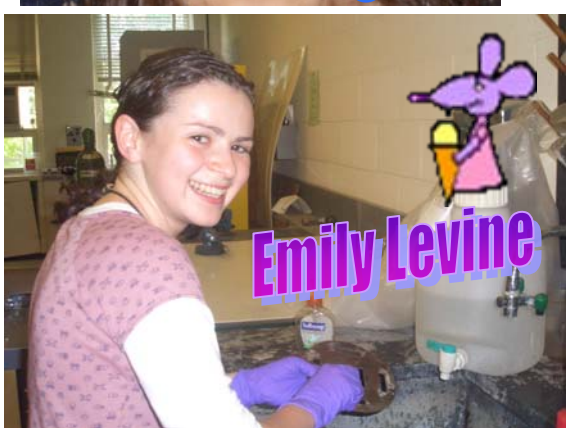

Daniel Katz


Hyung Jun Kim


Brienne Kugler


WonWoo Lee

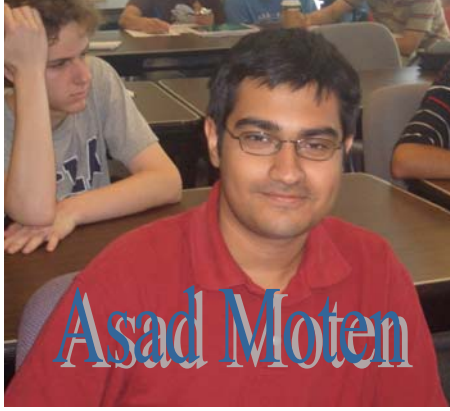

Danielle Lent


Emily Levine


Jacob Loewenstein


Ben Macaluso


Mili Mehta


Asad Moten


John Oh


Samantha Palmaccio


Sean Pí
3.14159


Shuai Qin

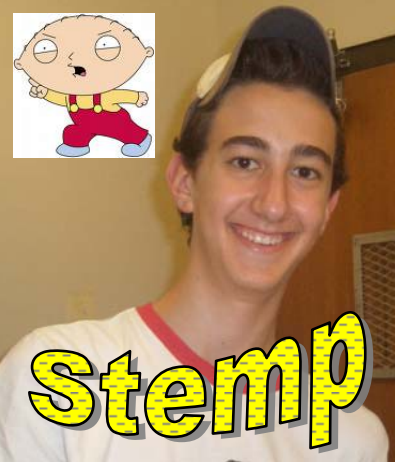

Alex Ramek

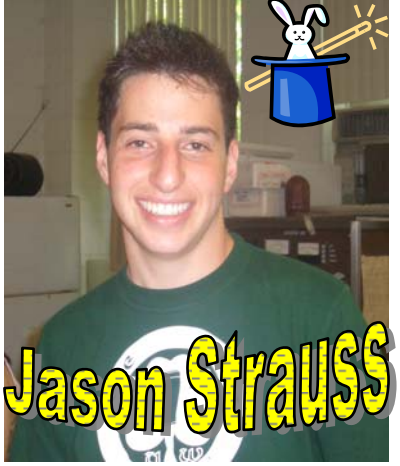

Radha Ramjeawan


Danielle Schwartz


Preya Shah


Jonathan Steinman


Stemp

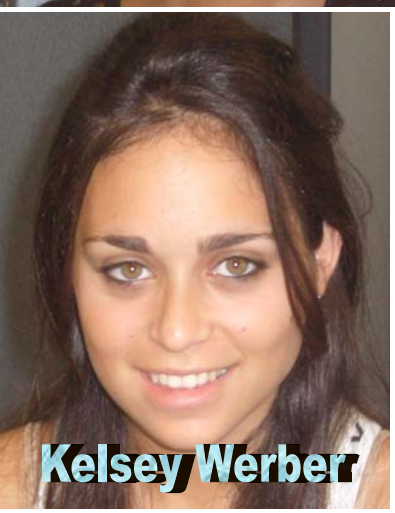

Jason Strauss


Phillip Tan


Pooja Vasudevan


Prane Wang

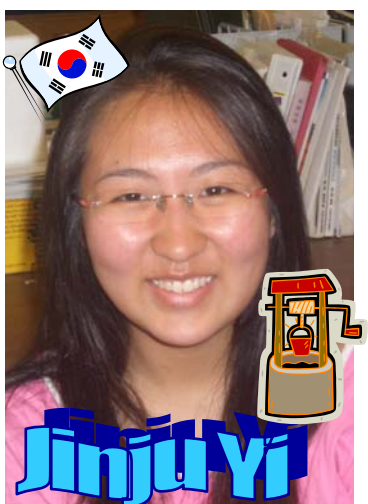

Mary Catherine Wen


Kelsey Werber


Matthew Wieder


Debbie Yee


Jenny Yeh


Jinju Yi


Kiwoong Yoo


Summer Scrapbook


Life in the Lab


Lab Work


Fun in the sun
YUCATAN
GUINNESS


Southampton Bay
Cruise


Southampton Bay Cruise


Nissequogue River

Summer 2006

Garcia MRSEC NSF
Polymers at Engineered Interfaces
SUNY Stony Brook • Polytechnic University • CUNY • North Carolina State University

The Garcia Center

invites you to attend the

Annual Summer Symposium

of the

Research Scholars Program

on

Friday, August 11, 2006

between

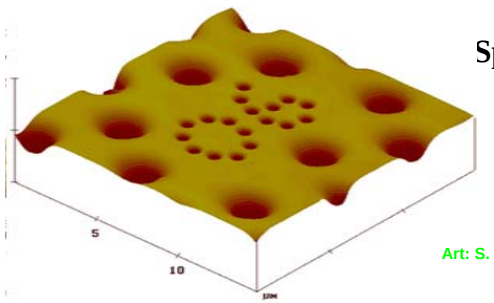
10:00 AM-1:00PM

in the

SAC Auditorium

Art: H. Shpuntoff, M. Wen

RSVP on or before August 8
(631) 632-6097
or e-mail
Abstracts1@hotmail.com



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Art: S. Mehra, J. Reitman

Schedule of Events

- **Guest Speaker**
  David Manning
  Executive Vice President, Corporate Affairs and Chief Environmental Officer, Keyspan Energy
- **Scientific Symposium presented by the students**
- **Artistic Program arranged by the students**
- **Buffet Luncheon**

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Polymers at Engineered Interfaces
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Summer Research Symposium Program

August 11, 2006
SAC Auditorium

10:00-10:15 Seating and Student Musical Performance
Organized by *Ayla Bloomberg and John Jerome*

10: 15-10:25 Welcome *Miriam Rafailovich*
Dean Yacov Shamash

Greetings from New York State Elected Officials
Favorite REU Award, elected by popular student vote:
LENNY SLUTSKY, DUKE UNIVERSITY

10: 25-10:40 Opening Address: *David Manning, Keyspan Energy*
Executive Vice President, Corporate Affairs
Chief Environmental Officer

10:30- 10:40 ***Session I: Clean Energy Solutions***

Chairs: *Amulya Bhagat,* New York University
Allyson Ho, John Hopkins University
Vikas Muralis University of Pennsylvania

Optimum Conditions for Methane Hydrate Formation In A High Pressure Chamber
Emanuel Beica, Bayport-Blue Point High Sschool
Daniel Fourman, Ward Melville High School

The Effect of Thiol-Functionalized Nanoparticles on the Efficiency of Polymer Electrolyte Membrane Fuel Cells
Debbie Yee, Great Neck North High School

Platinum Nanoparticles: From Energy Storage to Cancer Treatment
Daniel Katz, Hebrew Academy of Five Towns and Rockaway

10: 40-10:50 ***Session II: Green Processing of Bulk Polymers with Supercritical CO_2***

Chairs: *Mitchell Fourman,* Stony Brook University
John Iraci , Cornell University

Analyzing the Effects of Supercritical Carbon Dioxide and Additives on the Revitalization of Recycled Polymers
Danielle Lent, Stella K Abraham High School for Girls
Emily Levine, Stella K Abraham High School for Girls

Evaluating the Effects of Supercritical Foaming on Ethylene Vinyl-Acetate in Pure and Blend Form
Michael Gebhardt, Half Hollow Hills High School East
Prane Wang, Half Hollow Hills High School West

10:50-11:00 ***Session III: Enhancing Properties with Supercritical CO_2: Polymer Coatings & Membranes***

Chairs: *Ayla Bloomberg,* Harvard University
Rachel Rosenfeld, Shalavim Yeshiva Institute for Girls

The Effect of Supercritical Carbon Dioxide on the Selective Permeability of Polymer Membranes
Phillip Tan, Valley Stream High School

Supercritical Carbon Dioxide ($scCO_2$) and Nanoparticle Induced Swelling of Polymers for Nano-lithography and Micro-electronics
Brienne Kugler, Jericho High School
Jacob Loewenstein, Hebrew Academy of Five Towns and Rockaway

11:00-11:10 ***Session IV: Nanocomposites and Thin Films***

Chairs: *Sean Mehra,* Yale University
Jeffrey Reitman, Yale University

Self Assembly of Diblock Copolymers for Testing Polymer Stabilization to Improve Industrial Lubrication and Nano-imprint Lithography
Jason Strauss, North Shore Hebrew Academy High School
Hila Calev, Ward Melville High School

Hole Growth in Crosslinked Thin Polymer Films
Jonathan Steinman, Roslyn High School

11:10-11:20 ***Session V: Flame Retardant Polymers***

Chairs: *Nicolas Chery,* European School of Chemistry, Polymers, and Materials

Study for the Optimal Triple-Blend Flame Retardant System
WonWoo Lee Jericho High School
John Oh, Jericho High School

Flame Retardant PS/PMMA Blended With Carbon Nanotubes
Danny Stemp, North Shore Hebrew Academy High School
David Garczynski, North Shore Hebrew Academy High School

11:20-11:30 ***Session VI: Effects of Magnetism on Cells***

Chair: *Nicole Brenner,* Stony Brook University

Influence of Static Magnetic Fields on Protein Adsorption and Organization
Jaimie Jerome, Ward Melville High School

Cell Proliferation and Alignment on Magnetic Polymer-Clay Nanocomposites
Mary Catherine Wen, Archbishop Molloy High School
Jenny Yeh, St. Agnes Academy

11:30-11:50 ***Session VII: Electrospinning: Producing Non-woven Scaffolds for Biomedical and Active Filtration Systems***

Chair: *Hilana Lewkowitz-Shpuntoff,* Princeton University

Cell Morphology of Human and Cancerous Fibroblasts as a Function of Electrospun HA Hydrogel Scaffold Crosslinking Densities
Yusuf Anwar, Syosset High School
Kai Chao, Half Hollow Hills High School

The Effects of the Diameter of Poly(methyl methacrylate) Electrospun Fibers on the Morphology of Dermal Fibroblast Cells
Alicia Franco, Brentwood High School
Preya Shah, Ward Melville High School

Electrospinning and Spin-Casting Bacteria for the Filtration of Groundwater
Fayrisa Greenwald, Massapequa High School

Smart Scaffolds: Developing a Biocompatible Poly(methyl methacrylate) Matrix for Tissue Enginnering
Asad Moten, Clear Creek High School
Pooja Vasudevan, Wheatley High School

11:50-12:00 Break and Buffet Catered by Wing Wan Chinese Restaurant of West Hempstead and Sponsored by 

12:00-12:20 ***Session VIII: Cells in Nanostructured Environments***
Chairs: *Jessica Fields,* Princeton University
Sagar Mehta, Harvard University

Cell Growth, Cytoskeletal Structure, and Protein Expression in the Presence of Cloisite Na+
Brian Fromm, North Shore Hebrew Academy High School
Crystalee Forbes, Uniondale High School

The Effects of Poly-Butadiene Thin Films on Dermal Fibroblast and Adipose Stem Cell Growth and Differentiation
Benjamin Macluso, Sachem East High School

Effects of Clay Substrates on Fibronectin Conformation and Fibroblast Cell Growth
Radha Ramjeawan, Uniondale High School

The Use of Silica Beads as a Specific Targeting and Diagnostic Protocol for Cancer
Sean Pi, North High School

12:20-12:35 ***Session IX: Mechanical Properties of Cells***
Chair: *Taylor Bernehim,* University of Pennsylvania

The Effects of SPS (Sulfonated Polystyrene) on Induced and Noninduced Pulpal Stem Cells
Shuai Qin, Ward Melville High School
Margaret Davidson, Chapin High School

A Novel Early Cancer Cell Detection System
Adam Fields, Jericho High School
Alex Ramek, Hebrew Academy of Five Towns and Rockaway

Effects of Substrate Stiffness on Cell Morphology, Cytoskeletal Structure, and Elasticity
Kristin Hall, Smithtown High School

Mathematical Modeling of Fibroblast Migration
Victoria Hung, Smithtown High School West

12:35-12:50 ***Session X: Biological Effects of TiO_2 Nanoparticles***

Chair: *Michal Simpser,* Stern-Yeshiva University

The Effect of Ultraviolet Radiation on Different Components of Sunscreen with Ti02
Adam Hyams, Jericho High School
Kiwoong Yoo, Jericho High School

The Stability of Natural Compounds in the Presence of UV Light and Sunscreen Components
Nikki Ackerman, Jericho High School
Kelsey Werber, Jericho High School

The Use of Chemical and Mechanical Coatings as a Mechanism to Prevent the Damaging Effects of Photoactivated Titanium Dioxide on DNA
Matthew Wieder, SAR High School

12:50-1:10 ***Session XI: Polymers: Impact on the Environment, Medical and Consumer Applications***

Chair: *Julian Salazar,* Teacher at Louis Armstrong High School
Robert de La Cruz, Teacher at Valley Stream Central High School

Plastics in the Environment
Yehuda Grossman, Davis Renov Stahler Yeshiva High School
Yosef Guterman, Hebrew Academy of Nassau County

Skin Mechanics and the Effects of Age: Application of DISC
Mark Elstein, Bayport-Blue Point High School

Properties of Hydrogels Composed of Poly(ethylene oxide)-poly(propylene oxide)-poly(ethylene oxide)-poly(acrylic acid), A Potential for Transdermal Drug Delivery
Grace Chow, Herricks High School
Mili Mehta, The Wheatley School

Pluronic F127 as an Applicable Replacement for a Degenerated Nucleus Pulposus
Ankuri Desai, Ward Melville High School

1:10-1:25 ***Session XII: Detecting Viruses & DNA***

Chairs: *Jennifer Daniels,* Stony Brook University

Molecular Templating for Rapid Bioterrorism Detection
Vijay Jain, Herricks High School,
Jinju Yi, Plainview-Old Bethpage John F Kennedy High School

Use of Magnesium Ions to Modify DNA Adsorption and Electrophoresis on Surfaces
Hyung Jun Kim, Jericho High School

DNA Electrophoresis on Indium Tin Oxide Conducting Surfaces
Michael Ding, Glen Cove High School

1:25-1: 45 ***Session XIII: Organizations of Proteins at Polymer Surfaces***

Chairs : *Lenny Slutsky,* Duke University
Kate Dorst, Dowling College

Fibrinogen: A Study of Structure and Function
Jency Daniels, St. Anthony's High School

Biomineralization on Mixed Protein Templates
Yishu Huang, Ward Melville High School

The Role of Tissue Non-Specific Alkaline Phosphatase in the Biomineralization of Osteoblasts
Samantha Palmaccio, Sachem High School East

Conductivity of Silicon and Fibronectin Adsorption
Danielle Schwartz, The Wheatley High School

ADJOURN

Session I:
Clean Energy Solutions

Chairs: Amulya Bhagat

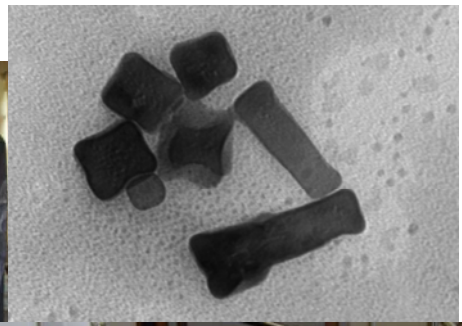
Allyson Ho

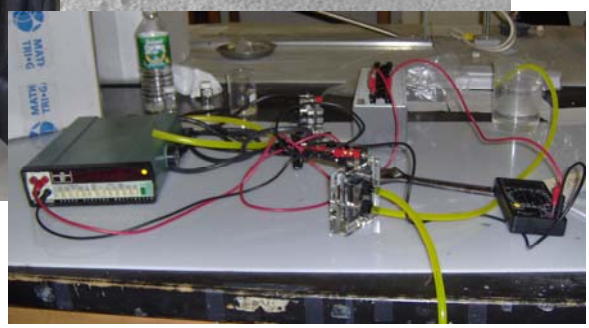
Vikas Muralis

Emanuel Beica, Daniel Fourman

Debbi Yee

Daniel Katz





Optimum Conditions for Methane Hydrate Formation in a High Pressure Chamber

Emanuel Beica, Bayport-Blue Point High School
Daniel Fourman, Ward Melville High School
Allyson Ho Johns Hopkins University, Sean McCormack Duke University,
John Jerome, Stony Brook University

Dependency on foreign oil has caused sundry entanglements for the United States. These conflicts have given an impetus for the augmentation of the search for alternate energy sources. Methane hydrates could eventually cause the search to terminate auspiciously. This substance is found abundantly in permafrost and below the ocean in the proximity of coasts. Estimates state that the current reserves of methane hydrate are equivalent to 137.5 trillion barrels of oil[1]. Contrastingly, methane hydrates can also have very negative effects. Namely, they can hinder the extraction of oil via blockage of pipelines. By deducing the optimum temperature and pressure conditions for the formation of methane hydrates, one could thwart the formation of this substance in pipelines by ensuring that the necessary temperature/pressure parameters of formation are not present therein. In addition, by ascertaining these optimum conditions of formation, one could also form methane hydrates and use them for storage of methane for use as an alternate fuel. This method would be much more economical than the current method of natural gas liquefaction.

We believe that there exist optimum conditions for methane hydrate formation. Such conditions are present where there are large deposits of methane hydrate near coastal areas. Unfortunately, the pressures and temperatures cannot be studied directly at the source because of the difficulty of safe extraction.

For our experiment, we replicated the underwater conditions (Figure 1) which are conducive to the creation of methane hydrate. De-ionized dihydrogen monoxide was placed on a Teflon disc which was subsequently placed in a high-pressure chamber. The chamber was then cooled to a maximum of 10˚ Celsius via the utilization of an Isotemp Refrigerated Circulator. Next, the chamber was pressurized to 1000psi-1150psi with methane. To detect for the formation of methane hydrate, we utilized a high-intensity laser. We aimed this laser through sapphire windows – which were located on the façade of the high-pressure chamber – to a detector which was connected to a multimeter. The voltage output of the multimeter was dependent on the state of the substance on the Teflon disc; therefore, water would allow much more light to pass through than methane hydrate. Consequently, the multimeter would display a much lower voltage (.25 mV compared to 2.2 V) when methane hydrate was present within the chamber. To ensure accurate readings from the multimeter, we covered the apparatus with canvas to keep away light pollution. Furthermore, we used blow dryers to ensure that condensation on the sapphire windows evaporated and didn't weaken the laser beam.

In finality, there is certainly an optimum condition for the formation of methane hydrate. Experimentation has shown us that some temperature/pressure parameters are more conducive to methane hydrate formation than others. Since there are infinite parameters of temperature and pressure that can be tested, however, future experiments must make more efficient use of interpolation to limit the manifold combinations possible by eliminating certain futile parameters.

1. http://ic.ucsc.edu/~wxcheng/envs23/lecture12/C_cycle_prt.html

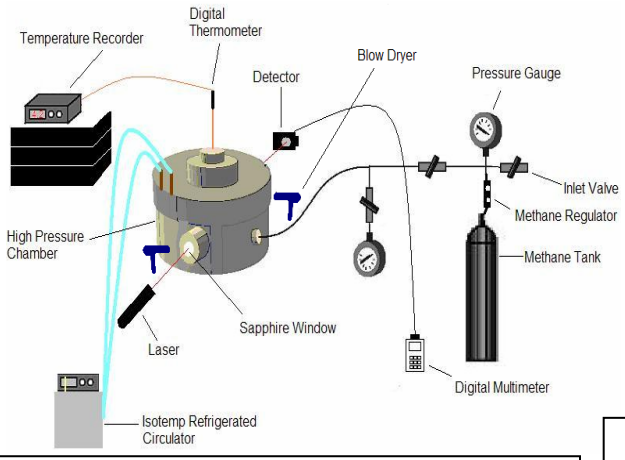


Figure 1: Schematic of the experimental apparatus for measuring the phase diagram of methane hydrate.

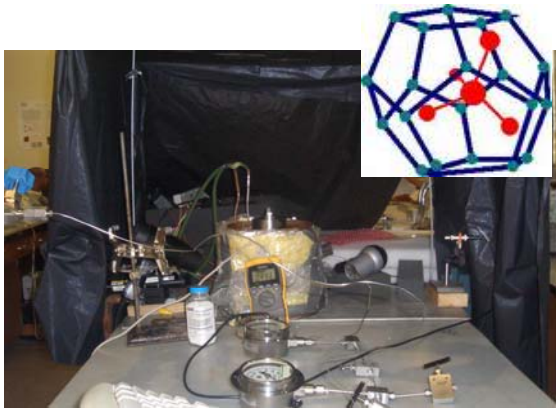


Figure 2: The actual experimental apparatus, showing position of the air dryers enabling the laser light to pass through without water scattering. Inset: Methane hydrate crystal from ref. 1

The Effect of Thiol-Functionalized Nanoparticles on the Efficiency of Polymer Electrolyte Membrane Fuel Cells

Debbie Yee, *Great Neck North High School, Great Neck, 11023*
Michelle Simpser, Sijia Zhao, Dr. Miriam Rafailovich, Dr. Anatoly Frenkel
Department of Material Science and Engineering, Stony Brook University

A search for alternative energy sources has risen due to a growing concern over resource depletion and environment preservation. The polymer electrolyte membrane (PEM) fuel cell shows great promise as a future power system since it has a high efficiency and a low pollution[1]; water being the only byproduct of electrochemical reactions in the fuel cell. The polymer electrolyte membrane used in the fuel cell was a perfluorosulphonated ionomer membrane, Nafion®, due to its high ionic conductivity[2].

While PEM fuel cells are a potential new energy source, there are many limitations which restrict its use on a large scale. For example, PEM fuel cells have a low energy output, requiring multiple cells to be used in unison. This study concentrates on improving the efficiency of individual PEM fuel cells. Metallic nanoparticles are used to increase fuel cell efficiency by storing hydrogen thereby facilitating hydrogen gas diffusion within the cell. A Langmuir-Blodgett trough is used to place a layer of either thiol-functionalized palladium, platinum, or gold nanoparticles onto the Nafion membrane. These nanoparticle-layered membranes were then placed in a fuel cell setup consisting of a polymer electrolyte membrane (PEM) fuel cell, a voltmeter, a resistor, and an ammeter. The resistance was controlled to increase the current produced, and voltage readings determined the power output.

Results indicated that there was a general trend of higher energy production in gold and palladium nanoparticle-layered membranes. Current work involves testing the effect platinum nanoparticles on the PEM membrane, and using x-ray reflectivity to determine nanoparticle thickness for the Nafion® membrane.

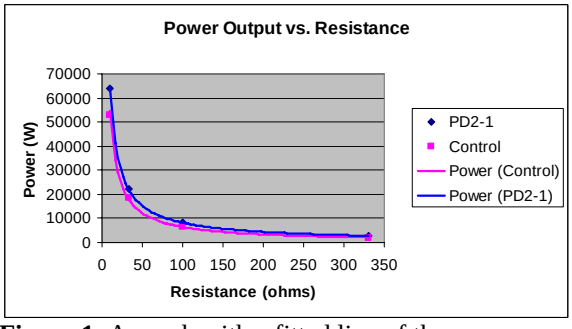


Figure 1: A graph with a fitted line of the power output of the fuel as a function of the decreasing resistance. The fitted line indicates that there is a higher efficiency for the palladium-layered membrane.

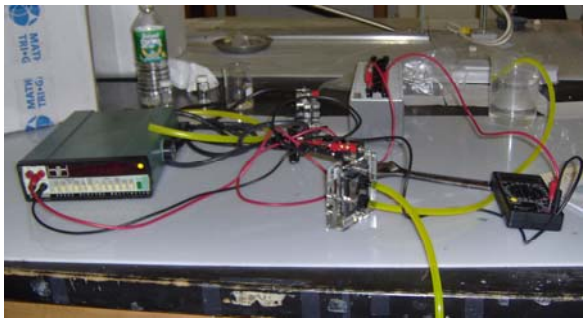


Figure 2: Fuel Cell Setup. The PEM fuel cell is connected in series with a resistor and an ammeter. The voltmeter is connected parallel to the resistor and the ammeter.

[1] Hong Sun, Guangsheng Zhang, Lie-Jin Guo, Hongtan Liu. Journal of Power Sources 158 (2006) 326-332
[2] A. Sacca, A. Carbone, R. Pedicini, G. Portale, L. D'Ilario, A. Longo, A. Martorana, E. Passalacqua. Journal of Membrane Science 278 (2006) 105-113

Platinum Nanoparticles: From Energy Storage to Cancer Treatment

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Michal Simpser, Stern College for Women, New York, NY
Yuan Sun, Stony Brook University, Stony Brook, NY 11794-2275

Platinum on the bulk scale offers unique catalytic and conductive abilities but when brought down to the nanoscale its properties are both altered and enhanced, due to the increased surface to volume ratio. I discovered that on the nanoscale platinum is toxic to cells, however if coated in specific targeting agents, the platinum nanoparticle's destructive abilities can be utilized to destroy cancerous cells while leaving healthy somatic cells unharmed. Cancerous cells require exponentially greater amounts of folic acid than do normal cells and thus it is an excellent way to "trick" cancerous cells into absorbing the toxic platinum nanoparticles. I devised a simple one step method to coat platinum nanoparticles with folic acid. This technique produced Pt nanorods and spheres, approximately 20 The "nanotherepy" that I have devised has the potential to treat cancers without the devastating side effects of current chemotherapies. I have also discovered that platinum on the nanoscale has a very high affinity for hydrogen. Platinum nanoparticles are capable of absorbing nearly 38% hydrogen by mass (Figure 2). This finding is significant in increasing the safety and efficiency of fuel cells. Currently fuel cells require the use of hydrogen stored at high pressure in its gaseous form; however this is very dangerous in mobile applications due to the volatile and explosive nature of hydrogen gas. I have devised a method of storing hydrogen in a solution of colloidal platinum nanoparticles, which will increase fuel cell safety by reducing the volatility of the stored hydrogen.

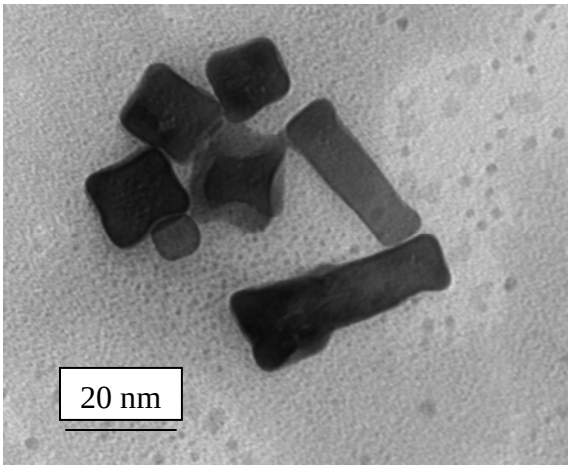


Figure 1: Platinum nanorods and cubes coated with Folic acid.

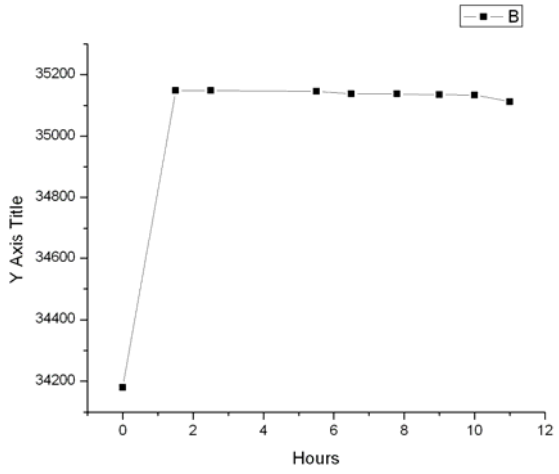


Figure 2: Increase in weight following exposure to hydrogen of the Pt nanoparticles.

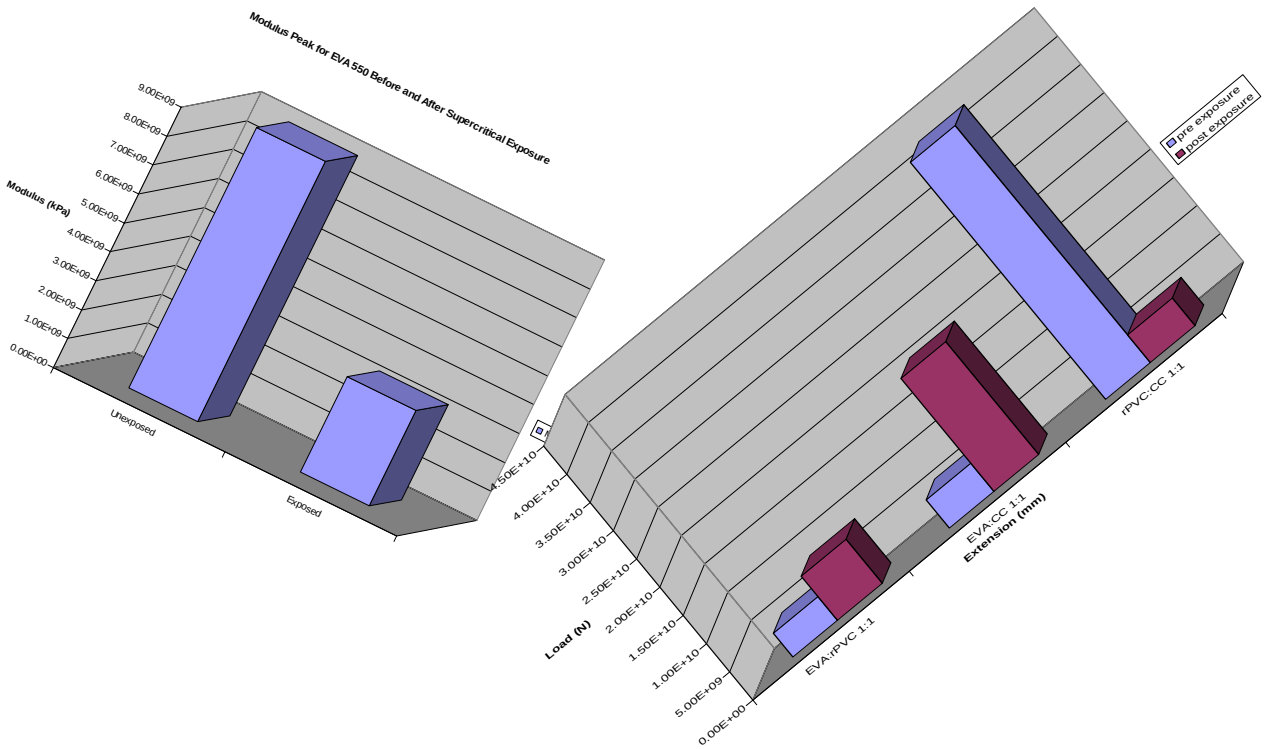
Session II: Green Processing of Bulk Polymers with Supercritical CO_2

Chairs: Michell Fourman

John Michael Iraci

Danielle Lent, Emily Levine

Michael Gebhardt, Prane Wang



Analyzing the Effects of Supercritical Carbon Dioxide and Additives on the Revitalization of Recycled Polymers

Danielle Lent and **Emily Levine**, Stella K Abraham High School for Girls
Mitchell Fourman and Miriam Rafailovich, Dept. of Materials Science and Engineering, Stony Brook University
John Iraci, College of Engineering, Cornell University

Pressing need exists for an expanded range of applications for recycled plastics. However, upon recycling, the physical properties of polymers are diminished. Here we show that new usages for all recycled polymers exist by mixing them together, thereby combining their properties, with the aid of supercritical carbon dioxide.

An effective method recently discovered to compatibilize these immiscible materials involves the usage of supercritical carbon dioxide (scCO2). scCO2 is a highly energetic phase in which there is no discernible distinction between a liquid and gas. In this unique state, scCO2 shows enhanced solubility by lowering the interfacial tension between different polymers, thus increasing their compatibility.[1]

Recycled computer cases (rHIPS) and PVC (rPVC) were combined with equal proportions of pure Ethylene Vinyl Acetate (EVA) to obtain a common benchmark for supercritical exposure. In addition, the three were mixed together in di-polymer blends, along with varying percentages of Cloisite 20A clay. Resulting blends were exposed to scCO2 at 1200 psi(g) and 97 F.

Analysis of blends revealed significant improvement in the physical properties of the blends, but no change in chemical properties. DMA results indicate an increase in the modulus of EVA mixed blends after supercritical exposure, indicating polymer foaming and a subsequent increase in blend strength. However, the mixing of two glassy polymers resulted in a sharp decrease in peak modulus after scCO2 exposure. Results were confirmed by Instron stress/strain analysis. Results showed an increase in peak extension in EVA mixed blends with lower peak load, while the non-EVA blend showed a decrease in maximum extension and an increase in peak load.

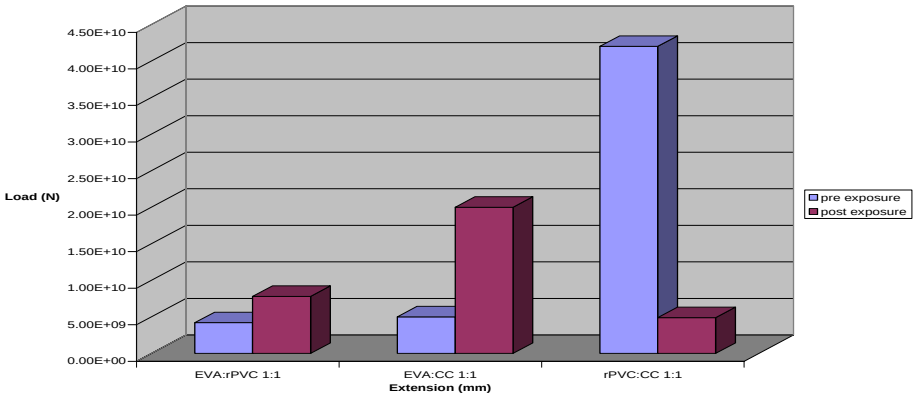


Figure 1: Peak Modulii of Recycled Blends Before (left) and after (right) scCO2 Exposure (1200 psi(g), 97 F)

[1] Palermo, E. Si, M. Occhiogrosso, R. Berndt, C. Rudomen, G. Rafailovich, M. "Effects of Supercritical Carbon Dioxide on Phase Homogeneity, Morphology, and Mechanical Properties of Poly(styrene-blend-ethylene-stat-vinyl acetate)" Macromolecules **2005**, 38, 9180-9186

Evaluating the Effects of Supercritical Foaming on Ethylene Vinyl-Acetate in Pure and Blend Form

Michael Gebhardt, Half Hollow Hills High School East
Prane Wang, Half Hollow Hills High School West
Mitchell Fourman and Miriam Rafailovich, Department of Materials Science and Engineering, Stony Brook University
John Iraci, College of Engineering, Cornell University

In the modern world where plastic has become an essential necessity, major industries have turned to materials engineering for a source of cheaper and more effective polymers. Ethylene-vinyl acetate (EVA), a rubber-like polymer with high ductility is a natural candidate due to its unique properties. EVA is an excellent foaming polymer and is employed in the production of bottle caps and athletic shoes.

Supercritical carbon dioxide (SC CO_2) serves an important role in the foaming process. CO_2 has a critical temperature of 87.3 ^oF and a critical pressure of 1073 psi (g). In the supercritical range CO_2 has the viscosity of a liquid and diffusive property of a gas. This unique property allows SC CO_2 to act as an efficient foaming agent to strengthen the ductile nature of EVA. The purpose of this project is to correlate the effects of SC CO_2 foaming on different grades of EVA and to test the effects of certain surfactants on supercritical foaming and mechanical properties.

A series of processes have been undertaken to confirm this hypothesis. EVA variant samples were created through the melt-mixing Brabender, heat press and supercritical exposure machine. Cloisite 20A is added to pure EVA 260, 550 and 770 resins at varying concentrations of 4%, 8% and 12% by mass. For data analysis, the modulus of pre-exposure and post-exposure samples is examined using Dynamic Mechanical Analysis (DMA). Instron tensile testing determines the maximum load necessary to overwhelm a blend's tensile strength.

As a result, significant outcomes have been displayed throughout the course of the experiment. The numerous samples have exhibited substantial foaming during supercritical exposure. The EVA variants each demonstrated unique amounts of foaming. DMA results also indicate a considerable decrease in modulus in exposed samples, while no chemical change is evident.

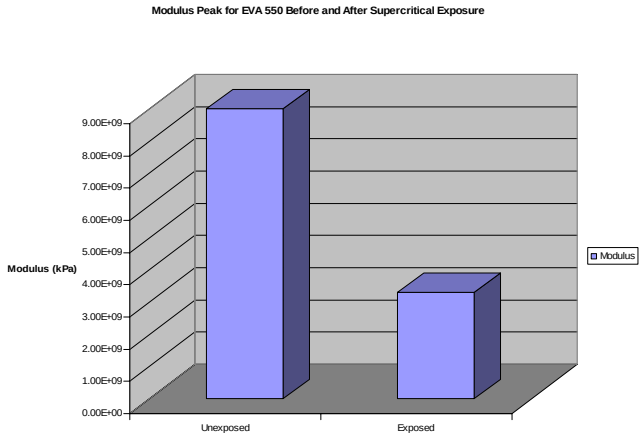


Figure 1- Peak modulus DMA results for EVA 550 before and after supercritical exposure. Data shows a decrease in modulus as a result of exposure.

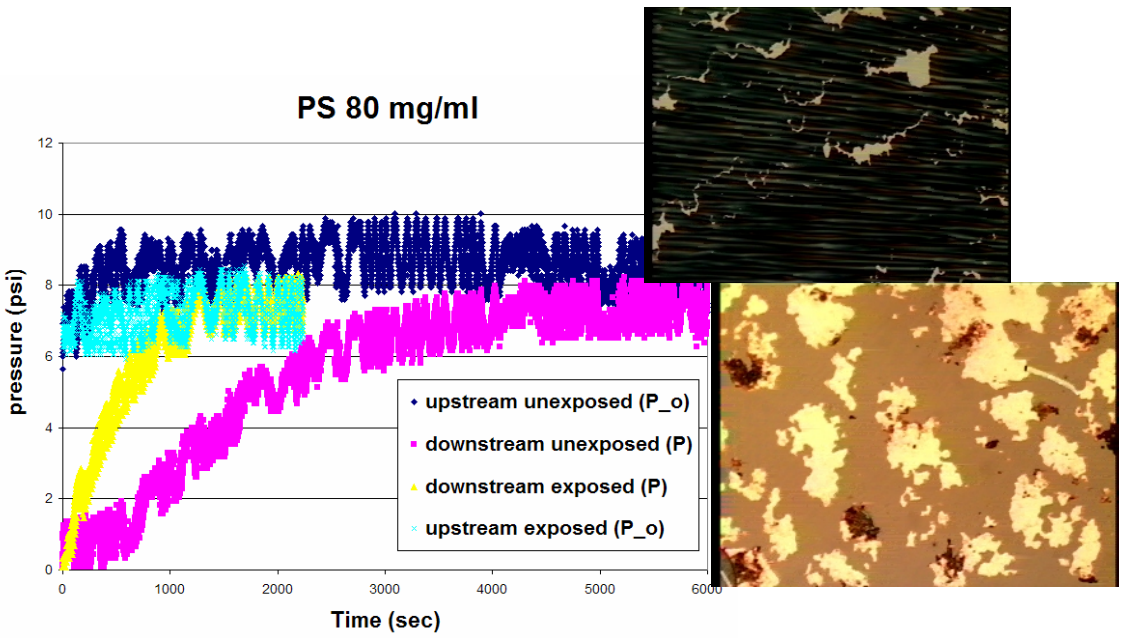
Session III: Enhancing Properties with Supercritical CO_2: Polymer Coatings and Membranes

Chairs: Ayla Bloomberg

Rachel Rosenfeld

Phillip Tan

Brienne Kugler, Jacob Loewenstein



The Effect of $scCO_2$ on the Selective Permeability of Polymer Membranes

Phillip Tan, Valley Stream Central High School
Rachel Rosenfeld, The Sophie Davis School of Biomedical Education
John Jerome, Miriam Rafailovich, SUNY Stony Brook
Devinder Mahajan, Brookhaven National Laboratory

It has been shown that $scCO_2$, especially at the density fluctuation ridge, can penetrate and swell polymer thin films up to 60%, introducing porosity, and thus increasing permeability [1]. We hope to apply this concept in the development of a film for a gas mask which can filter, with pores about the size of CO_2, large molecules such as viral DNA and heavy gases, while allowing for free flow of smaller molecules, particularly oxygen and carbon dioxide, for breathing. Such a gas mask would help to combat the threat of airborne viruses, for instance SARS, and bio-terrorism.

Polymer membranes of Polystyrene (200K), Polymethyl-methacrylate (255K), and PolyCarbonate (23K) were created by spincasting at 2500 rpm for 40 seconds their respective solutions on glass slides. The concentrations of these solutions varied from 20 mg/ml to 100 mg/ml. Half these membranes were exposed to $scCO_2$ in a high pressure chamber at 1200 psi and 36°C. All were then floated upon washer-like substrates, which had holes of either a ~0.25 in or ~0.125 in diameter, resulting in a freestanding film covering the hole in the center. To test the permeability of these membranes, these samples were placed in a permeability apparatus (Figure 1) which monitors gas flow through the membrane.

Films exposed to $scCO_2$ were more permeable than unexposed films, as expected. Thick films (>6000 Å) with lower freestanding area (because of smaller hole ~0.125 in in diameter) require initial pressures greater than 6 psi to induce gas flow. Using Fick's first law, $P=P_0(1-e^{-ct})$, where P_0 is constant pressure in the chamber before passage through the membrane, and P is pressure of the chamber to which gas flows after passing through the membrane as a function of time, we fit a least squares regression to the data points and were able to calculate a value for c, the permeability coefficient. The graph (Figure 2) demonstrates that the gas flow indeed follows Fick's law, and that the graph of the exposed film has a higher value of c than that of the unexposed, since equilibrium was reached in less time. More thicknesses of films and as well as the addition of nanoparticles will be tested.

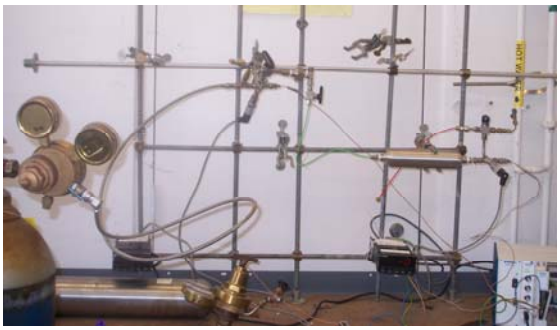


Figure 1. Permeability Apparatus at BNL

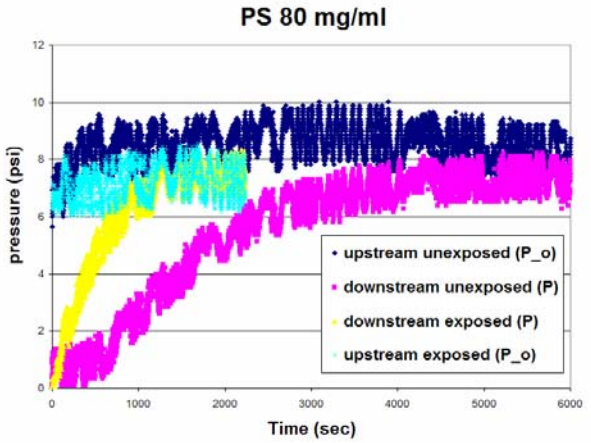


Figure 2. Pressure data points follow the graph of Fick's first law, $P=P_0(1-e^{-ct})$

[1] Koga, T.; et al. *The effect of density fluctuations in supercritical fluids; new science and technology for polymer thin films.* Physica B 357 (2005) 73-79.
[2] Koga, T.; et al. *Density-Fluctuation-Induced Swelling of Polymer Thin Films in Carbon Dioxide*. Phys. Rev. Let. 89, 12 (2002).

The Effect of Supercritical Carbon Dioxide ($scCO_2$) on the Metallization of Polymer Thin Films and Electrospun Fibers

Brienne Kugler, Jericho High School
Jacob Loewenstein, HAFTR High School
L. John Jerome, Miriam Rafailovich, Jefferey Chang
Department of Material Sciences and Engineering, Stony Brook University
Ayla Bloomberg, Harvard University
Vandana Sood, University of Pennsylvania

Metallized polymers are in high demand for various applications in the electronics industry, in particular microscale printed circuit boards (PCBs) and flexible circuit boards (FCBs). However, because of a polymer's weak intermolecular Van der Waals forces and a metal's strong metallic bonding, the metal/polymer interfaces becomes unstable and prone to dewet and deteriorate over time[1]. To rectify this situation, we proposed a method utilizing $scCO_2$, which is able to swell polymer thin films and form a region of low density[2], which we postulate would change the strength of the metal/polymer interface. By controlling what regions were exposed to $scCO_2$, we could alter the strength of the metal/polymer interface, making it easier to create PCB patterns without the use of hazardous chemicals to etch away a Cu surface. We also tested the effect of $scCO_2$ on the diameter of electrospun fibers, and on their ability to be metallized. Electrospun fibers have applications in conducting wires for microelectronic mechanical systems, in water filtration, and even in hydrogen storage.

Polycarbonate and Poly(methyl methacrylate) were dissolved in toluene and diluted to thicknesses of 300 Å, 600 Å, and 1000 Å. Each solution was spuncast onto HF-etched Si wafers. A thin film of each thickness was exposed to $scCO_2$. The samples were then analyzed on the Atomic Force Microscope (AFM) to ensure cleanliness and examined via ellipsometry to ensure swelling. 300-500 Å of copper metal was vapor deposited in a vacuum chamber onto the samples. The samples were again observed under the AFM and appeared flat. To further test adhesion, we utilized the peel test ASTM – d3359 standards. This test attempts to remove the metal layer from the surface. As shown in Figures 1 and 2, we observed that $scCO_2$ weakened adhesion for PC, which already has strong adhesion, and improved adhesion for PMMA. X-ray reflectivity was used to confirm the thickness and the peel test results.

Polyimide, which we used in the form of Kapton, is a self extinguishing, thermally stable, flexible, durable polymer. It is the most desired substrate for FCBs; however, it adheres extremely poorly to metal. Kapton samples were cut, and we determined that the best cleaning agent was DI water based on water contact angle measurements. Kapton was exposed to $scCO_2$ and the water contact angle decreased to 71.11° from 86.90°, which would indicate a favorable interaction with the metal. PolyhedralOligomericSilsequioxane (POSS) nanoparticles were deposited on two pieces of Kapton, one of which was exposed to $scCO_2$. These pieces of Kapton were metallized and underwent peel tests.

In addition to thin film metallization, the effect of $scCO_2$ on the diameters of PS and PMMA electrospun fibers with various concentrations of POSS and Carbon Nanotube nanoparticles, and on their ability to be metallized effectively were tested.

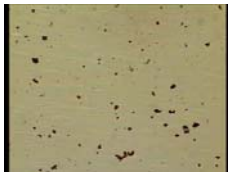


Figure 1A
PC control
(1000 Å)

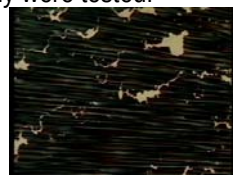


Figure 1B
PC exposed $scCO_2$
(1000 Å)

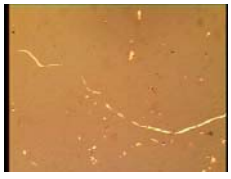


Figure 2A
PMMA control
(600 Å)

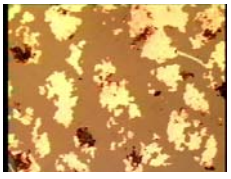


Figure 2B
PMMA exposed $scCO_2$
(600 Å)

[1] **Koga, Tadanori, Jerome, J.L., Gordon, C., Rafailovich, M. H., Sokolov, J. C. Metallizable Polymer Thin Films in Supercritical Carbon Dioxide. Unpublished.**

[2] **Koga, Tadanori, et al. "Low-Density Polymer Thin Film Formation in Supercritical Carbon Dioxide." Applied Physics Letters 83.21 (Nov. 2003): 4309-4311.**

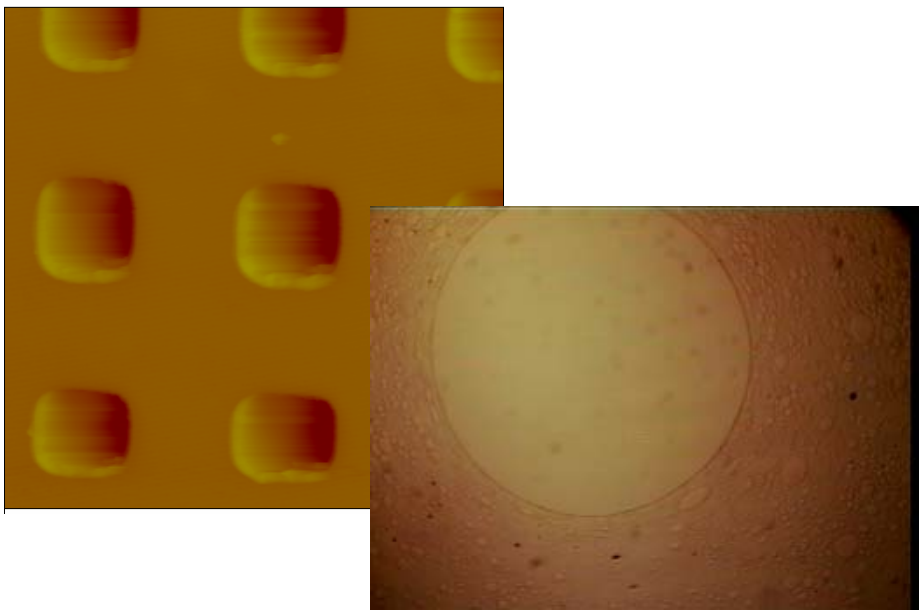
Session IV: Nanocomposites and Thin Films

Chairs: Sean Mehra

Jeffrey Reitman

Jason Strauss, Hila Calev

Jonathan Steinman



Self Assembly of Diblock Copolymers for Testing Polymer Stabilization to Improve Industrial Lubrication and Nano-imprint Lithography

Jason Strauss, North Shore Hebrew Academy High School, Hila Calev, Ward Melville High School
Jeff Reitman, Sean Mehra, Yale University, Dr. Miriam Rafailovich, Jaseung Koo, Stony Brook University

Diblock copolymers have become of increasing interest to scientists today because of their unique kinetic properties. Depending on their molecular weights and concentrations, they self-assemble into structures such as spheres, cylinders and horizontal layers (lamellae)[1]. Based on these properties, diblock copolymers were studied for utilization in two applications: dewetting studies and nano-imprinting lithography studies.

Dewetting is a phenomenon that occurs with all polymers over time and causes many problems in industrial polymer lubricants. The experimental hypothesis is that supercritical carbon dioxide, a fluid which acts as a compatibilizer for polymer thin films[2] will be able to reverse or prevent the effects of dewetting by reducing the glass transition temperature of the polymer and plasticizing the polymer.

PS-b-PMMA (mw: PS: 14,900, PMMA: 13100) and dPS-b-PMMA (mw: dPS: 46,000, PMMA: 37,000) polymer thin films were spun cast onto HF-etched silicon wafers and annealed for 22 hours at 170ºC in an oven to allow them to order. The surface topography of the films was then observed using atomic force microscopy. Island and hole structures were found on the surface of the samples (Figure 1). These findings are consistent with experimental observations that surface characteristics of the diblock copolymer are dependent on the film thickness and lamellar thickness of the polymer, as shown in the following equation[3]:

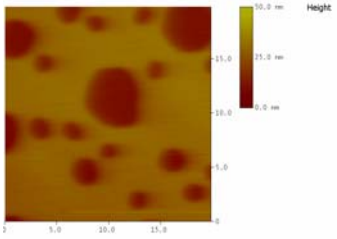
To Produce Holes: $T(film) < (n+1/2)t(lamella)$ To Produce Islands: $T(film) > (n+1/2)t(lamella)$

In future experimentation, the diblock copolymer samples will be exposed to supercritical carbon dioxide and then a monolayer of PMMA will be floated on top. The samples will then be annealed to observe dewetting as a function of time, thickness of the film, and the molecular weight of the polymers. A control will also be established to observe the dewetting in non-exposed diblock films, as well as in exposed and non-exposed PS-PMMA bilayers.

Although miniaturization is always a goal of circuitry, nanolithography is reaching its limits as nanoscale features emerge at the forefront of technology. Polymers, used as photoresists during nano-imprinting lithography, destabilize when formed into features on the nanoscale.

The aim of the current project was to maximize stability by adding nanoparticles to the polymer matrix. PMMA was used because of its known application as a photoresist. Gold nanoparticles and carbon nanotubes were added to PMMA solutions, spun cast on silicon wafers, and then stamped in a vacuum oven using a silicon etched stamp with 1x1 and 2x2 μm features. Moduli of all the samples were tested using scanning probe microscopy a feature of the AFM. While PMMA and PMMA with carbon nanotubes showed a large change in modulus after stamping, the PMMA thin film with gold particles exhibited a negligible change in modulus showing gold's ability to stabilize the polymer features. To further test the increased stability, custom made, smaller stamps are required. Since it has been established that diblock copolymers can produce custom features, islands or holes, this polymer is ideal for creating smaller stamps.

To make a stamp, the assembled diblock copolymer will be sputtered with argon ions. The PMMA thin films will be stamped with the wafer created from the diblock copolymer and tested for change in modulus. Based on the previous results, it's hypothesized that the gold nanoparticles will resist a change in modulus caused by the instability of the smaller features. This would lead to the conclusion that gold is the optimal nanoparticle for the stability of nanoscale features for imprint lithography.



Fig, 1: Image of ordered diblock with holes

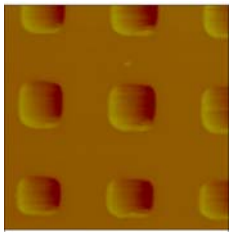


Fig. 2: Relative Modulus of PMMA with Nanoparticles

1. Matsen, M. W. ; Bates, F. S. Macromolecules 4, 1091 (1996)
2. Koga, Jerome, Seo, Rafailovich, Sokolov, Satija, (2005). "Effect of Density Fluctuating Supercritical Carbon Dioxide on Polymer Interfaces." Langmuir. *21*, 6157.
3. Coulon, G.; Ausserre, D.; Russell, T. P.J. Phys. Fr. 1990, 51, 777.
4. Coulon, G. ; Collin, B. ; Ausserre, D. ; Chatenay, D. ; Russell, t. P. *J. Phys. Fr.* 1990, 51, 2801.

Hole Growth in Crosslinked Thin Polymer Films

Jonathan Steinman. Roslyn High School, Round Hill Rd., Roslyn Heights, NY
Song Li, Dr. Jonathan Sokolov, Dr. Miriam Rafailovich, Stony Brook University

The issue of stability in thin polymer films is of significant scientific and technological interest, for both understanding of properties of polymers as well as to develop applications in coatings, adhesives, lithography for electronics[1]. This study aims to develop a method of determining crosslink density in polymer free standing films crosslinked by gamma radiation using a hole growth technique. This study is performed near the glass transition temperature, where elasticity and plasticity are important factors for polymer dynamics.

To begin the process, free standing films of polystyrene with thickness of 120 nm, molecular weight ranging from 123k to 650k, were crosslinked with Co_{60} gamma irradiation at a rate of 800 krad per hour, for times up to 48 hours. Samples were annealed under vacuum at 97ºC to allow nucleated holes to grow. Pictures of growing holes were taken via an automatic capture camera with a magnification of 20 X (Figure 1).

According to previous research, holes grow linearly with time, with the rate of growth decreasing with gamma irradiation exposure time. Rates of growth of hole diameter vs. time were observed from 3 μm per minute to 7 μm per minute[2]. In addition, measurements of viscosity will be recorded in order to determine the viscoelastic properties of the freestanding polymer film. Future work is hoped to be done using multi-layered films and observing hole growth and behavior. If the predictions are supported, the viscoelastic properties of the thin films can be determined. Also, explanations can be used to understand the polymer behavior when nucleated holes are allowed to grow. Theories that consist with experiments near the glass transition temperature that explain a linear growth law can be used to explain the polymer's behavior.

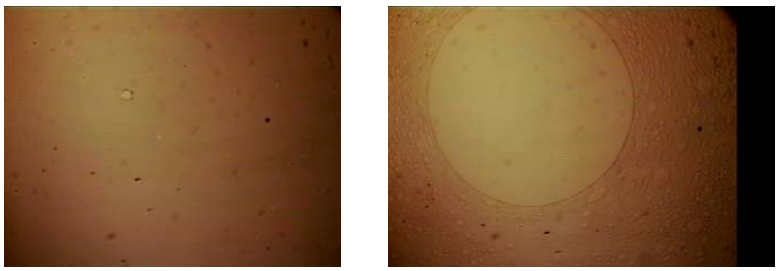


Figure 1. Pictures taken of a nucleated hole growing in a vacuum oven.

[1] J.H. Xavier, C. Li, M. H. Rafailovich, J. Sokolov. *Dynamics of Ultrathin Films in the Glassy State.* Langmuir. Vol. 21, Number 11. 4 March 2005.

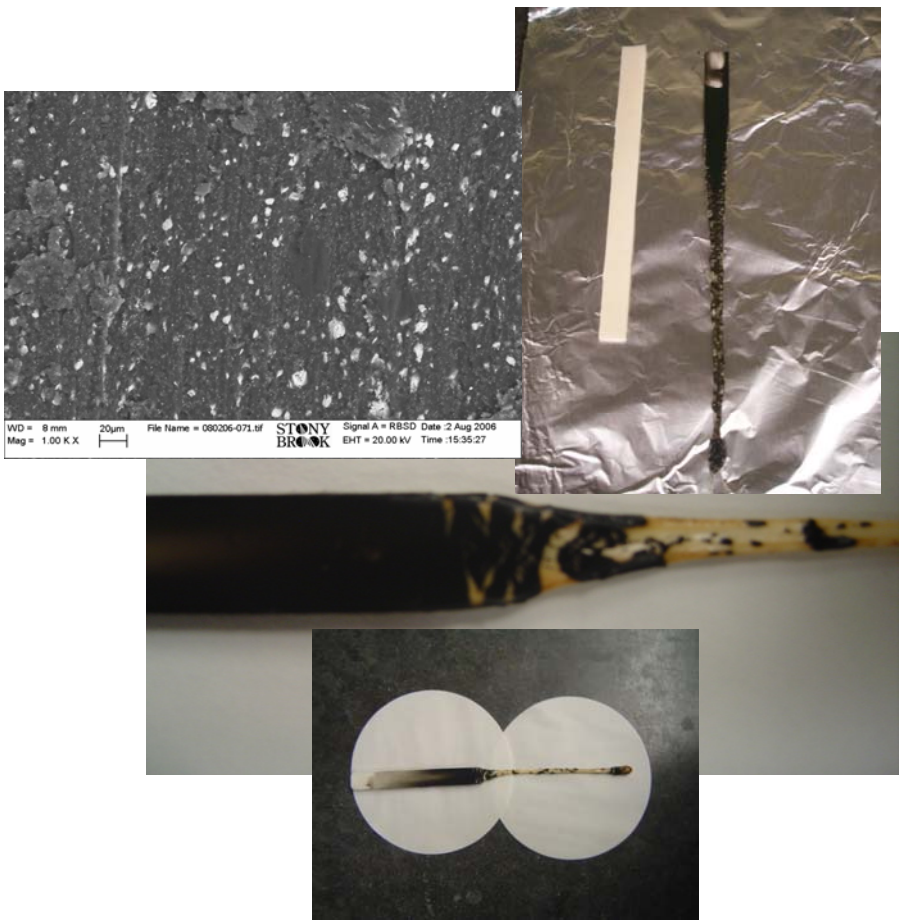
[2] J.H. Xavier, Y. Pu, C. Li, M.H. Rafailovich, J. Sokolov. *Transition of Linear to Exponential Hole Growth Modes in Thin Free-Standing Polymer Films*. Macromolecules. Vol. 37, Number 4. 5 December 2003.

Session V: Flame Retardant Polymers

Chairs: Nicolas Chery

WonWoo Lee, John Oh

Daniel Stemp, David Garczynski



Study for the Optimal Triple-Blend Flame Retardant System

WonWoo Lee, John Oh Jericho High School, NY 11753

SeongChan Park, Sijia Zhao, Miriam Rafailovich Stony Brook University, Stony Brook, NY, 11794

Due to the presence of combustible materials and possibility of burning everywhere, flame retardant has become an integral material for modern life. Current flame retardants in industrial use meet the standards set by the government and exhibit satisfactory performances at preventing monetary and human losses from fire. However, they do have undesirable effects that need to be solved with urgency. Notably, DBDE (decabromine diphenyl ether), one of the most popular compounds used for flame retardants, is classified as toxic and known to cause neurological damages in animals including humans.[1] Consequently, the European Union has banned the material in Europe, and the U.S. government stated that it will prohibit its use by 2008.

In effort to deal with current flame retardants' detrimental potentials and simultaneously to improve their efficiency, we blended various polymers and clay nanoparticles that have flame retardant properties.[2] Our research chiefly involved polyvinyl chloride (PVC), polyethylene (PE), and polypropylene (PP) into a polymer triple-blend in addition to other additives we had hypothesized to enhance the net product's efficiency. We created the blend samples using a twin-blade C.W. Brabender at 190(+/-)5 °C and pressed them into appropriate shapes and thickness depending on the tests we wanted to run with them. Finally, we ran several tests with them to test their efficiencies and chemical/physical properties. For instance, the samples initially went through the UL-94 V0 test to determine the mixing concentration with the optimal self-extinguishing performance. We also studied the materials with TEM, SEM, and small-angle X-ray diffraction test to understand their final chemical/physical properties.

We are also attempting to synthesize clay with properties more desirable than that of clays currently used in our study. Depending on successful synthesis of the clay, we will research for even more efficient and less detrimental flame retardant blend.

1. Birnbaum, Linda B. "PBDE Flame Retardants: Toxicology, Health Effects and Risk Assessment" American Public Health Association 15 Mar. 2005

2. Wang D., EcholsK., Wilkie C. „Cone calorimetric and thermogravimetric analysis evaluation of halogen-containing polymer nanocomposites" Fire and Materials 2005; 29:283-294

Figure1: PE/PP control sample after the UL-94 V0 test. One can see that pure polymer blend is not strong enough to prevent dripping.

Flame retardant PS/PMMA blended with Carbon Nanotubes

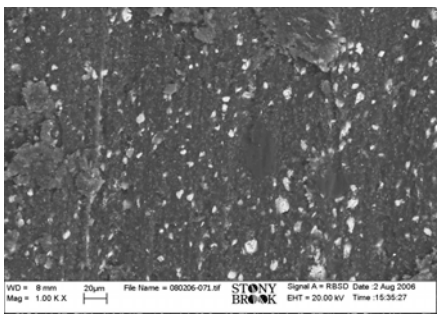
Danny Stemp and David Garczynski- North Shore Hebrew Academy High School, Great Neck NY
Seong Chan Park and Dr. Miriam Rafailovich, Stony Brook University

In this project, the goal is to create a material that is flame retardant using carbon nanotubes. We are adding nanotubes to a blend of PS/PMMA in order to make it flame retardant. We are using nanotubes because they form a jammed networkwhich traps the heat and the fire. This project is very important because we are trying to minimize the amount of bromine in flame-retardants. Bromine is a toxic chemical, and when it is released into the air, it can be harmful. The goal, therefore, is to use the nanotubes as a substitute to the bromine.

Our hypothesis is that the nanotubes will be able to help in increasing the ability to self-extinguish. In order to mix the materials together, we used the brabender and made seven different combinations with different concentrations. Three of the combinations had no DB, and the other four had DB. We kept the percentages of PS and PMMA constant at 70% and 30% respectively. We used different percentages of nanotubes while keeping the amount of DB constant at 15%. After making the molds, we did 3 tests: UL94 test, DMA test, and a heating test. The UL94 test was when we actually lit the polymer on fire. The DMA test recorded the modulus and glass transition temperature of the polymer, while the heating test just heated the polymer so that later we would be able to cross section it and look at it under the SEM.

When we performed the UL94 tests with the material that did not contain the bromine, they all failed. In order to pass the V-0 standard, the after-flame time for each individual specimen must be less then 10 seconds and must not reach the holding clamp, and the specimen can not drip. When we used the specimens with the bromine, the specimens passed the V-2 standard, but not the V-0. They did self-extinguish, but not quick enough to pass V-0, and they dripped. However, when the specimens with the nanotubes were tested in comparison to the specimen without the nanotubes, we saw that the specimens with the nanoutubes extinguished faster then the specimens without the nanotubes. This shows that the nanotubes aided in the self-extinguishing process, but couldn't put out the flame completely.

When looking at the specimen from the heating test under the SEM, we saw the bromine particles, but couldn't see the nanotubes because they were too small, therefore we couldn't draw any conclusions from the SEM images. My results proved my hypothesis to be correct because the nanotubes did aid in the self-extinguishing process, but we are still trying to find a concentration that will pass the UL94 V-0 test. We have come to the conclusion that we must add more then 250mg of nanotubes in order to make the material flame retardant, but we can be exited because we already know that nanotubes work with single polymers, so we hope that they can work with blends as well.



SEM image 1000x of:
PS/PMMA/BD/AO/CNT
70%/30%/15%/4%/0.595%

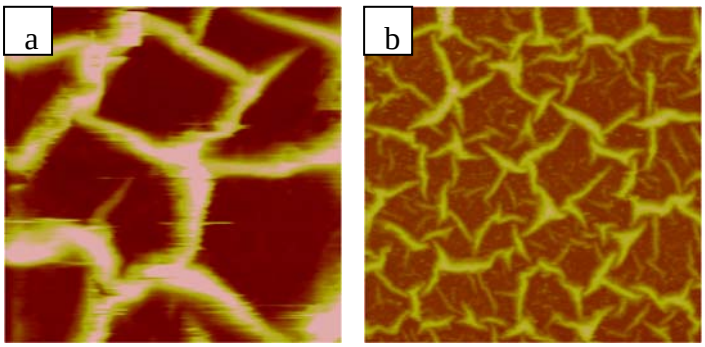
Before and after picture of a failed UL94 test. The specimen on the right failed because it dripped and did not self-extinguish quickly enough.

Session VI: Effects of Magnetism on Cells

Chair: Nicole Brenner

Jaimie Jerome

Mary Catherine Wen, Jenny Yeh



Influence of Static Magnetic Fields on Protein Adsorption and Organization

Jaimie Jerome, Ward Melville High School
Lenny Slutsky, Duke University
Kate Dorst, Dowling College
Nadine Pernodet, Stony Brook University

Strong static magnetic fields have become of great concern and research in the field of science. Although they have proven to have beneficial applications such as in dentistry and bone research[1], their long term affect on the human body is still unknown. Proteins and cells are known to be diamagnetic materials. Therefore they might orient in the presence of a strong magnetic field[2,3]., and the protein orientation and adsorption will be affected. If the extracellular matrix (ECM), composed mainly of proteins, is affected in term of organization, the consequence will be dramatic on cell behavior, as these cells will not recognize the proteins and therefore will not adhere, migrate and proliferate.

In order to respond to these questions, we prepared sulfonated polystyrene surfaces, which induce and show spontaneous protein fibrillogenesis. Wafers were cleaned using the Modified Shirake Method, spun with 8 mg/ml solution of partially Sulfonated Polystyrene (SPS), and placed in the vacuum oven over night. After being put into 24- well dish, the wafers were then covered with 100µg/ml solution of Fibronectin and Fibrinogen. Four wafers, 2 of each protein, were placed in the incubator as control while another four wafers were placed in between strong magnets on top and below the dish. The magnets were parafilmed to the dish and placed in the incubator. During a second trial, osteoblasts in serum-free media were plated onto the wafers in order to follow their ECM secretion. After five days, the samples were scanned by Atomic Force Microscope (AFM) for imaging and also mechanical properties. As seen in the figure below (Fig.1), the protein organization was significantly affected by the magnetic field. The protein network formed in presence of a magnetic field presents smaller fibers and smaller mesh size compared to the control. In the future, we are planning to follow the protein adsorption as a function of the orientation and strength of the magnetice field. Also, as the ECM organization has been affected by the magnetic field, we want to plate cells on these disrupted ECM and follow cell behaviors (adhesion, migration and proliferation).

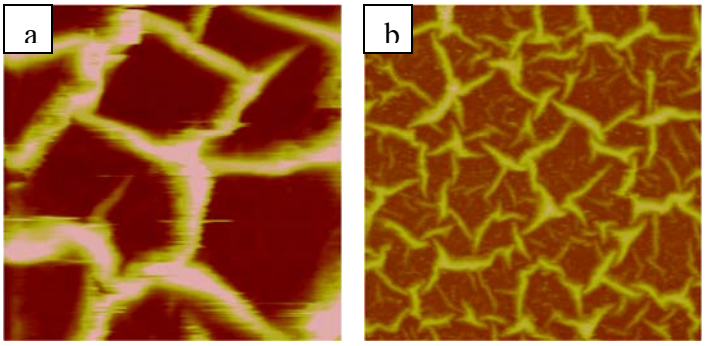


Fig.1: AFM images of fibronectin protein incubated on SPS films (a) in absence and (b) in presence of a magnetic field.

[1] Y, Yamamoto, Y Ohsaki, T Goto, A Nakasima, and T Iijima . "Effects of static magnetic fields on bone formation in rat osteoblast cultures." Journal of dental research. 82 (12)(2003): 962-966.
[2] Iwasaka, Masakuza, J Miyakoshi, and S Ueno. "Magnetic field effects on assembly pattern of smooth muscle cells." In vitro cellular & developmental biology. Animal. 3 Fig. 2 3): 120-123.
[3] Iwasaka, Masakuza, Masateru Ikehata, Junji Miyakoshi, and Shoogo Ueno. Strong static magnetic field effects on yeast proliferation and distribution." Biochemistry. 65(2004): 59-68.

Cell Proliferation and Alignment on Magnetic Polymer-Clay Nanocomposites

Mary Catherine Wen, Archbishop Molloy High School, Briarwood, NY
Jenny Yeh, St. Agnes Academy, Sugar Land, TX
Hilana Lewkowitz-Shpuntoff, Princeton University, Princeton, NJ
Nicole Brenner, SUNY Stony Brook
Dr. Nadine Pernodet and Dr. Miriam Rafailovich, Department of Materials Science and Engineering, SUNY Stony Brook

Current technologies for healing bone fractures are not efficient because of the failure to stimulate osteoblast growth on the prosthetic implant [1]. Additionally, polymers have many chemical and mechanical properties that would make for effective prosthetics. However, even though there are a number of polymers that have been certified by the FDA for internal use, most of them do not support cell growth, and this poses a problem for cell regeneration around the implant. Previous studies have shown that strong magnetic fields can facilitate the healing process by aligning osteoblasts and stimulating bone formation [2]. Therefore, the goal of our project is to develop a polymer surface in which osteoblast growth will be enhanced, and the alignment of the osteoblasts will be controlled. We hypothesized that by adding clay and iron to the polymer, the osteoblasts' growth would be enhanced because not only do the clay and iron make the polymer surfaces harder, making them a better surface for cell growth, but the iron and clay also have important nutrients such as magnesium that are beneficial for cell growth. Furthermore, by adding the iron in combination with the clay in the polymer surfaces, the polymer surfaces become magnetic, allowing us to grow cells in a magnetic field. We hypothesized we could enhance and control the osteoblast alignment by placing the cells on the magnetic polymer surfaces in a magnetic field.

The nanocomposites consisting of polymer and iron-coated clay create internal magnetic fields. Iron provides the magnetic properties of the nanocomposite, and when coated on clay, it is uniformly distributed throughout the polymer. In addition, clay enhances cell growth on polymer surfaces [3] because it contains an abundance of minerals that support cell growth. Prior research has shown that cells migrate toward harder surfaces [4], and clay can increase the modulus of the polymer to favor cell growth. Thus, nanocomposites of polymers and clay could prove to be useful biomaterials.

We wanted to test the biological, chemical, and mechanical compatibility of the nanocomposite with natural bone. In order to find the most effective internal magnetic field, we tested different amounts of clay and iron pentacarbonyl in a 1:1 and a 1:2 ratio. We created four types of substrates: pure polymer, 90% polymer with 10% clay, 90% polymer with 10% clay and iron pentacarbonyl in a 1:1 ratio, and 90% polymer with 10% clay and iron pentacarbonyl in a 1:2 ratio. We also created varied external magnetic fields in two orientations: horizontal and vertical. We will plate osteoblasts onto the nanocomposites to determine the effects of the internal and external magnetic fields.

Growth curves will display the viability of the osteoblasts on the nanocomposites, and confocal imaging will determine the orientation of the cells to the magnetic field. A Hall Probe will measure the uniformity and strength of the external magnetic field, and vibrating sample magnetometry will determine the magnetism of the nanocomposite. Transmission electron microscopy will reveal the uniformity of the iron-coated clay distribution, and the composition of the nanocomposite will be verified through Fourier transform infrared spectroscopy. Mechanical analysis of the polymer will involve tensile testing with the Instron and thermogravitometric analysis to determine the decomposition rate of the polymer.

[1] Qu C, Qin Q, Kang Y. A hypothetical mechanism of bone remodeling and modeling under electromagnetic loads. Biomaterials. 27 (2006) 4050-4057.
[2] Ueno S, Sekino M. Biomagnetics and bioimaging for medical applications. Journal of Magnetism and Magnetic Materials. 304 (2006) 122-127.
[3] Pyun J, Matyjaszewski K. Synthesis of Nanocomposite Organic/Inorganic Hybrid Materials Using Controlled/"Living" Radical Polymerization. Chemical Materials. 13 (2001) 3436-3448.
[4] Lo CM, Wang HB, Dembo M, Wang YL. Cell movement is guided by the rigidity of the substrate. Biophysical Journal. 79, (2001) 144.

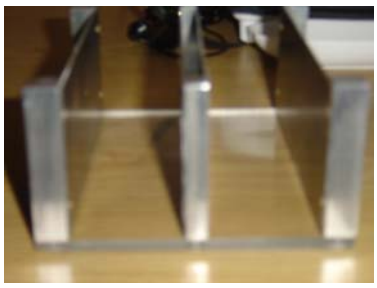


Fig. 1 Special cell designed for cell and protein cultures in a magnetic field.

Session VII: Electrospinning: Producing Non-woven Scaffolds

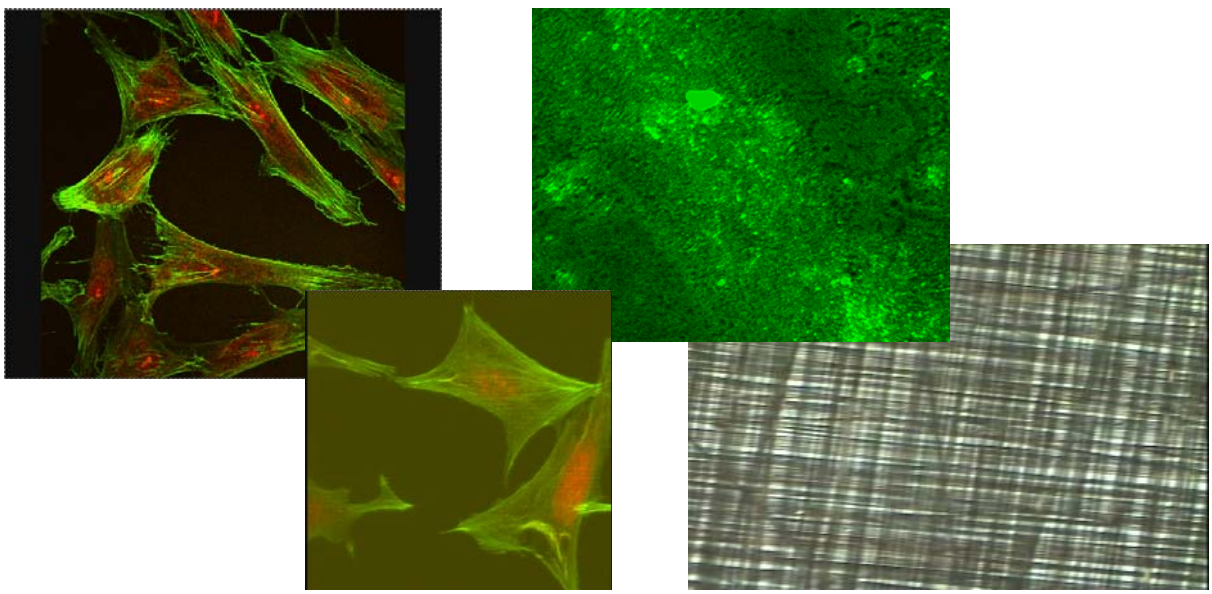
Chair: Hilana Lewkowitz-Shpuntoff

Yusuf Anwar, Kai Chao

Alicia Franco, Preya Shah

Fayrisa Greenwald

Asad Moten, Pooja Vasudevan



Cell Morphology of Human and Cancerous Fibroblasts as a Function of Electrospun HA Hydrogel Scaffold Crosslinking Densities

Yusuf Anwar, *Syosset High School*
Kai Chao, *Half Hollow Hills HS*
Yuan Ji and Dr. Miriam Rafailovich, *Stony Brook University*

Tissue engineering applications necessitate the ability to mimic the natural extracellular matrix (ECM) for the purpose of cell migration and proliferation. During the wound healing process of an injury, fibroblasts synthesize and uphold connective tissue. These processes rely on the on the ability of cells to exert the necessary mechanical forces to remodel the ECM. Often, this results in reciprocal reactions that alter the mechanical properties of a cell. Iterative interactions between the cellular adhesion molecules (CAD) of a cell, such as integrins, and the ECM create tensegrity forces in a cell's actin cytoskeleton. Previous studies have shown that altering the mechanical properties of a cell's underlying substrate can modify the cellular morphology of a cell.[1] Fibroblasts adjust to the mechanical surface properties of its surroundings, but little is known about the mechanisms that control adhesion on a hydrogel. Additionally, cancerous fibroblasts may have weaker tensegrity forces, therefore affecting adjustments to the surface it is on. To fully understand the mechanisms behind fibroblast morphology, HA scaffolds were electrospun at varying thicknesses in order to provide different surfaces for the fibroblasts to migrate across. By observing adhesion through confocal microscopy, fibroblast morphology of normal and cancerous cells will be determined.

In order to fabricate an appropriate scaffold, the material used must be able to support successful tissue repair and regeneration. Previously, cells seeded on solvent casted HA hydrogel films through lyophilization have been shown to proliferate strictly to a 2D geometry. Thus, a more novel method of fabricating a 3D microporous scaffold was used to facilitate the proliferation of cells.[3] Dual syringe reactive electropsinning was used to create a cross-linked HA 3D nanofibrous scaffold. The crosslinking components included thiolated HA derivative, 3, 3'-dithiobis (propanoic dihydrazide)-modified HA (HA-DTPH), and Poly (ethylene glycol)-diacrylate (PEGDA). 1.25% HA-DTPH solution was mixed with PEGDA solution in a 4 to 1 volume ratio at varying concentrations (4.5%, 2.25%, 0.75%) to obtain HA-PEGDA-HA hydrogels of different crosslinking densities.[2] To assist the formation of fibers, PEO was then added into the HA-DTPH solution at an optimal weight ratio of 1:1 in respect to HA-DTPH. As the aqueous solution was being electrospun, HA-DTPH was crosslinked simultaneously through a dual syringe setup. Next, the scaffold was then placed in DI water to remove PEO, which yielded a cross-linked HA-DTPH nanofibrous hydrogel scaffold. The hydrogel was then UV sterilized for twenty minutes. Subsequently, human FN was added to the hydrogel and incubated for 2 hours to allow for attachment to the surface of the scaffold. Normal and cancerous CF-31fibroblasts were seeded on the fibronectin-adsorbed electrospun HA-DTPH nanofibrous scaffolds for 24 hours in vitro. Cell morphology was observed by fixing and staining the cells using Alexa Fluor 488 and Propidium iodide (PI) to stain actin and nuclear features, respectively. Using confocal microscopy, images were taken which showed morphologies of cells on a glass coverslip and nanofibrous scaffold. The normal cells formed an extended dendritic network morphology while the normal cells adhered to their respective substrates in a flat 2D geometry (see figures 1 and 2). Future research will use Scanning Electron Microscopy (SEM) and Confocal Microscopy to observe the surface morphologies of scaffolds and the adhesion of normal and cancerous cells at varying crosslinking densities, respectively. As tissue engineering leads to the development of new scaffolds, the potential to regulate dynamic cellular behavior through substrate manipulation will be important in engineering new designs. The mechanical differences observed in the electrospun HA-DTPH nanofibrous scaffolds show promising potential for further applications in tissue engineering.[3]

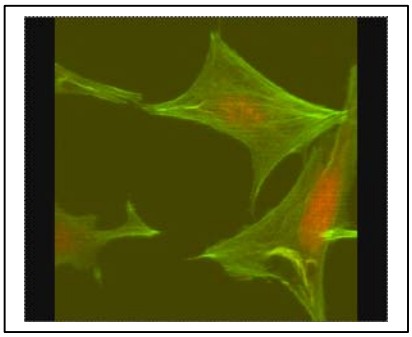


Figure 1: Cells on flat 2D substrate (control)
2:1 HA-PEDGA Bovine FN

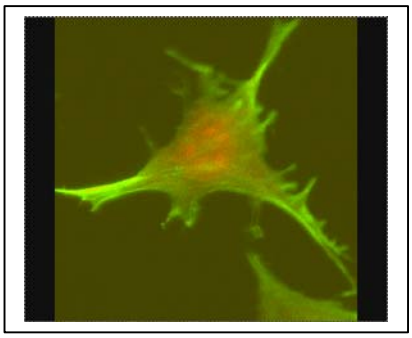


Figure 2: Cells on 3D scaffold (experimental)
2:1 HA-PEDGA Bovine FN

References:
1. Grinnell, Frederick. "Fibroblast biology in three-dimensional collagen matrices." Elsevier. (2003): 264-269.
2. Ghosh, Kaustabh, et al. "Rheological Characterization of in Situ Cross-Linkable Hyaluronan Hydrogels." American Chemical Society. (2005): 2857-2865.
3. Ji, Yuan; Ghosh, Kaustabh. "Electrospun three-dimensional hyaluronic acid nanofibrous scaffolds." Elsevier. (2006): 3782-2792.

The Effects of the Diameter of Poly(methyl methacrylate) Electrospun Fibers on the Morphology of Dermal Fibroblast Cells

Alicia V. Franco: Brentwood High School
Preya Shah: Ward Melville High School
Ying Liu, Miriam Rafailovich, Stony Brook University.

Tissue engineering is one of the fastest growing fields in biomedical research. The goal of this experiment is to search for improved scaffolds that would enable the restoration and reconstruction of tissue in chronic wounds. By using electrospun poly(methyl methacrylate) (PMMA) fibers to mimic the natural structure of extracellular matrices, we can develop a biocompatible scaffold that would enable dermal fibroblast to grow and thrive.[1] Electrospinning was used because of its ability to produce micro to nano scale fibers from a polymer solution by means of electrostatic force.[2] A sleek jet of the solution is thus emitted onto a substrate, the solvent is evaporated in the process, and the polymer is reduced to a thin fiber. The fibers produced are collected in a random orientation by a grounded metal plate a few centimeters away. We would like to create a variety of fiber diameters by alternating one of the numerous factors that affect the fiber diameter, and determine the effect of fiber diameter on dermal fibroblasts.

A PMMA solution was electrospun onto PMMA-coated silicon wafers. In order to vary the diameter of the fibers, the type of solvent used in the electrospinning solution was changed. We changed the solvent because different solvent have different dielectric constants[3]. The concentration of PMMA was kept at a constant 20%. PMMA was dissolved in Dimethylformamide (DMF), Tetrahydrofuran (THF), and Chloroform. As shown in Figure 1, the DMF solution produced the thinnest fibers with a diameter of around 200 nm, but also produced some beads, which could be reduced through the help of organic salts. While the THF solution produced similarly sized fibers as the DMF, the fiber diameter was not homogenous and numerous beads were formed on the fibers. As shown in Figure 3, when chloroform was used as a solvent, the fibers were much thicker (about 4 to 10 micrometers in diameter) but were very homogeneous and without beads.

As shown in Figure 2, we plated cells on a PMMA thin film and observed them under the confocal microscope. In the future, we would like to plate fibroblast cells onto different electrospun substrates in order to see how they react to different diameter fibers. By finding the optimal fiber morphology, we can create a biocompatible scaffold that can be used to heal chronic wounds.

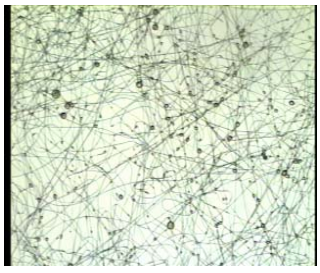


Fig. 1: PMMA fibers on Dimethylformamide

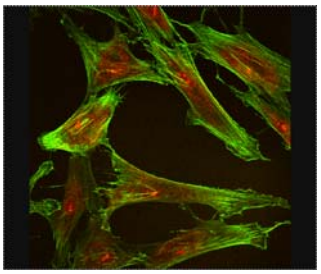


Fig. 2: Fibroblast on thin film

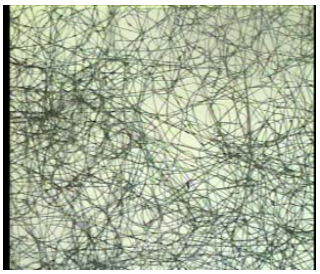


Fig. 3: PMMA fibers using Chloroform

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[2] D. Li and Y. Xia. *Electrospinning of Nanofibers: Reinventing the wheel?* Advance Materials. Vol. 16, No. 14, July 19, 2004.
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Electrospinning and Spin-Casting Bacteria for the Filtration of Groundwater

Fayrisa Greenwald, Massapequa High School, 4925 Merrick Road, Massapequa, NY
Yuan Ji, Dr. Miriam Rafailovich, Stony Brook University

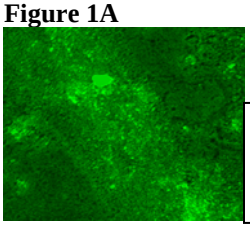
It has been discovered that uranium is contaminating the groundwater. Uranium has been found in mining sites and in areas where weapons were enriched. The uranium is seeping into groundwater flowing through these areas, and is making the water hazardous to the health of humans[1]. Recent studies have demonstrated that bacteria in the groundsoil can reduce the amount of nitrogen, uranium, and sulfate in contaminated aquifer systems[2]. Bacteria have also been suspected to reduce the amount of toxic contaminants in landfills[3]. In order to better purify the groundwater, this study will attempt to create fibers which the bacteria can live on to be placed in the pipes, and to create a coating for the pipes containing the bacteria.

Spin-casting is a method of producing a film by spinning a solution on a substrate and evaporating the solvent. Dead *E. coli* bacteria were spun-cast with 10mg/mL, 20mg/mL, and 30mg/mL poly(acrylic acid) (PAA) in water. The samples were observed under the atomic force microscope and it was ascertained that the bacteria were in all of the films.

Electrospinning is a process which includes shooting a solution from a syringe by applying a voltage and thus creating fibers from the solution[4]. A solution of 2 percent 900K poly(ethylene oxide) (PEO) in water was combined with a solution of 0.2 percent 2mg/mL collagen in PBS to create a PEO and collagen solution. The bacteria were added to this solution, which was then electrospun. The electrospun fibers with the bacteria were observed under the confocal microscope under 10X magnification. It was first observed that there were more bacteria alive than were dead. Approximately twenty minutes after the observation began, it was found that there were more bacteria dead than alive. Figures 1A and 1B were taken near the end of the observation; they are of the same bacterial cells on the fibers under two different stains. The green stain in Figure 1A stained all of the bacteria in the sample, while the red stain in Figure 1B stained only the dead bacteria. The areas stained green in Figure 1A which were not stained red in Figure 1B represent the living bacteria. In the future, different concentrations of PEO and water and solutions with other solutes will be electrospun in an attempt to create a solution from which the bacteria can live and multiply on the fibers. The fibers may then be inserted into the pipes to filter large particles and small particles from the groundwater, since the bacteria will be able to digest the small particles.

The PEO and collagen solutions and other solutions with different solvents, such as PAA, will be spun-cast with the bacteria in order to create a thick film in which the bacteria will be able to survive and multiply. By coating the pipes with this thick film, the groundwater which flows over the film will be able to be filtered by the bacteria which will digest the small hazardous particles from the groundwater.

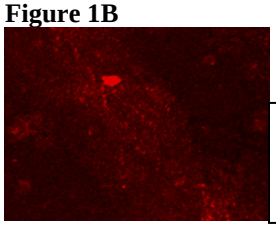
Figure 1A



The bacteria visible in Figure 1A but not visible in Figure 1B were alive.

The green stain attached to all of the bacteria present in the sample.

Figure 1B



The red stain attached to all of the dead bacteria present in the sample.

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[1] Hickey, Hannah. "For Uranium Cleanup…Bacteria?" *Stanford Report*. 19 May 2006 < http://news-service.stanford.edu/news/2006/may24/criddle-052406.html>.

[2] Ginder-Vogel MA, Fienen M, Mehlhorn T, Yan H, Caroll S, Pace MN, Nyman J, Luo J, Gentile ME, Fields MW, Hickey RF, Gu BH, Watson D, Cirpka OA, Zhou JZ, Fendorf S, Kitanidis PK, Jardine PM, Criddle CS. "Pilot-Scale In Situ Bioremedation of Uranium in a Highly Contaminated Aquifer. 2. Reduction of U(VI) and Geochemical Control of U(VI) Bioavailability," *Environmental Science & Technology*. 40 (12): 3978-3985 (2006).

[3] Wang Y, Ogawa M, Fukuda K, Miyamoto H, Taniguchi H. "Isolation and Identification of Mycobacteria from Soils at an Illegal Dumping Site and Landfills in Japan," *Microbiology and Immunology*. 50 (7): 513-524 (2006).

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Smart Scaffolds:
Developing a Biocompatible Poly(methyl methacrylate) Matrix for Tissue Engineering

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Pooja Vasudevan, Wheatley High School, NY
Ying Liu and Dr. Miriam Rafailovich, Department of Materials Science and Engineering.
Stony Brook University, Stony Brook NY 11794-2275
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Failure or loss of segmental bone tissue has been a major public threat that affects more than 150 million people worldwide[1]. Bone tissue loss has hindered human exploration of space as humans lose a substantial amount of bone in zero gravity[2]. Moreover, there are many diseases associated with the deterioration of bone tissue such as osteoporosis and osteosarcoma, which eventually lead to bone fragility and increased susceptibility to fractures of the hip, spine, and wrist[1]. However, the novel field of tissue engineering has allowed for the regeneration of lost bone tissue. In this field, bioengineered scaffolds are created to enable the human cells to migrate, proliferate, and secrete the necessary extracellular matrix components to regenerate tissue. In this study, we have designed a biocompatible Poly(methyl methacrylate) (PMMA) scaffold for tissue engineering. Fiber orientation is the fundamental factor that can have a significant impact on cell differentiation and growth. Consequently, we believe that by engineering a scaffold with optimum alignment, we can initiate bone tissue growth.

In order to determine the ideal alignment, the efficacy of aligned PMMA nano fibrous scaffolds for tissue engineering is described and their performance is compared to random PMMA scaffolds. Fibrous 3D PMMA scaffolds of different alignments were fabricated by an electrospinning technique under optimum conditions (fig. 1). Linear fibers were fabricated using choloroform as a solvent and a rotating mandrel at a rate of 2000 rotations per hour (Fig 2). Furthermore, random fibers were produced by a stationary mandrel.

As the PMMA scaffold was intended for tissue engineering, its suitability will be evaluated in vitro using normal 3T3 and cancerous ROS cell line of mouse osteoblast culture to see the effects on cell morphology.

Fig. 1
Electrospinning fibers on a rotating mandrel

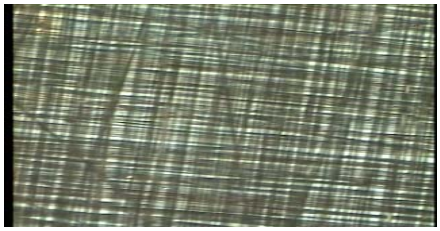


Fig. 2
Aligned fibers on thin film susbstrate

[1] http://www.osteofound.org/press_centre/fact_sheet.html

[2] http://weboflife.nasa.gov/currentResearch/currentResearchGeneralArchives/weakKnees.htm

Session VIII: Cells in Nanostructured Environments

Chairs: Jessica Fields

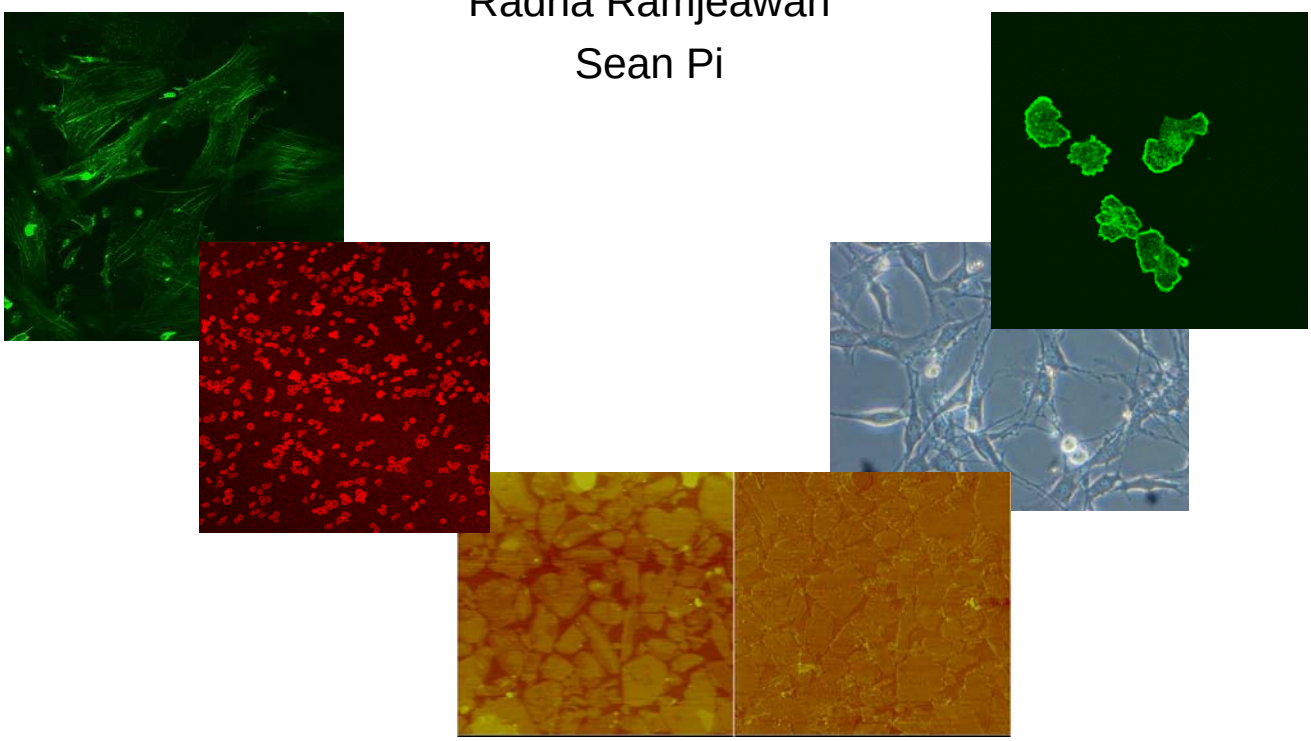
Sagar Mehta

Brian Fromm, Crystalee Forbes

Benjamin Macluso

Radha Ramjeawan

Sean Pi



Cell growth, Cytoskeletal structure, and protein expression in the presence of Cloisite Na+

Crystalee Forbes, Uniondale High School
Brian Fromm, North Shore Hebrew Academy High School
Dr. Miriam Rafailovich[1], Lourdes Collazo[1], Sagar Mehta[2], Elizabeth Casey[3]
[1]Department of Materials Science and Engineering, Stony Brook University
[2]Harvard University, Cambridge, MA
[3]Comsewague High School, Port Jefferson Station, NY

Organically modified layered-silicates or nanoclays have become an attractive class of organic hybrid materials. There is a wide range of applications in which they can be used, such as polymer nanocomposites, greases and cosmetics, adsorbent for toxic gases, and drug delivery carriers.[1] Previous studies have observed the interactions of various cell types on different clay surfaces and a strong affinity of the cells for this particular matrix has been established. However, little is known about the effect that these nanoparticles have, when absorbed by the cells. Thus, this investigation sought to examine the effects of Cloisite Na+ nanoparticles on cellular morphology, proliferation, and cytoskeletal structure as a function of nanoparticle dispersion and concentration.

Concentrations of .015%, .03%, .045%, and .06% Cloisite Na+ dissolved in cell media were prepared and tested on osteoblasts (MC-3T3-E1), glial (C6), cancerous osteoblasts (ROS 17/28), and cancerous liver cells (LNCa). Cell growth curves showed a dramatic decrease in cell counts with increasing concentration of clay. The effect was even more dramatic for both types of cancer cells (Figure 1). Optical images showed that an affinity between clay nanoparticles and the cell membrane exists (Figure 2).

Future investigations will include a more in depth analysis of the cells cytoskeleton through the organization of its F-actin fibers as well as any alterations in the nucleus between cancerous and normal cells exposed to different concentrations. We also plan to determine whether the proteins expressed in the cell changes based on increasing clay concentrations using western blot. Ultimately, a more thorough understanding of the cells direct interaction with clay nanoparticles will reveal whether they are being used safely for cosmetics and for other applications.

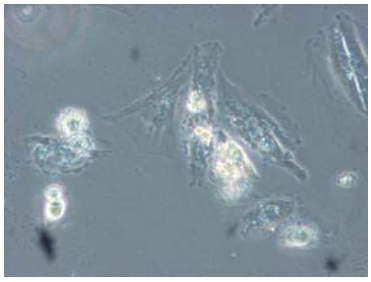


Figure 1 - ROS .015% Clay

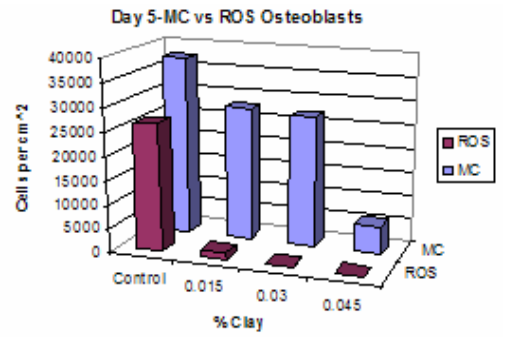


Figure 2 – Normal/Cancerous Osteoblast Growth Clay

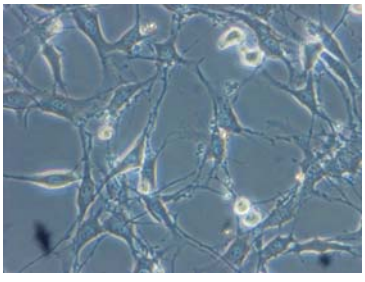


Figure 3 - MC .015%

[1] Bull. Mater. Sci., Vol. 29, No. 2, April 2006, pp. 133–145. © Indian Academy of Sciences.

The Effects of Poly-Butadiene Thin Films on Dermal and Adipose Fibroblast Growth and Differentiation

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Dr. Vaccariello, M., Dr. Rafailovich, M., Dr. Simon, M., Stony Brook University

While embryonic stem cell use in medical and scientific research remains controversial, many scientists are continuing to investigate the applications of adult somatic stem cells (e.g.: cells isolated from bone marrow, epithelial tissue, and from mesenchyml tissues). Unfortunately, many studies have shown that many types of conventional somatic cells have less differentiation potential than that of embryonic cells. However, recent studies have been conducted on a new adipose-derived fibroblast. These studies show that this type of somatic cell may be able to differentiate into several types of cells, a property known as mutipotency[1]. For example, in one study these cells were stimulated to differentiate into adipogenic, chondrogenic, myogenic, and osteogenic cells in the presence specific chemical inducers[2]. Thus the study of stem cell induction is a key facet of modern research, and controlling their differentiation may be crucial.

To make the polymer matrix, poly-butadiene was dissolved in toluene. Two concentrations were made in order to make thin films of different two different thicknesses, one of 300 angstroms (thin sample) and one of 3000 angstroms (thick sample). Square silicon wafers (approx. 5mm across) were prepared and cleaned in a mixture of HF and de-ionized water (1:3). The films were made by spinning the solution on a wafer at 2500 rpm. The films were then annealed for the proper times (1 hour thin, 24 hours thick). After the annealing process, dermal and adipose fibroblasts were plated on the films, and untreated silicon wafers for a control. Cells were incubated 72 hours, stained using Alexa-Fluor 488 and observed via confocal microscope.

Preliminary results of this experiment have shown that cells will in fact grow all tested surfaces. Figures 1-3 display the actin growth of the adipose cells, which has been stained green. In fact, this growth is nearly the same for each sample. Cell shape was slightly different. Cells on the thicker substrate appear to be slightly larger and more elongated. However, no conclusions can be drawn from this without further study of such factors as cell rigidity, and the presence of proteins and metabolites unique to different cell types. Thus this experiment requires further study before consequential data can be accrued.

Adipose Fibroblast Samples

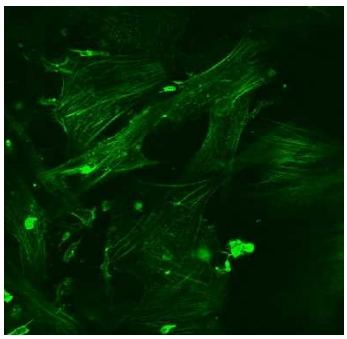

Figure 1
Control, no thin film

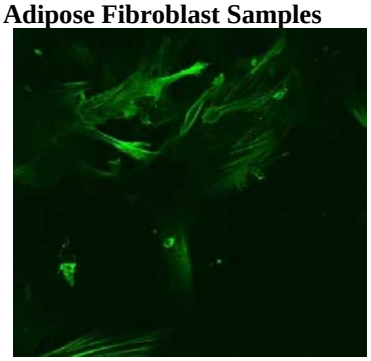

Figure 2
300 angstrom film

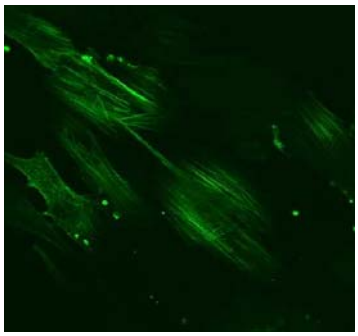

Figure 3
3000 angstrom film

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[1] . Molecular Biology of the Cell, Vol. 13, 2002- "Human Adipose Tissue Is a Source of Multipotent Stem Cells"

[2] Justesen, J, et al. *Subcutaneous Adipocytes Can Differentiate into Bone-Forming Cells in Vitro and in Vivo*, Tissue Engineering March 2004, Vol. 10, No. 3-4: 381-391

Effects of Clay Substrates on Fibronectin Conformation and Fibroblast Cell Growth

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Jaseung Koo, Dr. Miriam Rafailovich, Stony Brook University

Clay is a common resource found globally. Since it is naturally abundant in our environment, clay has been utilized as a cost effective material in architecture, industry, and agriculture.[1] Previous research has led to the conclusion that clay can be biocompatible.[2] However, prior studies have not observed the structural change of proteins and cell growth on clay surfaces. This study aims to examine the conformational change of Fibronectin (FN) and Fibroblast cell growth on Organo-clay and Sodium clay surfaces.

To initiate the experimental procedures, the Somasif MTE Organo-clay and Somasif ME 100 Sodium clay solutions were prepared. Next, the Langmuir Blodgett Technique was utilized to form a clay monolayer. For the Organo-clay monolayer, the silicon wafer was attached vertically to the LB trough dipper and lowered into the Organo-clay solution with distilled water. The target pressure was set to 26 mN/m. For the Sodium clay monolayer, the silicon wafer was attached horizontally to the dipper of the LB trough and lowered into the Sodium clay solution with a cationic surfactant. The target pressure was set to 22mN/m. After one hour, both silicon wafers had a clay monolayer. To study the uniformity of the clay monolayer, the AFM was used. X-ray reflectivity was also done to detect the clay monolayer. After these procedures, the protein solution was prepared. The first concentration was 2 µg/ml FN and 1 mg/ml in PBS buffer solution. The second concentration was 100 µg/ml FN and 5 mg/ml in PBS buffer solution. The protein solution will then be placed on the clay substrates to determine the conformational change of FN. A silicon wafer without clay will be used as the control.

Results from the AFM showed a uniformed monolayer for both samples. In Figure 1 you can observe the uniformed distribution of clay along the silicon wafer. From this preliminary data, we can explore the growth of the Fibroblast cells on the clay and protein surfaces to further understand the characteristics of Somasif MTE Organo-clay and Somasif ME 100 Sodium clay. Through this process, greater evidence will be obtained on the biocompatibility of clay. This information will also result in cell growth techniques for cell transplantations, cell adhesion and help in blood coagulation.

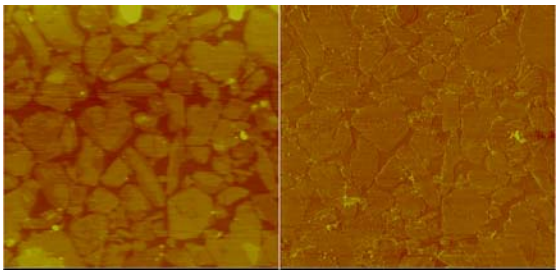

Figure 1 of the Organo-clay monolayer on Si wafer

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[1] *The Columbia Electronic Encyclopedia: Fact Monster*
http://www.factmonster.com/ce6/sci/A0857389.html

[2] Al-Muhaimeed, H, Tantawy, A, Abdul-Hamid, N, Abdul-Azim, M "Osseointegrational biocompatibility of the Nile's silt clay in skull bones", Australian Journal of Oto-Laryngology, July 2001

The Use of Silica Beads as a Specific Targeting and Diagnostic Protocol for Cancer

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Dr. Nadine Pernodet, Stony Brook University Material Sciences, Stony Brook, NY
Dr. Miriam Rafailovich, GARCIA MRSEC @ Stony Brook, Stony Brook, NY

Cancer is one of the most devastating diseases that exist. Unlike other diseases, cancers are caused by the internal malfunction of one's own body. Current treatment for cancer is composed of a strict regiment of chemotherapy drugs and targeted radiation exposure. This method, although mostly effective, also contains horrible side effects. Along with the excessive radiation exposure, the nanoparticles used as drug delivery systems for chemotherapy such as Fe2O3 are carcinogens[11]. Therefore, we propose a novel method in which cancer treatment is specifically targeted only toward cancerous cells. We attempt to create such a method via fluorescent silica microbeads. Also, we will compare these beads to currently used drug delivery nanoparticles in current chemotherapy treatment.

We analyzed the interaction between the beads and three different types of cells. We used normal keratinocytes as the control and SCC Cancerous keratinocytes and pancreatic cancer cells as variables to test the beads. Using confocal microscopy (Leica) we found that the beads stuck significantly more to the cancerous cells than the control cells (Figure 1). After preliminary analysis with the confocal microscope, we used the BIACore to analyze the kinetics of the binding of the beads to the cells (Figure 2) via sensogram. To compare with current nanoparticles used in chemotherapy treatment, we chose to test Eu2O3 coated in PVA, Eu2O3 coated in PVP, and Fe2O3 coated in PVA. We cultured normal fibroblasts and cancerous fibroblasts in DMEM (Dulbecco's Modified Eagle Medium) and let them incubate at 37 C for two days. Then we exposed them to the nanoparticles and incubated at 37 C for an additional day. Then we used the confocal microscope to analyze the effects of these particles on the fibroblasts.

For our future research we plan to complete our comparison between currently used nanoparticles in chemotherapy and silica microbeads in stem cells and cancer cells. We also hope to complete analysis on the BIACore to fully understand the kinetics behind microbead bonding to the cells.

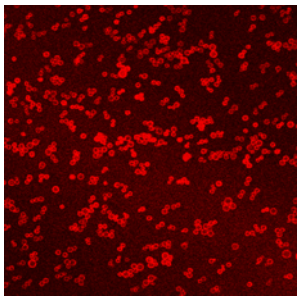


Figure 1- Silica Beads exposed to SCC Cancerous Cells

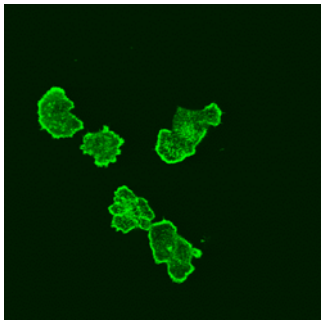


Figure 2- SCC Cancer cells after bead exposure

[1] Soto, K.F., Carrasco, A., Powell, T.G., Garza, K.M., and Murr, L.E. (2005). Comparative in vitro cytotoxicity assessment of some manufactured nanoparticulate materials characterized by transmission electron microscopy. Journal of Nanoparticle Research, 7: 145-169.

Session IX: Mechanical Properties of Cells

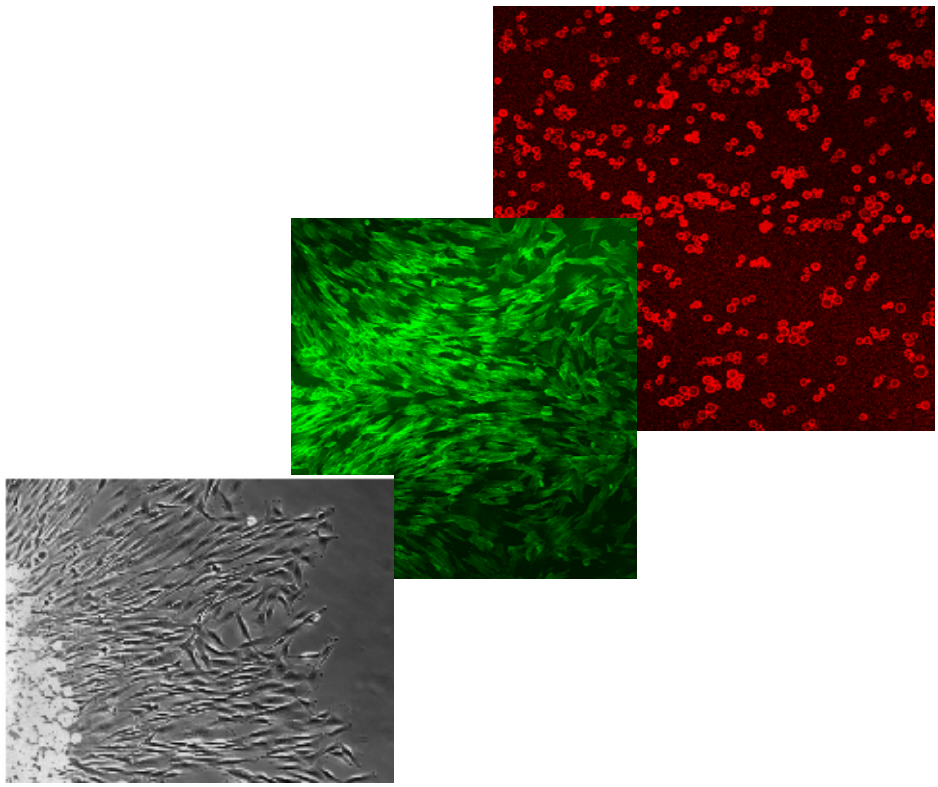
Chair: Taylor Bernheim

Shuai Qin, Margaret Davidson

Adam Fields, Alex Ramek

Kristin Hall

Victoria Hung



Effects of Sulfonated Polystyrene on Induced and Non-induced Pulpal Stem Cells

Shuai Qin, Ward Melville High School
Margaret Davidson, Chapin High School
Kate Dorst, Dowling University
Lenny Slutsky, Duke University
Dr Nadine Pernodet and Dr. Miriam Rafailovich
Department of Materials Science and Engineering, Stony Brook University

Stem cells have been rigorously studied for its potential in regenerative or reparative medicine.[1] However, the mechanisms that allow a stem cell to differentiate are still unknown. This study aims to determine the differences between a differentiating and non-differentiating stem cell. Sulfonated Polystytrene is known to stimulate cell adhesion, activate cell spreading and induce protein fibrillogenesis.[2] In order to study the formation and function of the cells, the ECM (extracellular matrix) formation of the stem cells was followed. The ECM is a network of protein and polysaccharide macromolecules that regulates cell behavior and is related to tissue formation.[3]

A prepared concentration of SPS (8mg/mL) was spun on hydrophilic Silicon wafers, cleansed using the Shirake method. The SPS wafers were then set to anneal for 24 hours at 170 degrees Centigrade. Incubated pulpal stem cells were then placed on the SPS wafers with media and serum. The 14-day cycle was then initiated. Three sets were planned to be imaged by AFM and Confocal Microscopy after 2 days, 7 days and 14 days incubation.

After 2-day incubation, mechanical responses from induced and noninduced cells looked very similar (fig. 1), in good agreement with the fact that the biomineralization should start after 7 days.

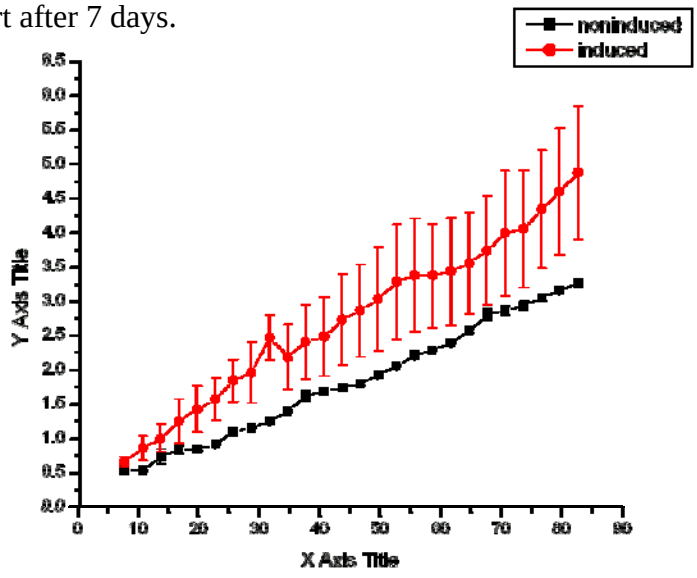


Figure 1: There is no significant difference between induced and noninduced cells after 2-day

[1] "Stem Cell Basics." Stem Cell Basics. 12 Aug. 2005. National Institute of Health. 7 Aug. 2006 <http://stemcells.nih.gov/info/basics>.

[2] Kowalczynska HM, Nowak-Wryzykowska M.,"Modulation of adhesion,spreaking and cytoskeleton organization of 3T3 fibroblasts by sulfonic groups present on polymer surfaces", *Cell Biology International* 2003, 27, 101-114

[3] Lukashev, Matvey E., Werb, Zena. "ECM signalling: orchestrating cell behaviour and misbehaviour.." Trends in Cell Biology 8(1998): 437-441.

From An Early Cancer Cell Detection System to Specific Cancer Drug Delivery Via Micro-particles

Adam Fields Jericho High School, Sean Pi North High, Alex Ramek HAFTR High School
M.H. Rafailovich, N. Pernodet, S. Ge, Stony Brook University
Jessica Fields Princeton University and Taylor Bernheim University of Pennsylvania
Department of Material Science and Engineering: SUNY Stony Brook University

The development of innovations in the field of cancer diagnostics is imperative to improve the rapid identification of malignant cells within the human body at an early stage. The present investigation offers a novel technique for early single cell cancer detection through the examination of differences in the mechanical properties of normal and cancer cells. A comparison of the moduli of normal versus cancerous osteoblasts on different substrates, namely petri dish cultures, polybutadiene (PB) spun on silicon, and glass, with varying percentages of normal versus cancer cells was made by using a new method, SMFM (lateral force modulation technique)[1]. Confocal microscopy imaging was also employed. Significant differences hope to be found between the moduli of normal and cancer cells on these substrates. This study provides evidence for an in-situ, rapid, cost effective, and minimally invasive methodology for early recognition of malignant cells.

As it has been reported, cancer cells present different receptors and therefore should have different affinities for specific fluorescent microbeads (Fig 1.) compared to normal cells. Therefore, this method can be used as a specific delivery system directly to the cancer cells. We experimented with fluorescent glass microbeads and discovered that their properties were cancer specific when used with SCC cells (Fig 2.) compared to normal keratinocytes. We also utilized BIAcore analysis to further understand the kinetics and interactions/adhesion between these particles. In the future, we are planning to test the affinity of these beads with other types of cancers and if successful will load these glass beads with therapeutic anticarcinogenic drugs for drug delivery.

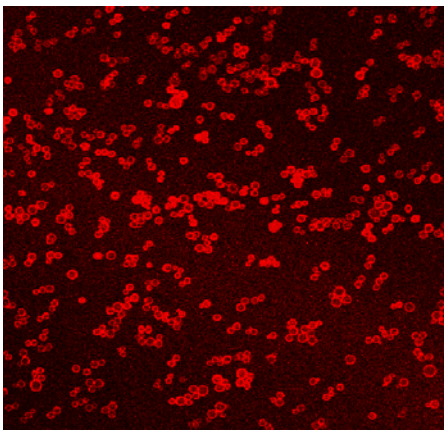


Fig. 2 Fluorescent Glass Bead Micro-particles

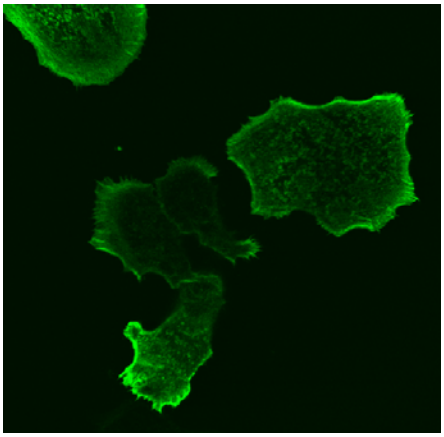


Fig. 2 SCC Keratinocytes

[1] Zhang, Y. *et al. Polymers* 44(11), 3327-3332 (2003)

Effects of Substrate Stiffness on Cell Morphology, Cytoskeletal Structure, and Elasticity

Kristin Hall[1], Nadine Pernodet[2], Miriam Rafailovich[2], Marcia Simon[3], Vladimir Jurukovski[3], Shouren Ge[2], Lenny Slutsky[4]

[1] Smithtown High School East, [2] Department of Materials Science and Engineering, SUNY at Stony Brook, [3] Department of Oral Biology & Pathology, SUNY at Stony Brook, [4] Duke University

Cellular transformation-whether in terms of stem cell differentiation or carcinogenesis-is commonly discussed in terms of genetic alterations that lead to modification or deregulation of cell growth.[1] Recent research has investigated how surface mechanics might dictate cell behavior, affecting both cell function and differentiation. Here, we are investigating whether different types of cells (normal keratinocytes, cancerous keratinocytes, and dental pulp stem cell)s respond in similar ways to surface mechanics, in terms of adjusting to the surface modulus and protein secretion. Also, we are exploring the possibility of differentiating stem cells through surface mechanics.

In order to study only surface mechanics independently of the surface chemistry, polybutadiene polymer was spun at different thicknesses, i.e. thick PB film (2000A) is soft compared to thin PB film (200A). Additionally, type one collagen was adsorbed at different concentrations over a sulfonated polystyrene film, giving us protein fibers with different mechanical properties. We show that by increasing the total concentration of collagen protein, the resulting stiffness of the polymerized network is increased. In conjunction with concentration-dependent stiffness, sulfonated polystyrene surfaces were used to permit the initiation of protein fibril formation, thereby allowing us to create collagen fibers of varied dimensions and with different capacities for bearing mechanical strain. We examine the effect of these mechanically varied matrices on cell elasticity, growth, actin organization, morphology, and cell migration. When normal keratinocytes and their cancerous counterparts were cultured on these substrates, Lateral Force Modulation measurements, i.e. modulus, showed that the cancerous cells were softer than normal cells on both the collagen and polybutadiene surfaces . However like the normal cells, the cancerous keratinocytes became softer on stiffer matricies. Confocal Microscopy indicated that morphologically, the normal cells had a cortical membrane and pattern of filapodia protrusion that differed significantly from the cancerous cells. Mutated forms of the cancerous keratinocytes were not sensitive to substrate mechanics.

Additionally, sulfonated polystyrene surfaces were used to study protein deposition. Cancerous extracellular matrix was much stiffer than the normal extracellular matrix, and had a less organized network.

Stem cells extracted from human dental pulp were also studied using the collagen and polybutadiene substrates. These cells reacted oppositely to the keratinocytes, becoming stiffer on the stiffer collagen and polybutadiene matrices, thereby indicating that each type of cell adjusts to mechanics but not always in the same way. Confocal Microscopy showed that the stem cells proliferated more on the harder substrates and exhibited stretched actin fibers (Figure 1). Contrastingly, the softer matrix appeared to provoke the cells to assume a more triangular, folded morphology (Figure 2). Further analysis of the cells' gene expression on these surfaces will be used to determine whether the elasticity and morphology changes are indicative of mechanically-induced differentiation.

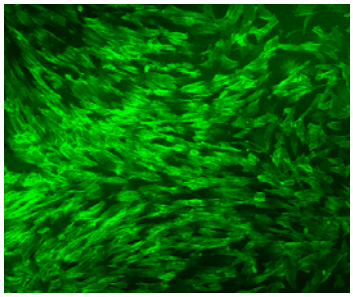


Figure 1 Dental Pulp Stem Cells cultured on Hard Polybutadiene Substrate and stained with Alexa Flour 488 for Actin

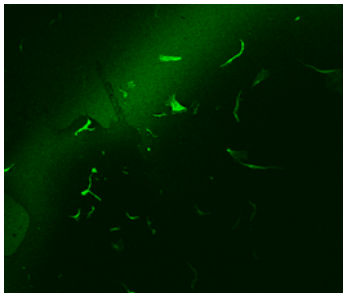


Figure 2 Dental Pulp Stem Cells cultured on Soft Polybudaiene Substrate and stained with Alexa Flour 488 for Actin

[1] Ingber, D. E. (2003). Tensegrity II. How structural networks influence cellular information-processing networks. *J. Cell Sci.* 116, 1397-1408.

Mathematical Modeling of Fibroblast Migration

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Zhi Pan, Dr. Miriam Rafailovich, Department of Materials Science and Engineering, SUNYSB, Stony Brook, NY 11794-2275
Kaustabh Ghosh, Dr. Richard A.F. Clark, Department of Biomedical Engineering, SUNYSB, Stony Brook, NY 11794-2275

Fibroblast migration is a critical function in wound healing and tissue regeneration. In connective tissue, fibroblasts are in low density, but cells migrate en masse into the wound, stimulated by chemical signals secreted by macrophages[1]. To understand the difference between single and en masse migration, I propose to model the velocity of a cell with respect to time, t, and the distances between the targeted cell and its neighboring cells, r_x and r_y, in their respective directions.

To study en masse cell migration, I did an agarose droplet migration assay. First, a hydrogel with a backbone of crosslinked hyaluronic acid was plated. Then, a droplet of a high-density solution of agarose and cells was placed on top of the hydrogel. Then the samples were incubated for 6, 15, or 24 hours. After the incubation period, the samples were viewed under a Nikon microscope. Using Metamorph Software, a picture of the sample was taken every fifteen minutes for one hour. To study single cell migration, a cell solution of fibroblasts and serum-free medium was seeded on to the hydrogel, but otherwise the same procedure was followed.

Metamorph software can be used to measure the distance a cell has moved from image to image in both en masse and single cell migration images, shown in Figures 1 and 2. It can also be used to measure distances between cells. In preliminary results, graphs of the distance a cell travels versus time, and separate graphs of r_x and r_y versus time, the trends indicate that as r_x and r_y increase, the distance the cell will travel decreases.

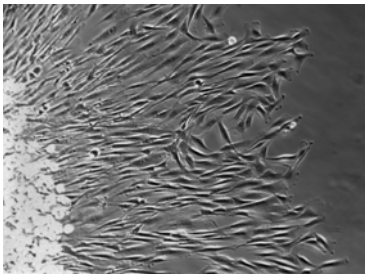
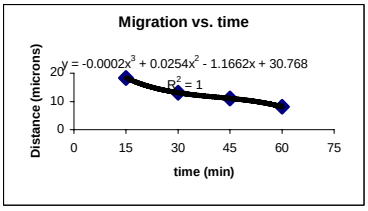


Figure 1: En masse cell migration after a 15 hour incubation period.



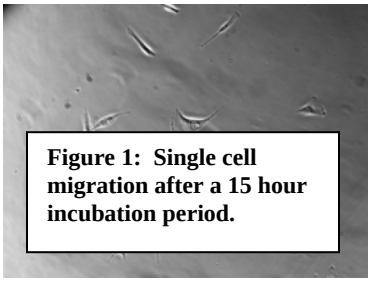
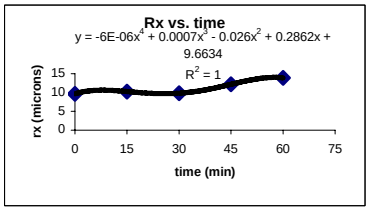
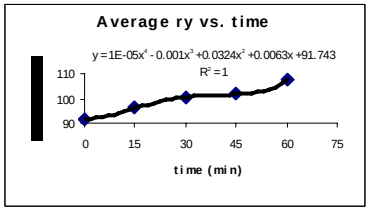


Figure 1: Single cell migration after a 15 hour incubation period.



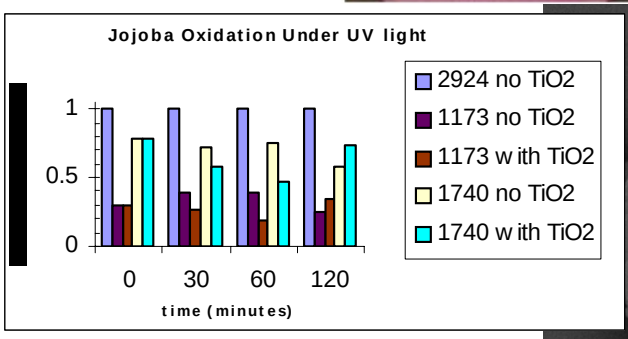


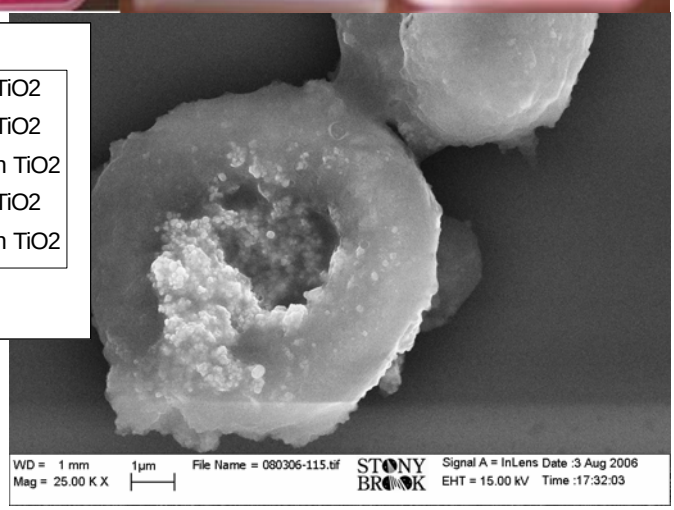
[1] Clark RAF, *et. al*: Fibroblast Migration Requires Three Distinct Functional Domains. *J Invest Dermatol* 121:695—705, 2003.

Session X: Biological Effects of TiO_2 Nanoparticles

Chair: Michal Simpser

Adam Hyams, Kiwoong Yoo
Nikki Ackerman, Kelsey Werber
Matthew Wieder





The Effect of Ultraviolet Radiation on Different Components of Sunscreen with Ti02

Kiwoong Yoo, Adam Hyams, *Jericho High School, Jericho, NY 11753*
Binquan Li, Miriam Rafailovich, *Stony Brook University, Stony Brook, NY 11794*

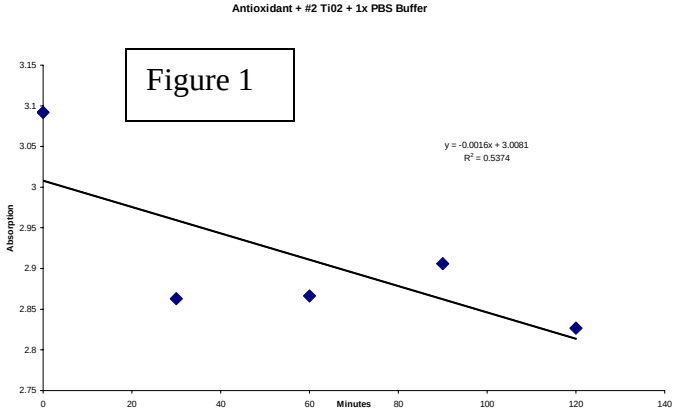
Titanium dioxide is a major component used as a physical blocker of ultraviolet light in sunscreens[1]. The three different types of ultraviolet radiation that are seen on earth are UVA with a wavelength between 315 and 380 nm, UVB with a wavelength between 280 and 315 nm, and UVC with a wavelength less that 280 nm. While the ozone layer absorbs the most harmful ultraviolet radiation, the UVC rays, it does not all of the UVB and UVA rays. Therefore, sunscreens are applied to the skin to combat the deleterious effects, such as aging of skin, DNA damage, of the UVA and UVB rays. Sunscreens that use titanium dioxide as the active ingredient can only, at an SPF (sun protection factor) of 15, block 93% of UVB rays and an SPF of 30 blocks on four percent more. This study is designed to test different coated titanium dioxide and entrapped titanium dioxide inside different polymers and compare it to rutile titanium dioxide. Plus, different proteins will be added to these solutions and tested separately to see a difference in the amount of light that is absorbed by the titanium dioxide.

The experiment began by first testing the different components of sunscreen including titanium dioxide. Using an ultraviolet-visible spectrophotometer (UV/VIS) to measure wavelength versus absorption, data was complied to test how much each titanium dioxide absorbed the ultraviolet light.

After this was completed, the tests on titanium dioxide were started. Six different solutions were made. The first solution was comprised of 5mL of 1X PBS buffer, 10µL of an antioxidant, and 20µg of regular rutile titanium dioxide. The second solution was made up of 5mL of 1X PBS buffer, 10µL of an antioxidant, and 20µg of coated titanium dioxide. The third, fourth, and fifth solutions were made up of 5mL of 1X PBS buffer and 20µg of titanium dioxide entrapped in three different polymers respectively. The sixth solution had 5mL of 1X PBS buffer; 20µg of the same coated titanium dioxide used in the second solution and 10µL of an antioxidant. Each of these solutions was exposed to UVC light for 30, 60, 90, and 120 minutes plus a control, which was not exposed to UVC light. The UV/VIS Spectrophotometer tested the amount of light that was absorbed by these solutions.

The data from the UV/VIS showed that for most of the samples, as the minutes of radiation increased, the absorption of the spectrum decreased. But as for a couple of samples, there were outliers that proved this trend false. The coated titanium dioxide called #2 was found to absorb the greatest amount of ultraviolet light. Pictures from the scanning electron microscope (SEM) showed the titanium dioxide held inside a ball of polymer.

For further research, the outliers from the data must be retested in order to remove any error. The data from the SEM and the Fourier transform spectroscopy (FTIR) will be used to understand the components of the titanium dioxide for future tests. Protein will also be added to the samples with titanium dioxide to see the effect ultraviolet radiation on them.



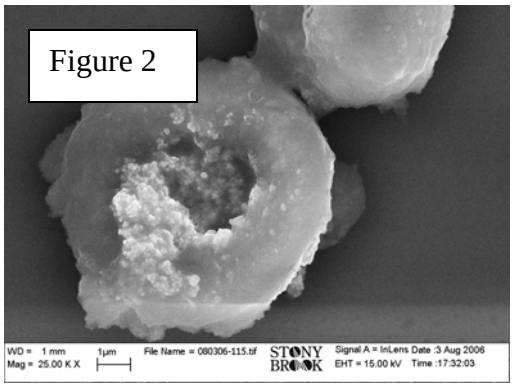


Fig 1. UV/VIS graph of data from coated $Ti0_2$ #2.

Fig. 2 SEM picture of one of the coated $Ti0_2$ called #4

1. "Safety of Sunscreens Containing Nanoparticles of Zinc Oxide or Titanium Dioxide." Therapeutic Goods Administration. 20 Feb. 2006. 28 July. 2006 <http://www.tga.gov.au/npmeds/sunscreen-zotd.htm>.

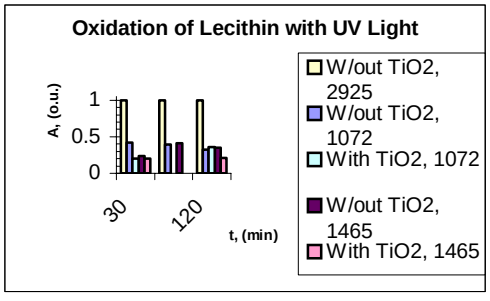
The Stability of Natural Compounds in the Presence of UV Light and Sunscreen Components

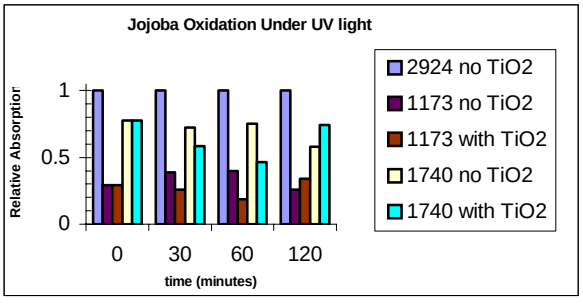
Nikki Ackerman, *Jericho High School*
Kelsey Werber, *Jericho High School*
Dr. Vladimir Zaitsev, Dr. Miriam Rafailovich, *Stony Brook University*

UV irradiation is a known cause of skin cancer[i]. Sunscreen application is the leading mechanism used to prevent skin cancer. However, there is an indication that sunscreen itself is not a safe substance[ii]. Sunscreen consists of both organic and inorganic UV blockers and oils. Organic compounds can be toxic in their purest form or they can become toxic when combined with other components of sunscreen in the presence of UV light. Titanium dioxide is stable by itself; yet, when in the presence of UV light TiO2 catalyzes the production of hydroxyl radicals. The release of hydroxyl radicals can harm human DNA and alter the permeability of cell membranes.

We intend to study the components of sunscreen (UV blockers, oils) and components of cells (DNA, proteins, lipids) during exposure to UV light. In particular, we have decided to work with Lecithin, Collagen, Jojoba Oil, Parsol 1789, and DNA from salmon testes. We plan to irradiate our samples under a UVA lamp (352nm). In order to measure the stability of these compounds, we chose to use UV Visible and IR Spectroscopy. By doing so, we will be able to compare samples in the presence of Titanium Dioxide to samples in their purest form. Our ultimate objective is to modify Titanium Dioxide, thus, hindering the photocatalytic activity of TiO2, while preserving the primary purpose of sunscreens. We intend to do so by coating the Titanium Dioxide particles with a poly(hydroxyethylmethacrylate) polymer.

Results show that absorption of the samples is altered after irradiation. For the oxidation of Lecithin, we can see that during the time of irradiation, absorption increases and then finally decreases. The absorption of the sample decreases more in the presence of TiO2 than without TiO2, indicating a greater degree of oxidation in the samples containing Titanium Dioxide. In the case of oxidation of Jojoba Oil, the absorption changes, but we cannot see a clear pattern. Thus, indicating that the process of oxidation is rather complex and requires further studies.





[i] Serpone, Nick, Salinaro, Angela, Satoshi, Horikoshi, Hidaka, Hisao. "Beneficial Effects of Photo-Inactive Titanium Dioxide Specimens on Plasmid DNA, Human Cells Yeast Cells Exposed to UVA/UVB Simulated Sunlight," *Journal of Photochemistry and Photobiology A: Chemistry 179 (2006) 200-212*

[ii] Nohynek, Gerhard, Schaefer, Hans. "Benefit and Risk of Organic Ultraviolet Filters," *Regulatory Toxicology and Pharmacology 33, 285-299 (2001).* June 2000

The Use of Chemical and Mechanical Coatings as a Mechanism to Prevent the Damaging Effects of Photoactivated Titanium Dioxide on DNA

Matthew S. Wieder – SAR High School, Riverdale, NY
Bingquan Li and Dr. Miriam Rafailovich, Stony Brook University

Titanium Dioxide (TiO_2) in its nanoparticle form is a commonly used ingredient in sunscreens because it can reflect and absorb UVA and UVB rays[1] which can damage skin and cause skin cancer. Although the benefit of this nanoparticle seems to be significant due to its ability to reflect these wavelengths of light, unfortunately when UV rays hit TiO_2, the TiO_2 generates hydroxyl radicals which can damage or destroy DNA.

In an effort to prevent these adverse effects of photoactivated TiO_2 both a chemically bonded coating and a mechanical coating were used on the TiO_2. It was predicted that the chemically bonded coating would be more effective due to its ability to fully coat and therefore prevent the exposure of DNA to hydroxyl radicals. Chromosomal DNA was used to test the effect of UV exposure on the relaxation (the stretching and recoil of chromosomes) of DNA coated with a regular, non functionalized TiO_2 nanoparticle, a chemically bonded coating for TiO_2 and a mechanical coating for TiO_2. Four samples were created for each type of coating. One with no exposure to UV rays, one exposed to UVA rays, one exposed to UVB rays and one exposed to UVC rays. An electric field of 30 volts was then applied to each sample for ten minutes and then the electric field was removed and each sample was given thirty minutes to recover with an image taken every minute.

In a second series of experiments lambda DNA was used to test the ability of each coating to prevent damage by hydroxyl radicals generated by photoactivation. For this experiment, five different TiO_2 nanoparticles were used: a regular non functionalized TiO_2 nanoparticle, a chemically bonded coating for TiO_2 and three different mechanical coatings for TiO_2. Three samples were created for each type of TiO_2, consisting of a sample exposed to UVA rays, a sample exposed to UVB rays and a sample exposed to UVC rays. The samples were then put in an agarose gel and gel electrophoresis was performed.

In a third series of experiments a free radical assay was performed on each of the TiO_2 nanoparticles. A dye was used that when exposed to hydroxyl radicals changes color thereby changing the spectrum of absorption. For this experiment three samples were created for each coating. One exposed to UVA rays, one exposed to UVB rays and one was concealed in the dark as a control. UV VIS was then performed on each sample to determine the spectrum of absorption which would evidence whether hydroxyl radicals were created or not.

Results thus far have shown that the chemically bonded TiO_2 particle has been most effective in preventing the damaging effects of UV rays. Of the samples exposed to UVA rays in the chromosomal DNA experiment the chromosomes coated with the chemically bonded coated TiO_2 recoiled the farthest showing it was less damaged than the sample coated with regular non functionalized TiO_2, which did not recoil as far. The lambda DNA experiment and the free radical assay experiment achieved comparable results. Of the samples exposed to UVB and UVC rays in the lambda DNA experiment, only the lambda DNA coated with the chemically bonded coating for TiO_2 survived. In the free radical assay it could be seen from exposure to UVA rays that the chemically bonded coated TiO_2 prevented production of hydroxyl radicals unlike the regular non functionalized TiO_2. (See Figure 1a-c)

These results are consistent with my initial hypothesis which was that the chemically bonded coating for the TiO_2 would be the most effective in preventing damage due to exposure to UV rays and the production of hydroxyl radicals. This coating will likely permit for the continued use of TiO_2 in sunscreens without its adverse effects.

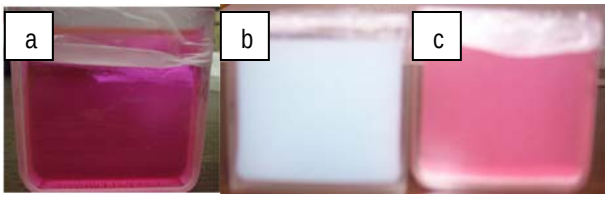


Figure 1: Free radical assay
a) Control – stock solution containing D&C Red
b) Regular non functionalized TiO2 nanoparticle in stock solution after exposure to UVA for 15 hours
c) Chemically bonded coated TiO_2 nanoparticle in stock solution after exposure to UVA for 15 hours

[1] R. Dunford, A. Salinaro, L. Cai, N. Serpone, S. Horikoshi, H. Hidaka and J. Knowland. *Chemical oxidation and DNA damage catalysed by inorganic sunscreen ingredients.* FEBS Letters. Volume 418, Issue 1-2, Pages 87-90

Session XI: Polymers: Impact on the Environment, Medical and Consumer Applications

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Chairs: Julian Salazar

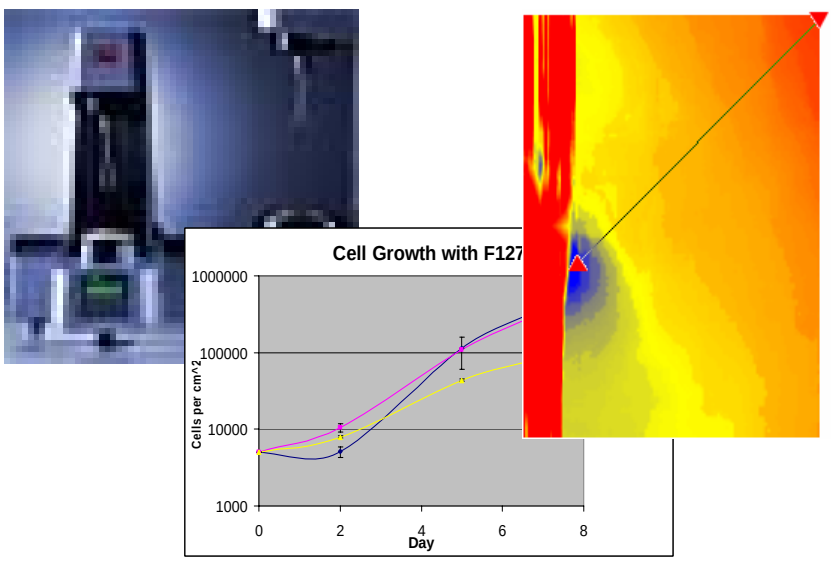
Robert de La Cruz

Yehuda Grossman, Yosef Guterman

Mark Elstein

Grace Chow, Mili Mehta

Ankuri Desai



Plastics in the Environment

Supervising Scientist: Dr. Miriam Rafailovich
Mentor: Julian Salazar
High School Students: Yosef Guterman & Yehuda Grossman

Recently there have been plastic like pellets washing up on beaches. The goals of our project are to find what these pellets are made of, where they're from, and how old they are.

In order to identify and determine the characteristics we had to perform several tests (Figure 1). We used a total of 180 pellets for the project; 60 of each color we sorted these pellets while measuring them for the diameter test. We used the pellets for every test. However, we also needed to use other materials and equipment for all tests. For the diameter and swelling diameter tests we used calipers, for swelling diameter we distributed the samples into three different solvents; Toluene, DMF, and Acetone. For weight we first placed empty 7ml vials in to a balance, then placed a sample into the vial and found the difference in the weights. To find the volume we used a graduated cylinder and measured the water displacement. For the melting point we used the DSC (Differential Scanning Calorimeter) machine at Hi-Lord Chemical in Hauppauge. To identify the samples we used the FTIR (Free Transmission Infrared) machine in Stony Brook.

At this point we have identified and characterized the samples. The samples are polyethylene at different levels of oxidation, with the brown samples being the most oxidized and the black samples being the least oxidized. We know this from the FTIR results which showed spikes that were largest in the brown samples' results and not significant in the black samples' results. In the future we hope to run tests to determine the age of these samples, as well as where the source of these pellets is located. We already have started in our tests to determine the age of these pellets. We did this by leaving several samples of each color in a UV box at Hi-Lord Chemical. We hope to simulate the conditions that caused these pellets to form and from there we can see how much time it was equivalent to in a natural environment. We will leave these samples in the UV box for 1000 hours.

Figure 1: Tests for ID and characteristics

Name of Sample	Diameter	Swelling Diameter	Swelling %	Weight/Mass	Volume	Density	DSC Melting Point	FTIR ID
White	**.182 cm**	**.188 cm**	**3.20%**	**93.8 mg**	**.95 ml**	**.9873 g/ml**	**169.65° C**	**Polyethylene**
Brown	**.159 cm**	**.168 cm**	**5.60%**	**68.0 mg**	**.75 ml**	**.9066 g/ml**	**111.15° C**	**Polyethylene**
Black	**.138 cm**	**.152 cm**	**10.10%**	**81.6 mg**	**.78 ml**	**1.046 g/ml**	**112.62° C**	**Polyethylene**

Measuring the changes in skin mechanics with age: (DISC analysis)

Mark Elstein Bayport-Blue Point High School,Isabelle Afriat, Prof. Klaus Mueller, Prof. Miriam Rafailovich

The DISC (Digital Image Speckle Correlation) method is a method of dynamically analyzing the deformation of materials by finding the differences in two images based on the displacement of recognizable landmarks. Among the many potential applications it has, this one is the modeling and analysis of the elasticity of skin in groups of young and old people. The skin is a viscoelastic material that can be analyzed like any other material, besides the fact that it is sensitive.

As a person ages, the skin fibers, such as collagen fibers, become weaker, smaller, less uniform, and more disorganized and entropic; this results in decreased unity, uniformity, and propagation of motion throughout the skin when a muscle is moved and less elasticity (resilience) of skin after a muscle is moved.

A high-resolution camera is used for photography for the purpose of having enough detail to encompass the pores of the skin. (The pores serve as the high-contrast "speckles" with which DISC uses to analyze the image.) The camera and the person are mounted in a restrictive and very stable position to prevent environmental movement from affecting the analysis. (In this way, external variables are minimized.) The initial picture is taken with the subject's face in a casual state, and the second (deformed) picture is carefully and swiftly taken after a slight skin displacement (in this case, closing the eye). The two images are compared and correlated by DISC software to obtain horizontal and vertical vector files recording the horizontal and vertical deformation in each pixel, respectively. From these vector maps, cross-section profiles were taken along certain lines (see Fig. 2) and plotted as graphs in Origin software (see Figs. 3 and 4) to fit exponential decay functions to the plots. The ratio was taken of the horizontal-stretch constants in the exponential-decay fits in the horizontal-deformation to that in the vertical-deformation plots. This was repeated for 3 radial profile directions in each subject's map (varying the right point but keeping the beginning point at the eye corner position); the averages of the exponential-decay constant ratios was taken among the profile directions, and the average of that for all the persons within a certain age group was taken and recorded separately for a group of young people and old people. The final average result for young (age 18-25) and old (age 40-59) is compared in Fig. 1. The average ratio of the young people's horizontal-stretch decay constants of vertical to horizontal deformation is much closer to 1 than that of the old people, indicating that young people's faces deform more uniformly in both the x- and y-direction than old people. This supports our hypothesis that young people's faces deform more uniformly than old people.

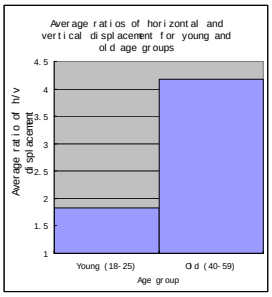


Figure 1 : Comparison between age groups of average ratios of deformation in the x direction to deformation in the y direction.

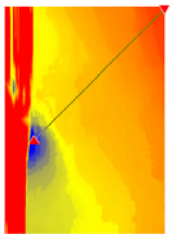


Figure2 : Horizontal-displacement (ΔX) color map of a profile of a young person's face when closing an eye.

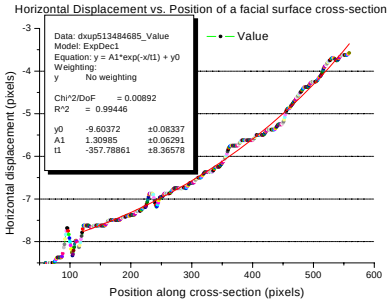


Figure 3 : Horizontal displacement graph (with exponential decay fit).

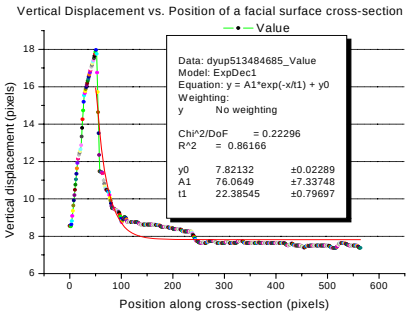


Figure 4 : Vertical displacement graph (with exponential decay fit).

Properties of Hydrogels Composed of Poly(ethylene oxide)-poly(propylene oxide)-poly(ethylene oxide)-poly(acrylic acid), A Potential for Transdermal Drug Delivery

Grace Chow, *Herricks High School, New Hyde Park, NY 11040*
Mili Mehta, *The Wheatley School, Old Westbury, NY*
Jun Jiang, Dr. Miriam Rafailovich, *Stony Brook University*

The delivery of drugs using thermoreversible hydrogels holds great potential in medical and pharmaceutical fields today. A triblock copolymer, composed of poly(ethylene oxide)-poly(propylene oxide)-poly(ethylene oxide) (PEO-PPO-PEO), commercially known as Pluronic F127®, is one of the most commonly studied families of reverse thermo-responsive biomedical polymers. Interestingly, this polymer remains a liquid at low temperatures but becomes a gel at body temperature due to the aggregation of hydrophobic PPO segments.[1] However, PEO-PPO-PEO gels display very high permeabilities and a level of viscosity that results in a excessively fast release of drugs, making the gels incompatible for clinical applications.[2] This study aims to strengthen and improve Pluronic gels by grafting poly(acrylic acid) to a backbone of PEO-PPO-PEO, allowing for a method of sustained drug delivery.

Synthesis of the F127-PAA copolymer involved free-radical polymerization. The F127 was dissolved in a neutralized solution of acrylic acid, and polymerization occurred in a nitrogen purged reaction vessel with the addition of appropriate solvent, catalyst, and initiator solution. The solution was then filtered and cleaned with heptane and allowed to dry in a vacuum pump. Various concentrations of the grafted copolymer were then dissolved in deionized water at low temperatures. To test the effect of pH variation on the gels, F127-PAA was dissolved in a 1% (wt/wt) solution of acid, salt, and base. The solutions were then placed in an incubator set at 37ºC, enabling gelation to occur. Elasticity and viscosity of the gels were measured with an AntonPaar Physica MCR 301 rheometer (Fig. 1).

Data that has been acquired so far shows that at higher concentrations, the gels show an increase in viscosity and elasticity. The addition of a salt and base also increased the viscosity and elasticity of the gel as compared to the addition of an acid. Future analyses of these gels will use Differential Scanning Calorimetry, Fourier Transform Infrared Spectrometry, and a coefficient expansion test. Furthermore, calculating the diffusion rate of a substance out of F127-PAA gels will determine whether they are optimal for drug delivery.

Fig. 1- AntonPaar Physica MCR 301 rheometer

[1] Ron Dagani. "Intelligent Gels," *Chemical and Engineering News*. June 1997.
[2] Alejandro Sosnik, Daniel Cohn, Julio San Roman, Gustavo A. Abraham. "Crosslinkable PEO-PPO-PEO-based reverse thermo-responsive gels as potentially injectable materials," *J.Biomater. Sci. Polymer Edn*, Vol. 14, No.3, pp. 227-239 (2003).

Pluronic F127 as an Applicable Replacement for a Degenerated Nucleus Pulposus

Ankuri Desai, Ward Melville High School, 380 Old Town Road, East Setauket, NY 11733
Dr. Miriam Rafailovich, Jun Jiang, Lourdes Collazo, Elizabeth Casey, Department of Materials Science and Engineering, Stony Brook University
Jack Lombardi, Estee Lauder Research Corporation

Dysfunctional intervertebral discs are a leading cause of lower back pain, with a lifetime prevalence of up to 80% in North America [1]. The primary cause for their failure is a degeneration of the nucleus pulposus, a gel-like substance located between the discs. Normally the nucleus pulposus, along with other components of the intervertebral disc, anchors adjacent vertebral bodies and by doing so allows for spinal stabilization, load bearing, and movement [2]. However, the nucleus pulposus may become herniated from sudden strain caused by lifting, twisting, or direct injury, or gradually from compressive loading. Instead of resorting to a surgical pathway to respond to this problem, it has been proposed to just replace the dysfunctional nucleus pulposus.

The purpose of this investigation was to determine the suitability of a PEO-PPO-PEO triblock copolymer, sold by BASF® as Pluronic F127, as a replacement for the nucleus pulposus. This polymer is a thermoreversible hydrogel, which shows promise as an applicable replacement because it can be injected into the vertebrate as a liquid, whereupon it would become a gel at the 37*C of body temperature. The effect of protein on Pluronic F127 was studied in order to determine the result of protein within the spinal column interacting with F127, after injection into the vertebrate. Thus, volume expansion at 25*C of 30% F127 with 0.5% and 1% albumin was studied through the use of KIMAX® Kimble ten milliliter graduated glass cylinders and a Fowler Caliper. This data was then compared to the expansion of pure 10%, 20%, 25%, and 30% F127 (figure 1).

Additionally, the G' Modulus of Pluronic F127 was studied to determine the strength of its resistance to shear. F127 was combined with 1% and 2% protein and then tested using an AR Rheology Advantage Instrument Control Rheometer to determine the point of structural collapse for both conditions (figure 2). It was found that the polymer with 2% protein had a higher yield point, indicating an increased strength compared to F127 with lower concentrations of protein. Finally, the effect of Pluronic F127 on cells was studied to determine the polymer's cytotoxicity. Glial cells were grown in an environment with 1% and 5% F127 and a seven day growth curve was created illustrating the polymer's effect (figure 3). F127 was found not to kill cells, but only to inhibit their proliferation.

Consequently, F127 is a cyto-friendly polymer that can be injected within the spinal column to replace a dysfunctional nucleus pulposus. Upon injection, it can combine with proteins that increase the expansion of the polymer as well as significantly increase its strength. Thus, Pluronic F127 is a suitable replacement for the nucleus pulposus and its properties are enhanced by interaction with the vertebrate's proteins.

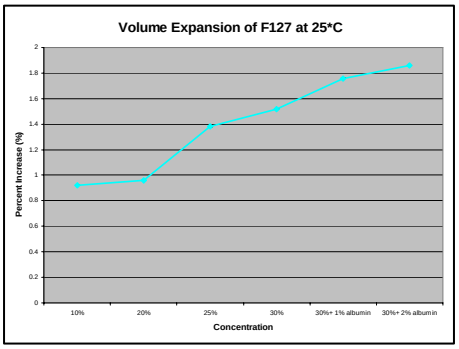


Figure 1

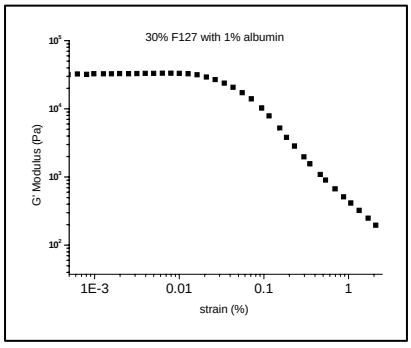


Figure 2

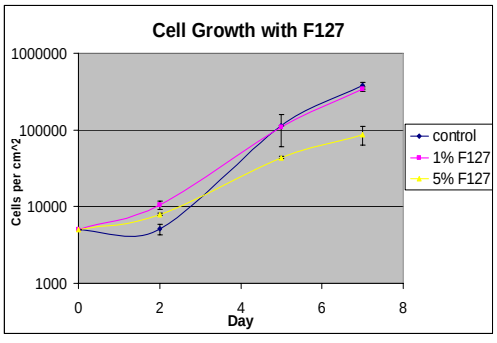


Figure 3

[1]. Hamilton, D. J., Seguin, C., & Wang J. (2005). "Formation of a nucleus pulposus-cartilage endplate construct in vitro." *Biomaterials* , 01-08.
[2]. Humzah MD, Soames RW. (1988) "Human intervertebral disc: structure and function." *Anatomical Records*; 220, 337–56.

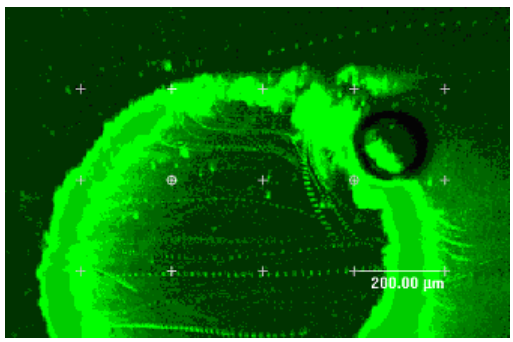
Session XII:
Detecting Viruses & DNA

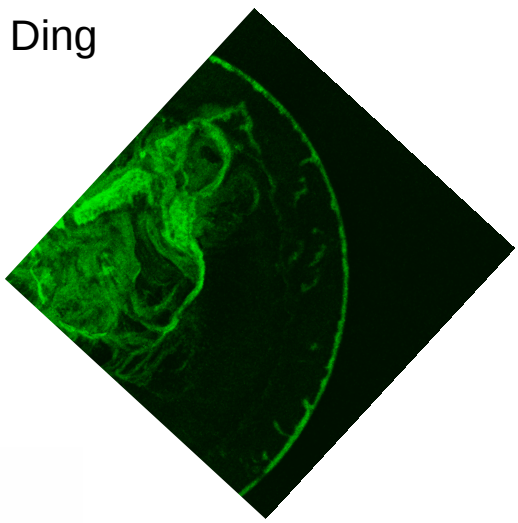
Chair: Jennifer Daniels

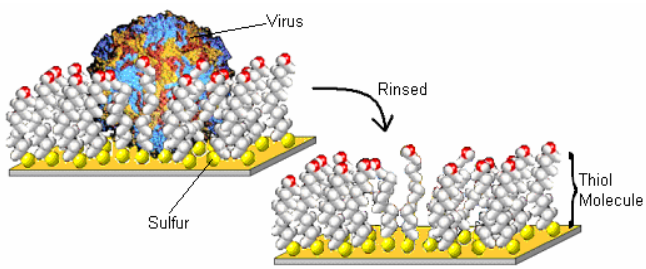
Vijay Jain, Jinju Yi

Hyung Jun Kim

Michael Ding







Molecular Templating for Rapid Bioterrorism Detection

Vijay Jain[1], Jinju Yi[2], Yantian Wang[3], Miriam Rafailovich[3], Jonathan Sokolov[3], Kalle Levon[4]
[1] *Herricks High School, New Hyde Park, NY*
[2] *Plainview-Old Bethpage John F Kennedy High School, Plainview, NY*
[3] *Dept. Materials Science & Engineering, SUNY at Stony Brook, NY*
[4] *Othmer Dept of Chemical & Biological Sciences & Engineering, Polytechnic University, Brooklyn, NY*

In recent years, with the escalating threat of bioterrorism, the need for biosensors has become paramount in order to identify bioterrorist agents. The need for on-the-spot detection to sense almost instantly and guarantee little or no false-positives has become a critical concern. Presently, technology for detection of viruses requires amplification of DNA through PCR, a process which may require hours for completion and verification. Surface engineering with thin-films is a useful technique in establishing the needed detection mechanism. This investigation implements the use of self-assembled monolayers [SAMs] to produce a viable surface chemistry for gold-silicon substrates to aid in the detection of biomacromolecules, specifically viruses.

Self-assembly describes the crystallization of surfactant polymers onto a substrate to produce a monolayer film.[i] This works most effectively using polymers of organosulfur derivatives, mainly thiols, which possess a sulfur-hydrogen (SH) base, to produce a highly-ordered film. A surfactant, 11-mercapto-1-undecanol—used for its hydrophilicity because of an added hydroxyl (OH) group—was co-adsorbed with biological macromolecules on a gold-plated electrode, as seen in *Fig. 1*. The thiolated molecules self-assembled into a highly-organized crystalline film chemically grafted to the surface, while the biomacromolecules were physically adsorbed. Molecular templates were then created by physically removing the biomacromolecules out of the film, thereby leaving shape and structure-specific cavities of the biomacromolecules in the SAM matrix.

An electrochemical response across the gold-thiol template was measured by a potentiometer. In testing for accurate detection, the constructed gold-thiol template was immersed in a solution of the biomacromolecules. A sharp voltage response occurred when the electrode was exposed to a solution containing the identical template molecules in concentrations as low as 10^{-6} mole/L. In contrast, when these templates were tested with solutions of similar or smaller molecules, the electrode exhibited a very limited voltage response. A comparison of the change in voltage of positive detection compared to the cross-testing has demonstrated 300% difference in potential difference, as seen in *Fig. 2*.

The ability to identify specific molecules represents a new chapter in self-assembly, as the self-assembly of macromolecules with sizes ranging from 10-300 nm has not yet been greatly investigated.[ii] This detection mechanism represents a viable option for the accurate identification of bioterrorist agents such as poliovirus and the aphthovirus (foot-and-mouth disease). Future work includes testing the electro-potential cell using the poliovirus and adapting this mechanism for possible use in the early detection of cancer.

**This investigation was supported by the New York State Center for Maritime and Port Security.*

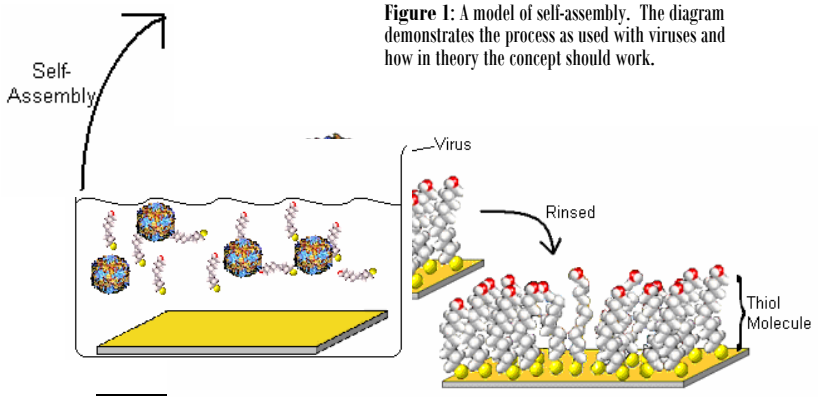
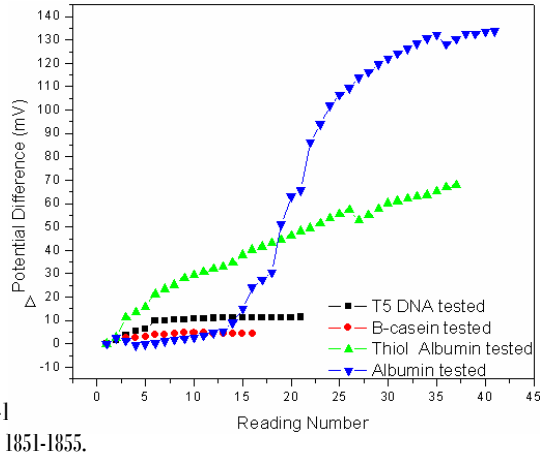


Figure 1: A model of self-assembly. The diagram demonstrates the process as used with viruses and how in theory the concept should work.



[i] Ulman, A (1996).Formation and structure of self-assembled monolayers. *Chemical Reviews. 96*, 1533-1

[ii] Levon, K, et al. (2005). Potentiometric sensor for dipicolinic acid *Biosensors & Bioelectronics*, 20(9), 1851-1855.

Use of magnesium ions to modify DNA adsorption and electrophoresis on surfaces

Hyung Jun Kim. Jericho High School, Jericho, NY
Jennifer Daniel, **Miriam Rafailovich**, **Jonathan Sokolov**, Stony Brook University

Electrophoresis is a technique to separate DNA segments according to their sizes under the action of an electric field. Currently gel and capillary electrophoresis are used to sequence DNA segments up to about 1000 base pairs. Information on small segments must be pieced together and the process is very time consuming.

Therefore, scientists are now searching for new ways to separate DNA. One of the new methods is surface electrophoresis, which drags DNA across a surface using an electric field. In surface electrophoresis too, DNA segments also break or get stuck. Finally, there is also speculation that some ionic solutions, such as magnesium chloride, affect the DNA absorption to the silicon surface and electrophoretic mobility.

To test the effects of added magnesium ions, DNA solutions with varying ion concentrations of magnesium chloride were prepared. First, DNA solutions were made, containing 6.3 μL of λ-DNA stock solution (500 μg/mL), 1.0 μL of YOYO stock solution (μg/mL) and 130 μL of 1× TBE buffer solution. Separately, a 1.0M magnesium chloride solution was prepared. Five aliquots of 20 μL of the DNA solution were deposited into centrifuge tubes and 2.5 μL, 5.0 μL, 10.0 μL, and 20.0 μL of the magnesium chloride solution were added to four of the tubes, the remaining one having no added magnesium. Then, five drops, approximately 1 μL each, of solutions from the five tubes were deposited on the bare silicon and left to dry. When completely dried, each drop formed a ring shape of DNA segments. Each drop was observed using the confocal microscope and then soaked in buffer solution (1× TBE) to wash off impurities and un-adsorbed DNA. After the impurities were washed off and the DNA remnants were dried, each drop was observed again.

Data that have been taken so far show that the fifth solution, a mixture of 20.0 μL of DNA solution and 20.0 μL of 1.0M magnesium chloride, is absorbed in a better manner than the other solutions (See Figs. 1 and 2). Next, we will measure the electrophoretic mobility of DNA in the presence of the differing amounts of magnesium to optimize the speed and resolution of the surface electrophoresis.

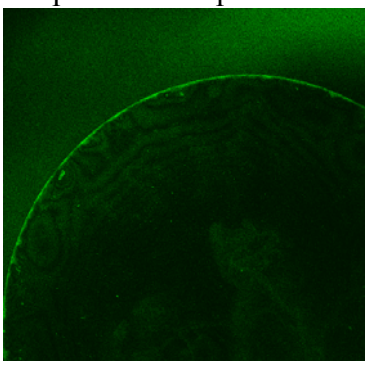


Figure 1

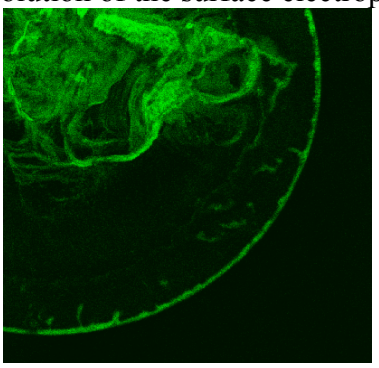


Figure 2

Figure 1. A drop of the mixture, 20 μL DNA solutions plus 20 μL magnesium chloride, before it is washed off.

Figure 2. A drop of the mixture, 20 μL DNA solutions plus 20 μL magnesium chloride, after it is washed off.

Foley, Micheal, "Macro-DNA: doing DNA fingerprinting and Gel Electrophoresis on a Large Scale." http://www.accessexcellence.org:8080/AE/AEPC/WWC/1994/dna_finger-printing.html

N. Pernodet, V. Samuilov, K. Shin, J. Sokolov, M.H. Rafailovich, D. Gersappe, and B. Chu, "DNA Electrophoresis on a Flat Surface, *Department of Chemistry, State University of New York at Stony Brook, Stony Brook, New York 11794-3400, Department of Materials Science and Engineering, State Universityof New York at Stony Brook, Stony Brook, New York 11794-2275*, 4 November 1999

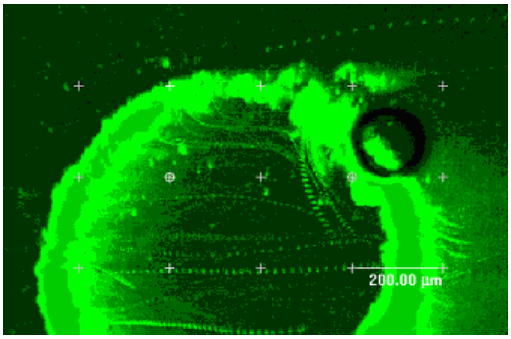
DNA Electrophoresis on Indium Tin Oxide Conducting Surfaces

Michael Ding, Glen Cove High School; Bingquan Li, Miriam Rafailovich and Jonathan Sokolov, Department of Materials Science & Engineering, Stony Brook University

Fractionation of DNA by size is vital to the advancement of genomic research. Gel and capillary electrophoresis are the two conventional methods for DNA separation. Unfortunately, the effectiveness of these two methods is compromised for large fragments of DNA. Recently, surface electrophoresis has been developed as a new technique that offers the potential to separate long DNA chains. Previous studies of surface electrophoresis have focused on non-conducting polymeric and semi-conductive surfaces [1]. In this study, a novel approach using conductive substrates for surface electrophoresis was explored. To understand the dynamics of DNA motion across a flat surface under the influence of an electric field, in situ analyses of movements of DNA fractions were performed.

A new method for depositing DNA was also developed. Traditionally, DNA solution is placed on a substrate by micropipette, forming a circular droplet of DNA. However, this ring formation is not ideal because DNA fragments start migrating from different curved positions. Thus, a polydimethysiloxane (PDMS) stamping technique was created to confine the DNA into a rectangular conformation that is more suitable for electrophoresis.

A drop of DNA solution was deposited on polyester films coated with indium tin oxide (PET-ITO.) The PDMS stamp was placed on top of the droplet, forming a rectangular shape of DNA. Mobility of DNA fractions was measured using fluorescence microscopy. Separation of DNA fragments was optimized by varying Tris-Borate-EDTA buffer concentrations from 10^{-3} to 10^{-1} X, DNA concentrations from 5 to 50 μg/ml and electric fields from 3 to 7 V/cm. The migration of YOYO-labeled DNA was examined using laser scanning confocal fluorescence microscopy.



Results indicate that conducting surfaces are promising for DNA separation by surface electrophoresis. DNA bands were visually observed in situ traveling under the influence of the electric field. This furthers the understanding of adsorption/desorption mechanisms.

Figure 1. Superimposed time-lapse fluorescence images of the movement of λ MonoCut DNA at PET-ITO surface.

1. Pernodet, N., Samuilov., Shin, K., Sokolov, J., Rafailovich, M.H., Gersappe, D., & Chu, B. (2000). DNA Electrophoresis on a Flat Surface. Physical Review Letters, 85 (26), 5651-5654.

Session XIII: Organizations of Proteins at Polymer Surfaces

Chairs: Lenny Slutsky

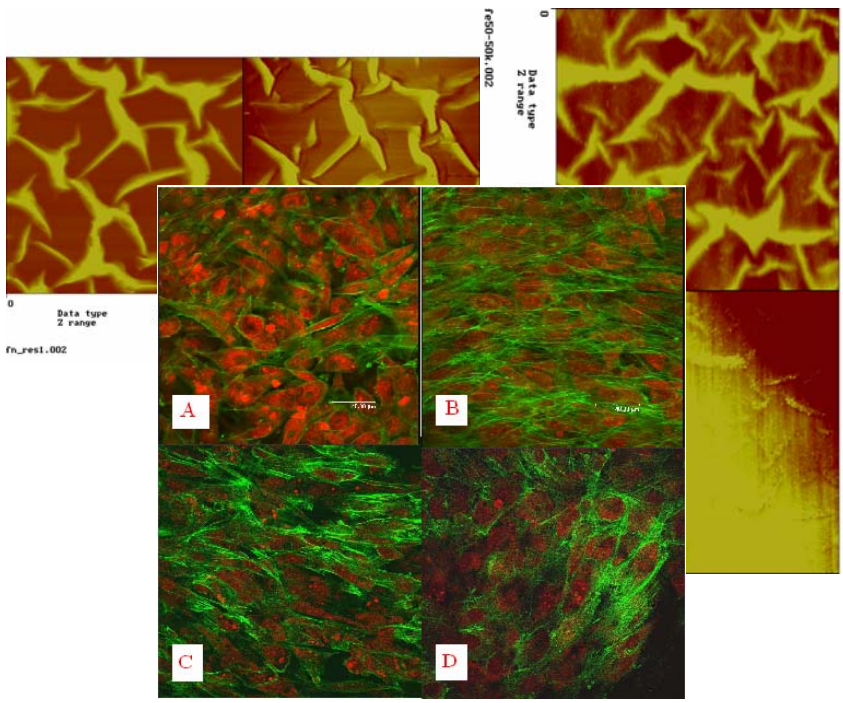
Kate Dorst

Jency Daniels

Yishu Huang

Samantha Palmaccio

Danielle Schwartz



Fibrinogen: A Study of Structure and Function

Jency Daniel, *St. Anthony's High School, 275 Wolf Hill Road, South Huntington, NY*
Kate Dorst, *Dowling College*
Lenny Slutsky, *Duke University*
Nadine Pernodet, Miriam Rafailovich, *Stony Brook University*

Fibrinogen is a plasma protein produced in the liver which is present in the skin's extracellular matrix (ECM). It is converted into insoluble fibrin during the crucial blood clotting and wound healing processes[1]. There are several different variants of fibrinogen, including I-2H and the highly soluble I-8, both of which were observed and analyzed in this study. This project was a basic study of the structure and function of the protein fibrinogen, without which the blood clotting process could not be initialized.

In order to simulate the ECM, 27% sulfonated polystyrene (SPS) was used. This polymer is known to mimic cell charge and causes proteins to migrate and unfold[2]. The SPS was dissolved in dimethyl formamide at a concentration of 8.0 mg/mL, and the resulting solution was spun cast onto silicon wafers to create thin films of approximately 250 Å thickness. The wafers were then annealed in a vacuum oven for 2-3 days, and the two fibrinogen types (I-8 and I-2H) were plated onto them. After being incubated for 3-4 days, surface topography and friction data on the samples were obtained using the atomic force microscope (AFM). Using the AFM, the protein fiber networks of both fibrinogen I-8 *(Figures 1 & 2)* and I-2H *(Figures 3 & 4)* could be observed. Mechanical properties and heights of the protein fibers were also recorded.

Preliminary findings and results show no significant differences between the two fibrinogen types. In one trial, the I-8 protein fiber network was irregular and could not be seen clearly under the AFM *(Figures 1 & 2)*. The hypothesis includes that the severe atmospheric humidity may have altered the proteins in some way and may have inhibited their ability to properly form a protein fiber network. Additionally, there may have been contaminants on the silicon wafers such as dust or dirt which were not properly removed and which may have had adverse effects on the thin film quality. Future work is hoped to be done, to observe these two fibrinogen variants in more depth and perhaps discern differences between them.

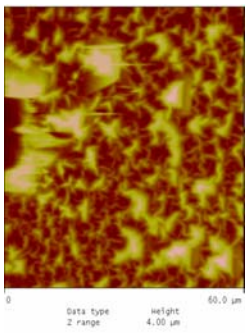


Figure 1
Fibrinogen I-8

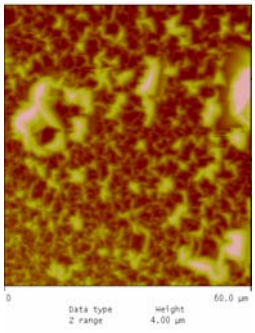


Figure 2
Fibrinogen I-8

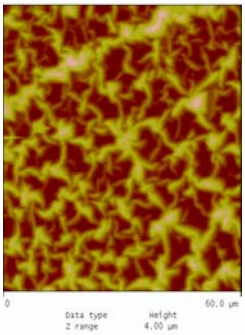


Figure 3
Fibrinogen I-2H

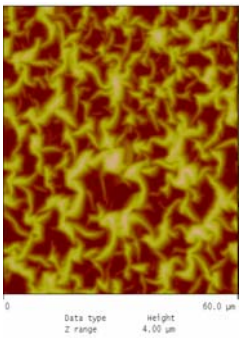


Figure 4
Fibrinogen I-2H

[Note: AFM image scale is 60.0 µm]

[1] Makogonenko, Evgeny, Tsurupa, G., Ingham, K., Medved, L. *Interaction of Fibrin(ogen) with Fibronectin: Further Characterization and Localization of the Fibronectin-Binding Site.* Biochemistry 2002; 41: 7907-7913.

[2] Pernodet N, Rafailovich M, Sokolov J, Xu D, Yang NL, McLeod K. *Fibronectin fibrillogenesis on sulfonated polystyrene surfaces*. J Biomed Mater Res. 2003; 15;64A(4): 684-92.

Biomineralization on Mixed Protein Templates

Yishu Huang. Ward Melville High School 380 Old Town Rd Setauket, NY 11733-3499
Miriam Rafailovich, Nadine Pernodet, Xiaolan Ba. Stony Brook University

Biomineralization is the process by which organisms produce minerals. While it creates a wide range of complex structures, very little is known about the actual process. Applications of further knowledge about biomineralization include effective treatment of bone disorders. The purpose of this research is to observe and study the early process of biomineralization in an artificial extracellular matrix created using mixed protein solutions. Our system, using sulfonated polystyrene film, is unique in the way that this surface induces spontaneous protein fibrillogenesis.

Silicon wafers were cut into 1cm by 1cm squares, cleaned and spuncast to create a thin film of sulfonated polystyrene on the wafers. To plate the wafers, different concentrations of mixed protein solution of fibronectin and elastin were used in ratios Fn-El= 25-75, 50-50, 75-25, and 100-0, in order to define the different influence of each protein on the biomineralization process, as protein adsorption is crucial to the development of tissues. [1] The samples were incubated for 3 days at 37°C, and examined with the atomic force microscope. Mechanical response from each successful fiber-yielding concentration was followed with lateral force modulation at t=0 and then samples were immersed in kitano solution for two hours to allow biomineralization.

The concentration of Fn-El=25-75 was found to be unsuccessful in creating protein fibers and in protein adsorption after looking at AFM images. Concentrations of Fn-El= 50-50 (see fig. 1), 75-25, and 100-0 yielded good fiber networks. Fibers showed no obvious signs of mineral deposition after two hours, although they became slightly more rigid (see figures 1 and 2). Data will be compared with that of fibers after 24-hour immersion in kitano solution.

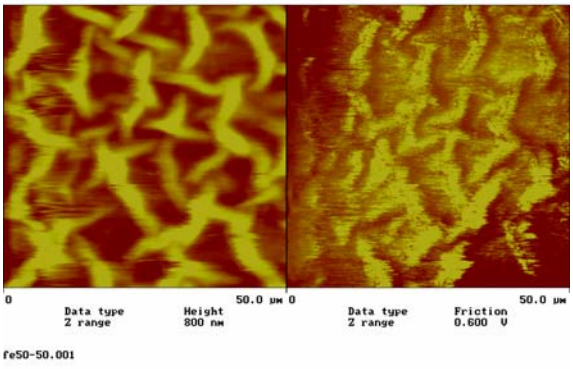


Figure 1
Fibronectin-elastin fibers= 50-50

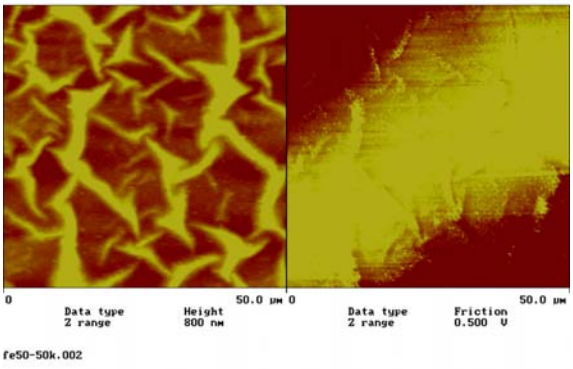


Figure 2
Fibronectin-elastin fibers= 50-50 after immersing in kitano for 2 hours

1. Nadine Pernodet, Miriam Rafailovich, Jonathan Sokolov, D. Xu, Nan-Loh Yang, Kenneth McLeod. *Fibronectin fibrillogenesis on sulfonated polystyrene surfaces.*

The Role of Tissue Non-Specific Alkaline Phosphatase in the Biomineralization of Osteoblasts

Samantha Palmaccio, Dr. Michael Vaccariello**,** Sachem High School East,
Dr. Yizhi Meng, Prof. Miriam Rafilovich, Nadine Pernodet, Stony Brook University

Bone is perhaps the most universal mineralized tissue in the subphyla Craniata, often functioning as a system of structural support and an ion reservoir.[1] However, the precise mechanisms of deposition of bone mineral are still unknown. Recent studies have suggested that mineral nucleation is triggered by the release of matrix vesicles enriched with tissue non-specific alkaline phosphatase(TNAP).[2] TNAP is known to be vital in bone formation yet its specific function is still unclear. It is hoped that by monitoring the levels of alkaline phosphatase activity while observing the biomineralization of cultured osteoblast cells, the specific function of the enzyme could be discovered.

A mineralizing and nonmineralizing subclone of MC3T3-E1 cells were cultured in α-MEM culture medium supplemented with glutamine, 10% fetal bovine serum, penicillin and streptomycin on 1cm by 1cm substrates of either plasma treated glass or polydimethylsiloxane (PDMS) or an empty polystyrene well for up to 28 days. Cells were incubated to near confluence when the medium was supplemented with L-ascorbic acid and β-glycerophosphate. Immunofluorescence staining was conducted using Alexa Fluor 488 Phalloidin and Propidium iodide before the cells were imaged using confocal scanning laser microscopy. The alkaline phosphatase activity was quantified by adding p-nitrophenyl phosphate disodium and 2-amino-2-methyl-1-propanol to cells and measuring the absorbance using Bio-Tek EL 800 Plate Reader.

Thus far the data obtained suggests that alkaline phosphatase activity levels significantly increase over time. As shown in Figure one the nonmineralizing subclone (-) has also been found to produce slightly higher levels of alkaline phosphatase activity than the mineralizing subclone (+) on all three substrates (Glass, PDMS and Empty Well). Confocal microscopy has yielded images such those in Figure 2. The images obtained have shown little observable differences between the mineralizing (A, C) and nonmineralizing (B, D) subclone over 7 and 14 days mineralization on glass and PDMS. Future work includes continuing current experiment and conducting transmission electron microscopy.

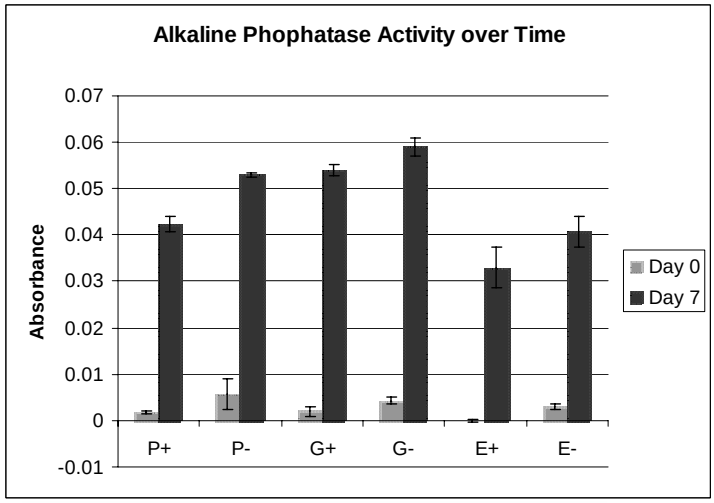


Figure 1 Alkaline Phosphatase Activity over Time

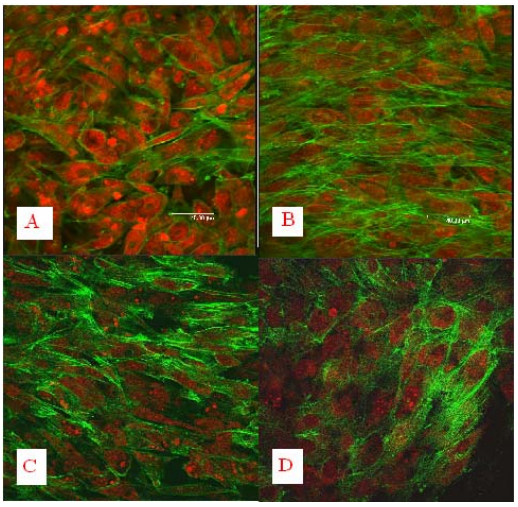


Figure 2: A-B Glass Day 7; C-D Glass Day 14

[1] Lowenstam, Heinz A., and Stephen Weiner. On Biomineralization. New York: Oxford University Press, 1989.

[2] Anderson, H. Clarke, Rama Garimella and Sarah E. Tague. "The Role of Matrix Vesicles in Growth Plate Development and Biomineralization." Frontiers in Bioscience 10(2005): 822-837.

Conductivity of Silicon and Fibronectin Adsorption

Danielle Schwartz, The Wheatley High School
Kate Dorst, Dowling College
Lenny Slutsky, Duke University
Nadine Pernodet, Miriam Rafailovich, Stony Brook University

The extracellular matrix (ECM) is a structure made up of a variety of protein molecules and polysaccharides. The ECM affects the many characteristics of a cell. These include how cells grow, move, adhere to, and migrate, which all play an integral part in the wound healing processes. In past experiments, it has been revealed that cells alter according to unique surface properties. It has been discovered that adsorption does not occur on gold surfaces.[1] With this discovery, it was hypothesized that the resistance of the substrate was an additional factor. Therefore, the amount of protein absorption that occurred on Silicon wafers was studied as a function of substrate resistance. ECM formation was studied on Sulfonated Polystyrene (SPS) surfaces which have been proven to induce spontaneous protein fibrillogenesis.[2] It was hypothesized that the ECM would increase in size as the resistance increased due to surface charge density.

Experimentation began when the resistance of various Silicon wafers was tested. An 8 mg/mL solution of SPS was then prepared and spun cast onto hydrophilic wafers of these different resistances. Before being spun cast these wafers were cleaned with the Shikraki method. After being spun cast, the SPS was allowed to anneal in the oven overnight at 170 degrees Celsius. This entire process was preformed twice once in order to plate Fibronectin and once in order to plate Osteoblasts in order to observe the surface and mechanical properties of the ECM under the Atomic Force Microscope (AFM).

The results of this process so far have shown that with Fibronectin there appears to be a threshold resistance. The average vertical and horizontal measurement of the fibers of the Silicon wafers of 176 Ω seem to be greater (vertically: 781.81 nm horizontally: 3.839 μm) than those of small resistance 20kΩ (vertically: 443.42 nm horizontally: 3.361μm) and most importantly those of extremely high resistance 1.14M (vertically: 496.57 nm horizontally: 3.121μm). This contradicts the hypothesis that as resistance increases the ECM will also increase in size.

a) b) c)

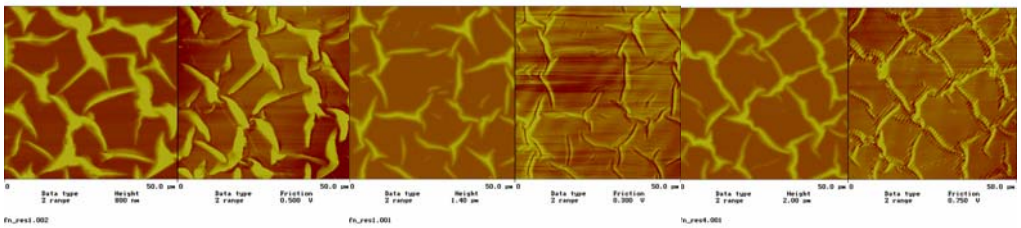


Figure 1: AFM images of adsorbed FN on PSS as a fuction of Si substrate resistance. Left: topography Right: friction (a) R=176 Ω (b) R=20kΩ (c) R=1.14M

[1] Pernodet, N.; Rafailovich M.; Sokolov, J.; Xu, D.; Yang, N. L.; Mcleod, K. "Fibronectin fibrillogenesis on sulfonated polystyrene surfaces." *Journal of Biomedical Materials Research* **2003,** 4, 684-692.
[2] Pernodet, N.; Slutsky, L; Jerome, John; Rafailovich M. "Control of cell morphology through protein organization on Au/Si micropatterns." *American Physical Society* **2004.**

Garcia MRSEC
Polymers at Engineered Interfaces

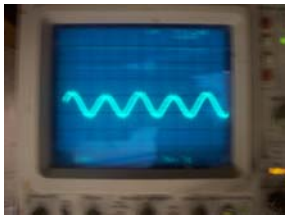
Summer Scholar Program Schedule of Activities

EVERY DAY STARTS WITH A GROUP MEETING IN HEAVY ENGINEERING!

CHECK SCHEDULE DAILY!

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
Week of 6/26	**26** 10:00 AM Group Meeting *Welcome, Attendance, Phone Numbers, Young Scholars, IDs, Parking*, Lourdes Collazo *Welcome, Lab Rules and Regulations, Communication,* Allen Sachs 11:00 AM *Thinking Outside the Box: The Fun and Challenge of Doing Transitional Research,* Srinivas Pentyala 12:00 PM Lunch 12:45 PM *Competitions, Journal Club,* Allen Sachs *Organization of Tour Groups,* Lourdes Collazo 1:30 PM Lab Tours *Atomic Force Microscopy*, Yantian Wang *Confocal Microscopy*, Srinivas Pentyala *Tensile Testing*, Richard Clark, Shazia Rana, Kaustabh Ghosh *Cell Lab*, Nadine Pernodet *Dermatology,* Dr. Richard Clark *Administration Building, Library, Staller Center, Gymnasium, Chemistry Stockroom* *Chemistry Building*, Al Silverstein	**27** 10:00 AM Group Meeting *Lab Notebooks,* Miriam Rafailovich *Distribution of Lab Boxes, Storage, Etc…,* Lourdes Collazo 11:00 AM *All About Spincasting,* Steven Schwartz 12:00 PM Lunch 1:15 PM *Chemical Disposal,* Lourdes Collazo *Machine Shop Tour and Lecture,* Lester	**28** 10:00 AM Group Meeting 10:30 AM *Biomineralization*, Elaine DiMasi 11:30 AM Lunch 12:15 PM *Siemens Westinghouse Math:Science:Technology Competition,* Jennifer Harper, Veronica Angeles 1:30 PM Research for Journal Club, ID's *CAD Lab,* Hary Jaber	**29** 10:00 AM Group Meeting *Drug Delivery and Hydrogels,* Daniel Cohen 11:00 AM *EH & S Safety Lecture* 12:30 PM Lunch 1:15 PM *TEM,* Eli Sutter 2:00 PM *Ovens and Vacuums*, Jon Sokolov 3:00 PM Lab Safety Quiz	**30** 10:00 AM Group Meeting 10:30 AM *Learning Science Databases,* Godling Johnson *Excel Tutorial,* Vladimir Zaitsev 12:30 PM PIZZA Lunch and Journal Club  2:30 PM *IDs, Absentees, New Arrivals & Problems Resolution,* Lourdes Collazo
Week of 7/3	**3** 	***4*** 	**5** 10:00 AM Group Meeting 11:00 AM *Ellipsometer Measurement of Thickness,* Henry White 12:30 PM Lunch 1:30 PM Spincasting	**6** 10:00 AM Group Meeting 10:30 AM *Statistics,* Miriam Rafailovich 12:00 AM Lunch 12:45 PM *Spincasting,* Lourdes Collazo	**7** 10:00 AM Group Meeting 10:30 AM *Waste Management and Marine Science,* Larry Swanson 11:30 AM *Group Presentation*, Taylor Bernheim 12:00 PM Lunch and Journal Club 2:30 PM Completion of Spincasting Lab
Week of 7/10	**10** 10:00 AM Group Meeting 10:30 AM *Mechanical Response of Cells,* Igor Sokolov 12:30 PM Lunch 1:15 PM *Spincasting: Completion and Analysis*	**11** 10:00 AM Group Meeting 10:30 AM *Energy Research,* Devindar Mahajan 11:15 AM *Nanocomposites in Commercial Use* 12:00 PM Lunch 1:00 PM Journal Reading Lab Work Meetings With Mentors 2:00 PM *The Science of Cosmetics,* Isabelle Afriat 3:30 PM Journal Reading Lab Work Meetings with Mentors	**12** 10:00 AM Group Meeting 10:30 AM  **Southampton Bay Cruise**	**13** 10:00 AM Group Meeting 10:30 AM Nissim Garti 11:30 AM Lunch 12:30 PM Journal Reading Lab Work Meetings with Mentors	**14** 10:00 AM Group Meeting 10:30 AM *Intellectual Property, Patents, Etc…,* Donna Tumminello 11:15 AM Group Presentations of Spincasting Results 12:15 PM Lunch 1:00 PM Lab Work Meetings with Mentors: Begin "Rules Wizard" and ISEF Forms
Week of 7/17	**17** 10:00 AM Group Meeting 12:30 PM Lunch 1:00 PM Work on Projects	**18** 10:00 AM Group Meeting 10:30 AM *Siemens Intellectual Property Department,* Joseph Condispoti 12:00 PM Lunch 1:00 PM Work on Projects	**19** 10:00 AM Group Meeting 11:30 AM Work on Projects 12:30 PM Lunch 1:00 PM Work on Projects	**20** 10:00 AM Group Meeting 11:30 AM *Microscopy Lecture,* Richard Clark 12:30 PM Lunch 1:00 PM Work on Projects	**21** 10:00 AM Group Meeting 10:15 AM *Polymer Dynamics,* Miriam Rafailovich 11:00 AM Group Presentations: *Polymer Disintegration and Environmental Effects,* Yehuda Grossman, Joseph Gutterman *Effect of Cloisite Clay Nanoparticles on Dermal Fibroblasts,* Brian Fromm, Sagar Mehta *Cytotoxic Effects of Nanoparticles on Normal Cells and on Stem Cell*

					Differentiation, Sean Pi *Cell Mechanics,* Kristin Hall
Week of 7/24	**24** 10:00 AM Group Meeting 10:30 AM Work on Projects 12:00 PM Lunch 1:00 PM Work on Projects	**25** 10:00 AM Group Meeting 10:30 AM Garcia Center Annual Canoe Trip on the Nissequogue River	**26** 10:00 AM Group Meeting 10:30 AM *Research Ethics,* Allen Sachs 11:15 AM Lunch 12:15 PM Work on Projects	**27** 10:00 AM Group Meeting 10:30 AM Polymer Dynamics, Dilip Gersappe 11:15 AM Lunch 12:15 PM Work on Projects	**28** 10:00 AM Group Meeting Group Presentations: *Swelling of Polymers with Nanotubes,* Hila Calev *Supercritical CO_2 Effect on Polymers for Gas Masks,* Philip Tan *F127 and Cells,* Ankurai Desai *Study on Pure EVA,* Mike Gebhardt, Prane Wang *Mathematical Modeling of Fibroblast Migration,* Victoria Hung *Cell Growth and Proliferation on Superparamagnetic Polymer-Clay Nanocomposites,* Mary Catherine Wen, Jenny Yeh *Recycled Polymers and Supercritical CO_2,* Danielle Lent, Emily Levine
Week of 7/31	**31** 10:00 AM Group Meeting 10:30 AM Work on Projects 12:00 PM Lunch 1:00 PM Work on Projects Sign Up for After-Hours Work	**1** 10:00 AM Group Meeting 10:30 AM Work on Projects 12:00 PM Lunch 1:00 PM Work on Projects	**2** 10:00 AM Group Meeting 10:30 AM Work on Projects 12:00 PM Lunch 1:00 PM Work on Projects	**3** 10:00 AM Group Meeting 10:30 AM Work on Projects 12:00 PM Lunch 1:00 PM Work on Projects	**4** 10:00 AM Group Meeting Group Presentations: *Effects of Magnetic Fields on Biomineralization of Osteoblasts,* Jamie Jerome *Electromagnetic Properties of Proteins,* Danielle Schwartz *Surface Effects on Stem Cells,* Margaret Davidson, Shuai Qin *TiO_2 Effects on Stem Cell Proteins,* Kiwoong Yoo, Adam Hyams *Biomineralization,* Samantha Palmaccio *Cell Growth on Clay Particles,* Radha Ramjeawan *Nanocomposites and Nanolithogoraphy,* Jason Strauss *Neuronal and Cancer Cell Growth on Nanopatterns,* Adam Fields, Alex Ramek *Cell Growth and Proliferation on Superparamagnetic Polymer-Clay Nanocomposites,* Mary Catherine Wen, Jenny Yeh
Week of 8/7	**7** 10:00 AM Group Meeting 11:00 AM Work in labs Prepare for Symposium	**8** 10:00 AM Group Meeting 11:00 AM Work in labs Prepare for Symposium	**9** 10:00 AM Group Meeting 11:00 AM Work in labs Prepare for Symposium	**10** 10:00 AM Group Meeting 11:00 AM Work in labs Prepare for Symposium	**11** **End of Summer Research Presentations** **SACAuditorium** **10 am- 3pm**



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Dr. Srinivas Pentyala: "Thinking outside the Box: The Fun and Challenge of Doing Transitional Research"
Dr. Steven Schwartz: "All About Spincasting"
Lourdes Collazo: "Chemical Disposal"
Dr. Elaine DiMasi: "Biomineralization
Jennifer Harper and Veronica Angeles "Siemens-Westinghouse Math:Science:Technology Contest
Dr. Daniel Cohn: "Drug Delivery and Hydrogels"
Dr. Klaus Mueller: "Digital Imaging
Dr. Johnson, BNL: "TEM"
Dr. Sokolov: "Ovens and Vacuums"
Ms. Godlin Johnson "Learning Science Databases"
Dr. Vladimir Zaitsev "Excel Tutorial"
Dr. Henry White: "Ellipsometer Measurement of Thickness"
Dr. Rafailovich: "Statistics"
Dr. Larry Swanson: "Waste Management & Marine Science"
Dr. Igor Sokolov: "Mechanical Response of Cells"
Lourdes Collazo: "Working with Cells"
Dr. Devindar Mahajan: "Energy Research"
Isabelle Afriat: "The Science of Cosmetics"
Dr. Nadine Pernodet: "Tissue Engineering"
Donna Tumminello: "Intellectual Property, Patents, etc."
Joseph Condispoti, Siemens Intellectual Property Dept.
Dr. Richard Clark, "Microscopy Lecture"
Allen Sachs: "Research Ethics"
Dr. Dilip Gersappe: "Polymer Dynamics"
Dr. Dick Stein, Natural Academy of Sciences: "Global Warming"

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