Garcia MRSEC

NSF

Polymers at Engineered Interfaces

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

Research Scholars Program 2007

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

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"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 a coordinated research program 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 Scholar Program offers the opportunity for high school teachers and students to perform research on the forefronts of polymer science and technology together with the 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.

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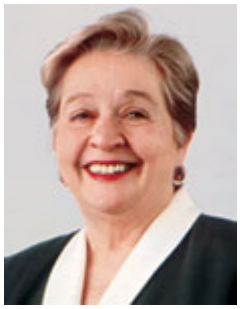
Miriam Rafailovich
Professor, Garcia MRSEC

Jonathan Sokolov
Professor, Garcia MRSEC



MESSAGE FROM PRESIDENT KENNY

Congratulations on completing the formal phase of the summer program. The presentation of your research to parents and teachers is a highlight in what has been a remarkable opportunity to nurture critical reasoning skills and experience science in a new and challenging environment.

You are among the top science students in the country. Garcia High School Research Scholars have been highly successful and recognized by the most respected scientists in the nation. You have worked closely with exceptional faculty and graduate students in the School of Engineering and the School of Medicine. We hope the program has provided a glimpse of what it's like to choose science research as a career; and that your academic experience has been enriched by the excitement of discovery.

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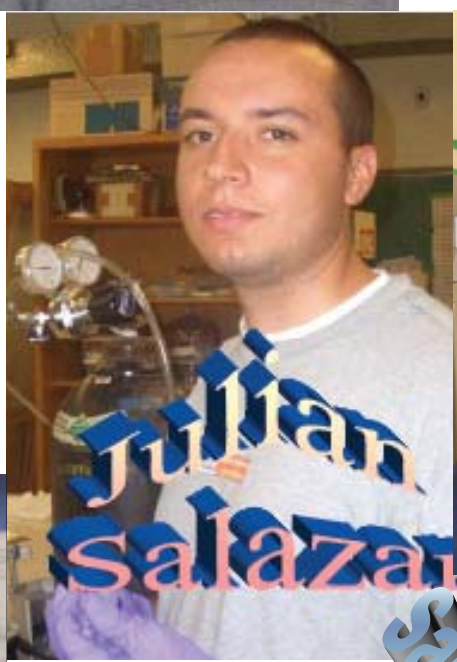
Many of you will go into medicine and health care where research is vital. Some of you will be engineers and scientists where progress occurs through science and research. Many may take a different road finding their life's work in other professions, such as law, business or the humanities; and this may be the only time you enter the world of research. We hope, regardless of your career path, you will continue to value science; and your experience this summer will allow you to apply it ethically and wisely throughout your lives.

Congratulations on your commitment to this outstanding program. We are confident in your ability to be the leaders of tomorrow.

Shirley Strum Kenny
President

Research Experience for Teachers



Grads & Post Docs


Tatsiana Mironava


Seongchan Pack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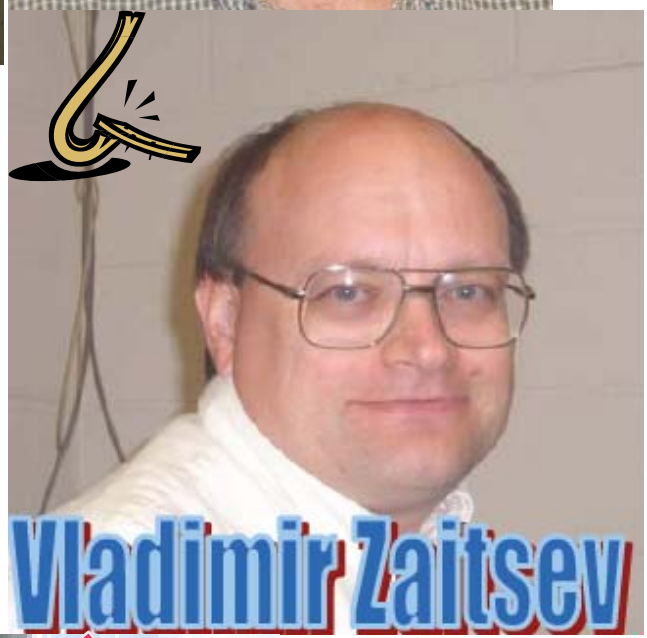
Vladimir Zaitsev


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Research Experience for Undergrads


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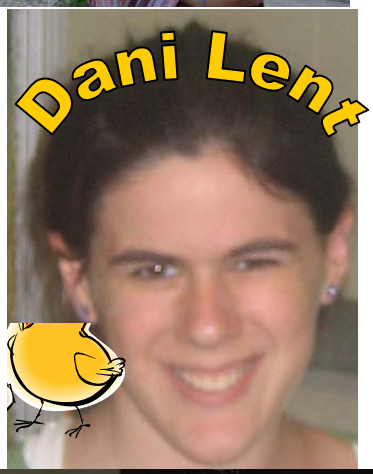
Dani Lent


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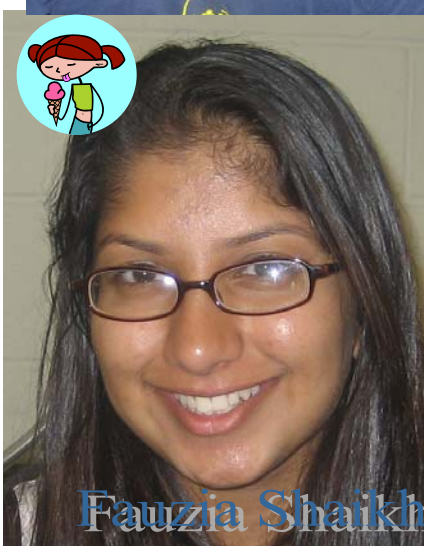
Fauzia Shaikh


Hiliana
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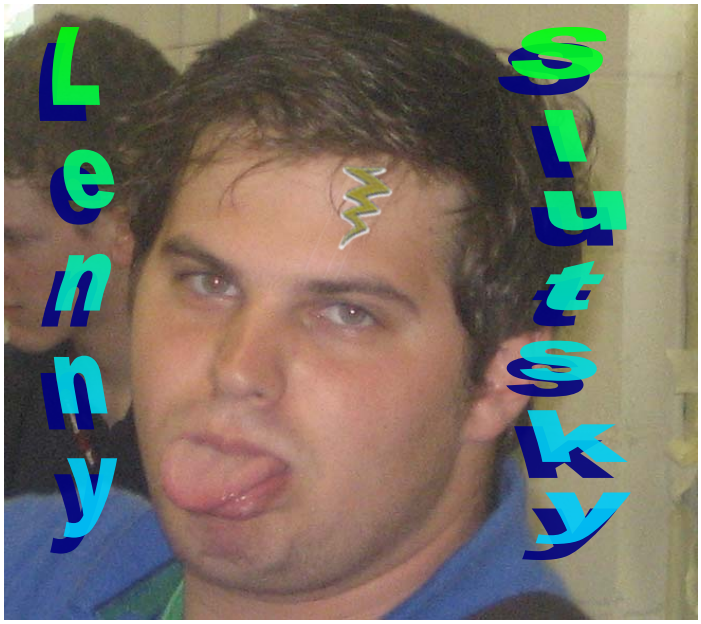
Lenny
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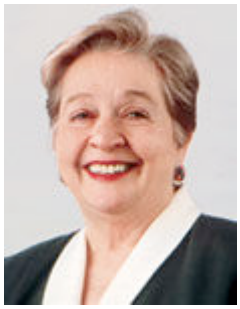
STONY BROOK
STATE UNIVERSITY OF NEW YORK



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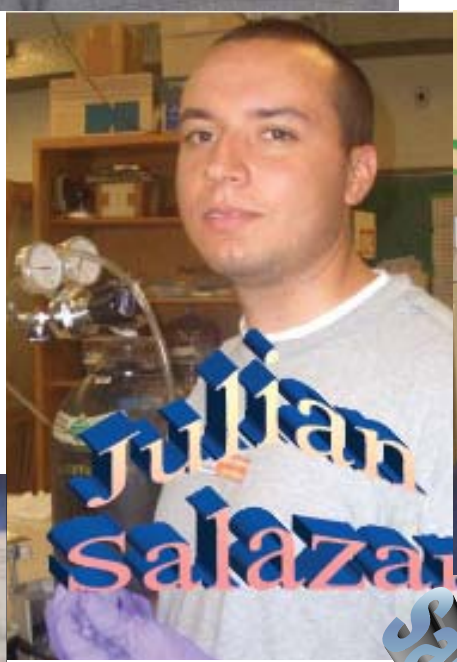

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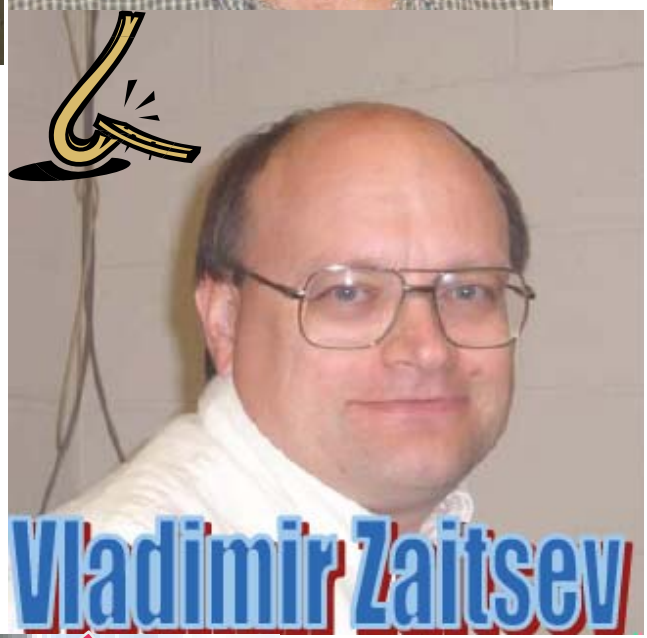
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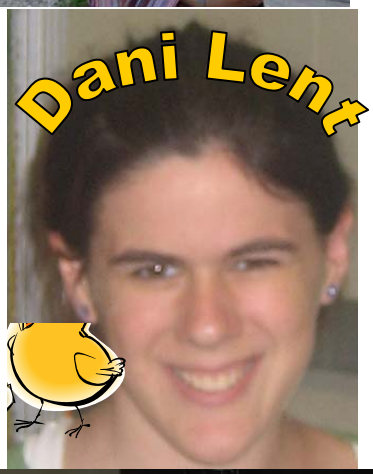
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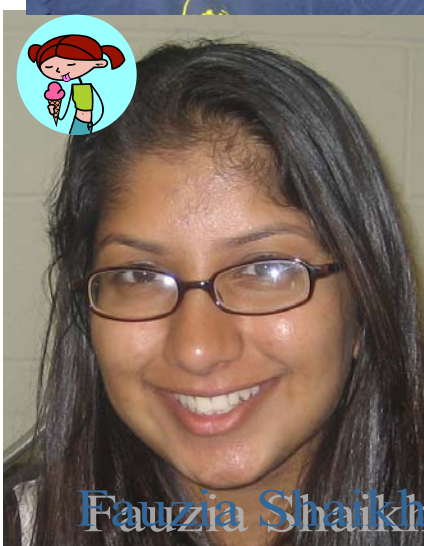
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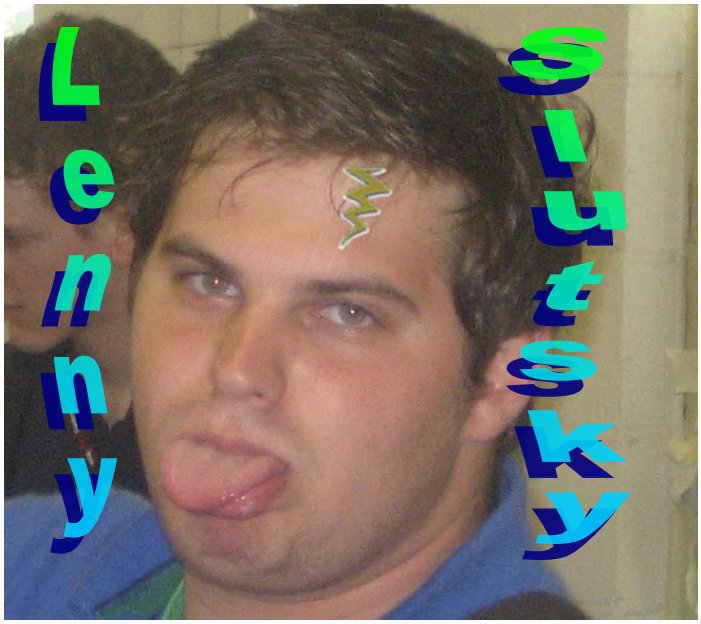
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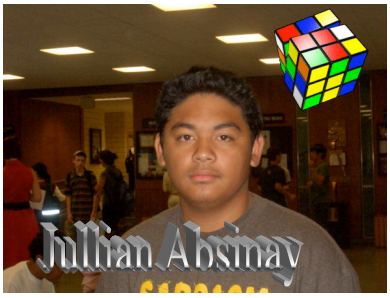
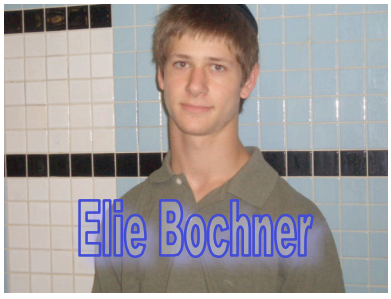
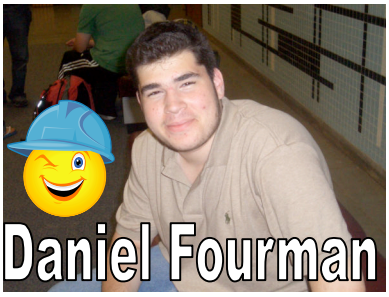
High School Summer Scholars 2007






Adam Fields

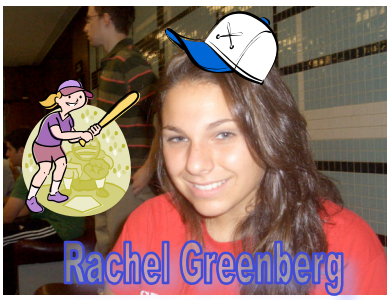

Mitchell Feinberg

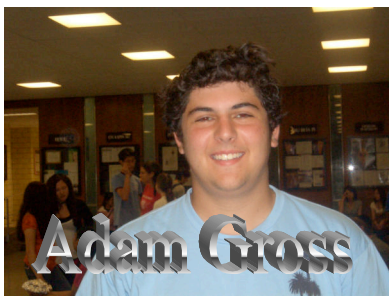

Daniel Fourman

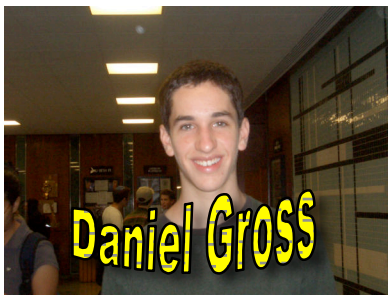

Lara Fourman


Joshua Gordonson


Justin Goldsmith

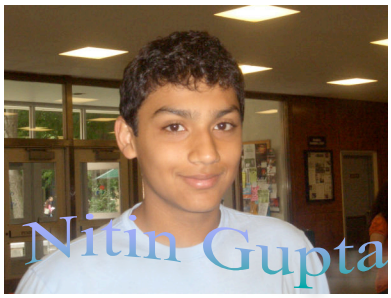

Rachel Greenberg

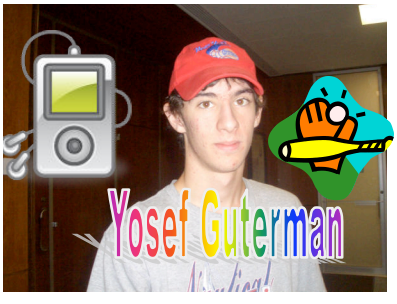

Adam Gross

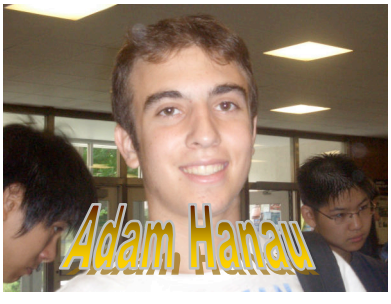

Daniel Gross


Sarajane Gross


Yehuda Grossman


Nitin Gupta


Yosef Guterman


Adam Hanau


Darren Huang


Janet Hui


Nabina Kabir

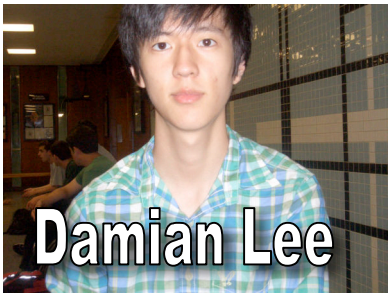

Chun-Kai Kao


Brian Kim

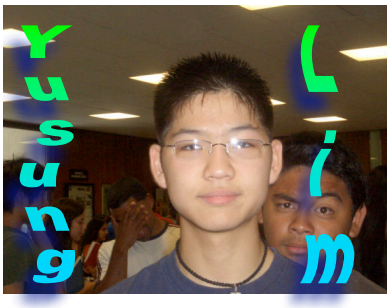

Hyungtae Kim


Sergey Kolchinskiy


Andrew Kugler


Damian Lee


Kimberly Leonard


Yusung Lim


Jovana Linnen


Tanya Masand

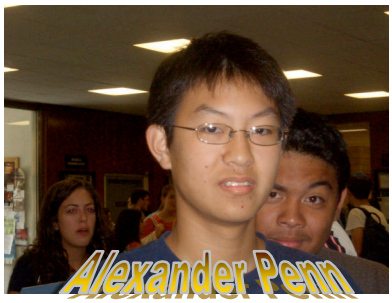

Mili Mehta


Jason Mogen


Dhruv Nandamudi


Rima Patel


Naina Prasad


Alexander Penn


Eliana Pfeffer

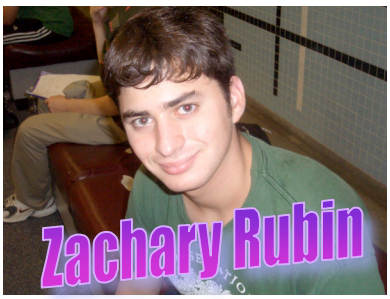

Ryan Price

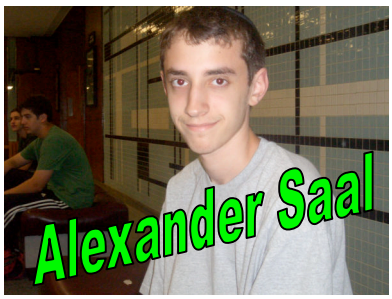

Radha Ramjeawan


Alex Ramek

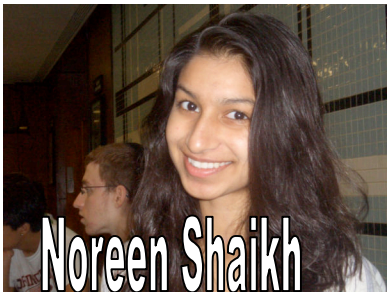

Amy Ramirez


Josh Rosenbaum


Zachary Rubin


Alexander Saal


Jordan Schachar


Noreen Shaikh


Jade Shi


Sanchita Singal


Daniel Stemp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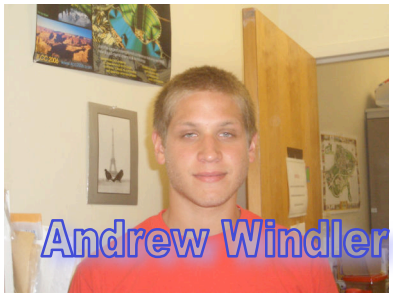
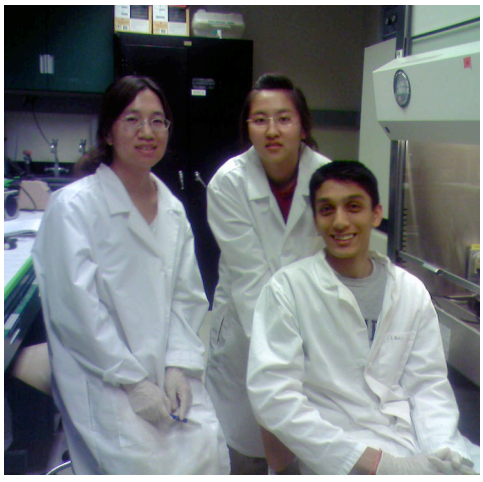

Andrew Windler

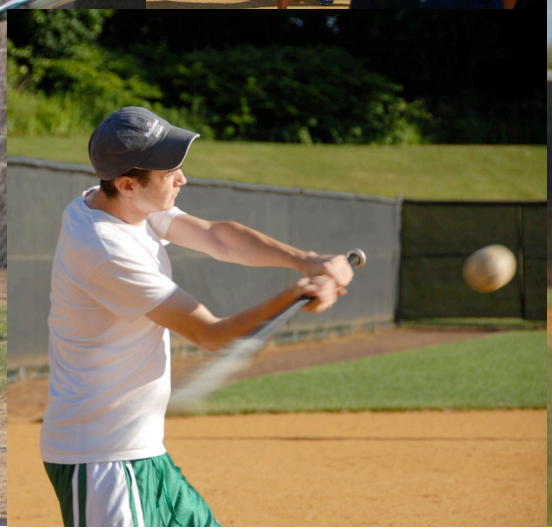

Eran Zapinsky



The First Day

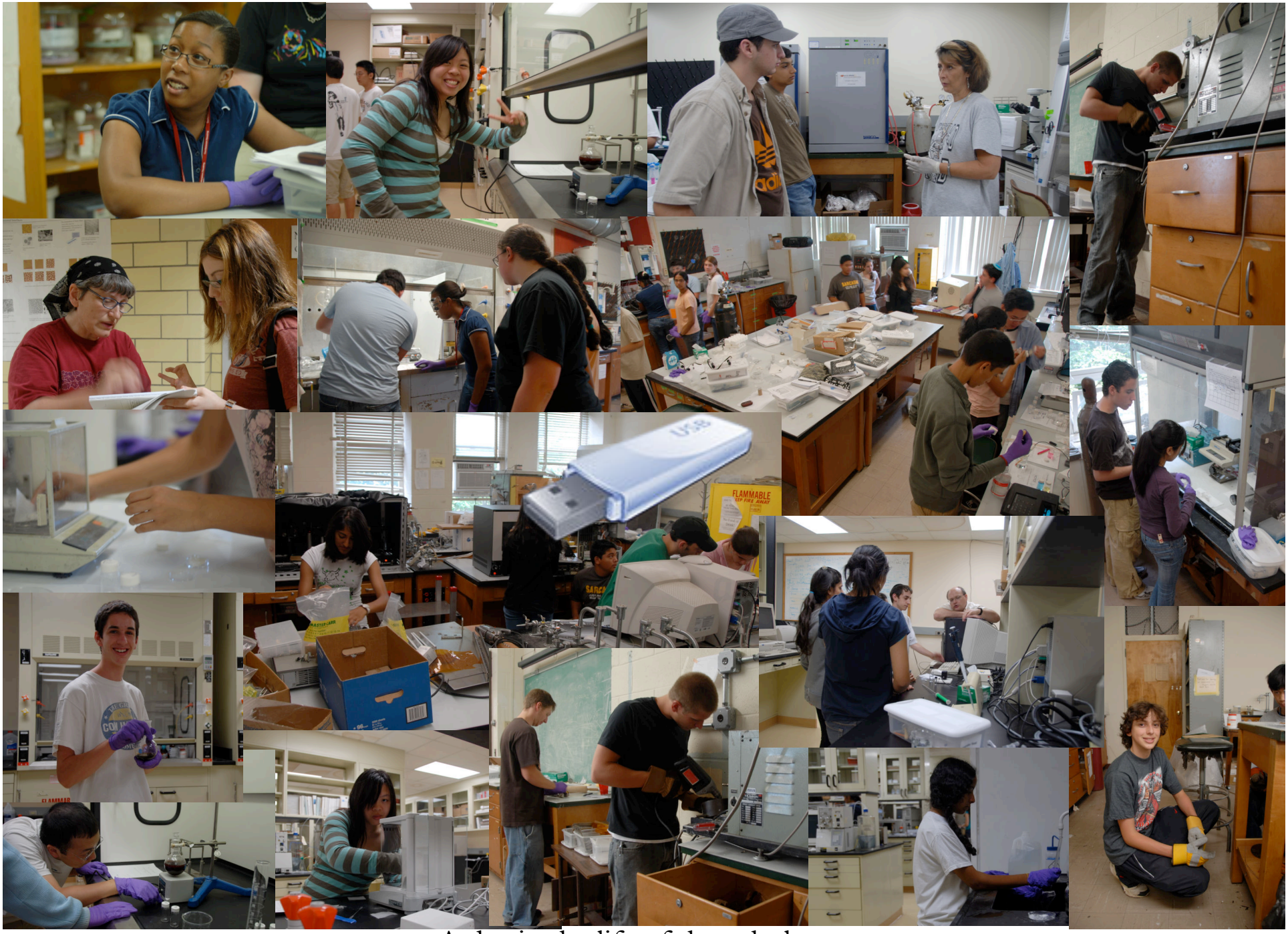
Happy Birthday Hilana!

Science nerds playing softball? Uh oh…



A day with Congressman Steve Israel


NITROGEN
Life in the Lab



A day in the life of the scholars…


Fun in the Sun


A Scientific Symphony
TAU BETA PI

Summer 2007

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RSVP on or before August 7
(631) 632-6097
or e-mail
GarciaResearch@gmail.com

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Rachel Greenberg, Sarajane Gross, Jordan Schachar,
Keratinocyte Extra Cellular Matrix:
Adam Gross and Jason Mogen

The Garcia Center

INVITES YOU TO ATTEND THE

Annual Summer Symposium

of the

Research Scholars Program

on

Friday, August 10, 2007

BETWEEN

10:00 AM-1:00PM

IN THE

Student Activities Center

Auditorium

Schedule of Events

- **Guest Speaker**

Dr. Leonard Poveromo

Director of Technology Research
Northrup-Grumman Corporation

- **Scientific Symposium presented by**

THE STUDENTS

- **Musical Program arranged by**

THE STUDENTS

conducted by

Dr. J. Jerome

- **Buffet Luncheon**

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

10th Annual Summer Research Symposium

10:00 – 10:10 Seating and Multi-Media Presentation
Musical arrangement: **Dr. John Jerome, RET**
Strings: ***Darren Huang, Abraham Chien, Somya Sundaresh, Sanchita Singhal, Nicole Elstein, Dan Fourman, Mitchell Fourman, Hilana Lewkowitz-Shpuntoff, Marc Elstein***
Flute: ***Jovana Linnen, Amy Ramirez, Lara Fourman***
Images: ***Sylvia Qu***

10:10- 10:20 Welcome, **Miriam Rafailovich**
Introduction **Allen Sachs**, Director of Research, North Shore Hebrew Academy HS

Remarks **John Hildebrand,** Newsday Senior Education Correspondent,
Dr. Uma Venkateswaram, National Science Foundation

10:20-10:30 Guest Lecture
Dr. Leonard Poveromo, Director of Technology Research
Northrup-Grumman Corporation

10:30-10:45 ***Session 1: Thin Films for Electronics***

Chairs: ***Robert de la Cruz,*** *Valley Stream High School*
Brienne Kugler, *MIT*
Garcia Staff: ***Yuan Sun, John Jerome, Johnny Wong***

A Macroscopic Study of Electron Tunneling Through Self-Assembled Gold Alkane-Thiol Monolayers
Matthew Alpert, Lawrence High School

A New Approach to the Production of Printed Circuit Boards Nanowires: Supercritical Fluids and its Effect on Polymer Thin Films and Electrospun Fibers
Yusung Lim, Herricks High School
Alex Penn, Monte Vista High School

Synthetic Spider Silk: A Novel Method for the Creation of a Strong and Flexible Material
Josh Gordonson, Syosset High School
HyungTae Kim, Philips Academy

10:45-11:00 ***Session 2: Energy and Methane Hydrates***

Chairs: ***Debbie Yee,*** *MIT*
Garcia Staff: ***Sijia Zhao, Yuan Sun, John Jerome, Johnny Wong***

Methane Hydrates
Daniel Fourman, Ward Melville High School
Jake Bryant, Ward Melville High School

Optimizing the Efficiency of Polymer Electrolyte Membrane Fuel Cells Using Palladium and Gold Nanoparticles
Kenny Kao, George School
Dan Gross, Walt Whitman High School

Hydrogenation of Platinum Nanoparticles for Fuel Cell Application
Justin Goldsmith, Half Hollow Hills High School West

11:00-11:20 ***Session 3: Nanoparticle Toxicity***

Chairs: ***Lucy Wu,*** *UCLA*
Sean Pi, *Princeton*
Garcia Staff: ***Tatsiana Mironava, Rachel Mu, Yuan Sun***

The Effects of Nanoparticles on Breast Cancer Cells
Mili Mehta, The Wheatley School

The Effect of Nanoparticles on Adipocytes and the Process in which the Nanoparticles Enter the Adipocytes
Etan Zapinsky, SAR High School
Adam Hanau, HAFTR High School

The Effects of ZnO and TiO_2 Nanoparticles on Human Dermal Fibroblasts and Keratinocytes
Sowmya Sundaresh, Hicksville High School
Nicole Elstein, Bayport-Blue Point High School

Using Polymers to Prevent the Negative Effects of TiO2 on DNA and Proteins
Nabiha Kabir, Locust Valley Central High School
Alex Saal, SAR High School

Nanomedicine: The Effects of Protein Coated Nanoparticles on Cancerous Cells
Radha Ramjeawan, Uniondale High School

11:20-11:35 ***Session 4: Environmental Issues***

Chairs: ***Julian Salazar,*** *Louis Armstrong High School*
Garcia Staff: ***Lourdes Collazo***

Global Warming and Human Health: Effect of Increased CO_2 Concentration on Myoblasts in the Presence of Carbon Black, an Environmental Pollutant
Nitin Gupta, Jericho High School

The Effect of Copper Nanoparticles and Carbon Dioxide on Myoblasts
Zachary Rubin, North Shore Hebrew Academy High School

Plastic Sand
Yosef Guterman, Hebrew Academy of Nassau County

11:35-11:55 ***Session 5: Special Polymers and Surfaces***

Chairs: ***Elizabeth Casey,*** *Comsewogue High School*
Jason Strauss, *MIT*
Garcia Staff: ***Jennifer Segui, Chunhua Li, Jiali Cai***

Constructing a Biocompatible Scaffold for the Proliferation of Astrocytes
Sruti Akella, John Jay High School
Julian Abinsay, Pablo Academy
Noreen Shaikh, Half Hollow Hills High School East

Flat Panel X-Ray Detectors for Digital Radiography: Planarization of TFT Arrays Using Polyaniline Thin Films
Abraham Chien, Stuyvesant High School
Elie Bochner, Yeshiva University High School for Boys

Comparing the Melting Temperature of EVA Spun Thin Films vs. Thick Films
Andrew Kugler, Jericho High School

The Molecular Weight of Recycled PS Products: A Spin Casting Experiment
Elizabeth Casey, Comsewogue High School

11:55-12:10 ***Session 6: Blending Polymers with Supercritical Fluids***

Chairs: ***John Iraci***, *Cornell University*
Danielle Lent, *Yeshiva University*
Emily Levine, *Yeshiva University*
Steve Lubin, *Duke University*
Mitchell Fourman *Stony Brook University*
Garcia Staff: ***Seongchan Pack***,

Creating a More Environmentally Friendly Flame Retardant
Sergey Kolchinskiy, Lawrence High School
Jade Shi, Los Altos High School

Creating Biodegradable Organic Polymer Composites Using Surfactant and Supercritical Fluid Exposure
Josh Rosenbaum, Yeshiva of Flatbush
Kimberly Leonard, Half Hollow Hills High School East

Enhancing the Properties of Polystyrene and Poly (methyl methacrylate) Blends Using Supercritical Carbon Dioxide and Clay Nanotubes
Andrew Windler, Half Hollow Hills High School East

12:10-12:30 ***Session 7: Cells and Proteins on Surfaces***

Chairs: ***Lenny Slutsky***, *Duke University*
Kate Dorst, *Dowling College*
Garcia Staff: ***Tatsiana Mironava, Chunhua Li, Chunghueh Chang (Simon), Xiaolan Ba, Ja Koo***

An Analysis of Biomineralization on Sulfonated-Polystyrene Surfaces: Comparing Cancerous and Non-cancerous Osteoblast Crystals and Investigating Dental Pulp Stem Cells Differentiation
Adam Gross, Half Hollow Hills High School West
Jason Mogen, Half Hollow Hills High School West

Normal Extracellular Matrix vs. Cancer Extracellular: A Look at the Cell Mechanics
Jovanna Linnen, Uniondale High School

Cell Response to Engineered Surfaces: From Bone Generation to Self-Assembled Fibrinogen Clotting
Adam Fields, Jericho High School
Alex Ramek, HAFTR

Influence of Surface Mechanics on Cell Differentiation Using the Polymer Polybutadiene
Joanne Anthonypillai, Holy Trinity High School
Jackie Belizar, Miller Place High School

Regulation of Cell Behavior Through Mechanical Characterization of Polybutadiene (PB) Fibers
Pooja Vasudevan, The Wheatley School

12:30-12:50 ***Session 8: Cell Dynamics & Cells on Surfaces***

Chairs: ***Hilana Lewkowitz-Shpuntoff,*** *Princeton University*
Fauzia Shaikh, *Harvard University*
Sylvia Qu, *Duke University*
Paula Huang, *Cornell University*
Shuang Chen, *Stony Brook University*
Ram Shankar, *Princeton University*
Garcia Staff: ***Rachel Mu, Tatsiana Mironava, Ying Liu, Zhi Pan, Lourdes Collazo, Chunhua Li, Nicole Brenner***

Human Dermal Fibroblasts Morphology on Oriented Poly (methyl methacrylate) Scaffolds
Ryan Price, Jericho High School
Brian Kim, Manhasset High School

Finding the Optimum Scaffold for the Growth and Proliferation of Myocardium and Satellite Cells
Rachel Greenberg, North Shore Hebrew Academy High School
Sarajane Gross, North Shore Hebrew Academy High School
Jordan Schachar, Yeshiva of Flatbush

Optimized Cell Migration Along Functionalized Surfaces
Danny Stemp, North Shore Hebrew Academy High School
Dhruv Nandamudi, Monta Vista High School

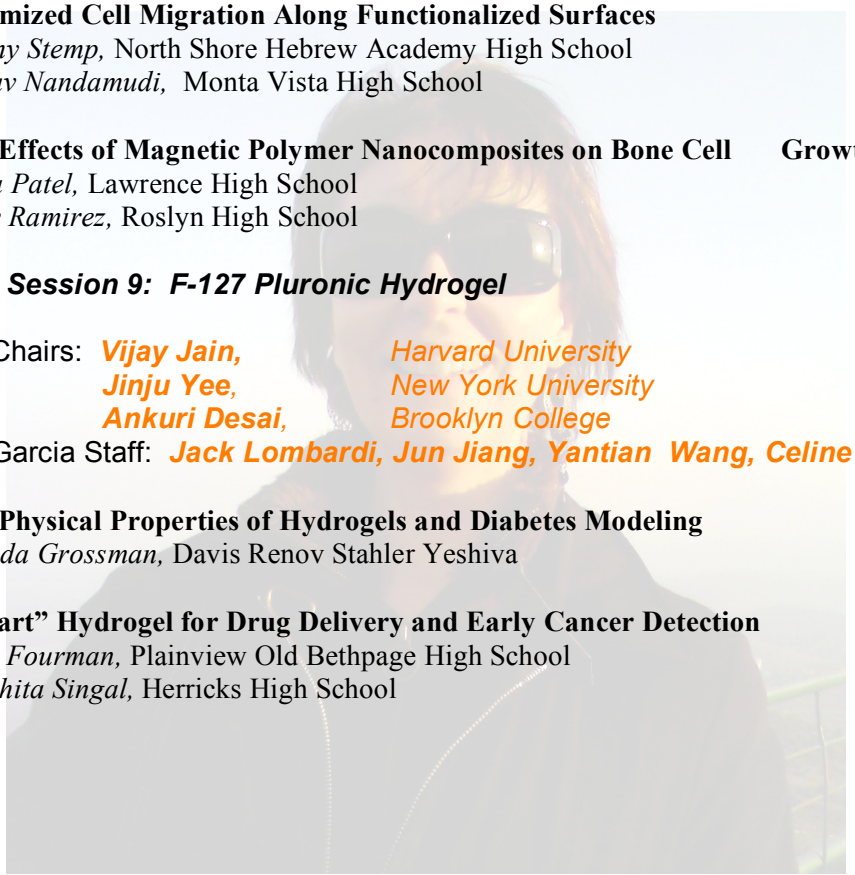
The Effects of Magnetic Polymer Nanocomposites on Bone Cell Growth
Rima Patel, Lawrence High School
Amy Ramirez, Roslyn High School

12:50-1:10 ***Session 9: F-127 Pluronic Hydrogel***

Chairs: ***Vijay Jain,*** *Harvard University*
Jinju Yee, *New York University*
Ankuri Desai, *Brooklyn College*
Garcia Staff: ***Jack Lombardi, Jun Jiang, Yantian Wang, Celine Pujol***

The Physical Properties of Hydrogels and Diabetes Modeling
Yehuda Grossman, Davis Renov Stahler Yeshiva

"Smart" Hydrogel for Drug Delivery and Early Cancer Detection
Lara Fourman, Plainview Old Bethpage High School
Sanchita Singal, Herricks High School



Encapsulation of Bacteria in Electrospun Nanofibers for Water Purification
Mitchell Feinberg, Smithtown High School East
Tanya Masand, Locust Valley High School

Molecular Imprinting to Recognize Alzheimer's Disease Biomarkers
Darren Huang, Locust Valley High School
Damian Lee, Northern Valley Old Tappan High School

1:10-1:25 ***Session 10: DNA***

Chairs: ***Robert Winston***, *Thomas Edison High School*
Jennifer Daniels, *Stony Brook University*
Garcia Staff: ***Chien-Hsiu Lin***

The Effect of HEMA-Coated Zinc Oxide Nanoparticles and UV Radiation on DNA
Naina Prasad, The Wheatley School
Janet Hui, Half Hollow Hills High School East

Combing ssDNA on Polymer and Aptamerized Surfaces
Eliana Pfeffer, Ramaz High School

A Novel Coating that Reduces the Toxicity of Nanotitanium Dioxide and Zinc Oxide
Michael Tischler, Jericho High School

Session I:
Thin Films for Electronics

Chairs: Robert de la Cruz

Brienne Kugler

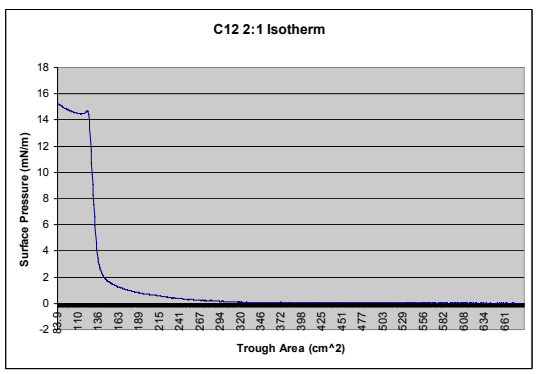
Garcia Staff: John Jerome

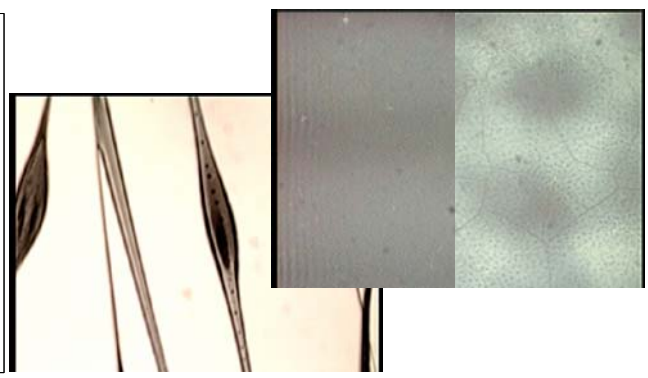
Yuan Sun, Johnny Wong

Matthew Alpert

Yusung Lim, Alex Penn

Josh Gordonson, HyunTae Kim





A Macroscopic Study of Electron Tunneling Through Self-Assembled Gold Alkane-Thiol Monolayers

Matthew Alpert, Lawrence High School
Rebecca Isseroff, Lawrence HS; Yuan Sun, Dr. Miriam Rafailovich, SUNY Stony Brook

Quantum mechanics asserts that all objects can behave as both particles and waves. This tenet of quantum theory has many fascinating consequences, among which is quantum tunneling. The wave nature of an object is characterized by its wave function, denoted by the Greek letter Ψ. The wave function is used to describe a physical system, and is a function of the object's position in space, with the probability of finding that object at a given location proportional to the square of the magnitude of the wave function at that location ($P \sim |\Psi|^2$).

Consider an object approaching a potential energy barrier, such as a "wall." This object's wave function can extend past the barrier, creating a non-zero probability of the object being on the other side of the wall. When the object does successfully make it to the other side of the wall, the phenomenon is known as quantum tunneling. Since electrons are very small in size and mass, they have larger quantum wavelengths than more macroscopic objects, making the quantum phenomenon they exhibit more noticeable.

The phenomena known as Coulomb blockade is a direct result of electron tunneling. When a current is run through two conductors separated by an insulating barrier, some electrons will tunnel through the barrier. Since not all electrons tunnel through the barrier (since there is only a probability they will tunnel), the barrier provides an effective resistance. A device known as the single-electron transistor takes advantage of the Coulomb blockade phenomenon. However, as of yet, Coulomb blockade has only been utilized in single-electron devices which are difficult to create, and has not yet been observed on the macroscopic level.[1]

Alkanethiol-functionalized gold nanoparticles are clusters of gold atoms surrounded by long carbon chains. Therefore, these gold nanoparticles should exhibit Coulomb blockade properties since they are essentially conductors (gold atoms) separated by insulating barriers (alkanethiol chains.)

Monolayer thin films of Au nanoparticles synthesized in ratios of 1:1, 2:1, 3:1, and 4:1 gold-thiol, and functionalized with C6, C12, and C18 thiol lengths, were formed using the Langmuir-Blodgett (LB) trough(fig. 1). As the monolayer is formed the thiol groups self-assemble, creating tremendous regularity in the distance between gold particles of the monolayer. The monolayer thin films were deposited on silicon wafers as well as TEM grids for study using scanning electron microscopy (SEM) and transmission electron microscopy (TEM).

Due to the high regularity and self-assembly of the monolayers, this research hypothesizes that the gold nanoparticles can be used to observe Coulomb blockade properties on the macroscopic level. The monolayers will be deposited on chips in order to measure their electrical properties. The chips, with a monolayer of nanoparticles deposited between two electrodes, will measure the current across the junction when a constant voltage is set across the electrodes. Ohm's law can be used to determine the effective resistance of the monolayer. The varying gold to thiol ratios as well as differences in the lengths of the thiol chains themselves should give each monolayer its own characteristic resistance. This research has applications for nanoscale circuitry.

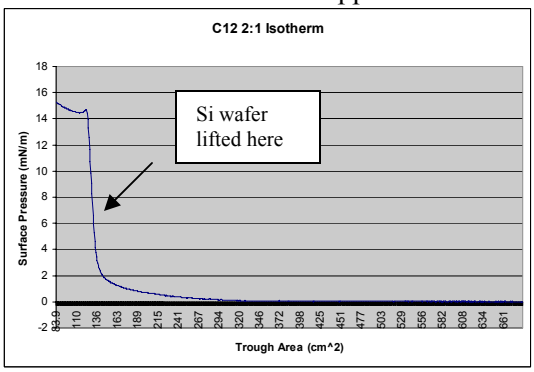


Figure 1. The monolayers are deposited on a silicon wafer submerged in the LB water subphase and vertically lifted when the surface pressure became ~7 mN/m.

This research was funded by the Simons Foundation.

[1] *Coulomb blockade and the Kondo effect in single-atom transistors*. Park, Jiwoong et al. *Nature* 417, 722-725(2002).

A New Approach to the Production of Printed Circuit Boards and Nanowires: Supercritical Fluids and its Effect on Polymer Thin Films and Electrospun Fibers

Alex Penn, Monta Vista High School
Yusung John Lim, Herricks High School
L. John Jerome, Miriam Rafailovich, Robert De La Cruz
Department of Material Sciences and Engineering, Stony Brook University
Brienne Kugler, Massachusetts Institute of Technology

With the rapid spread of computerization comes an increasing demand for cheap and easily manufactured electronics. The worsening of global warming leads to a necessity for environmentally friendly processes. Currently, printed circuit boards (PCBs) are produced through harmful and expensive methods such as plasma or acid etching. Many byproducts of these methods require expensive disposal, with the costs of disposal often exceeding the cost of production. However, by using supercritical carbon dioxide ($scCO_2$) to swell the polymer and increase or decrease the metal adhesion[1], we hope to develop a process in which thin films can be easily patterned with metal. So far, we are determining the difference between amorphous, semi-crystalline, and crystalline polymer thin films and their reactions to $scCO_2$, above and below the supercritical ridge. We have spun solutions of Polystyrene dissolved in toluene, Polycarbonate in chloroform, and Poly (ε-caprolactone) (PCL) in toluene with thicknesses of 100Å, 200Å, 500Å, and 1000Å. After spinning, we exposed the samples to $scCO_2$ at three points above, at, and below the density fluctuation ridge of 1200 PSI at 36˚C. We have discovered that exposure to $scCO_2$ enhances the crystal structure of Poly (ε-caprolactone), demonstrated in Figure 1. Additionally, we used atomic force microscopy to analyze the samples of PCL to confirm this trend. These films have also been masked with a solution of Poly (ethylene oxide) and water prior to supercritical exposure. After metallizing these samples, various peel test will determine the strength of the metal-polymer adhesion and whether this process can be successfully used in industry.

The second phase of this experiment involves the creation of uniform nanowires using Poly (methyl methacrylate). Since nanowires are expensive and difficult to produce consistently in quantity[2], we are testing a new method of creating thin, uniform nanowires that are easy to fabricate. We believe that exposure to $scCO_2$ will cause the Poly (methyl methacrylate) fibers to grow uniformly. In addition, we hypothesize that the inclusion of gold nanoparticles will assist in the formation and metallization of these fibers, as demonstrated in Figure 2. Therefore, we have electrospun fibers of 20% and 15% by weight PMMA in chloroform and added 0.25, 0.5, and 1 mg/mL of gold nanoparticles. We will also test different parameters for electrospinning, such as voltage and distance. After metallization, we will test the conductivity and resistance of individual nanowires.

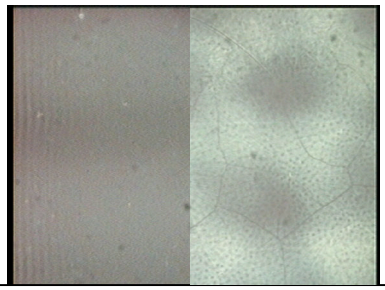


Figure 1. 50x magnification of 1000Å sample of PCL before and after exposure to $scCO_2$ at 1400PSI.

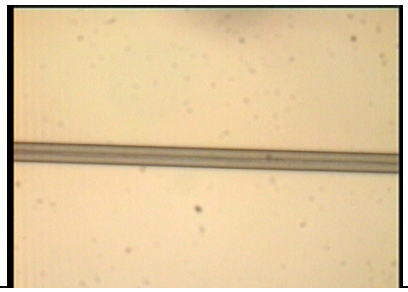


Figure 2. 50x magnification of 20% 1mg/mL PMMA fiber with gold nanoparticles

[1] Koga, Tadanori, Jerome, J.L., Gordon, C., Rafailovich, M. H., Sokolov, J. C. "Metallizable Polymer Thin Films in Supercritical Carbon Dioxide." Journal of Adhesion 81.7-8 (July, 2005): 751-764.
[2] Li, Dan, and Xia, Younan. "Electrospinning of Nanofibers: Reinventing the Wheel?" Advanced Materials 16.14

Synthetic Spider Silk: A Novel Method for the Creation of a Strong and Flexible Material

Josh Gordonson, Syosset High School
Hyungtae Kim, Phillips Academy Andover
L. John Jerome, Robert De La Cruz, Miriam Rafailovich
Department of Material Sciences and Engineering, Stony Brook University
Brienne Kugler, Massachusetts Institute of Technology

Spider silk combines two properties, strength and flexibility, that make it integral for many applications, such as bulletproof vests, suspension bridges, and even a space elevator. Spider silk is unique because it is composed of two main proteins, one of which is a highly organized pleated beta sheet, the other a less organized amorphous "filler." Despite the many advantages to the use of spider silk, spider silk is inherently difficult to harvest because of the territorial nature of spiders. As a result, scientists have turned to the lab to create a synthetic material that emulates both the strength and flexibility present in natural spider silk.

Scientist working done at MIT showed that a silk-like fiber with properties comparable to that of natural spider silk could be produced by mixing a rubbery polymer (polyurethane) with clay. We proposed to electrospin fibers of an array of polymers with various nanoparticles in order to determine the effect of nanoparticles on electrospun fibers. Additionally, we exposed the fibers to $scCO_2$, a solvent shown to propagate a polymer's natural state, in order to see the effect of $scCO_2$ on the fibers.

We began our experiment by dissolving Ethylene vinyl acetate (EVA), a semi-crystalline co-polymer, and clay nanoparticles, Polyhedral Oligomeric Silsesquioxane (POSS), and carbon nanotubes in chloroform. The solutions were then electrospun onto silicon wafers ($2cm^2$) and half of them were exposed to $scCO_2$. Images were taken of them under an optical microscope and the fibers were subsequently analyzed on the Atomic Force Microscope (AFM) for topography and modulus.

The fibers with pure EVA were beaded. The addition of clay and POSS nanoparticles created uniform and straight fibers without any beads. Exposure to $scCO_2$ did not visibly affect the fibers at the optical microscope's limits. AFM images showed dewetting holes present in the fibers that contained POSS nanoparticles. The exposure of these fibers to $scCO_2$ resulted in a smoother fiber, without the dewetting seen in the unexposed fibers.

After measuring the modulus in the EVA, EVA with POSS, and both exposed $scCO_2$, it was found that exposure to $scCO_2$ makes the modulus of the fiber decrease, implying that the fiber is harder after exposure to $scCO_2$

We plan to also spin fibers of Polystyrene and Poly (methylmethacrylate) with oxidized carbon nanotubes, POSS, and clay dissolved in Dimethyl formamide (DMF). Carbon nanotubes are known to increase the strength and flexibility of materials when they are integrated into their structure. Potentially, carbon nanotubes could make the mechanical properties of our fibers similar to those of natural spider silk. Unfortunately, the carbon nanotubes did not dissolve in chloroform, but we found that oxidized carbon nanotubes will dissolve in DMF. We plan on measuring the modulus of these fibers with the AFM. Additionally, we will observe the fibers under the Scanning Electron Microscope and the Transmission Electron Microscope to observe the nanoparticles within the fibers and see any change with exposure to scCO2.

Figure 1: Pure EVA Fibers

Figure 2: EVA with Clay Nanoparticles Fiber

This work was funded by National Science Foundation.

Session II: Energy and Methane Hydrates

Chairs: Debbie Yee, MIT;

Garcia Staff: Sijia Zhao

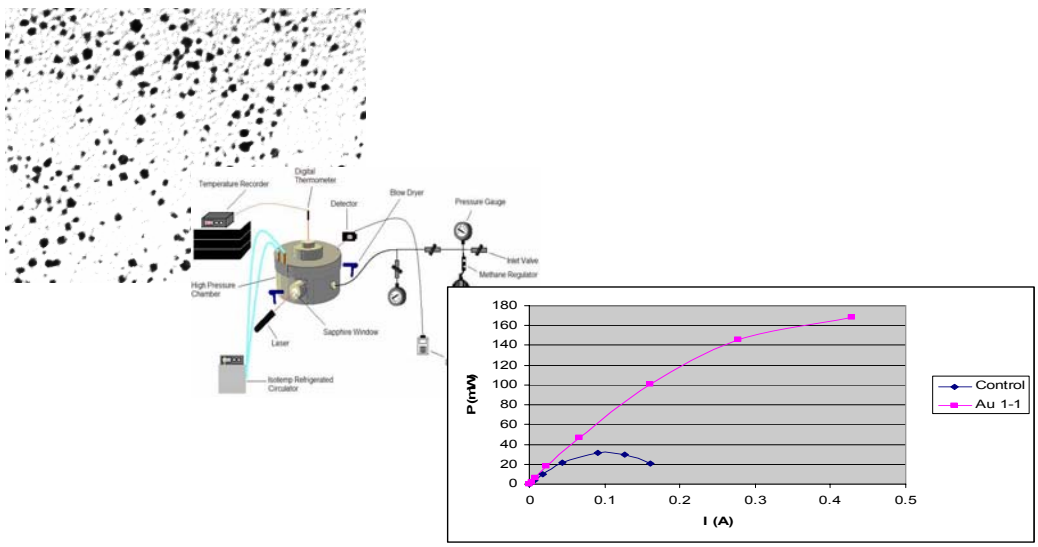
Yuan Sun, John Jerome

Johnny Wong

Justin Goldsmith

Daniel Fourman, Jake Bryant

Kenny Kao, Dan Gross



Methane Hydrates

D. Fourman Ward Melville High School, J. Bryant Ward Melville High School,
J. Jerome Suffolk County Community College, T. Koga Stony Brook University,
J. Wong Stony Brook University, M. Rafailovich Stony Brook University,
D. Mahajon Brookhaven National Lab

With the earth's oil reserves continuing to diminish in size, it is necessary to look for alternative options for fueling today's society. One possible solution to the oil dilemma is a form of methane called methane hydrates. Methane hydrates are located below ocean sediment and under ground in permafrost regions (2). Although methane hydrate reserves are not inexhaustible, they are found of the coasts of most continents (Figure 1) and present in very large quantities with estimates ranging up to 400 quintillion cubic feet and 200 quintillion cubic feet in the US alone(1). This large reserve is approximately 110 times the size of current supplies of natural gas and over twice as large as gas, oil, and coal reserves combined.

A methane hydrate is a molecule of methane surrounded by a lattice of ice. When the lattice forms it creates a hollow dodecahedron shape which surrounds the methane molecule (Figure 2). Clathrate hydrates are formed when water freezes under very high pressures (3). When located under ocean sediment, methane hydrates are usually found out a depth of 800m-1000m, this is called the 'gas hydrate stability zone'(3). Because the hydrates are located at such a low depth, this makes extraction very difficult. However, its depth seems to be the only obstacle with extraction because reserves are often located relatively close to the shoreline.

The purpose of our experiment was to find an optimal set of temperature and pressure in which I methane hydrate can form. We are able to deduce these values using our current system (Figure 3), in which we monitor temperature, pressure, and voltage from a photosensitive detector, the purpose of the detector is to sense the formation of the hydrate using a laser diffraction method (Figure 4), in which a laser aimed through our high-pressure chamber (in which the hydrate is formed) will yield a much higher voltage when there is only liquid in the Teflon dish, and once the methane hydrate (a solid) forms, there will be a drastic decrease in light that is perceived through the photosensitive detector.

To increase the accuracy of our experiment, or to better replicate actual methane hydrate formation conditions, we used the surfactant Pluronic F-108 to simulate various impurities and sediment found in the ocean. We found that the addition of this surfactant not only alters the phase diagram of methane hydrate, but it also enable a methane hydrate to exist in atmospheric conditions for much longer than usual.

In the near future we plan to take a sample of our methane hydrate to be analyzed in a gas chromatography machine to definitively show that what we have created is a methane hydrate. We also plan to simulate actual formation conditions better as well, using separate and combined runs of clay and seawater.

Figure 1: Hydrate deposits(3)

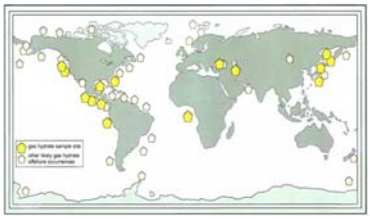


Figure 4: Laser Defraction

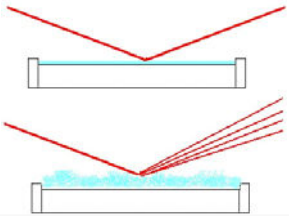
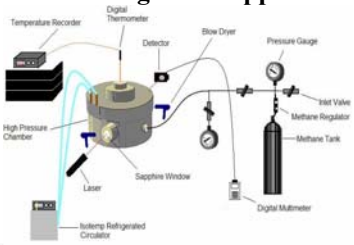


Figure 3: Apparatus



References

1. U.S. Geological Survey Marine and Coastal Geology Program. "Gas (Methane) Hydrates- A New Frontier." http://marine.usgs.gov/fact-sheets/gas-hydrates/title.html, September 23, 2006.

2. Collett TS Kuuskraa VA. Hydrates contain vast store of world gas resources. Oil and Gas J 96:90-95, 1998.

3. "Methane Clathrate." http://en.wikipedia.org/wiki/Methane_hydrate, September 21, 2006.

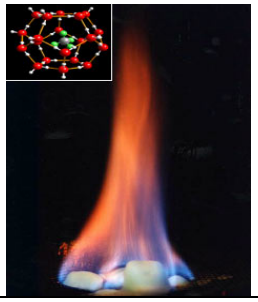


Figure 2: Hydrate burning with molecular structure. (3)

Optimizing the Efficiency of Polymer Electrolyte Membrane Fuel Cells Using Palladium and Gold Nanoparticles

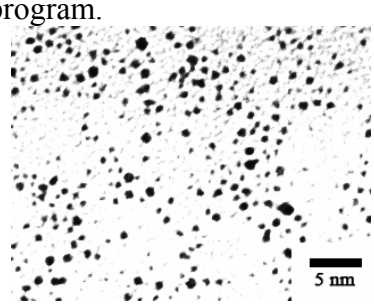
Chun-Kai (Kenny) Kao, *George School*;
Daniel Gross, *Walt Whitman High School*;
Debbie Yee, *Massachusetts Institute of Technology*;
Sijia (James) Zhao and Miriam Rafailovich; *Department of Material Science and Engineering, Stony Brook University*

There is an increasing need for alternative energies coinciding with the rising concern about the negative impacts of pollution on the ecosystem. Polymer electrolyte membrane fuel cells (PEMFC) have a promising future as an alternative energy source because they are highly efficient, have low operating temperatures, and produce only water, an environmentally friendly byproduct of electrochemical reactions, when pure hydrogen is used.[1] However, this fuel cell has low overall power output, and therefore currently has limited use in industrial applications.

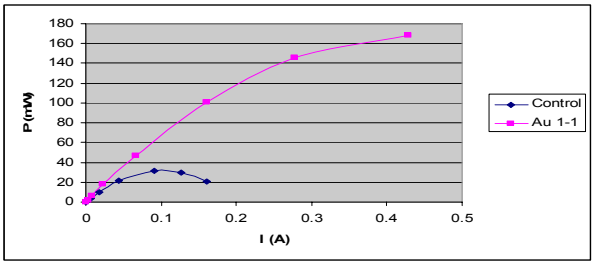
The purpose of this study is to increase the power output of each individual fuel cell using various metallic nanoparticles; these nanoparticles facilitate hydrogen diffusion, and thus increase the generated power output. Gold (Au) and Palladium (Pd) nanoparticles were synthesized with different metal-to-thiol ratios and different shapes. The two-phase liquid-liquid method[2] was used to synthesize thiol-functioned Au and Pd sphere nanoparticles, while the seedless and templateless method[3] was used to synthesize palladium nanorods and nanocubes. A Langmuir-Blodgett trough was used to deposit a single layer of nanoparticles onto Nafion®, the perfluorosulphonated ionomer membrane. The fuel cell was tested under controlled resistance, while voltage and current were recorded to determine the power output.

Results confirmed the hypothesis that metallic nanoparticles large increases in power output, up to six times compared to that of the control. Current work involves experimenting with nanorods and nanocubes, as well as testing conductive nanoparticles such as carbon nanotubes.

This work was supported by the Simons Foundation and the NSF MRSEC program.



Transmission Electron Microscope Image Of Au Nanoparticles



Comparison of control fuel cell to Au modified fuel cell.

[1] Tang Hao-lin, Pan Mu, Mu Shi-chun, Yuan Run-zhang. *Journal of Wuhan University of Technology-Mater.Sci.ed.* (Sep. 2004): 7.
[2] Mathias Brust, Merryl Walker, Donald Bethell, David J. Schiffrin, and Robin Whyman. *Journal of Chemistry Society, Chemistry Communication* (1994): 801.
[3] Yuan Sun, Hongwen Zhou, Yimei Zhu, Eli Sutter, Yuan Ji, Miriam H. Rafailovich, and Jonathan Sokolov. *Chem. Mater.* (207): 2065.

Hydrogenation of Platinum Nanoparticles for Fuel Cell Application

Justin Goldsmith, *Half Hollow Hills High School West*
James Zhao, Yuan Sun, Dr. Miriam Rafailovich, Dr. Vladimir Zaitsev, *Stony Brook University*
Debbie Yee, *Massachusetts Institute of Technology*

Increased energy consumption is becoming a major problem in today's society. Due to current methods of producing energy, greenhouse gasses are emitted into the atmosphere, thus worsening the effects of global warming. Current research is focused on finding alternative energy sources to substitute the use of fossil fuels. Fuel cells have great potential as an alternative energy because they produce no harmful byproducts. However, the use of fuel cells is limited because they need a source of pure hydrogen to generate sufficient energy for industrial applications. Currently, it is difficult to safely store compressed hydrogen because it is very volatile.

Platinum particles on the nanoscale have unique characteristics that enable them to adsorb hydrogen[1]. The purpose of this project is to use this property to store hydrogen for fuel cell uses. Hydrophilic Platinum nanoparticles were synthesized using one-phase method[2], and kept in water solution. The nanoparticles were then hydrogenated in solution and on mica in the hydrogenation chamber at of 60 pounds per square inch (psi). Results illustrated no hydrogen adsorption at such low pressure.

Current work focuses on exposing the nanoparticles on mica and in solution at higher pressures of hydrogen (1000 psi). I predict that at such high pressures there will be significant hydrogen absorption in both the solution and the nanoparticles on mica. This will enable the particles to hold sufficient hydrogen to run the fuel cell.

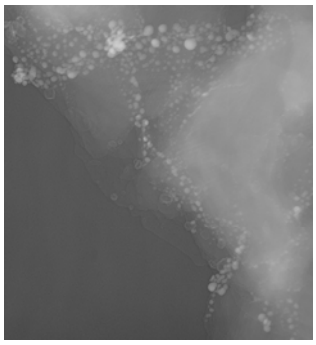


Figure 1: Transmission Electron Microscope Image of Platinum nanoparticles

Figure 2: Diffraction pattern, Face-Center Cubic, of Platinum nanoparticles

[1] Oudenhuijzen, M.K.; Bokhoven, J.A.; Miller, J.T.; Ramaker, D.E.; Koningsberger, D.C.; J. AM. Chem Society. (2005) Vol 127, No. 5

[2] Yee, C.; Scotti, M.; Ulman, A.; White,H.; Rafailovich, M.; Sokolov, J.; Langmuir (1999) Vol 15, 4316-4316

Session III: Nanoparticle Toxicity

Chairs: Lucy Wu, Sean Pi, Batya Herzberg

Garcia Staff: Tatsiana Mironava, Rachel Mu

Yuan Sun

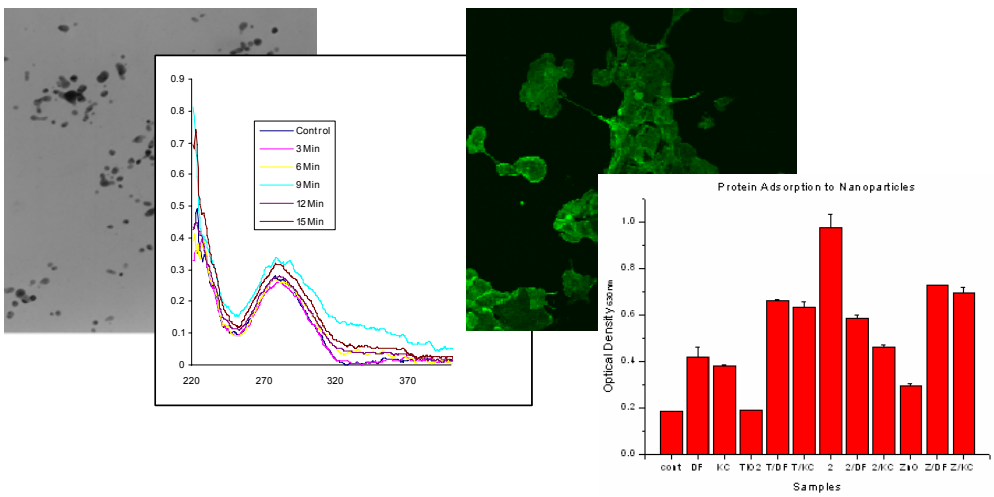
Mili Mehta

Etan Zapinsky, Adam Hanau

Sowmya Sundaresh, Nicole Elstein

Nabiha Kabir, Alex Saal

Radha Ramjeawan



The Effects of Nanoparticles on Breast Cancer Cells

Mili Mehta, *The Wheatley School, 11 Bacon Road, Old Westbury, NY 11568*
Rachel Mu, Miriam Rafailovich, *Stony Brook University*

Nanotechnology, the most rapidly developing modern field, holds potential in many disciplines of science. The field is concerned with the synthesis and manipulation of particles whose dimensions are nanometric, billionths of a meter. The appeal that nanoparticles offer is that they offer these particles display significantly different electrical, physical, or chemical properties than those of the same composition, but with larger dimensions—in other words, their properties are size-dependent.

However, the effect that nanoparticles have on the human body is a matter that has to be studied in a multi-faceted way. It has been shown that gold-citrate nanoparticles have adverse effects upon human dermal fibroblasts. These nanoparticles were shown to affect the cytoskeleton of the cells by affecting the actin fibrils, which, in turn, affected the cell growth, migration, and differentiation.[1] Yet, as stated earlier, nanoparticles with different composition and coatings will display significantly varying effects upon cells in the body. In addition, these same nanoparticles may affect differentiated cell types in different ways. Therefore, in order to assess the risk of nanoparticles on human health, several different studies must be conducted.

Conversely, certain types of nanoparticles may have damaging effects on cancerous cells. If these nanoparticles affect cancer cell behavior in the same way that they affect normal cell behavior, they offer a potential for an anti-cancer therapy. Thus, my study was conducted to see the effects of a variety of nanoparticles on breast cancer cells. The nanoparticles studied included gold-citrate particles, which varied in size, gold-folate particles, and platinum-folate particles. Each of these different types of particles had to be synthesized in precisely the right conditions, and then tested for size using Transmission Electron Microscopy (TEM). In order to determine limitations in cell growth, cells were incubated with different concentrations of each of the nanoparticles. After 24 hours, an MTT assay was conducted in order to determine the cell death. The addition of MTT, a yellow tetrazolium salt, allows the mitochondrial enzymes in living cells to reduce the salt into insoluble purple formazan crystals, which then produces a colored solution that is quantifiable using a spectrophotometer. The MTT dose-response curve shown below (Figure 1) displays the concentration of small Au- citrate nanoparticles resulting in 50% inhibition of cell growth.

In the future, confocal microscopy will be used in order to determine the exact effects of the nanoparticles on the cancerous cells. In addition, each experiment performed with the cancerous cells will also be performed on a control of non-cancerous human breast cells, in order to compare the effects.

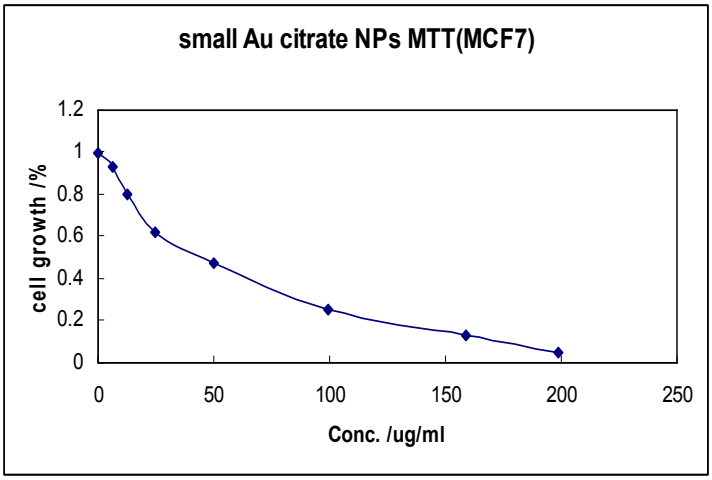


Figure 1—MTT curve showing the concentration at which cell growth inhibition is at 50%.

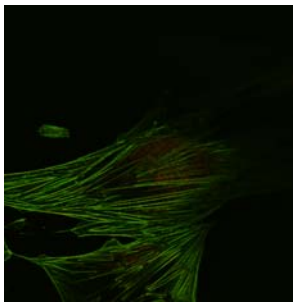
[1] Pernodet, N., Fang, X., Sun, Y. *Adverse Effects of Citrate/Gold Nanoparticles on Human Dermal Fibroblasts.* Small 2006; 766-773

The Effect of Nanoparticles on Adipocytes and the Process in which the Nanoparticles Enter the Adipocytes

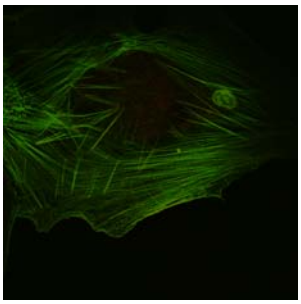
Adam Hanau, Etan Zapinsky

Here, we are studying the effect of different kinds of nanoparticles on human adipocytes. We decided to study the effects that nanoparticles have on adipocytes in particular because obesity is a growing problem and we want to find a solution to solve this problem. Researchers in Seoul National University did similar research by trying to find an anti-obesity drug.[1] We want to find a nontoxic way to shrink the adipocytes by reducing the size of the fat vacuoles inside of them. To do so, we placed various concentrations of TiO2, TiO2 #2 (surface modified TiO2), and ZnO in a media/serum along with adipocytes. We then fixed our cells with formaldehyde and stained them with PI and Alexa Fluor. Once our cells were stained we viewed them under the Confocal Microscope. To understand the way in which these nanoparticles enter into adipocytes, we incubated these same nanoparticles at the same concentrations with the media/serum used to culture cells. We then removed the media and measured the percent of proteins that adsorb to nanoparticles using a spectrometer. Another method was also used to measure the amount of adsorbed proteins on nanoparticles, TGA, by observing the change in molecular weight as the proteins were burned.

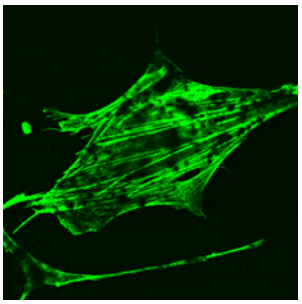
We found that ZnO at 0.4 mg/ml, 0.6 mg/ml and 0.8 mg/ml killed the cells, while at 0.2 (mg/ml) there were fewer cells after 3 days than the control, where there was normal cell growth. After 3 days, as the concentration of TiO2 increased the amount, and size of the cells decreased. Using the TGA we found that TiO2 and ZnO had no coating on them, while TiO2 #2 has a 6% coating of antioxidant and polymer. This coating was developed to protect cells from nanoparticles adverse effects.[2] Under confocal, adipocytes incubated with this coated nanoparticles survived and looked healthy.



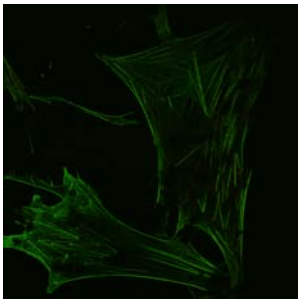
Control
63x



ZnO
0.2mg/ml
63x



TiO2
0.8mg/ml
63x



TiO2 #2
0.8mg/ml
63x

[1] H.S. Moon, D.D. Guo, et al. Regulation of adipocyte differentiation by PEGlyated all- *trans* retinoic acid: reduced cytotoxicity and attenuated lipid accumlationJournal of Nutritional Biochemistry 18 (2007) 322-331.

[2] Wilson A. Lee *[1], Nadine Pernodet[1,] et al . The efficacy of surface modified nano titnanium dioxide against photocatalytic activity for the ultra violet irradiation

The Effects of ZnO and TiO_2 Nanopaticles on Human Dermal Fibroblasts and Keratinocytes

Nicole Elstein, Bayport-Blue Point High School
Sowmya Sundaresh, Hicksville High School
Dr. Nadine Pernodet and Dr. Miriam Rafailovich
Department of Materials Science and Engineering, Stony Brook University
Lenny Slutsky, Duke University
Sean Pi, Princeton University

Titanium dioxide, zinc oxide, and #2 nanoparticles (titanium dioxide coated with antioxidants) are commonly found in cosmetics and sunscreen. TiO_2 is a photocatalyst under UV light and ZnO is photostable, so they can be used to protect the skin by filtering out UV rays. However, they pose as a problem because they may penetrate through the skin and produce harmful free radicals. Sunscreens that don't utilize nanoparticles are visible on the skin, giving off a white tinge, and don't rub into the skin well. Therefore, these nanoparticles were introduced to solve this issue because they absorb into the skin cells. [1] In our experiment, the purpose was to observe the effects of these nanoparticles on keratinocytes (KC) and dermal fibroblasts (DF), which are found in the epidermis of the skin, in different concentrations. This is crucial because concerns have risen about whether these nanoparticles are safe for skin because the cells could absorb them and cause damage to the cells.

Two methods were used to analyze protein adsorption to nanoparticles: a protein assay, using a photospectrometer, and a thermogravimetry analysis, which burned off the protein from the sample. The following two procedures used normal and cancerous keratinocyte cells. The cells were then exposed to the three different nanoparticles at four different concentrations of 0.2, 0.4, 0.6, and 0.8 mg/ml. Next, the cells were imaged under the confocal microscope after staining the nucleus with propidium iodide and the actin with Alexa fluor 488. Currently in progress, a cell growth curve is being determined to quantify how the nanoparticles affect cell proliferation.

The protein assay showed that most of the proteins did adsorb to the nanoparticles. The sample containing the #2 nanoparticles had the highest value of proteins that adsorbed to the nanoparticles; therefore hypothesizing that the antioxidants in the sample reacted with the reagent used. Figure 1 displays the results of the protein assay. Under the confocal microscope, the samples with the normal keratinocytes and the nanoparticles had a fewer amount of cells than the normal keratinocytes without them. The ZnO nanoparticles generally killed off all the cells in most of the samples, on both normal and cancerous cells. In Figure 2, the confocal images show that there was an adverse effect after the cancerous cells were exposed to the #2 nanoparticles. The amount of cells decreased and the shape of the cell changed. The scope of this project could be expanded to include observing the effect of the nanoparticles on the specific cell functions, such as DNA replication or protein synthesis. In addition, depending on the amount of harm these nanoparticles cause, new precautions could be taken and products could be developed with different substances that have a less dramatic effect.

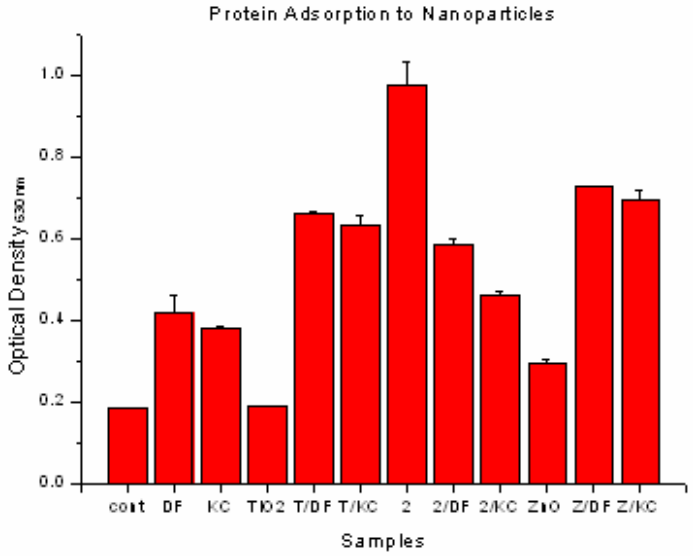


Figure 1. Protein assay results: using TiO_2 (T), ZnO (Z), and #2 (2) nanoparticles with DF and KC protein media

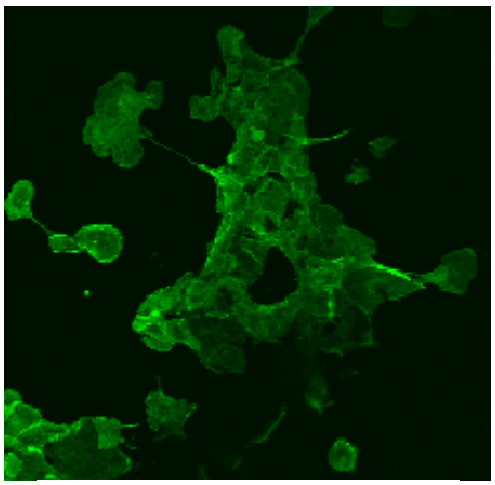


Figure 2. Cancerous keratinocytes with #2 nanoparticles at 0.8 mg/ml at 20x. Stained for actin with Alexa fluor 488.

[1] Pernodet, Nadine; et al. *Adverse Effects of Citrate/Gold Nanoparticles on Human Dermal Fibroblasts*. Small (2006) 766-733.

Using Polymers to Prevent The Negative Effects of TiO_2 On DNA and Proteins

Alex Saal SAR High School
Nabiha Kabir Locust Valley High School
Vladimir Zaitsev, Miriam Rafailovich

Titanium dioxide is a common ingredient in suntan lotion and cosmetic products. It is used as a physical blocker of UV light which can cause cancer[1]. However, TiO_2 is a photo catalyst and when exposed to UV light it oxidizes bioparticles around it potentially destroying them. As the size of the TiO_2 particles used in the suntan lotion and other cosmetic products becomes smaller and smaller they enter cells much more easily. Once the TiO_2 has entered the cell if it is exposed to UV light the TiO_2 can oxidize bioparticles in the cell, including DNA and proteins damaging the workings of the cell.

Our experiment is to determine whether or not coating TiO_2 nanoparticles with hydroxyethyl methacrylate (HEMA) will prevent the particles from damaging DNA and Albumin.

We exposed solutions of DNA and Albumin to UV light for varying amounts of time, measured absorption again and created a graph which can be seen in figure 1. We found that after being exposed to UV light over a period of two hours the absorption was reduced significantly.
We then exposed solutions of DNA and Albumin to UV light in the presence of TiO_2 made for sunscreen and cosmetics. We found that the DNA did get destroyed, whether we exposed it over long periods of time or shorter periods of time. As you can see in figure 2 all of the absorption spectra are with in .1 optical units of each other, this suggests that there was not much change from the beginning to the end at two hours. Another illustration of this can be seen in figure 3 where the control which was not exposed to the UV light had equal absorption as samples that had been exposed.

There are several possible explanations for this data. The TiO_2 we used had a coating of Aluminum Oxide which we did not think would affect oxidation. The most likely explanation for the data therefore is that the Aluminum Oxide coating shielded the DNA from oxidation. While this did not allow us to test our polymer coatings on the DNA it is still a positive result because it shows that the coating prevents oxidation which is what we were trying to achieve all along.

Future work would be to determine whether a polymer coating prevents the nanoparticles from entering the cell, because even if the particles are inactive it is preferable for them not to enter the cell.

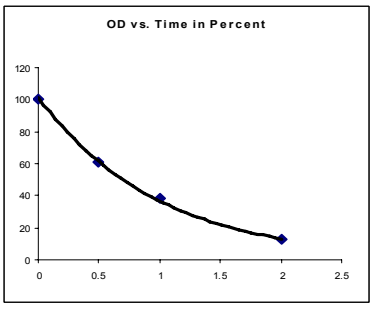


Figure 1: Optical density of irradiated DNA vs. Time

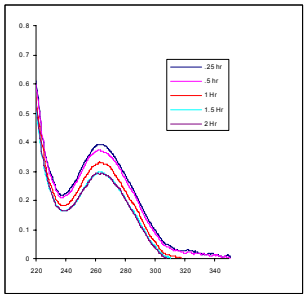


Figure 2: Absorption spectrum of DNA + TiO_2 over 2 hours

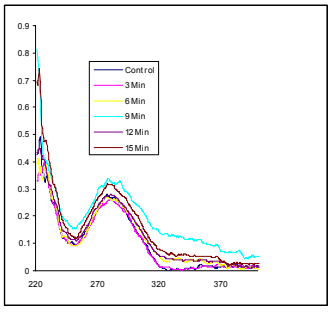


Figure 3: Absorption spectrum of spectrum of DNA + TiO_2 over 15 minutes

[1] Serpone, Nick, Salinaro, Angela, Satoshi, Horikoshi, Hidake, 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)*

Nanomedicine: The Effects of Protein Coated Nanoparticles on Cancerous Cells

Radha Ramjeawan, Uniondale High School
Yuan Sun[1], Dr. Nadine Pernodet[1], Dr. Miriam Rafailovich[1], Batya Herzberg[2]
[1]Department of Materials Science and Engineering, Stony Brook University
[2]Stern College, New York City

Cancer is a growing epidemic and accounts for one in four deaths in the United States. It is estimated that 559,560 Americans will die of Cancer in 2007. [1] Thus, advancement in cancer biology is imperative. One promising approach for detecting and obliterating malignant cells is the use of nanoparticles. Nanoparticles are defined as microscopic man made objects whose size is less than 100 nm. [2] The present investigation entails utilizing protein coated nanoparticles to destroy cancerous cells.

To initiate the experimental procedures, platinum and gold folate nanoparticles were synthesized. The platinum nanoparticles were easily synthesized but the gold particles posed as a problem because they aggregated. We proposed an innovative method of synthesis for nanoparticles that are extremely time efficient (approximately 20 minutes for the entire synthesis) and requires no addition of heat. This synthesis consisted of neutralizing the folic acid (the coating of the platinum and gold nanoparticles) by adding potassium hydroxide and continually stirring at room temperature. After the particles were synthesized, transmission electron microscopy (TEM) was done to deduce if our method of synthesis was successful. Then, the particles were incubated with proteins. Four samples were prepared: 2 ml of platinum folate particles with 360 µl of PBS , 2 ml of platinum folate nanoparticles with 40 µl of FBS and 360 µl of PBS, 2 ml of gold folate nanoparticles with 360 µl of PBS, and 2 ml of gold folate nanoparticles with 40 µl of FBS and 360 µl of PBS . After the samples were incubated for 24 hours, they were centrifuged, washed and freeze dried for TGA testing.

The results received thus far ensured that the new method of synthesis was effective because nanoparticles were produced as seen in the TEM images in figure 1a and 1b. Additionally, TGA data revealed that there was a difference in weight loss between the control (nanoparticles without protein) and nanoparticles with protein. Figures 2a and 2b show that the nanoparticles with protein exhibited 70% weight loss while the control exhibited 29% weight loss. Thus, this confirms that the proteins did indeed stick to the nanoparticles because more organic matter was burned off of the sample, leading to a higher weight loss percentage. Therefore, this data provides initial evidence that the protein coated nanoparticles were engineered correctly. Further studies include introducing the protein coated nanoparticles to cancerous cells to determine if these particles will have any significant effects on these cells. This research is important because it could potentially become an alternative method for treating cancer. Most importantly, this study could open new possibilities of stabilizing and decreasing cancer deaths.

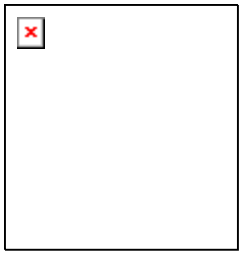


Figure 1a
Pt. folate nanoparticles

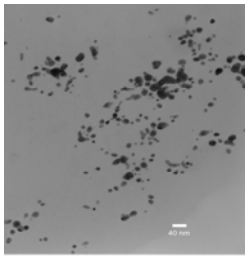


Figure 1b
Au folate nanoparticles

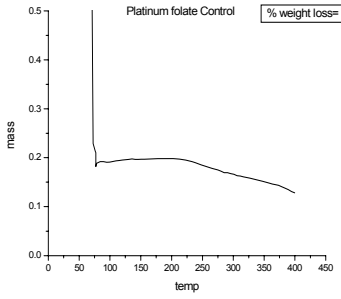


Figure 2a

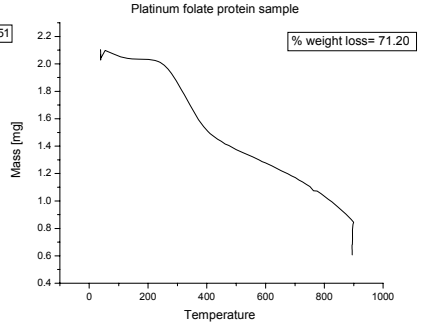


Figure 2b
TGA Data

1. Gu Frank, Karnik R, Wang A, Frank A, Hong S, Langer R., Targeted Nanoparticles for cancer therapy, Nanotoday June 2007, Volume 2 Number 3
2. Ferrari Mauro, Cancer Nanotechnology: Opportunities and Challenges, Nature Reviews Cancer, March 2005, Volume 5

Session IV: Environmental Issues

Chair: Julian Salazar, Louis Armstrong High School;

Garcia Staff: Lourdes Collazo

Nitin Gupta

Zachary Rubin

Yosef Guterman

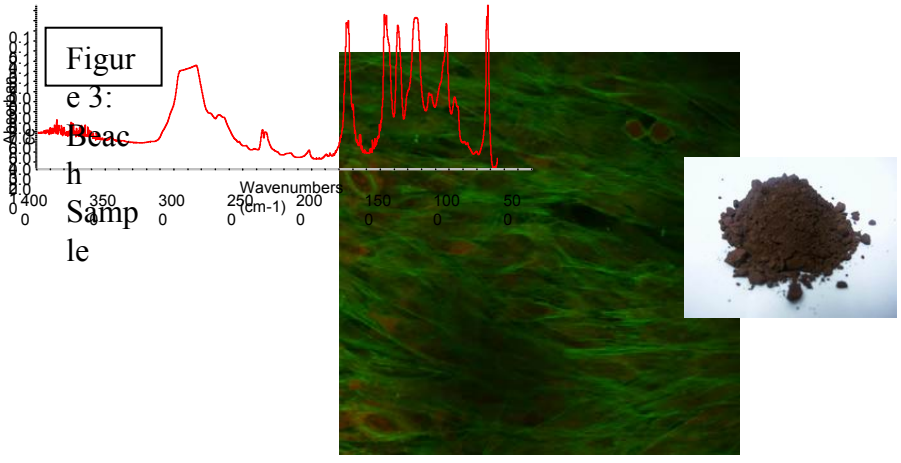


Figure 3: Beach Sample

Global Warming and Human Health: Effect of Increased CO_2 Concentration on Myoblasts in the Presence of Carbon Black, an Environmental Pollutant

Nitin Gupta [*], *Lourdes Collazo* [**], *Miriam Rafailovich* [**]
[*] *Jericho Senior High School, Jericho, NY*
[**] *Dept of. Materials Science & Engineering, SUNY at Stony Brook, NY*

Global warming is, potentially, the most devastating threat that mankind is facing today. One of the major gases implicated in the genesis of global warming is carbon dioxide (CO_2). Although literature is replete with studies that question the role of humans in this phenomenon, there is no doubt that human activities over the least 50 years are largely responsible for as much as a 25% increase in ambient CO_2 levels as evidenced by the Keeling Curve.[1] The present study was designed to look at the effects of increasing CO_2 on myoblast growth in the presence of carbon black, an environmental pollutant originating from rubber tires.[2]

Primarily, to test the effects of CO_2 on the pH of DMEM media, 12 ml of media was added to 100 mm petri dishes, which were then placed in an incubator set at 37.4 degrees Celsius and various CO_2 concentrations. The DMEM from each of the dishes was transferred to 50 ml plastic tubes, and a pH meter, consisting of an electrode, was used to determine the overall trend of CO_2 vs. pH of DMEM media. The results matched the hypothesized results; as the CO_2 concentration increased, the pH of DMEM decreased.

Myoblasts, cells that develop into muscle cells, were plated in 100 mm petri dishes at 8,000 cells/cm^2 . It was decided that the Myoblasts were to be placed at the extremes of the CO_2 concentration, 5% (concentration in the human body) and 20% (a drastic increase in body CO_2). The cells in the dishes to be placed in an incubator set to CO_2 concentration of 5% were fed DMEM, which had a pH of 6.8. The cells in the dishes to be placed in an incubator set to a CO_2 concentration of 20% were fed DMEM, which had the original pH of the media, approximately 7.0. This reversal in the pH of media fed to the Myoblasts served to remove the effects of the pH of the media and, in turn, the effects of the CO_2 concentrations could be observed. In addition to the two conditions, plates at 5% CO_2 with media of pH=6.8 and plates at 20% CO_2 with media at pH=7.0, samples, which acted as controls, were placed at 5% CO_2 with media at pH=7.0. Furthermore, 35 mm plates, with the same conditions, were also incubated and to be fixed and stained for imaging with a Confocal Light Microscope. After 1 day, 3 days, and 6 days, the cells, excluding the controls, which were counted at 2 days and 5 days, were counted and a trend was established *(fig. 1)*; with increasing CO_2, the cell counts were significantly less. Additionally, the day 3, 5% CO_2 with pH=6.8, Myoblasts appear healthier than the day 3, 20% CO_2 with pH=6.8 (*fig. 2)*.

Researching the additional effects that occur when Myoblasts are in the presence of carbon black is to be tested soon.

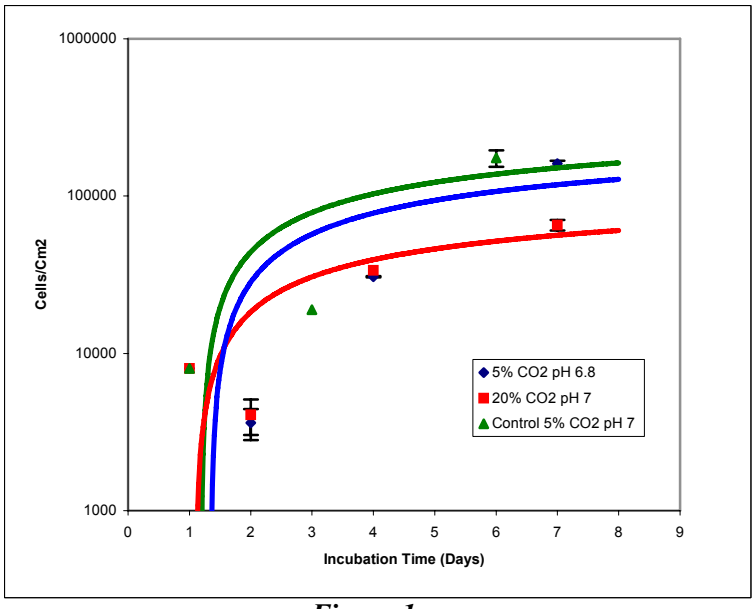


Figure 1

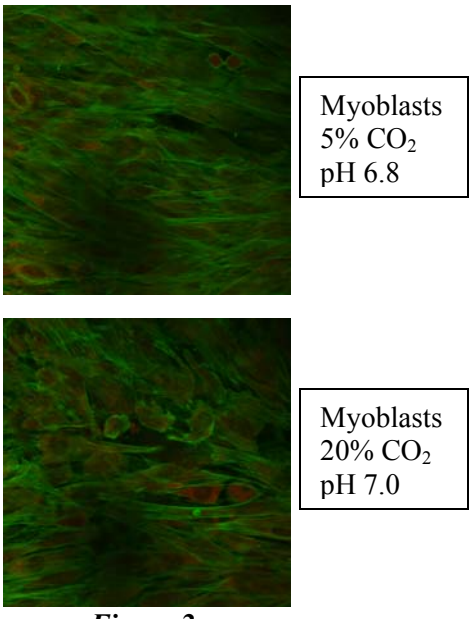


Figure 2

[1] R. B. Bacastow, C. D. Keeling, and T. P. Whorf, Seasonal Amplitude Increase in Atmospheric CO_2 Concentration at Mauna Loa, Hawaii, 1959-1982, Journal of Geophysical Research, 90, 10529-10540, 1985.

[2] W.P. Linak and R.K. Srivastava, Evaluation of Carbon Black Slurries as Clean Burning Fuels, V. 73, No. 12, pp. 1911-1917, 1994.

The Effect of Copper Nanoparticles and Carbon Dioxide on Myoblasts

Zachary Rubin, North Shore Hebrew Academy High School
Lourdes Collazo, Miriam Rafailovich
Department of Materials and Engineering, Stony Brook University

Water pollution is increasingly significant problem in modern society. Experiments have shown that copper nanoparticles in freshwater solutions are harmful to fish[1], as are increasing levels of carbon dioxide. Furthermore, copper nanoparticles were shown as tumor inhibitors[2]. Thus, the purpose of this study was to examine the effect of Cu nanoparticles and CO_2 on cells.

Myoblasts, stem cells that exist in muscles, were plated onto Petri dishes and were combined with 99.9% pure copper at concentrations of 0%, .03%, .06%, .15%, and 2%. All samples were incubated at 37ºC, at CO_2 concentrations of 5% and 20%. Cells were counted on a hemocytometer and examined under a confocal microscope, on days 1, 3, and 6.

To date, we have examined the samples that have not been treated with copper. Thus far, cells exposed to higher concentrations of CO_2 appear less striated and more dispersed, which indicated that they are less healthy than those exposed to lower concentrations. The cells exposed to all concentrations of copper died by day 1.

Thus, our preliminary conclusion is that higher concentrations of carbon dioxide are harmful to myoblast cells. In addition, copper nanoparticles of all tested concentrations prove lethal to the cells.

Further testing by lowering copper concentration will be undertaken to show the effects of minimal concentrations on the cells. In addition, other nanoparticles, such as hydrophilic silica, will be tested on cells in a similar manner to study their effects.

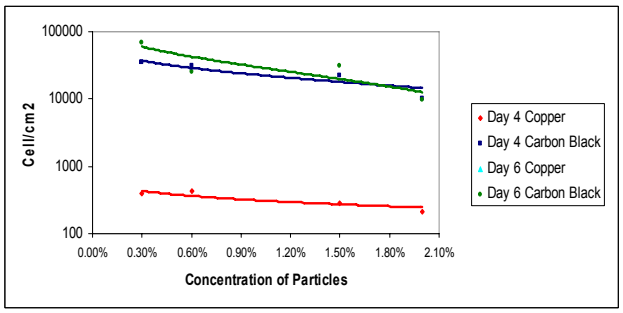


Figure 1a: Cu Nanoparticles

Fig.1b : Cell number as a function of Nanoparticle Concentration

[1] Roch, M, and Ja McCarter. "Hepatic Metallothionein Production and Resistance to Heavy Metals by Rainbow Trout (Salmo Gairdneri)--II. Held in a Series of Contaminated Lakes." Comparative Biochemistry and Physiology os 77 (1984): 77-82. 5 Aug. 2007 <www.pubmed,org>.

[2] L, Qi, Xu Z, Jiang X, Li Y, and Wang M. "Cytotoxic Activities of Chitosan Nanoparticles and Copper-Loaded Nanoparticles." Bioorganic & Medicinal Chemistry Letters os 1 (2005): 1397-1399. 6 Aug. 2007 <pubmed.org>.

Plastic Sand

Yosef Guterman; HANC Uniondale
Mentor: Julian Salazar
Supervising Scientist: Dr. Miriam Rafailovich

This year for our project we used two different types of Polyethylene pellets. The first types of pellets were used as a control group; this group was Virgin Polyethylene manufactured by DuPont Teijin. The second group was composed of pellets that were exposed to UV light in order to artificially age them; these pellets were artificially aged for the equivalent of ten years in this manner. We ran our samples through a series of tests; one of the most important of these tests was the FTIR test. We used this test in order to see how much cross-linking occurred in the artificially aged samples (figure 2) when compared to virgin polyethylene (figure 1) and samples we used last year that were collected on the beach at Robert Moses State Park (figure 3). The reason why finding the amount of cross linking occurred in the samples is crucial is because it shows us how long it take for the samples to oxidize as well as help to explain why the sample show different physical properties than virgin polyethylene that has not been oxidized.

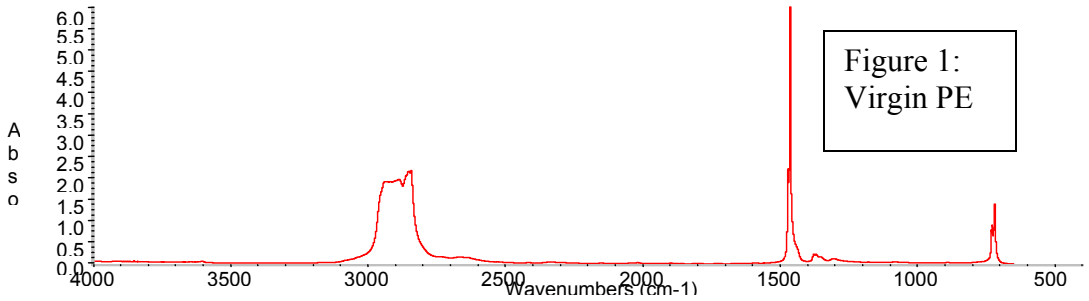


Figure 1: Virgin PE

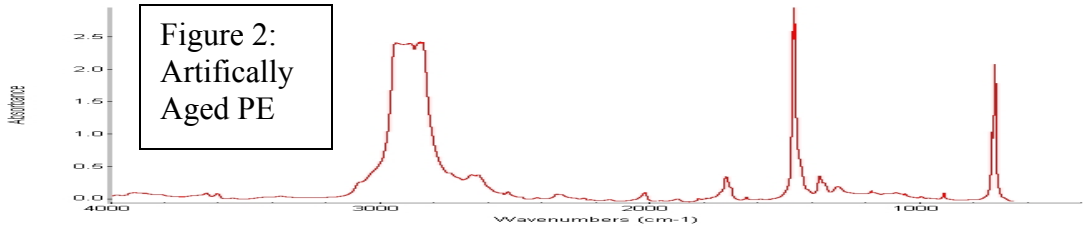


Figure 2: Artifically Aged PE

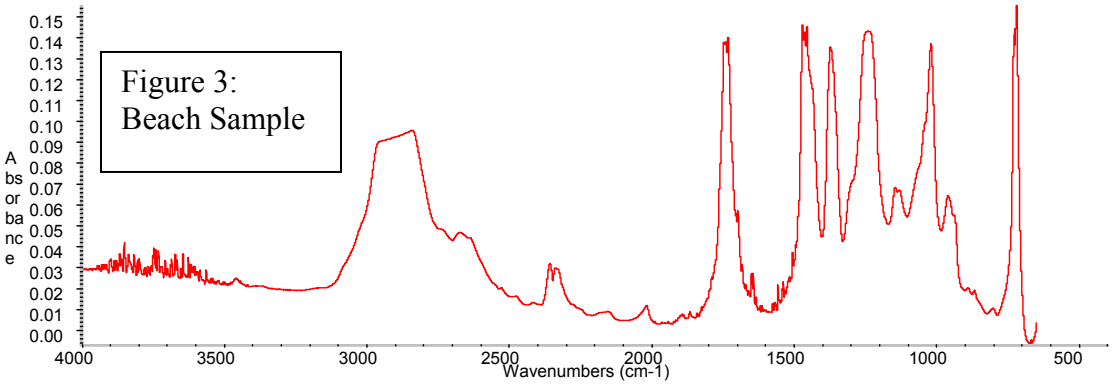


Figure 3: Beach Sample

[1]

[1] http://www.mindfully.org/Plastic/Ocean/Plastic-Aquatic-EPA842B92010-Dec92_ES.htm

Session V: Special Polymers and Surfaces

Chairs: Elizabeth Casey, Comsewogue High School;

Jason Strauss, MIT;

Garcia Staff: Jennifer Segui

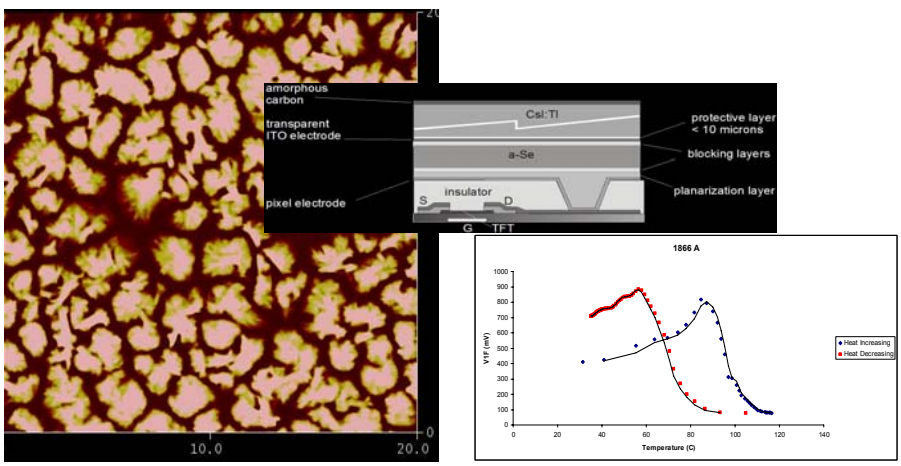
Chunhua Li , Jiali Cai

Sruti Akella, Jullian Abinsay, Noreen Shaikh

Abraham Chien, Elie Bochner

Andrew Kugler

Elizabeth Casey



Enzymatically Synthesized Polymers for Tissue Engineering

Jullian Abinsay, Pablo Academy, **Sruti Akella**, John Jay High School, **Noreen Shaikh** Half Hollow Hills High School, **Jason Strauss,** MIT, **Jiali Cai,** Brooklyn Polytechnic, **Chunghua Li, Miriam Rafailovich**, Stony Brook

In cases of paralysis, the connective tissue between nerve cells—also known as astrocytes—splinters and blocks signals to and from other nerves. Unlike other cells, neurons are unable to repair themselves after damage. Previous attempts at engineering astrocytes in the laboratory have been unsuccessful because when grown synthetically, the endings of astrocytes branch out rather than grow in a striated formation. The direction and structure of the tissue's growth is important because this functional end of the astrocyte permits the nerve cells to transmit signals. A revolutionary new polymer, diacid octandiol, has recently been formulated that has potential uses in constructing a bio-compatible scaffolding for these astrocytes. Created from a whole cell biotransformation, it is a copolymer made from an amalgamation of oleic acid, stearic acid, and octandiol, retaining properties from its three components. Because the polymer is enzymatically synthesized and non-toxic, it is ideal for plating cells. To identify the characteristics of this polymer, we spun cast thin films of varying concentrations and generated a thickness curve. The Atomic Force Microscope (AFM) was to determine the polymers' melting points and crystalline topography. Using silicon wafers coated with the polymer thin film, we plated cells in a 24-well plate. The proliferation of the cells was closely monitored in a growth curve provided by cell counts on days three and six.

The cells are grown on the thin films to test the compatibility of cells on the polymer. In the future, a polymer solution, dissolved in chloroform, will be electrospun into long, uniform fibers. These polymer strands will mimic the striations on which the astrocyte would grow, thereby forming an environment conducive to cell growth. If the cells are able to successfully utilize the polymer scaffold as a mechanical support system, the newly growing astrocytes can be implanted around damaged nerve tissue, thereby permitting the transmission of inter-neuron signals.

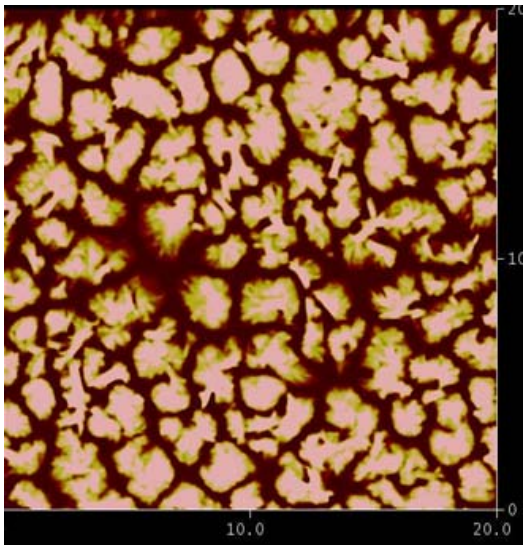


Figure 1: Yixin 031, concentration 15mg/mL, supercritical

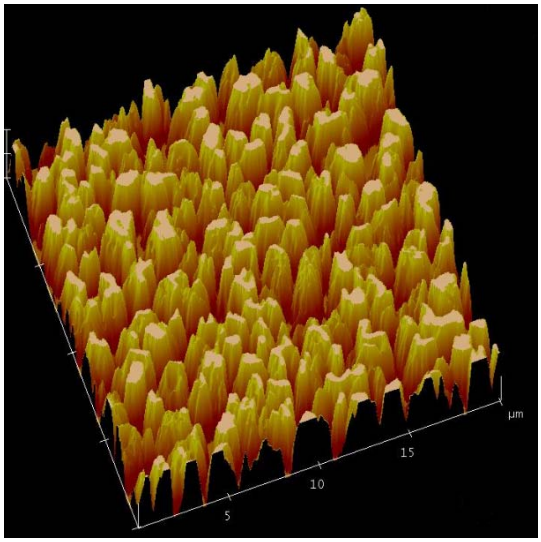


Figure 2: Yixin 077, concentration 10mg/mL supercritical

Flat Panel X-Ray Detectors for Digital Radiography: Planarization of TFT Arrays Using Polyaniline Thin Films

Elie Bochner[1,5], Abraham Chien[2,5], Jennifer A. Segui[3,4], Wei Zhao[4], Miriam Rafailovich[5], and Jonathan Sokolov[5]

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[2] Stuyvesant High School, New York, NY 10282
[3] Department of Biomedical Engineering, State University of New York at Stony Brook, Stony Brook, NY 11794 – 8460
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Flat panel x-ray detectors for digital radiography have been used in the clinic for nearly a decade and enable the rapid acquisition of high resolution x-ray images with excellent contrast. However, current x-ray detectors are optimized for imaging applications that use higher detector entrance exposures that can produce a large signal thereby overcoming the electronic noise associated with the thin film transistor (TFT) readout process. A novel indirect x-ray detector concept proposed by Zhao et al., referred to as SHARP-AMFPI (Scintillator – HARP Active Matrix Flat Panel Imager)[1] enables variable x-ray to charge conversion gain by using a thin layer of amorphous selenium to create a detector compatible with both regular and low dose radiographic procedures (figure 1). However, micron-scale variations in the surface topography of the TFT arrays result in non-uniform gain arising from thickness variations in the a-Se layer, which dramatically decreases the image quality. We propose to use thin-films of polyaniline (PANI-EB), an intrinsically conductive polymer, as a planarization layer between the a-Se and ITO pixel electrode on the TFT array. Using a contact angle measurement system, we determined the optimal cleaning method to improve wetting of the ITO substrate with the PANI-EB solution. The surface topography of spun-cast PANI films on various substrates was measured with atomic force microscopy. The resistivity of the undoped PANI films and ITO surfaces was measured using a standard 4-point-probe technique. The results of this study suggest that polyaniline films could be utilized to planarize the TFT array in SHARP-AMFPI, however, further work is needed to determine if PANI thin films or conductive PANI composites are best suited to create a flat-panel x-ray detector with variable gain.

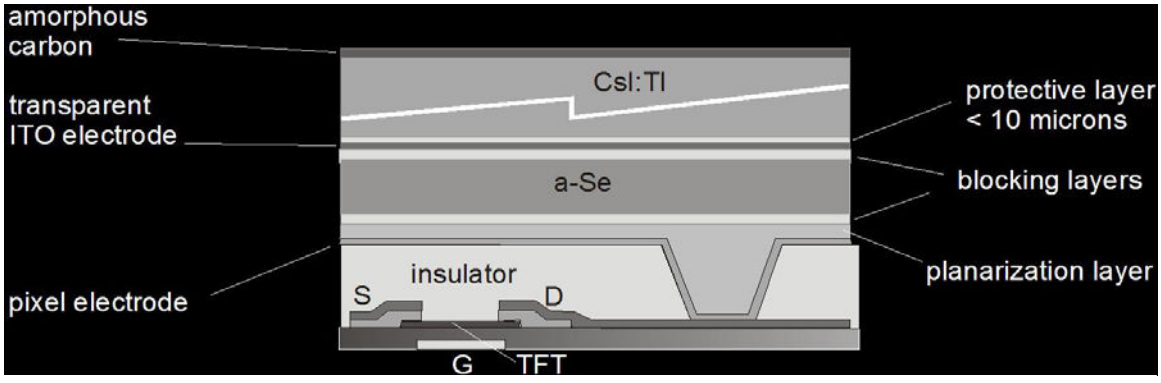


Figure 1. SHARP-AMFPI indirect conversion x-ray detector uses avalanche gain amorphous selenium (HARP) to convert optical photons to charge. The applied electric field across a-Se determines the detector gain.

[1] Zhao, W, et al. "Indirect Flat-Panel Detector with Avalanche Gain: Fundamental Feasibility Investigation for SHARP-AMFPI (Scintillator HARP Active Matrix Flat Panel Imager)." Medical Physics 32 (2005): 2954-2966.

Comparing the Melting Temperature of EVA Spun Thin Films vs. Thick Films

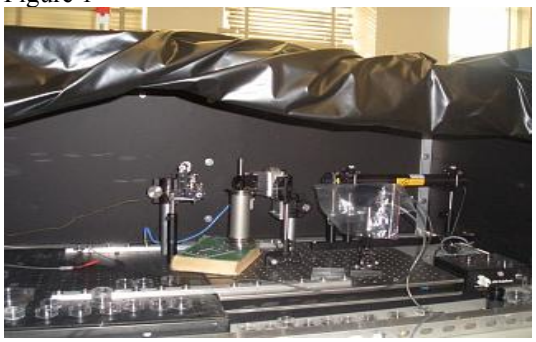
Andrew Kugler, Jericho Senior High School
Wei Liu, Jonathon Sokolov, Miriam Rafailovich
Department of Materials Sciences and Engineering at Stony Brook University

Polymer thin films are an upcoming interest in both sciences and technology because of their different mechanical properties than bulk polymers and their ability to be used as coatings and adhesives for electrical equipment. Past studies of thin films have shown that melting temperature (Tm) does change as the thickness increases. Kim et al.[1] have noticed that as thickness decreased below 300 nm, the Tm was found to decrease dramatically. Unfortunately, previous data from similar studies do not show large differences of melting point between the thinnest and thickest films; the results may not be accurate because the data may be the result of one of many sources of error.

The current study consists of comparing melting point of Polyethylene vinyl acetate (EVA) at different thicknesses. Shear modulus force microscopy (SMFM), atomic force microscopy imaging (AFM), and optical methods were used to determine the Tm. Both SMFM and AFM were conducted using an atomic force microscope and a heating stage. For SFMF, the sample was put on the stage while the amplitude was measured. For AFM, images were taken as the sample began to melt. The optical measurements were conducted with the use of a laser, two polarizers lined perpendicularly to each other, a photo-elastic modulator, and a photodetector. Samples were placed on a holding stage while the laser melted the sample. As the sample melted, the birefringence decreased, decreasing the intensity of the light. In the experiment, samples ranging from 116 A to 1866 A were measured.

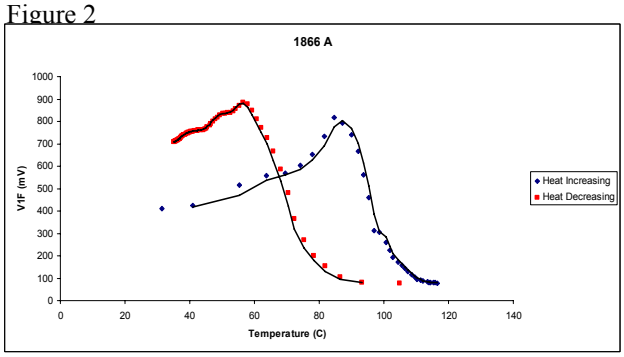
It is evident from the data that as thickness increased, the Tm increased. For SMFM, a range of approximately 20°C was observed for this range of thicknesses. For the lowest thickness (167 A), Tm was approximately 80ºC while the largest thickness (1688) was approximately 100ºC. Likewise, for the laser experiments, a similar range (with similar temperatures) was observed. Not only do these data show a large difference, consequently proving the study, but they also suggests that the AFM and laser experiments are correct methods for observing the melting point of thin films.

Figure 1



The setup for the optical experiments consists of (in order) a laser, polarizer, PEM, sample stage, polarizer, and a photodetector.

Figure 2



A typical graph of Temperature vs. V1F (light intensity) for the optical experiments. A decrease in the blue curve signifies the sample melting. For 1866 A,

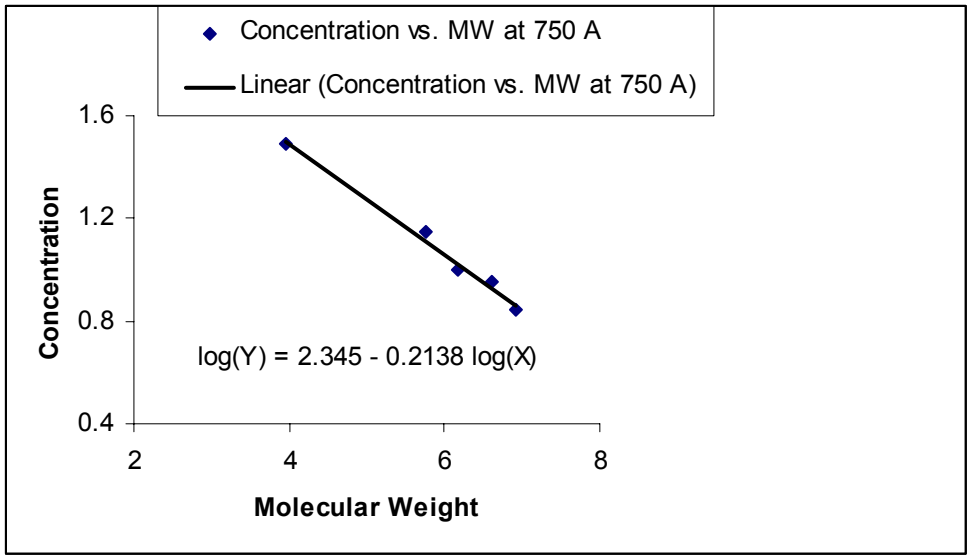
1. Jae Hyun Kim [1], Jyongsik Jang [1 *], Wang-Cheol Zin "Thickness Dependence of the Melting Temperature of Thin Polymer Films

Teaching Research Methodology Via a Group Experiment in Spin Coating

Elizabeth Casey, Teacher, Comsewogue HS **Robert De La Cruz**, Teacher, Valley Stream HS
Together with **All the HS students in the Garcia Summer Research Scholar Program**

The Garcia MRSEC program, sponsored by the NSF at Stony Brook University, believes in the ideal that collaboration in research is key in the growth and maturation of young scientists. The program prides itself on its ability to have student groups made up of educational levels from high school through graduate school, allowing the participants to collaborate on projects. Through the past eleven years the group has produced ground breaking research in the areas of biomaterials/polymer interface, polymers, and flame retardants. Each summer a group of approximately sixty students, teachers and mentors work in the Material Science Department of Stony Brook University where they learn how to effectively perform internet research, use tutorials and read literature on spin casting. Students take part in a spin casting scientific investigation, obtain data, and extrapolate the molecular weights using the tutorial. Allowing the students to collaborate with undergraduates that have previously been participants at GARCIA, submersing them into the lab activities and group discussions prepares the students for their own independent research projects.

In an effort to gain a greater understanding concerning the technique needed to clean silica wafers and to perform spin casting the members of the Garcia MRSEC group performed experiments using various wafer surfaces. Polystyrene solutions prepared in increasing concentrations from three different sources (pellets, coffee cups, and packaging peanuts) were spun onto the wafer surface. Viscosity of the polystyrene solutions was measured as a function of the thickness. An ellipsometer was used to determine the thickness of the polystyrene layer. Molecular weights of the polystyrene were determined through graph analysis. Analysis of the data brought up questions of recycling soluble polystyrene from one form to another.



This graph represents the relationship between Concentration and Molecular Weight for a polystyrene film of thickness 750 Å. This graph was derived from the tutorial web page at the Garcia website (**http://polymer.matscieng.sunysb.edu/medha/index.html**). We were able to estimate the Molecular Weights of the polystyrene samples using this curve.

Session VI: Blending Polymers with Supercritical Fluids

Chairs: Mitchell Fourman

John Iraci, Danielle Lent

Emily Levine, Steve Lubin,

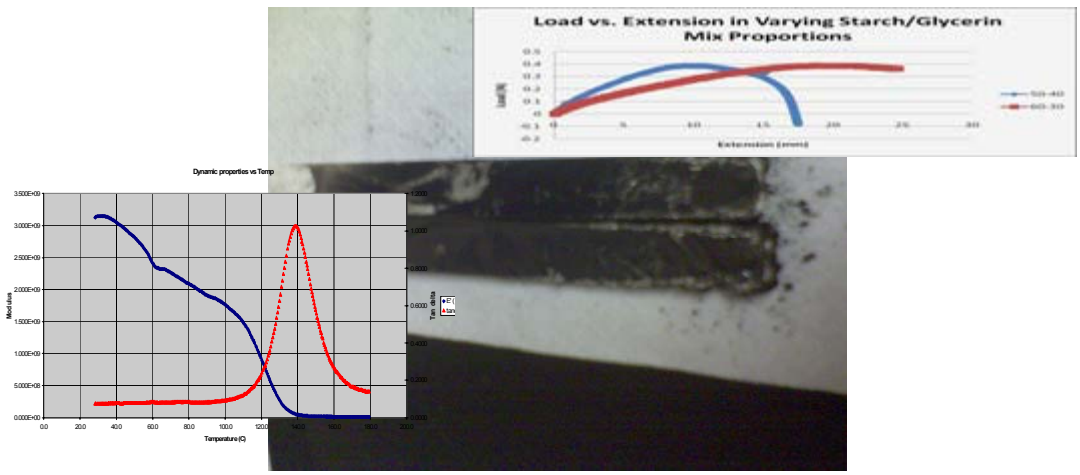
Ezra Bobo

Garcia Staff: Seongchan Pack

Sergey Kolchinskiy, Jade Shi

Josh Rosenbaum, Kimberly Leonard

Andrew Windler



Creating a More Environmentally Friendly Flame Retardant

Sergey Kolchinskiy and Jade Shi- Lawrence High School, Cedarhurst NY; Los Altos High School, Los Altos CA
John Iraci, Cornell University; Seongchan Park and Dr. Miriam Rafailovich, Stony Brook University

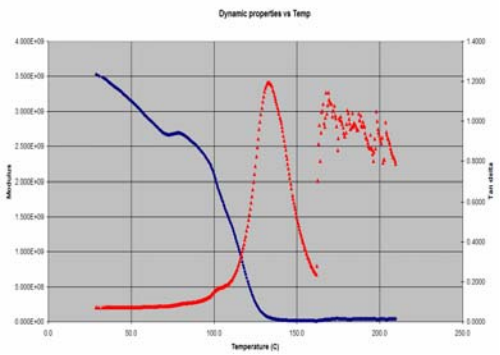
With the increasing prevalence of polymers in construction materials such as in waterproof coatings and bathroom fixtures, concern has naturally arisen regarding their flammability and potential hazards to society. The fact that most polymers easily ignite when exposed to a flame has generated reluctance among government agencies, industries, and consumers regarding the use of polymers despite the favorable qualities they possess in comparison to conventional materials (Si et al, 2007). Polymer flame retardancy has therefore been a field of extensive research for the past several years, and proposals have been made to diminish the fire hazard of many potentially useful polymers. Traditional halogen-based flame-retardants, such as decabromodiphenyl ether (DB), have proven to be effective in polymers. However, DB, like many other halogen-based additives, is toxic, and questions have therefore been raised regarding its widespread use (Siddiqi et al, 2003).

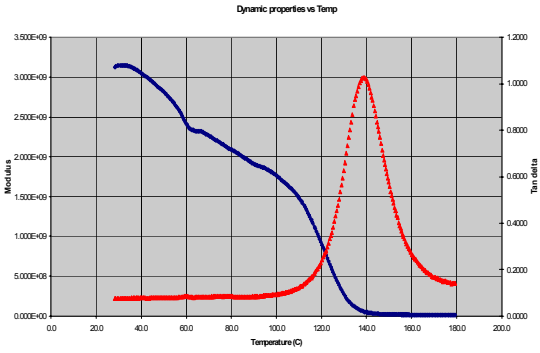
Using poly (methyl methacrylate) (PMMA) as a base polymer, we attempted to minimize and possibly eliminate DB from our samples and still maintain flame retardant characteristics. In addition, we also wished to maintain the favorable physical characteristics of PMMA, such as a high modulus, high impact strength, and high ultimate tensile strength. Phosphate-based flame-retardants have proven to be much less toxic than halogen flame retardants, and have been proposed as a viable alternative, but like many other flame-retardants, share the common drawback of being indispersible in most polymers. (Si et al, 2006) Since clay had previously been demonstrated to increase dispersity of flame retardant additives (Si et al, 2006), we incorporated small amounts of halloysite clay nanotubes (HNTs), which are especially effective in polystyrene (PS) blends (Du et al, 2006) into our samples. We prepared, using a Brabender, a control sample of 75% PMMA: 20% DB: 5% antimony trioxide (AO), using less DB than in conventional polymer/DB flame retardant blends. In order to compensate for this reduction, we sought to find synergies between clay and flame retardant additives, and prepared additional samples of 70% PMMA: 20% DB: 5% AO in which we incorporated 5% by weight of three varieties halloysite clay nanotubes (HNTs). The sample that is to be discussed in this abstract, however, is halloysite soaked in resorcinol diphenyl phosphate (RDP).

Our samples were flame-tested in accordance with UL94 standards, and the RDP-soaked halloysite samples were one of the two that passed with a V-0 rating, This blend especially showed little physical degradation during burning, as well as the development of a thin, consistent layer of char on the polymer surface, as shown in Figure 2.

We tested the mechanical properties of our samples using dynamic mechanical analysis (DMA). Both our control and RDP-soaked halloysite samples produced a higher expected modulus than pure PMMA, which at a maximum reaches only about 3.157 x 10^9 Pa. **(4)** Our control sample, containing PMMA, AO, and DB produced a modulus of 3.50 x 10^9 Pa, while our sample with PMMA, AO, DB, and RDP-soaked halloysite produced a similar modulus of 3.30 x 10^9 Pa. This increase in modulus from PMMA can perhaps be explained by the fact that because DB, AO, and RDP-soaked halloysite all disperse very well in PMMA (seen from smooth red graphs from Figures 1 and 3), they are able to influence the PMMA matrix consistently by possibly increasing intermolecular attractions or surface area between the polymer chains or by directly incorporating their (higher?) moduli consistently throughout the matrix. We attribute the slight degradation in modulus of our RDP-soaked halloysite sample to be due to the incompatibilities between pure halloysite and DB and AO. However, because RDP was shown to be a very effective dispersion agent for halloysite, as shown from the smooth Figure 3 graph, we believe that slight gap in modulus is fairly insignificant in comparison to our overall results and is caused mainly by experimental error (inconsistency in Brabending, etc.)

Our results suggest that RDP and halloysite share a synergy that promotes both effective dispersity and flame retardancy. This combination can be used to minimize DB in PMMA blends and make PMMA more viable in society.





(From left to right 1-3)
Figure 1: DMA of 75% PMMA: 20% DB: 5% AO
Modulus (beginning of blue line): 3.50 x 10^9 Pa
Figure 2: DMA of 70% PMMA: 20% DB: 5% AO: 5% RDP-soaked halloysite
Modulus: 3.20 x 10^9 Pa
Figure 3: Post flame test image of 70% PMMA: 20% DB: 5% AO: 5% RDP-soaked halloysite sample. Thin, consistent layer of char is produced and little physical degradation (melting) is observed.

References:

1. Si, M.; Zaitzev, V.; Goldman, M.; Frenkel, A.; Peiffer, D.; Weil, E.; Sokolov, J. C.; Rafailovich, M.; *Polymer Degradation and Stability*. **2007**, Volume 92, 86-93
2. Siddiqi, M. A.; Laessig, R.H.; Reed, K.D.; *Clinical Medicine and Research*. **2003**, Volume 1, 281-290
3. Du, M.; Jia, D.; Guo, B.; *European Polymer Journal*. **2006**, Volume 42, 1362-1369
4.eFunda. http://www.efunda.com/materials/polymers/properties/polymer_datasheet.cfm?MajorID=acrylic&MinorID=4
(accessed 08/07/2007), A page with mechanical properties of poly(methyl methacrylate) (PMMA)

Creating Biodegradable Organic Polymer Composites using Surfactant and Supercritical Fluid Exposure

Kimberly Leonard, Joshua Rosenbaum, John Iraci, Mitchell Fourman, Emily Levine, Danielle Lent

Here we show that it is possible to create a biodegradable plastic that can be used for industrial purposes. Currently plastics that are being utilized commercially, are not able to decompose and degrade in the environment. Starch is a polymer commonly associated with food and is produced naturally in the environment. Accompanied by a plasticizer, like Glycerin, starch could become a commercially viable plastic. In order to achieve this, the starch plastic must be ductile as well as have a satisfactory tensile strength. The exposure of these plastics to supercritical carbon dioxide (sc CO_2) was studied to determine whether such a process would increase either of these properties. scCO_2 is a phase of carbon dioxide beyond the temperature of 87.3°F and 1073 psi(g), in which carbon dioxide is a universal solvent and can improve the mechanical properties of polymer blends (Palermo 2004). The addition of clay nanotubes was also studied with the intention that an increase in the modulus of samples would make the plastic more commercially viable.

Our results showed that depending on the amount of starch vs. glycerin used, the properties of the plastic varied greatly. Our results supported our hypothesis that an optimal starch/glycerin proportion exists. As figure one shows, with increasing concentration of starch, toughness (or area under the graph) increases as well. The samples were tested for their biodegradability by water and flame exposure. Further research includes the addition of wood fibers to the starch and glycerin samples as well as varying the concentration of the nanotubes in the samples. Lastly, the total effect of supercritical exposure on samples will be determined.

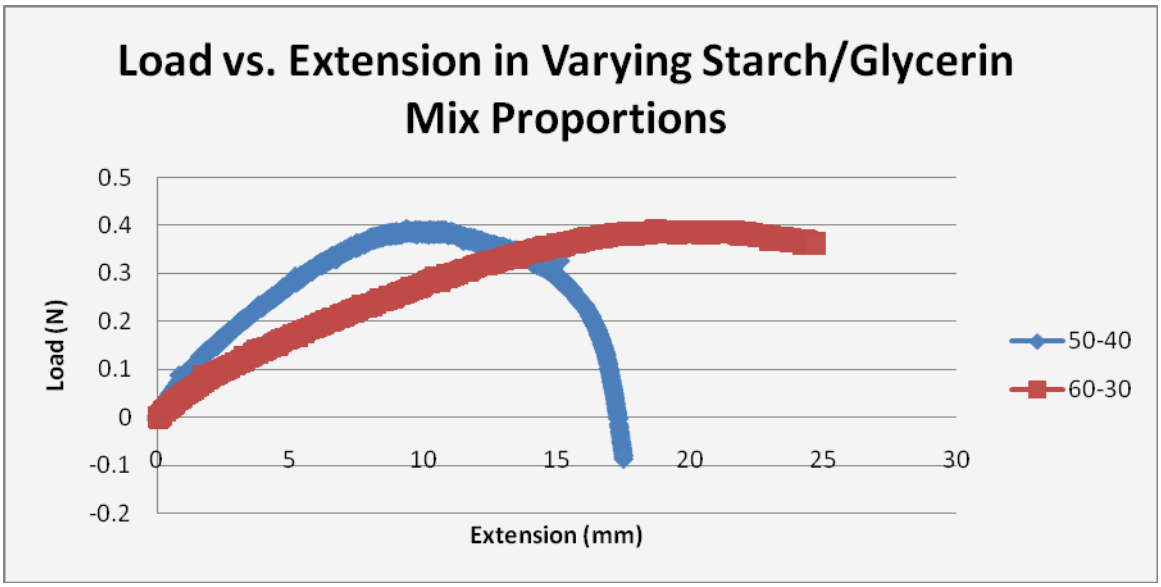


Figure 1: Graph showing relative extensions and maximum loads of starch/glycerine mixtures as a function of extension.

Enhancing the Properties of Polystyrene and Poly(methyl methacrylate) Blends using Supercritical Carbon Dioxide and Clay Nanotubes

Andrew Windler,[1] Steven Lubin,[2] Seongchan Park,[3] and Miriam Rafailovich[3]

[1]*Half Hollow Hills High School East, Dix Hills, New York 11746*
[2]*Duke University, Durham, North Carolina 27708*
[3]*Dept. of Materials Science and Engineering, Stony Brook University, Stony Brook, New York 11794*

Current recycling techniques require the sorting of polymer products and can become quite economically illogical. As a result, only 5.2% of plastics generated in 2003 were recovered through standard recycling methods, the lowest percentage of all municipal solid wastes.[1] Clearly, a more effective way to recycle and enhance the properties of these polymers is needed and has become the focus of much research. For example, previous work has shown that the addition of Cloisite 6A has allowed for greater surface interaction between Polystyrene (PS), a polymer found in everyday items like plastic cups and packing peanuts, and Poly(methyl methacrylate) (PMMA), another common polymer typically known by the trade name Plexiglas, thus increasing the compatibilization of the two polymers.[2] Additionally, supercritical carbon dioxide (sc CO_2) has been shown to compatibilize previously immiscible polymer blends in specific temperature-pressure dependent regimes, known collectively as the density fluctuation ridge.[3]

To expand upon this research, we have introduced three types of halloysite (clay) nanotubes to the PS/PMMA blends: untreated (uCN), Q-Salt treated (fCN), and RDP soaked halloysite nanotubes. A 50% PS 50% PMMA blend (control) was mixed and its properties were compared to blends of 90% PS 10% uCN, 90% PMMA 10% uCN, 45% PS 45% PMMA 10% uCN, 45% PS 45% PMMA 10% fCN, 45% PS 45% PMMA 10% RDP (percent by mass). The samples of PS/PMMA and halloysite nanotube blends were exposed to supercritical carbon dioxide (sc CO_2) along the density fluctuation ridge at 8.3 MPa and 36.6°C for 45 minutes. Preliminary data has shown that the combination of halloysite nanotubes and sc CO_2 treatment has proven to be effective in compatibilizing the two polymers by reducing the discrepencies in mechanical properties. For example, Dynamic Mechanical Analysis (DMA) tests have shown that the control blend has two distinct glass transition temperatures (T_g), one at 80.1˚C and one at 120.7˚C (Figure 1a), while the 45% PS 45% PMMA 10% fCN blend has only one distinct T_g at 87.9˚C (Figure 1b). Also, the control blend failed to be flame retardant, while the 45% PS 45 % PMMA 10% RDP blend after exposure to sc CO_2 achieved the V-2 standard for flame testing and was able to self extinguish itself within four seconds. Transmission Electron Microscopy will verify the polymers' compatibilization through analysis of specific polymer domain size and surface area interaction. Due to the process's nonspecific, inexpensive, and environmentally friendly nature, it may prove to be a valuable process in the efficient recycling of common polymers.

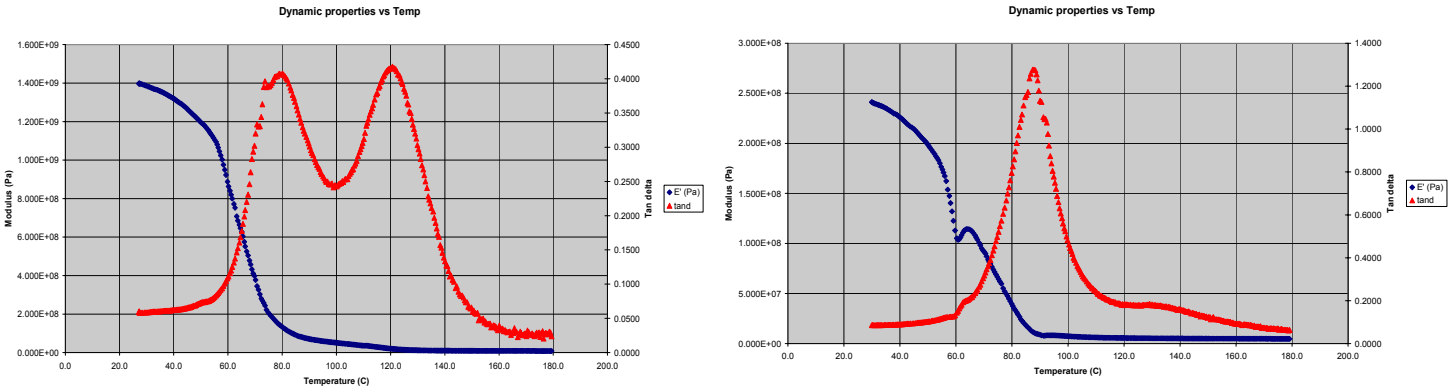


Figure 1. Dynamic Mechanical Analysis Results of PS/PMMA showing Dynamic Properties versus Temperature: (a) 50% PS 50% PMMA (b) 45% PS 45% PMMA 10 % fCN after exposure to sc CO_2 at 8.3 MPa and 36.6°C for 45 minutes

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[1] EPA. 2003. Environmental Protection Agency. http://www.epa.gov/msw/pubs/msw05rpt.pdf#search=%22plastics%2C%20united%20states%2C%20trash%22

[2] Si, M.; Araki, T.; Ade, H.; Kilcoyne, A.; Fisher, R.; Sokolov, J. and Rafailovich, M. Compatibilizing bulk polymer blends by using organoclays. Macromolecules. 2006, 39, 4793-4801.

[3] Koga, T, et al. Density-Fluctuation-Induced Swelling of Polymer Thin Films in Carbon Dioxide. Phys. Rev. Lett. 89, 125506 (2002)

Session VII: Cells and Proteins on Surfaces

Chairs: Lenny Slutsky

Kate Dorst , Chunghueh (Paula) Chang,

Ram Shankar, Shuang Chen

Garcia Staff: Tatsiana Mironava, Chunhua Li

Xiaolan Ba,Ja Koo, Chunghueh (Simon) Chang

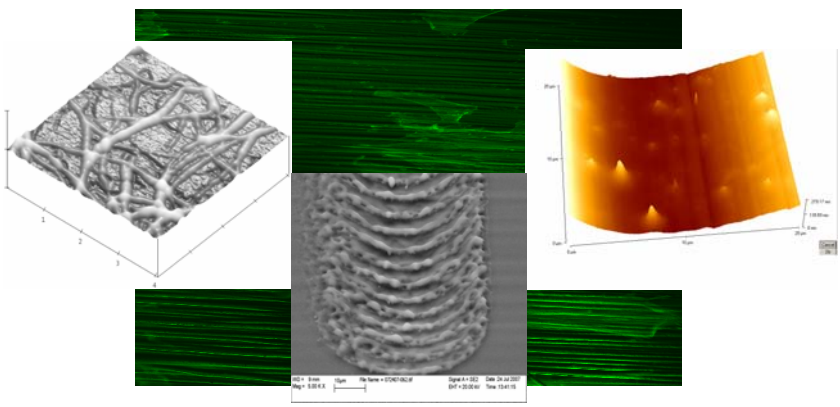
Adam Gross, Jason Mogen

Jovanna Linnen

Alex Ramek, Adam Fields

Joanne Anthonypillai, Jackie Belizar

Pooja Vasudevan

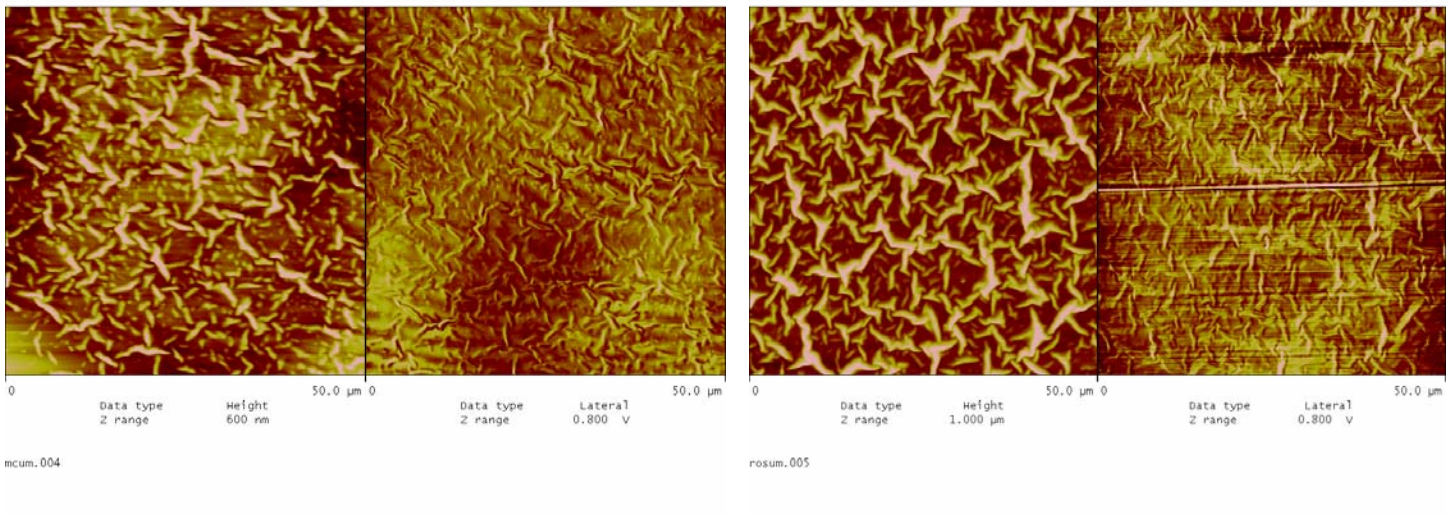


An analysis of biomineralization on sulfonated-polystyrene surfaces: comparing cancerous and non-cancerous osteoblast crystals and investigating dental pulp stem cells differentiation

Jason Mogen, Adam Gross, *Half Hollow Hills HS West*
Nadine Pernodet, Miriam Rafailovich, Xiaolan Ba, *SUNY Stony Brook*
Kate Dorst, *Dowling College*

Recent studies have proven that sulfonated-polystyrene (SPS) surfaces induce spontaneous extracellular matrix (ECM) fibrillogenesis. (Pernodet 684-692) Our investigation involves plating cancerous and non-cancerous osteoblasts to study the differences between their ECMs, the biomineralization process, and the resulting calcium-phosphate (CaP) crystals. With cancer-related deaths increasing, it is important to characterize these morphological and structural changes that occur both within and surrounding various cell types. Our primary experiment compares potential differentiation and biomineralization of dental stem cells, which may provide evidence of SPS's ability to instigate ECM growth and hydroxyapetite (HA) crystal formation. After determining SPS's growth-stimulating properties through a confocal microscopy and fluorescent assay, we plated cancerous and non-cancerous osteoblasts and keratinocytes on a thin coating of SPS. We utilized the atomic force microscope (AFM) to analyze the ECM elastic modulus and average fiber heights prior to (Fig.1) and following the completion of differentiation and biomineralization. The scanning electron microscope (SEM) then compiled a 3D image of the crystal structure and analyzed the chemical composition. A more detailed picture will be obtained with the transmission electron microscope (TEM), displaying the crystal lattice. Through the results that will be obtained in weeks to come, we can determine if there are any statistically and structurally significant differences between cancerous and non-cancerous ECMs and CaP crystal formation, and establish whether or not further investigation is necessary into the influence of SPS surfaces on cell differentiation and biomineralization.

Fig.1- Initial ECM images of non-cancerous (left) and cancerous (right) osteoblasts taken by AFM. Cancerous osteoblast fiber heights are significantly greater than non-cancerous osteoblast fiber heights.



Pernodet, Nadine. "Fibronectin Fibrillogenesis on sulfonated polystyrene surfaces." Wiley Periodicals, Inc. (2003): 684-692.

Normal Extracellular Matrix vs. Cancer Extracellular: A Look at the Cell Mechanics

Jovanna Linnen[1], Dr. Miriam Rafailovich[2], Dr.Nadine Pernodet[2], Kate Dorst [3]

[1]Uniondale High School, [2]Department of Materials Science and Engineering, SUNY at Stony Brook, [3]Dowling College

The ECM is a structure that is not part of any cell but is very intertwined between the spaces of the cell. Although it is essentially ignored in most descriptions of cell development, it is one of the most important components for the formation of cells.
Some of the functions of the ECM include the assistance of cell proliferation, support and anchor for cells, a barrier for other tissues and most importantly cell communication (via adhesion to cells). . Cell adhesion molecules known as integrins are responsible for the cell to cell communication in the cell. The goal of the project is to look at the ECM on a structural and physical scale. Within that goal, their will be focus the cell mechanics of the ECM and comparison of thicknesses and fiber heights of cancer cells vs. normal cells.

In order to start the experiment, one must first spincast sulfonated polystyrene onto silicon wafer. Before the polymer was applied to the wafer, the wafer was first cleaved, cleaned and dried before any spinning occurred. The thin film created during spin casting needed to be annealed; therefore the newly spinned films were put into a vacuum oven for a period of 24 hours. After the 24 hour period, the cells were then plated by a Grad student. Two days later, the cells were switched by a grad student: Normal/ Normal, Norma/ Cancer, Cancer/ Normal, Cancer/Cancer. The switched cells were then incubated for a 2 day period and were AFM. Using the AFM, one was able to retrieve images and the cell mechanics of each type of cell.

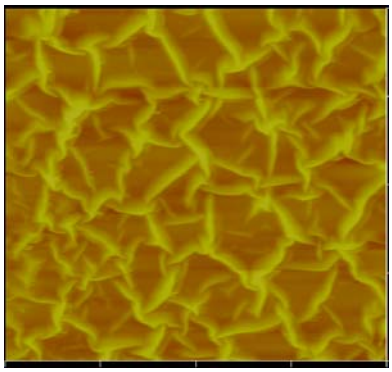


Fig.1 AFM image of Normal Keratinocytes on Normal Keratinocytes; 80 µ.

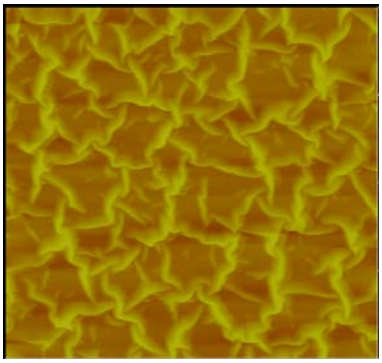


Fig.2 AFM image of Cancerous Keratinocytes on Cancerous Keratinocytes; 80 µ.

1

[1] Bissell, Mina (1998). Extracellular matrix signaling: integration of form and function in normal and malignant cells, Current Opinion in Cell Biology 1998, 10:640-646.

2 Ingber, D.E. (2006). Mechanical control of tissue morphogenesis during embryological development, Int. J. Dev. Biol. 50: 255-266

Cell Response to Engineered Surfaces: From Bone Generation to Self-Assembled Fibrinogen Clotting

Adam Fields[1], Alex Ramek[2], Sean Pi[3], Nadine Pernodet[4], Tatsiana Morovina[4], Jaseung Koo[4], Dennis Galanakis[4], Miriam Rafailovich[4]

[1]Jericho High School
[2]HAFTR High School
[3]Princeton University
[4]SUNY Stony Brook

This work was supported by the Simons Foundation, Garcia MRSEC Polymers at Engineered Surfaces, and the National Science Foundation (NSF)

Within the human body, surfaces play a major role in determining cell action and protein conformation. Here we show that surface interactions alone influence stem cell differentiation and fibrinogen clot formation, respectively. Presently, in order to induce biomineralization and differentiation of dental pulp stem cells, the right components must be added to the media in which they grow. We investigated whether we could induce dental pulp stem cells to produce calcium without special media if they proliferated on a surface comparable in hardness to that of bone. The biomineralization capacity of dental pulp cells (DPCs) was assessed through shear modulation force microscopy (SMFM), scanning electron microscopy (SEM), and confocal microscopy. We found that the relative moduli of these cells became harder over a four week period when cultured on polybutadiene (PB) thin films on silicon wafers and that calcium production was successful (Figs.1 and 2). This engineered osteointegration[1] was generated on thin 200 angstrom PB surfaces with hardness comparable to that of bone. These results provide implications for the tissue engineering of mineralized tissue for use in the treatment of bone fractures or osteoporosis. Similarly, it is quite hard to produce a fibrinogen clot on an artificial surface and the enzyme thrombin is essential for fibrin fiber formation. We demonstrated that by using a novel hydrophobic clay, surface interactions between the fibrinogen and clay allowed for self-assembly of a fibrinogen clot[2] (Fig. 3) without the addition of thrombin. We demonstrated this by using atomic force microscopy and gel electrophoresis. Further, dermal fibroblasts successfully proliferated on this clot (Fig 4), demonstrating the biocompatible nature of this clot/clay substrate. This engineered healing mechanism has the potential to enhance wound healing, especially in patients with delayed mechanisms for inflammation and repair including diabetics, hemophiliacs, and others with autoimmune diseases. Additionally, we show that on an alternative hydrophilic biocompatible clay substrate clotting did not occur (Fig. 5). Thus, this surface provides an optimal interface for artificial organ growth and implantation and provides an effective model for surface influence on cell proliferation.

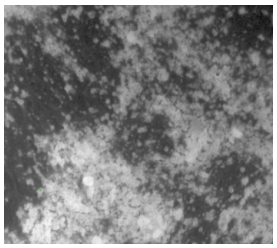


Fig 2: Confocal Image: *Calcium on PB*

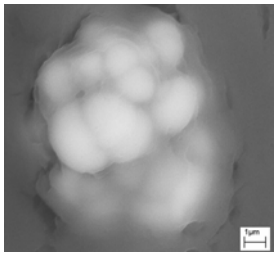


Fig 1: SEM Image: *Calcium on Thin PB*

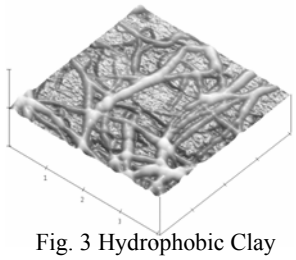


Fig. 3 Hydrophobic Clay fibrinogen fibers

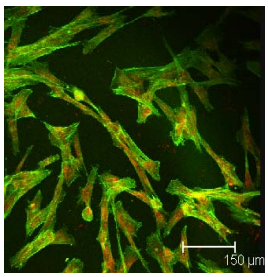


Fig 4: Confocal Image: *Dermal Fibroblasts on Clot and Clay*

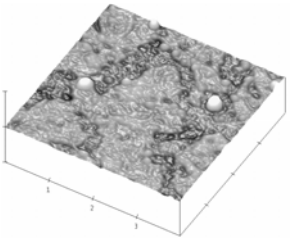


Fig. 5 Hydrophilic Clay fibrinogen fibers

[1]H. Nakamura et al. (2005). Molecular and biomechanical Characterization of Mineralized Tissue by Dental Pulp Cells on Titanium. *J Dent Res* 84(6): 515-520.
[2]Robert A. S. Ariëns et al. (2002). Role of Factor XIII in Fibrin Clot Formation and Effects of Genetic Polymorphisms. *Blood* 100(3): 743-754.

Influence of Surface Mechanics on Cell Differentiation Using the Polymer Polybutadiene

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Jackie Belizar, Miller Place High School
Mentor: Dr. Nadine Pernodet, Stony Brook University
REU: Lenny Slutsky, Duke University
REU: Kate Dorst, Dowling College
Acknowledgements: Dr. Miriam Rafailovich, Chun Hua, Sean Pi, Stony Brook University.

The importance of cell differentiation, in modern biology, is enormous. Cell differentiation is vital for stem cells to transform into other cells. [1] In recent studies, surface mechanics have been investigated to see if surface mechanics have an influence on cell differentiation. In this study, we are trying to see how the influence of surface mechanics will affect the cell differentiation of pre-adipocytes.

To begin the process, we prepared two Polybutadiene (PB) solutions with toluene as the solvent. Each solution was created to form a thin film with a certain thickness. One thickness was 200Å, which was the thinner film (2mg/ml). The other thickness was 2000Å, which was the thicker film (20mg/ml). After letting the PB solutions fully dissolve for a couple of days, we prepared 60 1cm square Silicon (Si) wafers. Of these 60 wafers, 24 were thin film, 24 were thick film, and 12 were control. Of the 24 thin, 12 were to be induced to produce fat while the other 12 were not to be induced. The same was done to the 24 thick wafers. Before spin casting, we cleaned and made the Si wafers hydrophobic. Then, we annealed the thinner of the two sets of Si wafers for about an hour and the thicker wafers overnight. Later, a representative from the skin bank plated our Si wafers with pre-adipocytes, and we then placed our cells in incubation for about a week. After this incubation period, we used the Atomic Force Microscope (AFM) to measure the mechanics of our cells.

Based on the results from the AFM, we were able to determine that the non induced and induced thin samples were starting to differentiate. This differentiation was also occurring in the thick samples. However, there were more cells on the thick samples than there were on the thin samples. We also discovered that the more differentiated cells had the softest surfaces. Another interesting result is that on the thin samples, we saw that the cells had produced black dots. We hypothesize that our cells are eating the PB thin films. The next step in our future research is to use the Confocal Microscope to look at the pre-adipocytes on 3-D imaging. We hope to gain a better understanding of what the black dots produced by our cells really are. Also, we have a second incubation period of two weeks. After this second incubation period, we will be able to see how much differentiation has occurred in our pre-adipocytes from the first incubation period.

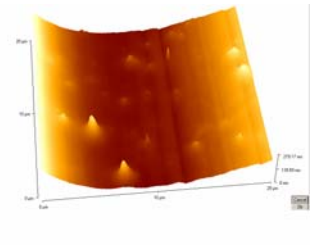


Fig. 1 PB film on a Si wafer

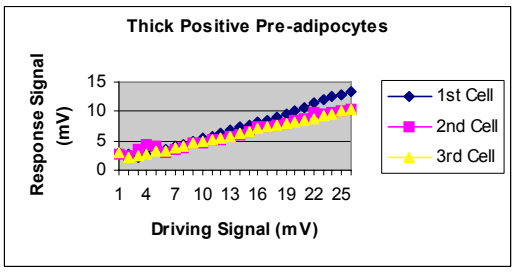


Fig. 2 Modulus of pre-adipocyte cells on PB

1. Keller, Gordon. "Embryonic Stem Cell Differentiation: Emergence of a New Era in Biology and Medicine." Genes and Development: 19:1129-1155. 2005.

Regulation of Cell Behavior through Mechanical Characterization of Polybutadiene (PB) Fibers

Pooja Vasudevan, Wheatley High School, NY
Chunhua Li, Chungchueh Chang, Nadine Perinodet, **Dr. Miriam Rafailovich**, Stony Brook University

The growing field of tissue engineering addresses the fundamental concepts of human biology through improving human health.[1] Previous studies within this field have shown that engineered polymer fibrous substrates can be used to biomimick our native Extracellular Matrix (ECM) by allowing cells to grow, migrate, and send the necessary signals to form functional tissue. Cells change their morphology on the underlying substrate because they are very sensitive to local nanoscale patterns of topography.[2] In this study, we have designed a biocompatible Polybutadiene (PB) matrix to initiate cell growth and spreading. Through engineering this PB matrix , we are trying to understand how cells respond to different mechanical properties of the substrate through altering fiber diameter, density, rigidity, and orientation.

In order to design this matrix, various solutions had to be prepared for spin casting the thin films and electrospinning the fibers. For spin casting, a PB solution of 5 mg/mL was prepared using chloroform as the solvent. After the thin film was prepared, fibers were electropun onto the thin film. To overcome the beads and optimize fiber diameter, solutions at 1%, 3%, 6%, and 8% of PB by weight were dissolved in THF. The 8% PB solution resulted in fibers of about 5 um with no beads (Fig 1). Modulus testing under the AFM showed the fibers to be very soft and elastic. These PB fibers were then electrospun in both a random and linear orientation. Linear fibers were fabricated using a rotating mandrel at 80 rpm for 15 minutes to create a single layer (Fig 2) and 45 minutes to create multiple layers of these fibers (Fig 3). Pre-adipocytes were then seeded onto these substrates and stained to be viewed under the confocal. The confocal images show that the pre-adipocytes followed the fiber orientation as the actin stretched along the linear fibers (Fig 4) Furthermore, the multiple layer fibers supported more cell attachment and spreading on the matrix (Fig. 5).

In the future, cancerous cells will be seeded onto these substrates to observe how the morphology differs from that of normal cells. The modulus of these cells will be tested under the AFM to compare rigidity as a function of orientation. Varying concentrations of clay will be added to the fibers to change the rigidity and crystalline structure of the fibers.

Fig. 1 PB fibers randomly oriented

Fig. 2 single layer with linear orientation

Fig. 3 multiple layer with linear orientation

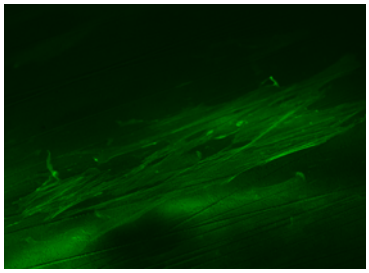


Fig. 4 Pre-adipocytes on single layer

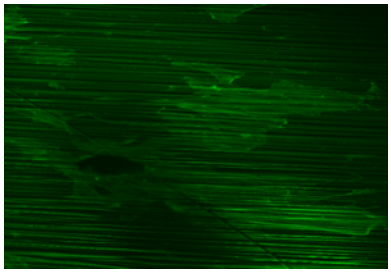


Fig. 5 Pre-adipocytes on multiple layers

[1] Kauffman, S.A. 1993. *The Origins of Order*. New York: Oxford University Press.
[2] Huang, S., and D.E. Ingber. 1999. *The structural and mechanical complexity of cell growth control*. Nature Cell Biology 1(5): E131-138

Topographical and Mechanical Patterning for Cell Culture Using Laser Ablation

Ram Shankar, Princeton University , *Jaqueline Belizar,* Miller Place HS, *Joanne Anthonypillai*, Holy Trinity HS
Jon Longtin, Department of Mechanical Engineering, SUNY Stony Brook
Nadine Pernodet, Miriam Rafailovich, John Jerome, Department of Materials Science , SUNY Stony Brook

According to Donald Ingber's tensegrity model[1], cells both actively and passively change their structural conformation and force distribution to maintain a dynamic equilibrium in their environment. Thus, we seek to show that adipose cells grown on a grated thin film substrate made up of polybutadiene spun onto Silicon will show clear changes in cell modulus as a function of thin film thickness. To produce accurate and repeatable results, we cut "wells" of varying thicknesses directly on silicon wafers using femtosecond laser ablation. Manipulation of laser power, duration and pass-counts created grooves of varying depth, which were measured using an atomic force microscope. We found that depth decreased linearly as duration decreased, but the effects of laser power and pass counts were non-linear. In addition, at higher pass counts the outer-fringes of the cut became increasingly distorted and molten (Figure 2), further corroborated by the increased presence of silicon oxides (SiO_2). We found the optimum conditions of ablation to be at.2% to 1% of the laser's total power (1.8.1 kW) with a laser velocity between 3 and 9 microns/sec and no more than 2 passes per cut. Using these parameters we created wells ranging from 20-600 nanometers in depth; note in figure 1 that the depth is not constant as each laser sends a spherical pulse forming a series of trenches. We are awaiting the results on cell modulus.

1. Ingber, D.E., The Architecture of Life. Scientific American Jan 1998; 278:48-57.

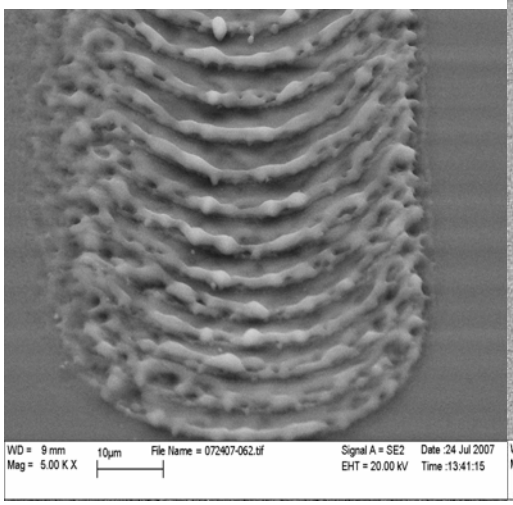


Figure 1

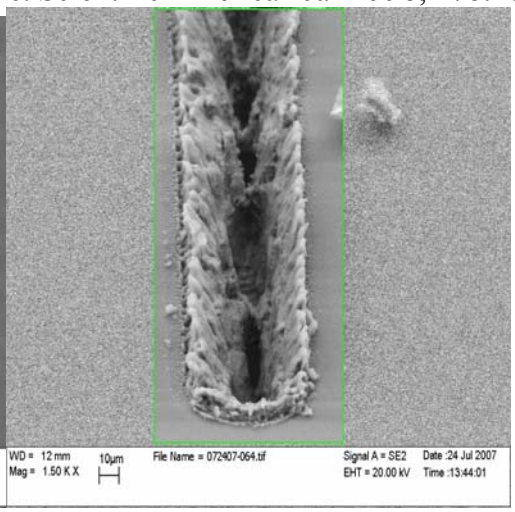


Figure 2

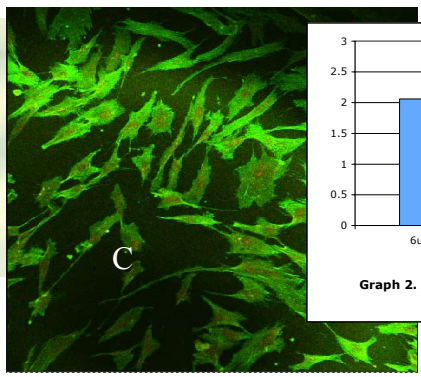
Figure 1 and 2: SEM images of laser ablated Si wafers

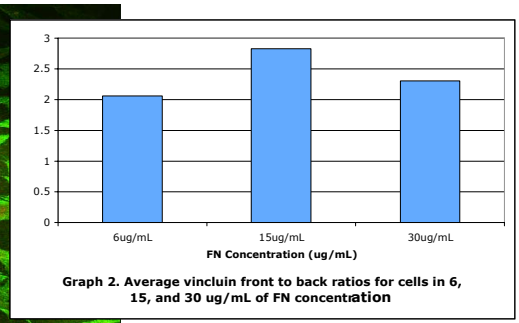
Session VIII: Cell Dynamics and Cells on Scaffolds

Chairs: Hilana Lewkowitz-Shpuntoff, Fauzia Shaikh, Sylvia Qu, Paula Huang, Shuang Chen, Nicole Brenner

Garcia Staff: Chunhua Li, Tatsiana Mironava, Ying Liu, Zhi Pan, Lourdes Collazo

Ryan Price, Brian Kim, Rachel Greenberg, Sarajane Gross, Jordan Schachar, Danny Stemp, Dhruv Nandamudi, Rima Patel, Amy Ramirez





Graph 2. Average vincluin front to back ratios for cells in 6, 15, and 30 ug/mL of FN concentration

Human Dermal Fibroblasts Morphology on Oriented poly (methyl methacrylate) Scaffolds

Brian Kim Manhasset High School
Ryan Price Jericho High School
Ying Liu, Dr. Miriam Rafalovich, Stony Brook University

The WTEC report estimates that nearly $3.5 billion have been spent on tissue engineering in the last decade[1]. This said, in the past decade, tissue engineering has grown to be one of the largest fields of biomedical research.

Tissue engineering can generally be defined as the application of scientific and engineering principles to the design, construction, modification, growth and maintenance of living tissues. Engineering tissues and organs with mammalian cells and a scaffolding material is a new approach in contrast to the use of harvested tissues and organs. In the tissue engineering approach, the scaffold plays a pivotal role in cell seeding, proliferation and new tissue formation in three dimensions[2].The ultimate goal of this study was to analyze cellular mechanics across oriented scaffolds. The 3-dimensional extra cellular matrix was mimicked through oriented poly (methyl methacrylate) (PMMA) nanofibers in random, one-way and two-way alignments. By mathematically approaching cellular morphology, proliferation and migration, an optimal fiber design could be developed in the future.

20% PMMA in chloroform solutions were prepared on 30mg/ml PMMA in toluene solution coated silicon wafers. Electrospinning was the method chosen for preparing the fibers because it produces polymeric fibers with diameters in the range of 10μm–10 nm by accelerating a charged polymer jet under a high electric field[3]. The fiber diameters of random, one way and two way aligned fibers were not significantly different as the concentrations of the solutions remained constant.

Cells were seeded on the PMMA nanofibers and observed on days 3, 6 and 9 and images were taken under the confocal microscope at 20x and 63x. As shown in figure one, A is under 63x and B, C and D are under 20x. The images qualitively revealed that seeded cells grew along the oriented fibers.

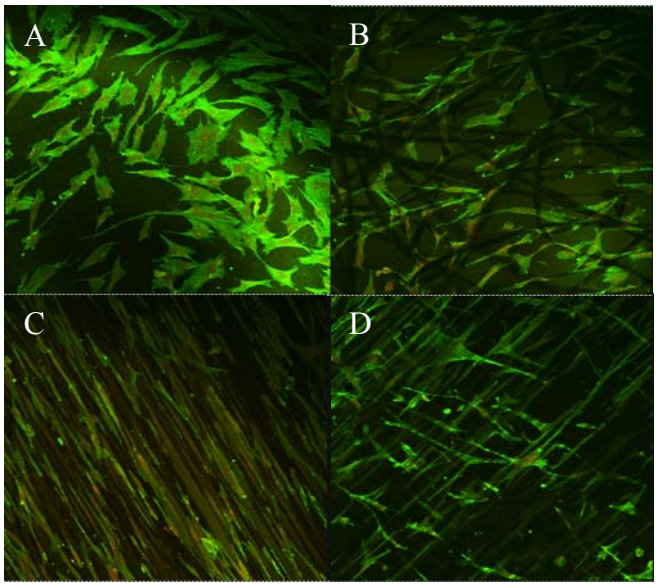


Figure 1- Cells on oriented surfaces
A- PMMA thin film
B- Random Aligned Fibers
C- One Way Aligned Fibers
D-Two Way Aligned Fibers

[1]Michael J. Lysaght, Joyce Reyes. Tissue Engineering. 2001, 7(5): 485-493.
[2]L.A Smith, P.X. Ma. Science Direct. 2003, 39(3): 125-131
[3]Bibekananda Sundaray, V. Subramanian, and T. S. Natarajan.Appl. Phys. Lett. 88-91

Finding the Optimum Scaffold for the Growth and Proliferation of Myocardium and Satellite Cells

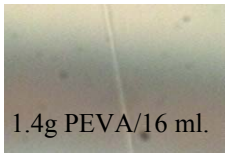
Rachel Greenberg, Sarajane Shaw Gross, Jordan Schachar, , Allen Sachs
North Shore HS
Chunhua Li, Shuang Chen, Lourdes Collazo, Miriam Rafailovich, SUNY Stony Brook
Paula Huang, Cornell University

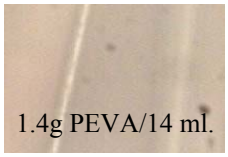
In the world of science today, a great extent of research has been done in the field of regeneration of cardiac tissue. Science researchers Ray C.J. Chiu, Audrius Zibaitis, Race L. Kao have set the basis for the purpose of our experiment with their examination of myocardium cells' regeneration post trauma. Damaged skeletal muscle, a type of striated muscle attached to the bone, is able to regenerate due to the presence of satellite cells in the tissue. Satellite cells, which are found in the muscle between the basal lamina and the sarcolemma, have two functions: to aid in the normal growth of muscle as well as to regenerate tissue after injury or disease. However, their lack of presence in cardiac muscle makes it impossible for these cells to serve as regenerators after injury. The purpose of our experiment is to create a scaffold via the procedure of electrospinning which would serve to be the optimum environment in which myocardium cells, with the help of satellite cells extricated from muscle tissue, could proliferate.

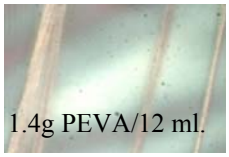
For the purpose of our research, thin films were required on which eventually, fibers would be spun. The wafers called for a treated surface which involved extensive cleaning. However, due to the crystalline structure of this specific polymer, thin film spin coating had to be done with hot wafers and hot solutions. The films were measured for individual thickness on the ellipsometer. In order to spin fibers successfully, a thickness of approximately 1,000 Å was needed. Anything thicker would have presented the issue of too much material on the wafer while a thinner treatment was not quite substantial. After many trials and errors, the films were ready for electrospinning. For this process, the polymer of ethylene vinyl acetate 550 proved to be too crystalline, becoming crystallized prior to ejection from the syringe. After many attempts to create our ideal fibers PEVA 260, a less crystalline polymer, attested to achievement! Finally, fibers were created. Fibers were produced from solutions of 1.4 grams of PEVA 260 and 8 ml., 10 ml., 12 ml., and 14 ml. concentrations of chloroform. When observed under the microscope, the fibers with a higher concentration of polymer appeared to have a greater diameter than that of a solution with a lesser concentration of polymer.

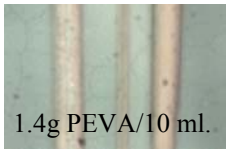
PEVA 260 fibers no clay

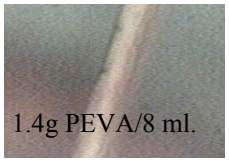
PEVA 260 fibers with clay


1.4g PEVA/16 ml.


1.4g PEVA/14 ml.


1.4g PEVA/12 ml.


1.4g PEVA/10 ml.


1.4g PEVA/8 ml.

Additional solutions containing Cloisite Clay 10A in percentages of 0 (control), .07, .35, and 3.5 were also utilized. After weeks of measuring the modulus and thickness and testing various parameters, the satellite cells were ready to be plated onto the allotted scaffolds.

Statistics show that 36.3%, or 1 in 2.8, deaths are a result of cardiovascular infraction or injury. In their, "Adult Stem Cells for Myocardial Repair", Felipe Prósper, Ana Perez, Juana Merino, Gregorio Rábago, Juan Carlos Chachques, Milagros Hernández, Joaquín Barba, Eduardo Alegria, Juan José Gavira, Angel Panizo and Jesús Herreros report that recent studies have used myogenic cells, embryonic stem cells, hematopoietic stem cells and even the induction of undamaged cardiomyocytes to replicate. The purpose of this would be to introduce a cell population that can mimic the functions of a normal cardiac cell. Successful cardiac tissue engineering would provide a valuable alternative therapy for end-stage heart failure, and due to the limited availability of organs for transplantation, cell transplantation seems to be a promising solution. However, it is of great importance to examine the effects the satellite cells will have on the cardiac cells prior to implantation. Creating a scaffold with the use of electrospinning will, in essence, mimic the striations present in natural myocardial tissue and allow us to examine the growth of these cells in their "natural environment."

Optimized Cell Migration along Functionalized Surfaces

Danny Stemp. *North Shore Hebrew Academy High School, Great Neck, NY*
Dhruv Nandamudi. *Monta Vista High School, Cupertino, CA*
Zhi Pan, Dr. Miriam Rafailovich. *Department of Material Science and Engineering; SUNY Stony Brook, Stony Brook, NY*
Hilana Lewkowitz-Shuptoff. *Princeton University, Princeton, NY*
Fauzia Shaikh. *Harvard University, Boston, Ma*

The importance of cell migration is recognized in such essential and fundamental processes as embryogenesis, wound healing, inflammation, and tumor metastasis. Cell migration is also crucial to technological applications such as tissue engineering to colonize biomaterial scaffolding.

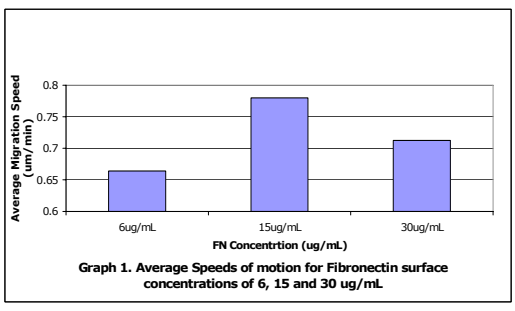
Accumulated study suggests that cellular migration is based on adhesions formed between the cell surface receptor proteins, such as integrins, and substrate ligands. Such attachments are more abundant on the front end of the cell, the result of polarization that allows directional integrity during migration.

Fibronectin (FN) is an essential substrate ligand that allows the aforementioned adhesions to form. However, the amount of such protein necessary to establish optimal migration speeds remains unclear due to the paradox concerning it. As already suggested, FN is essential for cell migration; however, it is also essential for cell adhesion. These two processes counteract each other; therefore, a concentration of FN must be determined in order to maximize the net force of the cell, instead of the number of adhesions. Although more adhesion points exert a greater force, cell migration is only propelled if the cell is polarized.

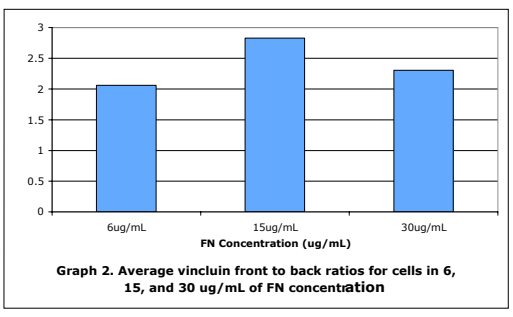
To this end, we analyzed cellular migration on FN concentrations of 6, 15, and 30 μg/mL in order to determine the concentration resulting in maximized migration speed. The results, presented in Graph 1 below, reveal that the 15 ug/mL concentration provided the highest migration speed of 0.780 um/min. While the lack of adequate adhesions in the 6ug/mL field slows cell motion, the excessive number of those same adhesions in the 30ug/mL field similarly hinders migration.

Furthermore, cells in the three fields of study were examined for internal concentrations of vinculin, the protein attached to the ends of actin filaments that form focal adhesions with the substrate, or extracellular matrix (ECM). Vinculin counts, then, correlate directly to the number of adhesions present. Particularly, the ratio of vinculin in the front end of the cell to the back end was calculated, in order to measure the degree of polarization. Graph 2 presents the results, clearly revealing that the cells in the most favorable field, 15ug/mL, had the greatest front/back vinculin ratio.

Lastly, cellular stiffness was calculated and compared using atomic force microscopy (AFM)—recent studies elucidate that stiffer cells are healthier and consequently migrate better. Again, the results remain consistent with the previous observations—the cells in the 15 and 30ug/mL fields were stiffer and consequently healthier, allowing for greater motion than the cells in the 6ug/mL field.



Graph 1. Average Speeds of motion for Fibronectin surface concentrations of 6, 15 and 30 ug/mL



Graph 2. Average vincluin front to back ratios for cells in 6, 15, and 30 ug/mL of FN concentration

The Effects of Magnetic Polymer Nanocomposites on Bone Cell Growth

Amy Ramirez and Rima Patel- Roslyn High School, Roslyn, NY; Lawrence High School, Cedarhurst
Rebecca Isseroff, Lawrence High School; Hilana Lewkowitz-Shpuntoff, Princeton University; Nicole Brenner, Dr. Richard Gambino, Dr. Miriam Rafailovich, Tatsiana Mironava and Dr. Nadine Perdonet, Stony Brook University

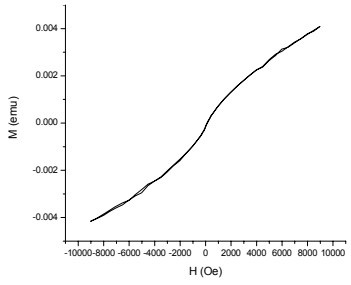
Every year more than 5 million bones are fractured within the United States and over 250,000 of these fractures result in nonunion. Polymethyl methacrylate, (PMMA) has been approved by the FDA to be used as bone cement. Additionally, it has been observed that electric fields occur in mechanically-loaded bones and are thought to be responsible for bone growth in that area. Therefore, an electro-magnetic field is hypothesized to enhance bone growth. In this study, we created a ferromagnetic clay polymer nanocomposite and tested its effects on bone osteoblast cell growth.

The magnetic clay polymer nanocomposite was synthesized using PMMA, Clay Cloisite 20A, and iron-pentacarbonyl. First, iron-pentacarbonyl was mixed with Clay Cloisite 20A in various ratios (3:1, 2:1, 3:1, respectively). When mixed, the iron-pentacarbonyl reacted with the Clay to create iron oxide (Fe_2O_3) nanoparticles dispersed within clay platelets. These nanoparticles were then mixed with PMMA in two different ratios (80% PMMA and 20% Clay, and 90% PMMA and 10% Clay). A Brabender evenly mixed the PMMA and the iron oxide nanoparticles for a half hour at 180ºC. The nanocomposites were then molded into various shapes for different tests using a heat press at 170° C.

A Vibrating Sample Magnetometer (VSM) was used to determine the magnetic moments of each of the different ratios. The nanocomposites XXXXXX had no magnetic moment, while 80%PMMA 20%Clay, 1:3 ratio of Clay to iron penta-carbonyl had the strongest magnetic moment (see figure below).

Dynamic Mechanical Analysis (DMA) is being used to determine the mechanical properties of the different ratios of iron-pentacarbonyl to clay and clay to PMMA. The modulus of the materials is expected to change with the varying ratios of clay and iron oxide.

To determine whether a magnetic field has any effect on the growth of cancer cells, cancerous osteoblasts were plated on the sample with 80%PMMA 20%Clay, 1:3 ratio of Clay to iron penta-carbonyl (which had the strongest magnetic moment), on plain PMMA, on PMMA-Clay, and on glass as a control. In order to increase the magnetic field, neodymium magnets were placed on either end of the Petri dishes that contained where the nanocomposite molds and cells. Cell growth at days 1 and 4 will be counted and confocal microscope pictures will be taken sometime before November, if only we can get Confocal time.



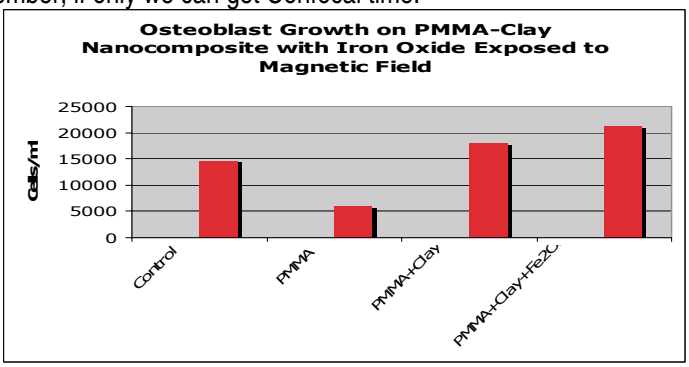


Fig 1: Hysterisis Loop of 80%PMMA 20%Clay 1:3 Clay:Fe_2O_3
Fig2: Osteblast growth

Session IX: Pluronic Hydrogels and Sensors

Chairs: Vijay Jain, Jinju Yi, Ankuri Desai

Garcia Staff: Jack Lombardi, Jun Jiang

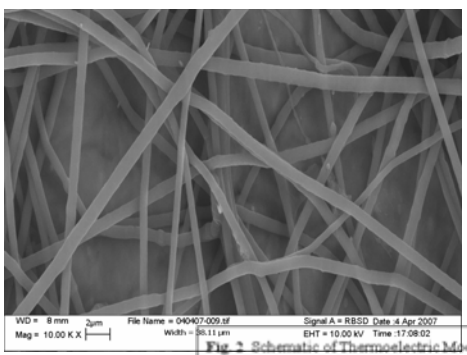
Yantian Wang, Celine Pujol

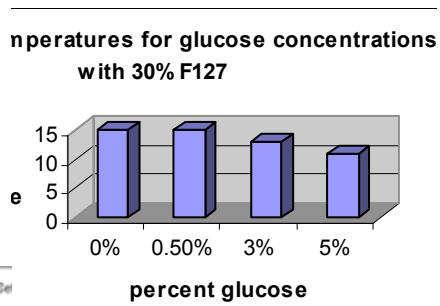
Yehuda Grossman, DRS Yeshiva

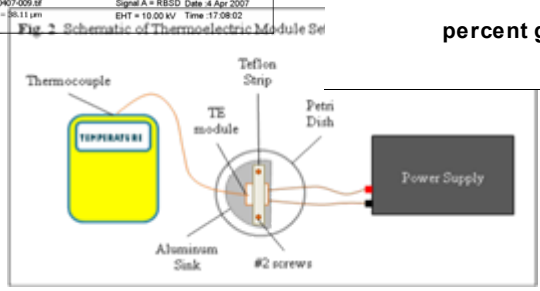
Lara Fourman, Sanchita Singal

Mitchell Feinberg, Tanya Masand

Darren Huang, Damian Lee







The Physical Properties Hydrogels and Diabetes Modeling

Yehuda Grossman
Dr Rafailovich, Jun Jiang, Ankurai Desai, and Jack Lombardi from Estee Lauder

Hydrogels hold great potential for the modeling of gels in the human body such as the eyes, knees, or lips. This is important in order to properly study and understand the effects of glucose in diabetic patients. Pluronic F127, is suitable to be used for such a purpose as it is a gel and the effect of glucose on its properties can be accurately studied. This hydrogel is a triblock copolymer that is thermoreversible, meaning that it can gel at higher temperatures and is a liquid at lower temperatures[1]. The purpose of this investigation is to use F127 as a model for natural gels within the body and simulate the effect that glucose has in the body.

The rheological properties of the hydrogel were studied, including the G' Modulus as a function of temperature and concentration in particular. This was performed in order to observe the effect of glucose on the stiffness of the hydrogel. Using an AR 2000 rheometer, I found that with 30% F127 the modulus decreased from 2*C to 50*C when the hydrogel contained 5% glucose. However, the modulus of the hydrogel increased with both 3% and ½% glucose, where the ½% glucose had the higher modulus. The same glucose concentrations with 15% F127 exhibited identical changes in their moduli but the moduli were much lower. The transition temperatures of the solutions decreased with increasing amounts of glucose (Figure 1). In order to discover the properties of the hydrogel on the micellar level computer modeling was used. F127 forms micelles or a certain type of aggregate at higher temperatures and concentrations[1]. Computer modeling in figure 2 shows that the micelles are more likely to loop than to bridge.

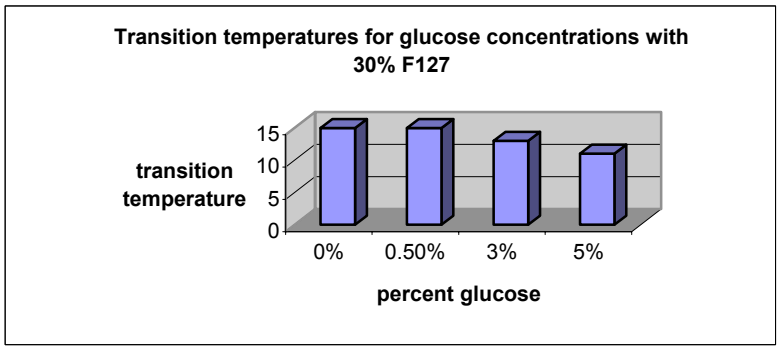


Figure 1: The transition temperature decreases as glucose concentration increases.

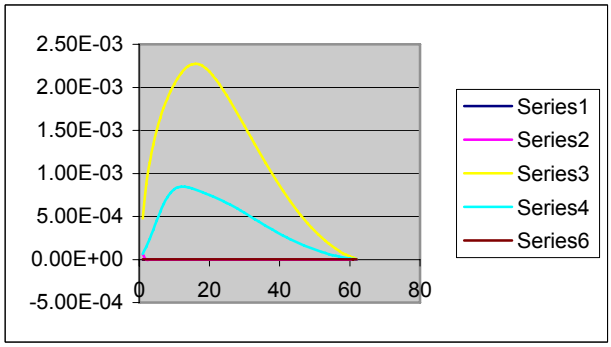


Figure 2:Most of the curve is to the left which shows that F127 loops more than it bridges.

1Kell Mortensen 1996 J. Phys.: Condens. Matter A103-A124

"Smart" Hydrogel for Drug Delivery and Early Cancer Detection

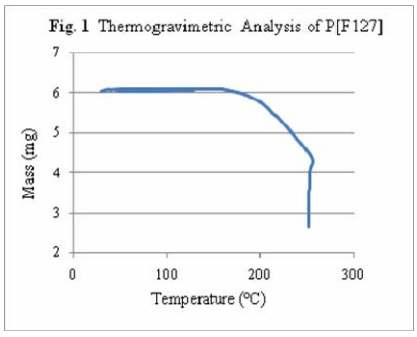
Lara Fourman[1], Sanchita Singal[2], Miriam Rafailovich[3], Vladimir Zaitsev[3], Ankuri Desai[3], Vijay Jain[4], Jinju Yi[5]
[1]*Plainview-Old Bethpage John F. Kennedy High School, Plainview, NY*
[2]*Herricks High School, New Hyde Park, NY*
[3]*Dept. of Materials Science & Engineering, SUNY at Stony Brook, NY*
[4]*Harvard University, MA*
[5]*New York University, NY*

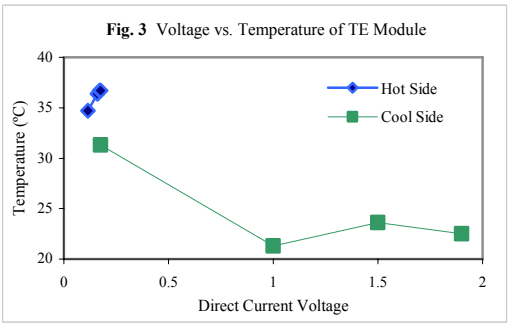
The thermo-reversible hydrogel poly(Pluronic F127) is a "smart" polymer, or a polymer that responds to small environmental stimuli with large property changes.[1] The unique property of Pluronic F127, a poly(ethylene oxide)-poly(propylene oxide)-poly(ethylene oxide) triblock copolymer, is its ability to become a gel at body temperature. Furthermore, its low toxicity makes it a valuable material for controlled drug release. By polymerizing PEO-PPO-PEO triblocks using hexamethylene diisocyanate (HDI) as a chain extender, the multiblock copolymer displays higher viscosity levels when compared to native F127, making it potentially suitable for biomedical applications.[2] This study aims to produce a hydrogel composed of "polymeric" F127 to aid in drug delivery and the early diagnosis of cancer.

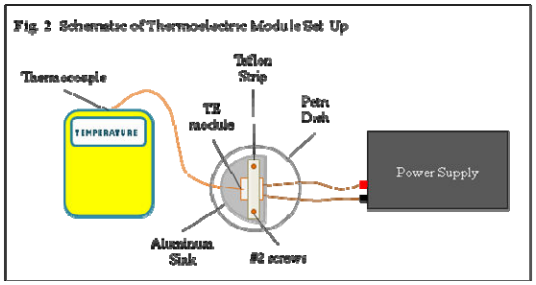
In order to observe the reverse thermal gelation (RTG) behavior of poly(Pluronic F127), a thin film of this polymer must adhere to the surface of a silicon wafer when submerged in liquid. These polymer thin films were produced through a method called spin-casting, in which a solution was spun onto a substrate at 2500 revolutions per minute for thirty seconds, causing the solvent to evaporate. Silicon wafers were spun-cast with concentrations of 5mg/mL, 10mg/mL, 15mg/mL, and 20mg/mL poly(Pluronic F127) in chloroform. The thicknesses of the polymer thin films were measured using an ellipsometer. These samples were then annealed for one hour at 115°C and 15 millitorr. When these annealed samples were measured with an ellipsometer, a decrease in film thickness was observed. Thermogravimetric analysis (TGA) was completed in order to determine the cause for this observation. Testing confirmed that the polymer begins to degrade at approximately 150°C. However, the vacuum pressure of the oven would cause polymer degradation to begin even earlier, starting at about 100°C (Fig. 1).

In order to test if the polymer adheres to the silicon wafer when in liquid, the samples were submerged in deionized water at 10°C for five minutes, and film thicknesses were measured using an ellipsometer. The thickness of the polymer films were within the range of control silicon wafers that were not spun-cast with poly(Pluronic F127). Therefore, the polymer thin films dissolved in water and did not adhere to the silicon wafer.

Volumetric expansion of the gel was measured at body temperature (37°C). It was found that the gel expanded 2.877%. The polymer's behavior will also be observed by sending a fixed amount of electrical energy through a thermoelectric (TE) module, which will then heat to 37°C and cool to the temperature the polymer forms a gel (20°C) (Fig. 2 and 3). An aluminum sink was designed to hold the thermoelectric module. Further work includes cross-linking and electrospinning the polymer onto silicon wafers and applying these findings to designing a hydrogel for drug delivery and early cancer detection.







[1]Roy, I., et al. (2003). Smart Polymeric Materials: Emerging Biochemical Applications. *Chemistry & Biology*, 1161-1171.
[2]Cohn, D., et al. (2003). Improved reverse thermo-responsive polymeric systems. *Biomaterials*, 3707-3714.

Encapsulation of Bacteria in Electrospun Nanofibers for Water Purification

Mitchell Feinberg, Smithtown High School East
Tanya Masand, Locust Valley High School
Ying Liu and Dr. Miriam Rafailovich, Stony Brook University

Groundwater contamination has and continues to be a growing problem around the world. Microorganisms, disinfectants, inorganic and organic chemicals, and radionuclides can be found in our drinking water, and these contaminants can be very harmful to humans.[1] It has been theorized that bacteria can be used to reduce the amount of toxic contaminants in water. In this study, bacteria were electrospun in order to create fibers that can be used for water purification.

The technique of electrospinning was used to eject a polymer solution of Pluronic® F-127-dimethacrylate from a syringe as an ultra-thin jet to synthesize a random non-woven mat of nanofibers (Figure1). This process is driven by the application of a high voltage to the apparatus, creating two simultaneous electrostatic forces: an electrostatic repulsion force between the induced surface charges on the polymer and a Coulombic force exerted by the external electrical field.[2] Parameters such as the ejection rate and the viscosity of the solution affect the diameter and analogous pore size of the fibers. [2]

In our study, a 1mL solution of 13% F-DMA and an additional 0.03g Poly[ethylene oxide] (PEO) in water was electrospun. Prior to electrospinning, the solution was mixed with gram-negative *Escherichia coli* bacteria, and IPTG staining was used to examine if the bacteria remained alive in the nanofibers. Tetramethylethylenediamene (TEMED) was added to the solution for later evaporation-initiated crosslinking of the fibers with Ammonium Persulfate (APS). After examining the fibers under the LEICA confocal microscope, it was determined that the bacteria were no longer viable; it was postulated that the TEMED was cytotoxic to the bacteria.

A novel method of crosslinking F-DMA, by utilizing L-Ascorbic Acid and Ferrous Sulfate, is the major focus of this study and is being investigated for its non-toxicity to bacteria. A 4mL solution of 13% F-DMA with an additional 0.12g PEO was created, L-Ascorbic Acid and Ferrous Sulfate were used instead of TEMED, and Ammonium Persulfate (APS) was still used to vapor-initiate the crosslinking. The APS had previously been tested for toxicity to bacteria.

In the future we plan to electrospin the bacteria with the new crosslinking chemicals and image the fibers under the confocal microscope to assert that they remain viable under these conditions. Once we are certain that the bacteria remains alive in the fibers, water purification tests with the resulting hydrogel fiber will be conducted.

Acknowledgements: Dr. Daniel Cohn, The Hebrew University of Jerusalem, Israel;
Dr. Celine Pujol, Stony Brook University

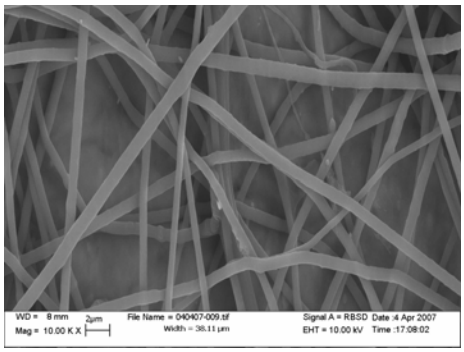


Figure 1. SEM image of electrospun F-DMA nanofibers

[1] U.S. Environmental Protection Agency. "Drinking Water Contaminants." 28 Nov 2006. <http://www.epa.gov/safewater/contaminants/index.html>

[2] D. Li and Y. Xia. "Electrospinning of Nanofibers." Advanced Materials. 16 (2004): 1151 – 1153.

Molecular Imprinting of a Biosensor to Recognize Biomarkers for Early Alzheimer's Disease Diagnosis and Bioterrorist Agent Detection

Damian Lee[1], Darren Huang[2],Vijay Jain[3] , Jinju Yi[4], Miriam Rafailovich[5], Yantian Wang[5]

1 Northern Valley Regional High School, Old Tappan, NJ

2 Herricks High School, New Hyde Park, NY

3 Harvard University, Cambridge, MA

4 New York University, New York City, NY

5 Dept. Materials Science & Engineering, SUNY at Stony Brook, NY

Alzheimer's disease is an incurable neurodegenerative disease that mainly afflicts people over the age of 65. In the first stage of AD, the beta amyloid peptide forms the major constituent of the plaque deposits that aggregate on neurons years before clinical symptoms can even be observed. However, the development of an accurate diagnostic tool could aid hospitals in providing timely relief and appropriate treatment for patients. The novel application of biosensors, devices that can convert biological responses into electrical signals, can be used to implement a holistic diagnosis of Alzheimer's disease. Simultaneously, biosensors can be tested to detect other biomolecules including viruses and bacteria by using the same mechanism.

Templated thin films of 11-mercapto-1-undecanol surfactant self-assembled on gold coated silicon substrates for biosensing properties. By the principles of molecular imprinting, spontaneous adsorption of biomolecules on the surface formed receptor cavities after washing that were complementary to the molecular dimensions and chemistry of a target analyte. With the introduction of an amylase imprinted sensor to an amylase solution, a significant increase in voltage was detected via the potentiometer, a device that converts the reaction into an electrical signal. Tested in comparison with amylase, beta-amyloid, the primary source of AD, was analyzed extensively for potentiometric signals in experimental trials. As shown in Fig. 1, the βA imprinted sensor emitted a recognizable and sensitive signal when it came into contact with beta-amyloid. The βA imprinted sensors were also tested for specific qualities in selectivity, reusability, and durability.

An association of zinc in the causation of AD was strengthened when recent *in vitro* studies showed that it had induced βA protein clumping similar to that found in senile plaques. [1] Thus, by imprinting model nanoparticles, i.e. gold, platinum, and zinc, sensors successfully detected the metals as well as measured the high concentrations that can lead to AD.

Representing another whole range of biomarkers, Gram-positive *E. coli* and Gram-negative *Staphylococcus auerus* bacteria were imprinted onto gold chips. As seen in Fig. 2, a detectable signal was also relayed at low concentrations in the Gram+ trials with Gram+ bacteria imprinted sensors.

Utilizing the data curves of biomolecules, we can determine the predictive concentrations of samples of unknown analyte concentrations. Across the trials of these various analytes, target concentrations as low as 10^{-7} M were accurately detected in solution. Future studies for AD diagnosis include analyzing the Apo E gene mutations, an genetic AD development factor, as well as testing *in vivo* applications [1].

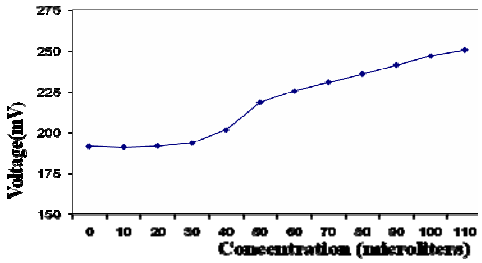


Fig. 1. Beta-Amyloid curve, displays increase in voltage with increase in concentration

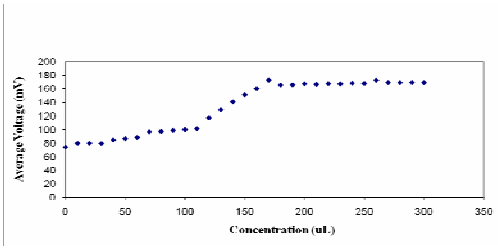


Fig. 2. Gram-positive bacteria curve, displays increase in voltage and eventual leveling out as concentration increases

[1] Cuajungco, Math P. *Zinc and Alzheimer's Disease: is there a direct link?* Brain Research Reviews, Apr. '97. 219-236.

Session X:
DNA

Chairs: Robert Winston

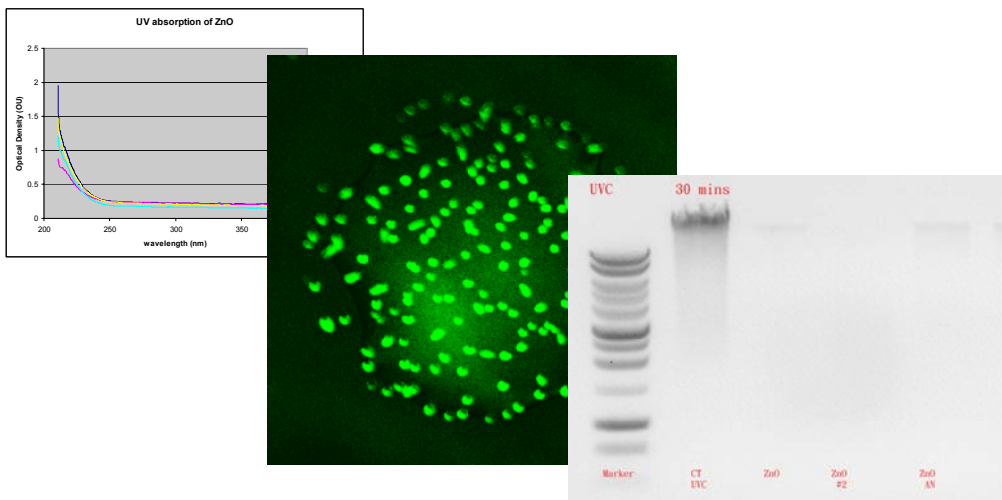
Jennifer Daniels

Garcia Staff: Chien-Hsiu Lin

Naina Prasad, Janet Hui

Eliana Pfeffer

Michael Tischler, Preya Shah



The Effect of HEMA-coated Zinc Oxide Nanoparticles and UV Radiation on DNA

Naina Prasad, *The Wheatley School, NY*
Janet Hui, *Half Hollow Hills High School East, NY*
Dr. Vladimir Zaitsev, Dr. Miriam Rafailovich, *Stony Brook University*

Zinc oxide is an ingredient commonly used in sunscreens because of its ability to reflect and absorb UV rays, which can cause skin cancer.[1] However, although the ZnO absorbs UV light efficiently, it presents a new dilemma, by catalyzing the formation of free radicals which can cause oxidations that can also detrimental to DNA and human cells. Studies have indicated that coating the nanoparticles with certain compounds such as polymers can help capture the free radicals and reduce photosensitivity.[2]

In our research, we intend to study the effects of zinc oxide and UV radiation on DNA bases: guanosin-5'-triphosphat and adenosin-5'-triphosphat through the use of spectrometry. We plan to use a UVA lamp to irradiate samples of DNA alone and ZnO added to the DNA at half hour increments to confirm that ZnO does indeed have a harmful effect on DNA. We also plan to coat the zinc oxide nanoparticles with (poly)hydroxyethylmethacrylate and test if the polymer coating can obstruct the photocatalytic activity of the ZnO, while preserving the original function of the particles to protect against UV radiationPhotochemical Synthesis and Spectral-Optical Characteristics of ZnO/Cu and ZnO/Ag/Cu Nanoheterostructures.

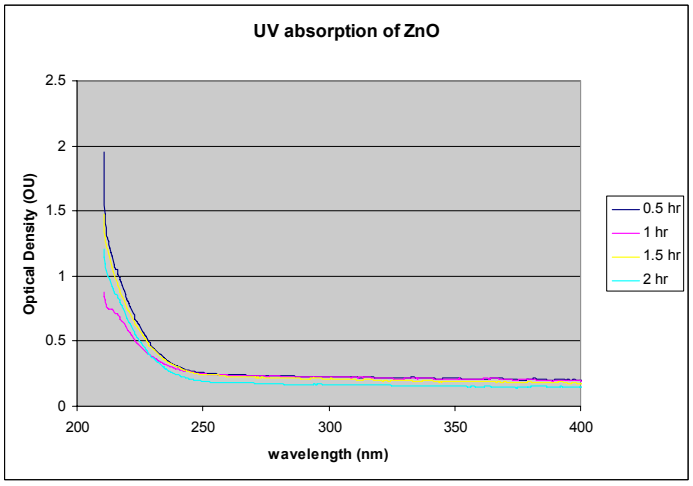


Figure 1: Control graph of spectrometry results for the UV absorption of ZnO; As the ZnO spends more time under the UV, its ability to absorb UV decreases, which is the expected outcome.

[1] Mahltig B. et al. (2005) Thin Solid Films 485 pp 108-114
[2] Dunford, R. et al. (1997) FEBS Letters 418 pp. 87-90

Combing ssDNA on Polymer and Aptamerized Surfaces

E. Pfeffer, J. Daniel, Dr. J. S. Sokolov, R. Winston

As interest in genetics booms, it spurs more questions about the properties of DNA and its interactions, ways of measuring its length and elasticity, and the possibility of efficient sequencing methods for detected genetic defects. Therefore, much work has been done in combing double-stranded DNA in order to immobilize long chains of DNA on surfaces[1]. Combing is a physical stretching of DNA, manipulating it into attaching to z surface at the 3' carbon end of the molecule, so that the rest of it will be pulled vertically as the surface is dipped into and out of the buffer solution containing the DNA. However, though double-stranded combing has been done and often improved over the years, no work has ever been done on single-stranded combing, something that would have far greater applications, especially concerning genetic sequencing. In order to do this, we first had to m ake ssDNA which was done by using a REPLI-g Mini kit supplied by Qiaten in order to first denature and then amplify the DNA. Afterwards, in order to test that ssDNA was successfully produced, drops of a solution containing 30µL of a .025 µg/µL TE and ssDNA mixture and 2µL of YOYO-1 were deposited onto a silicon surface coated with a floated layer of 12.5 mg/mL polymethyl methacrylate about 1000 Å thick. We found that, unlike dsDNA which forms a ringlike structure with dsDNA concentrated and combed at the edges of the evaporated droplet (see figure 1), ssDNA adheres so strongly to the surface that after evaporation, ssDNA can be found scattered about in a circle-like array, as seen in figure 2.

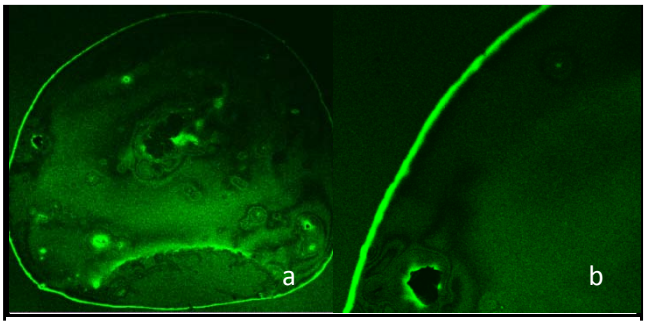


Figure 2: a) Double stranded DNA on a silicon surface as imaged under a 10x Leica Confocal Microscope objective lens. Notice that the DNA is concentrated and combed at the edges of the droplet. B) The droplet's side, amplified.

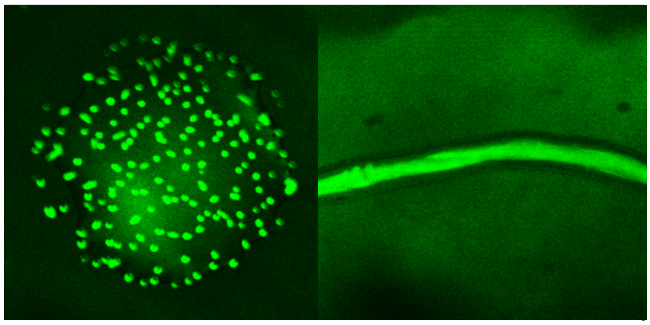


Figure 1: A) Single-stranded DNA on a silicon surface as imaged under a 10x Leica Confocal Microscope objective lens. Notice that the DNA is everywhere and is not concentrated at the edges. B) One of the DNA bundles, amplified.

Following this success, it was now necessary to proceed with the actual combing of the DNA, which proved fruitless when we worked with the traditional MES buffer solution at a pH of 5.65. Therefore, we prepared a wide range of buffers with varying pHs in order to determine the optimal conditions to enable ssDNA to adhere to the PMMA surface. This testing is still currently in progress.

In the future, we hope to find the optimal pH and thereby comb ssDNA onto a PMMA surface. After this has been completed, we will move onto aptamerized silicon surfaces in order to create a more controlled process[2], which would be of far more use to the scientific and medical community.

---

[1] One such prolific research group published a paper crucial to my research: Allemand, J.-F., D. Bensimon, L. Jullien, A. Bensimon, and V. Croquette. "pH-Dependent Specific Binding and Combing of DNA." Biophysical. 73(1997): 2064-2070.

[2] Spiridonova, V. A., and A. M. Kopylov. "DNA Aptamers as Radically New Recognition Elements for Biosensors." Biochemistry 67(2002): 706-709.

A novel coating that reduces the toxicity of nano titanium dioxide and zinc oxide

Michael Tischler[1], Lucy Wu[2], Amit Mehta[3], Chien H. Lin[4], Nadine Pernodet[4], Miriam H. Rafailovich[4]

[1]*Jericho Senior High School*
[2]*University of California Los Angeles*
[3]*Cornell University*
[4]*Stony Brook University*

In 1978, the FDA approved the use of zinc oxide and titanium dioxide nanoparticles in cosmetics. However, recent evidence[1] has shown that these nanoparticles may pose serious health problems. When exposed to UV light, the electrons on the Zno and TiO2 nanoparticles become excited and produce free radicals, causing oxidation and consequently damaging cells[1]. Estée Lauder has created novel coatings for TiO_2 and ZnO nanoparticles that we hope will reduce their toxicity. Our study seeks to prove that these new, coated nanoparticles will protect cells against damage to DNA and proteins and ensure continued cell proliferation.

In our study, we utilized bacterial lambda DNA and casein protein that were treated with ZnO and TiO_2 nanoparticles and then exposed to UV-A, UV-B, and UV-C light for specific periods of time. These samples were then subjected to gel electrophoresis (Fig. 1) from which we determined that while the anionic coating protected the DNA and casein the best for the ZnO nanoparticles, the preeminent coating for the TiO_2 was the special "#2" coating. In addition, we mapped keratinocyte cell growth for eight days to compare the effectiveness between the two different ZnO nanoparticle coatings on cell propagation. We found that the cells exposed to the nanoparticles with the anionic coating proliferated most similarly to the control cells.

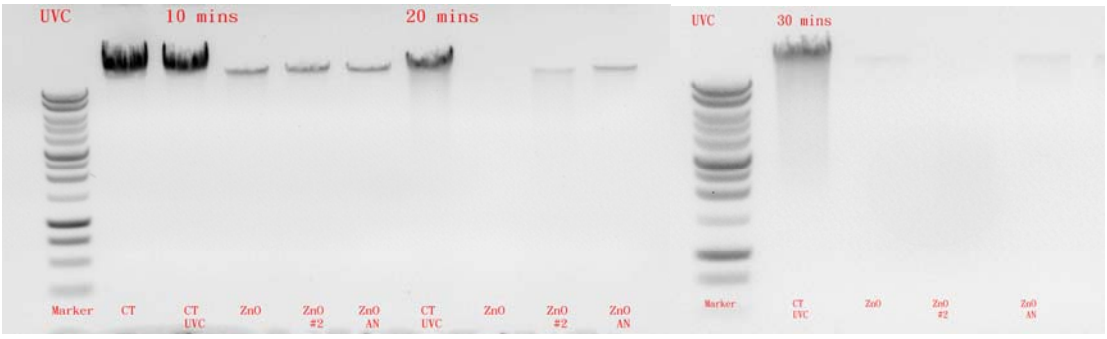


Figure1 *DNA gel with exposure to UV-C light for 10, 20, and 30 minute intervals. The DNA bands become less intense as the exposure time for the UV-C light increases.*

[1] Dunford, Rosemary, et al. "Chemical Oxidation and DNA Damage Catalysed by Inorganic Sunscreen Ingredients." Federation of European Biochemical Societies (Oct. 1997): 87-90.

DNA Surface Electrophoresis on Membrane Surfaces with Varying Charge Densities

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

The fractionation of DNA molecules is an integral aspect of molecular biology, especially genomic research. It is primarily achieved by DNA electrophoresis, a technique that employs an electric field to separate strands of DNA by chain length. Conventional electrophoretic methods, such as gel and capillary electrophoresis, use a topologically restrictive sieving matrix that allows shorter DNA strands to travel farther than longer strands in a fixed amount of time. However, these methods are limited due to lengthy preparations and an inability to characterize longer chains.

Recently, an electrophoretic technique has been developed that separates DNA as it travels along a flat surface such as a silicon wafer coated with silane monolayer films.[1] Surface electrophoresis has been shown to separate a broad band of DNA using surface friction rather than topological constraints.[2]

In this study, surface electrophoresis was performed on a negatively charged, polyethersulfone (PES) membrane surface. A droplet of 20% lambda DNA solution labeled with either EtBr or YOYO dye was deposited on the PES surface in an electrophoretic cell (Figure 1). Tris-Borate-ETDA buffer solution was added to the cell, and an electric field was applied. DNA mobility was determined using laser scanning confocal fluorescence microscopy. Preliminary results indicate that it is possible to separate DNA by electrophoresis on PES surfaces.

Future work will include surface electrophoresis on PES surfaces with different charge densities to vary the strength of the DNA-surface interaction.

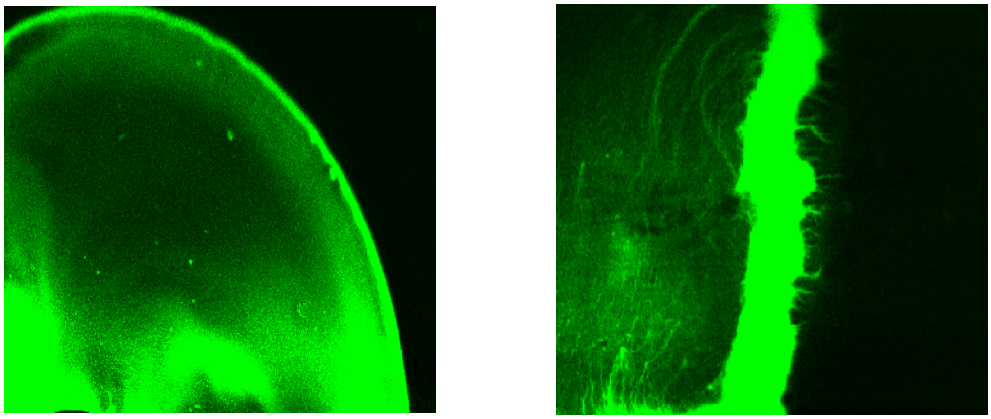


Figure 1: (a) DNA Droplet viewed under confocal microscope (b) DNA strands are visible on outer edge of DNA droplet

[1] Pernodet, N., Samuilov., Shin, K., Sokolov, J., Rafailovich, M.H., Gersappe, D., & Chu, B. (2000). Physical Review Letters, 85 (26), 5651-5654.

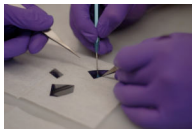
[2] Seo, Y-S., Samuilov, V., Sokolov, J., Rafailovich, M., Tinland, B., Kim. J., & Chu, B. (2002). Electrophoresis, 23, 2618-2625.

Garcia MRSEC
Polymers at Engineered Interfaces

Summer Scholar Program Schedule of Activities

EVERY DAY STARTS WITH A GROUP MEETING

CHECK SCHEDULE DAILY!

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
Week of 6/25	25 10:00 AM Group Meeting *Welcome, Outline of Program, Introductions,* Dr. Miriam Rafailovich *Welcome, Attendance, Phone Numbers, Young Scholars, IDs and Parking,* Lourdes Collazo *Welcome, Lab Rules and Regulations, Communication,* Dr. Allen Sachs 11:00 AM *Thinking Outside the Box: the Fun and Challenge of Doing Transitional Research,* Dr. Srinivas Pentyala 12:00 PM Lunch 12:30 PM Organization of Tour Groups 1:00 PM Lab and Campus Tour	26 10:00 AM Group Meeting 11:00 AM *Skin Bank,* Dr. Marsha Simon 12:00 PM EH & S Training 1:30 PM *Chemical Disposal,* Lourdes Collazo 2:30 PM *Laboratory Ovens and Vacuums,* Dr. Jon Sokolov 3:30 PM *Journal Club Instructions,* Dr. Allen Sachs	27 10:00 AM Group Meeting Safety Quiz 11:15 AM *Lab Notebooks,* Dr. Miriam Rafailovich *Questionnaire,* Sylvia Qu *Contests,* Dr. Allen Sachs 12:45 PM Lunch 1:30 PM *Biosafety Training,* Bob Holthausen 2:45 PM *BE/MD Program,* Dr. Jack Fuhrer 3:30 PM SINC Site Journal Club Work	28 10:00 AM Group Meeting 11:00 AM *Spincasting Nanocomposite Films,* Dr. Steven Schwartz 12:00 PM Lunch 1:00 PM *Polymers,* Dr. Dilip Gersappe 2:00 PM Stony Brook ID Cards, Distribution of Lab Boxes, Journal Club Preparation 	29 10:00 AM Group Meeting 10:30 AM REU Meeting Spincasting Planning *Learning Science Databases,* Ms. Godlin Johnson *Excel Tutorial,* Dr. Vladimir Zaitsev 12:30 PM Lunch and Journal Club 2:30 PM IDs, Absentees, New Arrivals, and Problem Resolution
Week of 7/2	2 10:00 AM Group Meeting 10:30 AM *Biomineralization-Nature's Nanomaterials Studied by Synchrotron X-Rays,* Dr. Elaine Dimasi 11:30 AM *Diatoms and Coccoliths in the Ocean- from Biomineralization to Global Warming,* Dr. Cindy Lee 12:30 PM Lunch 1:30 PM *Laser Experiment & Ellipsometry,* Chunhua Li	3 10:00 AM Group Meeting 10:30 AM *Global Warming,* Dr. Zhou 11:30 AM *Polymers,* Dr. Dilip Gersappe 12:30 PM Lunch 1:30 PM Journal Club Work and Early Dismissal for the Holiday	4 	5 10:00 AM Group Meeting 10:30 AM *Electron Microscopy and Nanotechnology,* Dr. Yimei Zhu *DNA Research in the Polymer Lab,* Dr. Jon Sokolov 11:30 AM Spinning Lab 1:00 PM Lunch 1:30 PM Spinning Lab	6 10:00 AM Group Meeting 10:15 AM Group Presentations, Zhi Pan *Spinning Lab Assignment,* Dr. Miriam Rafailovich 10:30 AM *Mitigatin Global Warming with Renewable Fuels,* Dr. Devinder Mahajan 11:30 AM *Preparing for LISEF-How to Do Your Paperwork,* Dr. Allen Sachs 12:30 PM Lunch 1:00 PM Journal Club Presentations
Week of 7/9	9 10:00 AM Group Meeting 10:30 AM *Rapid Prototyping,* Dr. Jim Quinn Spinning Lab Work 12:30 PM Lunch 1:30 PM *Patents and I. P.,* Donna Tumminello 2:30 PM Spinning Lab, Ellipsometry	10 10:00 AM Group Meeting 10:30 AM *Cells and Surfaces,* Dr. Nadine Pernodet 11:30 AM *Methane Hydrates,* Dr. Tadanori Koga 1:30 PM *Physics,* Dr. Walter Schmelling Lab Spinning and Ellipsometry	11 10:00 AM Group Meeting 10:30 AM *Advanced Studies of nanomaterials, Dr. Anatoly Frankel* 11:30 AM *Statistics, Dr. Miriam Rafailovich* 12:30 PM Lunch 1:30 PM Group Meetings to Prepare Spinning Reports 2:30 PM Work on Projects, Consult with Mentor about Rules Wizard and ISEF forms	12 10:00 AM Group Meeting 10:30 AM Hand in Individual Lab Reports Meeting with Mentors, REUs, and Grad Students to Assign Projects 11:30 AM *Statistics Part II and Flame Retardant Materials,* Dr. Miriam Rafailovich 12:30 PM Lunch 1:30 PM Spinning Group Meeting to Organize PowerPoint Presentations for Friday Work on Projects	13 10:00 AM Group Meeting 10:30 AM *Spinning Group Reports,* Amy Ramirez; Yehuda Grossman  12:00 PM *Annual Garcia Center BBQ* 2:00 PM Work on Projects
Week of 7/16	6 10:00 AM Group Meeting Sign-Up for Rapid Prototype Lab Visit 10:30 AM *Electron Microscopy,* Petr Oleynikov 11:30 AM *The Siemens Foundation and the Siemens Math:Science:Technology Competition,* Jim Whaley 12:30 PM Lunch 1:30 PM Work on Projects	17 10:00 AM Group Meeting 10:30 AM *Research Ethics,* Dr. Allen Sachs 11:30 AM Lunch 12:30 PM Meeting of Cell Lab Peronnel Work on Projects 2:30 PM *Rheology and Polymers,* Dr. Ralph Colby	18 10:00 AM Group Meeting 10:30 AM *Visit to Rapid Protoyping Lab,* Dr. Jim Quinn Work on Project 12:30 PM Lunch 1:00 PM Work on Projects 	19 10:00 AM Group Meeting 11:00 AM *Meeting of String Players to Prepare for Symposium,* Dr. John Jerome *Announcement of Photo Contest for Symposium,* Dr. Rafailovich 11:30 AM Lunch 12:30 PM Work on Projects	20 10:00 AM Group Meeting 10:30 AM *Group Presentations:* Eliana Pfeffer; Adam Fields, Alex Ramek; Mili Mehta; Daniel Fourman, Jake Bryant; Josh Rosenbaum, Kimberly Leonard 12:00 PM Lunch 1:00 PM Work on Projects

Week of 7/23	23 10:00 AM Group Meeting 10:30 AM Work on Projects 12:00 PM Lunch 1:00 PM Work on Projects	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 Work on Projects 12:00 PM Lunch 1:00 PM Work on Projects	26 Annual Garcia Center Canoe Trip on the Nissequogue River	27 10:00 AM Group Meeting 11:30 AM *Group Presentations:* Rachel Greenberg, Sara Jane Gross, Jordan Schachar; Etan Zapinsky, Adam Hanau; Sowmya Sundaresh, Nicole Elstein; Jiovanna Linnen; Julian Absinay, Sruti Akella, Noreen Shaikh, Naina Prassad; Joanne Anthony Pillai, Jackie Belizar; Mitchell Feinberg, Michael Tischler, Brienne Kugler 12:00 PM Lunch 1:00 PM Work on Projects
Week of 7/30	30 10:00 AM Group Meeting 10:30 AM *Group Presentations:* Lara Fourman, Sanchita Singal 11:00 AM Lunch 12:00 PM Work on Projects	31 10:00 AM Group Meeting 10:30 AM *Group Presentations:* Lara Fourman, Sanchita Singal; Yosef Gutterman 11:00 AM Lunch 12:00 PM Work on Projects	1 10:00 AM Group Meeting 10:30 AM *Group Presentation:* John Lim, Alex Penn 11:00 AM Lunch 12:00 PM Work on Projects	2 10:00 AM Group Meeting 10:30 AM *Group Presentation:* Sergey Kolchinskiy 11:00 AM Lunch 12:00 PM Work on Projects	3 10:00 AM Group Meeting 10:30 AM *Group Presentations:* Jason Mogen, Adam Gross; Abraham Chien, Elie Bochner; Andrew Kugler; Andrew Windler; Jade Shi; Nitin Gupta, Zachary Rubin; Hyungtae Kim, Josh Gordonson; 12:00 PM Lunch 1:30 PM Work on Projects
Week of 8/6	6 10:00 AM Group Meeting 11:00 AM Trip to Grumman Lab 12:00 PM Lunch 12:00 PM Work on Projects	7 10:00 AM Group Meeting 10:30 AM Group Presentations *Siemens Corporation: Intellectual Property and Patents*, Joseph Condispoti 11:30 AM Lunch 12:03 PM Work on Projects	8 10:00 AM Group Meeting Visit from Congressman Steve Israel 10:30 AM *Group Presentations:* Daniel Gross, Kenny Kao; Justin Goldsmith; Brian Kim, Ryan Price; Janet Hui, Naina Prasad, Yosef Guterman 11:30 AM Lunch 12:30 PM Work on Projects	9 10:00 AM Group Meeting 10:30 AM *Group Presentations:* Radha Ramjeawan; Matthew Alpert; Nitin Gupta, Zachary Rubin; Amy Ramirez, Rima Patel; Pooja Vasudevan; Alex Saal, Nabiha Kabir; Damian Lee, Darren Huang 11:30 AM Lunch 12:30 PM Work on Projects	10 **Summer Science Symposium** **SAC Auditorium** **10 am- 3pm**

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We gratefully thank the following guest speakers for their lectures to the 2007 Garcia Program participants:

Dr. Srinivas Pentyala
Dr. Marsha Simon
Bob Holthausen
Dr. Jack Fuhrer
Dr. Steven Schwartz
Dr. Dilip Gersappe
Ms. Godlin Johnson
Dr. Vladimir Zaitsev
Dr. Elaine Dimasi
Dr. Cindy Lee
Chunhua Li
Dr. Zhou
Dr. Dilip Gersappe

Dr. Yimei Zhu
Zhi Pan
Dr. Devinder Mahajan
Dr. Jim Quinn
Donna Tumminello
Dr. Nadine Pernodet
Dr. Tadanori Koga
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Dr. Anatoly Frankel
Petr Oleynikov
James Whaley
Dr. Ralph Colby
Dr. Jim Quinn

Special thanks to our sponsors:

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