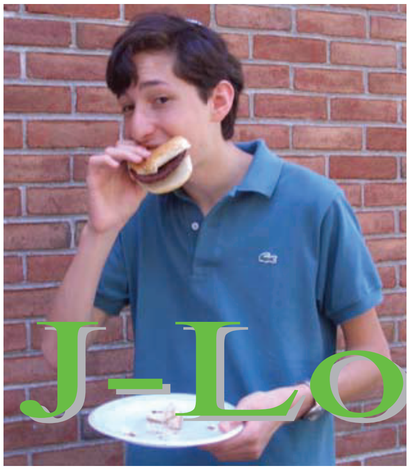

Hilana
Lewkowitz-
Shpuntoff


Ron Li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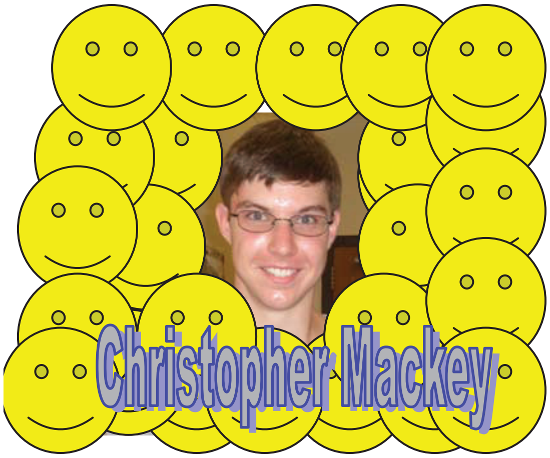
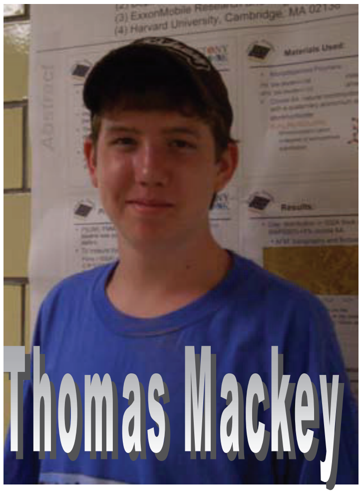
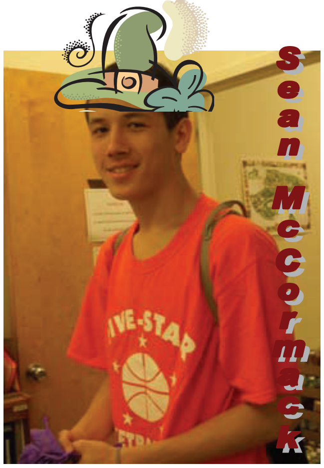

Christopher Mackey


Thomas Mackey


Shahruck Mallick


Sean McCormack


Vikas Murali


Kiran Nandigam


Eugerie
Andre
Narcisse

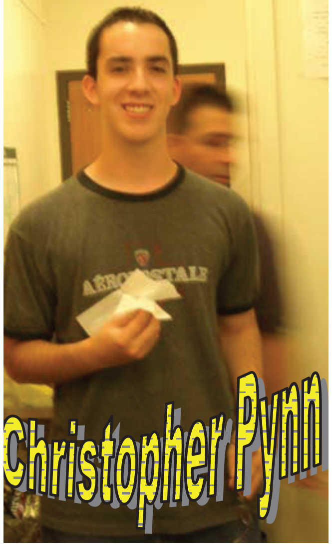

John Oh


Samantha Palmaccio


Anupama Pattabirman


Alexandra Peyser


Sean Pi


Christopher Pynn


Sanjida Rahman


Sarvesh Ramprakash
MONTGOMERY
COUNTY
32


Rachel Rosenfeld


Jamie Rosengard

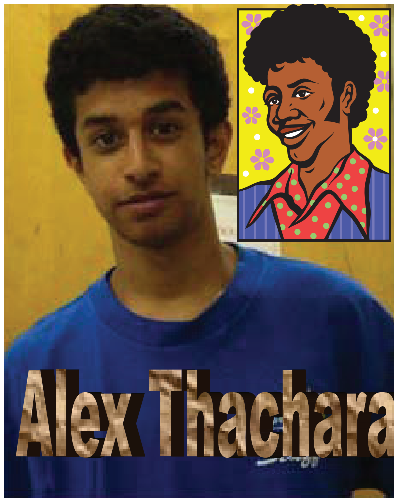

Matthew Schlossberg

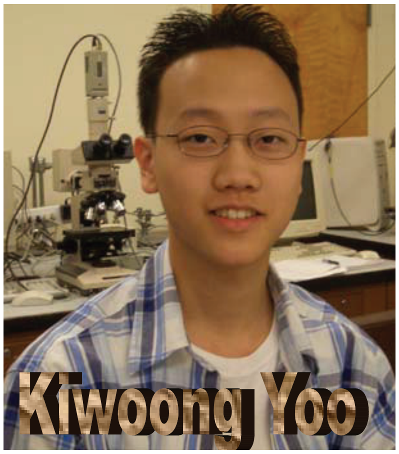

POLICE


Mike Serbin


Fauzia Shaikh

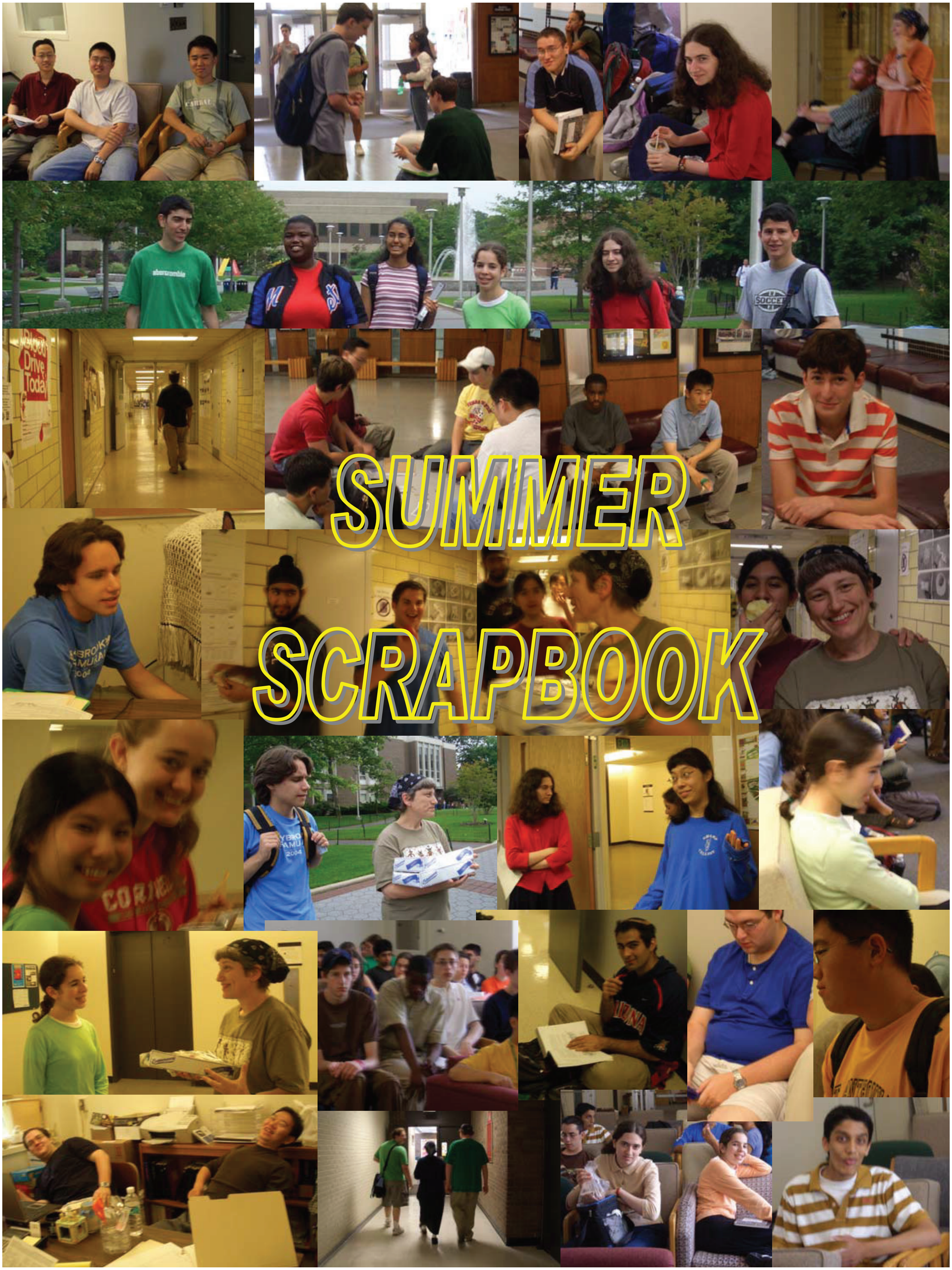

Marc Sherwin





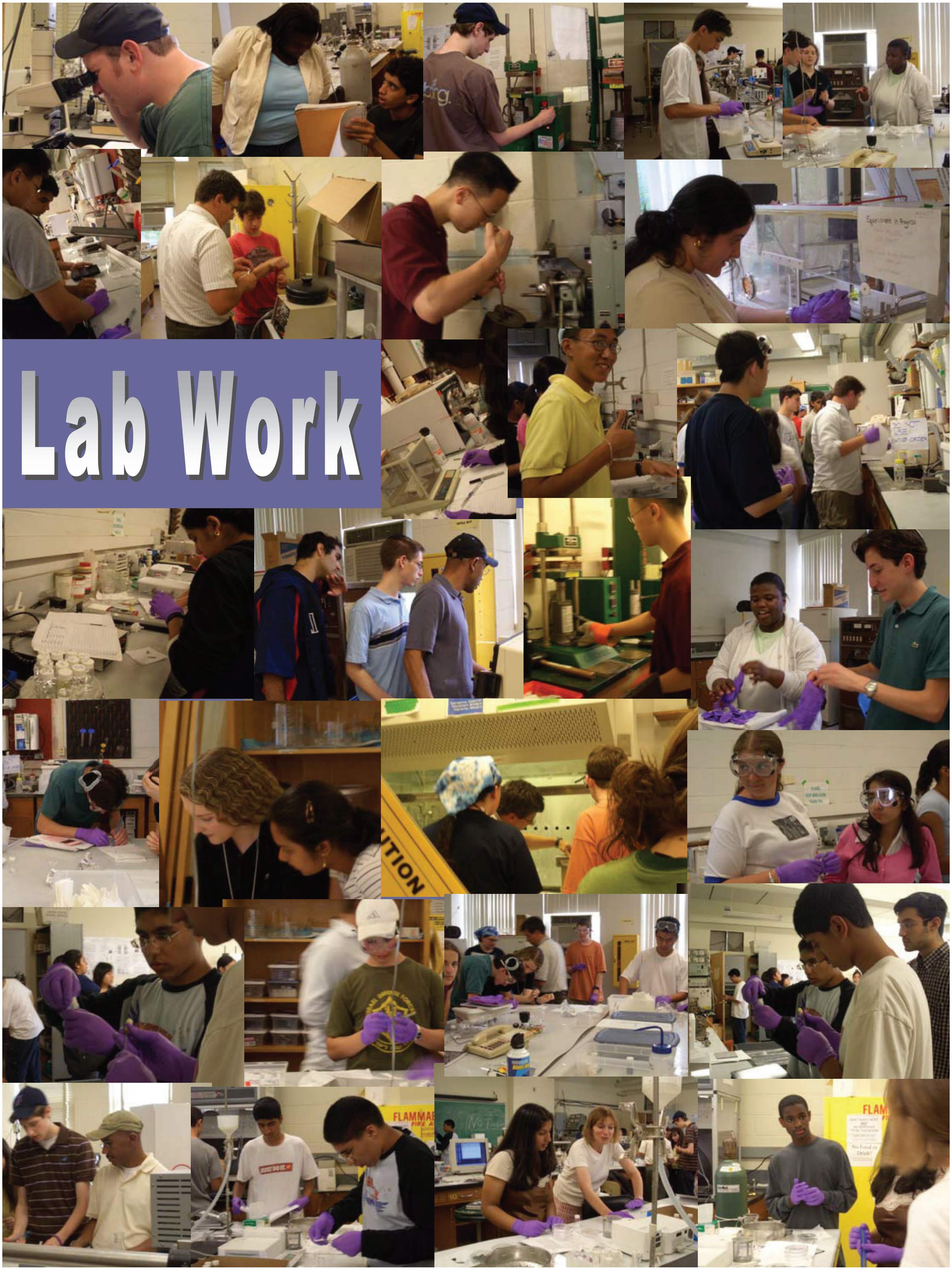
Problems and Complaints
can be brought to:

SUMMER SCRAPBOOK




GREEN BAY PACKERS
HUNK'S
KOSHER PIZZA & FALAFEL
FIRST AID
UTZ Pretzel Stix
Twizzlers
BRISK

Lab Work


Experiment in Progress
DO NOT USE
OUT OF ORDER
ITION
FLAMMAB
FLAM
No Food or Drink!

Fun in the Sun

Journal Club

BNL


NO ADMITTANCE
TESTING IN PROGRESS
THIS DEPARTMENT HAS WORKED
8601 DAYS
WITHOUT A LOST TIME ACCIDENT
THE BEST PREVIOUS RECORD WAS
0713 DAYS
DO YOUR PART! HELP MAKE A NEW RECORD
CAUTION
CONTROLLED AREA

LOGGED IN AND ZONED OUT

A Colorful Visit

Summer 2005

Garcia MRSEC

Polymers at Engineered Interfaces

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

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The Garcia Center

invites you to attend the

Annual Summer Symposium

of the

Research Scholars Program

on

Friday, August 12, 2005

between

10:00 AM-1:00PM

in the

SAC

Ballroom B

Art: T. Bernheim, S. Sokolov

Guest Speaker

Daniel Maes

Vice President of Skin Biology Research for The Estée Lauder Research Laboratories

Special Guest: Suffolk County Legislator

Brian Foley

Scientific Symposium organized and presented by the students.

Buffet luncheon & artistic program arranged by the students.

RSVP on or before August 9

(631) 632-6097 or (516) 458-9011

or e-mail

SaraRafSok@gmail.com

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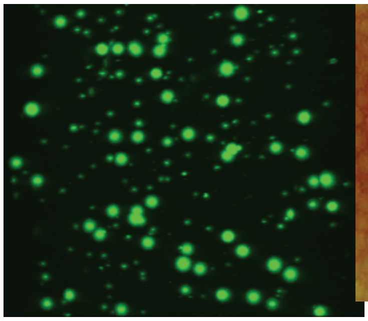
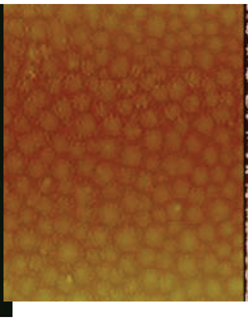
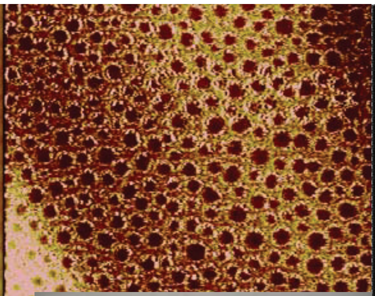
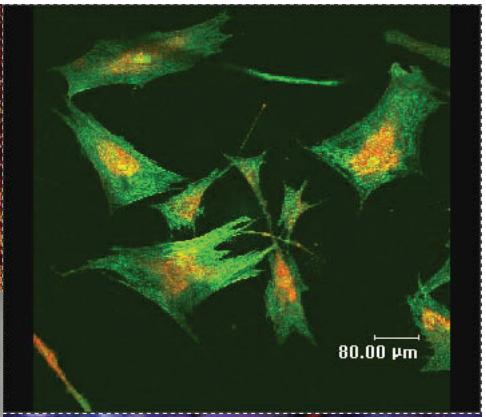
Stony Brook University

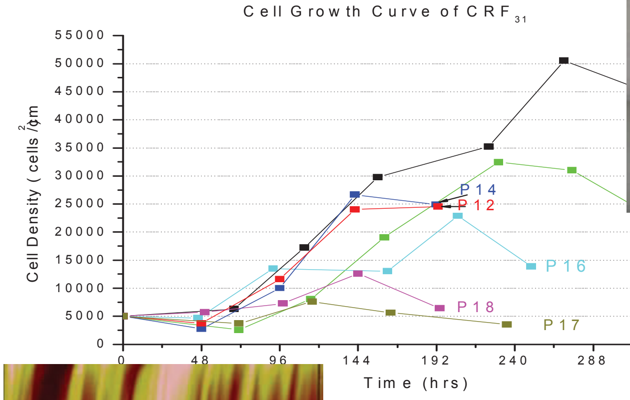
Special thanks to: Entenmann's and Mr. Herb Weiss for summer rerreshments

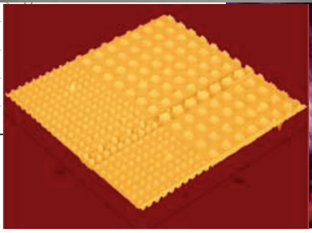


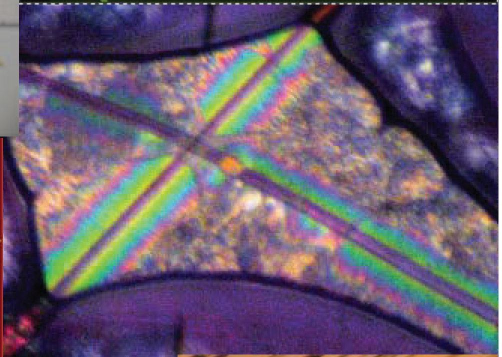


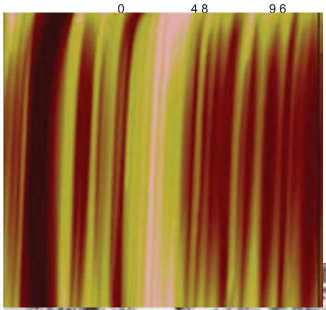



80.00 µm

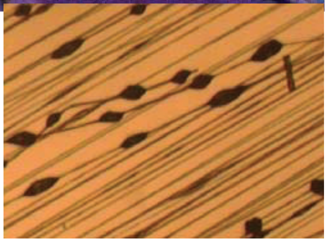

Cell Growth Curve of CRF31
Cell Density (cells / µm2)
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
0
48
96
144
192
240
288
Time (hrs)
P14
P12
P16
P18
P17

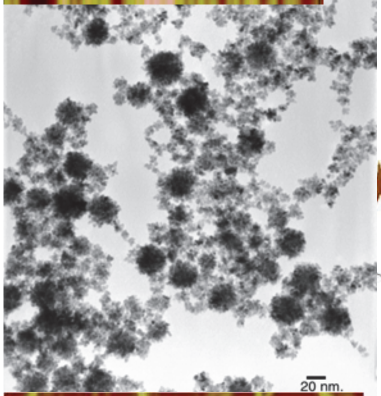


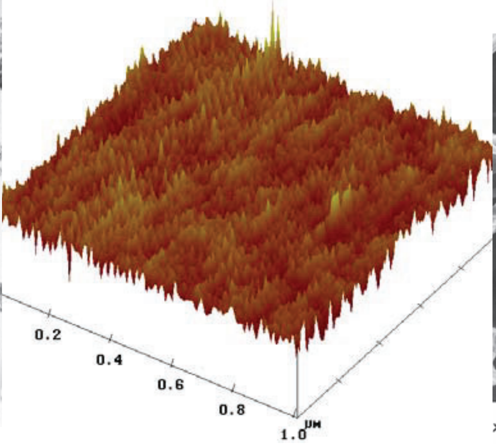


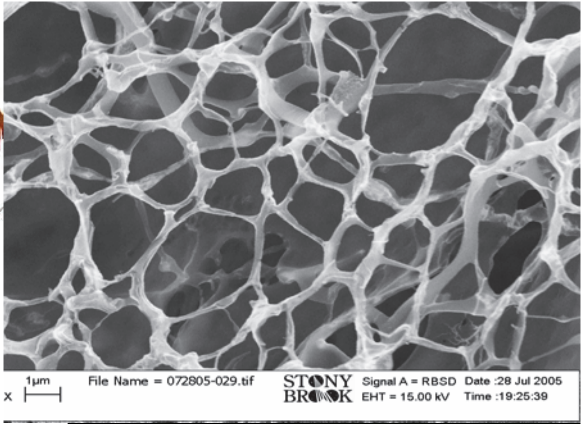


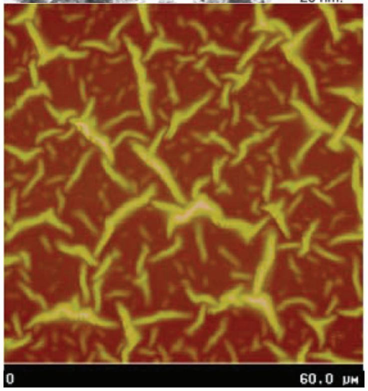
Abstracts

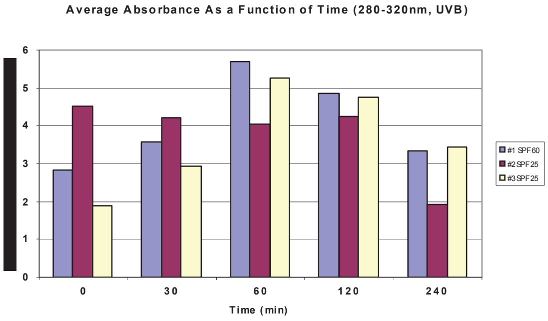


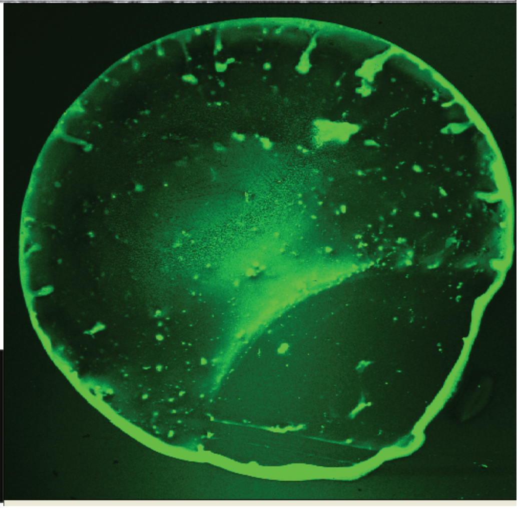

20 nm.

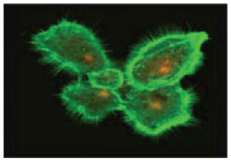

0.2
0.4
0.6
0.8
1.0
µM

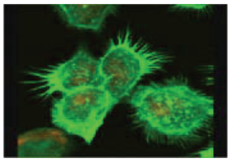

1µm
x
File Name = 072805-029.tif
STONY BROOK
Signal A = RBSD
EHT = 15.00 kV
Date :28 Jul 2005
Time :19:25:39

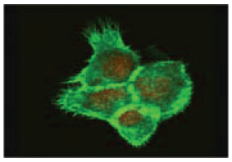

0
60.0 µM

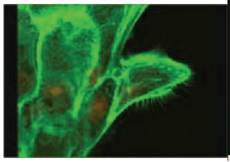

Average Absorbance As a Function of Time (280-320nm, UVB)
6
5
4
3
2
1
0
0
30
60
120
240
Time (min)
#1 SPF60
#2 SPF25
#3 SPF25











Garcia MRSEC NSF
Polymers at Engineered Interfaces
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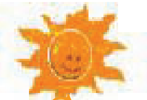
”



Summer Research Symposium Program

Friday, August 12, SAC Ball Room B

10:00-10:15 Welcome *Miriam Rafailovich*

Greetings: Matt Cohen, Representing the Hon. Charles P. Schumer
The Hon. Steven Englebright New York State Assembly
The Hon. Brian Foley Suffolk County Legislator

10: 15-10:30 Opening Address: Dr. Daniel Maes, PhD
Vice President of Research in Skin Biology
Estee Lauder Research Laboratories

10:30- 10:40 Session I: Supercritical Fluids

Processing Bulk Polymers with Supercritical Fluids
Chair: **John Iraci,** Cornell University

Fuel Cells: Optimization of Polymer Electrolyte Membranes
Eugérie André Narcisse**,** Uniondale High School, NY
Sarvesh Ramprakash, Winston Churchill High School, MD
Brian Albert, Solomon Schechter High School, NY

Universal Polymer Compatibilization Using Supercritical Fluids
Alex Thachara, The Wheatley School, 11 NY
Jinju Yi, John F. Kennedy High School, 50 Kennedy Drive, NY

10: 40-10:50 Session II: **Introducing Porosity: Membranes and Homeland Security**

Chair: **Mordechai Bronner ,** Yale University

The Effect of $scCO_2$ on the Porosity of Polymers

Rafael Holzer, Rambam Mesivta, Lawrence, NY

Rachel Rosenfeld, HAFTR, Woodmere, NY

The Effects of POSS (Polyhedral Oligomeric Silsesquioxane) on The Selective Gas Permeability of Polymer Blend Thin Films

Allyson Ho, Clements High School, Sugarland, Texas

Creating a Viral Sensor Using Self-Assembled Monolayers

***Vijay Jain*, **Herricks High School, New Hyde Park, NY

***Harriman Lee*, **The Wheatley School, Old Westbury, NY

10:50-11:15 Session III: **Influence of Nanoparticles on Cell Functions**

Chair: ***Avtar Singh***, Cornell University

The Properties of Colloidal Platinum Nanoparticles in Hydrogen Storage, Semiconductors and Their Effects Cellular Organization of Actin

***Daniel Katz*:** HAFTR High School: 389 Central Avenue**,** Lawrence, NY

***Vikas Murali*:** Staples High School, 70 North Avenue, Westport, CT

Effects of Titanium Dioxide Nanoparticles on Cellular Behavior

Lauren Sipzner *and* ***Jaimie Stettin*** : YUHS for Girls, NY

Cell Growth on EVA-clay and PB-clay Nanocomposites

Hilana Lewkowitz-Shpuntoff*,* Great Neck South High School, NY

Mary Catherine Wen, Archbishop Molloy High School, NY

Cell Growth on PMMA-clay Nanocomposites

Kaitlyn Hay *and* ***Urooj Khan*** Jericho High School, NY

The Effects of Phosphorous Based Fire Retardants Containing Nano-Clays on Cellular Properties and Growth.

***Daniel Hefter*,** DRS High School, Woodmere, NY

***Jacob Loewenstein*,** HAFTR HS, Woodmere, NY

A Comparison between the Application of Titanium Dioxide on Keratinocytes and on Squamous Cell Carcinoma

Kiran Nandigam, Sachem East High School, Farmingville, NY

Jon Espitia, Sachem East High School, Farmingville, NY

11:15-11:35 Session IV**: Looking at Genomic Materials**

Chair: ***Eric Petersen,*** Harvard University

DNA Electrophoresis on Micro-Patterned Surfaces
Sean McCormick , Jericho HS, NY
Eric Petersen, Harvard University, MA

The Effects of Titanium Dioxide on Chromosomal DNA
Matthew S. Wieder – SAR High School, Riverdale, NY
Gary Halajian, Half Hollow Hills High School East, NY

The Effect of UV Radiation on Sunscreen and the Reaction of Sunscreen with Biomolecules
Irina Zaitseva , Centereach High School , NY

The Effects of Poly-l-lysine on DNA Adsorption to Surfaces
Preya Shah, Paul J. Gelinas Jr. High School, Setauket, NY
Jennifer Daniel, St Anthony's High School, South Huntington, NY

11:35-11:45 SessionV: **Supercritical Fluid Processing of Thin Films**

Chairs: ***Chelsea Gordon,*** Harvard University
Sylvia Qu, Duke University

The Effects of Supercritical Carbon Dioxide on Deuterated Polystyrene and Polyethylene Blends
Payvand Ahdout, Roslyn High School, Roslyn Heights, NY
Christopher Pynn, Half Hollow Hills High School West, Dix Hills, NY

The Effects of Supercritical Carbon Dioxide and Ethane on Metallization of PS and PMMA with POSS Nanoparticles
***Jamie Rosengard*,** Half Hollow Hills HS West, Dix Hills, NY
Brienne Kugler, Jericho High School, Jericho, NY

The Metallization of EVA (ethyl-vinyl acetate) Polymer Thin Films Using Supercritical Carbon Dioxide and Nanoparticles.
***Fauzia Shaikh*,** Half Hollow Hills HS East, Dix Hills, NY

11:45-11:55 Session VI : **Effects of Fillers on Adhesion and Wetting**

Chair : **Michoel Snow, Cornell University**

The Effects of Cloisite Clay 6A on Adhesion at Polymeric Interfaces
***Anupama Pattabiraman*,** Academy for the Advancement of Science and Technology, Hackensack, NJ

Alexandra Peyser, Ramaz Upper School, New York, NY

Fracture Toughness and Flame Retardance Using Polycarbonate, Styrene Acrylonitrile, and Organoclay Polymer Blends
Vinay Krishnan, Dev Anand Wheatley High School, Old Westbury NY

11:55-12:15 Session VII: **Crystallization Phenomena**
Chair: **Madeline Augustine,** Stony Brook University

Thin-Film Crystallization of Polycaprolactone
Ashish Bakshi, Manhasset High School, Manhasset, New York
Rajesh Atluri, Herricks High School, New Hyde Park, New York

The Formation Rate of Methane Hydrate with the Use of Surfactants in a High Pressure Chamber
Kyle Horning. Sachem East High School, Farmingville, NY
Shahrukh Mallick**.** The Wheatley High School, Old Westbury, NY

Effect of Polymer Thin Film Thickness on Melting Point: A Comparison of Different Techniques
Debbie Yee*,* Great Neck North High School, Great Neck,
Victor Wang*,* Great Neck South High School, Great Neck

The Effects of Supercritical Carbon Dioxide on the Properties of Polyimides
Alexandra Daly, Plainview Old Bethpage John F. Kennedy High School

12:15-12:25 Session VIII: **Materials for Biomedical Applications**
Chair: **Jeff Reitman,** Yale University

Synthesis of a Biocompatible Magnetic Polymer
Nicole Brenner, Lawrence High School Cedarhurst, NY

Characterization and Applications of Thermoreversible Hydrogels
Mohan Gautam, Sachem East High School, Farmingville, NY
Ankuri Desai, Ward Melville High School, East Setauket, NY

The Effect of Nanoparticles and Nanopillar Array Feature Size on Adhesivity of Nanopatterned Polymer Thin Films
Wilfred Wong, Herricks High School

12:25-12:35 Session IX: **Age and Cells**

Chair: **Joshua Meisner**, Columbia University

Cell Mechanics of Different Aged Human Dermal Fibroblasts
Victoria Hung, Smithtown High School, Smithtown, NY
Swetha Kambhampati, University High School, Irvine, CA
Sanjida Rahman**,** Stuyvesant High School

The Effects of Cell Passaging on Proliferation of Human Dermal Fibroblasts
Ming-Jie Wang: Elwood-John H. Glenn High School

12:35-12:45 Session X: **Response to Substrate Mechanical Properties**

Chair: **Sean Mehra**, Yale University

Analysis of Keratinocytes' Mechanical and Physiological Behavior in Response to Varying Collagen Substrates
Crystalee Forbes**,** Uniondale High School
Kristin Hall Smithtown High School

Analysis of Aged and Cancerous Fibroblasts on PB Substrates
Sean Pi North High School, Laguna, California
Michael Serbin**,** Kennedy High School, Bellmore, NY

12:45-12:55 Session XI: **Electrospinning**

Chair: **Matthew Schlossberger**, Dartmouth University

Using Metallic Nanoprticles to Enhance the Properties of Polystyrene and Poly(ethylene oxide) Electrospun Fibers

Batya Matla Herzberg, Toby A. Klein *Stella K. Abraham HS*

A New Spin on Scaffolds:
Engineering an Electrospun Hyaluronic Acid Matrix to Enhance Wound Healing
Amardeep S. Grewal, Detroit Country Day Detroit, Michigan
Tom Mackey*,* South Side High School Rockville Centre, NY

12:55-1:15 Session XII: **Forming Patterns on Surfaces: Cells and Proteins**
Chairs: **Lenny Slutsky**, Duke University
Jessica Fields, Princeton University

Nanopatterns to Control Cell Mechanics
***Taylor Bernheim*,** Ramaz Upper School, NY, NY

A Novel Method for Diagnosing Fibrinogen Abnormalities
Chris Mackey, South Side High School, Rockville Centre NY,

The Effect of Angiogenic Inhibitors and Growth Factors on Matrigel Angiogenesis
Jeremy L. Hsu, Winter Springs High School,Winter Springs, Fl,

The Future of Cancer Diagnostics: Using Micro-patterning as a tool to compare cancer cells and their ECM to normal cells their ECM
Jessica Fields, Princeton University
Kathryn Dorst, Dowling College

Engineering **a Second Generation Hydrogel Matrix for wounds**
Ron Li, Valley Stream Central High School, Valley Stream, NY

Templating Biomineralization Using Self Assembling Proteins
Marc Sherwin, *The Wheatley* School, *Old Westbury,* .
Samantha Palmaccio, *Sachem High School East, Farmingville, NY*

Session XIII: **Flame Retardant Polymers**
Chair : **Michael Goldman, Yeshiva University**

A Study on Fire-Resistance in Polymer Blends using Clay and Bromine
Jeddy Chen, Ward Melville High School

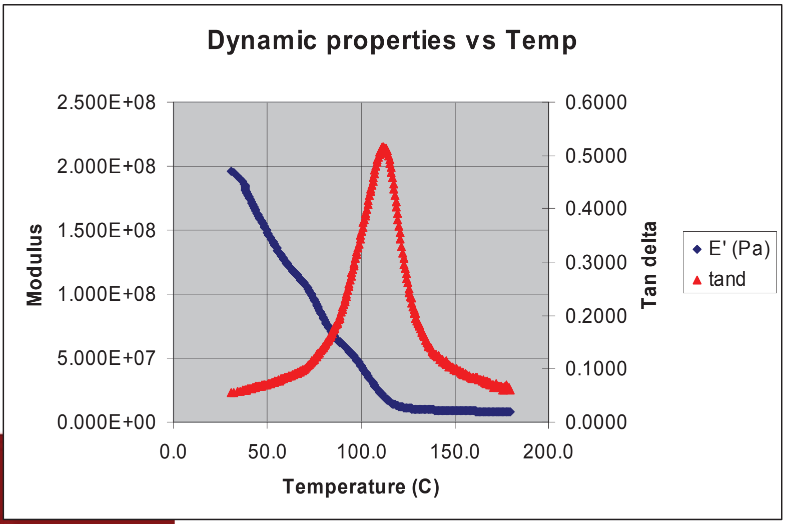
A Non-Halogen Self-Extinguishing HIPS/Phosphate/Clay Nanocomposite
John Oh**, **Wonwoo Lee, Kiwoong Yoo, Jericho High School, NY 11753

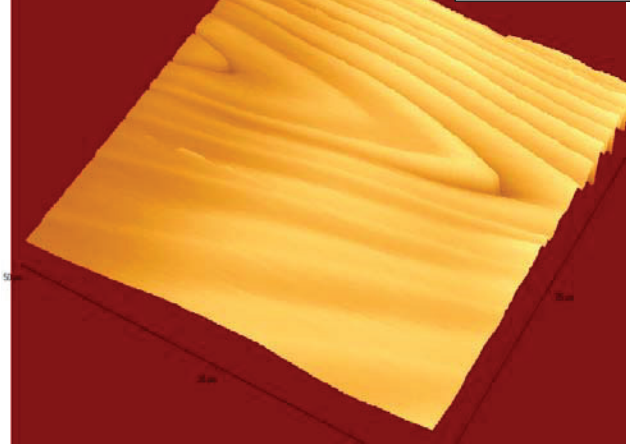
Enjoy Lunch, Movie, and Music arranged by our students

Enjoy Lunch, Movie, and Music arranged by our students

Session 1:
Supercritical Fluids

Directors: Dr. John Jerome, Dr. Ron Occiogrosso
Chairs: John Iraci, Mordechai Bronner
Eugerie Andre Narcisse, Sarvesh Ramprakash, Brian Albert
Alex Thachara, Jinju Yi
Rafael Holzer, Rachel Rosenfeld
Allyson Ho
Vijay Jain, Harriman Lee



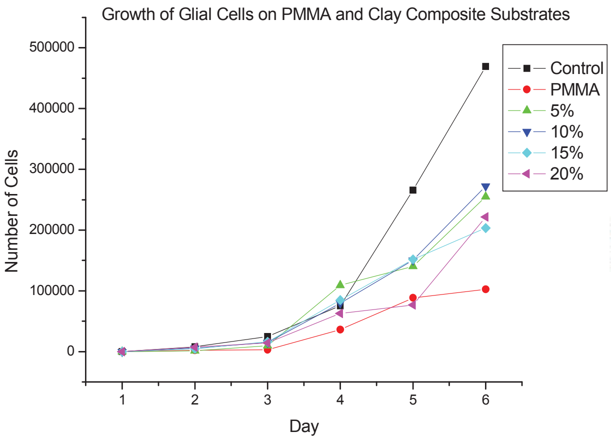


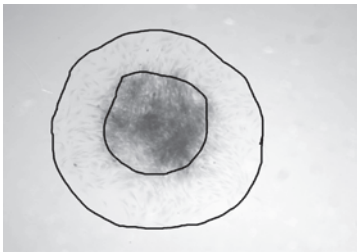
Session 2: Influence of Nanoparticles on Cell Functions

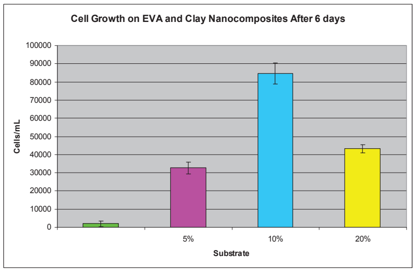
Directors: Dr. Nadine Pernodet, Xaiohua Fang

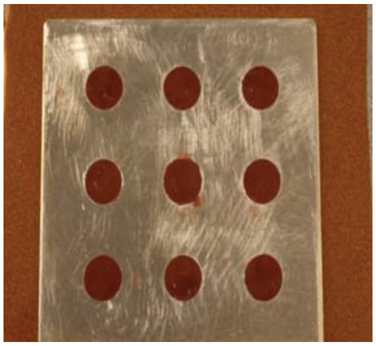
Chair: Avtar Sing

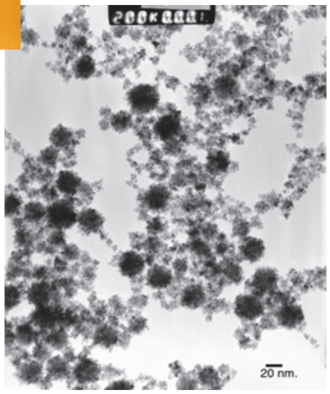
Daniel Katz, Vikas Murali
Lauren Sipzner, Jaimie Stettin
Kaitlyn Hay, Urooj Khan
Hilana Lewkowitz-Shpuntoff, Mary Catherine Wen
Daniel Hefter, Jacob Loewenstein
Kiran Nandigan, Jon Espitia









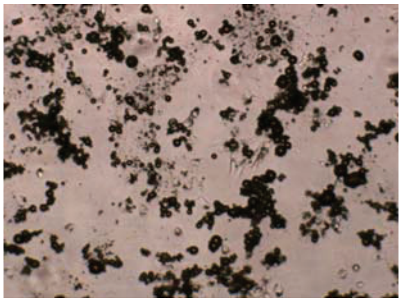


A Comparison between the Application of Titanium Dioxide on Keratinocytes and on Squamous Cell Carcinoma

Kiran Nandigam, Sachem East High School, Farmingville, NY 11738
Jon Espitia, Sachem East High School, Farmingville, NY 11738
Mike Vaccariello, Sachem East High School, Farmingville, NY 11738
Mariam Rafailovich, Department of Materials Science and Engineering, Stony Brook

Nanoparticles are in great demand for cosmetics since they are nearly invisible. A problem that these particles pose, however, is that they penetrate cells and may be potential causes of various health problems. Titanium dioxide is a commonly used nanoparticle found in many daily used products such as sun tan lotion, toothpaste, paper, and paint[1]. It is important to investigate the properties of titanium dioxide on epidermal cells (keratinocytes) because it may be a potential carcinogen. TiO_2 is also known for its photocatalytic effect that could possibly be used for chemotherapy to kill cancer cells. Studying the effects of titanium dioxide on cells is important as it is consistently involved with our lives. Cells were put into 24-well plates and created solutions of .1 mg/mL, .3 mg/mL, and .5 mg/mL titanium dioxide in DME media. At intervals of 2 days, 5 days, and 8 days, cell counts were taken to observe cell viability with the different concentrations of nanoparticles. Results have shown that the titanium dioxide is indeed harmful to all cell growth, though it seems to have a much greater toxic effect on the cancer cells at the tested concentrations (figure 1). These cells die out 1.5 times faster than the keratinocytes, as seen in cell counts. The O33 Kerationcytes are less sensitive to nanoparticles than the SCC-13 cancer cells exposed to the nanoparticles (figure 2), though more cancer cells appear as cancer proliferates faster. The LD50 for the keratinocytes appears to be approximately 0.1 mg/mL of TiO_2 while the cancer cells seem to have a LD50 at an even lower concentration This project is significant because it could alter the products people use to make safer goods that won't have damaging effects on the body. Further studies include whether mitochondrion DNA is affected by nanoparticles, causing cancerous mutations; whether exposure to UV light will cause oxygen radicals to form, increasing the degree of cell damage; and how deep the nanoparticles penetrate the skin.

(Fig.1) SCC-13 cells in DME media without TiO_2.



(Fig.2) SCC-13 cells in a .3 mg/mL solution of TiO_2 media.

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[1] Bastarache, E. (n.d.). Titanium dioxide. Retrieved Jul. 15, 2005, from http://citationmachine.net/index.php?mode=form&g=&list=nonprint&cm=9.

The Effects of Phosphorous Based Fire Retardants Containing Nano-Clays on Cellular Properties and Growth.

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Currently, polymers are replacing natural materials because polymers can provide specific desired properties at sensible costs. However, the current generation polymers used by the public are highly flammable and, when burned, release toxins into the air creating a health hazard for those exposed. In order to avoid such negative properties, flame-retardant polymers were developed and synthesized. Flame retarded polymers are designed to absorb heat and remove oxygen from the air preventing fires. It removes oxygen from the air by bonding molecules with free oxygen surrounding the fire. These polymers utilize Poly brominated diphenyl ethers, which are highly effective fire extinguishers. However, the said bromines cause numerous hazards to people and the environment. These Bromines have been linked to tumors, neuro-developmental toxicity and thyroid hormone imbalance[2]. These bromines are not only toxic to human cells but they evaporate and become incorporated into the water supply and the air. Furthermore, in order for the bromine to be effective as a fire retardant it must be released along with the base polymer of the mixture, and as such, the presently used Bromine based polymer mixtures must contain a Bromine percentage of thirty to forty percent. Due to the need for such high percentages of the toxic substance bromine, the problem has become exacerbated and as a result, a bromine substitute in fire-retardants is in high demand.

Such was the case when nano-clays were utilized to create a phosphorous based fire-retardant[3] which has a benign effect on the environment and yet is highly effective at extinguishing flames. However, a new problem has arisen. The scale of nano particles is so small that such particles can easily enter the body, through skin penetration and other methods, and bypass the membrane of cells which cannot stop particles of such size. It is believed that such particles can be harmful and hazardous to cells and as such, our goal this year test the said flame retardants effects on he cells of the human body, and attempt to witness its specific effects. Human neural cells were plated onto molds of our fire retardant, blended and pressed with a Brabender Twin Screw Extruder and a Carver Hot Press. We created a custom mold containing nine slots the size of a well of a 24 well tray. The base polymers, Ethyl Vinyl Acetate and Poly-methylmethacrylate, were used as a control in order to differentiate its effects from the effects of the phosphorus and clay. The fire retardants were blends of the base polymer, Phosphorus, Magnesium Hydroxide, and nano-clays. Varying the amount of clay in the fire-retardant, the numbers of cells that grew on the fire retardant samples were calculated and compared to the number of cells grown on the control molds. The effects that the clay had on cell structure and protein absorption were also observed.

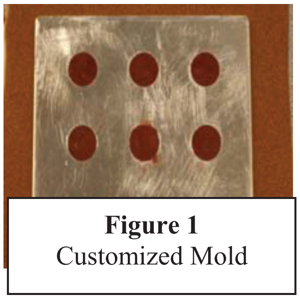

Figure 1
Customized Mold

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[2] Siddiqi, Muhammad Akmal, PhD, Ronald H Laessig, Phad, and Kurt D Reed, MD. "Polybrominated Diphenyl Ethers (PBDEs): New Pollutnts–Old Diseases ." Clinical Medicine & Research 1.4 (Sept. 2003): 281-290.

[3] Price, Dennis, et al. "Flame retardance of poly(methyl methacrylate) modified with phosphorus-containing compounds ." Polymer Degradation and Stability 77 (2002): 227–233.

The Properties of colloidal Platinum Nanoparticles in Hydrogen Storage, Semiconductors and their effects cellular organization of Actin.

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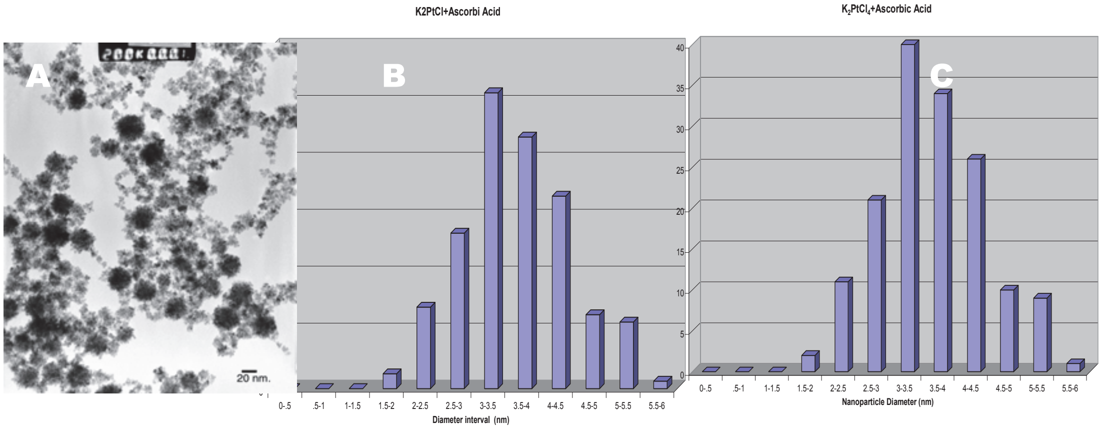
Vikas Murali: Staples High School: 70 North Avenue, Westport, CT,

Rebecca Isseroff, Dr.Nadine Pernodet, Dr. Miriam Rafailovich, Dr. Vladimir Samuilov, and **Yuan Sun,** Department of Material Science and Engineering, Stony Brook University.

Interest in nanoparticles has increased in recent years with the realization that unique properties may be obtained from otherwise ordinary materials. Colloidal metal nanoparticles are of particular interest because of their potential uses in electronics, as drug delivery systems and absorbents. The purpose of investigating platinum nanoparticle's hydrogen affinity for applications such as fuel cells, stems from the previous knowledge that bulk platinum has a high affinity for hydrogen, therefore we have hypothesized that platinum nanoparticles will have a considerably greater hydrogen storage potential due to their much greater surface to volume ratio. In respect to cellular activity, we hypothesize that colloidal platinum nanoparticles will cause definite effects in the reorganization of actin microfilaments and the particles may concentrate themselves in specific cellular regions. Platinum nanoparticles are promising semiconductors because of their ability to allow electron tunneling, especially when the particles are relatively closely situated. In the process of our research, we created platinum nanoparticles by several methods. The particles were synthesized by four different processes that had never been used for platinum synthesis. Among these methods was the reduction of K_2PtCl_4, a platinum salt, by sodium borohyride, the reductant for this experiment, at room temperature. This method produced spherical platinum nanoparticles with a mean size of 3.8 nm with an approximately normal relative frequency distribution. Reduction of this platinum salt with the alternative reductant, ascorbic acid, produced similar particles with slight aggregation. Colloidal nanoparticles were also produced when H_2PtCl_6, a platinum salt, was reduced with ascorbic acid. This method produced large aggregated particles. In another method of nanoparticle production, H_2PtCl_6 was reduced with sodium borohydride. Upon TEM (transmission electron microscopy) it was determined that nanoparticles were non-existent in the sample.



A) TEM image of platinum nanoparticles produced with K2PtCl4 reduced with Ascorbic acid. (B) Histogram representing relative frequency distribution of the nanoparticle's diameter (nanoparticles from A). (C) Histogram representing frequency distribution of the nanoparticle's diameter (nanoparticles from A).

Effects of Titanium Dioxide Nanoparticles on Cellular Traction Forces

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Today's sunscreens and cosmetics are increasingly using titanium dioxide (TiO_2) nanoparticles because of its ability to scatter and reflect radiation from the sun, in addition to its high cosmetic appeal when compared to skincare products containing particles of larger sizes [1]. Despite its increased use, little research has been done on how these nanoparticles affect human dermal cells. Images taken with the Transmission Electron Microscope (TEM) show that TiO_2 nanoparticles are small enough to cross the cellular membrane and penetrate the cell. On top of this, the cells have no mechanisms to remove the nanoparticles from within their cytoplasm. This project seeks to determine the effects that the presence of TiO_2 nanoparticles in the cells has on the traction forces and migration of dermal fibroblasts, and to ultimately determine whether products with these nanoparticles are safe for human use.

Dermal fibroblasts contaminated with two concentrations (0.4 mg/mL and 1 mg/mL) of TiO_2 nanoparticles will be compared to each other and to a control which contains no nanoparticles. Substrates made with thiol functionalized hyaluronic acid (HA-DTPH), cross linked with poly ethylene glycol diacrylate (PEGDA) for greater stability, and conjugated with recombinant fibronectin functional domains (rFNfd) in order to mimic the extracellular matrix will be used for the fibroblasts to attach to and spread on. Fluorescent beads that are 40 nanometers in size will be added to the hydrogel substrates. The traction forces will be measured using a Leica Confocal Microscope and the Digital Imaging Speckle Correlation (DISC) technique. After the cells are allowed to spread, they will be trypsinized so that they detach from the substrate. The deformation of the fluorescent beads will be analyzed in order to get the traction forces. Confocal images will also be taken to see how the TiO_2 nanoparticles affect the actin cytoskeleton, which plays an important role in traction forces. The results of this experiment will have significant implications for the continued use of TiO_2 nanoparticles in cosmetics and sunscreens.

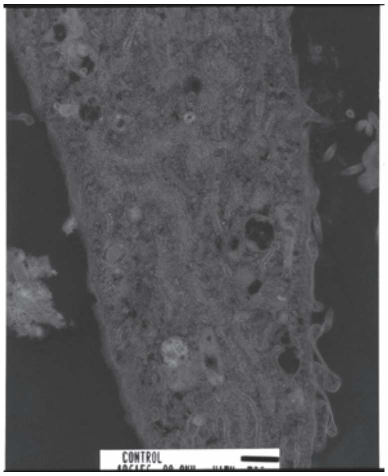

Figure 1: cell without TiO_2 nanoparticles

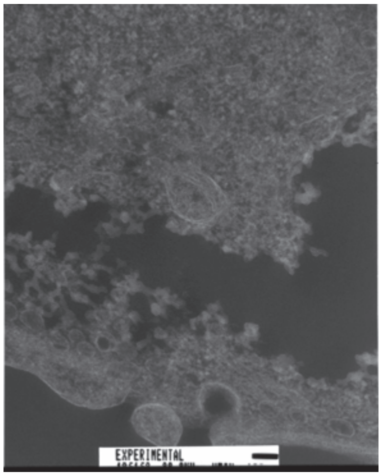

Figure 2: cell with TiO_2 nanoparticles

[1] Robb, J.L. Ultrafine titanium dioxide. A new ingredient for sun and skin care. *Cosmetics Toiletries Manufacture*, Century Press: 166-169 (1992).

Effects of Titanium Dioxide Nanoparticles on Cellular Behavior

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Yeshiva University High School for Girls
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Currently, titanium dioxide is becoming a more prevalent ingredient in cosmetic products. This metal oxide, a white pigment with a high refractive index, is able to scatter and reflect light, and is therefore frequently used as a physical sun blocker or pigment. At the nanoscale, there is no real barrier which can prevent their entry into cells. Health concerns are raised as to whether the presence of these nanoparticles can impair normal cell function. To test this hypothesis, we conducted cell migration assays, and cell proliferation studies.

In order to measure the effect of the nanoparticles on cell migration, we plated a high density of cells, with samples of either neural or dermal, in the presence of 14 nanometer TiO2 particles in agarose droplets. Our results indicate that the nanoparticles inhibit the cell migration of the dermal fibroblasts, but have insignificant effects on the neural cells.

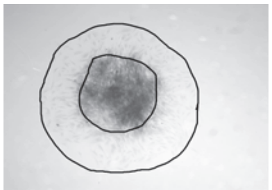


Figure 1-
Dermal Fibroblast
Control

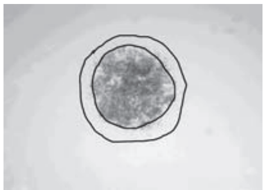
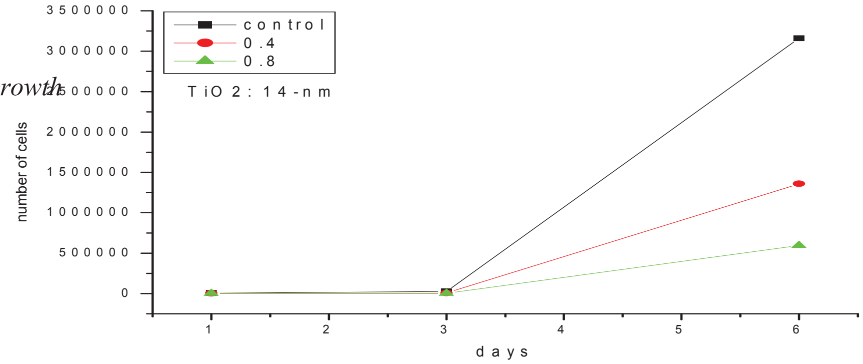


Figure 2-
Dermal Fibroblast w/
TiO2

To determine the level of influence on cell proliferation, we conducted growth curve studies on neural and dermal cells with varying TiO2 concentrations. Hemacytometer cell counts again support our hypothesis, illustrating that high concentrations of the metal oxide hinder normal cell activity, reducing cell number by 50%. Additionally, confocal images show weakened cell structure in the nanoparticle-treated samples.

Figure 3-
Neural Cell Growth
Curve



Further studies will focus on extracellular matrix formation in the presence of TiO2, as well as the repetition of these experiments using forms of the nanoparticles with various shapes and sizes. We will also analyze actin organization, as actin is related to cell migration and proliferation.

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N. Serpone,A. Salinaro, A.V. Emelin, S. Horikoshi, H. Hidaka, J. Zhao, An in vitro systematic spectroscopic examination of the photostabilities of a random set of commercial sunscreen lotions and their chemical UVB/UVA active agents, Photochem. Photobiol. Sci., 2002, **1,** 970-981

K. Peters, R.E. Unger, C.J. Kirkpatrick, Effects of nano-scaled particles on endothelial cell function in vitro: Studies on viability, proliferation, and inflammation, Journal of Material Science, 2004, 321-325

Cell Growth on PMMA-clay Nanocomposites

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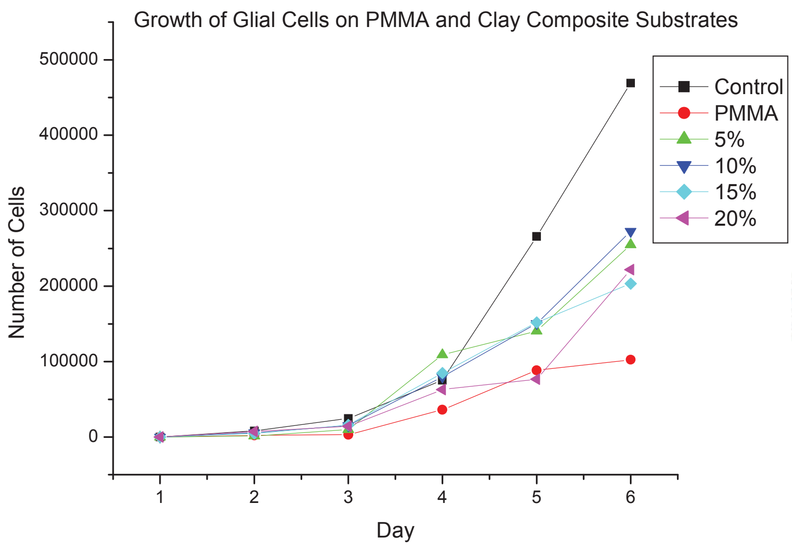
Polymeric substrates do not generally support cell growth. Accordingly, many drawbacks are faced with biological implants constructed of polymer, such as pacemakers and joint and hip replacements. Our research focuses on the interaction between neural cells and polymeric substrates with clay nano-composites.

Substrates for cell growth were prepared by spin-casting nanocomposite thin films of PMMA and Cloisite 6A clay onto glass coverslips. The clay concentration was varied to examine the effect on cell viability. Atomic force microscopy was used to study the exfoliation of the clay in the thin film (See Figure 1). C_6 Glial cells were plated on these substrates and the cell number was counted over a period of one week (See Figure 2). Fluorescent staining with Propidium Iodide and Alexa Fluor 488 was used to examine the nucleus and F-actin organization. The cytockeleton, a network of f-actin fibers, is critical to cell health and mobility.

The growth curve for glial cells on spuncast PMMA indicates that cells prefer PMMA-clay nanocomposites to pure PMMA. Interestingly, the substrate with the most clay did not support the most cell growth.

In addition to analyzing PMMA-clay composite surfaces, we also conducted a bulk experiment with pure PMMA and 10%-clay in order to investigate why the cells preferred the 10%-clay composite over the other concentrations. Future avenues for our research include conducting the same experiment above, but with the polymer poly aniline which has conducting properties. Such a polymer could be used for applications that rely on transmission of electrical impulses, such as pace makers.



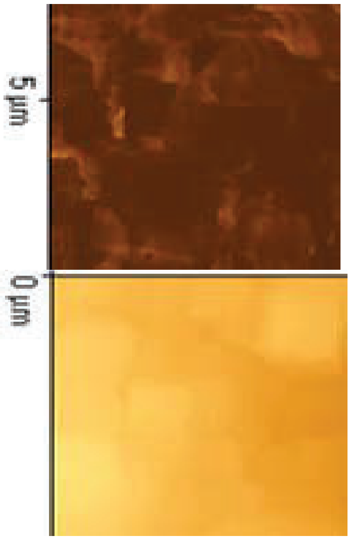


Figure 1: Cell growth curves for substrates with different clay concentrations.
Figure 2: SPM Images of a PMMA substrate with 10% Cloisite 6A clay (top) friction (bot) topography.

Cell Growth on EVA-clay and PB-clay Nanocomposites

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Mary Catherine Wen, Archbishop Molloy High School
Avtar Singh, Cornell University
Nadine Pernodet and Miriam Rafailovich,
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Cell migration and proliferation are essential to physiological processes such as morphogenesis and wound healing. Previous studies show that cell migration can be controlled by substrate rigidity.[1] Cells preferentially migrate toward hard surfaces, which provide traction for cells. The addition of clay to soft polymers, such as ethylene vinyl acetete (EVA) and poly butadiene (PB), can be used to alter the hardness of the material. Furthermore, preliminary studies at our lab indicate that clay fillers enhance cell growth on polymer surfaces. Thus, nanocomposites of soft polymers and clay could prove to be useful biomaterials.

In our experiment, we explore cell viability on bulk and thin film polymer-clay substrates. A Brabender was used to create EVA and Cloisite 20A clay mixtures, which were molded into disks. Solutions of EVA and 5, 10, 15 and 20% Cloisite 20A clay by weight were spuncast onto glass coverslips to create the remaining substrates. Atomic force microscopy was used to examine the substrate morphology (See Figure 1). The nanocomposites were seeded with C6 glial cells and a growth curve was constructed. The cells were stained using Propidium Iodide and Alexa Fluor 488 to observe the nucleus and F-actin organization.

After 6 days, bulk disks with 10% clay were found to best support cell growth, far better than pure EVA (See Figure 2). The higher clay concentrations supported less cells, suggesting too much clay has a deleterious effect on cell growth. Further research will be conducted to investigate this result. Furthermore, PB-clay nanocomposites will be studied as substrates for cell growth.

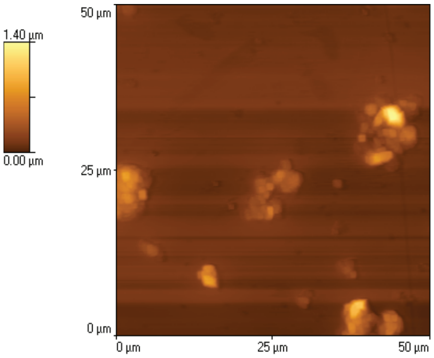


Figure 1. AFM image of solution (15% clay) spun cast onto silicon wafer

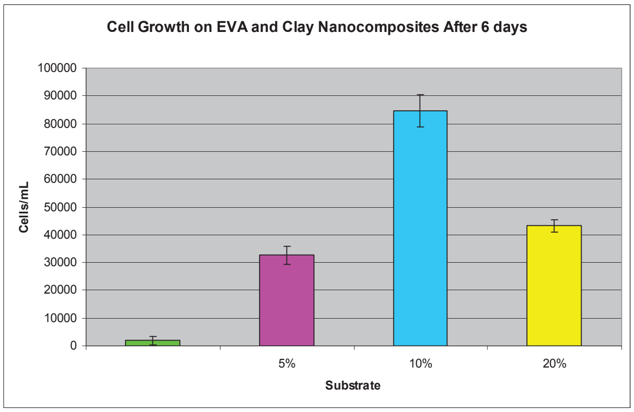


Figure 2. Shows the cell growth of the C6 glial cells on the bulk disks of the different Clay/EVA percentages after 6 days

1. Lo, C. M., Wang, H. B., Dembo, M., and Wang, Y. 2000. Cell Movement Is Guided By the Rigidity of the Substrate. Biophysical Journal. 79:144-152.

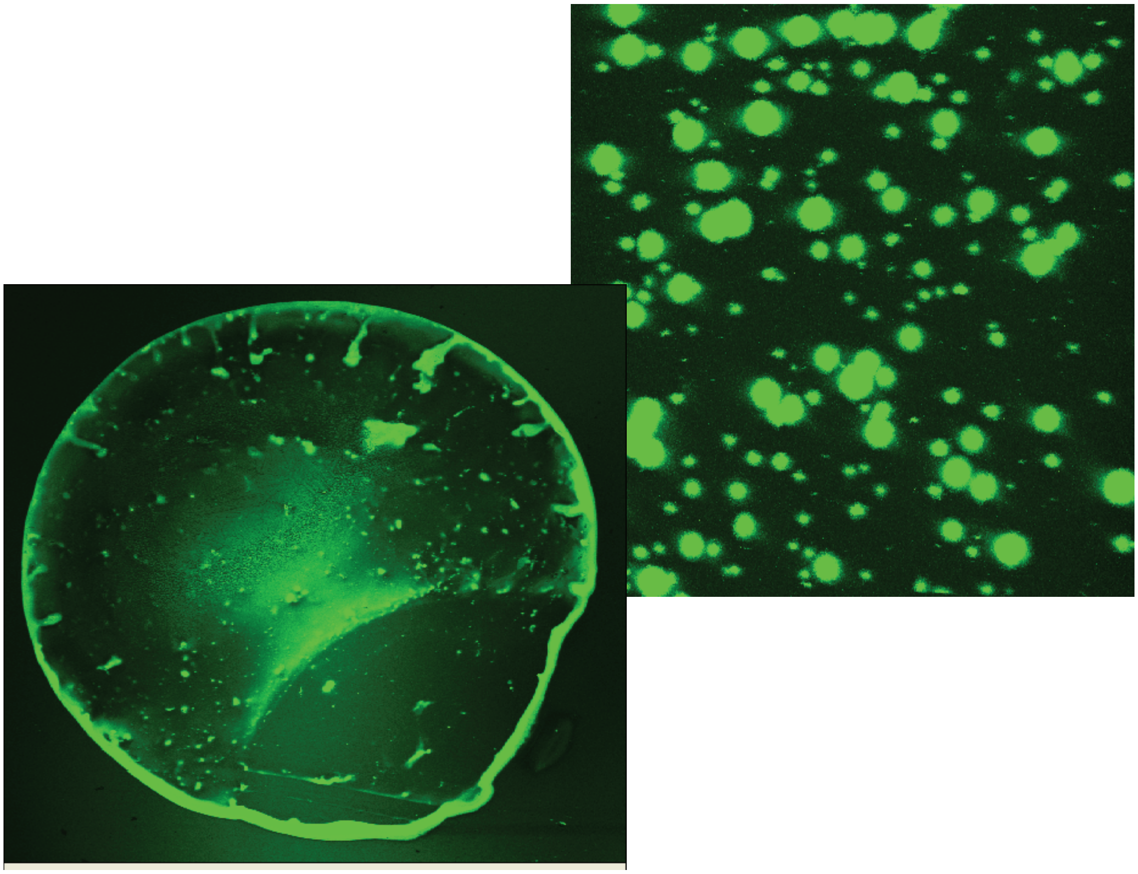
Session 3:

Looking at Genomic Materials

Directors: Bingquan Li, Vladimir Zaitsev

Chair: Eric Petersen

Sean McCormack, Eric Mansfield
Matthew Wieder, Gary Halajian
Irina Zaitseva
Preyah Shah, Jennifer Daniel



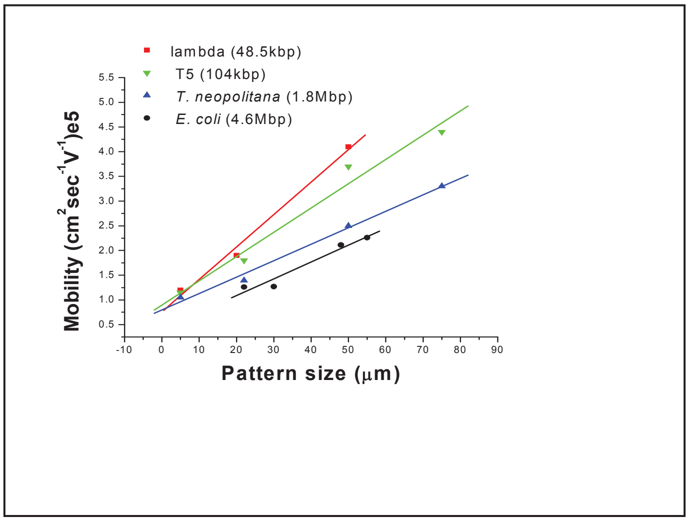
DNA Electrophoresis on Micro-Patterned Surfaces

Sean McCormick*, Eric Petersen+, Bingquan Li, Vladimir Samuilov, Miriam Rafailovich, Jonathan Sokolov, Benjamin Chu#
Stony Brook University, Dept. of Materials Science and Engineering, #Dept. of Chemistry, *Jericho High School, +Harvard University

The separation of DNA is typically based on the concept of topological restriction [1-3] where junction points in a gel, entanglements in a polymer solution or porous arrays of particles may act as the trapping mechanisms. Gel electrophoresis is the most common form of DNA fractionation; it was the primary technique used to separate DNA fragments in the Human Genome Project. In recent years, there has been a proliferation of attempts to design new methods of DNA separation utilizing artificial gels consisting of inorganic corrugated matrices have been proposed. Arrays of two-dimensional posts [1], microchannels with well-defined constrictions[3], and three-dimensional arrays of silica beads [2] are among the multitude of proposed methods. Recently, we have demonstrated a method of DNA fractionation on a surface without topological constraint[4]. The mechanism is based solely on interaction of DNA with the surface, not topological constraints.

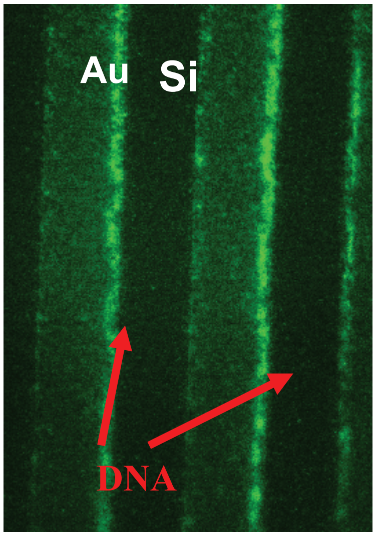
In this work, we further probe the interaction of DNA with a surface by varying the surface properties of the substrate. We used Whitesides microcontact printing [5]to create alternating stripes of silicon and gold on a surface. Mobility of DNA (kilo-mega bp) across the patterned surface with an electric field oriented normal to the stripes was measured via laser induced fluorescence detection. A confocal laser scanning system (Leica TCS SP2) and CCD camera were used to image DNA on the patterned surface.

Results indicate that the mobility of DNA on a patterned surface scales linearly with the pattern size (strip width) [FIG1]and the dispersion decreases with pattern size. Furthermore, confocal imaging has revealed temporarily trapping of DNA along Au/Si interfaces during electrophoresis [FIG2]. Larger DNA chains are shown to escape the Au/Si trap faster than smaller ones, similar to the result demonstrated by Craighead. Thus, we can infer a two-part mechanism for surface electrical transport across a micropatterned surface; transport across homogeneous surfaces and escape from entropic traps at the Au/Si interface.



←FIG1

FIG2 →



The Effects of Titanium Dioxide in Sunscreens on DNA

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Many sunscreens today contain titanium dioxide (TiO_2), a nanoparticle that reflects and absorbs damaging UV rays efficiently. Due to its ability to reflect and scatter UVA and UVB rays, TiO_2 is generally considered a safe physical sunscreen[1]. The safety of this chemical is questionable due to the fact that TiO_2, when in the presence of UV rays, generates hydroxyl radicals, which can damage or destroy DNA. The purpose of this study is to quantify DNA damage resulting from exposure to these radicals and possibly prevent the damage from occuring.

Chromosomal DNA was used to create four different samples; one untreated control sample, one coated with TiO_2, one exposed to UVC rays and one coated with TiO_2 and exposed to UVC rays. The samples were then observed under a confocal microscope and the size and roundness of the DNA in each sample were compared. In a second experiment, two samples of lambda DNA were used. The first sample contained just lambda DNA, and the second sample contained lambda DNA coated with TiO_2. Both samples were exposed to UVC rays and then electrophoresis was used to examine the size and number of broken strands. In a third experiment DNA was used to create four new samples; one coated with green tea extract, one coated with green tea extract and TiO_2, one coated with hydroquinone and one coated with hydroquinone and TiO_2. All four samples were then exposed to UVC rays and observed under the confocal microscope.

Results show that the combination effects of TiO_2 and UV rays created the most DNA damage. Fragmentation was greatest while fragment size was the smallest in this sample whereas in samples that were treated with TiO_2 or UV alone fragmentation was not as drastic. Figure 1a at shows the chromosomal DNA by itself without anything added. Figure 1b shows the DNA coated with TiO_2 and exposed to UV rays. Through analysis of the samples it was observed that the size of the individual particles became smaller and many pieces of chromosome broke off leaving the chromosome with jagged edges. (See figure 1b) This extensive damage was not observed in the samples of DNA with TiO_2 and the DNA exposed to UV rays. Results of the third experiment were very promising. The DNA in all four samples was undamaged, showing that the hydroxyl radicals released by the TiO_2 were captured and were therefore unable to destroy the DNA.

These results were consistent with expected outcomes although the damage to chromosomal DNA exposed to both TiO_2 and UV rays was even greater than anticipated. This may have been due to a much larger discharge of hydroxyl radicals than was expected. Thus, it would appear that TiO_2 destroys a large part of DNA when exposed to UV rays and is a potential health risk that needs to be researched further.

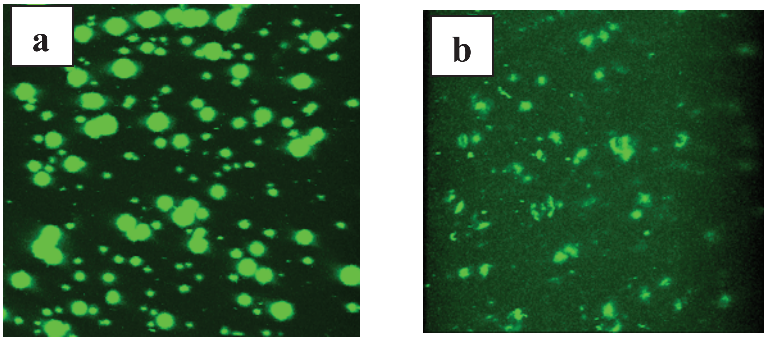

Figure 1: Human chromosomes suspended in Agarose gel (a) without particles and (b) with TiO2 particles and exposure to UV light.

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[1] Dunford, Rosemary et al. Chemical oxidation and DNA damage catalysed by inorganic sunscreen ingredients. FEBS Letters Volume 418, Issues 1-2, 24 November 1997, Pages 87-90

The Effect of UV Radiation on Sunscreen and the Reaction of Sunscreen with Biomolecules

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Despite increased awareness and promotion of sunscreen use, skin cancer rates are still on the rise.[2] Higher SPF is intended to allow you to stay out in the sun longer. But are such tactics safe? Organic and inorganic UV filters are two major components of sunscreens. It is known that organic filters are unstable and tend to degrade when exposed to light and oxygen. TiO_2, as well as other inorganic filters seem to be a good solution because their stability may render reapplication of sunscreen unnecessary. However, studies show that TiO_2 acts as a photocatalyst when exposed to UV light in an aqueous environment and generates oxidative radicals.[3] This may pose a serious threat to our DNA when we use sunscreen.

To test the stability of various sunscreens, I used a Rayonet photochemical mini-reactor to expose samples of each to UVB light. As Fig. 1 shows, prolonged exposure causes a reduction in the absorptive properties of the sunscreens. Clearly sunscreen loses its effectiveness due to exposure to UV, this may raise the need to reapply sunscreen periodically. As an alternative TiO_2, which is a more stable physical sunscreen, may be used to create more effective sunscreens, which would not lose their absorptive properties as quickly as conventional sunscreens. In order to reduce the photocatalytic properties of this component, and therefore reduce any potential hazards they may cause, I intent to experiment with applying polymer coatings on TiO_2 nanoparticles. A stable, non-reactive component such as polymer coated TiO_2 may be the ideal solution to a safe and long lasting sunscreen.

In the future I intend to study the photocatalytic properties of TiO_2 and the potential effects they may have on DNA. Furthermore, I will be conducting experiments to test the effects of polymer/organic coatings on the activity of TiO_2 nanoparticles, as well as the effect of these coated particles on DNA. In addition, I intend to obtain and test samples of modified TiO_2 particles used in a commercial sunscreen.

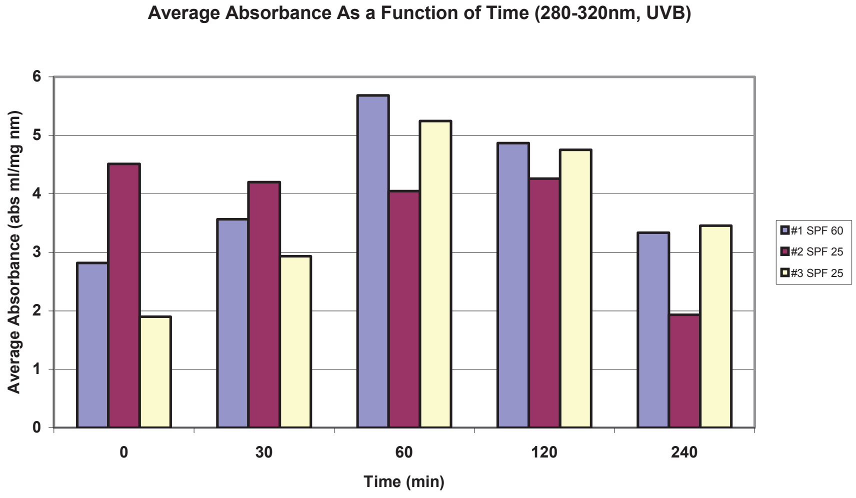

Figure 1: Adsorption of UVB by various sunscreen lotions.

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[2] Almahroos, M., A. K. Kurban. *Clinics in Dermatology*. 2003; **21**: 311-314.

[3] Dunford R. et al. *Federation of European Biochemical Societies*. 1997; **418**: 87-90

The Effects of Poly-l-lysine on DNA Adsorption to Surfaces

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Jennifer Daniel, St Anthony's High School, South Huntington, NY
Eli Hatchwell, Cold Spring Harbor Laboratory, Cold Spring Harbor, NY
Miriam Rafailovich, Jonathon Sokolov, Department of Materials Science and Engineering, SUNY Stony Brook, NY

The purpose of this experiment is to find a surface strongly adsorbing to DNA to anchor long, chromosomal molecules. This will enable the DNA strands to either be combed (stretched out along the surface) or wrapped around a small rod, in order to measure the lengths of the strands. It is our goal to examine a certain genetic disorder in which the affected individual's chromosomal lengths differ from that of a healthy individual's by 1%. We would like to be able to distinguish this difference optically. In this study, poly-l-lysine was used because of its success in previous studies which have shown strong nucleotide adsorption to surfaces covered with poly-l-lysine (Meng et al, Nature Genetics **9**, 432 (1995)).

Surfaces used for the studies included silicon wafers and ITO (indium tin oxide)/glass, each with and without adsorbed layers of poly-l-lysine. Additionally, PMMA was spun onto a silicon wafer. When poly-l-lysine was used, samples were soaked in .001% solution diluted in 10^{-2}X TBE buffer, for varying amounts of time. Concentrations of 25μg/ml to 100μg/ml of λ DNA solution in 10^{-2}X TBE were used to test adsorption to the surface, and 5μg/ml Ethidium Bromide (EtBr) dye was added for viewing under the confocal microscope. To test adsorption, droplets of λ DNA solution were deposited on the surfaces, with a drop size of approximately 2/3 μl. The samples were then viewed under the microscope.

Initial results, including tests of rinsing samples in buffer, indicate that poly-l-lysine solution was successful in strongly adsorbing DNA to surfaces. This can allow DNA to separate into measurable strands. In Figure 1a, DNA combing around the droplet is evident, and Figure 1b also illustrates a ring formation encircling the droplet. Further research will be done, including varying poly-l-lysine concentrations and soaking time to produce optimal adsorption. In addition, we would like to wrap DNA around a turning rod in order to measure single molecules of DNA. By using these methods, we hope to be able to characterize longer DNA strands than those studied by conventional methods.

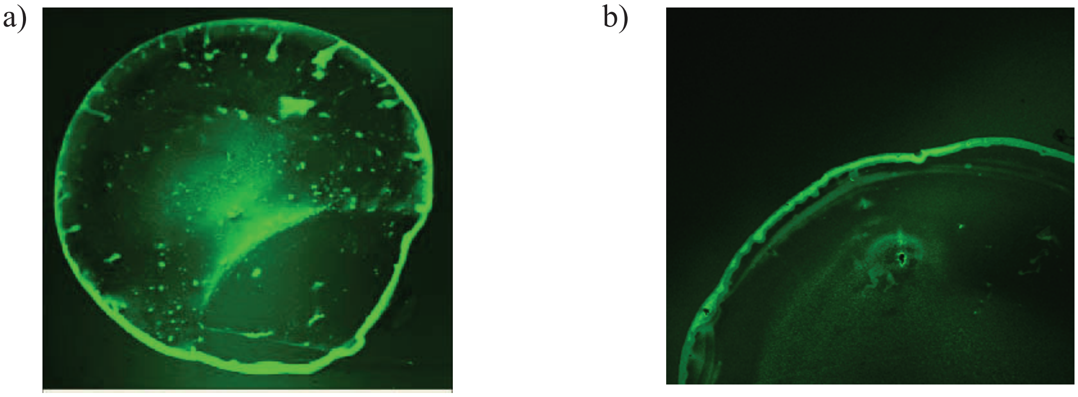


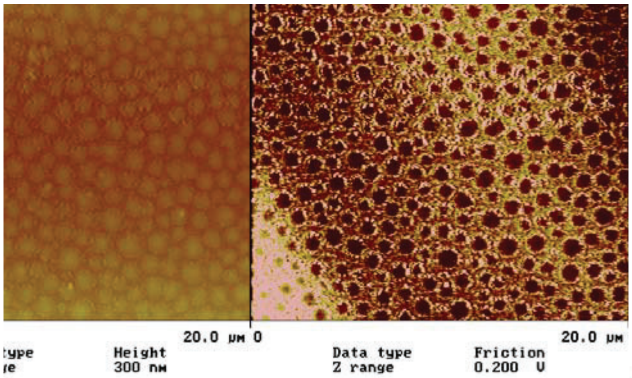
Figure 1. 20% λ DNA droplets (diluted in 10^{-2}X TBE buffer labeled with EtBr). a) Surface- Si soaked in .001% poly-l-lysine. b) Surface- ITO/glass soaked in .001% poly-l-lysine. Image size- 1.5 mm x 1.5 mm

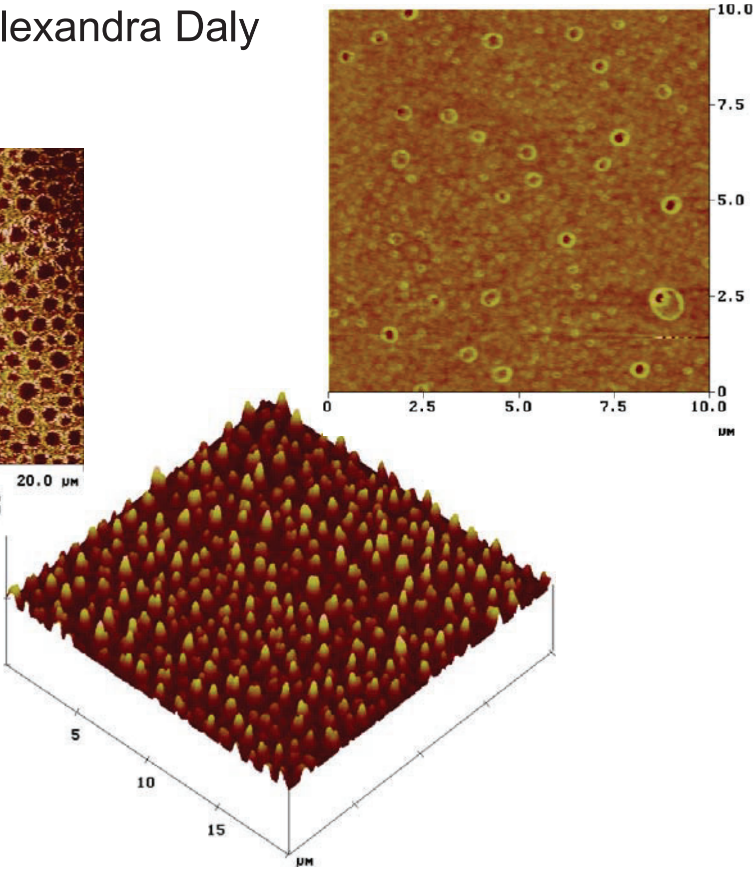
Session 4: Supercritical Fluid Processing of Thin Films

Directors: Dr. John Jerome

Chairs: Chelsea Gordon, Sylvia Qu

Paywand Ahdout, Christopher Pynn
Jamie Rosengard, Brienne Kugler
Fauzia Shaikh
Alexandra Daly





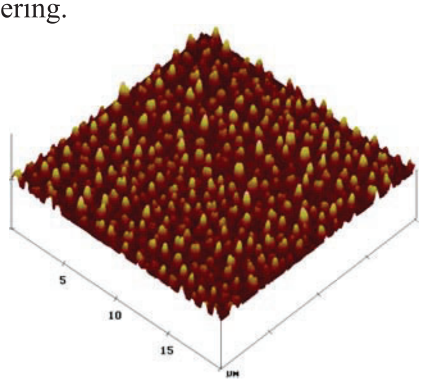
The Effects of Supercritical Carbon Dioxide on Deuterated Polystyrene and Polyethylene Blends

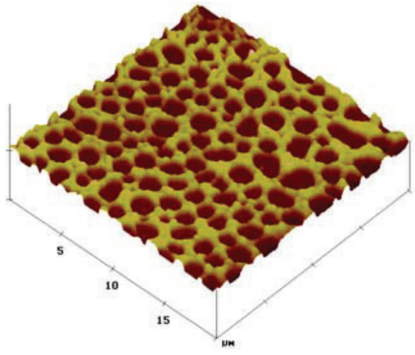
Payvand Ahdout, *Roslyn High School, Roslyn Heights, NY 11576*
Christopher Pynn, *Half Hollow Hills High School West, Dix Hills, NY 11746*
Feini Qu, *Duke University, Durham, NC 27708*
Dr. John Jerome and Dr. Miriam Rafailovich, *Department of Materials Science & Engineering, SUNY Stony Brook*

Polymers are found in two distinct structures: crystalline structures which have distinct shapes and patterns, and amorphous structures which are soft and easy to manipulate. At standard temperature and pressure these two types of polymers are immiscible.[1] Thus, the potential of supercritical fluids (SCFs) as a new method of polymer blending has been of interest to scientists.[2] We used Supercritical Carbon Dioxide ($scCO_2$) because of its low critical temperature and pressure, its environmentally friendly status, and its ability to swell polymer thin films when on the density fluctuation ridge.

We wanted to test the effects of time dependent $scCO_2$ exposure (12, 24, 36, and 48 hours) on blends of Deuterated Polystyrene (dPS), an amorphous polymer, and Polyethylene (PE), a crystalline polymer, in three different ratios (3:1, 1:1, 1:3). We expected to find more compatibility between the polymers as a function of increased exposure to $scCO_2$. The polymers were dissolved in toluene and spun-cast onto silicon wafers at thicknesses ranging from 200-300 Å. The wafers were then exposed to $scCO_2$ at 1200 psi and 36°C. Topography, contact angle, and melting point were looked at using atomic force microscopy (AFM).

In Figure 1, the untreated sample displays phase segregation, which is indicated by the extreme topographical ridges present on the surface. The signs of incompatibility are significantly reduced in Figure 2, which shows a sample treated with $scCO_2$ for 48 hours. The contact angle data correspond with AFM images, showing a decrease as exposure time increases. Our results thus far reveal that $scCO_2$ exposure increases dPS/PE compatibility. As we continue our research, we will study the composition of the samples using Secondary Ion Mass Spectrometry and X-Ray Scattering.





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iscible Polymer Blends. Department of Polymer Science. University of Southern Mississippi. 2005. http://www.pslc.ws/mactest/iblend.htm

[2] Koga, Tadanori. Akashige,E. Reinstein, A. Bronner, M. Seo, Y. Shin, K. Rafailovich, M. Sokolov, J. Chu, B. Satija, S. The effect of density fluctuations in supercritical fluids: new science and technology for polymer thin films. Physica B: Condensed Matter Volume 357, Issues 1-2 , 28 February 2005, Pages 73-79

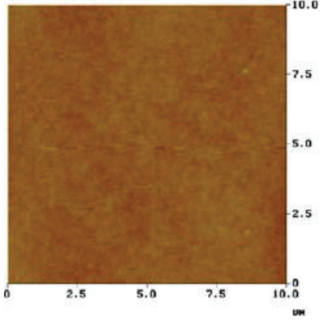
The Effects of Supercritical Carbon Dioxide and Ethane on Metallization of PS and PMMA with POSS Nanoparticles

Jamie Rosengard, Half Hollow Hills HS West
Brienne Kugler, Jericho High School
Chelsea Gordon, Harvard University
L. John Jerome, Miriam Rafailovich, Stony Brook University

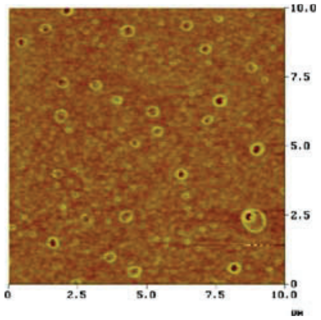
Supercritical fluid technology has emerged as a novel tool in the processing of polymers, both in the thin film and bulk form. Their unique properties, which fall between those of gases and liquids, render them ideal tools in the improvement of traditional industrial techniques [1]. Specifically, supercritical fluids (SCFs) have been shown to cause significant swelling near the surface of polymer thin films while avoiding the formation of large voids [2]. Here, we utilize this characteristic to determine whether the swelling induced by supercritical carbon dioxide (scCO_2) and supercritical ethane, as well as the addition of nanoparticles to polymer films, will enable metal to adhere more readily to sample surfaces, reducing dewetting.

Our experiment commenced with the creation of eight different solutions containing the polymers Polystyrene (PS) and Poly(methyl methacrylate) (PMMA) mixed with Polyhedral oligomeric silsesquioxane (POSS) in differing concentrations. For both PS and PMMA, we used concentrations of 0% POSS, 1% POSS, 5% POSS, and 10% POSS. These solutions were then diluted to three different thicknesses: 1500 Å, 1000 Å, and 500 Å. Following these dilutions, each solution was spun onto four Hydrofluoric Acid etched silicon wafers and summarily measured to determine the exact thickness of the films. In addition, images of surface structures were obtained through atomic force microscopy, and the melting points of each were measured. One sample from each set was then exposed to scCO_2 at the density fluctuation ridge conditions of 1200 psi and 36°C for 12 hours, one sample was exposed to supercritical Ethane at 770 psi for 12 hours, and one sample was annealed for 3 hours at 170°C. Each was compared to a control set of untreated films. The effect of each treatment was then analyzed through ellipsometry to determine thickness, and through atomic force microscopy to determine the domain structure. Samples will be metallized with Chromium and further analyzed using x-ray reflectivity to determine changes in interfacial width.

Results indicate that exposure to supercritical fluids does produce swelling in thin films. Early results with 12 hour exposure time have demonstrated segregation at the surface, as evidenced by figure (b). This contrasts figure (a), which shows the same sample without scCO_2 exposure. Our expectations are that further experimentation will demonstrate which thickness, concentration, and SCF will induce optimum metallization properties, and reduce dewetting to the greatest degree. Through the utilization of Young's equation, this data will then be used to calculate interfacial tension between the chromium and polymer. Practical applications of these results lie within the electronics world, for reduced tension between layers can be used as a means of creating more durable products including printer cartridges, semiconductors, and microscale printed circuit boards.



A: PS with 10% POSS unexposed



B: PS with 10% POSS exposed to scCO_2

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[1] Koga, T., Seo, Y.S., Jerome, J.L., Ge, S., Rafailovich, M.H., Sokolov, J.C., Chu, B., Seeck, O.H., Tolan, M., Kolb, R. *Low-Density Polymer Thin Film Formation in Supercritical Carbon Dioxide*. American Institute of Physics. Vol. 83, Number 21. 2003.

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

The Metallization of EVA (ethyl-vinyl acetate) Polymer Thin Films using Supercritical Carbon dioxide and Nanoparticles.

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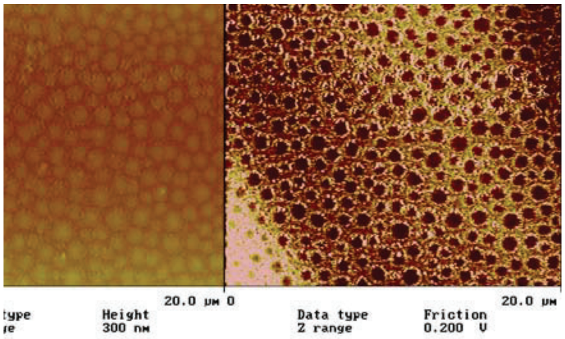
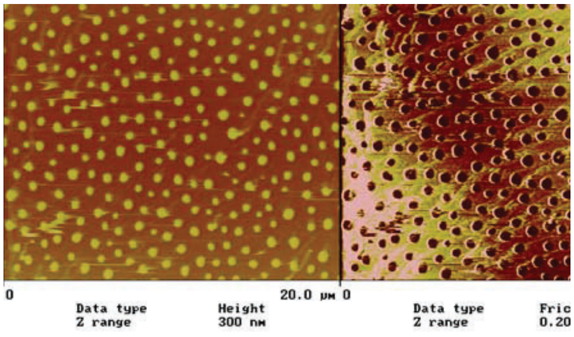
Chelsea Gordon, Harvard University
L. John Jerome, Miriam Rafailovich, Stony Brook University

Metallized polymers, imperative to the production of ink cartridges, circuits, food packaging, and car light reflectors, have been the subject of numerous studies due to their importance in industry. The life span of these products, however, is severely limited by the inevitable dewetting of metals on polymer surfaces due to unfavorable thermodynamic interactions. This study aims to improve the metallization process by exposing thin film samples of ethyl-vinyl acetate (EVA), an amorphous polymer with crystalline properties at higher grades, to supercritical carbon dioxide (scCO_2). Supercritical CO_2 is especially unique because of its pressure and temperature gradient, allowing it to retain density fluctuations and change the properties of polymer thin films.[1] Furthermore, nanoparticles will be added to samples, thus increasing the surface area of the metal-polymer interface and reducing dewetting.[2]

To begin the experimental process, solutions of EVA 265, 550 and 750 were combined with Gold nanoparticles (1% and 4%), POSS (10% and 50%) and clay 15A (1%) and spuncast onto clean silicon wafers. Half of the samples were exposed to scCO_2 at 1200 psi, and 36^{o} C for three hours, and half were left untreated for comparison. Sample thicknesses were measured using the ellipsometer, Rudolf Auto-El, and surface topography and friction data was obtained through atomic force microscopy. Polymers will then be metallized with Chromium through vapor deposition and again analyzed to determine the effects of the scCO_2 on metal adhesion. X-ray reflectivity will then be used to measure changes in interfacial width.

Results show that nanoparticles and scCO_2 alter the surface of polymer thin films. The images shown below show the topography of EVA 265 thin films with ten percent POSS before and after Supercritical Exposure. The second picture shows clearly how the nanoparticles aggregate on the surface of the films in clearly segregated groups. Cross sectional imaging reveals a significant increase in contact angle, indicating increased surface area. From this preliminary data, we can extrapolate a greater interface thickness and thus better adhesion of metal. Through this process, greater effectiveness in the metallization of polymers can be achieved, especially those with crystalline properties such as EVA. This information will result in longer lasting print cartridges and circuits.





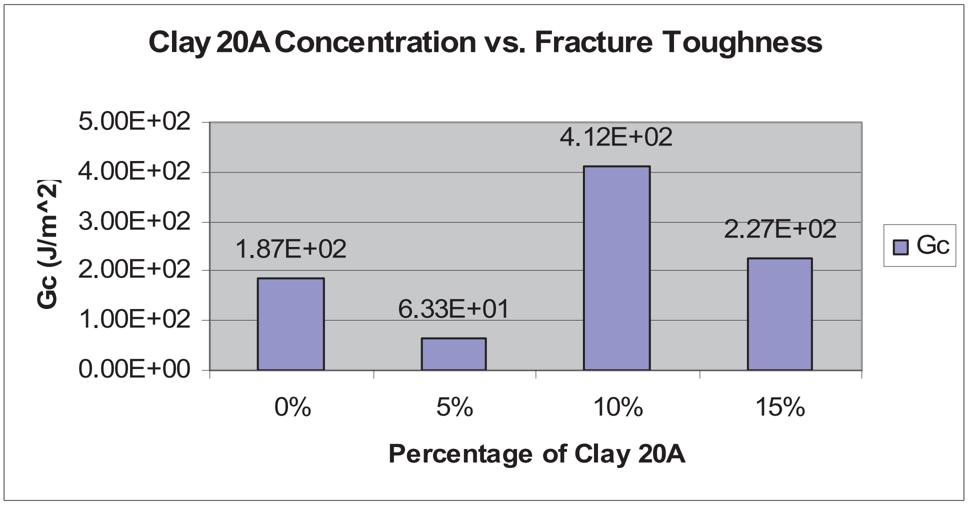
1. T. Koga, Y-S. Seo, J.L. Jerome, S. Ge, M.H. Rafailovich, J.C. Sokolov. *Low Density Polymer Thin Film Formation in Supercritical Carbon Dioxide.* Applied Physics Letters. Vol. 83, Number 21. 24 November 2003.
2. T. Koga, J.L. Jerome, C. Gordon, M.H. Rafailovich, J.C. Sokolov. *Metallizable Polymer Thin Films in Supercritical Carbon Dioxide.*

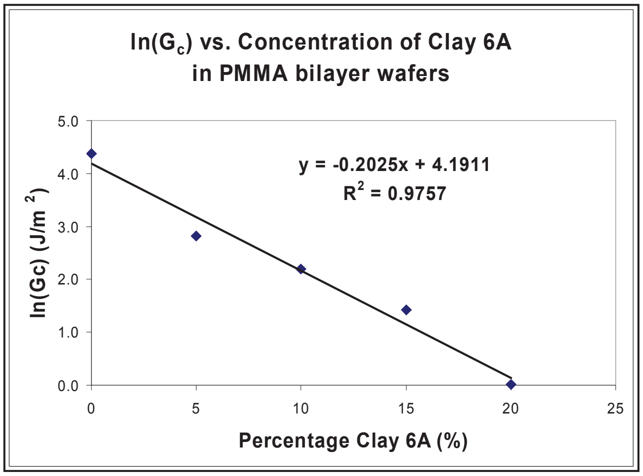
Session 5: Effects of Fillers on Adhesion

Director: Mayu Si

Chair: Michoel Snow

Anupama Pattabiraman, Alexandra Peyser
Vinay Krishnan, Dev Anand
Amulya Bhagad





The Effects of Cloisite Clay 6A on Adhesion at Polymeric Interfaces

Anupama Pattabiraman, Academy for the Advancement of Science and Technology, 200 Hackensack Ave., Hackensack, NJ 07601
Alexandra Peyser, Ramaz Upper School, 60 E. 78 St. New York, NY 10021
Michael Snow, Cornell University, Ithaca, NY
Miriam Rafailovich, Department of Materials Science and Engineering, Stony Brook University, NY

The purpose of this study was to determine the effects of filler on the adhesion at polymeric interfaces. One filler, Cloisite 6A clay, is used in industry as a strengthening agent, because it improves the mechanical and thermodynamic properties of materials.[1] Our experiments investigated the impact of Cloisite 6A on the strength of adhesion in polymers.

Samples of poly(methyl methacrylate) (PMMA) 120k containing 5%, 10%, 15%, and 20% clay 6A by weight were mechanically mixed using a Brabender twin screw extruder from C.W. Brabender Instruments, Inc. These samples were then molded into slabs using a hot press from Carver, Inc. set to 170°C and 7 metric tons for 20 min. Each slab was then annealed to another slab of the same clay concentration for 2 minutes at 170°C and 1.5 metric tons, allowing the polymer chains from the two slabs to entangle at the interface. The resulting bilayer wafers were then tested using the Asymmetric Double Cantilever Beam Model (ADCBM), which cracked the samples at their interfaces. Crack length measurements were subsequently used to calculate G_c, a quantification of the interfacial adhesion.

The formula for G_c is $G_c = \dfrac{3u^2ED^3}{8a^4\,(1 + 0.64D/a)^4}$, where u = wedge thickness, E = elastic modulus, D = thickness of the top slab, and a = crack length.

The results showed that fracture toughness of the PMMA/PMMA interface decreased exponentially with an increase in clay concentration, with an exponential coefficient of -0.21 (*Figure 1*). This finding is significant, because it shows that clay fillers, while beneficial to various bulk properties of polymers, can lower the adhesion at polymer interfaces. Future work will utilize Atomic Force Microscopy (AFM) to examine interfaces that have undergone adhesive failure and characterize the adhesion.

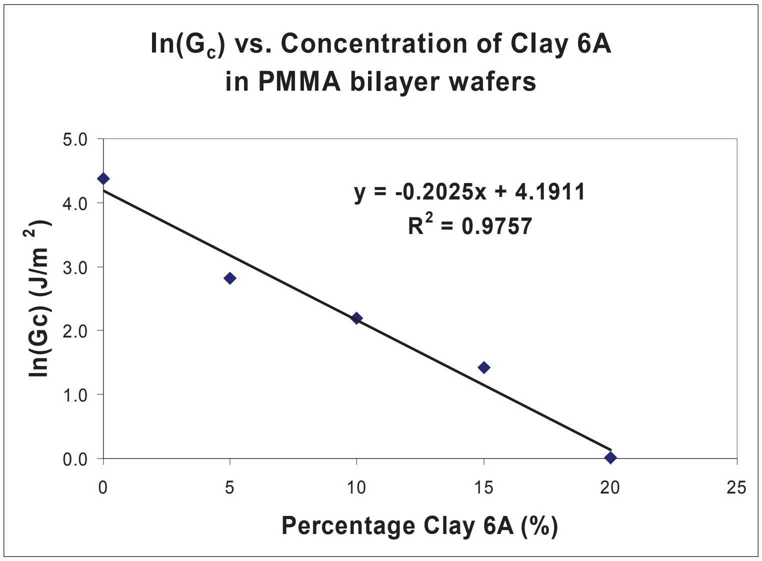


Figure 1. Semi-log plot of G_c vs. concentration of clay 6A, using fracture toughness data from 5%, 10%, 15%, and 20% clay 6A samples annealed for 2 min.

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[1] Sherman, L. M. *Plastic Technology*. June 1999.

Fracture Toughness and Flame Retardance Using Polycarbonate, Styrene Acrylonitrile, and Organoclay Polymer Blends

Vinay Krishnan, Dev Anand Wheatley High School, Old Westbury NY 11568
Mayu Si, Michael Snow, Madeline Augustine, Aryeh Sokolov,
and Miriam Rafailovich, Stony Brook University

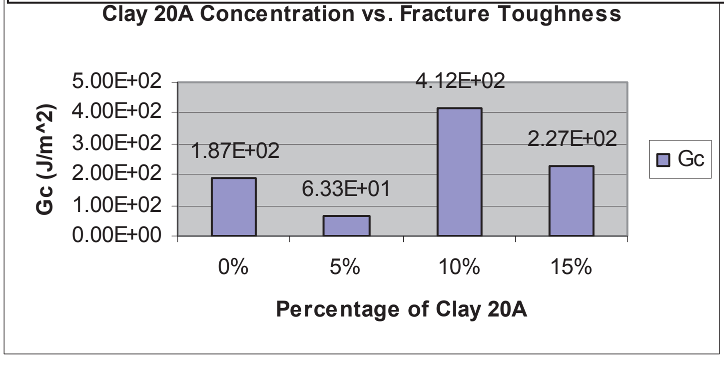
This purpose of this study was to determine the effect of clay nanocomposites on the interfacial adhesion and flame retardance of polymer blends. We used the filler Cloisite 20A; previous research has shown that the addition of this organoclay has been used to alter the morphology of polymer blends, increasing their mechanical and thermodynamic properties as well as their tensile modulus[2]. This higher tensile strength can increase the interfacial adhesion between the two polymers, resulting in an improved ability to resist pressure and prevent cracking. It is believed that the addition of organoclay will produce a material with increased fracture toughness.

In order to achieve this, PC (Polycarbonate) and SAN (Styrene Aacrylonitrile) were mixed together in the brabender at 210 degrees Celcius in a one to one composition ratio. Within each 50 gram sample, the organoclay was added in different concentrations, of 0%, 5%, 10%, and 15% clay. The samples were molded in a hot press at 210 degrees Celcius and then annealed together at 160 degrees Celsius at one metric ton for three minutes. The Asymmetric Double Cantilever Beam (ADCB) test was then used to measure fracture toughness. This was done by inserting a razor blade through the annealed interface promoting a crack site. With each advancement of the blade, the crack length would increase. The length would be measured until a constant crack length was found or part of the sample would crack due to strong adhesion between the polymers. With this data, we are able to calculate Gc, by using the equation;

$$G_c = \frac{3u^2 E D^3}{8a^4\left[1+0.64(D/a)\right]^4}\,(J/m^2)$$

The only altering variables would be 'a', the crack length, and 'E', the elastic modulus. Because a polymer blend was used, each individual polymer had its own modulus. To discover the modulus of the sample as a whole, DMA tests were done for one sample at each clay concentration. The test showed that samples with 10% clay concentrations had the highest modulus which was 4.518E +09. Concerning the Gc values, 10% also had the highest value of 4.10E+02. When more clay was added past that point, the samples became more brittle (*Chart one*). In the future, the flame retardance of the samples could be measured by the use of UL94 tests. It is expected that the samples with higher concentrations of clay will self-extinguish at a faster rate.

Figure 1: Fracture toughness vs. clay concentration
For PC/SAN blend



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[2] M. Y. Gelfer , Hyun H. Song , Lizhi Liu , Benjamin S. Hsiao*, Benjamin Chu , Miriam Rafailovich, Mayu Si, Vladimir Zaitsev
"Effects of organoclays on morphology and thermal and rheological properties of polystyrene and poly(methyl methacrylate) blends"
Journal of Polymer Science Part B: Polymer Physics Volume 41, Issue 1 , Pages 44 - 54

Calculating Viscosity of Polymer Thin Films Using Dewetting

Amulya Bhagat, Herricks High School, 100 Shelter Rock Road, New Hyde Park
Jae Sung Koo, Song Li, Miriam Rafailovich, Department of Engineering, Stony Brook University

"Dewetting" is the process in which microstructures form from a polymer which has a higher surface tension than its substrate. P. Lambooy *et. al* observed that the rate of dewetting can be correlated to a polymer's viscosity.[1] It was found that the viscosity of the polymer is able to be calculated by measuring the diameter of the microstructures formed during dewetting. The addition of nanoparticles, however, alters the polymers' viscosity. It is important to note the change in the properties of polymers altered by nanoparticles for efficient use in industrial applications. This study, therefore, measures the changes in viscosity of polymers with different concentrations of nanoparticles introduced.

The nanoparticles used in this experiment are silicon nanotubes. A PS/PMMA Bilayer was prepared on silicon wafers with the bottom layer having concentrations of 0.1%, 0.05%, 0.02%, 0.01% and 0% by weight silicon nanotubes. They were to be annealed in the Ultra High Vacuum Oven at 1 hour, 3 hours, 6 hours, 12 hours, 18 hours, 24 hours, 36 hours, 48 hours and 72 hours at 180 degrees Centigrade. The samples were to dewet after annealing in the vacuum oven. The microstructures then formed were to be measured under an optical light microscope. From these measurements, the viscosity could be calculated.

The samples, at this time, are annealing in the Ultra High Vacuum Oven. The samples studied so far are the unannealed 0.1% and the 18 hour 0.1% samples. The passage of 18 hours in the vacuum oven changes the surface of the silicon remarkably, displaying many dewetted microstructures of polystyrene.

100x Magnification of 0.1% by weight Si nanotubes annealed for 18 hours.

100x Magnification of 0.1% by weight Si nanotubes unanealed.

Figure 1: Dewetting from bilayer film of (left) annealed film containing Si nanotubes and (Right) Unannealed bilayer film.

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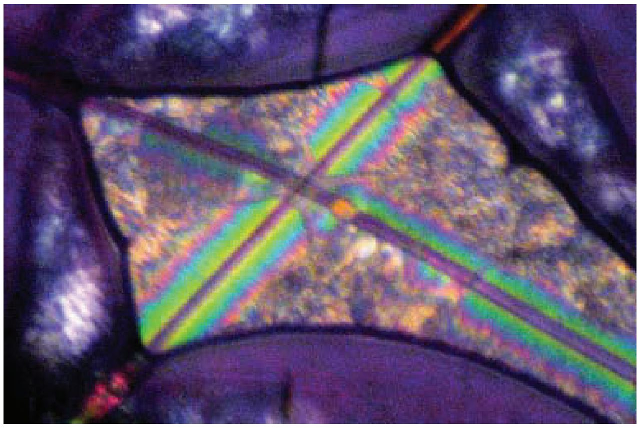
[1] Lambooy, P. "Dewetting at the Liquid-Liquid Interface." Physical Review Letters 76.7 (1996): 1110-1113.

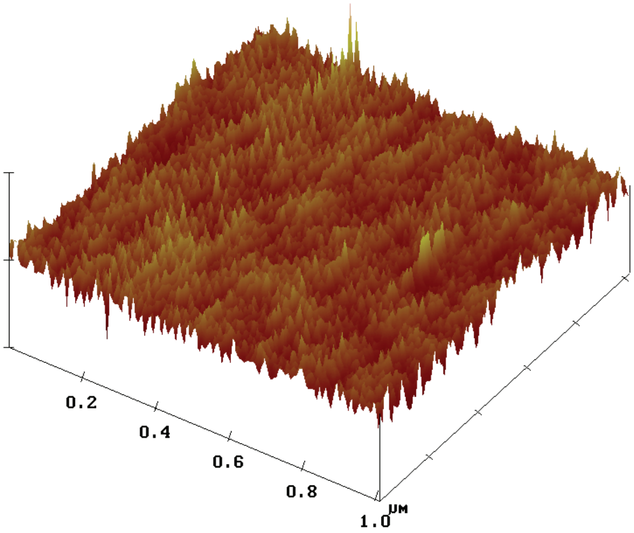
Session 6:
Crystalization Phenomena

Director: Dr. Yiantian Wang, Song Li

Chair: Madeline Augustine

Ashish Bakshi, Rajesh Atluri
Kyle Horning, Shahrukh Mallick
Debbie Yee, Victor Wang
Vijay Jain, Harriman Lee

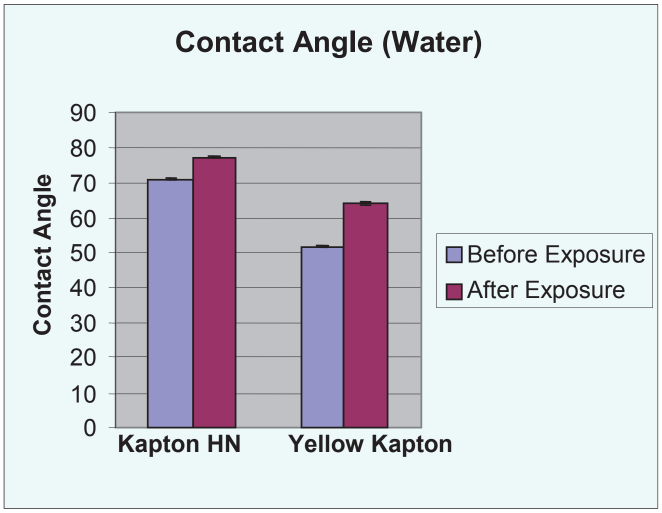




The Effects of Supercritical Carbon Dioxide on the Properties of Polyimides

Alexandra Daly, Plainview Old Bethpage John F. Kennedy High School
50 Kennedy Drive Plainview, NY 11803
Chelsea Gordon, Harvard University
John Jerome, Miriam Rafailovich, Department of Materials Science and Engineering, Stony Brook University

Metallized polymers are used in many industrial applications, such as the manufacture of compact discs, car light reflectors, computer casings, microscale printed circuit boards, and even food packaging.[1] Polyimides are incredibly heat and chemical resistant polymers that are useful in industry because they will withstand corrosion and heat, are thermally stable, resistant to fats and oils and transparent to microwave radiation. The metallization of these polymers is of interest, as the researcher will achieve a heat and chemical resistant polymer with metallic properties. It is hypothesized that with the use of supercritical carbon dioxide ($scCO_2$), Polyimides will be susceptible to metallization, and that $scCO_2$ will cause the polyimide to swell, thus creating a low density surface of greater area that will enhance metal adhesion.[2] In this study, water contact angle data was taken for two samples of Kapton® before and after exposure to $scCO_2$. Exposure time was 12h at 36°C and 1200 psi. Preliminary atomic force microscopy (AFM) images were taken. After exposure to $scCO_2$, it was found that the water contact angle for both samples increased. The contact angle of the sample of Fralock's Kapton HN Film increased by 8.6%, and the sample of yellow Kapton increased by 23.8%. As of this point, results are consistent with the previous hypothesis, as the changing of the contact angle indicates an alteration of the polymer surface by the $scCO_2$. Therefore, it is probable that Polyimides will be susceptible to metallization following exposure to $scCO_2$, as its physical properties are altered by exposure. The metallization of the altered Polyimides is to be done next in the study, along with x-ray reflectivity to elucidate the physical differences between the two samples of Kapton, and getting AFM images to analyze the differences in topography that the $scCO_2$ causes.



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1. Faupel, F; Zaporojtchenko, V; Strunskus, T; Erichsen, J; Dolgner, K; Thran, A; Kiene, M. *Fundamental Aspects of Polymer Metallization* Metallization of Polymers 2 (2001).
2. Koga, T; Seo, Y. S; Hu, X; Shin, K; Zhang, Y; Rafailovich, M. H; Sokolov, J. C; Chu, B; Satija, S. K. *Dynamics of polymer thin films in supercritical carbon dioxide.* Europhysics Letters, 60(4), 559-565, (2002).

Thin-Film Crystallization of Polycaprolactone

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Rajesh Atluri, Herricks High School, New Hyde Park, New York 11040
Dr. Yantian Wang, Dr. Miriam Rafailovich,
Department of Materials Science and Engineering, Stony Brook University

Polycaprolactone (PCL) is a biodegradable polyester that has a low melting point and viscoity, making it suitable for use in a number of applications, ranging from biomedical applications, such as tissue engineering, drug delivery systems, and implantable microdevicess, to environmental applications.[1] We have investigated crystallization in PCL, as crystallized polymer thin films have shown a number of benefits over their amorphous counterparts, such as increased hardness and better chemical resistance.[2]

A better understanding of how the semicrystalline structure changes the basic properties of PCL, such as the melting point, will help us innovate new applications for PCL, as a controlled crystal growth process may allow for the combination of a biodegradable polymer like PCL with heavily-used industrial polymers that typically do not break down easily. In this study, we have examined the crystallization properties of thin PCL films under geometric confinement. In addition, we have seen how filler substances, such as clay and microscale fibers, affect the PCL matrix.

Varying concentrations of PCL and PCL with Cloisite clay 6A were spuncast onto silicon wafers. To attain crystallinity, the thin films were annealed overnight in a vacuum oven. Topography and lateral force were measured across the surface by the atomic force microscope (AFM). While the pure PCL film showed organized lamellar structure, the clay composite had more complex surface features due to the clay particles acting as nucleation sites. Both the PCL and composite films will be observed under the transmission electron microscope (TEM) to see exactly how the clay has modified the film surface. Various micro-scale fibers (carbon, polyethylene, Kevlar, high-modulus carbon fibers) were inserted into PCL films and annealed, in order to observe any effects on film crystallization patterns. Optical microscopy showed that PCL transcrystalline layers grew from polyethylene (PE) fiber, potentially increasing the mechanical strength of the area surrounding the fiber. The effects of these layers on the melting point of the PCL will be observed for the first time by SMFM (shear modulation force microscopy).

We aim to exploit the difference between the crystalline and amorphous segments of PCL to demonstrate how polymeric products can be made suitable for biological use and more environmentally sound.

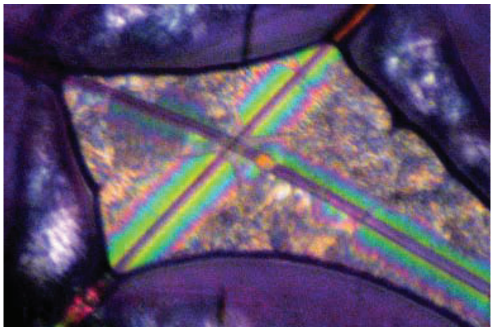

Figure 1 - PCL transcrystalline layers nucleating from PE fibers

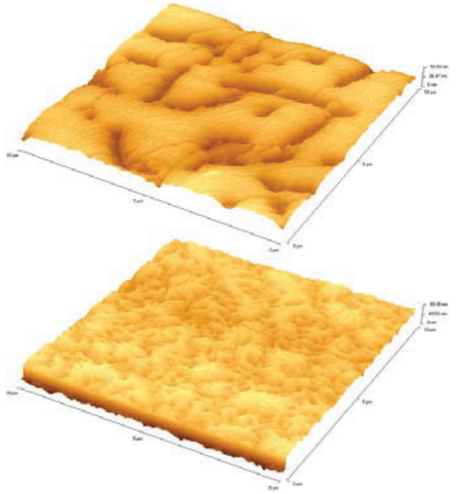

Figure 2 - 3-D views of PCL (top), PCL/clay (bottom) surface topography

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[1] Armani, D.K.; Liu, C. *Microfabrication technology for polycaprolactone, a biodegradable polymer*. Journal of Micromechanics and Microengineering, Vol. 10, pp. 80-84, 2000

[2] Wang, Y.; Ge, S.; Rafailovich, M.; Sokolov, J.; Zou, Y.; Ade, H.; et al. *Crystallization in the Thin and Ultrathin Films of Poly(ethylene-vinyl acetate) and Linear Low-Density Polyethylene*. Macromolecules, Vol. 37, pp. 3319-3327

The Formation Rate of Methane Hydrate with the use of Surfactants in a High Pressure Chamber

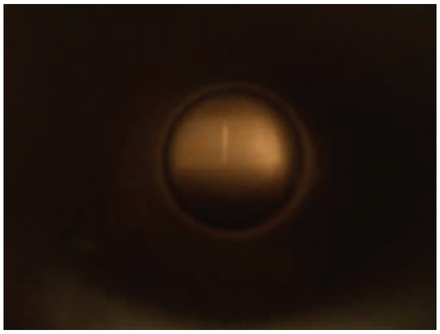
Kyle Horning. Sachem East High School, 177 Granny Rd., Farmingville, NY
Shahrukh Mallick. The Wheatley High School, 11 Bacon Rd., Old Westbury, NY
Dr. Miriam Rafailovich, Dr. Koga, T., Dr. Sokolov, Stony Brook University

Gas storage in hydrates has been studied because hydrates have been known to store large amounts of natural gas. The current standard methods of gas transportation are costly. With the use of methane hydrates, a cost efficient material could be used to transport large quantities of methane and hydrogen. Worldwide, methane hydrate sources are estimated to be comparable to 137.5 trillion barrels of oil.[1] It was thought to be that adding surfactants (F108) could increase the formation rate of methane hydrates in a high pressure-low temperature system. It was hoped that with the addition of F108 and other surfactants, the formation rate of the methane hydrate could at least be doubled. There was also speculation that there was an optimum point of concentration of surfactant; a higher concentration was not necessarily better.

Purified water was placed on a Teflon surface inside of a high pressure chamber. The chamber was cooled to a low temperature (3°C to 4°C) in respect to the pressure with accordance to the methane hydrate phase diagram[2]. Methane gas was released into the chamber, allowing for the methane hydrate to form. The time for this formation to occur was recorded using a light diffraction technique. A helium-neon laser was shot through a window of the chamber, and the intensity of the reflected beam was recorded by a light detector. Light diffraction occurred when methane hydrate nucleated, and the surface became rough.

Data that has been acquired so far has shown that as pressure decreases at a constant temperature, the formation rate of methane hydrate dramatically increases. With a pressure of 1100 PSI, it took an average of approximately 7 minutes for methane hydrate to form. Likewise, a pressure of only 800 PSI took nearly took 15 minutes. The light intensity remained constantly at .5mV, but dropped to .1mV when the methane nucleated. Future work is hoped to be done using other surfactants, such as SDS, and their concentrations.[3] If the hypothesis is supported, this storage method can be applied to amass large quantities of methane and hydrogen, which can be applied to practical uses such as alternate energy with hydrogen fuel cells.

Pressure chamber (left), laser (bottom left), voltmeter (right), high pressure crosses(bottom right).



Methane Hydrate on white Teflon surface below. Picture taken from window of High Pressure Chamber.

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[1] Lubick, Naomi. “B.C. Methane Hydrates”. *Geotimes*. http://www.geotimes.org/dec02/NN_hydrates.html, December 2002

[2] *Stanford Exploration Project.* http://sepwww.stanford.edu/public/docs/sep96/paper_html/node2.html, January 1998.

[3] Sun, Zhigao, Ma, Rongsheng, Fan, Shuanashi, Guo, Kaihua, Wang, Ruzhu. “Investigation on Gas Storage in Methane Hydrates,” *Journal of Natural Gas Chemistry*. April 2004.

The Effect of Polymer Thin Film Thickness on Melting Point: A Comparison of Different Techniques

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Clive Li, Dr. Jonathan Sokolov, Dr. Miriam Rafailovich
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Interest in polymer thin films and melting points has risen with applications to various electronic components, coatings, and adhesives. The physical properties of polymer films may change when their thickness is comparable to typical molecular size. Wang et al.[4] found a depression in melting point for thin films under 100 nm for both poly(ethylene-vinyl acetate) and linear low-density polyethylene. This study concentrates on finding the melting point of polycaprolactone (PCL) at various thicknesses ranging from 34.6 nm to 135.0 nm on polystyrene substrates (thickness of 80.4 nm). Optical and Atomic Force Microscopy (AFM) techniques were used to determine the melting point of PCL. The optical method involves a laser, two polarizers, and a photoelastic modulator. These were used to measure the birefringence, the disappearance of optical anisotropy, of the polymer at an elevated and decreased temperature. The birefringence dropped rapidly at about 56°C during heating, while upon cooling it reappeared at about 42°C. AFM Tapping Mode and shear modulation force microscopy (SMFM) techniques were used to confirm the melting point for films with various thicknesses. The results from using the AFM Tapping Mode showed a disappearance of crystal morphology at approximately 55°C - 60°C in the thickest and thinnest samples. With SMFM, a change in polymer softness was found at approximately 56°C - 59°C in both the thickest and thinnest samples.

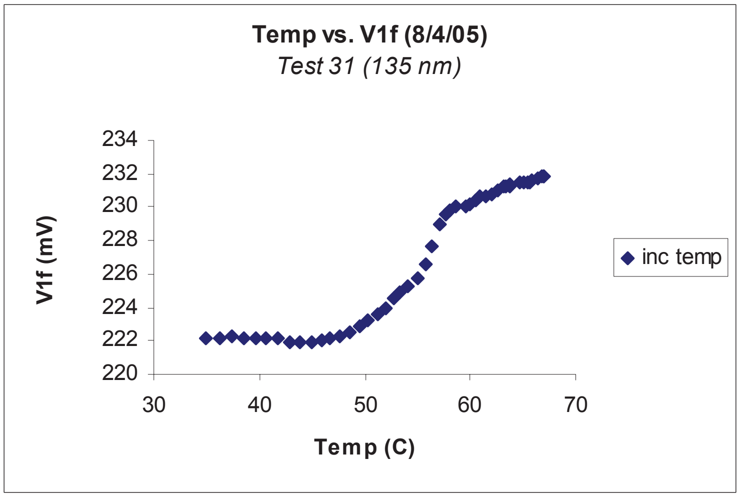

Figure 1: A typical plot of the signal from the detector as a function of increasing temperature from the optical method. The change in birefringence demonstrates that the melting point is approximately 56 or 57 degrees Celsius.

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[4] Wang et al., Macromolecules **37**, 3319-3327 (2004)

Creating a Viral Sensor Using Self-Assembled Monolayers

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Harriman Lee, The Wheatley School, Old Westbury, NY 11568
Dr. Miriam Rafailovich , Dr. Yantian Wang,
Department of Materials Science and Engineering, Stony Brook University, NY 11794

In recent years, the threat of terrorism, and furthermore bioterrorism, has become imminent upon our society. But, what if there's a way to detect, contain, or even prevent all of this from occurring? Biosensors, as proposed by K. Levon[5], are the key to identifying biological warfare agents. Indeed, this idea can be furthered with viruses, which are contagious and fatal to any individual who may be infected by them. A technique called the Self-Assembly of Monolayer thin-films, as described by A. Ulman[6], was used in this investigation. We hypothesized that in using the SAMs method to create a template for viruses, we could create a sensor for the poliomyelitis virus, commonly known as polio.

The essence of creating the sensor was to create a reference electrode with a template, with cavities as in Figure 1 below, of the virus that could be used in measuring the potential difference of the system. A significant change in the potential difference of the system would have indicated that a virus was present. In developing the electrode, the polymer Octadecyltrichlorosilane (OTS) was used because of it chemically grafts to the surface of the Indium Tin Oxide (ITO) glass surface, a valuable transducer with high sensitivity for a sensor. The struggle in experimenting was to find a possible combination of the OTS and protein, which was used in place of the virus. Because OTS reacts violently with water in the environment, it was difficult to find a solvent combination for the protein. The mixed solution of OTS and the polio virus was adsorbed onto the surface by dipping the substrate into it for some time.

The results of the experiment are tentative to further testing with the electro-potential cell and polio virus. The expected outcome is that the potential difference of the system will sharply change when the polio virus is present, indicating the presence of a virus.

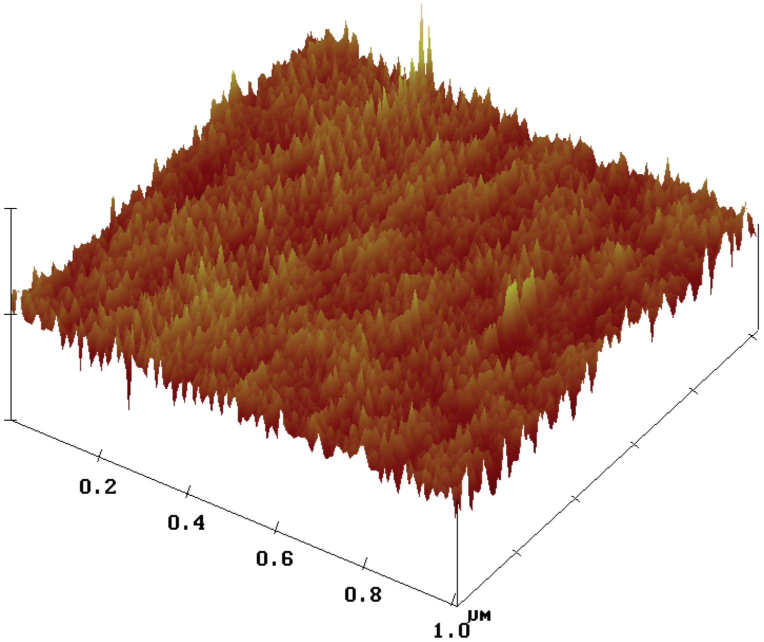

Figure 2. *A 3D AFM image of OTS with a washed out graft polymer showing cavities similar to those to be used in our template.*

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[5] Zhou, Yanxiu, Bin Yu, and Kalle Levon. "*Potentiometric sensor for dipicolinic acid*." Biosensors & Bioelectronics (2004): 1851-1855.

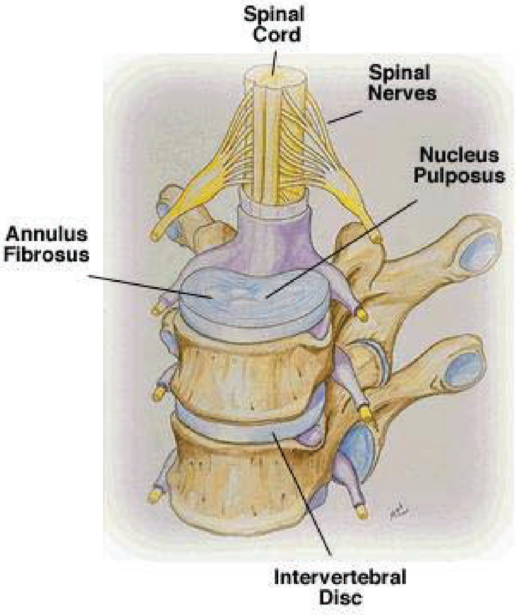
[6] Ulman, Abraham. *"Formation and Structure of Self-Assembled Monolayers."* Chem. Review (1996): 1533-1554.

Session 7: Material for Biomedical Applications

Directors: Dr. Jun Jiang, Rebecca Isseroff

Chair: Jeff Reitman

Nicole Brenner
Mohan Guatam, Ankuri Desai
Wilfred Wong



Synthesis of a Biocompatible Magnetic Polymer

Nicole Brenner, *Rebecca Isseroff*, Lawrence High School 2 Reilly Rd. Cedarhurst, NY 11516
Dr. Miriam Rafailovich, *Dr. Richard* State University of New York at Stony Brook

Human joints have cartilage, which produce synovial fluid, a natural lubricant that reduces the friction between the movement of the connecting bones. Artificial joints lack this natural lubricant, which leads to problems such as loosening of the joint, wearing away of the prosthetics and the connecting bones, and becoming a site of possible infection and disease[1]. The goal of this project is to develop an artificial lubricant that is biocompatible and can be externally magnetically manipulated for correct placement inside the artificial joint.

Various polymer-clay-iron oxide solutions were synthesized and tested to determine their magnetic characters. The synthesis of the EVA solution was 20% Clay 20A, 80% EVA (265 K) brabended together. A 10% solution by weight was made in toluene, and then injected with 10% by volume $Fe(CO)_5$. A 90 mg/ml toluene PMMA (120 K) solution was made and mixed with clay 6-A to a 25% by mass solution. It was then injected with 10% by volume $Fe(CO)_5$. The iron carbonyl solutions were allowed to stir overnight, uncovering them twice to allow the carbonyl to escape and admit oxygen for oxidation. The solutions turned brown, suggesting the presence of iron oxides. Pd-citrate nanoparticles were also synthesized by reduction with $NaBH_4$ and protected with NaCitrate. A 2.5×10^{-4} M solution was made with 4% PEO in water for experimentation.

Thick films of these polymer blends were made by pouring onto glass slides and allowing to dry overnight. Films were then analyzed by a Vibrating Sample Magnetometer (DMA – Model 1660 LHA) for magnetism. Films were also prepared for microtoming and TEM analysis to detect the presence of iron oxides dispersed within the clay platelets, and thin films were spun on hydrophobic silicon wafers for SEM analysis. Magnetometry indicated paramagnetism with a small ferromagnetic presence in the EVA-clay-Fe sample, paramagnetism in the PMMA-clay-Fe sample, but none in the Pd Citrate-PEO sample.

The magnetic properties of both the EVA-clay-Fe and the PMMA-clay-Fe polymer blends show promise in the potential use as an artificial lubricant that can be manipulated by an external magnetic field. Future work includes X-ray diffraction to determine the type of iron oxide that is present, EXAFS to determine the spacing between iron particles and other tests on the viscosity of the polymer blends with and without Fe.

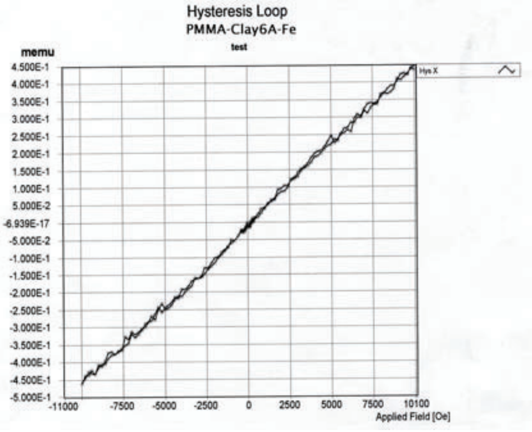


Figure 1: PMMA-Clay6A-Fe Hysteresis Loop shows full paramagnetism in the solution from magnetometry.

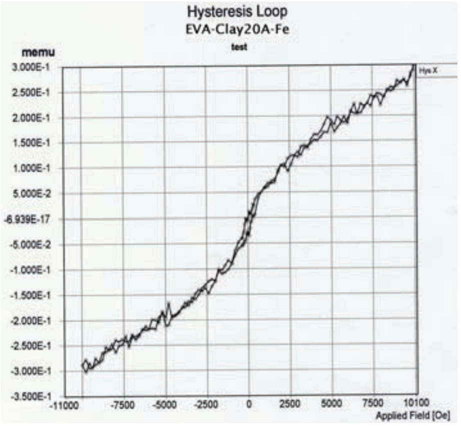


Figure 2: EVA-Clay20A-Fe Hysteresis Loop shows paramagnetism and slight ferromagnetism in the solution from magnetometry.

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[1] Tokash JC, Stojilovic N, Ramsier RD, Kovacik MW, Mostardi RA. *Surface Interface Analysis*. 2005; **37**: 379-384.

Characterization and Applications of Thermoreversible Hydrogel

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Ankuri Desai, Ward Melville High School, 380 Old Town Road, East Setauket, NY 11733
Jun Jiang, Dr. Miriam Rafailovich,
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With the increasing frequency of back pain among our growing population, the drive for research into this field is mounting. The intervertebral disc, located between vertebrae in the spinal cord (Figure 1), normally "cushions" the bones, and thus allows for flexibility. However, the intervertebral disk may become herniated when the inner semi-solid gel, nucleus pulposus, is pushed out of the outer disk margin through a tear or "rupture." Sequentially, the nucleus pulposus pushes against nerve cells, causing what is known as a "slipped disk," and stimulating pain receptors, which cause back pain to occur(1).

Studies are being furthered to replace the dysfunctional nucleus pulposus with a polyethyleneoxide-polypropyleneoxide-polyethyleneoxide tri-block copolymer, produced by BASF under Pluronic® F127. Interestingly, this amphiphilic polymer remains liquid until it is removed from a cool environment and exposed to ambient temperature, where it solidifies into a gel.

Thermal expansion testing of several concentrations at various temperatures was run to measure the volume expansion of the gel. Furthermore, this polymer's characteristics are being analyzed to ensure suitability as a nucleus pulposus replacement. The polymer's mechanical anisotropic property is being examined through viscosity tests (Figure 2), and future characterization studies include the construction of phase diagrams to illustrate its transition from liquid to gel using a Differential Scanning Calorimeter (DSC).

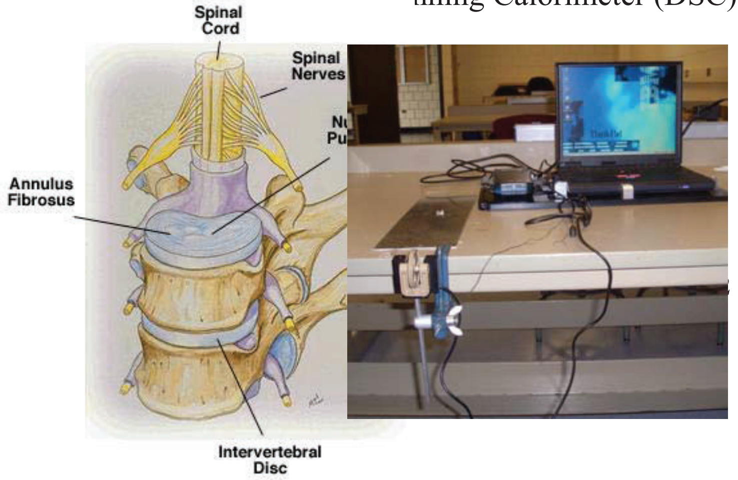

Figure 1: (Left): Schematic of Herniated disc from http://www.lowbackpain.com/img_spinalDiskNerves.jpg

(Right) : Experimenatl set up for friction measurments of the F127 polymer gel.

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(1). Ross et al. "Method of Treating an Intervertebral Disk." Patent No. US 6,264,659 B1. 1999.

The Effect of Nanoparticles and Nanopillar Array Feature Size on Adhesivity of Nanopatterned Polymer Thin Films

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Sean Mehra, Jeffrey Reitman, Yale University
Dr. Shouren Ge, Dr. Vladimir Samuilov, Dr. Miriam Rafailovich, Department of Materials Science and Engineering, Stony Brook University

In nature, geckos demonstrate the unique ability to stick to almost any surface, as smooth as glass, or as rough as a tree, and thus traverse any area vertically or even upside down. Geckos are able to adhere to such a variety of surfaces by exploiting Van der Waals forces, which are present in all materials. By utilizing dense arrays of high aspect ratio nanohairs, geckos are able to create enormous surface area, which multiplies the effect of Van der Waals forces so that the forces, normally insignificant, allow the gecko to adhere[2].

Recognizing the potential applications presented by this evolutionary trait, we chose to attempt to create a synthetic version of the gecko surface, and improve on previous attempts of creating a gecko adhesive. We hypothesized that a stronger, more effective adhesive would have features with higher aspect ratios (that is, longer but thinner pillars). Higher aspect ratios would create the greatest amount of surface area, thus generating higher adhesion forces through Van der Waals forces. We also wanted to determine whether stiffer features increased adhesivity by decreasing clumping between pillars.

We begin by creating nanopillar array patterns on polymer thin films, and we chose polystyrene (PS), due to its stiffer properties as a polymer and ease of use. PS is spun on silicon wafer to about 2000 angstroms. Using a silicon wafer stamp, etched with a nanopattern using an electron beam (Figure 1), and a nanolithographic vacuum press (Figure 2), a nanopillar array is imprinted on the PS thin film. Stamped features are either 2 microns by 2 microns, or 1 micron by 1 micron. Adhesion force difference between the dimensions are measured.

Then, nanoparticles are added to the pillars in order to make them directly more adhesive, or indirectly by stiffening features.

With this procedure, we hope to create a more efficient adhesive tape, closely modeling the gecko.

Figure 1: Example of nanopatterned stamp used to imprint features (taken under AFM)

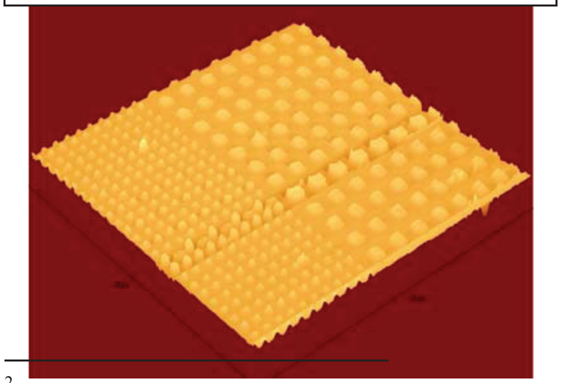

Figure 2: Vacuum press used to press patterns using pressure onto thin films

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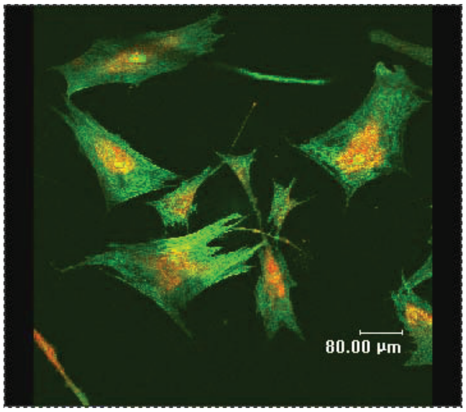
[2] Metin Sitti, and Ronald S. Fearing. Synthetic Gecko Foot-Hair Micro/Nano-Structures as Dry Adhesives. From Journal of Adhesion Science and Technology, vol 18, no. 7, 2003, pp. 1055-1074.

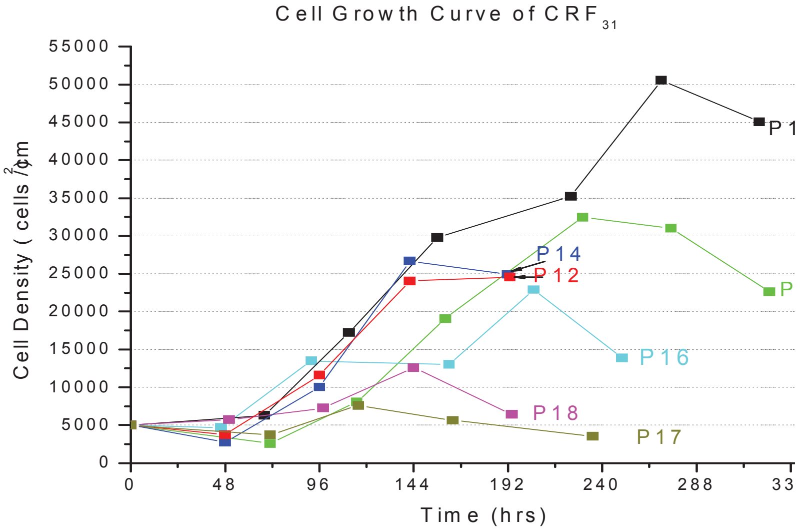
Session 8: Age and Cells

Director: Dr. Nadine Pernodet, Zhi Pan, Ying Liu

Chair: Joshua Meisner

Victoria Hung, Swetha Kambhampati
Ming-Jie Wang





Cell Mechanics of Different Aged Human Dermal Fibroblasts

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Swetha Kambhampati, University High School, Irvine, CA 92612
Zhi Pan, Dr. Miriam Rafailovich, Department of Materials Science and Engineering,
State University of New York, Stony Brook
Kaustabh Ghosh, Dr. Richard A. F. Clark, Department of Biomedical Engineering,
SUNY Stony Brook

It is often observed that older people display diminished wound healing abilities. However, the cause of this phenomenon is poorly understood. This study compares the cell mechanics of older dermal fibroblasts to younger dermal fibroblasts and analyzes the traction forces on the substrate generated by the cells of different ages. We believe that older cells may generate less traction force, thereby reducing their ability to migrate into the provisional matrix of a wound.[1]

To gather data on forces exerted on the substrate, 18 year old cells and 63 year old cells were allowed to migrate on a hydrogel of thiol functionalized hyaluronic acid (HA-DTPH) and recombinant fibronectin functional domains (rFNfd). The hydrogel was embedded with fluorescent beads 40 nm in diameter. By using a Leica confocal microscope and the Digital Image Speckle Correlation (DISC) technique, the displacement of the beads caused by the release of a cell from its adhesion points on the substrate can be used to measure substrate deformation. This, in turn, can be used to calculate the cell's stress and strain energy. Also, confocal images of stained fibroblasts were used to study the actin cytoskeleton to determine the health of the cell.

Our tentative results show that younger cells create more substrate deformation than older cells. The images of the fixed, stained cells show that the younger cells are larger and spread better than older cells. These factors indicate that older cells may not be able to exert as much traction forces as younger cells. In the future, the actin cytoskeleton must be observed at the molecular level to determine what is different between the cytoskeleton of different aged cells. Then, perhaps a treatment can be created to help facilitate better wound healing.

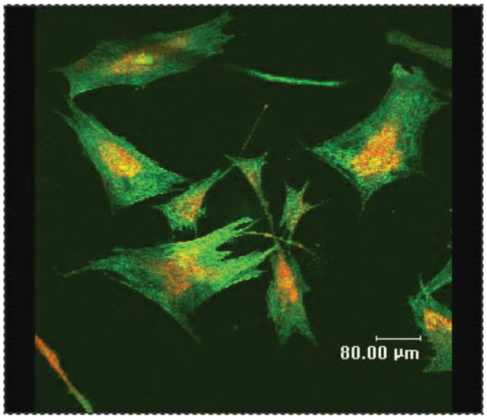


Figure 1: 63 year old cells.

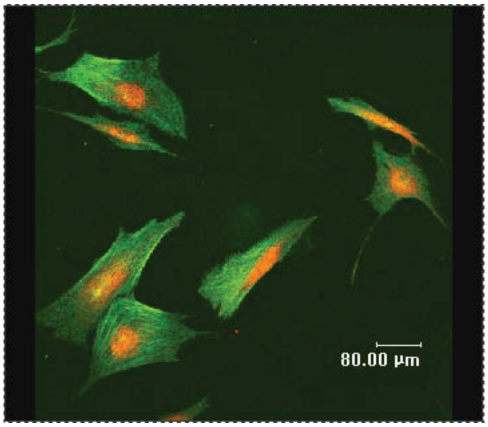


Figure 2: 18 year old cells.

[1] Ingber DE, Ostuni E, Wang N, Whitesides GM. 2002. Micropatterning Tractional Forces in Living Cells. Cell Motility and the Cytoskeleton 52:97-106.

The Effects of Cell Passaging on Proliferation of Human Dermal Fibroblasts

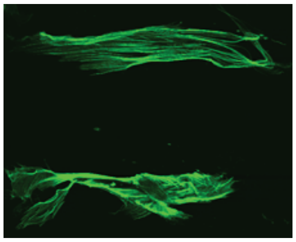
Ming-Jie Wang: Elwood-John H. Glenn High School
Ying Liu, Loudes Collazo MS, Dr. Miriam Rafailovich, Stony Brook University

In culture, human dermal fibroblasts often undergo passaging; a division of cells into separate flasks which induces a new passage of cells to be formed. Because of this continual splitting, a certain cell line will eventually generate many different passages of cells. However, the question then arises as to whether all of these passages are equally viable and will provide similar results for experimentation. Currently many industrial and research facilities are conducting experiments with dermal fibroblasts without regard to their passage number. We believe that as passage number increases, cell proliferation will be adversely affected with significant changes in morphology as well as extra-cellular matrix structure. We also wish to attempt to discern any differences in proteins distribution within cells of high and low passages.

Cells from the CRF31 cell line were grown in Dulbecco's Modified Eagle's Media and were incubated at 37 degrees centigrade and an atmosphere of 4.5% carbon dioxide. Cells were periodically fed for up to nine days (for each passage) and then split to form subsequent passages. Cells beginning from a low passage eleven were initially plated on round glass cover slips and cells densities were recorded every two days. This procedure was repeated up to a relatively high passage eighteen. From these cell densities, we generated a growth curve (figure 2)s which provided evidence to supports our hypothesis: as cell passage number increased, cell proliferation decreased significantly.

To observe cell morphology, we used the Confocal scanning microscope. Passage eleven day seven cells were imaged and compared to cells of passage eighteen day seven (figure 1). We found that the passage eleven cells exhibited the characteristics of healthy fibroblasts while passage eighteen cells tended to deviate from these characteristics.

Thus tentative results tend to support our original hypothesis: that increasing cell passage number will adversely affect cell health and proliferation. However, we plan on continuing our work and investigating various other factors. We would like to continue our cell culture with passages in the twenties to see if cell densities continue to decrease. In addition, we plan on using the Atomic Force Microscope to observe surface topography of high and low passage cells as well as measure the modulus of the cell surface. We will also plate cells of high and low passages on Polybutadiene and Sulfonated Polystyrene polymer surfaces to observe extra-cellular matrix growth. Finally we plan on using Western Blot analysis to discern any discrepancies between the protein distributions of high and low passage cells. In the end, we will have collected enough data to effectively verify our hypothesis.



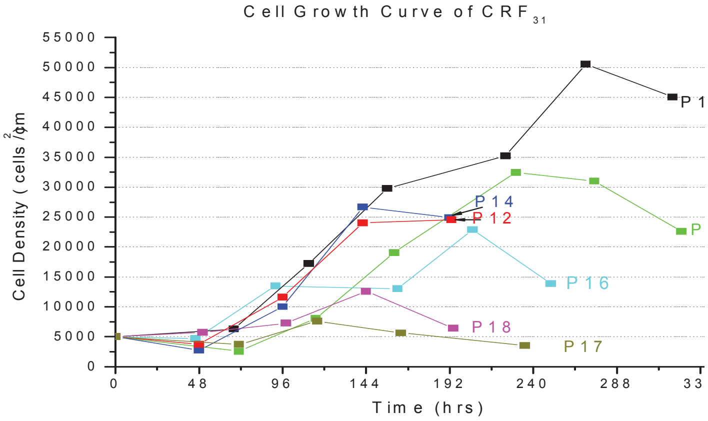


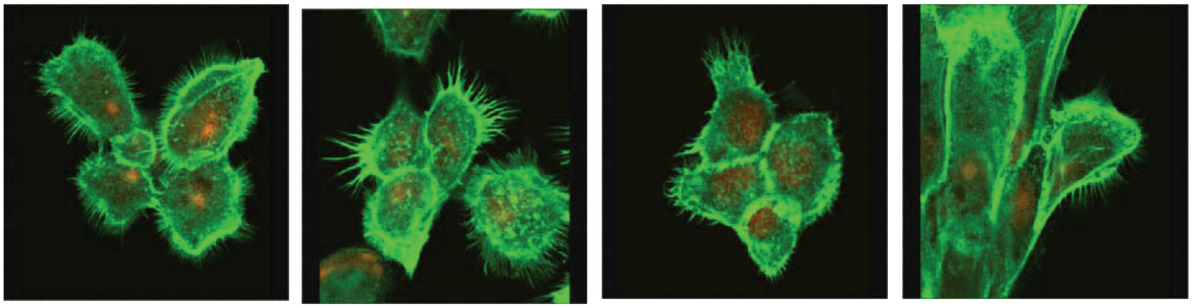
Figure 1: Confocal image of a Passage 18 Day 7 Fibroblast
Figure 2: Growth Curve of CRF31 for Passages 11-18.

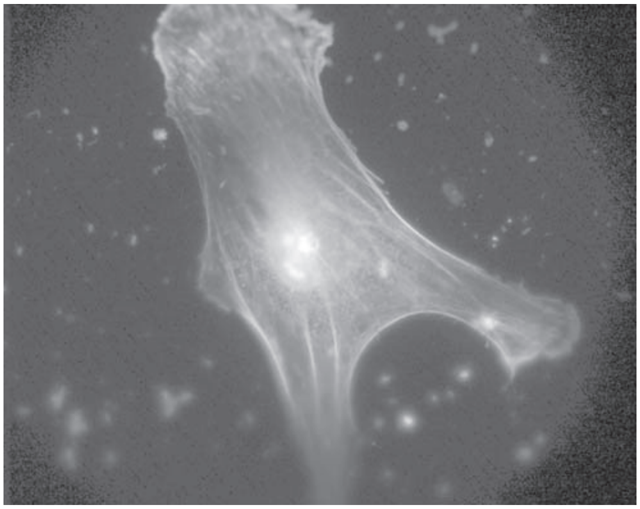
Session 9: Response to Substrate Mechanical Properties

Directors: Dr. Michael Vaccarriello, Zhi Pan, Xiaohua Fang

Chair: Sean Mehra

Crystalee Forbes, Kristin Hall
Sean Pi, Michael Serbin





Analysis of Keratinocytes' Mechanical and Physiological Behavior in Response to Varying Collagen Substrates

Crystalee Forbes, Uniondale High School, **Kristin Hall** Smithtown High School,
Dr. Michael Vaccariello, Sachem High School,
Dr. Marcia Simon, Department of Oral Biology & Pathology, SUNY at Stony Brook,
Dr. Miriam Rafailovich, Department of Materials Science & Engineering, State SUNY at Stony Brook

Bioengineered skin substitutes have emerged over the past twenty years as the most investigated and established of the advanced wound management technologies.[1] Although extensive research has been done to enhance these skin substitutes, a better understanding of the cells' mechanical as well as physiological responses to the wound environment is vital in order to improve skin substitute technology.[2] Recently, extensive research has been performed regarding the mechanical properties of dermal fibroblasts. Although the fibroblast plays a significant role in dermal skin repair, the keratinocyte is the major cell type of the epidermis, making up about ninety percent of the epidermal cells. Thus, this investigation focuses on the role of the epidermis in wound healing, examining both the mechanical and physiological properties of the keratinocyte cell. In this investigation, normal keratinocytes (*033*) and transformed keratinocytes (squamous cell carcinoma- *SCC-13*) were plated on cover slips coated with 0.012, 0.12 and 1.2 mg/ml of type I collagen, and grown for 48 hours. Cells were stained for actin using Alexa Fluor 488 Phalloidin, and counter-stained with Propidium Iodide to view the nucleus. The stained samples were then analyzed using Confocal Microscopy. Confocal images indicated the presence of fiber-like structures, tentatively classified as filapodia extending from the membranes of both types of cells. The filapodia showed different structural characteristics in accordance with different collagen densities and different cell types (healthy or cancerous.) For the *033* cells, the filapodia appeared to be most prominent at lower collagen concentrations (See Figures 1 and 2.) On the contrary, in the *SCC-13* cells the filapodia were more outstanding at higher collagen concentrations. Additionally, compared to the *O33* cells, the *SCC-13* cells had filapodia that were thicker, and more branched (See Figures 3 and 4.) Further experimentation will involve the incorporation of hyaluronic acid into the collagen substrate. Cell mechanics, will be evaluated on this combined substrate. Furthermore, the Atomic Force Microscope will be used to measure the cells' tensile strength as related to the rigidity of the substrate. Also traction forces for the cells will be generated using the Confocal Microscope. In the future, through the process of electrospinning, a more fibrillar collagen substrate will be created (which more closely mimics the *in vivo* environment.) Cell mechanics and behavior on this substrate will also be evaluated.

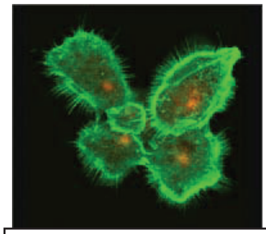


Figure 1

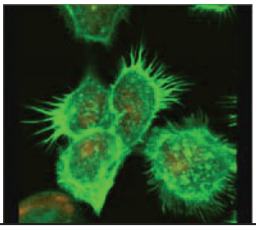


Figure 2

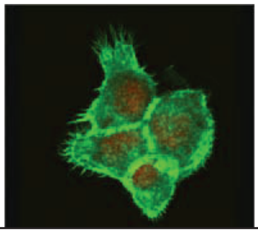


Figure 3

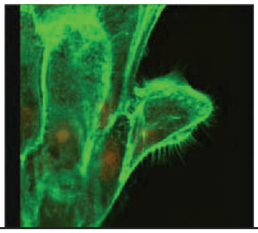


Figure 4

Figure 1: Normal Keratinocytes on Low Density Collagen .
Figure 2: Normal Keratinocytes on High Density Collagen
Figure 3: Cancerous Keratinocytes on Low Density Collagen
Figure 4: Cancerous Kerantiocytes on High Density Collagen

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[1] Machens H-G, Berger AC, Mailaender P: **Bioartificial Skin.** Cells Tissues Organs 2000;167:88-94 (DOI: 10.1159/000016772)

[2] Hassan Ugail, and Michael Wilson: **Modeling of oedemous limbs and venous ulcers using partial differential equations**. Theoretical Biology and Medical Modelling 2005, 2:28 (DOI:10.1186/1742-4682-2-28)

[1] Ingber Donald E. Tensegrity I. Cell structure and hierarchical systems biology.. *Journal of Cell Science*, Volume 116 (April 2003), pp. 1157-73

[2] Ingber Donald E. Tensegrity II. How structural networks influence cellular information processing networks.. *Journal of Cell Science*, Volume 116 (April 2003), pp. 1397-408

Analysis of Aged and Cancerous Fibroblasts on PB Substrates

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Nadine Pernodet, Lenny Slutsky, and Dr. Miriam Rafailovich Department of Materials Science and Engineering, Stony Brook University

Fibroblasts play many key components in the human body, but most importantly, it's migration and proliferation makes it a key point in wound healing. The extracellular matrix (ECM) plays a key role fibroblast migration, since as the ECM changes, the mobility and shape of the fibroblast changes with it. Fibroblasts adjust the mechanical surface properties to its surroundings, but little is known about the mechanisms behind the adjustments. More interestingly, cancerous and aged fibroblasts (as apposed to normal fibroblasts) lose their tensegrity, therefore making them unable to adjust to the surface it is on.[1, 2] To fully understand the mechanisms behind fibroblast migration, we used Polybutadiene (PB) films spun at varying thicknesses in order to provide different tensioned surfaced for the fibroblasts to migrate across. By observing migrations through Confocal Microscopy and Atomic Force Microscopy, we will be able to determine the mechanics behind the fibroblast migrations and also the deviations in cancerous and aged fibroblasts.

Three thicknesses of PB were spun with solutions of 17 mg/ml, 10 mg/ml, and 1.6 mg/ml. They were spun on silicon wafers cleaned to be hydrophobic by using Hydrofluoric Acid. After the PB was spun on the wafers, the samples were annealed in an oven at 120 degrees centigrade: 17 mg/ml for 12 hours, 10 mg/ml for 6 hours, and 1.6 mg/ml for 50 minutes. After annealing, cancerous and aged fibroblasts were plated on the three varying thicknesses, then fixed and stained with Alexa Flour 488 for confocal microscopy.

In the future, we will be analyzing the samples through atomic force microscopy to further understand the mechanics of the fibroblasts and how they differ between cancerous and aged cells.

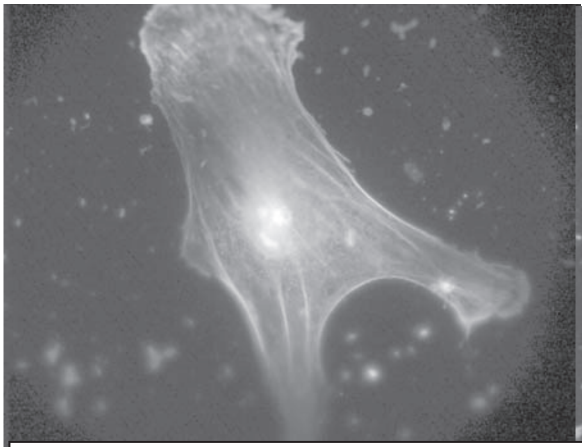

Figure 1: Cancerous Fibroblasts on 10 mg/ml of PB

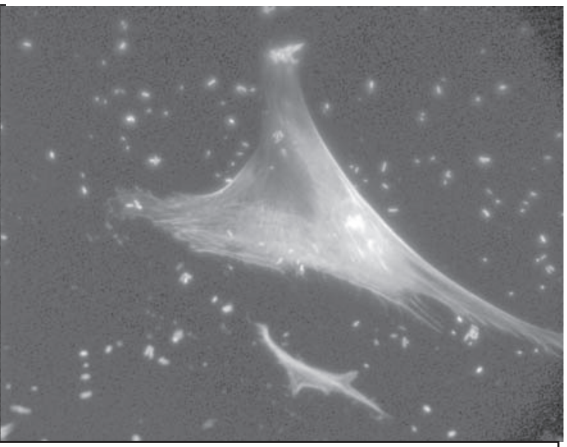

Figure 2: Normal Fibroblasts on 10 mg/ml of PB

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[1] Ingber Donald E. Tensegrity I. Cell structure and hierarchical systems biology.. *Journal of Cell Science*, Volume 116 (April 2003), pp. 1157-73

[2] Ingber Donald E. Tensegrity II. How structural networks influence cellular information processing networks.. *Journal of Cell Science*, Volume 116 (April 2003), pp. 1397-408

Session 10: Electrospinning of Polystyrene, PCL, and POSS Nanofibrers

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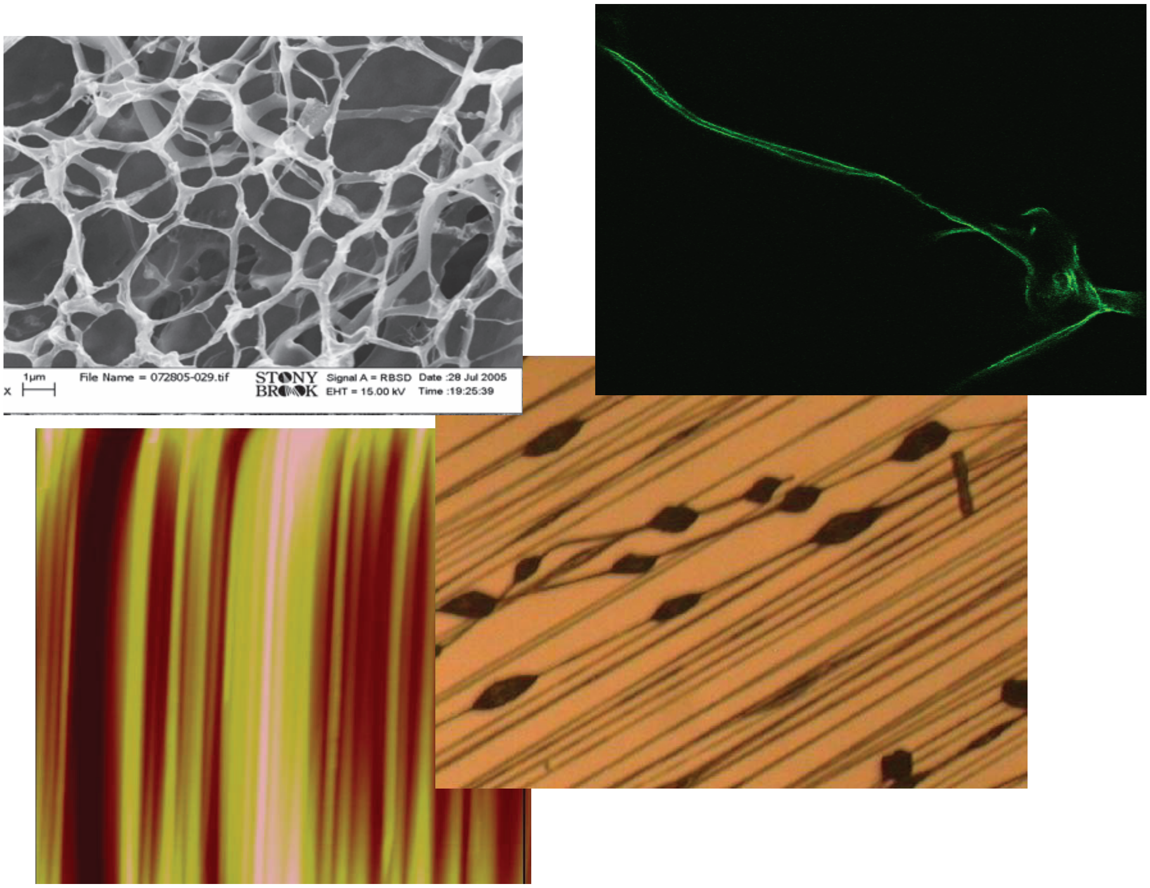
Directors: Yuan Ji, Jun Jiang

Chair: Matthew Schlossberger

Batya Herzberg, Toby Klein
Amardeep Grewal, Tom Mackey



Electrospinning of Polystyrene and POSS Nanofibers

Matthew Schlossberger, Dartmouth College
Yuan Ji and Dr. Miriam Rafailovich
Department of Materials Science and Engineering, Stony Brook University

The process of electrospinning permits polystyrene and polyhedral oligomeric silsesquioxane (POSS) nanofibers to be created that have a high surface area and a large degree of porosity. As a result, nanofibers can be laid across each other to create an optimal fiber matrix for filtering applications.[1]

The purpose of this experiment is to add POSS nanoparticles into the structure of a polystyrene nanofiber. Once this occurs, the electrospun nanofibers will be able to readily detect pathogens or noxious gases that are located in the air. A POSS nanoparticle has eight functional groups and this will allow a numerous amount of chemical indicators to be attached to this molecule. In order to carry out this experiment, solutions containing polystyrene and POSS must be created by using tetrahydrofuran (THF) as the solvent. The polystyrene concentration varies from 10% to 25% and the POSS concentration varies from 0% to 40%. These solutions are electrospun onto a silicon wafer and a sheet of aluminum foil. When electrospinning occurs, an applied electric field causes a jet of polymer solution to form and split into many nanofibers.[2] Then the nanofibers are collected on a stationary flat plate and on a rotating cylinder. Finally, the electrospun fibers are examined using Scanning Electron Microscopy (SEM) and Atomic Force Microscopy (AFM).

In order for a polystyrene and POSS nanofiber filter to be effective, it is essential that the POSS is incorporated into the fiber structure. SEM images show that the number of pores embedded on the fiber surface tends to increase as the POSS concentration increases. This allows individual fibers to have a greater surface area as the POSS concentration increases. (Figure 1) SEM images also show that electrospun fibers have a random orientation when they are electrospun on a stationary flat plate, but the fibers have a parallel orientation when they are electrospun on a rotating cylinder. (Figure 2) A parallel fiber orientation would make the manufacturing of nanofiber filters easier for businesses. With the use of SEM, Energy Dispersive Analysis of X-Rays (EDAX) was performed and this shows that silicon and oxygen are present inside the electrospun fibers. This signifies that POSS molecules are successfully embedded within the electrospun fibers. AFM images show that the surfaces of the fibers have a honeycomb structure and that pores exist on the surfaces of the electrospun fibers. In order to further confirm the fact that POSS molecules are located inside the electrospun nanofibers, future work will be done to measure the glass transition temperature of a cluster of fibers using Differential Scanning Calorimetry (DSC). It is expected that the POSS concentration will affect polystrene's Tg.

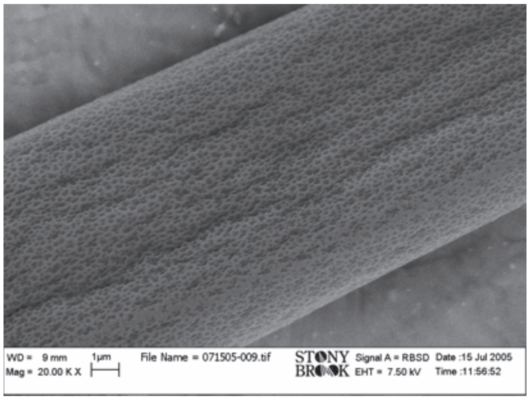


Figure 1: SEM image of pore structure on 20% polystyrene and 40% POSS fiber

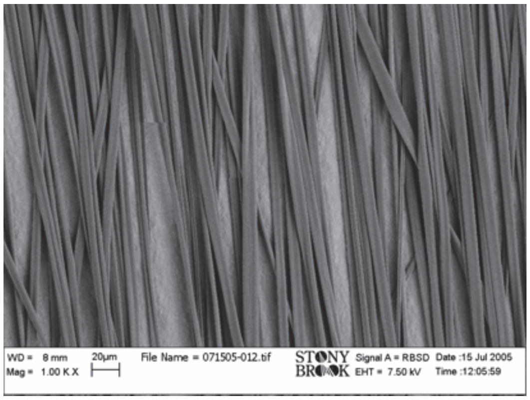


Figure 2: SEM image of 20% polystyrene and 20% POSS parallel fibers collected with a rotating cylinder

Using Metallic Nanoprticles to Enhance the Properties of Polystyrene and Poly(ethylene oxide) Electrospun Fibers

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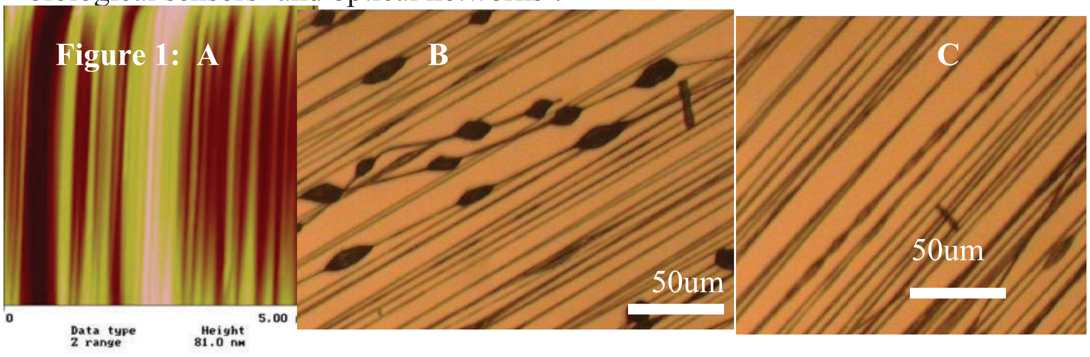
Rebecca Isseroff *Rambam Mesivta, Lawrence NY 11559*
Yuan Ji *Dept Material Science and Engineering SUNY Stony Brook*
Dr. Miriam Rafailovich *Dept Material Science and Engineering SUNY Stony Brook*

The goal of our research is to add gold, platinum, and palladium nanoparticles to solutions of polymers such as polystyrene and poly(ethylene oxide) and observe the properties of the fibers produced when these solutions are electrospun. Electrospinning is a process in which a polymer solution is placed into a syringe, whose needle is attached to a high voltage source. A syringe pump pushes the charged polymer solution toward a grounded target; because of the potential difference between the syringe and the target, fibers are pulled toward the target and deposit on it.[1] When the fibers are examined under an atomic force microscope, one can observe that they are porous. These pores are elongated when the fibers are spun onto a rotating target, indicating that the type of target affects the properties of the fibers. The addition of nanoparticles to the polymer solution also changes the fibers' properties (Fig.1). Some nanoparticles, like AuC-18, reduce the clumps of polymer, or beads, that appear on the fibers at lower concentrations of polymer (Fig. 1A,C). AuC-12, however, increases beading in the fibers (Fig. 1B). We postulated that this occurs because of variations in the sizes of the different nanoparticles. We also spun fibers containing palladium and platinum nanoparticles, which are known for their affinity for hydrogen, and are examining their capacity to store hydrogen; in addition, we will assess their magnetic moment. We will additionally be incorporating palladium nanoparticles into polymer solutions and analyzing catalytic ability. We are testing for the conductivity of the polymer fibers that are electrospun with gold nanoparticles. To date, we have concluded that PS fibers with 0.1% AuC-18 are not effective conductors. We are currently increasing the concentration of Au within our fibers to enhance their conductivity. Polymers are cheap and flexible; the resulting conducting fibers may be critical for the production of micro-electro-mechanical systems (MEMS) that have applications in mechanical and biological sensors[2] and optical networks[3].



AFM image of 20%PS/ 0.1% AuC-18 fiber. Scan size: 5 µm

Optical image of 20% PS / 0.1% AuC-12 fibers

Optical image of 20% PS/ 0.1% AuC-18 fibers

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[3] http://ee.usc.edu/faculty_staff/research_detail/nanomems_area.php

A New Spin on Scaffolds:
Engineering an Electrospun Hyaluronic Acid Matrix to Enhance Wound Healing

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Tom Mackey, South Side High School Rockvi lle Centre, NY 11570
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Stony Brook University, Stony Brook, NY 11794-2275
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Stony Brook University, Stony Brook, NY

With over five million cases of chronic ulcers reported yearly in the United States alone, the doors which lead to a discovery for a treatment to cure these unhealing wounds have never been more open. Chronic, or unhealing, wounds lack the necessary proteins which lead to normal tissue healing. A theory on the failure of ulcers to heal is the absence of fibronectin, a glycoprotein, in the wound space[1]. Fibronectin (FN) has three functional domains which enable it to interact with cellular integrins allowing it to signal and provide traction for vast fibroblast migration[1]. Hyaluronic Acid also facilitates in the process of wound repair by aiding in the disadhesion of cells for quicker cell migration, and by supporting a highly porous structure for greater cell proliferation[1].

We believe that by creating an electrospun scaffold made from crosslinked Hyaluronic Acid and Type III FN, the scaffold will be able to initiate chronic wound healing. To create such a scaffold, it was first necessary to optimize the concentration of the thiolated Hyaluronic Acid and the crosslinker, PEG-diathylate. Crosslinking the HA was imperative because an uncrosslinked HA scaffold would easily dissolve in water, having no effect on the migration of dermal fibroblasts. After testing concentrations of HA-DTPH ranging from 2.0% to 4.0% and PEGDA from 1.5%-9.0%, we discovered which solutions created an optimum scaffold by examining magnified images of the scaffold produced by a Scanning Electron Microscope (Fig. 1). Porosity, fiber diameter, and uniformity were all put into account when observing the scaffold images.

It was further necessary to determine the effectiveness of the scaffold for cell adhesion and migration. To test how well the scaffold supported cells, dermal fibroblasts with passages from 5-13 were cultured and then applied onto the crosslinked HA-DTPH matrix. After 24 hours, the cells were fixed and then stained, to be observed under a Confocal Microscope. The Confocal Microscope provided us with images of elongated migrating dermal fibroblasts (Fig. 2) which supported our hypothesis that the crosslinked scaffold would enable cells to migrate into it, which could therefore enable chronic wounds to heal. Further in-vitro and in-vivo tests to test the scaffold will be performed along with characterization experiments, which will help us better understand the morphology of the Hyaluronic Acid / Fibronectin scaffold.

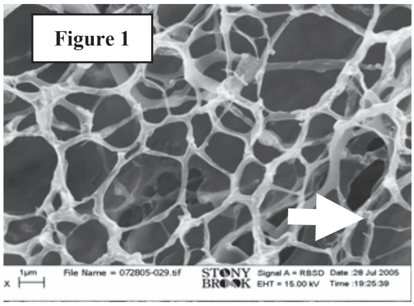
Figure 1

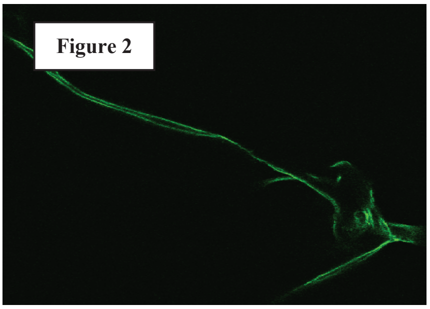
Figure 2

Fig 1: SEM image of the optimum scaffold lyophilized. Arrow corresponds to one micron.
Fig 2: Confocal Image of a migrating Dermal Fibroblast in a HA scaffold .

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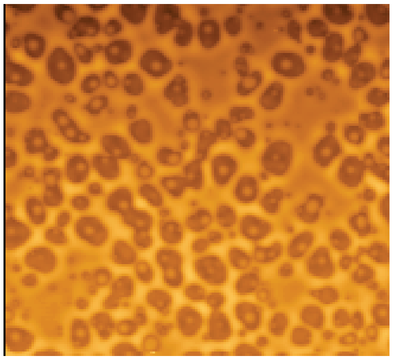
[1] Levine, Jacob Ariel. The Development of a Smart™ Matrix to Support Robust Fibroblast Migration. Thesis. Stony Brook: 2002.

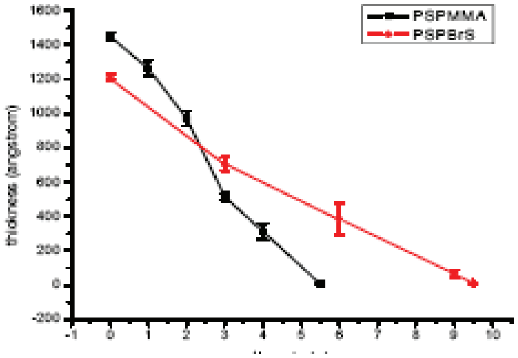
Session 11:
Forming Patterns on Surfaces: Cells and Proteins

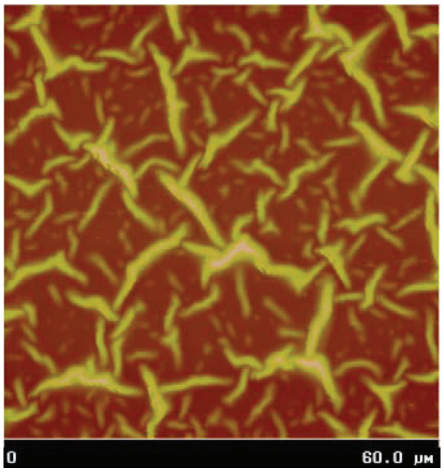
Director: Nadine Pernodet

Chairs: Lenny Slutsky, Jessica Fields

Taylor Bernheim
Chris Mackey
Jeremy Hsu
Jessica Fields, Kathryn Dorst
Ron Li, Marc Sherwin, Samantha Palmaccio







Nanopatterns to Control Cell Mechanics

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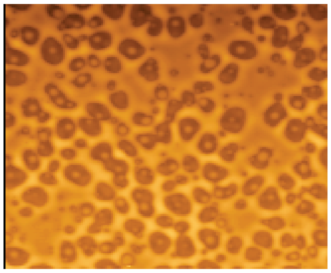
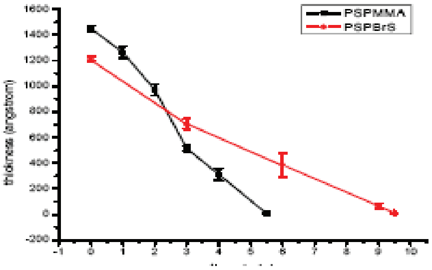
Madelyn Ho, Harvard University
Nadine Pernodet, Miriam Rafailovich, Shouren Ge, Department of Materials Science and Engineering, Stony Brook University

Although cells are on the micro-scale, our hypothesis is that nano-scale patterns will significantly affect cell behavior through their mechanics and their extracellularmatrix (ECM) organization. Curtis has reported that cells are extremely sensitive to their nanoenvironment and that it should be taken into consideration when designing next generation tissue engineering materials.[1] In accordance with this, we have to set up several environments to reproduce the cell organization of tissues as well as the ECM. The goal of our research is to determine the best, most regular nanopattern for cells to adhere and observe their mechanical properties in order to create tissues and organs in the future.

A blend of polystyrene (PS) and poly(methylmethacrylate) (PMMA) is used to create a recurring pattern, due to phase segregation because of their hydrophilic and hydrophobic traits.[2] The two polymers polystyrene and poly-bromo-styrene (PBrS) are also immiscible, thus phase segregate. In search of finding the most regular pattern, solutions of the two blends in varying ratios of 1:1, 1:9, 9:1, 3:7, and 7:3, were spun-cast on silicon wafers, with some annealed and some unannealed. Each sample was imaged under the Atomic Force Microscopy (AFM) and five of the twenty were distinguished as having the best patterns, as shown in Figure 1.

The ion mill was used to sputter the samples, in order to etch the nanopattern of the copolymer blend into the silicon. PS/PMMA samples were sputtered at intervals of one minute and PS/PBrS samples were sputtered at three minute intervals, to determine sputtering rate, as seen in Figure 2. Polybutadiene (PB) and sulfonated polystyrene (SPS) were spun-cast on the sputtered surfaces, and plated with cells to investigate whether the cells would adhere and organize on surfaces with varying mechanical properties as well as protein organization. This was further investigated by plating cancer cells on the nanopatterns. We hypothesize that major differences in the mechanics and matrices between normal cells and cancerous ones will be evident.





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[1] Curtis; Dalby; Gadegaard; Riehle; Wilkinson. *Journal of Biochemistry and Cell Biology* **2004**, 36(10), 20215-25.

[2] Morin, C.; Ikeura-Sekiguchi, H.; Tyliszczak, T.; Cornelius, R.; Brash, J.L.; Hitchcock, A.P.; Scholl, A.; Nolting, F.; Appel, G.; Winesett, A.D.; Kaznacheyev, K.; Ade, H. *Journal of Electron Spectroscopy and Related Phenomena* **2001**, 121, 203-224.

A Novel Method for Diagnosing Fibrinogen Abnormalities

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Lenny Slutsky, Duke University, Durham NC
Dr. Nadine Pernodet, Stony Brook University, Stony Brook NY
Dr. Dennis Galanakis, Stony Brook University, Stony Brook NY

Modern-day diagnosis of protein disorders involves a variety of methods including identification of abnormal proteins by antibodies, characterization of abnormal proteins by molecular mass, examination of family history, amino acid sequencing, and DNA analysis. These methods, while fairly effective, are only useful in diagnosing certain types of protein abnormalities and/or require large amounts of time and energy to complete. Recently, it was found that a charged polymer surface could induce soluble globular proteins to change conformation and form an organized protein network[3]. More importantly, it was noted that the structure and physical properties of these networks were characteristic to specific types of proteins. In this investigation, it was hypothesized that the organization and physical properties of normal, healthy fibrinogen networks formed using a charged surface, would differ from those of abnormal fibrinogen resulting from a genetic disorder.

To test the validity of the hypothesis, cleaned silicon wafers were spun-cast with 28% Sulfonated Polystyrene and placed in solutions of isolated fibrinogen molecules. Fibrinogen was taken from both healthy patients and a patient with a known fibrinogen disorder. After 48 hours, the surfaces were imaged using an atomic force microscope.

Resulting images (Fig. 1 and Fig. 2) depicted two fibrinogen networks that are clearly distinguishable from one another by network organization. The fibers of the healthy fibrinogen matrix are visibly larger and more cohesive those of the abnormal protein. Such data is promising to the development of an efficient and reliable method for protein abnormality detection. However, there are still several questions that must be answered before such a method becomes reliable; Are there certain protein abnormalities that this method will fail to detect? Can network differences be better detected by observation of the network's physical properties? What exactly causes the distinction of network organization? Further research will hopefully provide answers to these enigmas.

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[3] Nadine Pernodet, Miriam Rafailovich, Jonathan Sokolov, D. Xu, Nan-Loh Yang, Kenneth McLeod, (2001). *Fibronectin fibrillogenesis on sulfonated polystyrene surfaces*. Journal of Biomedical Materials Research, 64(4), 684 – 692.

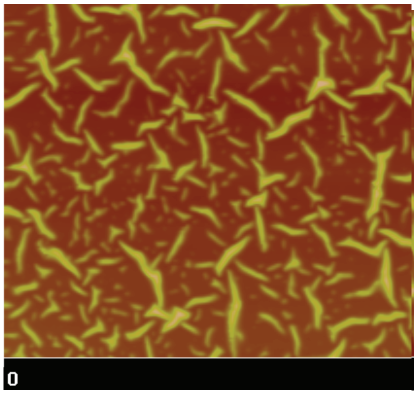

Fig. 1: Healthy Fibrinogen Network

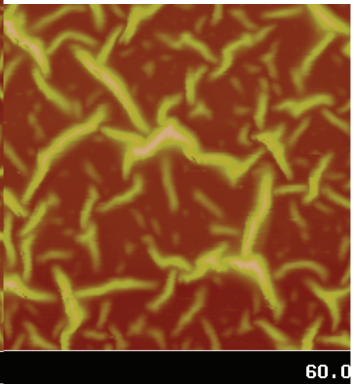

Fig. 2: Abnormal Fibrinogen Network

The Effect of Angiogenic Inhibitors and Growth Factors on Matrigel Angiogenesis

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Dr. Richard A.F. Clark, Biomedical Engineering, SUNY Stony Brook
Dr. Marcia Tonnesen, Dr. Padmaja Prabhu, Dermatology, SUNY Stony Brook
Dr. Miriam Rafailovich, Materials Science and Engineering, SUNY Stony Brook

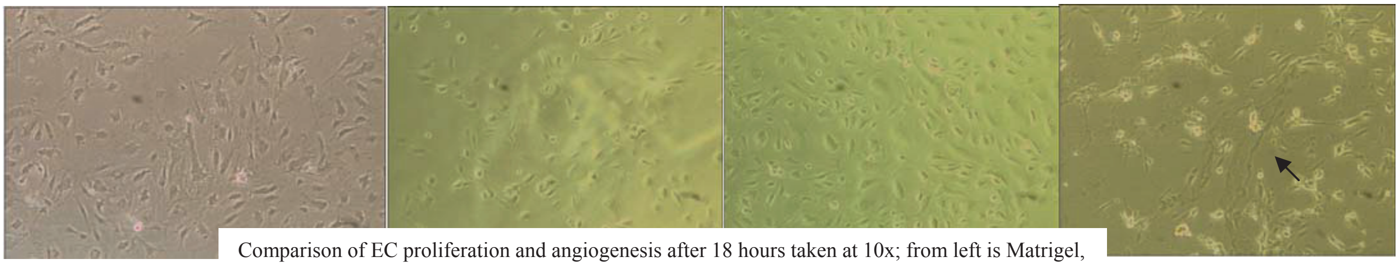
Angiogenesis, a naturally occurring process, is the process of blood-vessel growth and formation. It is a critical process in multiple events, including tumor growth and wound repair. Therefore, modulating angiogenesis can have potential implications in understanding and treating serious pathological conditions.

Endothelial cells (EC) comprise the lining of blood vessels and play an integral role in angiogenesis. In this project, our objective was to test the effect of EC growth on Matrigel, a basement membrane matrix derived from Engelbreth-Holm-Swarm (EHS) mouse sarcoma, and growth factor reduced (GFR) Matrigel, which has significantly reduced quantities of growth factors implanted in it; in addition, we tested the effects of added growth factors, such as vascular endothelial growth factor (VEGF) and basic fibroblast growth factor (bFGF). We also plan to test the effects of an inhibitor, anginex. The EC growth on Matrigel will be compared to EC growth on standard, non-angiogenic matrixes, including collagen, rat-tailed collagen, and fibrin gels. Because it is rich in extracellular matrix proteins, Matrigel is known to promote angiogenic-qualities among EC placed on the matrix[4]. On the Matrigel, EC begin to form capillaries, while on the collagen and fibrin matrices, EC only forms a monolayer[5].

First, we transferred EC to both Matrigel and GFR Matrigel. Next, VEGF and bFGF were added as experimental growth factors on both Matrigels. Finally, anginex will be added to test its inhibition effects. The blood vessel formation will then be compared to the vessel formation on the fibrin and collagen matrixes.

We hypothesize that angiogenesis will occur best on the standard Matrigel, because of the plethora of imbedded growth factors. In addition, we also believe that the bFGF will not increase blood vessel formation, because bFGF is the only growth factor not to vary in concentration between the growth factor reduced Matrigel and standard Matrigel. Finally, we predict that the anginex will have an anti-angiogenic effect, but that the abundance of growth factors will serve to counteract the inhibitor.

Our first results indicated that Matrigel promoted EC proliferation more than GFR Matrigel; in addition, we also found that rat-tailed collagen was more angiogenic than either collagen or fibrin. The rest of the experiment was underway at the time of publication.



Comparison of EC proliferation and angiogenesis after 18 hours taken at 10x; from left is Matrigel, GFR-Matrigel, fibrin, and rat-tailed collagen. Arrow indicates vessel formation.

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[4] Auerbach R, Akhtar N, Lewis R, Shinners L. (2000) Angiogenesis assays: Problems and pitfalls. *Cancer and Metastasis Reviews* **19:** 167-172.

[5] Nicosia RF, Ottinetti A. (1990) Modulation of microvascular growth and morphogenesis by reconstituted basement membrane gel in three-dimensional cultures of rat aorta: a comparative study of angiogenesis in matrigel, collagen, fibrin, and plasma clot. *In Vitro Cell Dev Bio* **26**(2): 119-28.

Engineering a Second Generation Hydrogel Matrix for the Healing of Chronic Wounds

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Kaustabh Ghosh[1], Dr. Fubao Lin[1], Dr. Miriam Rafailovich[2], Dr. Richard A.F. Clark[1].
[1]Department of Biomedical Engineering, SUNY Stony Brook
[2]Department of Materials Science and Engineering, SUNY Stony Brook

Chronic wounds, or ulcers, affect much of the population and are major health complications that remain to be solved. As a result, great effort is placed in finding ways to heal these otherwise non-healing wounds. Current commercially available products for wound healing are only around 25% effective. In this study, we are aiming to develop a much more effective treatment through creating a second-generation tissue engineered construct using a hydrogel scaffold.

An important extracellular matrix (ECM) protein studied in wound healing is fibronectin (FN)[1]. FN facilitates the migration of dermal fibroblasts during normal wound healing by acting as "tracks" for the cells to migrate on[2]. In the proteolytic environment of chronic wounds, FN proteins become degraded and float away, unable to facilitate fibroblast migration anymore and thus unable to aid in wound healing[1]. An engineered hydrogel scaffold could, in theory, anchor the FN in place and prolong their function. Previous studies demonstrated that FN is comprised of three main functional domains: 8-11, 12-15 and a variable 12-15V domain[3]. These fragments were crosslinked on a hydrogel scaffold and substantial migration of dermal fibroblasts was observed.

In this study, we found that platelet derived growth factor (PDGF), a protein present in the early stages of wound healing that accelerates fibroblast migration, binds to FN. We hypothesize that by incorporating a FN-PDGF complex on the hydrogel scaffold, a synergistic effect on the migration of dermal fibroblasts could be created. Solid hydrogel was diluted in SF-DMEM, crosslinked with FN fragments using PEGDVS, and incubated with PDGF to create gels on 24 and 48 well plates. Agarose droplet migration assays were performed on the hydrogel using CF-31 strain dermal fibroblasts. Cells were fixed and stained with Crystal Violet dye. Images were taken using a stereomicroscope and analyzed using Metamorph® software. Final results are still pending. By incorporating a FN-PDGF complex in the hydrogel, we hope to produce a more robust second-generation tissue engineered hydrogel scaffold for the healing of chronic wounds.

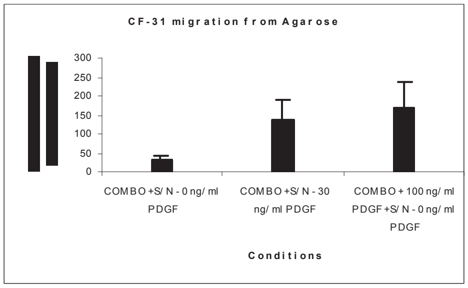


Figure 1. Preliminary results show a positive trend of cell migration from hydrogel containing only FN to hydrogel containing a FN-PDGF complex.

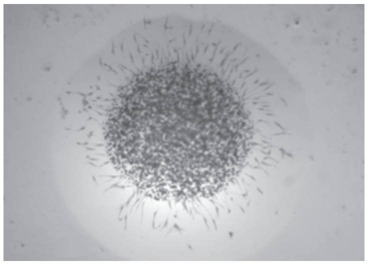


Figure 2. Migrating dermal fibroblasts from an agarose droplet on hydrogel.

References:

1. Clark, RAF., Ed. (1996a) The Molecular and Cellular Biology of Wound Repair.: Plenum Press, New York.
2. Greiling, D., Clark, RAF. (1997). Fibronectin provides a conduit for fibroblast transmigration from collagenous stroma into fibrin clot provisional matrix. *Journal of Cell Science.* 110, 861-870.
3. Clark, RAF., An, JQ., Greiling, D., Khan, A., Schwarzbauer, JE. (2003). Fibroblast Migration on Fibronectin Requires Three Distinct Functional Domains. *The Journal of Investigative Dermatology*. 121, 695-705.

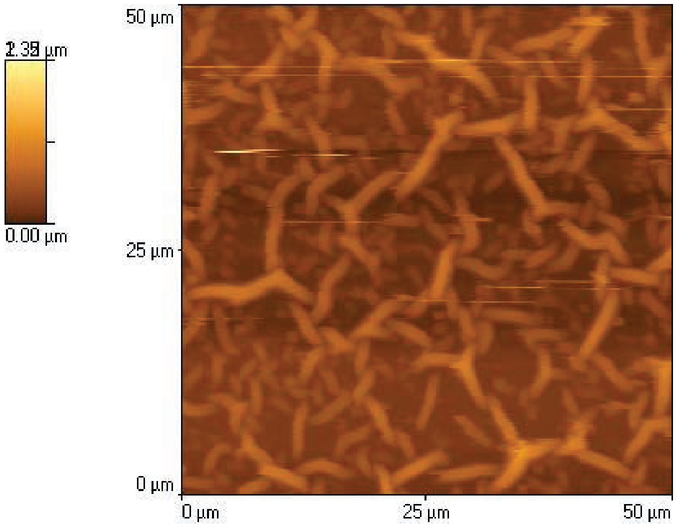
Templating Biomineralization Using Self Assembling Proteins

Marc Sherwin, *The Wheatley* School, *Old Westbury, New York 11568*
Samantha Palmaccio, *Sachem High School East, Farmingville, NY 11738*

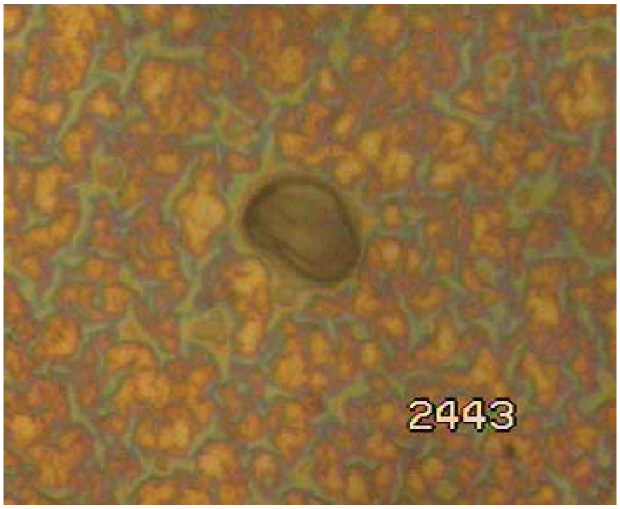
Ten million people in the US only currently suffer from Osteoporosis, a disease which results in the degrading of bone mass. It was estimated that hip fractures caused by osteoporosis in 2002 cost the world 18 billion dollars.[1] This condition, along with many other crippling ailments affecting the skeletal system, is costing a great deal of capital and lives. The need for an effective treatment for bone disorders has led to this investigation of various proteins and their role in biomineralization. Biomineralization is a process in which living organisms deposit minerals forming a hard dense layer. It is hypothesized that proteins found in living organisms help control the biomineralization process. Another study done using various proteins from abalone shells found that two specific proteins stopped calcium carbonate crystal growth. [2]

The purpose of this investigation is to determine the interaction between various proteins and biomineralization. If this relationship can be determined, then numerous new treatments for bone disease could be used.

A flow cell was used to study the mineralization of calcium carbonate on silicon wafers. A solution composed of $CaCl_2$ and $NaHCO_3$ was allowed to flow through the cell containing sulfunated polystyrene with or without various proteins. A total of four conditions are planned to be tested using this setup including a control with no proteins.



Fibronectin protein network plated on SPS



Fibronectin protein network with Calcium Carbonate crystal after completed flow cell trial

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[1] **http://www.nof.org/osteoporosis/diseasefacts.htm The National Osteoporosis Foundation**

[2] **Characterization of Two Molluscan Crystal-Modulating Biomineralization Proteins. Michenfelder et al.**

Session 12:
Forming Patterns on Surfaces: Cells and Proteins

Director: Mayu Si

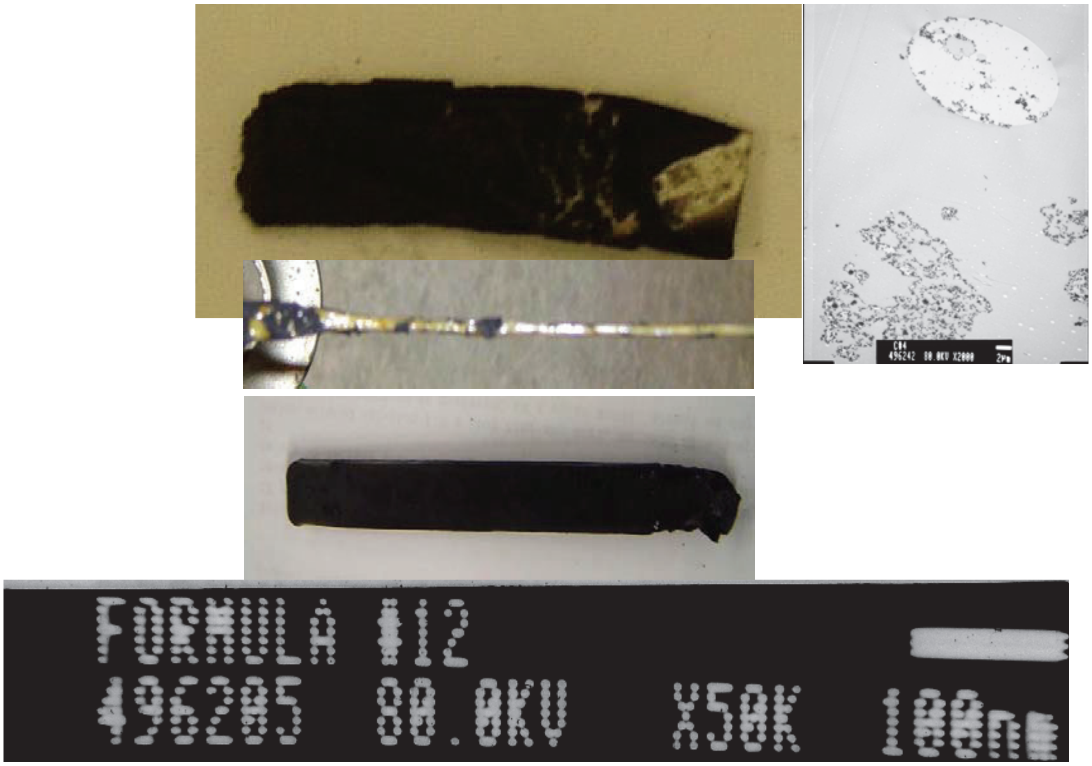
Chairs: Michael Goldman

Jeddy Chen

John Oh

Wonwoo Lee

Kiwoong Yoo



A Non-Halogen Self-Extinguishing HIPS/Phosphate/Clay Nanocomposite

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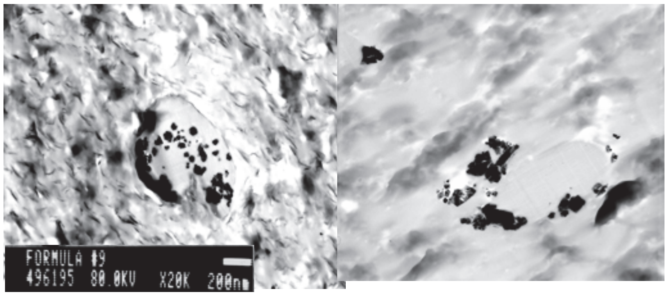
Mayu Si, Miriam Rafailovich, Stony Brook University, Stony Brook, NY, 11794

Recently, halogen flame retardants in industry have been proven to be potentially detrimental to neurological systems of humans. The major flame retardant used in high impact polystyrene is pentabromine diphenyl ether (PBDE), which is believed to be the main factor to cause the bromine level increase in human breast milk and has been banned in the European Union. In 2008, the USA government will illegalize the use of harmful bromines compounds and will coerce the industries to find a substitute for them. Our first hypothesis stated that adding clay nanoparticles into ABS and Br-PS systems (it has less toxic and damage to environmental issues) can improve the efficiency of flame retardants. Our second hypothesis stated that combining non-halogenated compounds with clay to make HIPS self-extinguish, completely replacing bromine compounds.

We prepared HIPS and ABS with different ratios of phosphate or Br-PS and clay by using the twin blade C.W. Brabender at 210 °C. Then, the samples were pressed into different shape for various characterization, such as DMA, LOI, UL-94 V0, and TEM tests. DMA measures the modulus of the material as a function of temperature and determine the glass transition temperature. The addition of 10% clay in the ABS systems increases the modulus by 6% compared to pure ABS. The LOI and UL-94 V0 tests determine the performance of flame retardancy. In the HIPS system the introduction of 3% high thermal stable MMT clay increases the LOI value from 28% of the sample without clay to 34%. Further the HIPS with 3% of MMT can achieve UL-94 V0 certification, while the sample without clay failed the test and kept dripping during the burning. The TEM images show that the addition of clay improves the dispersion of phosphate, resulting higher efficiency of ceasing the flame.



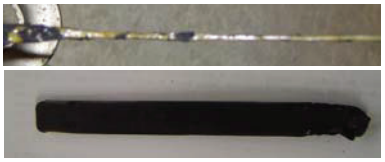


Figure 1. TEM images of ABS flame retardant nanocomposites: (A) ABS/Br-PS/Sb_2O_3/Cloisite 20A (100/15/4/10); (B) ABS/Br-PS/Sb_2O_3/Cloisite 20A (100/15/4/0)

Figure 2. The images of the sample after UL-94 V0 test: (A): HIPS/PPO/RDP/Clay (80/20/20/3); (B) HIPS/PPO (80/20)

The results led us to conclude that phosphate compounds is not an adequate substitute for bromine by itself but becomes effective with the addition of clay. Clay can effectively promote the char formation and becomes a physical barrier to slow down the burning process. The comparison of two types of clay in HIPS system indicates that the thermal stability plays a key factor to decide the performance of flame retardancy. Eventually, we came up with a sample that contains suitable amount of each material, but still passed the UL-94 V0 test.

California Legislature Passes Bill Banning PBDEs.” Brayton Purcell. Brayton Purcell. 4 Aug. 2005 <http://www.braytonlaw.com/news/legisnews/080103_ab301_pbde.htm>.
Raloff, Janet. “New PCBs?” Science News 25 Oct. 2003: 266. 4 Aug. 2005 <http://www.sciencenews.org/articles/20031025/bob10.asp>.

A Study on Fire-Resistance in Polymer Blends using Clay and Bromine

Jeddy Chen, Ward Melville
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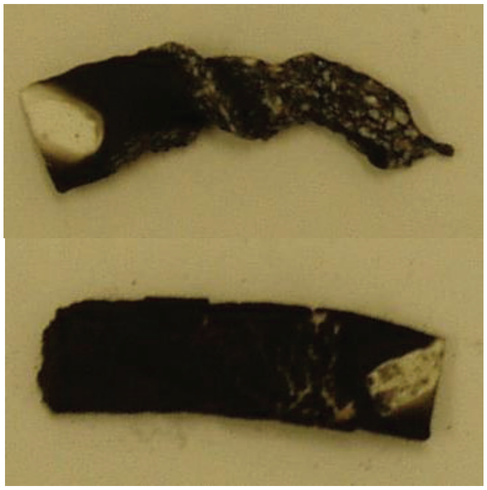
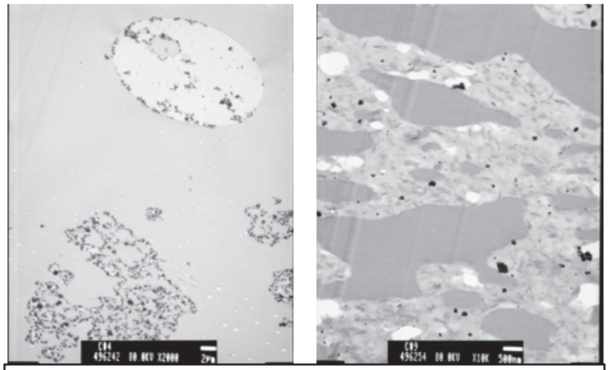
The poor thermodynamic properties of a polymer have always been a problem; their low melting points and ease of combustion make then susceptible to deformation and burning. Mixtures of traditional fire-retardants decabromodiphenyl ether[1] and clays[2] have been studied for their ability to enhance the polymer's thermodynamic properties.

Four different concentrations of clay, bromine, and polymers have been studied in three different polymer ratios. The polymers chosen were polystyrene (PS) and poly(methyl methacrylate) (PMMA) because of their naturally low resistance to thermal decomposition. The mixtures were analyzed with an ignition test and Limiting Oxygen Index LOI to see their flammability; a dynamic mechanical thermal analysis (DMTA) to see their modulus and strength; a Transmission Election Microscopy (TEM) to see the particle interactions; Ion Chromatography and Edge X-ray Absorption Fine Structure (EXAFS) to see the basic interactions. These were conducted on varied burn times in three second intervals from 0-12 seconds.

We have seen from the burn tests and the LOI that the presence of only clay or only bromine in a PS/PMMA mixture has little effect on the thermal dynamic properties, while with a combination of both substances, the polymer becomes very fire resistant and has the ability to self extinguish (below). From this we can conclude that this combination of two fire retardants could make normally non-fire resistant polymers more resistant to thermal decomposition. We see from the DMA that the addition of clay also increases the strength of the material.

We see from the TEM that the clay and bromine have a high affinity for PMMA. The clay also greatly increases the uniformity of the blend and allows the blend to resist thermal decomposition at longer burning times compared with blends without clay (below). Strong phase separation is observed at the 12 second burn time for all samples. Ion Chromatography and EXAFS have to be conducted.





Left: Top, without clay; Bottom, with clay.
Top: Left, TEM without clay at 5K magnification; Right, TEM with clay at 20K magnification, both at 9 sec burn.

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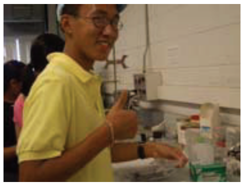
[1] G. Camino, L. Costa; Luda di Cortemiglia. *Polymer Degradation and Stability*, **1991**, 33, 131-154
[2] Gilman, Jeffrey W. *Applied Clay Science* **1999**, 15, 31-49

Garcia MRSEC
Polymers at Engineered Interfaces

Summer Scholar Program Schedule of Activities

EVERY DAY STARTS WITH A GROUP MEETING IN 2nd FLOOR LOUNGE

CHECK SCHEDULE DAILY!

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
Week of 6/27	27 10:00 AM *Introduction, Meeting the Graduate Students,* Lourdes Collazo & Miriam Rafailovich 10:30 AM *Science Competitions (Intel, ISEF, Westinghouse)* Alan Sachs *Lab Notebooks, Journal Club, Young Scholars, Grading Policy, Hand Out Starter Kits,* Ron Ochiogrosso, 11:30 AM *Fuel Cells and Methanhydrate*, Devinder Mahajan 12:00 PM Group Distributions for Afternoon Tours 1:00 PM *Biomedical Research*, Srivinas Paytala 1:30 PM Lab Tours *Atomic Force Microscopy*, Yantian Wang *Confocal Microscopy*, Zhi Pan *Tensile Testing*, Mayu Si, Michael Snow, Michael Goldman *Cell Lab*, Nadine Pernodet *Campus Tour, Life Science-Biostores* *Health Science Center* *Anesthesiology*, Paytala *Umic*, Greg Rudomen *Dermatology,* Dr. Richard Clark Administration Building, Library, Staller Center, Gymnasium, Chemistry Stockroom *Chemistry Building*, Dr. Silverstein	28 10:00 AM General Meeting 10:30 AM , *Biomineralization,* Elaine Dimasi *Intellectual Properties,* Donna Tummirello 1:00 PM *All About Spincasting*, Steve Schwarz 2:30 PM *Ellipsometer, Light, Measuring Thickness,* Henry White 3:30 PM *Fuel Cells*, Gary Halada	29 10:00 AM General Meeting 10:30 AM Environmental Healthy & Safety 11:30 *AM Chemical Waste Disposal Training*, Lourdes Collazo 12:00 *PM Laboratory Ovens, & Vacuum*, Jonathan Sokolov 1:00 PM All *About Polymers*, Dilip Gersappe 2:00 PM *Ovens Test and Demo*, Jonathan Sokolov 2:30 PM *Chemical Waste*, Lourdes Collazo 3:00 PM *Cell & Tissue Safety Video,* Michael Vacariella 3:30 PM Quiz	30 10:00 AM General Meeting 10:30 AM *Defects of the Human Genoma,* Eli Hatchwell 11:00 AM *All About Polymers Part II*, Dilip Gersappe 1:00 PM *Microscopy Lecture*, Richard Clark 3:00 PM *Journal Club Assignments,* Teachers & Ron Occhiogrosso 	1 10:00 AM General Meeting 10:30 AM High School Students Presentations *Siemens,* Taylor Bernheim/Jessica Fields, Allyson Ho/ Alex Thachara *LISEF,* Chelsea Gordon/ Sylvia Qu 12:30 PM *Excel Workshop in the SINC site,* Michoel Snow 
Week of 7/4	4 	*5* 10:00 AM General Meeting 10:30 AM SINC Site to Work on Data Base 1:00 PM Spinning	6 10:00 AM General Meeting *All About Polymers Part III,* Dilip Gersappe 11:00 AM *Machine Shop*, Lester 1:00 PM Cad Lab 2:00 PM Finish Spinning	7 10:00 AM General Meeting 10:30 AM *Chemistry & Cosmetics*, Isaac Cohen (Estee Lauder) 11:30 AM *Self Assembly of Thin Films,* Marek Urban 12:30 PM *Statistics I,* Miriam Rafailovich 1:30 PM *Evaluation of Spinning Data & Web Publishing*, Tara Sanfillipo & Prasad Akavoor	8 10:00 AM General Meeting 10:30 AM Report of the Seven Groups on Spinning 12:00 PM Journal Club 
Week of 7/11	11 Field Trip to Brookhaven National Laboratories	12 10:00 AM General Meeting 10:30 AM *How Adherent Cells Migrate and Steer,* Yu Li Wang 1:00 PM Electron *Microscopy-How It Works and When Do You Need It?* Eli Sutter 2:00 PM Organization Into Lab Groups and Mentor Assignment	13 10:00 AM General Meeting 10:15 AM *Biology of the Cell*, Nadine Pernodet 11:30 AM *Strategies for AP Calculus and Calculus SAT* II, Dr. David Kahn, Author of the AP Calculus Review Book Series 4:00 PM Basket Ball Game	14 10:00 AM *Flame Retardant Polymers,* Prof. Ed Weill 11:00 AM *The Siemens Westinghouse Competition*, Marie Gentile 1:00 PM Work on Projects!	15 10:00 AM *Intel Foundation on Intel Science Talent and the ISEF Competitions*, Katherine Silkin *Blood Plasma Proteins*, Dennis Gallenakis 11:00 AM Student Presentations 12:00 PM Journal Club
Week of 7/18	18 10:00 AM General Meeting 10:30 AM *Oral Presentation on Spinning*, Groups II and VII	19 10:00 AM General Meeting 10:30 AM *Discussion of Inspire Meeting and Organization of Spinning Paper*, Tara Sanfillipo	20 10:00 AM General Meeting *Review of Laboratory Waste Disposal and Safety, Lecture on Cell Culture, Staining, and Counting Procedures,* Lourdes Collazo	21 10:00 AM General Meeting *Greetings*, Shirley Strum Kenney *Statistical Analysis Part II*, Miriam Rafailovich	22 10:00 AM *General Meeting* *LiquiCubes and Micellosomes-New Nano Mesostructures Derived from Lyotropic Liquid Crystals,* Nissim Garti Group Reports Final Journal Club

Week of 7/25	25 10:00 AM General Meeting Collect statistics homework assignment 11:00 AM Work in Labs	26  10:00 AM General Meeting Assignment of Presenters for Friday 11:00 AM Work in Labs Trip to BNL to work	27 10:00 AM General Meeting *Meeting, Lab, and Equipment Rules* 11:00 AM Work in Labs	28 10:00 AM General Meeting 11:00 AM Work in Labs	29 10:00 AM General Meeting 11:00 AM Work in Labs Abstracts Due Jourbnal Club
Week of 8/1	1 10:00 AM General Meeting 11:00 AM Work in Labs	2 10:00 AM General Meeting 11:00 AM Work in Labs	3 **CANOE** **TRIP!!**	4 10:00 AM General Meeting 11:00 AM Work in Labs	5 10:00 AM General Meeting 11:00 AM Work In Labs 
Week of 8/8	8 10:00 AM General Meeting 11:00 AM Work in labs Prepare for Symposium	9 10:00 AM General Meeting 11:00 AM Work in labs Prepare for Symposium	10 10:00 AM General Meeting 11:00 AM Work in labs Prepare for Symposium	11 10:00 AM General Meeting 11:00 AM Work in labs Prepare for Symposium	**12** **End of Summer Research Presentations** **SAC Ballroom B** **10 am- 3pm**

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