Garcia MRSEC

Polymers at Engineered Interfaces

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

Research Scholar Program

2003

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

> "The program has no set time limits. Research is a lifetime learning experience, and we hope to remain a resource to our students long after 'graduation'."
>
> - Miriam Rafailovich
> Program Director

Garcia MRSEC NSF
Polymers at Engineered Interfaces
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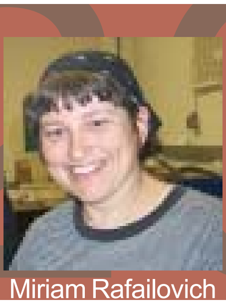
2003


Miriam Rafailovich


Jonathan Sokolov

Research Scholar Program

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

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

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

Sincerely

Miriam Rafailovich
Professor, Director, Garcia MRSEC

Jonathan Sokolov
Professor, Co-Direcrtor, Garcia MRSEC

Garcia MRSEC
Polymers at Engineered Interfaces
SUNY Stony Brook • Polytechnic University • CUNY • North Carolina State University
Miriam Rafailovich, Ph.D., Director   Ronald N. Occhiogrosso, Ph.D., Research Faculty Fellow
Dept. of Materials Science and Engineering, Stony Brook University, Stony Brook, N.Y. 11794-2275
Phone: 631-632-6097, Fax: 631-632-5764, e-mail: mrafailovich@ms.cc.sunysb.edu, rocchiog@juno.com

We would like to take this opportunity to thank Dr. Miriam Rafailovich and Dr. Jonathan Sokolov for the generous opportunity they have provided to us over the past 5 summers. It is hard to believe that we have been part of this wonderful *Young Scholars* program for already five years now. As the saying goes, “time flies when you’re having fun”, and this has certainly been the case here in their labs.

I (Dr.O.) can still recall the first time I walked into the office of Drs. Rafailovich & Sokolov in the spring of 1999, and met them. It was in the evening, around 8 PM, and I was immediately impressed with the amount of activity that I saw. Graduate students were busy with their work, and this brought back fond memories of my days in graduate school. I also met a high school student and thought how interesting that was; “Why should a high school student be here at this time of the evening?” I soon found out that high school students were as welcomed as undergraduate or graduate students, and that pretty much tells it all about these two uniquely different, compassionate professors.

Dr. Rafailovich explained to me the NSF sponsored RET *(Research Experiences for Teachers)* program opportunity that was available for high school science teachers. The program sounded like the perfect professional experience for both of us.

Over the years, we have been able to grow in our profession

Finally, a special thank you to all the REU’s for their tireless efforts they have expended throughout this summer.

Sincerely,

Dr.Ronald N. Occhiogrosso

Research Experience For Teachers

Ronald Occhiogrosso,
Coordinator

Rebecca Isseroff,
Co-Coordinator

Gary Gustavsen

John Jerome

Research Experience For Undergraduates

Shira Billet

Mordechai Bronner

Amruta Desai

Robert Fisher

Rikki Frankel

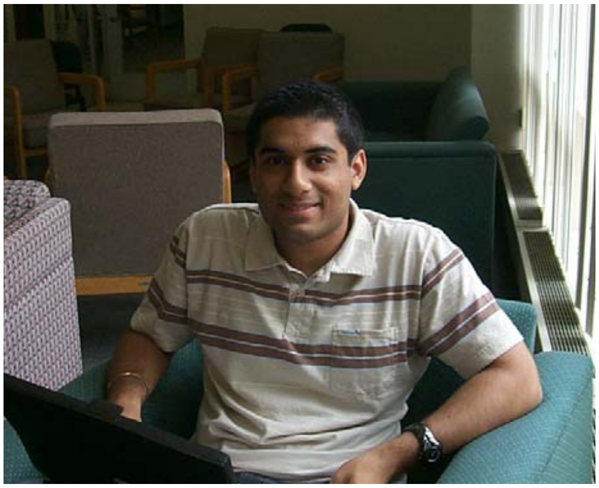
Michael Goldman

Stephanie Kaszuba

Joshua Levine

Abigail Maller

Aprajita Mattoo



Varun Mehta

Robert Samstein

Dmitri Serebrianik

Tedi Setton

Lenny Slutsky

Michael Snow

Other Programs

Arielle Galambos

Howard Hughes Medical Institute
Summer Research Grant

Donnie Isseroff

Medical School Student
Sackler School of Medicine, Tel Aviv

Edmund Palermo

Cornell Presidential
Research Scholars

Sravanesh Muralidhar

National Institute of Health-
Interdisciplinary Biomedical Research
Program

High School Summer Scholars 2003

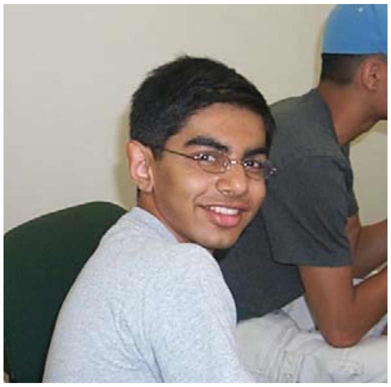
Christine Ahn

Christopher Becker

Ayla Bloomberg

Jennifer Braverman

Amy Brazin



Tanmay Chedda

Stanley Chang

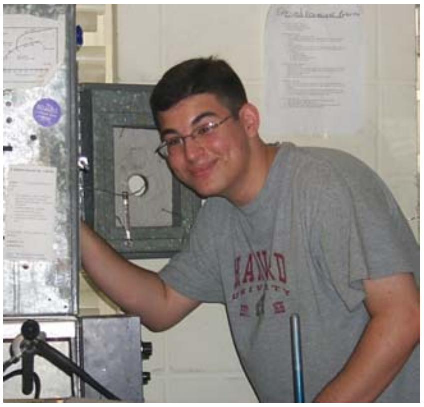
Benjamin Cohen

Matthew DiPasquale


Josh Etman


Jessica Fields


Michal Forman

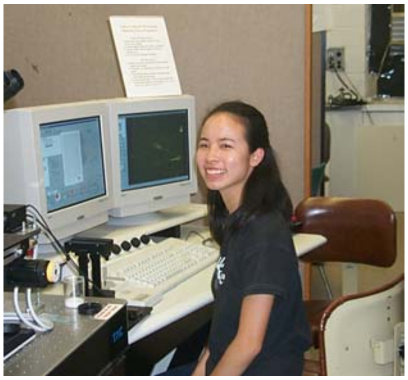

Mitchell Fourman


Chelsea Gordon


Jonathan Hefter


Evan Hertan


Joel Hertzfeld


Madelyn Ho


Maanasa Indaram


Jack Jacob

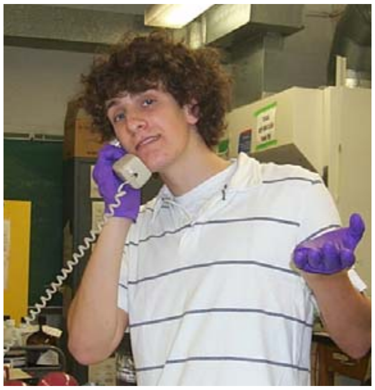

Jessica Jiang


Ezra Katz


Vivek Kuncham

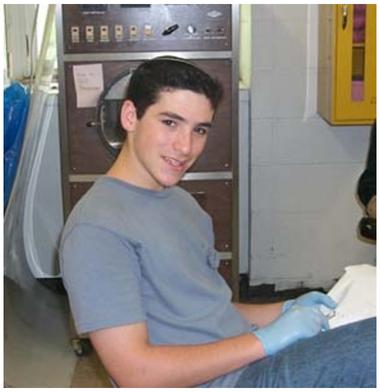

Helen Kyd


Sara Lefkovitz


Adam Lempel


Michael Levy


Aliza Lopchinsky


Daniel Lubelski


Steven Lubin


Eric Mansfield


Paul Marx


Alan Masand

Sean Mehra

Amit Mehta

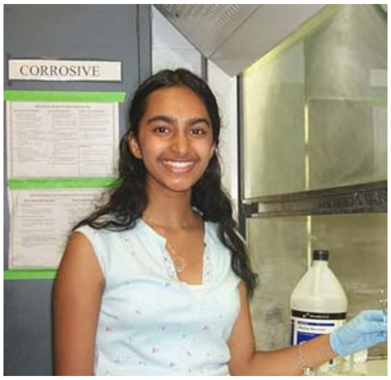
Sagar Mehta

Spencer Park

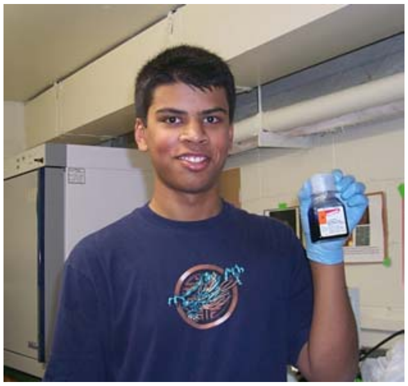
Gregory Parnes

Eric Petersen

Sylvia Qu



Aditi Ramakrishnan



Nik Ray-Mazumder

Aryeh Reinstien

Jeffrey Reitman

Andrew Scheur

Matthew Schlossberger

Chani Schonbrun

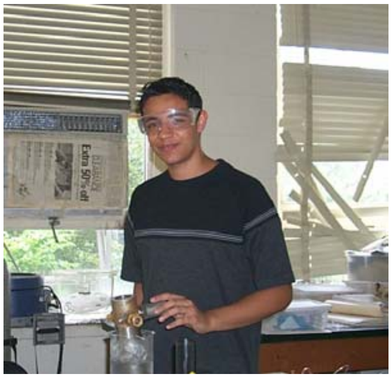
Bradley Schwartz

Saumya Sharma

Avtar Singh

Andrew Song

Vandana Sood



Shaan Waqar

Andrew Lillian

Philip Stern

Dena Nachman

Sara Rafailovich Sokolov

Not Shown:Arthur Yu

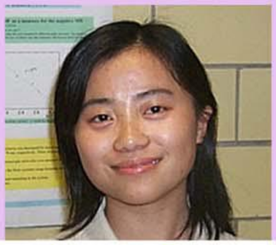
STAFF AND GRADS

SUNY, Materials Science


Dr. Shouren Ge


Lourdes Colazzo


Dr. Nadine Pernodet


Yuan Sun


Xiaohua Fang


Yantian Wang


Harry Xavier


Song Feng Li

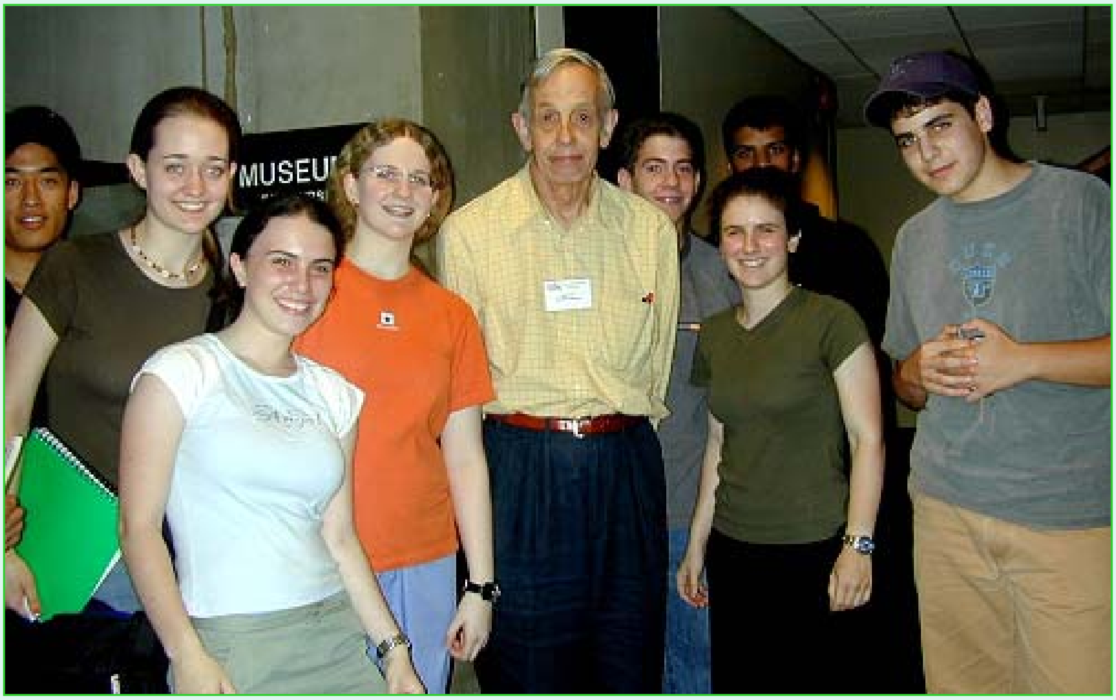

Bingquan Li


E Guan


Mayu Si


Yuan Ji

Summer 2003 Scrapbook



Garcia Students Meet John Nash





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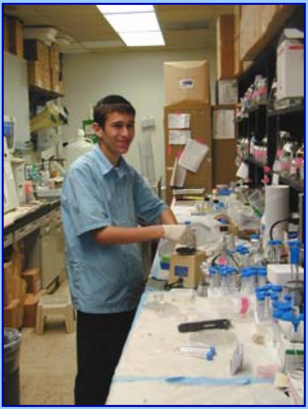
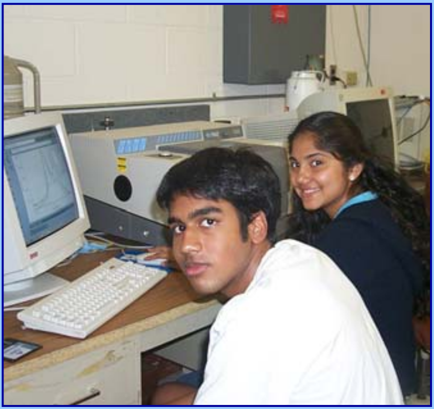
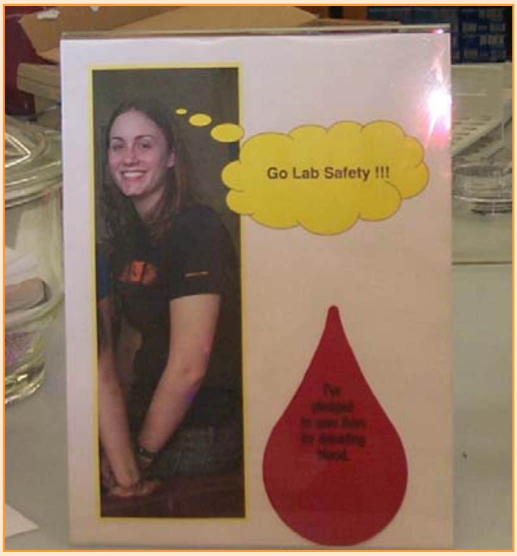
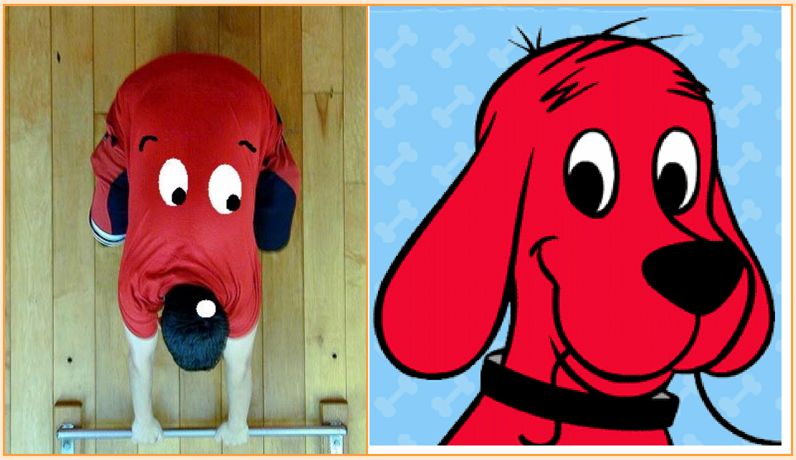
ERCROMBIE
KS AND RECREATION
CTIVITIE

EICHMANN
IN MY HANDS


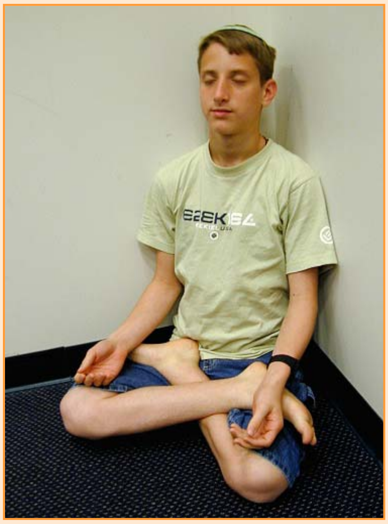




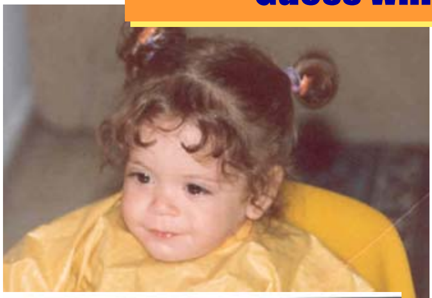
Is that Josh or is it Clifford the Big Red Dog?

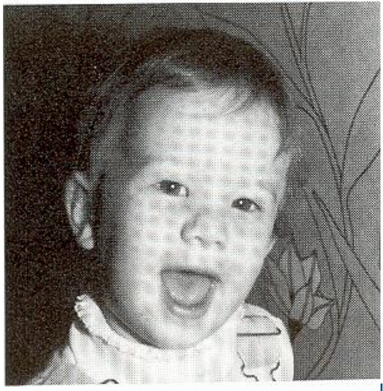
Abby Maller…
firm believer in lab safety

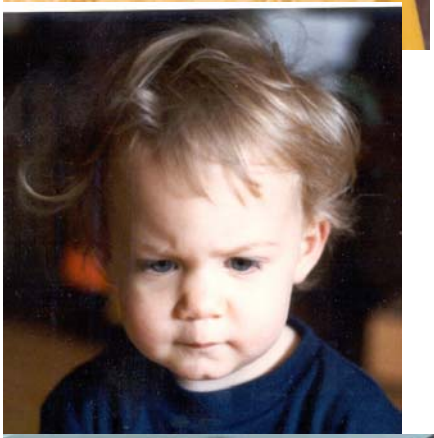


"Who R E U?"

Guess which REU is which







Choices: Rikki, Stephanie, Abby, Bronner, Josh, Lenny, Arielle, Tedi, Ed, Shira

Port Jeff Stargazing and Fishing Trip

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 6/30	**High School Summer Scholar Program Begins** **10:00** Welcome Meeting 11:00-12:30 Dr. White *Coherence of Light in Ellipsometers Part I* Room 143 12:30-1:30 *Intro to Library Resources* 2:30-3:30 Dr. O *Lab Notebook* **When free investigate research opportunities**	**July 1** 10:30-11:30 Jim Quinn *Laboratory Safety* Room 143 12:30-1:30 Chemical Disposal Room 313 Group 1+2 1:30-2:30 Chemical Disposal Room 313 Group 3+4 1:30-2:30 Dr. White *Ellipsometry Part II* Groups 1+2 12:30-1:30 Dr. White *Ellipsometry Part II* Groups 3+4 2:30-3:30 Dr O/REUs *Intro to Polymer Film Prep.* Room 143	**2** 10:30 -12:00 Web of Science/ Journal Club 12:30-3:30 *SI Wafer Prep and Solutions* Room 313 REUs	**3** ***All Students dorming must check out of their rooms***	**HAPPY 4th of JULY** 
Week of 7/7	7 10:00am Melanie Krieger Science Competitions 10:30am Dr. Richard Clark. Room 143 12:30-2:30 Groups 1& 2 Rm 313 Silicon Wafer cleaning & spinning 12:30-1:30 Groups 3&4 :Dr. Sokolov 1:30-3:30: Groups 3&4 Rm 313 Silicon Wafer cleaning & spinning. 2:30-3:30 Groups 1&2.: Dr. Sokolov	*8* Dr.Richard Clark, Microscopy I 10:30-11:30 Room 143	9 10:00 JUR Paper Discussion, Spinning Theory, Dr. Steve Schwarz 12:00 Group 2 Dr. Rafailovich, Statistics I, Error Analysis, Group 4 Spinning 1:00 Group 1 Excel, Group 3 Spinning 2:00: Group 1 Statistics, Group 2 Spinning, Groups 3 & 4 Excel 3:00 Group 1 Spinning, Group 2 Excel, Groups 3 & 4 Polymer Modeling, Dr. Dilip Gersappe Optional: Dr. Shafi *Nanoparticles* Dr. Shew *Theoretical Studies of Flexible Chain Polymers and Rigid Rods in External Fields*	10 10:00 Meeting 10:30 Breakout Sessions on Specific Areas of Research 12:45-2:15 Groups 1 & 2 Continue and Finish up with Spin Casting Work, Master Plot/Excel; Groups 3 & 4 Journal Club, Submit HW to REUs 2:15 – 3:45 Groups 1 & 2 Journal Club, Submit HW to REUs. Groups 3 & 4 Continue and Finish up with Spin Casting Work, Master Plot/Excel;	11 Prof. Al Tobin “Nanocomposite procesing
Week of 7/14	14 10:15 Dr. Richard Clark Microscopy II, room 143 11:15 Final Full New HS Group PB Project, Disseminate Assignments for Manuscript Presentation 1:30-2:30 Dr. Robert Hwang, Director, BNL Nanocenter, *lecture on Nanotechnology* 2:45-3:30, Groups 1 & 2 , *Error Analysis II, Stats 1, Error Bars*, Dr. Rafailovich, Room 143 2:45-3:30 Groups 3 & 4, *Modeling Polymers & Their Systems, Theory, Room 145*	15 10-11 General Meeting (Glass Doors), Discussion of Patents, Discussion of AT&T Award Presentation. 11:00 Meet with mentors, Begin evaporation experiments	16 10:15am David Abacasus Industrial Polymers *Going Commercial With Polymers ROOM 143* 10:30-11:30: Groups 1 & 2 Journal Club, Dr. Occhiogrosso; Groups 3 & 4 Journal Club, Mrs. Isseroff 11:30 Meet with Mentors. Begin Evaporation Experiments 2:30 AT&T Check Presentation, followed by lab tours	17 10:10:30 Jack Petersen, Donna Tuminello, General Organization Meeting 10:30-11:00 Journal Club – all groups 12:30 Work on Projects	18 10:-11:30 Group Meeting, Presentations: *Rheolgy:* Avtar Singh *PB Evaporation*: Aditi Ramakrishnan & Sylvia Qu *Statistical Analysis:* Paul Mark, Jeffrey Reitman, & Sean Mehra 11:30 Journal Club: Final ~5 Presenters 1:00 PB Manuscript Writers: Meet behind Glass Doors to Discuss Paper Preparation
Week of 7/21	21 10:00 Prof. Chris Berndt “Materials World”	22 10:00-10:30 General Organization Meeting 11:30 Work on Projects	23 Trip to Cold Spring Harbor Laboratory 4:15 Softball game (rained out)	24 10:00-10:30: General Organization Meeting 11:30 Work on Projects	25 10:-11:30 Group Meeting, Presentations: *Nanoparticles:* Michael Forman & Cheryl Schonbrun *Fracture Toughness:* Chris Becker & Matt Schlossberger *SCF Technology:* Abigail Maller & Robert Fisher; Greg Parnes & Shaan Waqar *Gels:* Donnie Isseroff & Ezra Katz 12:45 PB Manuscript Writers: Continue discussions on Manuscript Preparation
Week of 7/28	28 10:00-11:00 Dr. Kash Mittal, Editor Journal of Adhesion Science and Technology, Room 301 1 pm Dr. Richard Clark Microscopy III, room 143 11:30 Work on Projects	29 10:00-10:30: General Organization Meeting 11:30 Work on Projects	30 10:00-10:30 General Organizational Meeting 11:30 Work on Projects 4:15 Softball game	31 10:00-10:30 General Organizational Meeting 11:30 Work on Projects	1 10- 11:30 Group Meeting Presentations: *Crystalline Polymers:* Vivek Kuncham & Maanasa Indaram *Blends in Supercritical CO_2:* Steven Lubin & Mitchell Fourman *Patterning for Tissue Engineering:* Christine Ahn

Week of 8/4	4 10:00-10:30: General Organization Meeting 11:30 Work on Projects	5 10- 10:30 Mrs. Krieger LISEF checkup	6 10:00-10:30: General Organization Meeting 11:30 Work on Projects	7 10:00-10:30: General Organization Meeting 11:30 Work on Projects	8 10- 11:30 Group Meeting Presentations: *Nanotubes:* Jonathan Hefter & Michael Goldman *Dewetting of di-Blocks:* Paul Marx & Aditi Ramakrishnan *SCF Technology:* Amy Brazin *Tissue Culturing:* Jennifer Braverman *DNA Electrophoresis w/ Obstacles:* Stanley Chiang *Starch w/ Plasticizers:* Joel Herzfeld *SCF and Polymer Brushes:* Chelsea Gordon & Sylvia Qu *Magnetic Nanoparticles and Enzymes:* Josh Etman Get final symposium abstracts to Nancy's computer
Week of 8/11	11 10:00-10:30: General Organization Meeting 11:30 Work on Projects	12 10 – 12 Group Meeting Presentation*: Dr. Robert Shaler, Chief of NYC Forensic Science – DNA Electrophoresis and Forensic Science* Room 231 3 pm - Dr. Steve Schwartz, Queens College – Rheology of Polymers	13 10 – 12 Group Meeting Presentations: *Gold Nanotubes & Electrical Properties:* Matt DiPasquale *Nanocomposites:* Bradley Schwartz *DNA:* Jack Jacob *Patterning & Protein Org.:* Andrew Schuer & Jessica Fields *Wound Healing:* Vandana Sood & Ayla Bloomberg *DNA Electrophoresis:* Evan Hertan, Amit Mehta, & Robert Samstien *Cancer vs. Normal Cells:* David Spencer 12:30 Work on Projects 3 pm – Saumya Sharma – Optional Presentation 9 – 11 pm Boat Ride in Port Jefferson Harbor to watch the meteor shower Perseid	14 10 – 11 Group meeting split up into symposium groups to organize and rehearse REUs must get all presentations onto a zip disk 11:30 Last minute work on projects	**15** **End of Summer Research Presentations SAC Ballroom A 10 am- 3pm**

Attention Undergraduate Students
Involved in Research

The Journal of Adhesion Science and Technology

is Now Accepting Submissions for a

Special Issue dedicated to Undergraduate Research in Adhesion Science

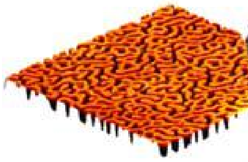
Submissions may be faxed to M. Mittal
Fax: 845-226-5174
Or E-mailed to M. Rafailovich
miriam.rafailovich@sunysb.edu
(PDF preferred or MS Word Files)
Deadline for Submissions: November 15, 2003

Editor: K. L. Mittal

Student Editorial Board for the Special Issue

GARCIA CENTER

RESEARCH SCHOLAR SYMPOSIUM



Garcia MRSEC

Polymers at Engineered Interfaces

NSF

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

August 18. 2003

Garcia Research Scholar Symposium, August 18, 2003

10:00 Welcome
10:05 - 10:20 *Mr. Albert Hoser, Ceo Siemens Foundation*

10:20 - 10:45 Session 1: Polymers In Supercritical Fluids
Chairs:, *Mordechai Bronner*

Gregory Parnes, Saan Waqur	Effects Of Supercritical Co_2 On The Mechanical Properties Of Ps/Eva Blends With Clay Nanocomposites
Steven Lubin	Etching And Exposure Of Thin Films Of Ps-Pmma On A Gold Substrate To Supercritical Carbon Dioxide
Mitchell Fourman	The Effects Of Supercritical Carbon Dioxide On Ps-Pmma, Pmma-Eva, And Pmma-Pb Polymer Blends
Chelsea Gordon, Sylvia Qu	Determining The Solubility Parameters Of End-Grafted Polystyrene In Supercritical Fluid
Amy Brazin	The Effects Of Nanoparticles In Ps When Exposed To $Scco_2$
Aryeh Reinstein, Mordechai Bronner	The Effect Of $Scco_2$ On The Porosity Of Polymers
Adam Lempel	The Effect Of Supercritical Carbon Dioxide On The Adhesion Of Polymers And Metals
*Robert Fisher And Abigail Maller	Investigating The Effects Of Reannealing Co2 Exposed Polymers

10:45 - 10:55 Session 2: Organic/ Inorganic Nano-Composites
Chairs: *Michael Goldman, Michael Snow*

Christopher Becker, Matthew Schlossberger, Michael Snow	The Effect Of Clays On Adhesion
Jonathan Hefter, Michael Goldman	High Performance Pmma/Carbon Nanotube Nanocomposites
Bradley Schwartz, Robert Fisher	Adding Clay To Recycled Polymer Blends

10:55-11:15 Session 3: Dna On Surfaces
Chairs: *Robert Samstein, ,*

Amit Mehta, Evan Hertan	Dna Surface Electrophoresis And Analysis Of The Eof
Saumya Sharma	Surface Electrophoresis Using Indium Tin Oxide And Nickel
Jack Jacob	Single Dna Molecule Imaging By Surface Electrophoresis
Eric Peterson	Dna Surface Electrophoresis On Micro-Patterned Surfaces
Avtar Singh	Electrophoretic Study Of Albumin And Other Proteins
Stanley Chang	Optimizing Electrophoresis Through Novel High-Dimensional Microlithographic Arrays

11:10-11:25 Session 4: Polymer Thin Films
Chairs: *Arielle Galambos*

Aditi Ramakrishnan, Paul Marx	The Effect Of Ps-Pmma Diblock Co-Polymer On Dewetting At The Ps-Pmma Interface
Arielle Galambos	Two And Three Dimensional Structures Of Diblock Copolymers At The Air/Water Interface
Sean Mehra, Jeffrey Reitman	Using Nanoparticles To Enhance Polymer Properties For Improved Commercial Applications: Space Lubricants To Nanolithography
Maanasa Indaram, Vivek Kuncham	Surface-Induced Crystallization Of Ethylene Vinil Acetate On Modified Metallic Substrates

11:25- 11:45 Session 5: Nano-Particles

Chairs: *Aprajita Matoo*

Micha.L Forman, Chani Schonbrun	Synthesis And Characterization Of Pdc$_{12}$ Nanoparticles Synthesized By The One-Phase And Two-Phase Processes
Joshua Etman	Immobilization Of Proteinase K Onto γ-Fe$_2$o$_3$ Nanoparticles
Arthur Yu	Functionalization Of Yttrium Aluminum Garnet Nanoparticles Using Ultrasonic Bath
Matt Dipasquale	Fabrications And Electrical Characteristics Of C18 Gold Nanoparticles
Nik Ray-Mazumder	The Effect Of Hydrophilic And Hydrophobic Gold Nanoparticles On Cf-31 Fibroblast Growth
* Jessica Jiang	Synthesis Of Fe And Fe Based Alloy Magnetic Nanoparticles In A Polymer Matrix Polymer Matrix

11:45-12:05 Session 6: Biomolecular Self Assembly

Chairs: *Donnie Isseroff, Lenny Slutsky*

Solid Surfaces:

Ayla Bloomberg, Vandana Sood	Glucose Effect On Ecm Proteins And Glycosylation Reaction Related To Diabetics
Jennifer Braverman	A Novel Method Of “On-On” Cell Patterning On Polymer Surfaces
Jessica Fields, Andrew Scheur	Patterning Applied To Protein Organization And Cell Adhesion
Madelyn Ho	Surface Topography Influence On Actin Organization
Christine Ahn	Growth And Manipulation Of Cells On Photosensitive Polymer With Protein Substrate

Ha Hydrogels

Eric Mansfield, Ezra Katz, Donnie Isseroff	An Analysis Of The Viability Of Phase Separation Methodology For The Creation Of A Porous Matrix Of Thiolated Hyaluronic Acid
Sravanesh Muralidhar	Viscoelastic Properties Of Fibroblasts Seeded On A Hyaluronan (Ha)/Recombinant Fibronectin (Rfn) Composite Behave As A Function Of Cross-Linking Density And Rfn Functional Domains
Helen Kyd, Sagar Mehta	Mechanotransduction, Fibroblast Migration, And Fibroblast Adhesion On Modified Hyaluronic Acid (Ha) Hydrogels

12:05- 12:35 Chinese Buffet and Audiovisual presentation Eric Petersen and Sylvia Qu

12:35-12:55 Session 7: Cells On Surfaces

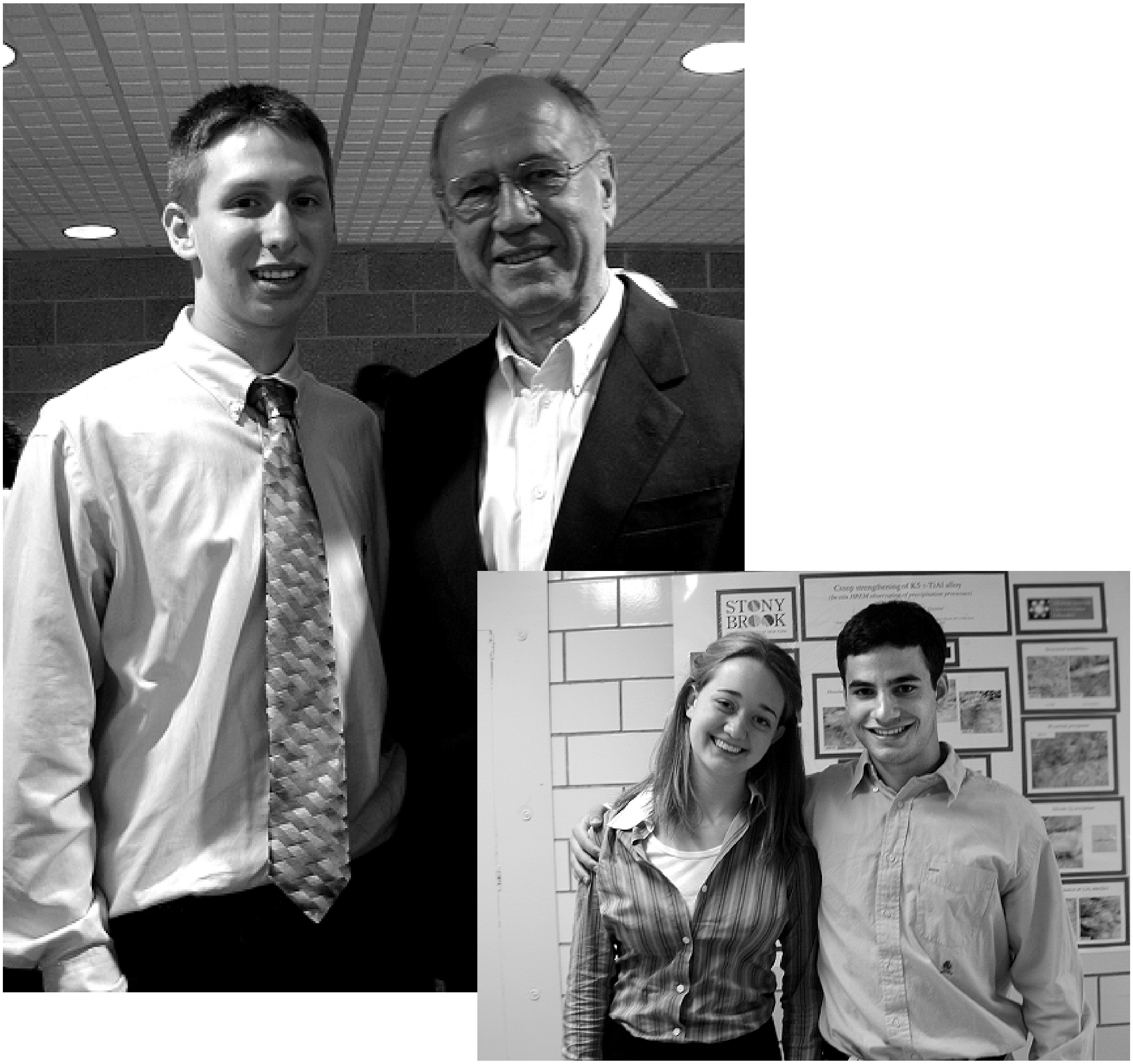
Chairs: *Stephanie Kaszuba, Tedi Setton,*

Spencer Park	Mechanical Properties And Ecm Formation Of Cancer Cells
Aliza Lopchinksy	Attachment Of Fibroblasts Onto Non-Enzymatically Glycated Fibronectin Coated Surfaces
Sarah Lefkovitz, Alan Masand	The Effect Of Various Polymers On Dermal Fibroblast Growth And Function
Benjamin Cohen, Daniel Lubelski	The Effect Of Different Polymers On Proliferation Of Mc-3t3-E1 Osteoblast-Like Cells

12:55- 1:15 Session 8: Bio/Medical/Commercial
Chairs *Aprajita Matoo*

Tanmany Chedda, Andrew Song	Pluronic Hydrogel As A Nucleus Pulposus Replacement In The Treatment Of Herniated Discs
Joel Herzfeld, Aprajita Matoo	Creation Of Biodegradable, Water-Soluble Polymers
Joshua Etman, Benjamin Cohen	Determining The Effectiveness Of Chitinase On The Growth Of A Microorganism Consortium
Andrew Lillian, Philip Stern	Database Organization From Patient Files
*Sara Rafailovich-Sokolov	Facial Recognition Using Digital Image Speckle Correlation
*Dena Nachman	Attention Deficit Hyperactivity Disorder In Adults

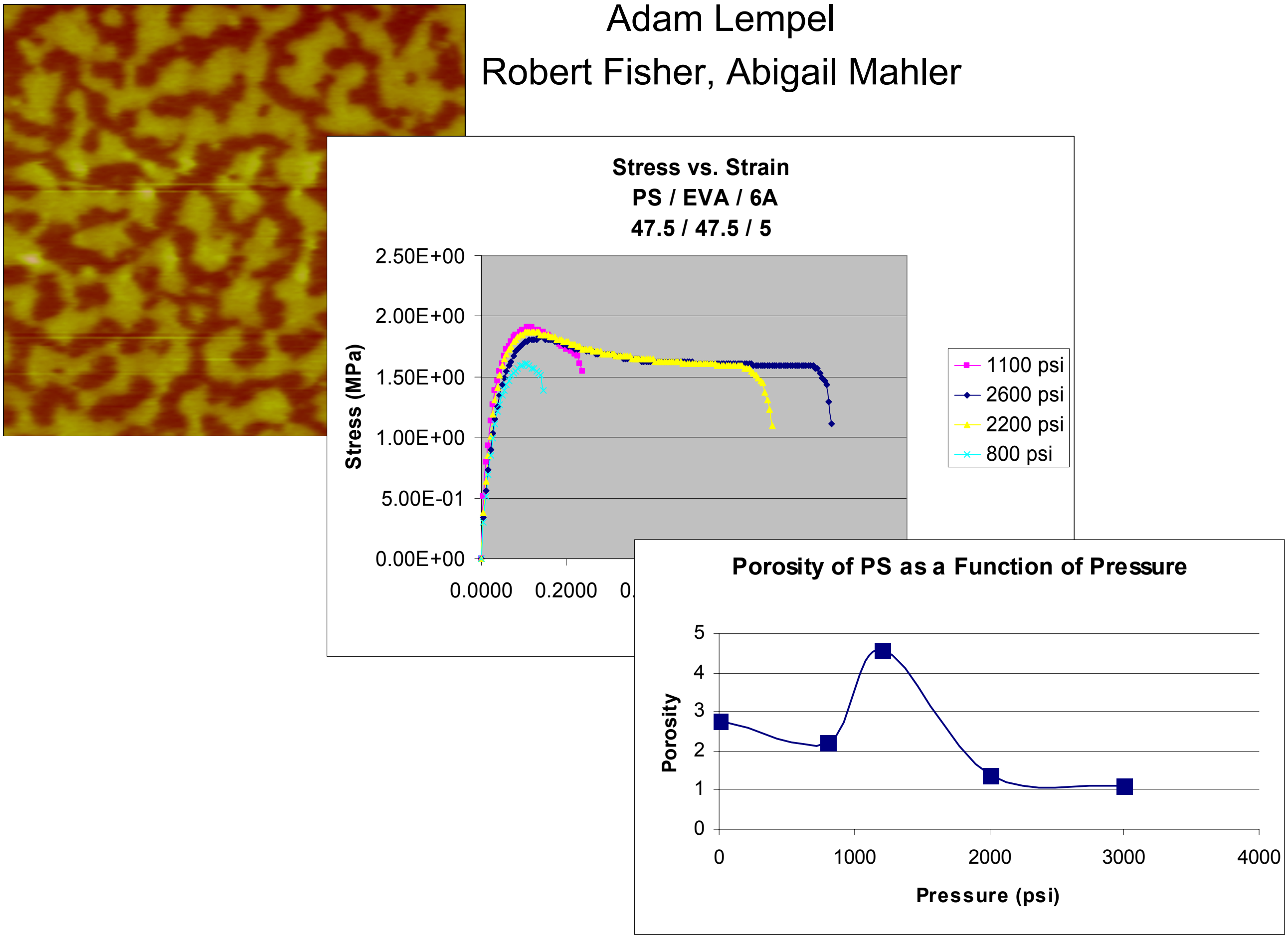
* Students Unable To Attend The Rescheduled Proceedings.



Session 1: Polymers in Supercritical Fluids

Chair: Mordechai Bronner

Gregory Parnes, Saan Waqur
Steven Lubin
Mitchell Fourman
Chelsea Gordon, Sylvia Qu
Amy Brazin
Aryeh Reinstein, Moedechai Bronner
Adam Lempel
Robert Fisher, Abigail Mahler



Effects of Supercritical CO_2 on the Mechanical Properties of PS/EVA Blends with Clay Nanocomposites

Gregory Parnes, HAFTR High School
Shaan Waqar, Half Hollow Hills H.S. East
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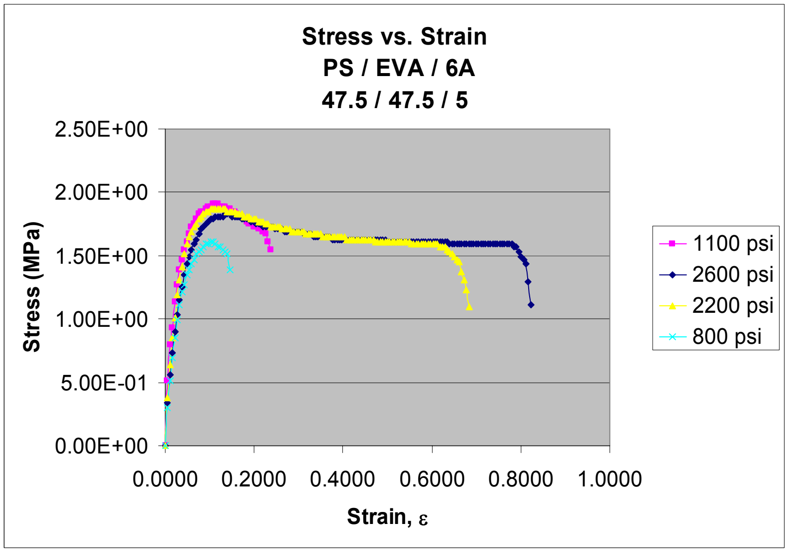
A supercritical fluid is a substance that exhibits both liquid-like and gas-like properties. One cannot distinguish between a substance's liquid phase and gas phase once the substance has turned supercritical. (1, 2) To become supercritical, a substance must exceed its critical pressure and temperature. Previous research has demonstrated that bulk plastic samples' morphology is adjusted by treatment with a super- or sub-critical gas such as CO2. (3)

The purpose of this study was to use supercritical CO_2 to improve the mechanical properties, such as the modulus of elasticity, of polymeric plastics in various ratios. The polymer used was Polystyrene (PS) / Ethylene Vinyl Acetate (EVA) with Cloisite 6A clay nanocomposites. The blends were exposed to various $scCO_2$ pressures at isothermal conditions (97^oF). Our goal was to discover the optimal $scCO_2$ pressure and the optimal ratio of PS/EVA/Cloisite 6A to be used to observe the most ductile material. The ratios of PS/EVA/Cloisite 6A clay that we used were 47.5/47.5/5, 45/45/10, 48/48/4, and 49/49/2. These ratios were prepared using a twin-screw extruder and samples were created using the dogbone molds and heat press. The samples were then exposed to various pressures of $scCO_2$. It was hypothesized that the ratio with the least percentage of clay would be tougher than ratios with higher percentages of clay, and also that increasing the $scCO_2$ pressure that the sample was exposed to would cause an increase in toughness.

Toughness can be seen from the area under the curve of a Stress-Strain curve. Results from Instron (Figure 1) testing of the 47.5/47.5/5 ratio show that $scCO_2$ exposure definitely leads to a stronger material. Figure 2 illustrates that the sample subjected to the highest pressure of $scCO_2$ resulted in the toughest material (which is also the most ductile).

Figure 1 – Instron Tester: Tinius Olsen H5KS

Figure 2 – Stress-Strain graph for 47.5/47.5/5 ratio



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Attention Deficit Hyperactivity Disorder in Adults

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Background: There is so much discussion in the lay press regarding diagnosis of attention deficit hyperactivity disorder (ADHD) in adults. It is important to make a correct diagnosis on these patients as treatment for each of the attention deficit disorders. While there are many screening tools for diagnosing ADHD in children, there are few structured evaluations of screening tools useful in making the diagnosis of ADHD in adults.

Materials and Methods: As part of developing a screening tool to be used in evaluation adults for ADHD, the literature was surveyed for useful categories of ADHD. Using Medline, MD consult, and Psychlit all papers discussing attention deficit in adults were reviewed. Search categories included drug and alcohol abuse and dependence, familial hyperactivity disorders, anxiety disorders, and depression disorders.

Results: Attention deficit disorders are associated with a higher risk of affective disorders in family members(1). 30-50% of children with ADHD become adults with ADHD (2) . Drug abuse in adolescents is predictive of substance abuse and ADHD as adults (3). These categories among others would be use in developing a screen tool to be used in diagnosing adult ADHD(5).

Conclusions: A short screening tool needs to be developed to diagnose adult ADHD. It should include brief sections on childhood experiences (school and friends), substance abuse and dependence, and antisocial behaviors. This tool will need to be validated on adolescents as they age into adulthood.

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Etching and Exposure of Thin Films of PS-PMMA on a Gold Substrate to Supercritical Carbon Dioxide

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Supercritical fluids (SCFs) have properties that are between that of a liquid and a gas, such as density, viscosity, and diffusivity. SCF technology has recently been studied in applications such as solvents and foaming agents due to their adjustable solvent strength, ability to plasticize many polymers, and their ability to enhance diffusion rates.[1] SCFs, specifically supercritical carbon dioxide (SC CO_2), have also been shown to compatibilize normally immiscible polymer blends.[2] This project sought to find the effects of both etching and exposure to SC CO_2 on polymer blends of polystyrene and polymethyl methacrylate (PS/PMMA).

An E-beam machine was used to create a thin layer of chromium and a layer of gold on a silicon substrate. A polymer blend of PS/PMMA was spun cast onto the Au substrate of two different thicknesses. The thinner thickness samples were annealed at 170°C for two days. Half of the samples of each thickness were exposed to SC CO_2 at the density fluctuation ridge. They were then etched for two, four, six, eight, and ten minutes using the ion mill. The other samples were first etched and then exposed to SC CO_2 at the same conditions. Atomic Force Microscopy (AFM), which measured topography and lateral force, was used to determine phase separation between the two polymers. Furthermore, Scanning Electron Microscopy (SEM) (Figure 1), which produced ultra-magnified images, was used to confirm AFM results.

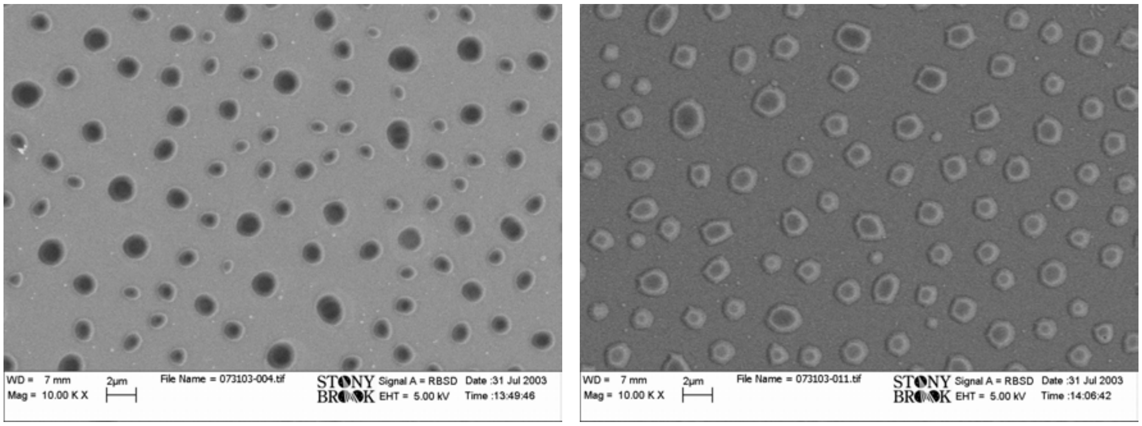

Figure 1: Five hundred angstroms of PS-PMMA on Au exposed to SC CO_2 then etched for 2 minutes (left) and 10 minutes (right). (SEM image magnified 10,000 times)

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The Effects of Supercritical Carbon Dioxide on PS-PMMA, PMMA-EVA, and PMMA-PB Polymer Blends

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Ronald Occhiogrosso Ph.D., HAFTIR
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Ductility and tensile strength are the two most important qualities of the ideal plastic. However, these two qualities are difficult to achieve in the same material, as most flexible polymers are very weak, and many strong polymers are very brittle. Therefore, a way to combine these qualities must be found. A polymer blend is one way to solve this problem. Because many polymer blends are incompatible, the blends that form are often brittle and weak[1]. Supercritical fluids are the answer to this situation. Supercritical fluid exposure can cause a “foaming effect” in the material, which releases many of the “pressure points” formed because of incompatibilities.

The polymers analyzed in this investigation include Polystyrene (PS), Poly(methyl-methacrylate) (PMMA), Ethylene Co-Vinyl Acetate (EVA, also known as Elvax), and Polybutadiene (PB). These polymers were combined to produce PS-PMMA, PMMA-EVA, and PMMA-PB. Different proportions of the subject polymers were analyzed as well. The blends were created by a C.W. Brabender heat intercalation device. Samples were formed using mold templates, and the resulting materials were exposed to supercritical carbon dioxide (SC CO_2).

Methods of analysis include Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM) for surface and cross section scanning respectively. Dynamic Mechanical Analysis (DMA) testing was used to determine modulus vs. temperature as well as an approximate glass transition temperature (T_g). SEM and TEM data showed dramatic changes in material composition and topography after exposure to SC CO_2. A sample such as PMMA-EVA showed a very chaotic surface before CO2 exposure, which was drastically evened out as a result of the exposure (Figure 1). DMA demonstrated a change in the slope of the modulus curve, and a merging of the two Tgs after exposure. Different proportions of the material witnessed different magnitude of reaction, indicating some polymers are more susceptible to SC CO_2 than others. Future work involves the addition of PS-PB blends, as well as X-Ray analysis

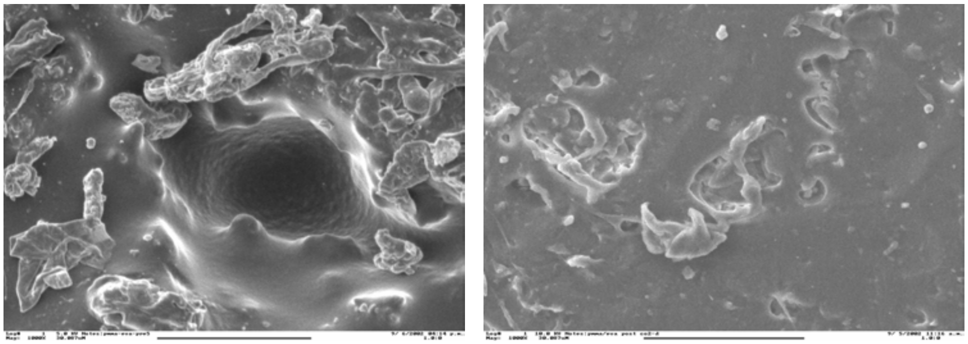

Figure 1: Left. SEM of PMMA-EVA before exposure. Right: SEM of PMMA-EVA 50/50 after SC CO_2 exposure at 115^{o}F and 1200 psi(g)

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Confinement: A Novel Procedure to create Ultra-Thin Materials Using Supercritical Fluids

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We have measured the phase separation of PS-PMMA in confinement and exposed to supercritical CO_2. Then, following the film preparation, no phase separation occurred in the films. Phase separation of the blend is initiated by heating the film above the glass transition temperature of both polymers. We also observe complete phase separation after the polymer blend has been exposed to supercritical CO_2 at 36^oC for three hours. This investigation focused on the effects of supercritical fluids on PS-PMMA, dPS-PMMA, and PS-PB polymer blends confined between silicon and a silicon oxide (SiO_2) layer.

Supercritical fluid (SCF) technology has recently been studied in applications such as polymer processing, polymer synthesis, reactor clean-up, and preparation of pharmaceutical products.[1] SCFs, specifically supercritical carbon dioxide (SC CO2), has also been shown to compatibilize normally incompatible polymer blends (Figure 1).[2]

Samples were analyzed using scanning electron microscopy (SEM), as well as atomic force microscopy (AFM). Witnessed on the samples was a phase separation in which one polymer formed a dot like pattern among a "sea" of the other polymer. Upon the application of cychlohexane acid, an acid that dissolves Polystyrene, the polymer that the dots were made out of was determined. When different concentrations of PS and PMMA (1:3 and 3:1) were used, we observed some lamellar transformation upon the removal of the SiO_2 capping layer, especially in the 1:3 ratio of PS-PMMA. In this ratio, the size of the dots varied significantly, as well as their order being less uniform.

Applications can be found in laser technology, where ultra thin materials are needed to serve as a buffer between devices. These materials also can be used as a sheath for wires, thus allowing them to be bunched more densely, and more effectively. Future work will involve Polyethylene, which has a very high density, and thus will be very reactive in confinement, as well as in a supercritical environment.

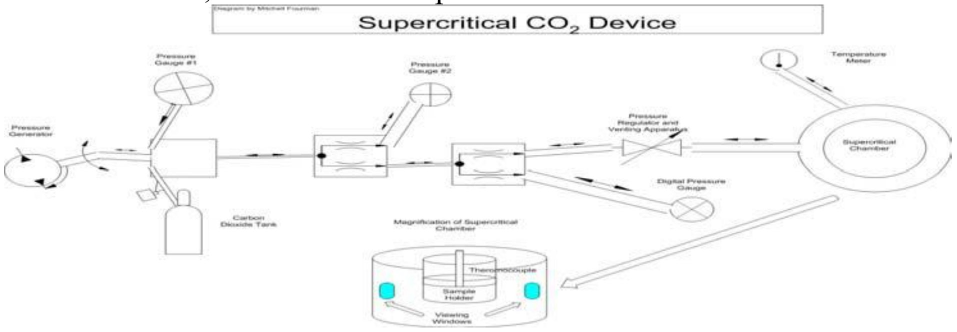

Figure 1: Diagram of the Supercritical CO_2 Device

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[1] Koga, Tadanori et al. "Density-Fluctuation-Induced Swelling of Polymer Thin Films in Carbon Dioxide" *Phys Lett,* **89,** 12 2002.
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Determining the Solubility Parameters of End-Grafted Polystyrene in Supercritical Fluid

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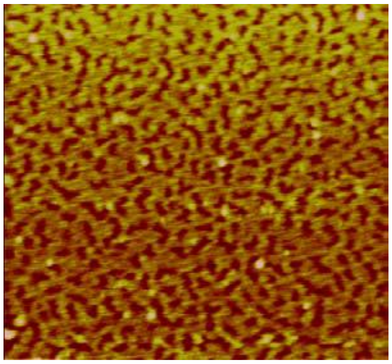
End-grafted polymers, also known as polymer brushes, have recently been recognized not only for their unique properties, but also for their technological applications. Due to their immobilization on a substrate, they are significant in processes such as chromatography, and lubrication.[2] Brushes are also utilized in the stabilization of colloids by preventing particle aggregation.[1] Because they are tethered to a surface, they are optimal materials for determining solubility because they can stretch without being removed from their original surface. Determining a polymer's solubility parameters in supercritical fluids is important because once such data is obtained, the temperature and pressure necessary in order to dissolve a polymer can easily be determined for future experimentation.

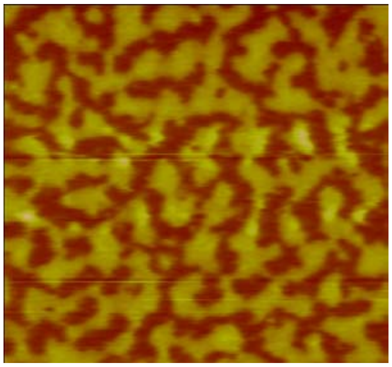
Polymer brushes were created by spinning COOH end functionalized polystyrene of molecular weights 10K, 50K, and 380K onto clean silicon substrates to thicknesses of one, two, and three radii of gyration. The polymer was then annealed overnight so that the carboxyl group at the end of the polymer chain reacted with the silicon and attached to it. Once the polystyrene was annealed to the surface, the excess, unreacted polymer was rinsed from the silicon using toluene. A thin layer of tethered polymer remained, and its thickness was measured using an ellipsometer. The topographies of the brushes were then examined through atomic force microscopy, as shown in Figure 1. The samples were exposed to supercritical CO_2 at 36°C and 1,200 psi for two hours. The thickness of each sample was then measured once more, and its topography was viewed through atomic force microscopy. The resulting image is shown in Figure 2. The same procedure will be repeated for pressures of 700, 1450, and 1700 psi using both supercritical CO_2 and supercritical ethane. A computer simulation will then be employed to determine the effects of supercritical fluids on polystyrene polymer brushes.

Preliminary results have shown that supercritical CO_2 causes a swelling of the end-grafted polymers. The average increase in thickness due to supercritical exposure at 36°C and 1,200 psi was 22.1 angstroms. The topography, as seen by atomic force microscopy, also changed as the polymer's environment changed from that of a poor solvent to that of a good solvent. After experimentation, the solubility of polystyrene in supercritical CO_2 and supercritical ethane at specific pressures can be obtained by reviewing the data.



1.86 microns

Figure 1



1 micron

Figure 2

Figure 1. PS polymer brush before exposure to supercritical CO_2.
Figure 2. PS polymer brush after exposure to supercritical CO_2.

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The Effects of Nanoparticles in PS When Exposed to Supercritical CO_2

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Nanotechnology has a wide range of applicability. The new process incorporates nano-sized particles to tailor structure needs and desires to specific fabricated end products. By integrating the dynamic effect of supercritical CO_2 with the new nanotechnology frontier, the properties of polymers can be enhanced and/or changed. The use of supercritical CO_2 is an especially important technique used today in order to replace environmentally hazardous solvents such as chlorofluorocarbons.

After exposure to supercritical CO_2, polystyrene (PS) swelled and became porous[1]. Gold (Au), Palladium (Pd), Cloisite 6A (clay), Collodial Silica, and carbon nanotubes, all in the form of nanoparticles, were added to solutions of PS in order to observe if the nanoparticles enhanced the swelling and porosity of the PS after being exposed to supercritical CO_2. Thin films of PS with nanofillers were floated side-by-side on silicon wafers to compare the swelling of the PS against the PS with the nanofillers. The thicknesses of each film were measured with the ellipsometer and were recorded. Each of the wafers was then subjected to supercritical CO_2 at 1200 psi and 36˚C for about an hour. Measurements of the new thicknesses were taken. Except for the clay nanofiller, each of the nanofillers (in PS) swelled to a similar amount as the PS film. The clay nanoparticles greatly affected the CO_2 adsorption by increasing the thickness by an average of 67.5%.

Atomic force microscope (AFM) images were taken of the Au/PS film and the Pd/PS film to study the porosity due to the addition of nanoparticles and SCF.

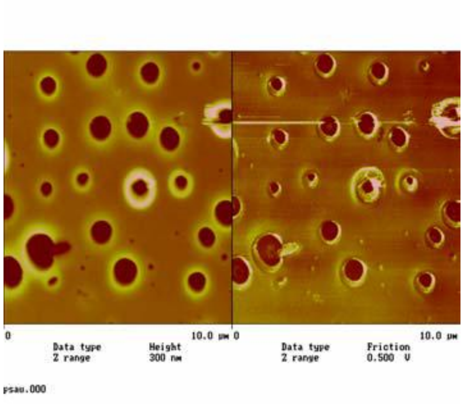

Image 1 (left): Au/PS exposed to SC CO2 with noticeable porosity.

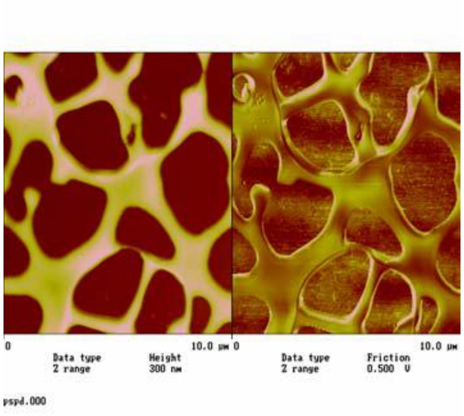

Image 2 (right): Pd/PS exposed to SC CO2 with increased porosity in comparison to PS film with Au nanoparticles.

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The Effect of $scCO_2$ on the Porosity of Polymers

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Mordechai Bronner, Yale University
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The ability to vary the permeability of gases in polymers has many applications in both commercial and security spheres. The purpose of this experiment was to find the means to selectively allow specific gases through a polymer thin film at fixed rates. For this experiment, different thicknesses of Polystyrene (280k, 65k, 650k, 900k, 2000k, 4000k) and Polymethyl-methacrylate (120k, 238k) were spun cast at 2500 rpm for 30 seconds onto glass slides. The thin films were then floated onto washers and tested for permeability to O_2 and CO_2 using their respective LabPro™ detectors. The experiment was then repeated with a new set of spun cast glass slides of the same thicknesses which were exposed to $scCO_2$ prior to floating. The glass slides were subjected to 1200 psi at 36°C for 60 minutes. The psi level was varied for one thickness to test for changes in porosity as a function of pressure. In addition, the time spent in the $scCO_2$ chamber was varied for one thickness to determine its effect on the polymer's permeability.

Our experiment showed that an increase in thickness resulted in a linear decrease in porosity in both polymers (see Figure 1). An increase in molecular weight had the same effect. Supercritical CO_2 increased the permeability of the polymers regardless of thickness or molecular weight. This is attributed to the swelling of the polymer induced by the $scCO_2$ [1, 2]. A sharp maximum in permeability was found at 1200 psi (see Figure 2).

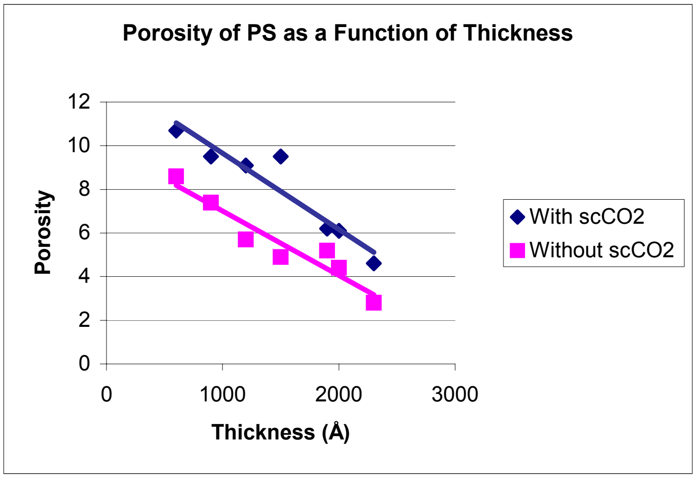

Figure 1. Porosity of PS, with and without $scCO_2$, as a function of thickness

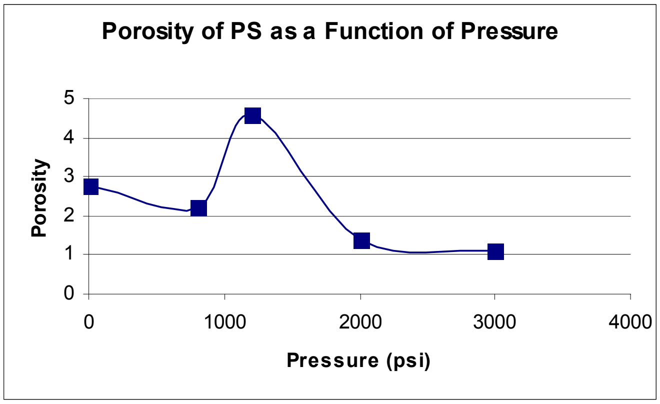

Figure 2. Porosity of PS (2300 Å) as a function of pressure

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The Effect of Supercritical Carbon Dioxide on the Adhesion of Polymers and Metals

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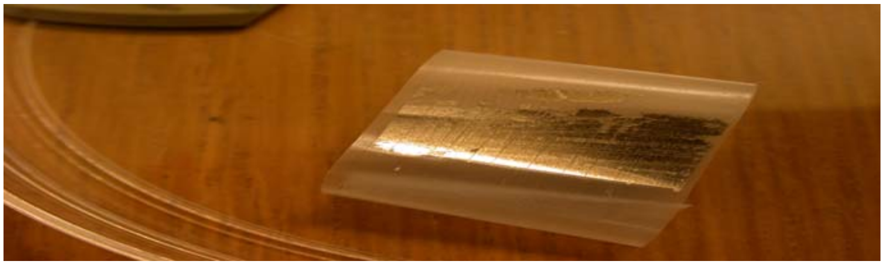
Polymer-Metal interfaces are found in many different applications of modern life from Teflon coated cookware to printed circuits on kapton. Polymers and Metals generally do not stick together well and therefore it is important to develop techniques to increase adhesion. Supercritical Carbon Dioxide has had some surprising results in the field of polymer research. It has been shown (at the Materials Science Labs at Stony Brook) to dissolve certain polymers (PMMA and EVA for example) and it has been shown to increase the bond strength in polymer blends. Koga has shown that supercritical carbon dioxide has the effect of decreasing the viscosity of polymers while increasing the number of voids. It is therefore feasible that supercritical carbon dioxide can have an effect on the adhesion properties of metals and polymers as an increased number of voids exposed to metal vapor can lead to a stronger interface.

The purpose of the research is to determine the effectiveness of the supercritical carbon dioxide on the adhesion properties of the polymers and metals. PMMA, Polystyrene, Polycarbonate thin films will be used with chromium or gold metal. Bulk Kapton will also be tested to see if the properties were affected. The thin film samples will be spun cast onto silicon wafers and then metalized. They will then be examined with an X-ray spectrometer to determine the interface width. Peel tests following ASTM – d3359 standards will then be applied. (Fig 1.) Peel test comparisons will be applied to all of the samples.

Fig 1. Piece of tape after ASTM d3359-02 Tape Peel Test



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Europhys. Lett., **60** (4), pp. 559–565 (2002)

ASTM Standard d3359 – 02, ASTM, 2002.

Investigating the Effects of Re-annealing Supercritical CO_2 Exposed Polymers

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Abigail Maller, Columbia University
Edmund Palermo, Cornell University
Miriam Rafailovich, Dept. Materials Science and Engineering, SUNY Stony Brook

Exposure of PS EVA blends to Supercritical Carbon Dioxide (scCO_2) has been shown to greatly increase the compatibility of the two polymers and thereby change their mechanical properties.[1] This change of properties creates a blend which could be used for various industrial purposed such as in athletic footwear and car bumpers. In order to determine the feasibility of molding the blend after exposure to scCO_2, several tests were done to determine how heating affects the properties of the post exposure blends.

Contact angles of PS EVA 50:50 thin films were measured using Atomic Force Microscopy (AFM) before and after annealing. The films were then exposed to scCO_2 and contact angles were re-measured. Finally, the samples were re-annealed, and contact angles were measured a final time. This process was mimicked using bulk samples of PS EVA that were blended in a twin-screw extruder. The blended samples were then pressed into rectangles. The modulus of elasticity of the rectangles was measured before and after exposure to CO_2, they were then heated above their Glass Transition Temperature (T_g), while under pressure, and the modulus was re-measured. These methods were used to determine whether heating the polymers over their T_g reverses the effects of scCO2. Preliminary results indicate that the contact angle of the films increases after annealing as can be seen in figure 1; decreases after exposure; and then after the samples are re-annealed, increases to a level between those measured after the first annealing, and after exposure to scCO_2. In the bulk samples, similar results were found. The modulus of the samples decreased after exposure to scCO_2 but after re-melting, the samples did not retain their original rigidity. Further testing will include measurement of the effect of re-melting on tensile strength and glass transition temperature of the blends. These preliminary results indicate that the effect of the scCO_2 is not fully reversed by heating the polymers. This means that should further testing bear out what we believe we have already started to prove, scCO_2 can be used as a tool for creating novel materials in industrial settings.

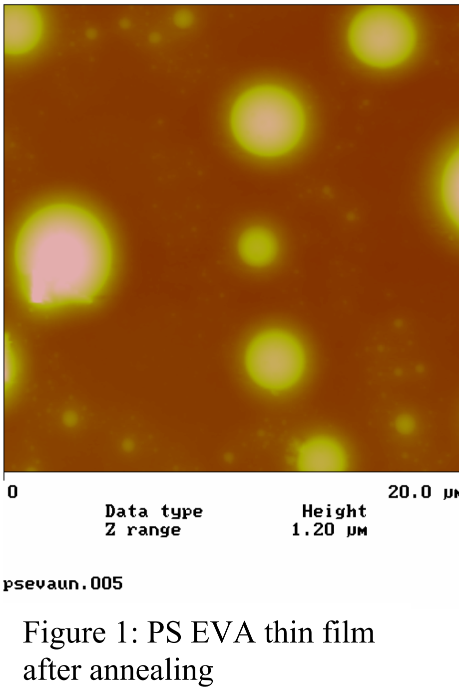

Figure 1: PS EVA thin film after annealing

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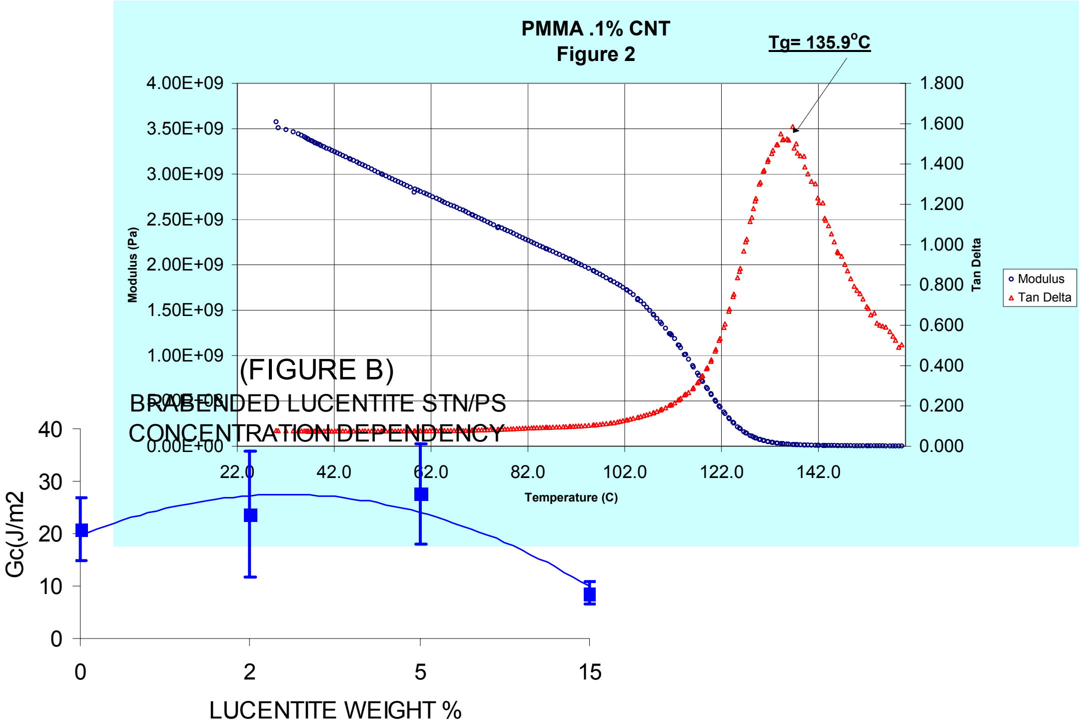
[1] Palermo E. et al. “Optimization of physical properties in a polystyrene / ethylene-co-vinyl acetate blend using supercritical carbon dioxide” submitted for publication

Session 2: Organic/Inorganic Nano-Composites

Chairs: Michael Goldman

Michoel Snow

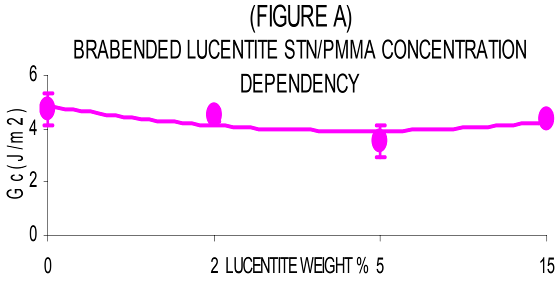
Christopher Becker,Matthew Schlossberger,Michoel Snow
Jonathan Hefter, Michael Goldman
Bradley Schwartz,Robert Fisher

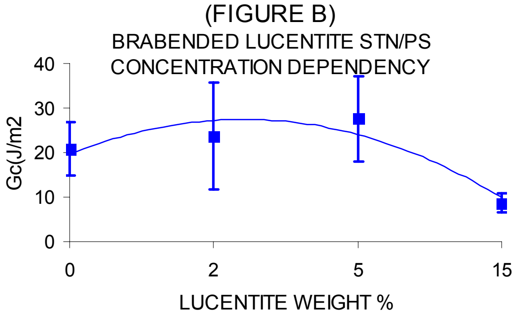


The Effect of Clays on Adhesion

Chris Becker, Locust Valley High School
Matthew Schlossberger, Plainview Old Bethpage JFK High School
Michael Snow, Cornell University
Miriam Rafailovich, Department of Materials Science and Engineering

Our research this summer consisted of testing two polymers, polystyrene and Poly(methyl methacralate). Both polymers are essential parts of everyday life, polystyrene being the second most popular polymer used as a plastic on the market today. If you used a car, a computer, a plastic cup or almost any other plastic today, you've dealt with polystyrene. Poly(methyl methacralate), better known in everyday living as Plexiglas, is also a vital part of daily living. With the high use and demand for these two polymers, the strength and versatility of these substances is constantly being studied or improved upon. [1] Adhesion is a topic of concern for polymer scientists, many spending entire lifetimes to find the ideal adhesion mixture for such popular polymers as polystyrene. Our research introduced artificial clays, with the trade name Lucentite, to the two polymers at different percentages and annealing times. The four Lucentites studied, Lucentite SPN, Lucentite SAN, Lucentite SEN and Lucentite STN were all tested at 2%, 5%, and 15%. To test these artificial clays, they would be mixed with the corresponding amount of polymer to make a 50 gram sample. This sample would be mixed in the brabender at 170° Celsius for 10 minutes, and then shaped into wafers. These wafers would then be annealed together at 160° Celsius for 6 minutes, using 1.5 tons of pressure to allow adhesive bonds to form due to entanglements between the polymer chains. These new annealed wafers are cracked using the Asymmetric Double Cantilever Beam tester. This testing method involves cracking the interface of the annealed wafers and measuring the propagation of the crack. This measurement allows for the calculation of the fracture toughness (Gc) of the polymer/artificial clay mixture. [2] In comparison to these brabended samples, the artificial clay mixtures would be spun on the polymer wafers. The spin-casting would be at 2500 RPMs for 20 seconds, enough to fully exfoliate the clay throughout the polymer. Then the wafers would be annealed together with the artificial clay at the interface to determine if this method of adhesion was stronger and more efficient. Both of these tests were also performed on Clay Cloisite 6A as a comparison of natural clays to artificial clays. We found that, when dealing with Poly(methyl methacralate), the Lucentites produced varied effects on Gc. In Lucentite SEN, there was an increase then a decrease in fracture toughness, peaking around 2% Lucentite. There was a general decrease in Gc of Lucentite STN mixtures, with a dip at 5%. (Figure A) There was also a decrease in Lucentite SPN. With polystyrene, there was a much larger fracture toughness, with nearly the same trends. In Lucentite STN we found an increase, then a rapid decrease in Gc. (Figure B) In Lucentite SAN, there was a decrease as the percentages grew. In addition to these findings, we hope to find the results for the remaining Lucentites, as well as Clay Cloisite 6A, an inorganic filler which imparts many beneficial bulk properties.





Figures. (a) Fracture Toughness Brabended Lucentite STN/PMMA Concentration Dependency of 0%, 2%, 5%, and 15%
(b)Fracture Toughness Brabended Lucentite STN/PS Concentration Dependency of 0%, 2%, 5%, and 15%

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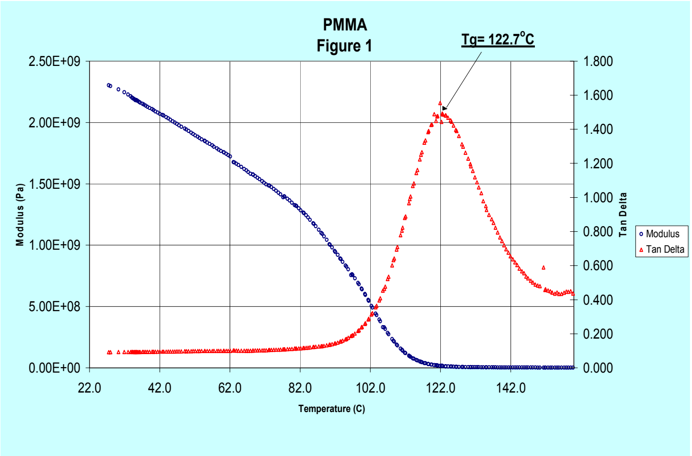
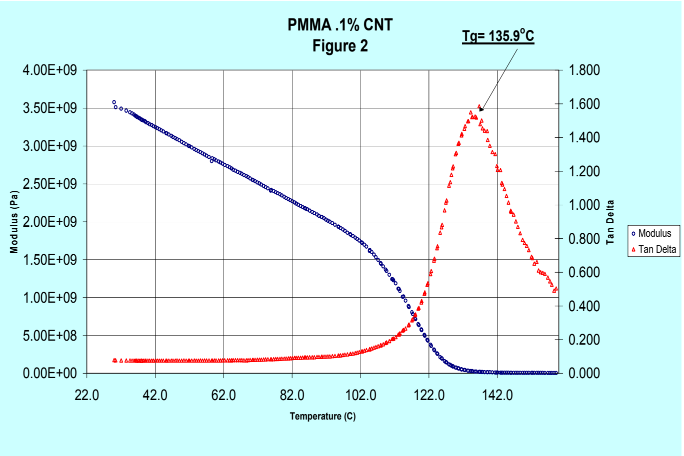
[2] Dai, Chi-An, Edward J. Kramer, et all. **"**Fracture Toughness of Polymer Interface Reinforced With Diblock Copolymer: Effect of Homopolymer Molecular Weight." http://www.completeaccess.net/ncsu/CHE_597J/docs/11-1.pdf. (1996).

High Performance PMMA/Carbon Nanotube Nanocomposites

Michael Goldman, Yeshiva Ohr Yerushalayim
Jonathan Hefter, DRS High School
Mayu Si, Dr. Miriam Rafailovich, Department of Materials Science and Engineering, SUNY Stony Brook

Carbon Nanotubes (CNTs), first discovered by Sumio Ijima[1] of NEC, are large fullerene molecules made up of sheets of carbon atoms, coaxially arranged in a cylindrical shape. They have been found to improve the mechanical properties[2-3] and thermal stability[4] of certain materials with which it is combined. It was hypothesized that if combined with PMMA, the nanotubes would serve to enhance the thermal and mechanical properties. The composite was prepared by melt mixing various concentrations (between 1% -.01%) of multi-walled carbon nanotubes with poly methyl methacrylate (PMMA). Dynamic Mechanical Analysis (DMA) revealed an increase in the glass transition temperature (Tg, The temperature at which a polymer changes phase from glassy to a rubber-like state) of 11-13°C regardless of concentration (i.e. Even the addition of .01% nanotubes results in a greater than 10.7% increase in Tg over pure PMMA)(see figures 1 and 2). Differential Scanning Calorimetry (DSC) confirmed these results. Additionally further DMA results demonstrated an interesting trend, that is when nanotube concentrations were above .5% the modulus of the nanocomposite was lower than that of pure PMMA, whereas at a concentration of .1% the modulus increases by nearly one order of magnitude. We believe that there is a critical loading value for CNTs with regards to their dispersion characteristics, that is above a certain concentration the nanotubes tend to clump together forming aggregates thus lowering the modulus of a given polymer, however loading less than that value will result in either not changing the modulus or possibly even increase it.





[1]"Helical microtubules of graphitic carbon", S Iijima Nature, vol.354, p56 (1991)
[2] "Exceptionally high Young's modulus observed for individual carbon nanotubes", M M J Treacy, T W Ebbesen and J M Gibson Nature, vol.381, p678 (1996).
[3] Bucking and collapse of embedded carbon nanotubes. O. Laurie, D.E. Cox, and H.D. Wagner. Appl Phys. Lett., 81(8):1638-1641,. 1998.
[4] “Thermal Degradation and Flammability Properties of\Poly(propylene)/Carbon Nanotube Composites”, Takashi Kashiwagi, Eric Grulke, Jenny Hilding, Richard Harris, Walid Awad, Jack Douglas, *Macromol.Rapid Commun.* 23, 764 (2002)

Adding Clay to Recycled Polymer Blends

Bradley Schwartz, Syosset High School
Robert Fisher, Columbia University
Edmund Palermo, Cornell University
Miriam Rafailovich, Department of Materials Science & Engineering, State University of New York at Stony Brook

A polymer tends to lose more than 30% of its mechanical strength after being recycled and becomes more immiscible with other polymers. Block copolymers or surfactants can be used to compatibilize polymers for miscibility, but the cost of obtaining surfactants and adding them to recycled polymer blends makes the process more impractical than simply producing virgin polymers. Recent research has shown that inexpensive montmorilonite clay platelets can enhance the mechanical strength, impermeability to gases, and flame retardation of isolated polymers. However, little research has been conducted concerning the effect of adding clay to blends of polymers.

Various combinations of recycled PVC, recycled polystyrene, and PMMA were blended together at 170°C for ten minutes. These samples were then duplicated with 5% of the blend consisting of Cloisite 6A, provided by Southern Clay Products. The samples were pressed at 347°F with six tons of pressure.

Each sample was analyzed with Dynamic Mechanical Analysis (DMA). It was found that modulo or stiffness of blends with Cloisite 6A was higher than those in blends without clay, which suggests that the clay enhances the mechanical strength of the polymer blends.

Transmission Electron Microscopy (TEM) was also used to analyze the samples. Figure 1 shows a cross-section analysis of a PVC, polystyrene and PMMA sample without clay, and Figure 2 shows the same blend with added Cloisite 6A. The domains of the different polymers in the sample without clay appear very large, and the polymers seem immiscible as expected. On the other hand, the polymers in the sample with clay have small domains, and hence are very miscible. The clay in this sample bends drastically around each polymer, enhancing the strength of the bonds between them.

Figure 1 (PVC+PS+PMMA)

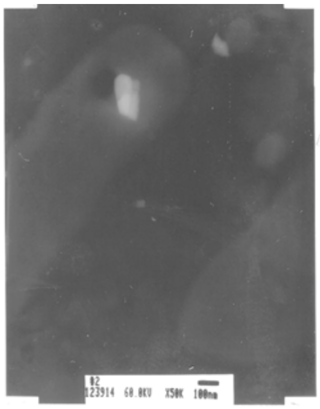


Figure 2 (PVC+PS+PMMA+C6A)

1. Basto, José Ricardo. (2002). MECHANICAL CHARACTERIZATION OF AGED RECYCLED POLYMERS AND APPLICATIONS Master's Thesis, West Virginia University, [On-line Abstract]. Available: http://etd.wvu.edu/templates/showETD.cfm?recnum=2649

Session 3:
DNA on Surfaces

Chair: Robert Samstein

Amit Mehta,Evan Hertan, Robert Samstein

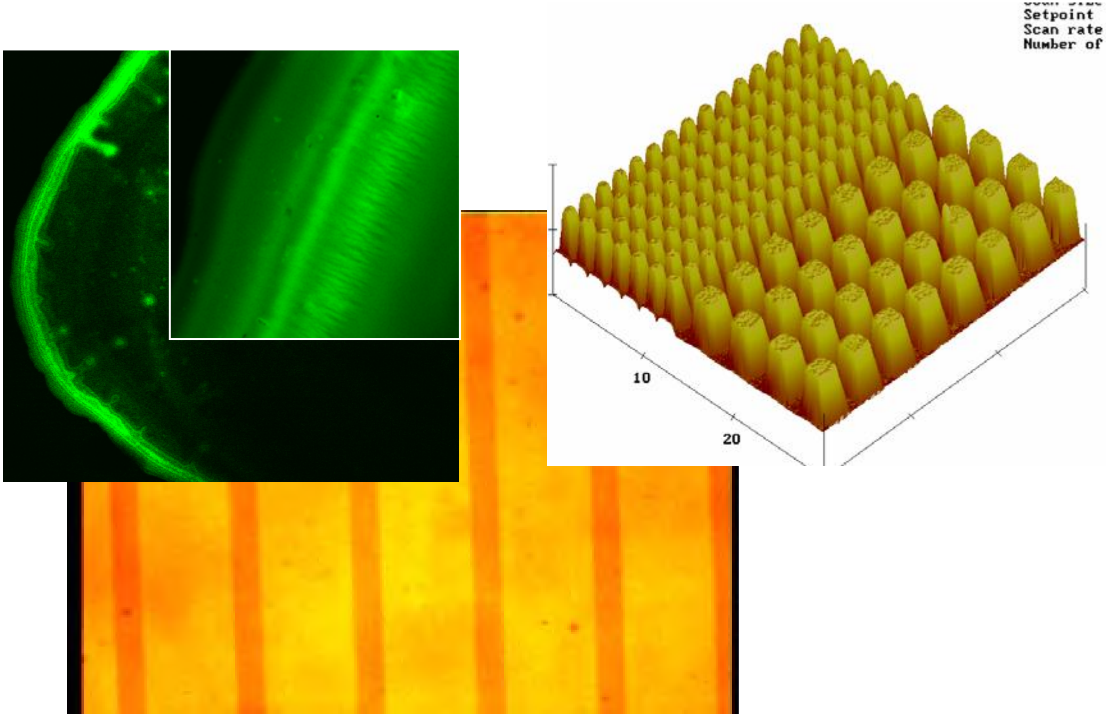
Saumya Sharma

Jack Jacob

Eric Petersen

Avtar Singh

Stanley Chang



DNA Surface Electrophoresis and Analysis of the EOF

Evan Hertan, Yeshivah of Flatbush H.S.
Amit Mehta, St. Anthony's High School
REU Mentor: Robert Samstein, Yale University
Bingquan Li, Dr. Miriam Rafailovich, Dr. Jonathan Sokolov,
Dept. Materials Science and Engineering, SUNY Stony Brook

Electrophoresis is a widely used technique employed to fractionate, identify, and sequence DNA strands. Current methods include capillary and gel electrophoresis, which rely on topographical restraints. Therefore, the size of the strand that is being analyzed is limited. Currently a new, two dimensional method has been developed on flat surface, which relies on the interactions between the surface and DNA. Longer strands tend to have more "bonds" to the surface, slowing down the negatively charged DNA molecule from moving to the positive electrode. This method has the potential to be incorporated into a microfluidic system, which could be used in fields ranging from forensics to bio-terrorism defense.

A droplet of DNA ranging from .3-.6μl is placed on various surfaces including glass and silicon with and without an OTS self-assembled monolayer. After the DNA has dried and adsorbed to the surface, the substrate with the DNA droplet is placed into an electrophoretic cell and a TBE buffer solution which contains a fluorescent dye is added. A 30V Electric field is then applied through the buffer and the microscope is set up to monitor the fluorescence 4-5mm away from the original drop.

In our project we are attempting to further understand the effect of the electrosmotic flow in surface electrophoresis. When an OTS layer is constructed on the substrate the electrosmotic flow (EOF) should be significantly decreased and the mobilities can be calculated with the minimized EOF. Lamda DNA was run on OTS covered glass and silicon with buffer concentrations ranging from 10^{-4} x to 3x TBE.

Efforts were also made to analyze circular and supercoiled DNA by surface electrophoresis. Future efforts will include Lamda, circular, and supercoiled DNA on a silicon surface with a gold nanopattern. Simulations have shown that the nanopatterned surface should refine the results and increase the resolution.

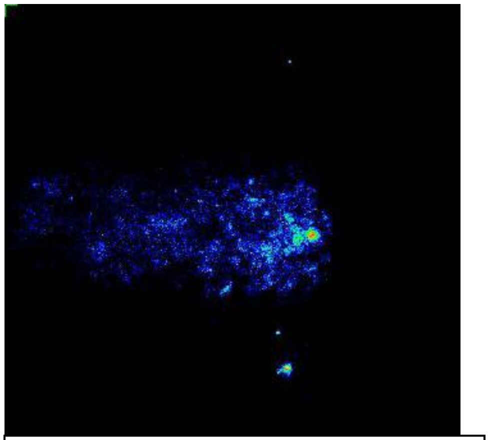


Fig. 2: Confocal microscope image of λ DNA moving during electrophoresis

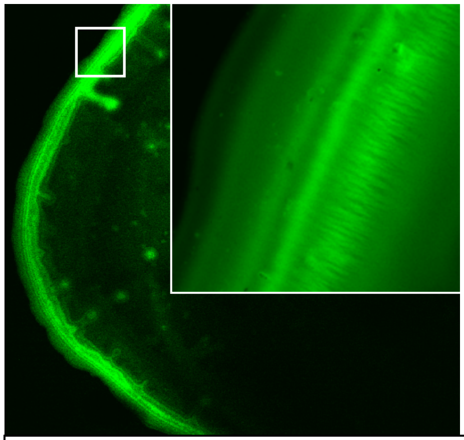


Fig. 1: Confocal image of dry droplet of ΦX174 supercoiled DNA with high resolution image demonstrating combing of the DNA.

References:

[1] DNA Electrophoresis on a Flat Surface, Pernodet, N., Samuilov, V., Shin, K., Sokolov, J., Rafailovich, M., Gersappe, D. and Chu, B., Phys Rev Lett, 85: (26), 5651-5654, Part 5651, (2000).

[2] DNA separation at a liquid-solid interface, Young-Soo Seo , Vladimir A. Samuilov, Jonathan Sokolov, Miriam Rafailovich, Bernard Tinland, Jaeseung Kim, Benjamin Chu ELECTROPHORESIS
Volume 23, Issue 16, 2002. Pages: 2618-2625

Surface Electrophoresis Using Indium Tin Oxide and Nickel

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Eli Hoory, Stony Brook University
Jonathan Sokolov, Dept. Material Science and Engineering, SUNY Stony Brook

DNA electrophoresis is a necessary step in almost any research involving molecular genetics. In recent studies it has been shown that a critical factor that controls the fractionation of DNA on a flat surface is the local friction between the adsorbed DNA segments and surface (1). Since the friction is controlled by the surface energy of the substrate, it is possible to design a surface to separate DNA fragments over a size range much larger than conventional range. When a DNA molecule is adsorbed on a flat surface, the balance between the loss of entropy and the energetic gain on adsorption of the molecule results in two forms of segments, loops that extend into the solution or trains which are contiguous segments adsorbed on the surface (2). If an electric field is applied in the plane of the surface, it leads to the electrophoretic separation of DNA. One of the major problems faced in this case is when electric current is applied random charges can build up on the surface, which obstructs the mobility of DNA.

In this study we use Indium Tin oxide (ITO), which is a conductor, to prevent charge build –ups which occur on insulating surfaces. Figure 1 shows a DNA droplet on the ITO surface. We also use Nickel coated silicon to study its chemical nature as it is applied in the electrophoresis technique and to observe DNA flow since we know Nickel is a good conductor. Surface conductance and friction also play a critical role in controlling electroosmotic flow (EOF) and we will compare EOF near these surfaces to previously studied silicon oxide surfaces. It has been shown that DNA mobility on different surface varies. In this study we are studying ITO and nickel surfaces and have made preliminary measurements of DNA liquid drops and surface electrophoresis.

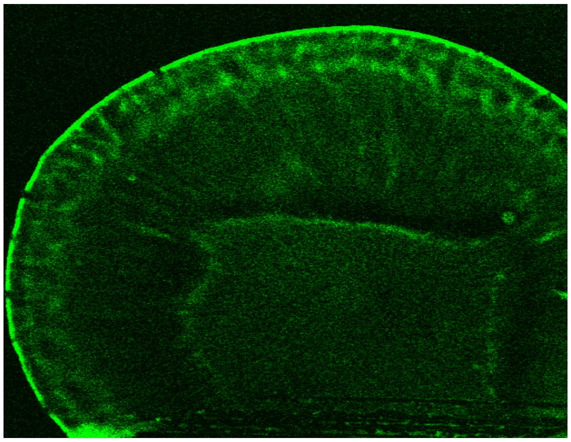

Fig.1. DNA droplet on ITO coated glass

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2. Luo, H and Gersappe. D. “Modeling the dynamics of DNA electrophoresis on a Flat Surface”. Electrophoresis 2002. Vol. 23. pp. 2690-2696.
3. Hayes, A. et. al. “ Electroosmotic Flow Control and Surface Conductance in Capillary Zone Electrophoresis”. Anal. Chem. 1993. Vol. 65. pp. 2010-2013.

Single DNA Molecule Imaging by Surface Electrophoresis

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Jonathan Sokolov, Eli Hoory
Dept. Material Sciences and Engineering, SUNY Stony Brook

The separation of Deoxyribonucleic acid (DNA) has become an important area of research in the Human Genome Project. Separation of DNA molecules will yield significant advancements in genetic engineering. This in turn, will improve our understanding of genetic abnormalities.

DNA is composed of a phosphate group, a ribose sugar, and four nitrogenous bases: adenine, thiamine, guanine, and cytosine. The DNA strand, or nitrogenous base pair sequence, corresponds to different amino acids which construct proteins, whereas proteins are responsible for our human configuration.

Electrophoresis is one of the many methods of DNA separation. Electrophoresis involves the use of an electric field to drag the DNA across a surface, gel slab, or capillary. Before the electric field is applied the desired image of DNA is a narrow ringed droplet. (Fig. 1). In our experimentation we are using PET-ITO ([2]Polyethylene terephthalate-Indium tin oxide) glass instead of silicon and nickel. PET-ITO is the chosen method due to its having a conductive and transparent surface. Transparency is significant because it will give less reflection from the substrate surface and therefore provide for better imaging. However, when working with lower resolution experiments (when not analyzing single molecules of DNA) silicon and ITO glass are the preferred methods of choice due to their low cost in comparison to the PET-ITO substance. The instrument being used to study DNA electrophoresis is the Leica Confocal Microscope. This instrument requires the use of a fluorescent dye (ethidium bromide) in the substance being imaged by the microscope's emitting lasers.

N. Pernodet[1] and her group of colleagues used silicon wafers and coated wafers with silane monolayer films, as the surfaces on which to separate different sizes of DNA. In their work they discovered the ability of a flat surface to separate DNA molecules results from the local friction between the surface and the adsorbed DNA segments. Using a flat surface and analyzing it under single molecule imaging we are hoping to find a reproducible method in which the DNA will separate across the PET-ITO surface, and we can identify the mechanism of DNA motion. After testing we were able to determine that ITO glass can also be used as the surface on which narrow and high-quality droplets of DNA form.

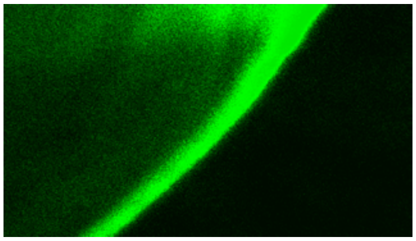

Fig. 1: droplet of DNA on a PET-ITO surface shows concentration in the outer ring.

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[1] N. Pernodet et. al. "DNA Electrophoresis On a Flat Surface." Physical Review Letters, Vol. 85, No. 26. December 25, 2000.

[2] www.mrs.org/meetings/spring98/ absbook/AbstractBookB.html

DNA Surface Electrophoresis on Micro-Patterned Surfaces

Eric Petersen, Ward Melville High School
Bingquan Li, Xiaohua Fang, Vladimir Samuilov, Miriam Rafailovich, Jonathan Sokolov, Dept. of Materials Science and Engineering, SUNY Stony Brook

Electrophoresis is one of the most important and widely used analytical techniques in molecular biology. It is an integral part of DNA sequencing, which has numerous applications ranging from genome sequencing to forensic science. Currently, there is great interest in constructing microfabricated devices for DNA analysis. Such devices have practical applications for DNA sequencing, and research value for understanding polymer dynamics problems. Previously, DNA separation has been demonstrated in microfabricated devices utilizing topological constraints, such as two-dimensional arrays of posts [1] and microfabricated channels [2]. However, topological constraint may not be the dominant mechanism for DNA separation; DNA separation has been demonstrated on a flat silicon surface without any topological obstacles [3].

The purpose of this study is to analyze the role of the chemical and electrical properties of the surface in influencing DNA surface transport. Micropatterns of gold on silicon and glass substrates were created by microcontact printing. A gold layer 100Å thick was deposited on the substrate. The micropattern was etched into a silicon wafer by photolithography and then copied onto a PDMS stamp. The PDMS stamp was then coated in thiol and applied to the gold surface. This substrate was then immersed in a gold etching solution, which removed the gold not coated by thiol, thus creating the micropattern (fig.1). Stamps of different dimensions (5x5μm, 6x14μm, 22x28μm) and orientations (parallel and normal to DNA movement) were created. DNA motion on the patterns was measured with a fluorescence detector and imaged on a confocal microscope with an intensified charge coupled device camera.

The gold micropattern influenced DNA movement during electrophoresis. On a pattern with gold strips oriented parallel to the electric field, the DNA moved rapidly onto the gold and became trapped there. The motion of the DNA molecules on the gold was very slow and irregular, compared to the linear flow of free draining DNA. In patterns of smaller dimensions (~<20x20μm), the normal orientation allowed DNA to pass through (fig.2), while the parallel orientation allowed very little or no DNA to pass. However, in patterns of greater dimension, the opposite result was found. Future studies will investigate DNA movement on patterns of many different dimensions, and in both parallel and normal orientations. Also, studies will be done on gold nanopatterned surfaces, and the result can be correlated to gold micropatterned surfaces.

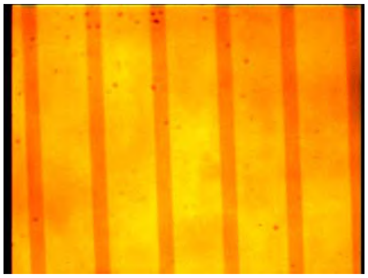

Fig.1-gold micropattern on silicon

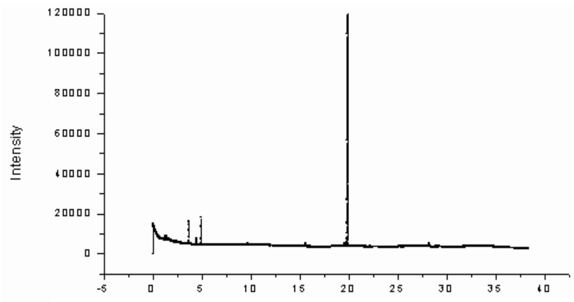

Fig.2-Electropherogram indicating detection of DNA movement on normal oriented Au micropattern

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[1] O. Bakajin *et al.*, Anal.Chem. **73,** 6053 (2001)
[2] J. Han, S.W. Turner, and H.G. Craighead, Phys. Rev. Lett. **83**, 1688 (1999)
[3] N. Pernodet *et al.*, Phys. Rev. Lett. **85**, 5651 (2000)

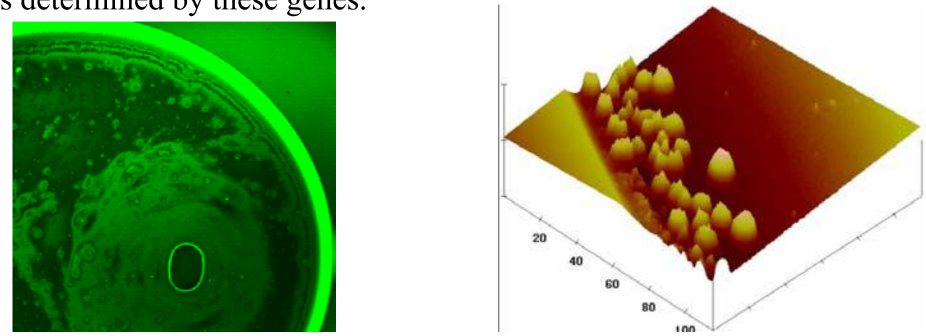
Electrophoretic Study Of Albumin And Other Proteins

Avtar Singh, Stuyvesant High School
Robert Samstein, Yale University
Miriam Rafailovich, *Jonathan Sokolov*, *Perumal Ramasamy*
Dept. of Material Sciences and Engineering, SUNY Stony Brook

Proteomics is a relatively new field attempting to identify the numerous proteins in the body and determine their specific functions, especially in relation to genes.[1] One method of identification is electrophoresis- this works by separating the proteins by size. However, the electrophoresis of proteins is difficult due to their small chain lengths (compared to DNA) and sensitivity to light, heat and motion. First, the correct dye must be used for staining each protein. This dye must combine with, and remain attached to, the protein. Next, the protein must be adsorbed to a flat surface. Variables for this phase include the dye, protein concentration, solvent concentration, buffer concentration and the substrate. By optimising these conditions, it is hopeful that separation by surface electrophoresis will be attainable.

Using the confocal microscope, we measured the mobility of the protein in a buffer solution. We tested the usefulness of various dyes and decided that Neutral Red worked best for viewing albumin under the confocal microscope (See Figure 1). We also used contact angle measurements to understand the absorption rate of these dyes at various concentrations of the protein. The AFM was used to study the morphology of the droplet (See Figure 2) as a function of protein concentration, buffer concentration and dye choice. Electrophoresis was performed using a custom made cell on glass and OTS Silicon.

After performing the electrophoresis on albumin, we plan to test other proteins, such as chitin and fibronectin. If staining can be achieved for these proteins, separation should be possible on the substrate. This would contribute to the Human Genome Project, which is trying to study genes and their traits- Proteins are responsible for the specific functions determined by these genes.[2]



Left: Confocal Image of droplet ring on OTS Si for contact angle measurement (0.1x TE, 250µg Al /mL TE, Neutral Red dye) **Right**: AFM image of droplet ring, 0.1x TE, 250µg Al /mL TE, OTS Si

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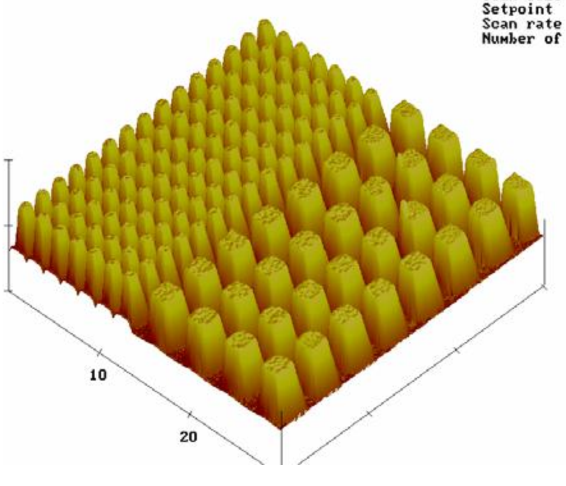
Optimizing Electrophoresis through Novel High-Dimensional Microlithographic Arrays

Stanley Chiang, Great Neck North High School
Jonathan Sokolov and Eli Hoory, Department of Materials Science at Stony Brook

The separation of DNA molecules according to size has been accomplished through several methods of electrophoresis: gel, capillary, and surface electrophoresis. However, the efficiency of these methods is limited, for there is an upper limit of 40000 base pairs (40 kbp) and several adverse side effects of electrophoresis prevent the method from thoroughly differentiating between particles of similar size. Such constraints make electrophoresis an impractical method to sequence human DNA of 3 billion base pairs. The usage of obstacles is a new frontier of electrophoresis and is not widely used. Volkmuth and Austin [1] introduced the archetype of obstacle electrophoresis that implemented a patterned surface created by microlithography. The low topography and small volume raised questions of the role of the obstacles in separating DNA. Recently, in a similar experiment performed by Seo *et al*. [2], the separation of DNA was posited to occur due to the interaction between the liquid-solid rather than the obstacles. Therefore, low-dimensional obstacles provided a 2-D interaction to limit the motion of the DNA rather than a 3-D sieving action. Novel high-dimensional microlithographic arrays were used in this experiment as a mean to provide an efficient method of surface electrophoresis. λ- Hind III Digest DNA and λ- DNA fragments were used in the surface electrophoresis experiments, and provided a wide arrangement of DNA sizes. The electrophoresis was studied through a Confocal Laser Scanning System TCS SP1 (Leica) Microscope with a Photomultiplier and 10X, 40X, and 150X dry objective lens. Extrapolation of data suggests that the mobility of DNA fragments is influenced by high-dimensional microlithographic arrays. Furthermore, the usage of high-dimensional topology proves an efficient method of sorting DNA according to size. High-dimensional obstacles are effective in surface electrophoresis and have a significant role in improving DNA separation.



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[1] W. D. Volkmuth, R. H. Austin. *Nature* 1992, 358, 600-602.

[2] Y. Seo, V. A. Samuilov, J. Sokolov, M. Rafailovich, B. Tinland, J. Kim, B. Chu. *Electrophoresis* 2002, 23, 2618-2625.

Session 4:
Polymer Thin Films

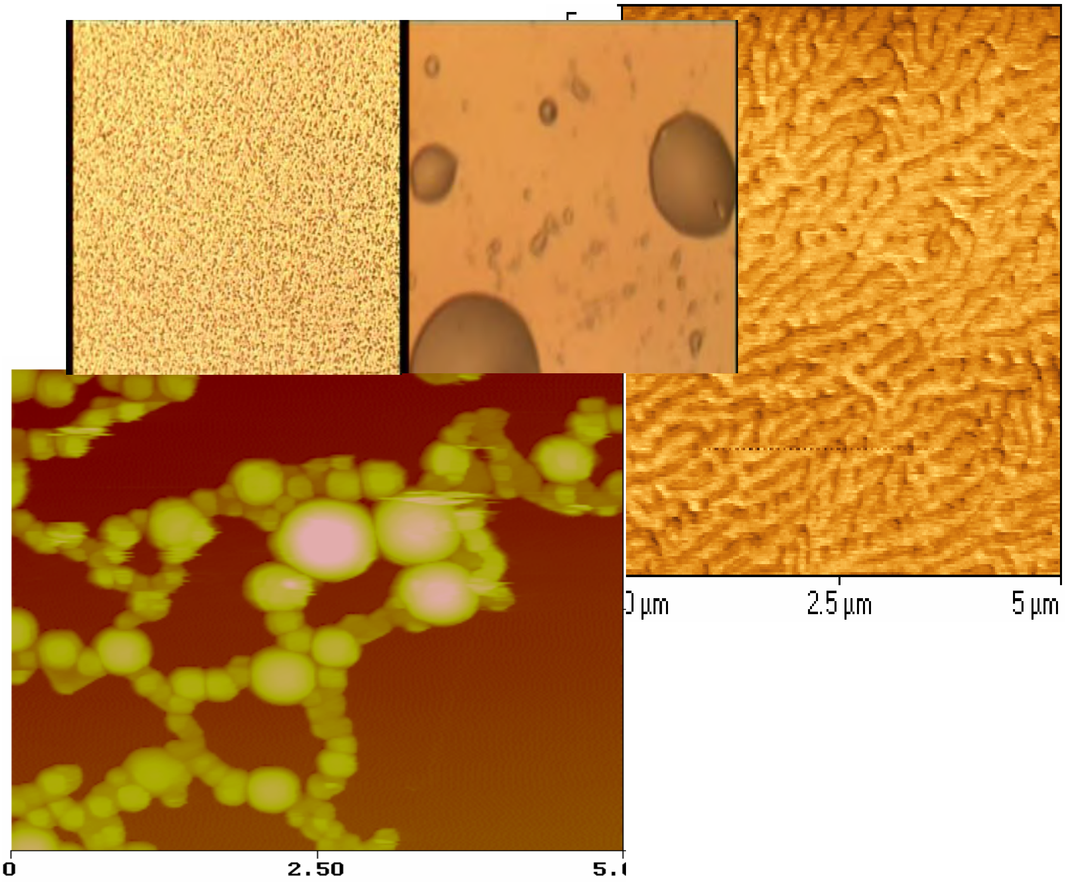
Chair: Arielle Galambos

Aditi Ramakrishnan,Paul Marx

Arielle Galambos

Michael Levy

Maanasa Indaram,Vivek Kuncham



The Effect of PS-PMMA Diblock Co-polymer on Dewetting at the PS-PMMA Interface

Aditi Ramakrishnan, Ward Melville High School
Paul Marx, Jericho High School
Chunhua Li, Miriam Rafailovich Material Science Research SUNY Stony Brook

Efficient techniques for manipulation of dewetting have been receiving increasing attention in the past few years from the scientific community. Such techniques could pattern chips, enhance the smoothness of lubricants, and have applications in surface coatings and micro- electronics. The phenomenon of dewetting occurs when polymer films, instead of spreading smoothly, randomly clump and form holes due to excessive heat. There are many factors that affect the rate and intensity of dewetting. One such factor is the addition of diblock co-polymers. Certain concentrations of diblock decrease the rate of dewetting, while others increase it. The diblock co-polymer PS-PMMA is made of *n* blocks of PS attached to *n* blocks of PMMA. When added in relatively small amounts, diblock inhibits the movement of the PS, which in turn decreases the rate of dewetting. However, when too much diblock is added, polymer brushes form and increase the movement of the PS, hence accelerating dewetting. Knowing which concentration of diblock co-polymer to use is a significant piece of information that can be used to manipulate dewetting.

The first experiment was targeted to determine the effect of concentration of diblock on the rate of dewetting, and furthermore, the optimal concentration of diblock that decreases dewetting the most. Six 290K PS solutions with concentrations of PS-PMMA (70k-70k) diblock copolymer ranging from 0-50% were floated onto 300K Poly(Methyl Methacrylate) covered silicon wafers. These samples were annealed at 170 degrees Celsius for 3 hour long periods. After every anneal, the samples were observed under an optical microscope for signs of dewetting. In Shichun Qu's paper **(1)**, it has been proposed that PS with a 30% concentration of diblock will inhibit the rate of dewetting the most, while, a concentration of 50% diblock, **(Fig. A)** will drastically accelerate the rate of dewetting.

The second experiment was targeted to determine the effect of molecular weight of PS on dewetting. PS solutions with molecular weights of 65K, 123K, 200K, and 290K with concentrations of PS-PMMA diblock of 30% and 50% were floated onto 8 300K PMMA covered silicon wafers. These samples were annealed at 170 degrees Celsius for 3 hour long periods as well. In the future, images observed under an optical microscope will determine if there is a strong relationship between molecular weight of PS and rate of dewetting.

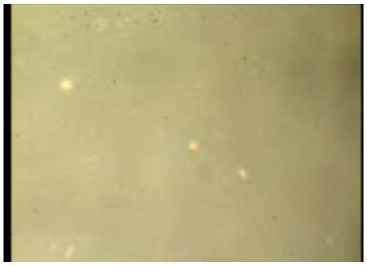


Fig. A 50% diblock concentration, 8 hours annealing, 100

1. Qu, Shichun. "Dewetting Dynamics at Polymer-Polymer Interfaces". 1997. pp. 66-84.

Two and Three Dimensional Structures of Diblock Copolymers at the Air/Water Interface

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Dr. Miriam Rafailovich, Department of Materials Science & Engineering, State University of New York at Stony Brook

As the sizes of structures in modern integrated circuits continue to decrease below 100 nm, the physics of conventional lithography imposes severe limitations. As the lithographic process reaches its confines such that it is no longer feasible to create perfect structures, it has become necessary to find alternate methods to make nanostructures. Diblock copolymers have the ability to self assemble making nanostructures that are built up from the molecular level. By taking advantage of self assembly, the confines of the lithographic process can be exceeded by making even smaller nanostructures. Using the polymer poly(styrene-block-ferrocenyldimethylsilane), the self-assembled nanostructures can exhibit magnetic properties under proper conditions (i.e., annealing conditions and film thickness). The applications of nanosized conductive and magnetic structures are vast, ranging from magnetic data storage in computers to nanowires in micro electrical mechanical systems (MEMS).

Poly(styrene-block-ferrocenyldimethylsilane) has been observed to form a variety of different morphologies such as micelles and cylinders.[1] These different morphologies are useful in many different applications, therefore it has become necessary to have a firm understanding of the ways in which the polymer self-assembles. We have investigated two different ways of making thin films. By spin coating films followed by annealing, we observed nanoposts imaged using an atomic force microscope (Figure1). The magnetic properties of these nanoposts will be examined using a vibrating sample magnetometer and substances such as iron carbonyl and cobalt carbonyl will be used to enhance the magnetic properties of the nanoposts.

We also made films of Poly(styrene-block-ferrocenyldimethylsilane) using a Langmuir Blodgett trough. We observed micelles in the LB films and noted that the size of the micelles can be controlled by the solution concentration and that the concentration is inversely related to the micelle size while the surface pressure does not have a significant effect on the size.(Figures 2 and 3). By understanding the properties of Poly(styrene-block-ferrocenyldimethylsilane) the morphology can be controlled to make structures with a variety of applications.

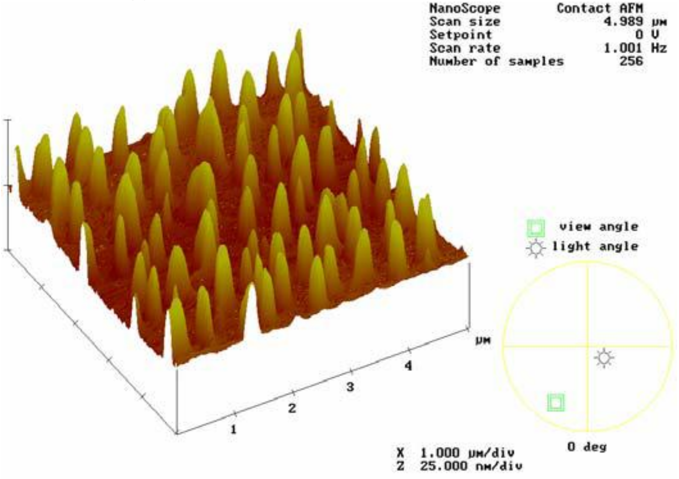
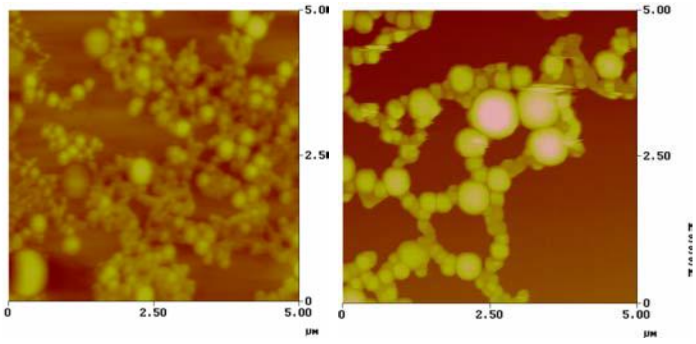


Figure 1: Nanoposts of Poly(styrene-block-ferrocenyldimethylsilane) in a 1mg/ml solution annealed for 3 days at 170°C and 3 days for 60°C



Figures 2 and 3: (2) LB film of SF 27/12 of a 1 mg/mL solution . (3) LB film of SF 27/12 of a 0.25 mg/mL solution. (The Z range for both above AFM images is 200 nm.)

[1] Lammertink, Robert, M. Hempenius, G. Vancso, K. Shin, M. Rafailovich, J. Sokolov. "Morphology and Surface Relief Structures of Asymmetric Poly(styrene-*block*-ferrocenylsilane) Thin Films." *Macromolecules,* 34 (4), 942 -950, 2001.

Two Dimensional Structures of Diblock Copolymers at the Air/Water Interface

Michael J. Levy, South Shore High School,
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Professor Miriam Rafailovich, Department of Materials Science & Engineering, State University of New York at Stony Brook

As feature sizes in modern integrated circuits continue to decrease below 100 nm, the physics of conventional lithography impose severe limitations. Therefore it seems necessary to go back a step and look at different possibilities of making nanoscale magnetic divices. Diblock copolymers have the ability to self assemble making nanostructures that would be built up from the molecular level. Using the polymer Poly(styrene-block-ferrocenyldimethylsilane), the selfassembled nanostuctures can exhibit magnetic properties under proper conditions (ie annealing conditions and film thickness). However, because the self-assembly is not controlled by outside devices the patterns have not been useful in microchip technology. The purpose of my research is to find a way to control the assembly primarily using concentration, pressure, and temperature.[1]

The applications of nano sized conductive and magnetic structures are vast. They can be used in integrated electromechanical systems, which are used in devices that range from integrated circuitry and high-density magnetic data storage to biochips for detecting hazardous chemical or biological agents. Other uses stem from the different phases that can be formed by altering the different variables while forming the films. These phases include spheres, posts, and complete lamellar layers.[2]

Using devices such as a spin coater and L.B. (langmuir Blodgett) trough to make thin films of Poly(styrene-block-ferrocnyldimethylsilane) it was deduced that the concentration of the solution and the size of the micelles are inversely related (Figures A and B). I hope to discover more of the factors that affect the formations and eventually be able to adjust the variables correctly for more useful shapes and patterns.

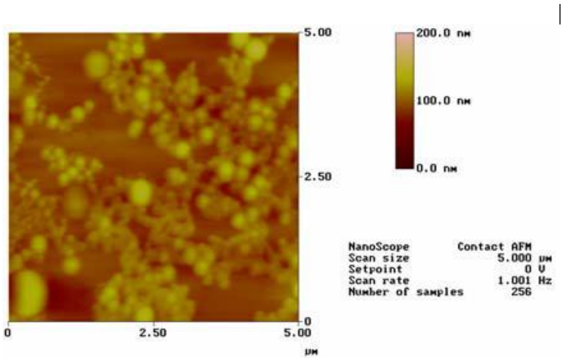

Figure A: LB film of SF 27/12 of a 1 mg/mL solution

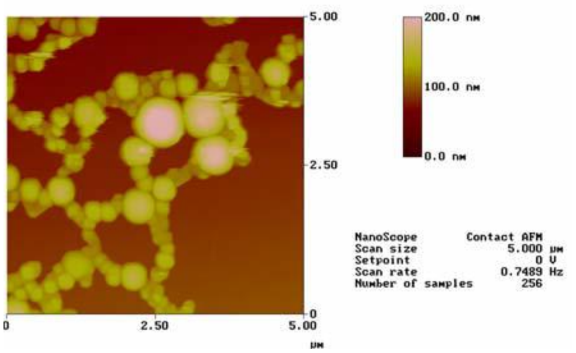

Figure B: film of SF 27/12 of a 0.25 mg/mL solution

References

(1) A Geometric Theory of Diblock Copolymer Phases, Gregory M. Grason
(2) The Physics of Block Copolymers: Oxford University, Ian W. Hamley

Using Nanoparticles to Enhance Polymer Properties for Improved Commercial Applications: Space Lubricants to Nanolithography

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Shira Billet, Princeton University
Dr. Miriam Rafailovich, Department of Materials Science & Engineering, State University of New York at Stony Brook

High performance polymers are required for the increasing demand for nanofabrication in industry. For example, lubricants are currently used in extreme conditions, i.e., space and miniature surfaces such as those in electronic components. Also, lithography of nanoscale features requires polymers to be able to maintain a thin structure over small scales. Homopolymers are reaching their limits in strength and stability and we propose hybridizing these polymers with nanoparticles to enhance their mechanical properties. Our research may make it possible to create more efficient space machinery and satellites, faster and smaller computer chips, and enhance a wide variety of potential commercial applications.

Dewetting is a major problem for industrial lubricants since it renders them ineffective at reducing friction, often causing machines to malfunction. Nanoparticles, such as various cloisite and artifical clays, POSS, silica, and carbon black, might be able to stabilize lubricants and prevent such a problem. To test this hypothesis, we measured the contact angle of droplets of the various silicone oil-nanoparticle solutions and deduced the interfacial energy between the lubricant and hydrophobic silicon substrate. Using the formula in Figure 1, we proved quantatively that the cloisite and artificial clays reduced the interfacial energy the greatest, thereby reducing the rate of dewetting (see Figure 2) [1].

Similarly, regarding nanolithography, polymers' stability is vital to the manufacturing of smaller and faster computer circuitry. Current polymers are unable to maintain their nanoscaled features and therefore melt and reduce their accuracy for printing chips. In our study, we used silicon stamps made of nanopatterned aluminum to simulate an industrial polymer mask and made a negative imprint on silicon wafers (spuncast with PMMA and PS with and without gold nanoparticles). We then ran our samples on the atomic force microscope in T_g mode to observe the glass transition temperatures of our polymer solutions and to see if nanoparticles successfully raised the glass transition temperature, making the polymer more stable at such minute thicknesses (see Figure 3) [2].

As we continue our study on the potential of nanoparticles to create optimal polymer-particle mixtures, we plan on using a rheometer to study whether nanoparticles enhance viscosity. Also, we will use a UV curable coating process to see how dewetting is affected as a function of shape on 3D surfaces.

$$\cos\theta = \frac{\gamma_S - \gamma_{LS}}{\gamma_L}$$

Figure 1. The equation used to find interfacial tension (Y_{LS})

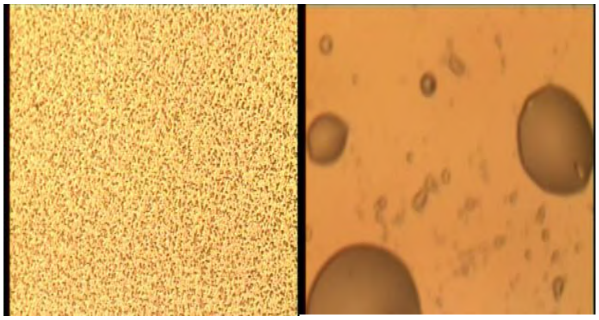

Figure 2. Cloisite Clay 6A-Silicone Oil vs. Control (Silicone Oil). You can see that the clay nanoparticles on the left prevent dewetting (seen on right).

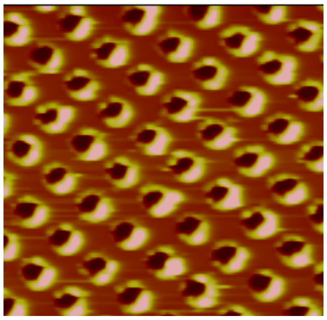

Figure 3. AFM image of nanoscale features of the imprinted PMMA wafer

[1] *Barnes, H.A., J.F. Hutton & K. Walters. An Introduction to Rheology. Amsterdam: Elsevier Science Publishers, B.V., 1989.*

[2] *Shear Modulation Force Microscopy Study of Near Surface Glass Transition Temperatures. Ed. S. Ge, Y. Pu, W. Zhang, M. Rafailovich & J. Sokolov. 01 Mar 2000. Department of Materials Science and Engineering, State University of New York, Stony Brook. 24 Jul 2003.*

Surface-Induced Crystallization of Ethylene Vinyl Acetate on Modified Metallic Substrates

Maanasa Indaram and **Vivek Kuncham**, The Wheatley School
J. Jerome, Y. Wang, M. Rafailovich
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Thin crystalline coatings possess unique and important properties such as hardness, toughness, wear resistance, and smoothness. By knowing which parameters could control these properties, the ability to engineer crystalline coatings could lead to many new important applications, such as protective scratch resistant layers, corrosion barriers, and lubricants for microelectromechanical systems (MEMS)[1].

The substrate upon which the film is created has been shown to have a great impact upon the film's crystallinity[2]. Thus, the purpose of this study is to determine the exact role of the substrate on crystallization. The four most common metals used in microchips and electric circuits – silicon, gold, copper, and chromium – were chosen as substrates for this study. The polymer used to create the crystalline coatings was ethylene vinyl acetate (EVA), an inherently tough, resilient, and flexible polymer with excellent environmental stress and crack resistance. Different film thicknesses of EVA were spincoated onto the four metallic surfaces, and crystalline morphology was observed through Atomic Force Microscopy (AFM). Results showed that as film thickness changed, the morphology progressed from spherulites to other crystalline formations (Fig. 1). Furthermore, the mechanical properties of melting point and hardness were determined in each sample, demonstrating that as the films are confined, these properties become very different from those of the bulk polymer.

In addition, the substrates were further modified through nanopatterning, a process that creates a series of bumps on the substrate surface (Fig. 2). Nanopatterns were made using solutions of polystyrene-polymethylmethacrylate (PS-PMMA) and polystyrene-ethylene-vinyl acetate (PS-EVA), which are known to phase separate upon spin coating, leading to a pattern that can be etched into the substrate using an Ion Mill. EVA was then spincoated onto the nanopatterned substrates in order to determine the effects of the metallic surface coupled with the newly formed topographical patterns. Future research includes quantifying the conductivity and degree of crystallinity on each surface.

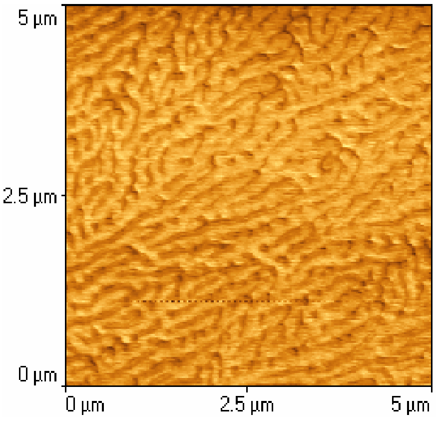


Fig. 2: Nanopatterned Surface

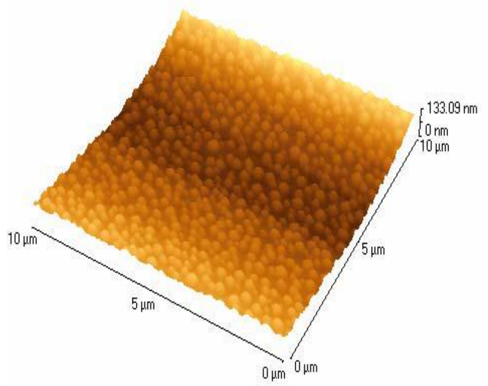


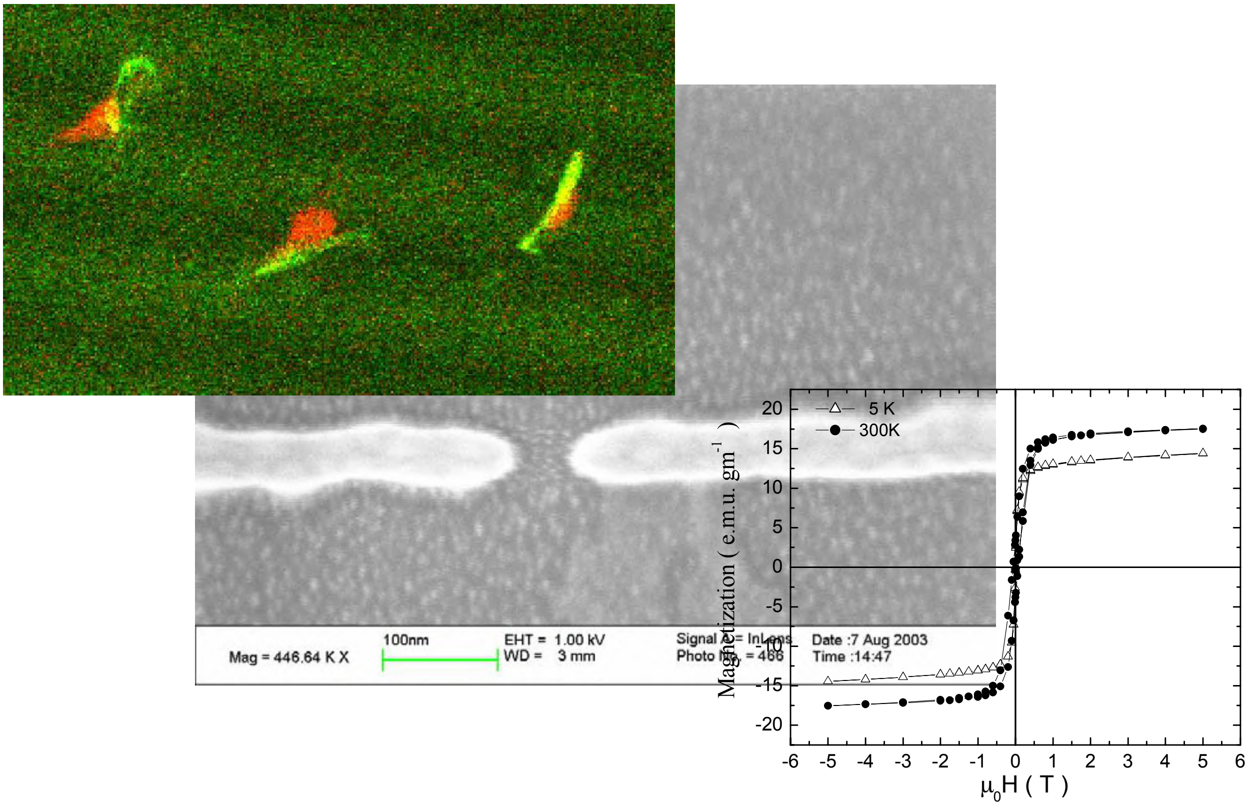
Fig. 1: Crystalline "Finger" Pattern

1. Rabolt, J. et. Al. "Structure in Thin and Ultrathin Spin-Cast Polymer Films". Science. August 1996. Vol. 273 No. 5277. pp. 912-915.
2. Reiter, G. and Sommer, J. "Polymer Crystallization in Quasi-Two Dimensions". Journal of Chemical Physics. 112, 9, 4376-4384, (2000).

Session 5:
Nano-Particles

Chair: Aprajita Matoo

Sean Mehra, Jeffrey Reitman
Michall Forman,Chani Schonbrun
Joshua Etman
Arthur Yu
Matt DiPasquale
Nik Ray-Mazumder
Jessica Jiang



Synthesis and Characterization of PdC_{12} Nanoparticles Synthesized by the One-Phase and Two-Phase Processes

Michal Forman, Chani Schonbrun, Stella K. Abraham High School for Girls
Rebecca Isseroff, Stella K. Abraham High School for Girls,
Dr. Anatoly Frenkel, Brookhaven National Laboratories, Yeshiva University,
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Dr. Miriam Rafailovich, Department of Materials Science and Engineering, SUNY Stony Brook

Palladium nanoparticles are of special interest because of their use as catalysts. Recent studies have also demonstrated potential benefits of using them to enhance the qualities of polymer thin films.[1]

Pd-dodecanethiol particles were synthesized by using the one-phase[2] and two-phase[3] processes. After drying the particles in a vacuum for two days, solutions were made in toluene at a concentration of 1 mg/mL. Dilutions of 1:25 were made and dropped on TEM grids to determine the size of the particles. It was found that the 3:1 Pd:thiol particles were actually much larger and possibly cubic in nature. 300 uL of 1mg/mL 1:1 and 3:1 PdC_{12} particles were applied on the water surface of an LB trough. The 1:1 particles aggregated and did not spread at all. The 3:1 particles seemed to have spread but on closer inspection as the barriers compressed contained islands of aggregates.

The 3:1 Pd:thiol particles synthesized by the two-phase process proved to be insoluble in both toluene and in water. The toluene mixture, however, was sonicated and further diluted 1:25 in toluene and dropped on a TEM grid. TEM analysis showed large clusters of micro particles instead of nanoparticles. The two-phase PdC_{12} 1:1 did spread on the LB trough and built up a surface pressure showing an isotherm transition from a monolayer to a multilayer. TEM grids and hydrophobic Si wafers were picked up at 3 mN, 7.8 mN, 10 mN, and 15 mN of surface pressure. The 1:1 nanoparticles of both the one phase and the two phase were analyzed by EXAFS at Brookhaven's NSLS where we determined, based on the peak analysis of Pd-Pd and Pd-S, that the two-phase particles are smaller and contain a larger ratio of thiols to Pd than the particles synthesized by the one-phase process (figures 1, 2). We will verify the size by TEM analysis.

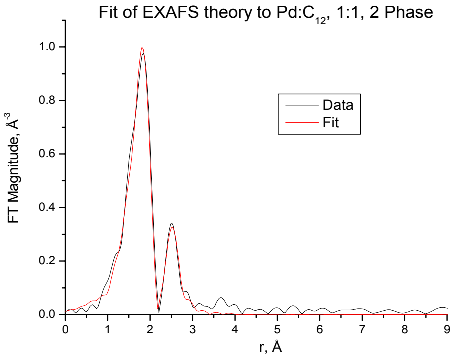

Figure 1. EXAFS data for PdC12 **2 phase** 1:1 taken at the NSLS

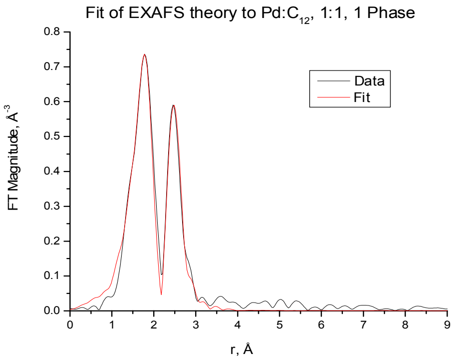

Figure 2. EXAFS data for PdC12 **1 phase** 1:1 taken at the NSLS

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2) Yee, Chanel K.; Jordan, Rainer; Ulman, Abraham; White, Henry; King, Alexander; Rafailovich, Miriam; Sokolov, Jonathan. "Novel One-Phase Synthesis of Thiol-Functionalized Gold, Palladium, and Iridium Nanoparticles Using Superhydride." Langmuir, 15(10): 3486-3491 May 11 1999
3) Brust, Mathias; Walker, Merryl; Bethell, Donald; Schiffrin, David J.; Whyman, Robin. "Synthesis of Thiol-derivatised Gold Nanoparticles in Two-Phase Liquid-Liquid System." J. Chem. Soc, Chem. Commun. 1994

Immobilization of Proteinase K onto γ-Fe_2O_3 ${}_N$anoparticles

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James Lai and Ansil Dyal
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Do to the fact that several enzymes have already been immobilized onto nanoparticles and other substances such as polymers already[1-2], the main goals of my project are to immobilize enzymes onto nanoparticles that do not aggregate and to functionalize nanoparticles in such away that enzymes can be immobilized onto them and still be active.

Nanoparticles are particles that have a diameter less than 100nm. Due to their unique size and physical properties, nanoparticles offer many advantages, especially to the pharmaceutical world. Nanoparticles can be used to immobilize enzymes. The immobilization of an enzyme is the act of binding an enzyme onto a particular substance such that it is no longer free; this is beneficial because it allows for immobilized substances to become reusable. Certain characteristics of the nanoparticle are necessary so that the immobilized substance can be used more then once. One of these characteristics includes strong magnetism, so that the substance once immobilized can be separated from the medium.

γ-Fe_2O_3 is a nanoparticle that has an average size of 15 to 20 nm (as seen in the TM picture above) and is ferrimagnetic, meaning that it contains magnetic properties without a magnetic field present and has a net magnetic charge to one side. In this study, γ-Fe_2O_3 was used for all these reasons and was prepared with out sonication to make sure the particles did not aggregate. No aggregation is important because it increases the surface area of the nanoparticles. (The viewing of γ-Fe_2O_3 taken by TM microscopy shows that the particles did not aggregate.)

In order to immobilize a substance onto a nanoparticle, a series of chemical interactions must be completed. First, the polymer around the nanoparticle must decompose to expose the bare particle. Then, the particle becomes oxidized and can be coated with a surfactant. The surfactant used in this study was Amino Dpeg$_4$ acid. The coating was confirmed through TGA as well as FTIR. The next step is adding a gluteric aldehyde linker, which will be the final link from the nanoparticle to the enzyme. In this study the enzyme Proteinase K was used.

In the future, the activity of the immobilized Proteinase K will be tested and compared to the activity of free Proteinase K.

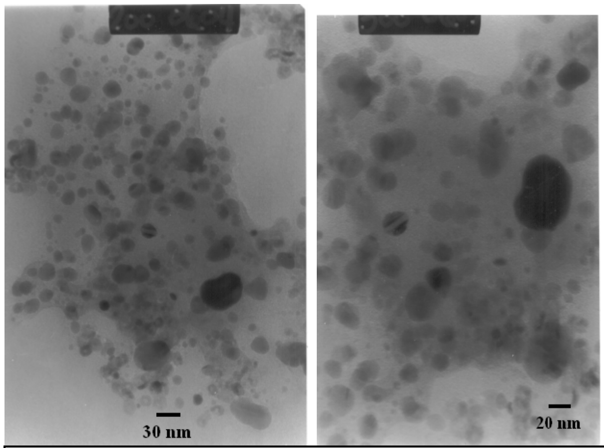

Fig. 1: γ-Fe_2O_3 coated with amino dpeg

1.Dyal, Ansil et al, Activity of Candida Rugosa Lipase Immobilized on Y-Fe_2O_3 magnetic nanoparticles.JACS:2003.
2.Caruso, Frank et al, Enzyme Multilayers on Colloid Particles: Assembly Stability and enzyme activity.ACS:2000.

Functionalization of Yttrium Aluminum Garnet Nanoparticles Using Ultrasonic Bath

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Assia Bakhtina, *James Lai, Abraham Ulman,* Polytechnic University
Miriam Rafailovich, Department of Materials Science & Engineering,
State University of New York at Stony Brook

Yttrium aluminum garnet ($Y_3Al_5O_{12}$, YAG) is an inorganic ceramic substance that serves many purposes. It is a high-temperature stable material with the highest creep resistance of any known oxide material [1]. It is good for ceramic-matrix composites and doped YAG is a solid-state laser material [1]. Due to recent research, a reliable and effective way has been developed for synthesizing YAG. The next step is to functionalize it to make it more compatible with organic substances [2].

In synthesizing the YAG, the method of sonochemistry was used. Sonochemistry is the use of ultrasound to generate high-temperature bubbles where the chemical reactions take place. The use of sonochemistry reduced the temperature required to synthesize pure YAG [1]. Sonochemistry was also used in coating the YAG with surfactants. The two surfactants that were used were octadecyltrihydrosilane ($CH_3(CH_2)_{17}SiH_3$) and stearic acid ($CH_3(CH_2)_{16}COOH$). For the reactions, each surfactant was mixed with YAG in a similar ratio in toluene. The mixtures were put into a sonic bath for 2~3 days approximately. For the stearic acid, an alternate way was tried in which the YAG was first sonicated in KOH for a day before mixing with the surfactant.

Infrared spectroscopy (IR) was used to analyze the samples. For the silane, the IR shows a minimum or nonexistent presence of the surfactant. There are no bands for CH_2 groups stretch of the surfactant in the spectrum. For the stearic acid, the absorbance peak at around 2900 shows that there is surfactant present because that is where the peaks for the CH_2 groups occur. Also, in the sample where the YAG was mixed with KOH first, the IR showed a very similar pattern, indicating that both procedures worked. The one with KOH, however, required less time in the ultrasonic bath.

Figure A

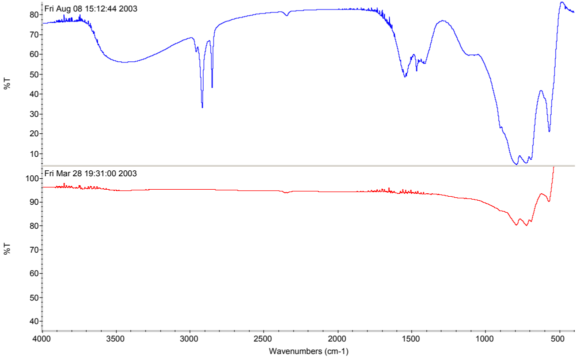

Figure B

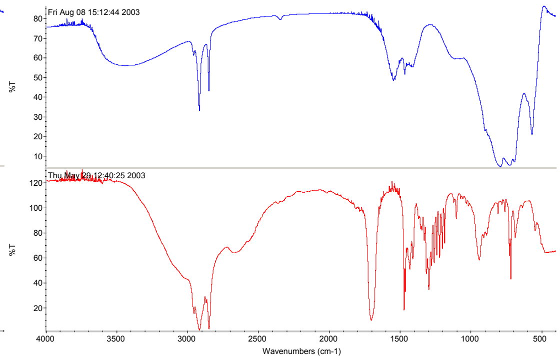

Figure A: IR spectrum of YAG with surfactant (stearic acid) on top and pure YAG on bottom.
Figure B: IR spectrum of YAG with surfactant (stearic acid) on top and pure stearic acid on bottom.

[1] Kurikka V.P.M. Shafi, Abraham Ulman, Jriuan Lai, Nan-Loh Yang, and Min-Hui Cui. “A New Route to Alumoxane Gel: A Versatile Precursor to γ-Alumina and Alumina-Based Ceramic Oxides”. American Chemical Society. March, 2003.

[2] Kurikka V.P.M. Shafi, Abraham Ulman, Xingzhong Yan, Nan-Loh Yang, Michael Himmelhaus, and Michael Grunze. “Sonochemical Preparation of Silane-Coated Titania Particles”. Langumuir **2001**, *17*, 1726-1730.

Fabrications and Electrical Characteristics of C18 Gold Nanoparticles

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The single electron transistor (SET) is a promising nanoelectronic device with applications ranging from detectors of biological molecules to components of quantum computers. Not only can it be made at a molecular-scale, using up far less space than conventional silicon transistors, but it also establishes great advantages in low power consumption and high packing density. The purpose of this research is to fabricate and characterize a novel SET using gold nanoparticles.

Unique arrangements of gold nanoparticles with C18 chains were self-assembled through the formation of Au-S covalent bonds. To synthesize the particles, a two-phase method was used along with a 1:1 ratio of gold to thiol in the reaction between $AuCl_4$ and $C_{18}SH$. The particles were dissolved in toluene to formulate a solution with a concentration of 1mg/ml.

The Langmuir-Blodgett (LB) method was used to pickup thin films of gold nanoparticles for analysis with a transmission electron microscope (TEM) and scanning electron microscope (SEM). A uniform monolayer of gold nanoparticles was deposited by horizontal lift on a copper TEM grid, as seen in figure 1, and on a chip with gold electrodes, as seen in figure 2. The electrical characteristics of the gold nanoparticles will be measured at cryogenic and room temperatures. To improve the ordering of the particle arrays, a vertical lift, as used by Takayuki[1], will be tested. Furthermore, particles similar to the gold and sulfur containing fullerene(C_{60}) nanoparticles used by Shish[2] will be introduced.

Figure 1. TEM image of gold nanoparticles at 260,000X.

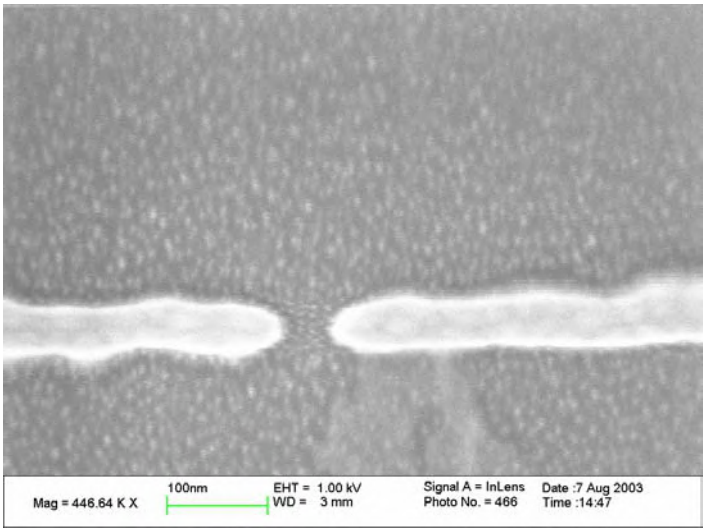

Figure 2. SEM image of gold nanoparticles on chip with gold electrodes at 446,640X.

1. Takahagi, Takayuki; Huang, Shujuan; Tsutsui, Gen; Sakaue, Hiroyuki; Shingubara, Shoso. "Fabrication of Two- and Tree-dimensional Structures of Nanoparticles Using LB Method and DNA Hybridization." Warrendale, PA: Materials Research Society, 2002.

2. Shih, Sheng-Ming; Su, Wei-Fang; Lin, Yuh-Jiuan; Wu, Cen-Shawn; Chen, Chii-Dong. "Fabrications and Electron Transport Properties of One Dimensional Arrays of Gold and Sulfur Containing Fullerene Nanoparticles." Warrendale, PA: Materials Research Society, 2002.

Synthesis of Fe and Fe-based Alloy Magnetic Nanoparticles in a Polymeric Media

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Devinder Mahajan and *Miriam Rafailovich*, Department of Materials Science & Engineering,
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Iron (Fe) magnetic nanoparticles have myriad potential and practical applications in catalysis in addition to information storage and electronics. In a society heavily dependent on transportation fuels, there is an increasing need to find an effective method for cleaning fuel. Nanoparticles are optimal for this catalytic purpose because of their small size and increased surface area. Moreover, as the data storage industry creates ever-shrinking devices, the largest hurdle has been to create a uniform thin magnetic film for magnetic recording [1]. As a solution, research has turned to iron (Fe) nanoparticles, due to the large surface area.

Two methods were used to synthesized Fe and Fe-based nanoparticles. The first method involved the thermal decomposition of iron pentacarbonyl (Fe $(CO)_5$) confined by micelles of Pluronic® triblock copolymers ($(EO)_x(PO)_y(EO)_x$) formed in the solvent mesitylene (C_9H_{12}). The procedure was carried out carefully and in a Hydrogen-Argon atmosphere to prevent oxidation. Chromium hexacarbonyl (Cr $(CO)_6$) in addition to iron pentacarbonyl was used to create alloy nanoparticles in a 9:1 ratio. The second method also synthesized iron nanoparticles using thermal decomposition. However, these nanoparticles initiated the polymerization of the styrene monomer, producing a polystyrene matrix encapsulating the Fe nanoparticles [2].

Superconducting quantum interference device (SQUID) magnotometry was conducted on both the pure Fe nanoparticles and Fe-Cr alloy nanoparticles. SQUID analysis suggests a 33% increase in magnetization in the Fe-Cr alloy nanoparticles when compared to the Fe nanoparticles (Figure A and B). This phenomenon may be a result of the Cr support. Transmission Electron Microscopy suggests the nanoparticles are of approximately 5nm and of uniform size. Mossbauer spectroscopy will be performed to conclusively determine paramagnetism. Further analysis will be conducted in order to establish the use of these nanoparticles for catalysis in hydrodesulfurization using Gas Chromatography.

Figure A.

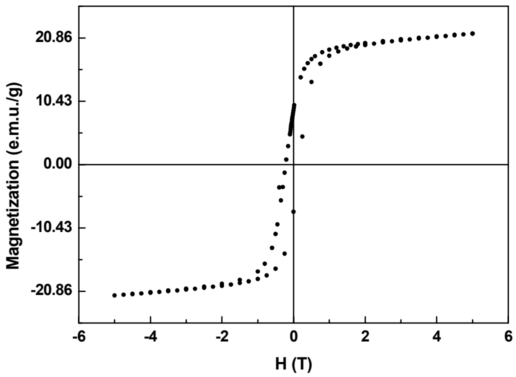
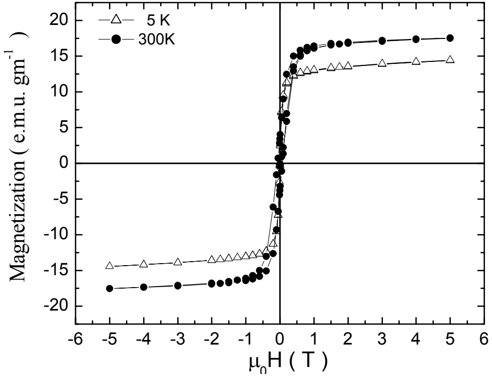


Figure B.



Figures. Magnetization versus applied field H hysteresis loop collected by SQUID magnotometry. (a) Results of the Fe-Cr alloy nanoparticles collected at 5K indicates saturation at 20 emu/g, whereas (b) the Fe nanoparticles saturated at a mere 15 emu/g at 5K.

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The Effect of Hydrophilic and Hydrophobic Gold Nanoparticles on CF-31 Fibroblast Growth

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Nanoparticles have many applications ranging from data storage to catalytic chemistry to biomedical engineering. Recently, gold nanoparticles have come into experimental use as non-invasive DNA transfection agents [2]. In this method the particles are attached to DNA and propelled by helium bursts into tissue. Unfortunately this method suffers a very low transfection rate. It is hypothesized that this low efficiency is due to both the low DNA adsorption rate to the particles and the cytotoxicity of the nanoparticles. The motivation for this project was therefore to determine in what way the transfection efficiency could be improved.

In a previous study, the addition of a surfactant led to increased DNA adsorption to the particles. When a solution of lambda DNA was drop cast onto a thin film of 1-Decanethiol ($C_{10}H_{21}SH$) functionalized gold nanoparticles [1], the DNA appeared to be inhibited from forming a normal ring pattern. The ring pattern formed was much smaller than the pattern that is formed on a bare gold surface. Additional analysis with Atomic Force Microscopy revealed that the DNA had indeed adsorbed to the thiol-functionalized surface. This suggests that instead of plain gold particles, particles should be coated with a surfactant to improve DNA adsorption.

In order to determine whether hydrophilic or hydrophobic particles are more effective for DNA transfection, a kinetics assay was performed to determine the amount of cells that were killed off by the nanoparticles. CF-31 Fibroblasts were plated for 24 hours with media and then exposed to one of two types of nanoparticles. One type, gold particles with sodium citrate ($Na_3C_6H_5O_7$) as a surfactant, was hydrophilic and the other type, gold particles with sulfonated polystyrene (SPS) as a surfactant, was hydrophobic. In order to expose the cells, the nanoparticles were mixed with media and plated.

The cells were counted at five time points after their exposure: 1 hour, 3 hours, 6 hours, 12 hours, and 24 hours. The cells were counted using a hemocytometer and Trypan Blue. Also, cells were imaged using Confocal Microscopy. Actin fibers within the cells were dyed green with Alexafluor 488 and nuclear material was dyed red with Propidium Iodide.

It was determined through counting the cells that the nanoparticles did indeed kill off cells. Regardless of type, exposure to either of the nanoparticles led to a smaller number of cells than the control. Also, it appeared that the hydrophilic nanoparticles were less cytotoxic. This can be seen in that there were generally more cells left alive in the sodium citrate-exposed samples than in the SPS samples.

This can also be seen through Confocal Microscopy. Some of the nuclei of cells exposed to SPS nanoparticles were ejected from the cytoplasm. In comparison, the sodium citrate nanoparticles did reduce the size of the cells but otherwise the cells were almost unchanged. This experiment should be repeated to confirm these findings.

Future research on DNA attachment to these particles in solution should be observed perhaps with end chain functional groups such as amines. Additionally, actual transfections using nanoparticles *in vivo* or *in vitro* should be compared with current methods for DNA transfection and vaccination.

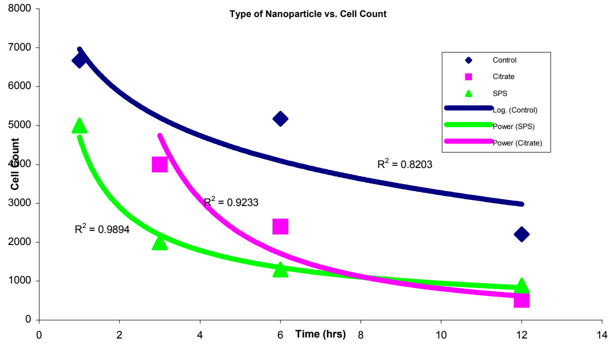

Figure 1. Nanoparticle Type vs. Cell Count

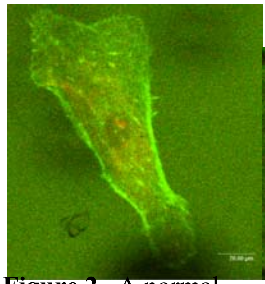

Figure 2. A normal Fibroblast (40x)

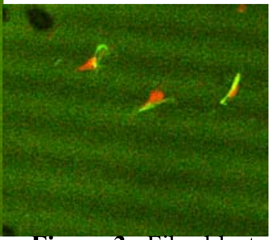

Figure 3. Fibroblasts exposed to SPS. Note the nucleus is outside the cytoplasm (10x)

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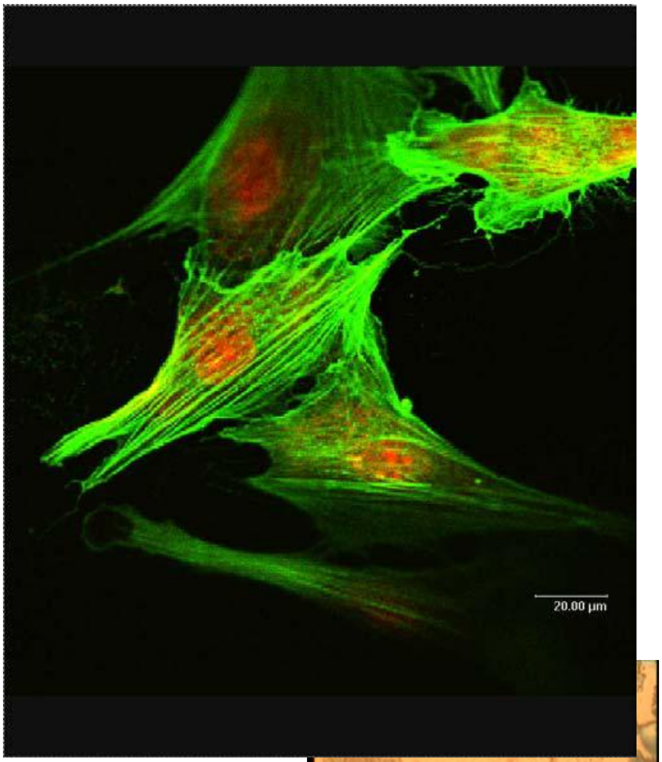
Session 6:Biomolecular Self Assembly



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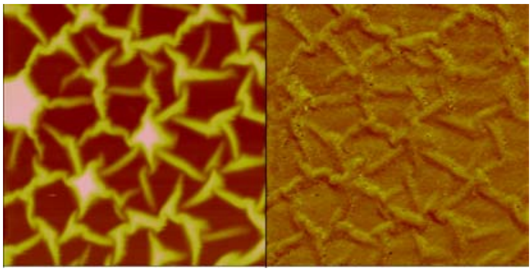

Glucose Effect on ECM Proteins and Glycosylation Reaction Related to Diabetics

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Fibrinogen and Fibronectin are plasma proteins, which play a major role in human wound healing. Fibrinogen converts to an insoluble fibrin "gel" following a cut, which eventually forms a clot to prevent blood loss. The clot is also functional in cell adhesion and migration for forming scars. Fibronectin is an adhesive glycoprotein that affects the adhesion and migration of cells (fibroblasts) in wound healing. (Ref. 1) The objective of this research is to observe the effects of glucose on the binding of these plasma proteins and human fibroblasts in the extra cellular matrix (ECM). In diabetics, excess glucose causes gylcosylation, a reaction between glucose and ECM. The fibers harden when exposed to glucose, causing them to break more easily, thus hindering wound healing.

Fibronectin (Fn) was incubated on a silicon (Si) substrate spun with the polymer, sulfonated polystyrene (SPS) 28%. (Figure 2) Different concentrations of glucose solution (1, 2, and 3mg/mL) were added to the wafers and fibronectin, leaving a set of Si wafers and Fn as the control. After the five day incubation period, images of the Si wafers in this solution were taken by the atomic force microscope (AFM). An additional set of SPS spun Si wafers incubated with the same glucose-Fn solutions were plated with human fibroblasts. (Figure 1) This same procedure will be performed using fibrinogen as a substitute for fibronectin.

At the 3 mg/mL glucose-Fn concentration the Fn fibers were observed to be harder than in the control. The control had a higher lateral response thus the fibronectin fibers were softer than those of the solutions with greater glucose concentration and a lower lateral response. (Ref. 2) The 3mg/mL glucose concentration did not affect the hardness in between fibers, meaning that the glucose interacts mainly with Fn in fibers. Fn conformation in these fibers might be more suitable for the glucose to interact with the protein. Glucose also affected the overall structure of the ECM. These data confirm the hypothesis that tissues harden in presence of glucose.

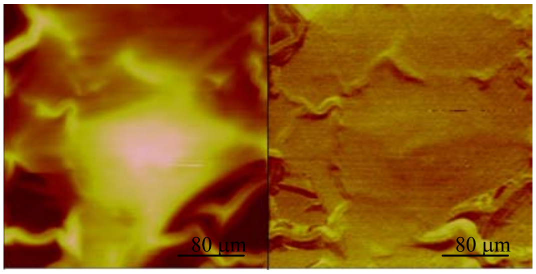

Figure 1. Human Fibroblasts plated on Fn and imaged by AFM

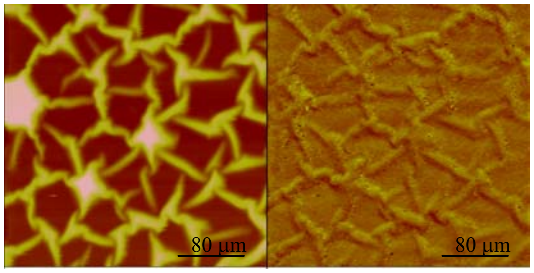

Figure 2. 5 days incubation of Fn imaged by AFM

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A Novel Method of “On-On” Cell Patterning on Polymer Surfaces

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Tissue engineering is a field of research that has the potential to create synthetic tissues and even complete organs. Development of this technology would reduce dependence on donor organs and tissues, which are perpetually in short supply (1) and can potentially be rejected by the recipient. To create synthetic tissue, researchers must be able to control the placement of cells. Prior research into cell patterning has primarily resulted in “on-off” patterns, with a single type of cells in some locations and no cells in others (2,3). In a true tissue, different types of cells are adjacent to one another, usually with no space without cells, and held together by the extracellular matrix (ECM). This research aims to create a two-step method to form “on-on” patterns, with one type of cell in some areas, and another type of cell in other areas.

In this method, a polymer bilayer is formed on a clean silicon wafer. The bottom layer is made of spun-cast poly (methyl methacrylate) (PMMA), a polymer known to allow for cell growth. After annealing, a mixture of polybutadiene (PB) or polybromostyrene (PBrS), and bovine serum albumin (BSA) is spun on top. BSA is known to prevent cell adhesion (4). Optical microscopy has shown that the BSA is distributed randomly on the PB and PBrS surfaces. For the first step of the two-step process, human dermal fibroblasts were cultured on the surface of the bilayer, and were shown by confocal microscopy to grow only on the PB or PBrS and not on the BSA (Figure 1). High concentrations of BSA in the surface were seen to cause diminished numbers of cells and smaller cell size. After growth has occurred, the BSA will dissolve slowly in cell growth media, revealing the PMMA underneath. For step two, human neuron cells will be cultured on the surface, but are expected to grow only on the PMMA, since all space on the PB would be taken up by the fibroblasts.

Future study will involve confocal microscopy of cells cultured on PBrS/BSA surfaces, dissolving BSA to reveal PMMA, and culture of neuron cells. Eventually, non-random patterns of albumin on the PB or PBrS surfaces may be generated.

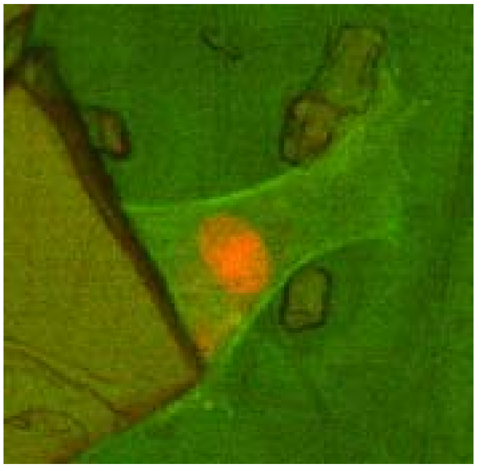

Figure 1: Fibroblast cell growing between BSA particles

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Patterning Applied to Protein Organization and Cell Adhesion

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The emergence of tissue engineering, a field involving the repair and substitution of tissues and cells, has led scientists to find ways to define cellular architecture. Currently, tissue engineering is dependent upon the capacity to control the organization and morphology of cells and proteins. Albumin and fibronectin are two proteins that aid in cellular processes. Albumin helps to maintain osmotic pressure, aiding the distribution of cellular fluids (1). In addition, fibronectin (Fn) is an excellent adhesive protein found in the extracellular matrix (ECM), plays a large role in tissue repair, and undergoes spontaneous fibrillogenesis when coming in contact with 28% SPS on silicon substrates (2).

Our current research focuses on the various approaches that affect the organization of proteins and cells on Silicon (Si) and Gold (Au) substrates. Specifically, this study investigates how these proteins and cells organize in relation to patterning on the micro-scale. Silicon surfaces were coated with 28% SPS, stamped by a protein solution of albumin or fibronectin, and finally plated with cells. Another method employed to see how cells and proteins organize was through gold (Au) etching and chromium (Cr) etching on Au/Si substrates.

Our findings were based on the analysis of cells and proteins on Si and Au substrates through the use of the Atomic Force Microscope (AFM) and optical microscopy. It has proven that fibronectin as well as albumin are organized according to the micro-patterned dimensions and that they do form only a monolayer on metal substrates. In terms of cell organization on SPS stamped substrates, the cells were reaching for the polymer where Fn was adsorbed (See figures 1 and 2 below). However, no cells were absorbed or observed on the same samples with albumin. This illustrates the selection of cell organization because Fn is quite compatible with Si/SPS in great contrast to albumin.

In addition, with the creation of our "cell" warmer in the lab, we are now capable of sustaining viable cells during Atomic Force Microscopy and Optical Microscopy. Previously, cells were not able to stay alive because room and media temperatures were unsuitable for life. Furthermore, before the utilization of our "cell" warmer, one was not able to apply external forces such as lasers. Now, on the other hand, future experiments can be conducted involving measurements and scanning of cells, proteins, and micropatterns on the AFM over long time intervals.

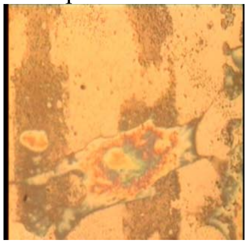

Figure 1

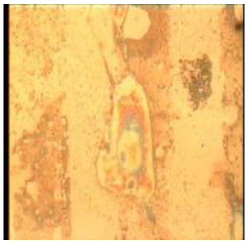

Figure 2

Both Figure 1 and Figure 2 are pictures of cells on stamped SPS with Fn. These pictures were taken through the use of the optical microscope.

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Surface Topography Influence on Actin Organization

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Understanding the adhesion and shape of cells is crucial to tissue engineering. Attachment, adhesion, and spreading are the first phases of the interaction between the surface and the cell, which then influences the ability of the cell to proliferate and differentiate[1]. Cells are able to sense their external environment, and the information is then transferred to the interior by their integrins. The adhesion of the cell to the surface involves focal contacts, which are located within the cell membrane, connecting to cytoskeleton proteins and acting as mechanosensors of the environment[2]. It has been shown that cell shape, which is linked to the behavior of actin filament alignment, is greatly influenced by patterned topography and chemical properties of the surface[1].

The focus of this project is to observe actin organization in response to patterned surfaces. Various surfaces with features on the micro- and nano-scale were used to observe the influence on fibronectin (Fn) and cell organization. Nanopatterns were created by spin-casting polybutadiene (PB) on silicon and allowing the polymer to dewet. Silicon gratings with various dimensions as well as aluminum/silicon surfaces with micron sized aluminum square depositions were also used. Micro-gratings were coated with sulfonated polystyrene 28%. Fn was then incubated on the substrates, and kidney epithelial cells were plated on the nanopatterns and dermal fibroblasts were plated on the micropatterns. The samples were stained with Alexa Fluor 488 for actin and propidium iodide for the nucleus to be imaged with confocal microscopy. Surfaces were also scanned with atomic force microscopy.

The actin of the cells on dewetted PB surfaces had distinct bundles where the actin radiated from a center point (figure 1), as opposed to flat PB where the actin filaments were aligned along the perimeter of the cells. On the Si gratings, the cells become elongated to adapt to its environment. The dermal fibroblasts were restricted either within the grooves or on the ridges, except on the gratings with smaller dimensions, where the cells were able to bridge the groove (figure 2). The actin filaments of the dermal fibroblasts align parallel to the gratings, while those cells bridging the groove form actin filaments that are perpendicular to the gratings in order to support itself. On the Al/Si surface, the Fn organized around the raised Al squares. We showed that cells adapt to their environment to survive by changing their actin organization.

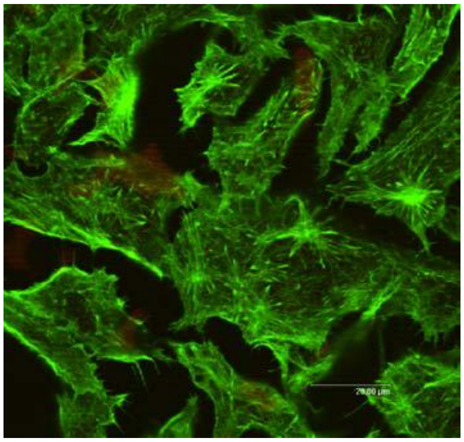

Figure 1: confocal image; kidney epithelial cells on dewetted PB surface

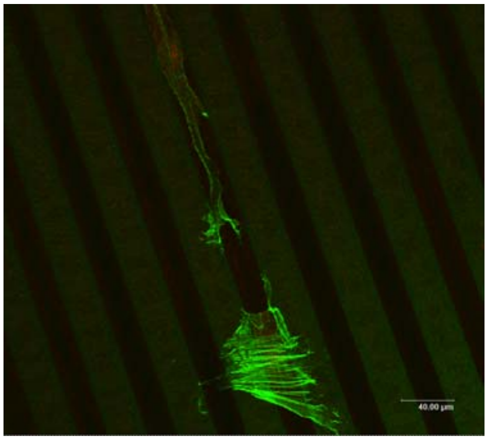

Figure 2: confocal image; top dermal fibroblast constrained within the groove; bottom cell bridging the ridges on Si grating

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Growth and Manipulation of Cells on Photosensitive Polymer with Protein Substrate

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Tissue engineering was first proposed in the United States in the mid-1980s to solve the problem of donor shortage in organ transplantation. Instead of requiring a highly compatible donor, tissue engineering allows doctors to create biological substitutes created by the cells of the recipient, significantly reducing the chance of rejection. The problem encountered by this method is that in order to create complex tissues, many different types of cells must be molded in specific order and organization. Complex tissues, such as organs, require multi-layers of cells. These must be built layer by layer in order to generate tissue.

The aim of this research is to show that a light sensitive polymer would be affected when exposed to light, even when in the presence of biomaterial, such as a protein. If the polymer can coexist and function with the substrate, then it can be useful in culturing cells. The "switch" in the polymer can be used to control the adhesion of cells[2]. Through this process, cells can be cultured layer by layer and then made into a whole tissue, using a cell scaffold to maintain the structure.

Results have shown that the polymer adhered to the Silicon surface; it was not removed when exposed to PBS buffer media. In addition, the fluorescent stain indicated uniform adsorption of the protein Heparin. It was also proved that it is possible regulate the dissociation of the polymer with ultraviolet light. There was good control over patterning, as well as good resolution and accuracy, therefore, the photosensitive polymer can coexist with biomaterials and still be controlled by light. The ultraviolet lamp can be used with accuracy to pinpoint a specific location and denature the desired area of the polymer. Figure 1 shows that a controlled pattern can be applied to the polymer, therefore confirming accurate and complete control over the denaturing of the polymer.

In addition, in figure 2, the cells shown from the AFM images prove that it is possible for three conditions to coexist: the photosensitive polymer, biomaterial substance, and cells. After successfully patterning surfaces with cells on them, the next step would be to denature one specific cell by means of a laser. This would be an advantageous method to remove a specific "bad" cell or cancerous cell among other healthy cells. The goal would be to denature a cell without having a negative effect on the surrounding cells. In addition, U.V. light will ultimately not be usable because it is harmful to cells. Since the wavelength of light required to activate the PCP photosensitive polymer is only 360-380 nm, an alternative source of light may be from an AlN crystal[3]. The AlN crystal, when activated by U.V. light, emits blue light. If positioned under the cells, the energy will be just enough to activate the polymer and light the cells, without exposing them to harmful light. We can then create a computer-controlled system for an automated process.

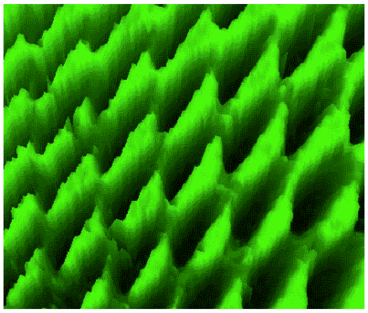

Figure 1

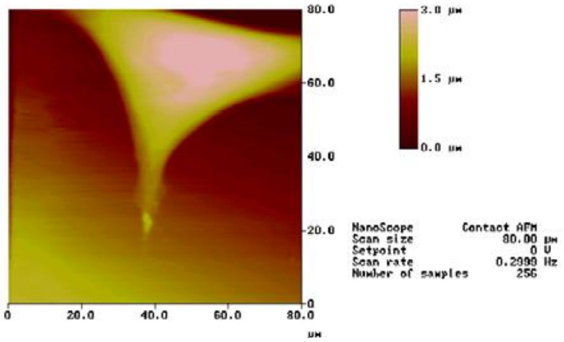

Figure 2

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An Analysis Of The Viability Of Phase Separation Methodology For The Creation Of A Porous Matrix Of Thiolated Hyaluronic Acid

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Porous, biocompatible hydrogels hold tremendous potential in the healing of chronic wounds in an effective, non-invasive manner. Since the highly proteolytic environment in a chronic wound significantly diminishes the capacity to heal, a matrix that resists biological and mechanical degradation is desirable. Hyaluronic Acid (HA) is a non-cytotoxic biopolymer found in significant proportion in the granulation tissue and is therefore used as a template for treatment of chronic wounds.

The inability of cells to migrate into a solid matrix necessitated the development of a porous matrix. The methodology examined is the two-component phase separation method to create a state in which one component could be dissolved out, thereby creating pores (Fig 1, Ref 1). Poly- (ethylene) glycol (PEG), Poly- (ethylene) oxide (PEO) and high molecular weight HA, all being water-soluble polymers, were used as the second component that would be dissolved out. The polymer was mixed with thiolated HA, then dissolved out of the HA hydrogel after the addition of a cross-linker, Poly (ethylene) glycol divinylsulfone (Ref 2). A porous Hylauronic acid gel-matrix remains, with the pore sizes depending on the molecular weight of the polymer.

Among future work being considered, a test utilizing fluorescent beads of various microscopic sizes to more accurately determine the nature of the pores, along with Confocal analysis would be beneficial. Eventually, the integration of fibronectin domains onto the HA to stimulate fibroblast migration would be studies, culminating in human clinical trials that utilize the finished product. An alternate method for inducing pores is gel molding. This method would be achieved by forming the hydrogel around a bed of micro needles, thus creating a porous hydrogel. Additionally, this method can be easily reproduced in large scale applications.

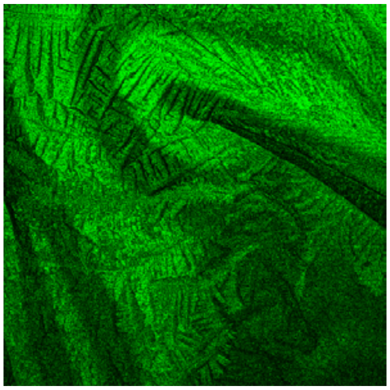

Figure 1. The image taken from a Confocal microscope shows phase separation of two components.

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Viscoelastic Properties of Fibroblasts Seeded on a Hyaluronan (HA)/Recombinant Fibronectin (rFN) Composite Behave as a Function of Cross-Linking Density and rFN Functional Domains

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Kaustabh Ghosh, Xiao Zheng Shu, Shouren Ge, Xiaohua Fang, Miriam Rafailovich, Glenn D. Prestwich, and Richard A.F. Clark, Department of Biomedical Engineering, State University of New York at Stony Brook

Extracellular matrix (ECM) molecules have a profound effect on cell growth, migration, and differentiation. Cell receptor binding to these molecules alters the cell's cystoskeletal arrangement giving an easily monitored display of cell phenotype (1,2). In engineering tissue, one can take advantage of known cell-ECM interactions to design scaffolds that have appropriate molecular clues for the desired cell function. Hydrogels are an ideal scaffold for engineering molecular specificity since their hydrophilicity eliminates non-specific protein binding (3). HA, a natural occurring hydrogel, can be thiol-derivitized so that specific molecules can be covalently linked to the HA during polymerization. HA hydrogels were prepared at different cross-linking densities of cross-linker, polyethylene glycol divinylsulfone (PEGDVS), varying the gel's stiffness, and linked to varying concentrations of the rFN functional domains, varying the adhesiveness of the cells to the HA matrix. We hypothesized varying cross-linker and rFN concentration would modulate the stiffness of the cell's surface (the surface modulus) and influence the cell's cytoskeleton. Fibroblasts were seeded on the HA matrix and their response, quantified by the surface moduli, to the underlying substrate was measured using the DI-3000 Scanning Force Microscope (SFM). Images of fibroblasts stained with alexa fluor-488 phalloidin for the actin cytoskelton were taken using the Leica confocal microscope showed semi-quantified cell spreading (Figure 1). The cell surface moduli were found to be a function of cross-linking density. The cells also showed a direct relationship between spreading on the substrate and their surface moduli. This indicates cells respond to both the viscoelastic properties and the adhesiveness of the engineered HA/rFN composite. The ability to easily monitor direct relationships between hydrogel physical properties and cell phenotype will greatly enhance our potential to design hydrogel composites for specific tissue engineering purposes. This study was supported by a training grant from the National Institute of General Medical Sciences (R25-GM62492).

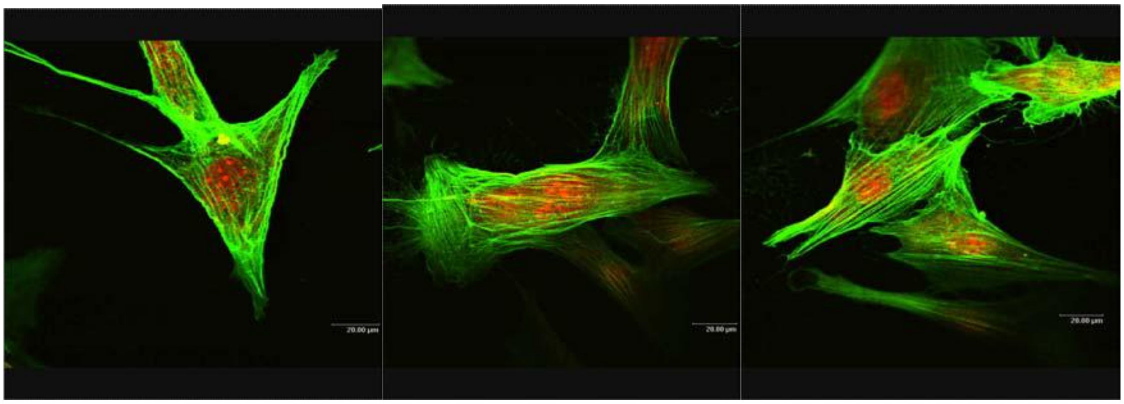

Figure 1 Fibroblasts on different substrates stained for both actin filaments and nuclei

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Mechanotransduction, Fibroblast Migration, and Fibroblast Adhesion on Modified Hyaluronic Acid (HA) Hydrogels

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Applications of tissue engineering require the control of the elasticity of biological scaffolds and of the mechanical properties of cells on an underlying substrate. Interactions between the integrin of a cell and its extracellular matrix (ECM) create tensional forces in the cell's actin cytoskeleton (1). Hyaluronic acid (HA), a biopolymer present in the ECM of all vertebrates, can be chemically crosslinked to obtain biocompatible hydrogels (2). Hydrogels can swell up to six times in volume when allowed to absorb water. In this study, mechano-chemical transduction pathways, cell migration, and the effect of glucose modification on human dermal fibroblasts plated on modified HA hydrogel surfaces was determined using scanning modulation force microscopy (SMFM) and confocal imaging microscopy.

Hydrogels were formulated by coupling three recombinant fibronectin (FN) fragments, previously found to be necessary and sufficient for the optimal migration of primary dermal fibroblasts, to a crosslinked thiolated HA backbone using poly (ethylene glycol) divinylsulfone (PEGDVS) as a crosslinker. Previous rheology experiments have shown that varying the concentration of crosslinker controls the elasticity or stiffness of the hydrogel (3). The elastic modulii (e.g. stiffnesses) of fibroblasts were correlated to the concentration (Φ_{XL}) of crosslinker, the concentration (Φ_{HA}) of HA, and the type of recombinant fragment of fibronectin (rFN_f) used. Mechanical properties were measured using SMFM. The samples were fixed and stained for actin cytoskeletons and imaged using a Leica SBS confocal microscope (see figure 1). Experiments involving the effect of different concentrations of glucose on cell adhesion and migration are underway. Cell migration assays were performed by observing cells migrating off cytodex-3 beads onto various HA hydrogel surfaces using a phase-contrast microscope.

Fibroblasts seeded on hydrogel containing $rFN_{8\text{-}11}$, which contains the main cell-binding domain of FN, had an elastic modulus significantly larger than those seeded on rFN_{v120} (see figure 2). Fibroblasts seeded on 3% HA had a larger modulus than those seeded on 1% HA. Moreover, cell modulus was found to vary with the Φ_{XL}. These results suggest that cells can sense both the underlying stiffness and adhesiveness of the substrate. Optimal cell migration was found on the hydrogel-fibrin clot sandwich containing three rFN_f. Results from glucose modification assays are pending.

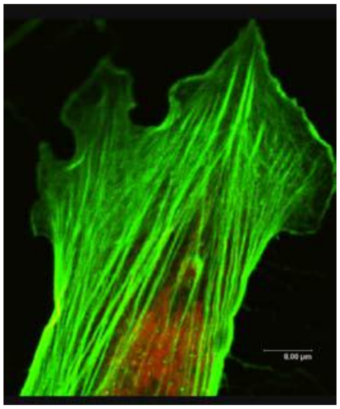


Figure 1-Confocal Image fibroblast on 3% HA (8-11) 6:1

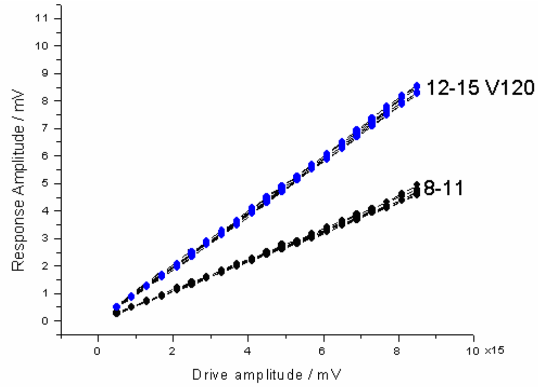


Figure 2-SMFM of fibroblasts on 2 different recombinant fragments of FN

(1) Ingber, D.E. *Journal of Cell Science*. 116:1397-1408. 2003.

(2) Shu XZ, Liu Y, Luo Y, Roberts MC, Prestwich GD. *Disulfide Cross-linked Hyaluronan Hydrogels.* Biomacromolecules. 2002 Nov-Dec;3(6):1304-11.

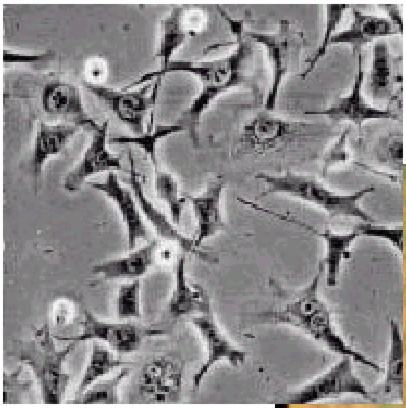
(3) Ghosh K, Shu XZ, Mou R., Lombardi J., Rafailovich M., Prestwich GD., Clark R. *A Comparison of Elasticity of the Crosslinked Hyaluronan Films and Hydrogel.* MRS. 2003.

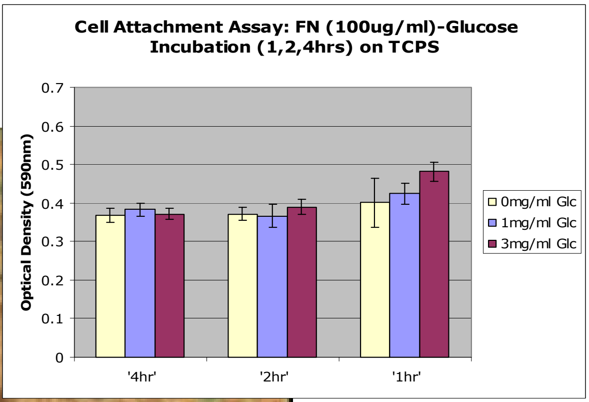
Session 7: Cells on Surfaces

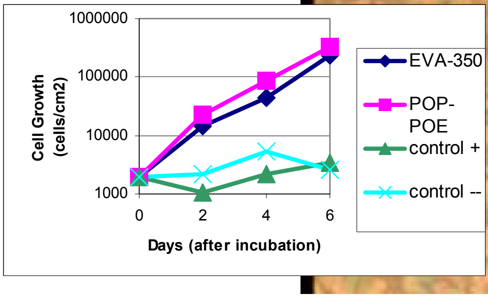
Chairs: Stephanie Kaszuba

Tedi Setton

Spencer Park
Aliza Lopchinksy
Sarah Lefkovitz,Alan Masand
Benjamin Cohen, Daniel Lubelski







Mechanical Properties and ECM Formation of Cancer Cells

Spencer Park, Westhill High School, CT
Lenny Slutsky, Duke University
Madelyn Ho, William P. Clements High School, TX
Dr. Nadine Pernodet, Miriam Rafailovich Ph.D., Department of Material Science and Engineering, SUNY Stony Brook

Extracellular matrix is a dynamic protein network that serves as a platform on which cells can divide, grow, and communicate with other cells. It is a well known fact that cells change and reshape their surrounding extracellular matrices (ECMs) in order to meet its needs and as a result to survive. A cancer cell undergoes the same process. During tumor progression, the ECM undergoes extensive remodeling, giving rise to the provisional matrix (1). Blood-borne proteins, including fibronectin, interact with pre-existing ECM components and with each other in order to help build this new unique matrix for the tumor cell. This new environment is the factor that makes cancer so hard to cure. A tumor cell's mutations in its DNA cannot be repaired, leading to the cell's ability to divide and grow without ending. Through research, some scientists had been able to come up with a hypothesis that the ECM of cancer cells and normal cells may be different and these differences could contribute to the finding of the cure for cancer. (2)

My research, therefore, is to prove the differences of the ECM formed by normal cells compared to cancer cells by analyzing the mechanical properties of the cells and the way they form the matrices. Silicon wafers were coated with sulfonated poly-styrene (SPS), a negatively charged polymer which as a result helps to unfold fibronectin, a protein which was incubated with SPS. Cells, both cancer and normal, were plated on these surfaces and were kept in the incubator at 37 C, an example of which is shown in Figures 1 and 2. Images of the cells and their ECM were taken by AFM and mechanical data taken by Lateral Force Modulation. Also, by using the confocal microscope, differences in actin organization of normal and cancer cells and their ability to adhere will be observed.

Because of the cells' tendency to adapt to their environments, I believe the ECM production should be different between normal cells and cancer cells. If this proves to be true, the mechanical results will also be different and my goal then, will be to figure out the reasons for such differences. Further results will come with the cancer cells.

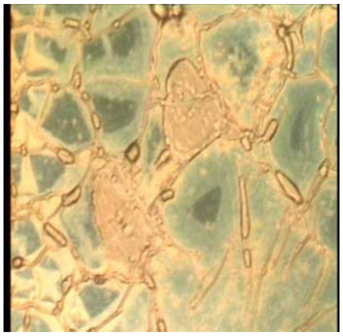


Fig 1 Fibroblast on fibronectin on 28% Sulfonated Poly-Styrene

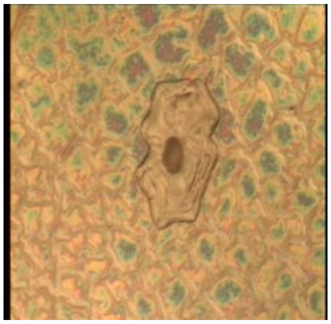


Fig 2 Cancer fibroblast on fibronectin on 28% Sulfonated Poly-Styrene

Reference:

1. Dror Robinson, Michael Segal, Zvi Nevo. "Giant Cell Tumor of Bone" Pathobiology. 2002-03
2. Laura Sanz, Luis Álvarez-Vallina. " "The extracellular matrix: a new turn-of-the-screw for anti-angiogenic strategies" TRENDS in Molecular Medicine. 2003

Attachment of Fibroblasts onto Non-Enzymatically Glycated Fibronectin Coated Surfaces

Aliza Lopchinsky. Stella K. Abraham High School for Girls
Shazia Rana, Richard A. F. Clark. Department of Biomedical Engineering, Stony Brook University

Diabetic patients often suffer from chronic wounds such as venous leg ulcers that fail to heal. Excess levels of glucose in these individuals may disrupt the fibronectin matrix, which is important for cell attachment, ultimately leading to wound healing. The purpose of this research is to determine the effects of elevated glucose levels on cell attachment to two-dimensional fibronectin matrices.

The cell attachment assay consisted of coating wells in a 96 well plate with 100ug/ml of fibronectin for 2hours at 37°C. The wells were washed and 0, 1, or 3 mg/ml glucose was added to the wells. Each glucose concentration was then incubated at 37°C for 1, 2, and 4 hours. The assay for quantifying cell attachment was performed by adding $1x10^4$cells/well, which were incubated for one hour at 37°C. Afterwards, 2% gluteraldehyde was used to fixate the cells and 0.1% crystal violet was added to stain the cells. The optical density was read at λ=590nm.

Comparing high glucose conditions (3mg/ml) to physiological glucose conditions (1mg/ml) it was found that there was no significant change in cell attachment during this early time course. However, the glucose incubation time course revealed a consistent decrease in cell attachment over the 1, 2 and 4 hour high glucose incubation time points. The greatest cell adhesion was found at 1 hour high glucose incubation, and the least attachment at 4 hours. This data implies that elevated levels of glucose does have an effect on cell attachment on fibronectin coated surfaces.

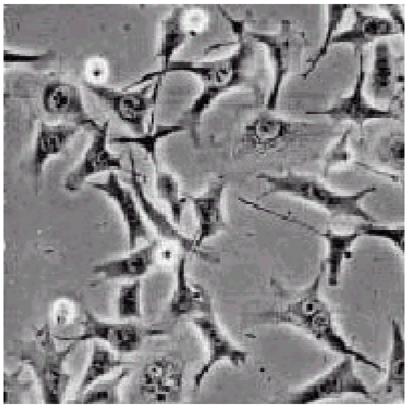


Figure 1. BHK-21 fibroblasts cultured on BD BioCoat Fibronectin Culture Slides attach and spread within one hour.

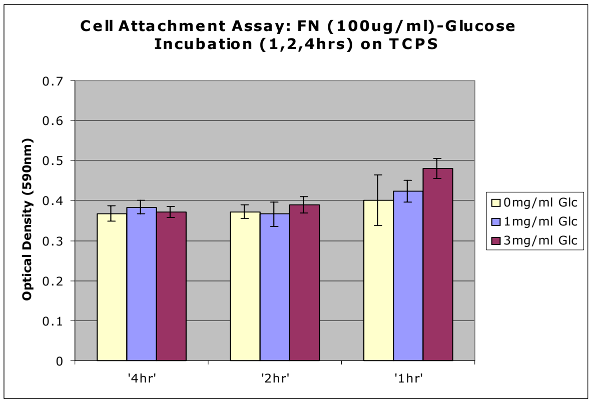


Figure 2. Cell Attachment Assay.

1. Greiling. Doris: Clark. Richard A. F. “Fibronectin Provides a Conduit for Fibroblast Transmigration from Collagenous Stroma into Fibrin Clot Provisional Matrix.” *Journal of Cell Science* 110, 861-870 (1997).
2. Pernodet. Nadine: Rafailovich. Miriam: Sokolov. Jonathan: Xu. D: Yang. Nan-Loh: McLeod. Kenneth. “Fibronectin Fibrillogenesis on Sulfonated Polystyrene Surfaces.” *Journal of Biomedical Material Research* 64A:684-692, 2003.

The Effect of Various Polymers on Dermal Fibroblast Growth and Function

Sara Lefkovitz, Stella K. Abraham High School
Alan Masand, Locust Valley High School
Josh Levine, Columbia University
Lourdes Collazo, Dr. Rafailovich, Dept. of Material Sciences and Engineering,
SUNY Stony Brook

In the human body, fibroblast cells *(Figure 1)* play an active role in the wound healing process. Fibroblasts are responsible for secreting collagen, a protein fiber that functions to close wounds by activating the clotting mechanism and allowing for new tissue to form and regenerate[1]. However, an overproliferation of fibroblasts can lead to the formation of cosmetically undesirable keloids *(Figure 2)* and hypertrophic scars, which result from the excessive collagen production by the fibroblasts[2]. The purpose of our research is to determine the effectiveness of various polymers, such as Polybutadiene and Polydimethylsiloxane, in moderating the growth of fibroblast cells, thereby helping to prevent the appearance of such scars.

Thin films of Polybutadiene and Polydimethylsiloxane at varying thicknesses, with and without clay, were spun cast and annealed. The samples were then incubated without carbon dioxide for 48 hours with media (10% FBS). Growth curves will be calculated for the different substrates. The nuclei and F-actin fibers of the fibroblast cells will be stained and analyzed using the confocal microscope. Lateral force modulation will also be used to analyze the mechanical properties of the cell and substrate.

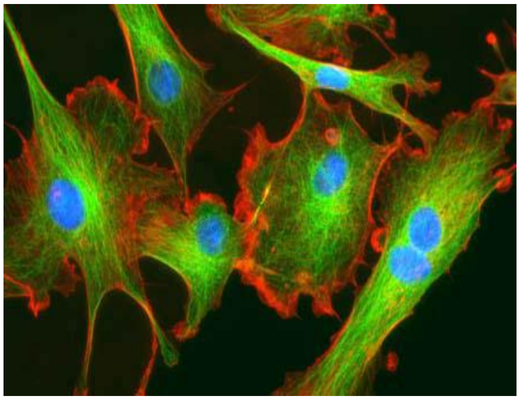


Figure 1.
Fibroblasts labeled with FITC, Rhodamine, and Dapi.
biomaterials.bme.northwestern.edu/ research.asp

Figure 2.
Keloid arising after an injury.
www.dermnetnz.org/dna.keloids/ keloid.html

1. "Collagen and Healing- How the Body Heals Ulcers & Burns." http://www.woundheal.com/healing/process01.htm (7 August 2003).
2. Phan TT, Sun L, Bay BH, Chan SY, Lee ST. "Dietary Compounds Inhibit Proliferation and Contraction of Keloid and Hypertrophic Scar-Derived Fibroblasts in Vitro: Therepeutic Implication for Excessive Scarring." http://www.ncbi.nim.nih.gov/entrez/query.fcgi?CMD=Text&DB=PubMed (2 July 2003).

The Effect of Different Polymers on Proliferation of MC-3T3-E1 Osteoblast-like Cells

Daniel Lubelski, HAFTR High School
Benjamin Cohen, HAFTR High School
Josh Levine, Columbia University
Lourdes Collazo, Dr. Rafailovich, Dept. of Material Sciences and Engineering
SUNY Stony Brook

Approximately 150,000-200,000 hip implants are performed in the U.S. each year, which accounts for 12% of all body implant procedures[1]. Hip replacements are currently made of titanium, a substrate which is not compatible with cells, inhibiting their growth and proliferation. The bio-incompatibility of titanium prevents osteoblasts, or bone cells, from effectively adhering to the implant, which can cause the rejection of the implant by the human body. If rejection occurs, the patient may either undergo additional surgery which often proves to be unsuccessful, or is given medication to suppress the activity of the immune system in rejecting the implant. Polymers that promote cell growth and adhesion could be used to coat a titanium implant and therefore improve the chances of acceptance by the body. The purpose of our research is to determine the effectiveness of various thin film polymer coatings in promoting cell growth.

According to Dr. Evangelos Manias, small amounts of clay can improve some physical properties of plastics so clay will also be mixed with some polymers to see if the clay improves cell growth.[2]

Thin films of polymethylmethacrylate (PMMA), polycarbonate, ethylvinylacetate-350 (EVA-350), Polyoxypropylene-Polyoxyethylene, and other polymers were spun cast onto silicon wafers to be plated with the MC-3T3-E1 osteoblasts. In addition, small amounts of clay (3%) were mixed with some polymers to see if there was any improvement in cell growth (Figure A). All polymer surfaces were then annealed at 170º C for one hour to ensure the polymers sterility and adhesion to the silicon surface. The thin films were then incubated with α-MEM media containing 10% FBS for 48 hours at 37C in a non-CO2 incubator. Controls groups were also created, with and without pre-incubations with media and serum.

MC-3T3-E1 cells were added to the surfaces at a density of 2,000 cells/cm2 and incubated at 37C and 5% CO2. Cell Growth was determined by counting at days 2, 4, 6 and 8 days after plating.

Because this is still an ongoing project, comparative data for cell growth on the different polymers is still pending. However initial data on EVA-350 and Polyoxypropylene-Polyoxyethylene shows that cell growth is better sustained on the Polyoxypropylene-Polyoxyethylene and that cell growth on both polymers far exceed the cell growth seen in the control groups (figure B).

Figure A.

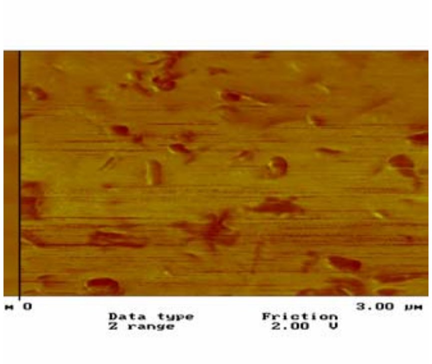


Figure A shows a picture of a PMMA with clay surface under the Atomic Force Microscope

Figure B.

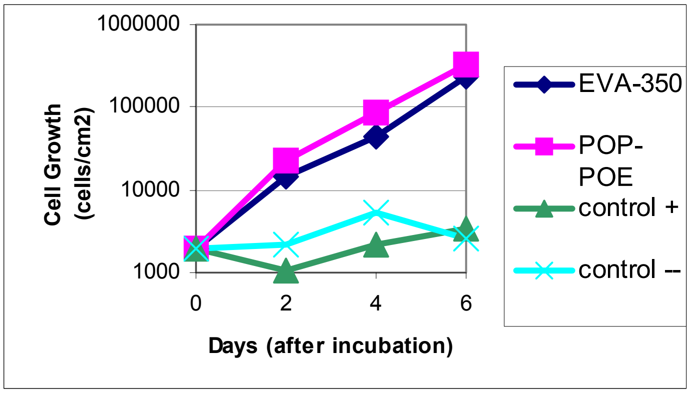


Figure B shows cell growth on Polyoxypropylene-Polyoxyethylene vs. growth on EVA-350 plus the two control groups (control + media and serum and control – media and serum)

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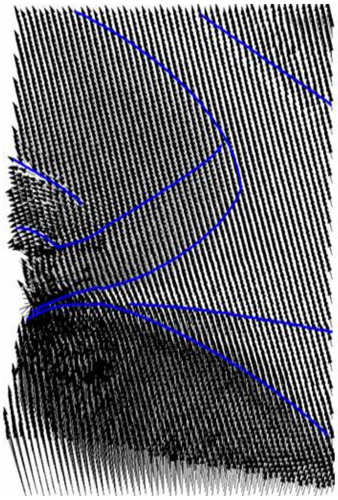
1. "Hip Implants Being Recalled; Potential Fracture Problem." FDA Talk Paper, 09/14/01
2. Dr. Manias. "Nano-Dispersion of Clays Makes Better, Cleaner Plastics." http://www.psu.edu/ur/2001/clayplastics.html. March 26, 2000

Session 8: Bio/medical/commercial

Chair: Aprajita Matoo

Tanmany Chedda, Andrew Song
Joel Herzfeld, Aprajita Matoo
Joshua Etman, Benjamin Cohen
Andrew Lillian, Philip Stern
Sara Rafailovich-Sokolov
Dena Nachman



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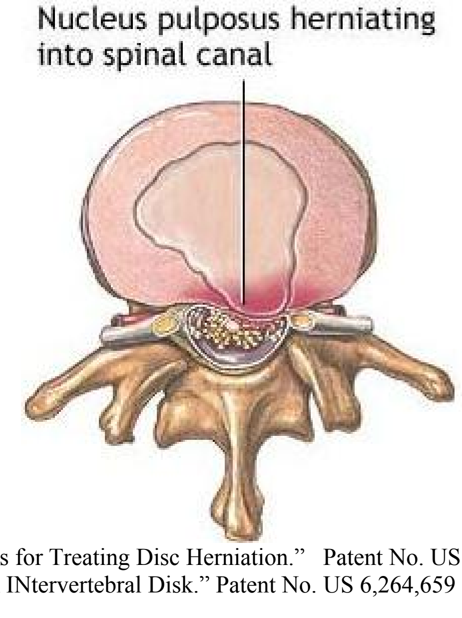
4/13/1987	30069844	4/16/2001	F/U Mastoiditis	OK
9/22/1993	669062	10/7/1998	Lyme Evaluation	Negative
7/27/1986	253525	7/2/1998	Positive PPD	Converter
1/17/1999	30132897	7/18/2002	no show	
3/26/1985	30068974	3/26/2001	Ehrlichiosis Evaluation	Parvovirus
10/20/1985	645683	1/26/1998	PPD test	Negative

Pluronic Hydrogel as a Nucleus Pulposus Replacement in the Treatment of Herniated Discs

Andrew Song, Jericho High School
Tanmay Chheda, Jericho High School
Dr. Miriam Rafailovich, Dept. Material Sciences and Engineering, SUNY Stony Brook

Recently, the importance of a less invasive procedure and a more effective treatment for correcting herniated discs has become essential. Normally, a healthy invertebrate disc acts as a “cushion” between the vertebrae of the spinal cord. A herniated disc is a fragment of the disc nucleus which is pushed out of the outer disc margin, into the spinal canal through a tear or “rupture.” In the herniated disc's new position, it presses on spinal nerves, producing pain down the accompanying leg. This produces a sharp, severe pain down the entire leg and into the foot. The spinal canal has limited space which is inadequate for the spinal nerve and the displaced herniated disc fragment. Current conservative treatments include physical therapy, epidural steroid injections and pain killers. If the pain does not subside after 6 to 12 weeks, surgery such as a microdiscectomy is necessary to alleviate the pain faster. Recently, more invasive procedures involve the total replacement of the invertebrate disc.

The polymers used in the study were pluronic polymers produced by BASF under the name Lutrol. Pluronic polymers are polyoxyethylene-polyoxypropylene block copolymers which have unique properties. Other materials used are considered “x-linkers,” which means it can diffuse throughout the body but pluronic polymers do not have this ability. When mixed with distilled water, this particular grade of Lutrol, F68 NF, formed a hydrogel at about 31°C and became less viscous at colder temperatures. The new procedure would involve the injection of the hydrogel at ambient temperature which would then form into a gel at body temperature that would ultimately match the viscosity of the nucleus pulposus. To achieve this, different concentrations were formed to determine the ideal solution. The solution of six grams of distilled water and four grams of the polymer was established as the ideal concentration after undergoing testing on the rheometer. Future work would include the testing of the rheology of actual nucleus pulposus as well as the biocompatibility of the hydrogel inside the disc.



1. Ferree, B. “Methods and Apparatus for Treating Disc Herniation.” Patent No. US 6,245,107 B1. 1999.
2. Ross et al. “Method of Treating an INtervertebral Disk.” Patent No. US 6,264,659 B1. 1999.

Creation of Biodegradable, Water-Soluble Polymers

Joel Herzfeld, Haftr High School
Apra Mattoo, Columbia University
Miriam Rafailovich, Department of Material Science Stony Brook University

Today, hundreds of plastic "six-pack rings" are probably being dumped into our oceans. These take 400 years to break up, or, if they are photodegradable, six to eight weeks in good conditions.[1] Even so, these polymers never really disappear. If a polymer could be constructed that would rapidly and safely dissolve, and not leave residue in the ocean, as well as biodegrade in landfills or composts, this problem would be solved. Starch is commonly used as a biodegradable polymer, as it is natural, renewable, easily biodegradable, and water-sensitive. Polyvinyl alcohol (PVA) and polyacrylic alcohol (PAA) are two polymers that are both readily water-soluble, but will not biodegrade in soil.[2] If starch were copolymerized with these two resins, a copolymer could be formed that would dissolve in water, and still break up in soil.

In my experiment, we first made a control polymer that had a fifty:fifty PVA:PAA ratio. Then, we spin-casted it onto a hydrophilic Si wafer so that we could readily observe the sample on a microscope. The image is expected to have "hills" with high contact angles. An experimental sample was also created, with a 45:45:10 ratio of PVA:PAA:Corn starch. This was also spin-casted onto a hydrophilic Si wafer, and was also observed under a microscope. The experimental polymer will be water-soluble and biodisintagratable, as the biodegradation of the starch will cause the remaining copolymer to lose mechanical properties and become susceptible to physical breakdown. Tests on the polymers involving using a microorganism consortia are being carried out to see if the starch will properly degrade in a soil environment.

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[1] Water-Soluble Polymers. Butler et al. American Chemical Society. Printed in the US, 1991.

[2] Handbook of Polymer Degradation. Amin et al. Printed in New York, 1992.

The Effect of Different Polymers on Proliferation of MC-3T3-E1 Osteoblast-like Cells

Daniel Lubelski, HAFTR High School
Benjamin Cohen, HAFTR High School
Josh Levine, Columbia University
Lourdes Collazo, Dr. Rafailovich, Dept. of Material Sciences and Engineering
SUNY Stony Brook

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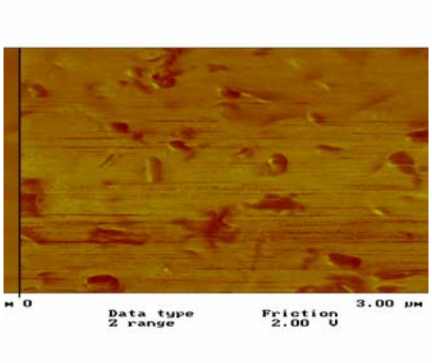
Figure A.



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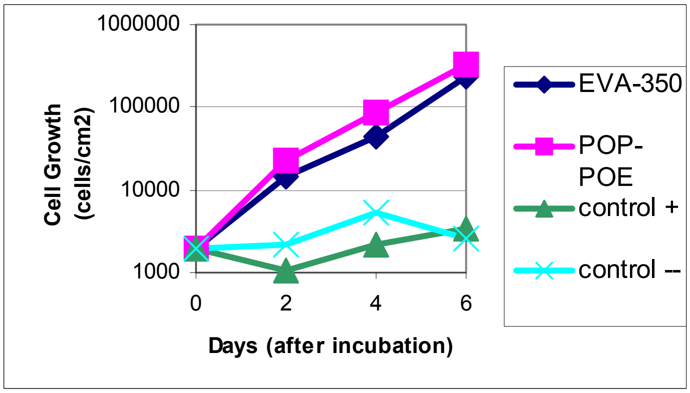

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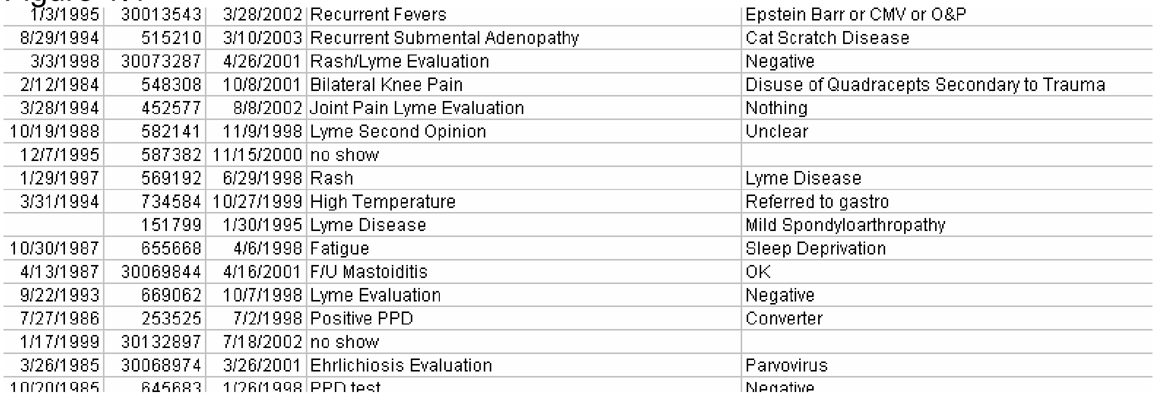
Database Organization from Patient Files

Philip Stern, North Shore Hebrew Academy High School
Dr. Sharon Nachman, Pediatric Infectious Diseases, SUNY Stony Brook

Background: Clinicians see many patients over the course of their careers but rarely take time to analyze data from their patients over time. One of the ways these files can be used is by collecting data from them and creating a database. Databases such as these have been used innumerable times for research. Recently Nachman et al (1) published a report on diagnosing Lyme Disease in the central nervous system. This report contained data obtained from pooling patient information at Stony Brook and …..This combination of information was made possible by organizing patient charts in a similar data base. A sample of the excel spread sheet used to generate the data base is shown in figure 1.1.
Materials-Methods: The department of Pediatric Infectious Disease has been in existence since 1990 and all files are kept in paper format in a locked cabinet. The focus of this project is to create a digital database of these files. Excel software was used to create spreadsheets which included but was not limited to name, record number, age, date of visit, reason for visit and diagnosis. The top five diagnoses in Infectious Disease are Lyme Disease, Tuberculosis, Osteomyelitis, recurrent fevers and rash.
The database is now being used to categorize patients by diagnosis with the aim of retrospective and prospective evaluations of disease. Over 800 files were entered into the database, encompassing approximately 40% of the existing files.
Conclusion: This database can now be used to categorize files by diagnoses and for retrospective analysis of Tuberculosis. Databases such as this are crucial to clinical research in the Infectious Disease setting.

Figure 1.1



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1/17/1999	30132897	7/18/2002	no show	
3/26/1985	30068974	3/26/2001	Ehrlichiosis Evaluation	Parvovirus
10/20/1985	645683	1/26/1998	PPD test	Negative

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Establishment of a Database for the Hematology/Oncology Department

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Background—
Over the past years, the pediatrics department has split into several sections. One of them being the Hematology/Oncology department. Like all hospitals, this department kept files and records on all patients that have visited. What I have done was digitally stored on all of these files onto the computer system as a database so they can all be easily accessed.

Methods/Materials—
The program I used to make the file system was Microsoft Word, in which I created a spreadsheet to store all of the patient information. This would make it accessible and viewable to anybody that needed to see the patient information. Information that was stored on each patient was the name, date of diagnosis, type of diagnosis, start and end dates of treatment, and the type of treatment it was as well as any miscellaneous but important information.

Conclusion—
There was a purpose in storing all the files and information of these patients. Not just to put them on a computer, but to make it easier to cross reference different files of the same patient. The study being done by the Hematology/Oncology department was to track the bone/mineral content of the patient as a side effect of the type of treatment)in these cases, chemotherapy or radiotherapy) on the bone/mineral content of the patient. This will make it easier to track and treat patients over time with the best treatment available.

Facial Recognition Using Digital Image Speckle Correlation

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Using the equation for stress and strain [1] we calculated the sheared stresses and principal stresses of the facial muscles as they move. By taking the sheared stress, a combination of the two individual forces that pull on the muscle for each movement it makes, by dividing the sheared strains into two individual principle stresses of x and y, we were able to find a pattern unique to each individual based on force and displacement of the muscle strains. By taking pictures of individuals and focusing on the area starting from below the eyes till the chin(mainly the cheek) we plotted vector diagrams and color- stress/strain diagrams. The stress-strain diagrams showed us based on the distance between each color, the amount of displacement regarding the skin movement, the farther apart the colors were from each other, the greater the displacement as represented by the strain equation. By converting each movement of the skin into points to be plotted, those points were then plotted in a vector diagram which showed, in small vectors, which way the skin was pulled depending on how it was pulled as represented and calculated using the stress equation. As can be seen in figure 1, the skin pores make ideal “speckles” for this technique.

In order the see how the skin changes depending the circumstances, a picture was taken of a hand normally and then, it was deformed by pushing it up and then down, the pictures were then converted into stress-strain diagrams in order to visualize how much displacement the skin undergoes. Then a certain polymer that hardens on the skin was applied to the same spot and again pictured normally, and then pushed up or down and again the points were converted into a strain diagram in order to see how much the displacement of the skin had changed, which there was less of because the polymer hardened the skin, next, a moisturizing/soapy mixture was applied to the same skin after it had been cleaned of the previous polymer and again photographed un normal, up and down positions and plots converted into strain diagrams and was shown that the skin was more pliable and exhibited greater displacement areas. When the polymer was placed on the skin, before picturing the movements, there was trials of three times that after having applied the soapy and polymer on evenly to the skin was photographed every 30 seconds to see the progressive effects it had the skin as it dried. Regarding the soapy, the skin became smooth and the polymer as it dried made the skin shrink. Next, pictures were taken of people with their heads in a restraint making movement such as smiling and the pictures were taken as progressively as they smiled. Then, by focusing on the area from below the eyes to the chin, strain and vector diagrams were made to record the displacement before and after deformation of the face.

The side of a person’s eye was placed between two restraints and pictures were taken of the eye in normal position and then stretched by the restraints the camera was then focused in on a specific patch of skin within each picture in order to identify how the skin deformed and changed depending upon how it was moved.

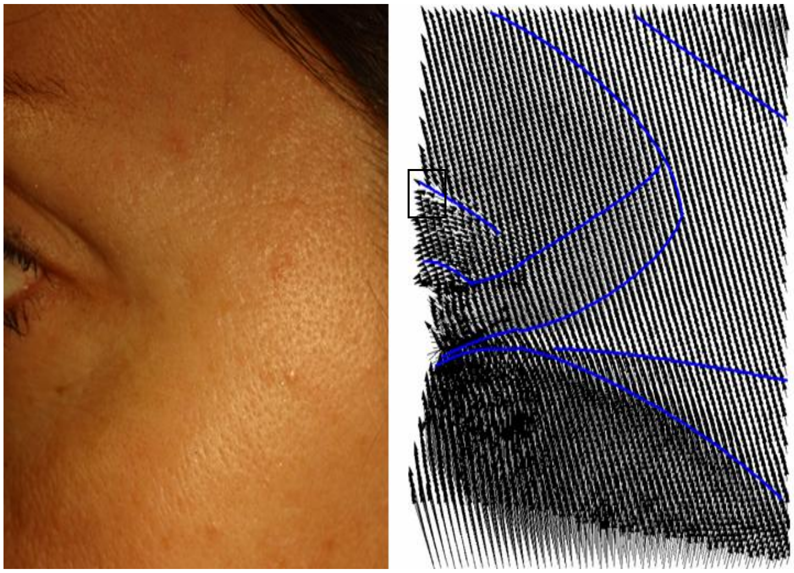

Fig.1. Left: original reference face picture. Right: The corresponding vector map of The blue lines indicate the “Dynamic Wrinkles”.

[1] E Guan, Chuanyu Feng, Hong Miao and Xiaoping Wu: An Assessment of Digital Speckle Correlation Method; Proc. of the SEM Annual Conference on Theoretical, Experimental and Computational Mechanics, Cincinnati, 1999: 19-22.

Attention Deficit Hyperactivity Disorder in Adults

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Background: There is so much discussion in the lay press regarding diagnosis of attention deficit hyperactivity disorder (ADHD) in adults. It is important to make a correct diagnosis on these patients as treatment for each of the attention deficit disorders. While there are many screening tools for diagnosing ADHD in children, there are few structured evaluations of screening tools useful in making the diagnosis of ADHD in adults.

Materials and Methods: As part of developing a screening tool to be used in evaluation adults for ADHD, the literature was surveyed for useful categories of ADHD. Using Medline, MD consult, and Psychlit all papers discussing attention deficit in adults were reviewed. Search categories included drug and alcohol abuse and dependence, familial hyperactivity disorders, anxiety disorders, and depression disorders.

Results: Attention deficit disorders are associated with a higher risk of affective disorders in family members(1). 30-50% of children with ADHD become adults with ADHD (2) . Drug abuse in adolescents is predictive of substance abuse and ADHD as adults (3). These categories among others would be use in developing a screen tool to be used in diagnosing adult ADHD(5).

Conclusions: A short screening tool needs to be developed to diagnose adult ADHD. It should include brief sections on childhood experiences (school and friends), substance abuse and dependence, and antisocial behaviors. This tool will need to be validated on adolescents as they age into adulthood.

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