NanoFlorida 2018
11th Annual Nanoscience an Engineering Research Conference

October 5 – 7, 2018
Florida Institute of Technology
Melbourne, Florida
Welcome to the 11th annual NanoFlorida 2018 Conference! The organizers, Prof. Kurt Winkelmann and Jim Brenner, are pleased to welcome you to Florida Tech. There are 75 talks, 49 posters, 3 instrument demonstration sessions and a Career Expo at NanoFlorida 2018. This year, we offer sessions on the following topics:

- Nanomedicine,
- Nanomaterials Education, Characterization and Thin Films,
- Nanotechnology in Agriculture, and
- Photonics, SERS, FTIR, Simulation, & Nanowires and Self-Assembly.

We would like to thank all of our sponsors.

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We also thank the National Science Foundation for their support. Most of all, we thank you for attending and we hope you enjoy the conference.

Best Regards,
Kurt Winkelmann       Jim Brenner
Chemistry              Chemical Engineering
Dr. Kurt Winkelmann is an Associate Professor of Chemistry at Florida Tech. He attended Virginia Tech as an undergraduate and received his Ph.D. from Auburn University. Dr. Winkelmann joined Florida Tech after completing his postdoctoral work at Northwestern University in 2001. He co-teaches an introductory nanotechnology lab with Dr. Jim Brenner and has been involved with several NSF-funded education projects that promote student learning of nanotechnology. Research in his group explores topics in physical chemistry, nanotechnology, and environmental science. He is also interested in education research related to these subjects. Current education research topics include evaluating the efficacy of virtual labs for general chemistry and developing new nanotechnology lab experiments for first-year students.

Dr. Jim Brenner is the co-founder and current chair of the Nanotechnology Minor Program at the Florida Institute of Technology. He received a Ph.D. from the University of Michigan and worked on several nanotechnology projects during a postdoc at Argonne National Laboratory. Since 1998, he has been a faculty member at Florida Tech working on projects in hydrogen purification, self-assembly and aggregation of nanomaterials, chemical and biological sensors, waste-to-energy, fuel, and chemicals, and most recently, 3D printing of tissue scaffolding and tissue engineering test beds. Dr. Brenner specializes in materials characterization, particularly TEM. Dr. Brenner has received several NSF grants for nanotechnology education and written 27 papers. He has received eight teaching awards.

We wish to thank our student volunteers for their assistance organizing NanoFlorida 2018:

Princess Akande  Ziyad Al Hinai  Megan Bass  Kristen Brenner  Colin Breslin  Timofey Broslav
Reed Coffey  Antonio Gentilini  Bryan Goldstein  Daniel Hocheimy  Alexis Hopkins  Adrien Hosking
Tanner Johnson  Logan Johnson  Kyle Kercher  Robert Koss  Marlisa Lim  Filippo Mazzanti
Dallas Nash  Soha Patil  Thomas Quaid  Colin Snyder  Janani Srinivasan  Kenneth Verderber

NanoFlorida 2018 Steering Committee Members:

Jim Brenner, Florida Tech  Sylvia Daunert, University of Miami  Gregory Hudalla, University of Florida
Jack Judy, University of Florida  David Kumar, Florida Atlantic University  Hedi Mattoussi, Florida State University
Tyler Maxwell, University of Central Florida  Shyam Mohapatra, University of South Florida
Maedeh Mozneb, Florida International University  Madhavan Nair, Florida International University
Mandip Sachdeva, Florida A&M University  Swadesh Santra, University of Central Florida
Kurt Winkelmann, Florida Tech
**NanoFlorida 2018 Conference Schedule**

**Friday, October 5, 2018**

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<tr>
<td>Career Fair Setup</td>
<td>9 – 11:30 am</td>
<td>Clemente Center</td>
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<tr>
<td>Career Fair Interviews</td>
<td>Noon – 3 pm</td>
<td>Clemente Center</td>
</tr>
<tr>
<td>Anton Paar Product Demos</td>
<td>1 – 2, 2 – 3, 3 – 4:30 pm</td>
<td>OPS rooms 202 and 209</td>
</tr>
<tr>
<td>Keynote Speaker</td>
<td>2 – 3 pm</td>
<td>OEC room 137</td>
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<tr>
<td>Dr. Lisa Friedersdorf, Director of the National Nanotechnology Coordination Office</td>
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<tr>
<td><em>The NNI and You</em></td>
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<tr>
<td>Move Career Fair displays</td>
<td>3 – 5 pm</td>
<td>Clemente Center &amp; OEC atrium</td>
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<tr>
<td>Sponsors Dinner</td>
<td>6:30 pm (Meet at trolley 6:15 pm in front of OEC)</td>
<td>The Mansion, Melbourne, FL</td>
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Building codes: Olin Engineering Center (OEC), Olin Life Sciences (OLS), Olin Physical Sciences (OPS)
### Event List

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<tr>
<th>Event</th>
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<tr>
<td>Breakfast, Registration, Poster Setup &amp; Exhibitor Setup</td>
<td>7:30 – 8:30 am</td>
<td>OEC 1st Floor Atrium</td>
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<tr>
<td>Organizers Welcome</td>
<td>8:30 – 8:35 am</td>
<td>OEC room 118</td>
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<tr>
<td>Drs. Kurt Winkelmann and Jim Brenner</td>
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<tr>
<td>Research Office Welcome</td>
<td>8:35 - 8:45 am</td>
<td>OEC room 118</td>
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<tr>
<td>Dr. Tristan Fiedler, Associate VP for Research</td>
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<tr>
<td>Keynote Address Introduction</td>
<td>8:45 – 9 am</td>
<td>OEC room 118</td>
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<tr>
<td>Dr. Chenzhong Li, NSF CBET Program Officer</td>
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<tr>
<td>What does NSF support in Nanotechnology?</td>
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<tr>
<td><strong>Convergence Research and NSF 10 Big Ideas</strong></td>
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<tr>
<td>Keynote Address</td>
<td>9 – 9:50 am</td>
<td>OEC room 118</td>
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<tr>
<td>Dr. Luke Roberson, Senior Principal Investigator for Flight</td>
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<tr>
<td>Research Flight Operations and Research at NASA’s</td>
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<tr>
<td>Kennedy Space Center</td>
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<tr>
<td>Break</td>
<td>9:50 – 10 am</td>
<td>OEC atrium</td>
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<tr>
<td>Session Talks</td>
<td>10 am – 12:20 pm</td>
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<tr>
<td>Lunch</td>
<td>12:20 – 2 pm</td>
<td>Panther Dining Hall</td>
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<tr>
<td>Poster Session</td>
<td>12:30 – 2 pm</td>
<td>2nd and 3rd floor OEC atria, 1st and 2nd floorOPS atria</td>
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<tr>
<td>Session Talks</td>
<td>2 – 5:30 pm</td>
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<tr>
<td>NanoFlorida Steering Committee Meeting</td>
<td>5:30 – 6 pm</td>
<td>OEC room 137</td>
</tr>
</tbody>
</table>

Building codes: Olin Engineering Center (OEC), Olin Life Sciences (OLS), Olin Physical Sciences (OPS)

Session A: Nanomaterials Education, Characterization & Thin Films in OEC room 118
Session B: Nanomedicine in OLS room 129
Session C: Nanotechnology in Agriculture in OLS room 130
Session D: Photonics, SERS, FTIR, Simulation, Nanowires and Self-Assembly in OEC room 137
Sunday, October 7, 2018

<table>
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<th>Event</th>
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<tbody>
<tr>
<td>Breakfast</td>
<td>8 – 9 am</td>
<td>OEC 1st Floor Atrium</td>
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<tr>
<td>Keynote Address</td>
<td>9 – 9:50 am</td>
<td>OEC room 118</td>
</tr>
<tr>
<td>Prof. Sudipta Seal, FASM, University Distinguished Professor</td>
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<tr>
<td>Rare Earth Oxide Nanoparticles, REON From Metallurgy to Biomedicine</td>
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</tr>
<tr>
<td>Session Talks</td>
<td>10 am – 12:40 pm</td>
<td>OEC room 118</td>
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<tr>
<td>Awards and Closing Ceremony</td>
<td>12:45 – 1:00 pm</td>
<td>OEC room 118</td>
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Building codes: Olin Engineering Center (OEC), Olin Life Sciences (OLS), Olin Physical Sciences (OPS)

Session A: Nanomaterials Education, Characterization & Thin Films in OEC room 118
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Session C: Nanotechnology in Agriculture in OLS room 130
Session D: Photonics, SERS, FTIR, Simulation, Nanowires and Self-Assembly in OEC room 137
Keynote Talks

Friday, 2 - 3 pm, Olin Engineering Center, room 137
Lisa Friedersdorf, Director of the National Nanotechnology Coordination Office
The NNI and You

Saturday, 8:45 - 9 am, Olin Engineering Center, room 118
Chenzhong Li, Program Officer for the National Science Foundation
Professor, Biomedical Engineering, Florida International University
What does NSF support in Nanotechnology? Convergence Research and NSF 10 Big Ideas

Saturday, 9 - 9:50 am, Olin Engineering Center, room 118
Luke Roberson, Senior Principal Investigator, NASA Kennedy Space Center
Flight Operations and Research at NASA Kennedy Space Center

Sunday, 9 - 9:50 am, Olin Engineering Center, room 118
Prof. Sudipta Seal, FASM, University Distinguished Professor
Rare Earth Oxide Nanoparticles: REON From Metallurgy to Biomedicine

Session A: Nanomaterials Education, Characterization and Thin Films
Olin Engineering Center, Room 118

Saturday Morning Session Chair: Dr. Jim Brenner, Florida Tech

Nanomaterials Education, Characterization and Thin Films – Olin Engineering 118 – 10:00-10:40
Saturday
What Should a Hands-On Nanoscience & Nanotechnology Curriculum Look Like?
James R. Brenner, Kurt J. Winkelmann, Joel A. Olson, Yekaterina Lin, Shaohua Xu, Lisa M. Cole-Burnett, Benjamin J. Burnett, Kavitha Hari, Kyan Ali, Jack Kindred, Andres Phillips, Florida Tech, Department of Biomedical and Chemical Engineering and Sciences, jbrenner@fit.edu

Saturday
An Overview of Modern Nanoparticle Characterization: Three Techniques
Jeff Bodycomb, Horiba Scientific Corporation

Saturday
Multicomponent Metal Oxide Semiconductors for Visible Light-Activated Catalytic Degradation of Polychlorinated Biphenyls
Elsayed M. Zahran, Marc R. Knecht, Leonidas G. Bachas
Departments of Chemistry, University of Miami and Ball State University
Nanomaterials Education, Characterization and Thin Films – Olin Engineering 118 – 11:40-12:00 Saturday
Enhancing Nanoparticle Tracking Analysis (NTA) with Fluorescence Tags
Gary Linz, Particle Metrix

Nanomaterials Education, Characterization and Thin Films – Olin Engineering 118 – 12:00-12:20 Saturday
Determination of the Overall Antioxidant Strength of Teas Combining Metal Nanoparticles, Plasmonics, and Fluorescence: Designing New Experiments for Physical Chemistry Laboratory
Julie Donnelly, Stephanie Castillo, Warinya Chemnasiri, and Prof. Florencio E. Hernandez, The University of Central Florida, Department of Chemistry

Saturday Afternoon Session Chair: Dr. Joel Olson, Florida Tech

Nanomaterials Education, Characterization and Thin Films – Olin Engineering 118 – 2:00-2:20 Saturday
Advanced Applications in Nanoscale Device Fabrication Enabled by Novel Focused Ion Beam Instrumentation
Joseph Klingfus¹, Jason E. Sanabia¹, Sven Bauerdick², and Ralf Jede²
¹Raith America, Inc., 1377 Long Island Motor Parkway, Suite 101, Islandia, NY 11749, USA
²Raith GmbH, Konrad-Adenauer-Allee 8, PHOENIX West, Dortmund, 44263, Germany

Sub-Molecular QSAR: Using Scanning Tunneling Microscopy Simulations for Rational Drug Design
Joel T. Olson, Department of Biological and Chemical Engineering and Sciences, Florida Tech

Nanomaterials Education, Characterization and Thin Films – Olin Engineering 118 – 2:50-3:10 Saturday
Catalytic Performance of Defect Laden h-BN Revealed by Correlative AFM and ToF-SIMS Characterization
Yi Ding*, Fernand Torres-Davila, Richard Blair, and Laurene Tetard
Department of Physics, The University of Central Florida

Nanomaterials Education, Characterization and Thin Films – Olin Engineering 118 – 3:10-3:30 Saturday
Crystallinity-Transport Investigations of Nanoscale Ru Conductors at Al₂O₃ and/or SiO₂ Interfaces
Asim Khaniya, Sameer Ezzat, Prof. William E. Kaden, and Prof. Kevin Coffey, Advanced Materials Processing and Analysis Center, The University of Central Florida
Controlling Catalytic Hydrolysis at Gold Nanoparticle Surfaces
Efram Goldberg and Prof. Andrew Knight, Florida Tech, Department of Biomedical and Chemical Engineering and Sciences

BREAK

Adsorption Characteristics of Small Molecules on Silica-Covered Ru(0001)
Muhammad Sajid, Prof. William Kaden and Prof. Abdelkader Kara, The University of Central Florida, Department of Physics

Effect of Non-Uniform Electric Field in Microstructured (La_{1-x}Pr_y)_{1-x}Ca_xMnO_3 Thin Film
Ambika Shakya*, Ashkan Paykar, and Prof. Amlan Biswas
The University of Florida

Methanol Partial Oxidation Mechanisms on a Single-Site Catalyst Pt_1/ZnO(10-10): A First-Principles Study
Tao Jiang¹, Takat B. Rawal², Duy Le¹, and Talat S. Rahman¹
¹Department of Physics, University of Central Florida
²Center for Molecular Biophysics, Oak Ridge National Laboratory

Monte Carlo Simulation of Percolation Transport in Transparent, Conductive Metal Nanowire Networks
Shreshtha Mishra*, Junying Li, Tsung-Ying Tsai, Jeremy Hicks, and Prof. Ant Ural
The University of Florida

Modeling of Nanocomposite Materials for Eddy Current Suppression in High Frequency Conductors and Power Inductor Cores
Connor Smith and Prof. David P. Arnold, The University of Florida

**Sunday**

**Sulfur Induced Embrittlement in Nickel: A Molecular Dynamics Approach**
Doruk Aksoy*, Remi Dingreville, and Prof. Douglas Spearot, The University of Florida, Department of Mechanical Engineering

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**Session B: Nanomedicine**

**Olin Life Sciences Building, Room 129**

Saturday Morning Session Chair: Dr. Sapna Deo, University of Miami

Nanomedicine – Olin Life Sciences 129 – 10:00-10:30 Saturday

**Nanoparticulate Ophthalmic Drug Delivery Systems using Polymeric Thermo-Reversible Materials**
Yashwant Pathak, Priyanka Bhatt and Vijay Sutariya
Pharmaceutical Sciences, College of Pharmacy, University of South Florida

Nanomedicine – Olin Life Sciences 129 – 10:30-10:50 Saturday

**A Novel Synthesis of Carbon Nitride Dots for Target-Specific Biomedical Applications**
Piumi Liyanage, Regina Graham, Charles Chusuei, Keenan Mintz, Yiqun Zhou, James Harper, Atula Wickramanayake, and Prof. Roger Leblanc, Department of Chemistry, The University of Miami

Nanomedicine – Olin Life Sciences 129 – 10:50-11:10 Saturday

**Design of Nanodrugs for Application in Biomedical Therapies**
Suzana Hamdan, Sapna Deo, Shanta Dhar, W. Dalton Dietrich, and Sylvia Daunert
The University of Miami, BioNIUM

Nanomedicine – Olin Life Sciences 129 – 11:10-11:30 Saturday

**Carbon Dots Development in Synthesis, Characterization and Applications**
Yiqun Zhou and Prof. Roger M. Leblanc, The University of Miami, Department of Chemistry

Nanomedicine – Olin Life Sciences 129 – 11:30-11:50 Saturday

**In Situ Evaluation of Stability and Mobility of Nanoparticles in Blood and Tumor Tissue**
Dr. Ana C. Bohorquez, Mythreyi Unni, Sayali Belsare, Andreina Chiu-Lam, Lori Rice, Christine Pamoto, Dietmar Siemann, and Prof. Carlos Rinaldi, The University of Florida, Departments of Chemical and Biomedical Engineering

Saturday Afternoon Session Chair: Dr. Mandip Singh Sachdeva, Florida A&M University
Aspects of Nano-bio-technology for Drug Delivery to Manage CNS Diseases
Prof. Ajeet Kaushik and Prof. Madhavan Nair, Center of Personalized Nanomedicine, Institute of Neuroimmune Pharmacology, Department of Immunology and Nano-Medicine, Herbert Wertheim College of Medicine, Florida International University

Development and Characterization of Cyclosporine A Loaded PLGA Nanoparticles for Effective Delivery and Reduced Toxicity
Ilkin Nasirli, Priyanka Bhatt, Priya Narvekar, Vijaykumar Sutariya, and Prof. Yashwant Pathak, Department of Pharmaceutical Sciences, College of Pharmacy, University of South Florida

Tryptophan Carbon Dots and Their Ability to Cross the Blood-Brain Barrier
Keenan Mintz, Guillaume Mercado, Yiqun Zhou, Yiwen Ji, Sajini Hettiarachchi, Piumi Liyanage, Charles Chusuei, Julia Dallman, and Prof. Roger Leblanc, The University of Miami, Department of Chemistry

Triple Molecule Conjugated Carbon Dots as a Nano-Drug Delivery Model for Glioblastoma Brain Tumors
Sajini Hettiarachchi, Regina Graham, Keenan Mintz, Steven Vanni, Yiqun Zhou, Zhilli Peng, and Roger M. Leblanc

Extended Delivery of Retina Drugs Through Injections of Oleogels
Russell Macoon and Prof. Anuj Chauhan
Department of Chemical Engineering, The University of Florida, Nanoscience Institute for Medical & Engineering Technology

Sustained Release Formulation of Noscapine HCl using Hot Melt Extrusion (HME) Technique: Formulation and Pharmacokinetics
Arvind Bagde*, Ketan Patel, Nikkumar Patel, and Prof. Mandip Singh Sachdeva
Florida A&M, College of Pharmacy and Pharmaceutical Sciences

Close-Packed Langmuir Monolayers of Saccharide-Based Carbon Dots at the Air-Subphase Interface
Elif S. Seven*, Shiv K. Sharma, Keenan J. Mintz, Dihya Meziane, Yiqun Zhou, and Roger M. Leblanc, Department of Chemistry, University of Miami
A Novel Conductive and Flexible Film for Neural Differentiation
Keila Neri Alvarado-Estrada, Goh Eyleen, Chin Eunice Wei, Chaichana Kaisorn, Rachel Sarabia-Estrada, Alfredo Quinones-Hinojosa, and Manuel Monleon-Pradas
Mayo Clinic Jacksonville

Sunday Morning Session Chair: Yu-Ping Yang, University of Miami

Dielectrophoretic Manipulation and Electroporation of Vaccinia Virus Using Carbon Nanoelectrode Arrays
Prof. Foram Madiyar, Sherry Basset, Omer Farooq, Stefan Rothenburg, Christopher Culbertson, and Jun Li, Embry Riddle Aeronautical University

DNA Nanomachine: New Approach for Cancer Treatment
Daria Nedorezova and Prof. Dmitri M. Kolpashchikov, ITMO University

Towards a Point-of-Care Test for Bacterial Vaginosis: Design and Development of a Rapid Test for Vaginolysin
Devon Pawley, Emre Dikici, Sapna Deo, Margaret Fischl, Sylvia Daunert, The University of Miami, BioNIUM

Modeling and Optimizing DNA-Nanodevices for the Inactivation of Influenza A Virus
Aleksandr Spelkov and Prof. Dmitri M. Kolpashchikov, ITMO University

DNA-Based Nano-Constructs for Visual Detection of Rifampin-Resistant Mycobacterium Tuberculosis
Ryan Connelly, Evgeny Morozkin, Charles Verduzco, and Prof. Yulia V. Gerasimova, The University of Central Florida, Department of Chemistry

Synthesis of Nanodrugs for Targeted Therapeutic Hypothermia in Treatment of Traumatic Brain Injury
Emily Rabinovich, Suzana Hamdan, Emre Dikici, Helen Bramlett, Sapna Deo, W. Dalton Dietrich, and Prof. Sylvia Daunert, The University of Miami, BioNIUM

Telmisartan Synergistically Enhances CFM 4.16 and Erlotinib Combination Therapy Through Enhanced Tumor Penetration
Ebony Nottingham¹, Arindam Mondal¹, Imran Vhora¹, Ketan Patel¹, Arun K. Rishi², Mandip Singh Sachdeva¹, Florida A&M¹; Wayne State University²
Session C: Nanotechnology in Agriculture
Olin Life Sciences Building, Room 130

Saturday Morning Session Chair: Dr. Hyeran Kang, University of Central Florida

Nanotechnology in Agriculture – Olin Life Sciences 130 – 10:00-10:30 Saturday
Tracking Translocation of Model Therapeutics in Plant Tissue with Advanced Fluorescence Imaging
Gregory Miller\textsuperscript{a,b}, Torus Washington II\textsuperscript{a}, Tyler Maxwell\textsuperscript{a,b}, Swadeshmukul Santra\textsuperscript{a,b,c,e}, Andre Gesquiere\textsuperscript{a,b,c,d,*}
\textsuperscript{a}NanoScience Technology Center, University of Central Florida; E-mail: andre@ucf.edu
\textsuperscript{b}Department of Chemistry, University of Central Florida
\textsuperscript{c}Department of Materials Science and Engineering, University of Central Florida
\textsuperscript{d}The College of Optics and Photonics (CREOL), University of Central Florida
\textsuperscript{e}Burnett School of Biomedical Sciences University of Central Florida

Nanotechnology in Agriculture – Olin Life Sciences 130 – 10:30-10:50 Saturday
Development of Locally Systemic Pesticide (LSP) Particles Against Bacterial Spot Disease of Tomato
Ali Ozcan, Mikael Young, Mitsushita Doomra, Briana Lee, Jeffrey Jones, Mathews Paret, Laurene Tetard, Swadeshmukul Santra, University of Central Florida, Departments of Physics and Chemistry

Nanotechnology in Agriculture – Olin Life Sciences 130 – 10:50-11:10 Saturday
Nanoscale Investigation of Mode of Antibacterial Activity of Multivalent Nanoparticles on Xanthomonas perforans
Briana Lee, Ali Ozcan, Mitsushita Doomra, Nicholas Castaneda, Parthiban Rajasekaran, Hyeran Kang, Swadeshmukul Santra, Laurene Tetard, The University of Central Florida, UCF Nanoscience and Technology Center

Nanotechnology in Agriculture – Olin Life Sciences 130 – 11:10-11:30 Saturday
Evaluation of Novel Zinc-Based Nanomaterial to Control Growth and Biofilm Formation of Xanthomonas citri in Batch Cultures and Under Media Flow Conditions in Microfluidic Chambers
Hajeewaka Mendis, Mikael Young, Ali Ozcan, Swadeshmukul Santra, Evan Johnson, Leonardo De La Fuente, The University of Central Florida, Department of Chemistry

Nanotechnology in Agriculture – Olin Life Sciences 130 – 11:30-11:50 Saturday
Heavy Metal Free Quantum Dots - A Robust Delivery Vehicle for Antibiotics for Enhanced Antibacterial Activity
Tyler Maxwell\textsuperscript{*}, Parthiban Rajasekaran, Mikael Young, Morgan Schaff, and Swadeshmukul Santra, The University of Central Florida, Department of Chemistry
Saturday Afternoon Session Chair: Dr. Swami Rajaraman, University of Central Florida

Nanotechnology in Agriculture – Olin Life Sciences 130 – 2:00-2:30 Saturday
Multiscale Exploration of Plants' Responses to External Physicochemical Factors
Prof. Laurene Tetard, UCF Nanoscience Technology Center and Department of Physics, The University of Central Florida

Nanotechnology in Agriculture – Olin Life Sciences 130 – 2:30-2:50 Saturday
Antimicrobial Magnesium Hydroxide Nanoparticles as an Alternative to Cu Biocide for Crop Protection
Ziyang Huang, Parthiban Rajasekaran, Ali Ozcan and Swadeshmukul Santra, The University of Central Florida, Department of Chemistry

Nanotechnology in Agriculture – Olin Life Sciences 130 – 2:50-3:10 Saturday
Zinkicide™: A Systemic Bactericide for Managing Huanglongbing
Maria Campos, Mikaeel Young, Ali Ozcan, Parthiban Rajasekaran, Tyler Maxwell, Monty E. Myers, Evan Johnson, James H. Graham, and Prof. Swadeshmukul Santra, The University of Central Florida, Department of Chemistry

Nanotechnology in Agriculture – Olin Life Sciences 130 – 3:10-3:30 Saturday
Solid-Contact Paper-Based Zinc Ion Sensing Electrodes to Monitor Dissolution of ZnO Nanoparticles
Parth Patel, Stephanie M. Armas, Andrea Bances-Monard, Ali Ozcan, Karin Y. Chumbimuni-Torres, and Prof. Swadeshmukul Santra, University of Central Florida, Department of Chemistry

Nanotechnology in Agriculture – Olin Life Sciences 130 – 3:30-3:50 Saturday
Bactericidal Activity of a Cu/Zn Hybrid Nanomaterial on Copper-Tolerant Xanthomonas Perforans and Impact on Xanthomonadin
Renato Carvalho, Kamil Duman, and Prof. Mathews Paret, The University of Florida, North Florida Research & Education Center

BREAK

Nanotechnology in Agriculture – Olin Life Sciences 130 – 4:00-4:20 Saturday
Antimicrobial Mode of Activity of Ultra-Small Size ZnO Nanoparticles
Mitsushita Doomra\textsuperscript{γ,μ,*}, Ali Ozcan\textsuperscript{μ,λ}, Zon Thwin\textsuperscript{ν,λ}, Tyler Maxwell\textsuperscript{μ,λ}, Maria Campos \textsuperscript{μ,λ}, Mikael Young\textsuperscript{γ,μ}, and Swadeshmukul Santra\textsuperscript{γ,μ,λ,*},

\textsuperscript{γ}Burnett School of Biomedical Sciences, \textsuperscript{μ}NanoScience Technology Center, \textsuperscript{λ}Department of Chemistry and \textsuperscript{ε}Department of Materials Science and Engineering, University of Central Florida

Nanotechnology in Agriculture – Olin Life Sciences 130 – 4:20-4:40 Saturday
Green Synthesis of Low-Cost, Facile, and Quick Nanosensors for the Detection of Inorganic Mercury in Water
Development of Smart Nano-Delivery Systems for Enhancing Bactericides and Fertilizers Use Efficacy
Xiaoping Xin, Zhenli He, Megan Hill, Randall Niedz, and Prof. Brent Sumerlin
The University of Florida, Department of Chemistry

Wearable Electronic Sensors
Prof. Jayan Thomas
The University of Central Florida, UCF Nanoscience Technology Center

Sunday Morning Session Chair: Dr. Swadesh Santra, University of Central Florida

Advanced Cu Formulations for Crop Protection
Prof. Swadeshmukul Santra, Mikaeel Young, Ali Ozcan, Parthiban Rajasekaran, Maria Campos, A. Strayer, Y.Y. Liao, Monty E. Myers, Evan Johnson, James H. Graham, J. B. Jones, and M. L. Paret, The University of Central Florida, Department of Chemistry

Utilizing Fluorescence Lifetime Imaging Microscopy to Monitor Small Molecule Translocation in Citrus Seedlings
Gregory Miller and Prof. Andre Gesquiere, The University of Central Florida

Microneedles as Wearable Devices for Diagnostic and Therapeutic Monitoring of Citrus Trees
Avra Kundu, Cacie Hart, Charles Didier, Laboni Santra, Tariq Ausaf, and Prof. Swaminathan Rajaraman*, The University of Central Florida, UCF Nanoscience Technology Center

Silica-Based Quaternary Ammonium Nanocoated Mesh for Harmful Algal Bloom (HAB) Control and Water Disinfection
Daniela Diaz, Ikenna Ezeodurukwe, Jared Church, Mikaeel Young, Swadeshmukul Santra and Woo Hyoun Lee, UCF Nanoscience Technology Center

Development of Antimicrobial Active ZnS:Mn Nanoparticles
Zon Thwin, Ali Ozcan, Nirav Modha, Mikaeel Young, and Prof. Swadeshmukul Santra, The University of Central Florida, Department of Chemistry
Evaluating Copper Uptake through Nanotechnology-Assisted Delivery to Combat Bacterial Spot Disease in Tomato Plants
Ahmad Khater\textsuperscript{1,3}, Briana Lee\textsuperscript{1}, Mikhael Soliman\textsuperscript{1,2}, Ali Ozcan\textsuperscript{1,3}, Swadeshmukul Santra\textsuperscript{1,3}, Laurene Tetard\textsuperscript{1,4}
\textsuperscript{1}NanoScience Technology Center, University of Central Florida, Orlando, FL, 32826,\textsuperscript{2}Department of Materials Science and Engineering, University of Central Florida, Orlando, FL\textsuperscript{3}Department of Chemistry, University of Central Florida, Orlando, FL, 32816\textsuperscript{4}Department of Physics, University of Central Florida, Orlando, FL, 32816

Tracking and Detection of Bactericidal Quantum Dots
Zachary T. Untracht, Ali Ozcan, Swadeshmukul Santra, and Hyeran Kang
UCF NanoScience Technology Center

Session D: Photonics, SERS, FTIR, Simulation, Nanowires, and Self-Assembly
Olin Engineering Center, room 137

Saturday Afternoon Session Chair: Dr. Sung J. Kim, University of Miami

Photonics, SERS, FTIR, Simulation, Nanowires, and Self-Assembly – Olin Engineering 137 – 2:00-2:30 Saturday
Bioinspired Design of Next Generation Structural and Thermal Materials
Prof. Nima Rahbar, Worcester Polytechnic Institute, Worcester, MA

Photonics, SERS, FTIR, Simulation, Nanowires, and Self-Assembly – Olin Engineering 137 – 2:30-2:50 Saturday
Pigmented Contacts Lenses for Cystinosis and Photophobia Treatment
Poorvajan Sekar* and Prof. Anuj Chauhan, Department of Chemical Engineering, The University of Florida, Nanoscience Institute for Medical & Engineering Technology

Photonics, SERS, FTIR, Simulation, Nanowires, and Self-Assembly – Olin Engineering 137 – 2:50-3:10 Saturday
Multi-Modal 3D Surface and 3D Volume Characterization on Elytra of a Florida Beetle
Dr. Edward Principe, Gary Scheiffele, and Dr. Ana C. Bohorquez, The University of Florida, Department of Biomedical Engineering

Photonics, SERS, FTIR, Simulation, Nanowires, and Self-Assembly – Olin Engineering 137 – 3:10-3:30 Saturday
Smart Shape Memory Polymer Photonic Crystal for Anti-Counterfeiting Applications
Calen Leverant and Prof. Peng Jiang
The University of Florida, Department of Chemical Engineering
Photonics, SERS, FTIR, Simulation, Nanowires, and Self-Assembly – Olin Engineering 137 4:00-4:20 Saturday

Jing Guo and Prof. Jin He, Florida International University, Physics Department and Biomolecular Science Institute

Photonics, SERS, FTIR, Simulation, Nanowires, and Self-Assembly – Olin Engineering 137 – 4:20-4:40 Saturday

Multifunctional Nanopipette for Potential Sensing of Single Nanoparticle Collision Events
Popular Pandey, Javier Garcia, and Prof. Jin He
Department of Physics, Florida International University

Photonics, SERS, FTIR, Simulation, Nanowires, and Self-Assembly – Olin Engineering 137 – 4:40-5:00 Saturday

Advanced Simulation Environment for the Study of a Plasmon FET as a Biosensor
Mark Ciappesoni, Seongman Cho, Mohammad Arif, and Prof. Sung Jin Kim
The University of Miami, BioNIUM

Sunday Morning Session Chair: Dr. Shaohua Xu, Florida Tech

Photonics, SERS, FTIR, Simulation, Nanowires, and Self-Assembly – Olin Engineering 137 – 10:00-10:30 Sunday

Nano Imaging in Our Understanding of Alzheimer’s Disease Pathogenesis
Prof. Shaohua Xu, Department of Biomedical and Chemical Engineering and Sciences, xshaohua@fit.edu

Photonics, SERS, FTIR, Simulation, Nanowires, and Self-Assembly – Olin Engineering 137 – 10:30-10:50 Sunday

Effects of Dihydromotuporamine C Derivatives on Actin Assembly Dynamics
James B. Heidingsa,b,*, Amirah Mathinb, Kristen Skruberc, Aaron Muthc, Otto Phanstiel IVc, Hyeran Kangb,d,s,§
aBurnett School of Biomedical Sciences, University of Central Florida
bNanoScience Technology Center, University of Central Florida
cDepartment of Medical Education, University of Central Florida
dDepartment of Physics, University of Central Florida

Photonics, SERS, FTIR, Simulation, Nanowires, and Self-Assembly – Olin Engineering 137 – 10:50-11:10 Sunday

Characterization and Printability of Polysaccharide Based Hydrogels to Study Self Assembly of Tumor Spheroids
Aragaw Gebeyehu, Arindam Mondal, and Prof. Mandip Singh Sachdeva, Florida A&M University, College of Pharmacy and Pharmaceutical Sciences
Molecular Crowding Effects on Actin Filament Assembly Kinetics
Ryan R. Marracino\textsuperscript{a,b}, Bryan Demosthene\textsuperscript{b}, Mahammad Gardashli\textsuperscript{b}, and Hyeran Kang\textsuperscript{a,b,c}
\textsuperscript{a}Burnett School of Biomedical Sciences, College of Medicine, University of Central Florida
\textsuperscript{b}NanoScience Technology Center, University of Central Florida
\textsuperscript{c}Department of Physics, University of Central Florida

Direct Evaluation of Single Hydrogel Nanofiber Mechanics Using Persistence Length Analysis
Angie M. Diaz\textsuperscript{1,*}, Zeyang Zhang\textsuperscript{1,2}, Briana Lee\textsuperscript{1}, Felix M. Hernandez Luna\textsuperscript{1,3}, Yuen Yee Li Sip\textsuperscript{1}, Xiaoyan Lu\textsuperscript{1,2}, James Heidings\textsuperscript{1}, Laurene Tetard\textsuperscript{1,4}, Lei Zhai\textsuperscript{1,2,*}, Hyeran Kang\textsuperscript{1,4§}
\textsuperscript{1}NanoScience Technology Center, University of Central Florida
\textsuperscript{2}Department of Chemistry, University of Central Florida
\textsuperscript{3}Department of Mechanical Engineering, Inter American University of Puerto Rico
\textsuperscript{4}Department of Physics, University of Central Florida

Effects of Macromolecular Crowding on Actin Bundles Induced by Actin Crosslinking Proteins
Jinho Park and Hyeran Kang
UCF NanoScience Technology Center and the Departments of Physics and Materials Science and Engineering, The University of Central Florida
Poster Topics and Locations

Nanomedicine (NM)
Olin Life Sciences 1st Floor Atrium

Self-Assembly (SA)
Olin Life Sciences 2nd Floor Atrium

Tissue Engineering and 3D Printing (TE)
Olin Life Sciences 2nd Floor Atrium

Catalysis, Adsorption, and Thin Films (CA)
Olin Engineering Center 2nd Floor Atrium

Sensors (SE)
Olin Engineering Center 3rd Floor Atrium

Nanomedicine

NM-1 1st Floor Olin Life Sciences Atrium
**PCBA Polymer Nanoparticles Incorporating PhotoCORM to the Brain**
Almutasim Alwagdani and Prof. Yi Liao
Department of Chemistry, Florida Institute of Technology, Melbourne, FL 32901

NM-2 1st Floor Olin Life Sciences Atrium
**Treating Castration Resistant Prostate Cancer with the Simultaneous Delivery of Chemotherapeutics and Anti-Inflammatory Agents**
Akil A. Kalathil, Rakesh K. Pathak, Uttara Basu, Anis Ahmad, Shrita Sarkar, Anil Kumar, Bapurao Surnar, Saba Ansari, Katarzyna Wilczek, Michael E. Ivan, Brian Marples, Nagesh Kolishetti and Shanta Dhar, The University of Miami, BioNIUM

NM-3 1st Floor Olin Life Sciences Atrium
**Modulation of Glioma Stem Cells with Targeted Nanoparticle Delivered Cisplatin Prodrug for Glioblastoma**
Shrita Sarkar, Bapurao Surnar, and Prof. Shanta Dhar, The University of Miami

NM-4 1st Floor Olin Life Sciences Atrium
**Gallium Combinations with Different Antibiotics Provide Alternate Treatment Options to Traditional Antibiotic Therapy for Pseudomonas aeruginosa and Acinetobacter baumannii Infections**
Nirav Modha, Mikael Young and Prof. Swadeshmukul Santra, The University of Central Florida, Department of Chemistry
New Microarray Data Analysis Techniques in Evaluating the Effect of Nanomedicine Treatment
Bin Xue, Department of Pharmaceutical Sciences, College of Pharmacy, University of South Florida, The University of South Florida

Multifunctional Therapeutic Nanoparticles for Atherosclerosis
Mainak Banerjee, Bapurao Surnar, Bhabatosh Banik, and Prof. Shanta Dhar, The University of Miami, BioNIUM

Preparation and Intranasal Formulation of Nanodrugs of Opioid Addiction Antagonists for Stroke Recovery
Nadia Peyravian, Suzana Hamdan, Cristina Otero, Emre Dikici, Michal Tobroek, Sapna Deo, and Sylvia Daunert, The University of Miami, BioNIUM

Determination of Polycyclic Aromatic Hydrocarbons (PAH) Exposure in Firefighters via GCMS Analysis of Urine
Alexia Lydia Kafkoutsou, Emre Dikici, Alberto Caban-Martinez, Prof. Sapna Deo, and Prof. Sylvia Daunert, The University of Miami, BioNIUM

Polymer Based Nanomedicine for Trans-Epithelial Oral Delivery of Ivermectin for Zika
Bapurao Surnar and Shanta Dhar, The University of Miami, BioNIUM

Selective Targeting of Breast Cancer Brain Metastases by Cisplatin Prodrug Nanoformulation
Bapurao Surnar, Mohammad Zahid Kamran and Shanta Dhar*
The University of Miami, BioNIUM

Dry Formulation of Ivermectin Nano-devices for Oral Delivery for Zika Virus
Anuj Shah, Bapurao Surnar, Mohammad Zahid Kamran, and Prof. Shanta Dhar, The University of Miami, BioNIUM

Microneedle-Assisted Delivery of Model Therapeutics to Plant Tissue
Laboni Santra, Tariq Ausaf, Avra Kundu, and Prof. Swaminathan Rajaraman
Oviedo High School/The University of Central Florida
NM-13 1st Floor Olin Life Sciences Atrium
Formulation Development and Characterization of Herbal Drug Based Nutraceuticals
Priya Narvekar, Priyanka Bhatt, Yashwant Pathak, Vijaykumar Sutariya
Department of Pharmaceutical Sciences, College of Pharmacy, University of South Florida

NM-14 1st Floor Olin Life Sciences Atrium
Development of a Novel Chitosan-Based Drug Delivery System
Sanjana Konda and Prof. Swadeshmukul Santra, The University of Central Florida, UCF Nanoscience Technology Center

NM-15 1st Floor Olin Life Sciences Atrium
Hydrogels for Tunable Affinity-Controlled Release of Carbohydrate-Binding Proteins
Juan Pablo Olguin, Antonietta Restuccia, and Prof. Gregory Hudalla, The University of Florida, Department of Biomedical Engineering

NM-16 1st Floor Olin Life Sciences Atrium
Design and Evaluation of Nabumetone Solid Lipid Nanoparticles Oral Formulation Using Hot Melt Extrusion (HME) Technology as a Continuous Manufacturing Process with Compritol® 888 ATO
Nilkumar Patel, Arvind Bagde, Shallu Kutlehria, Mandip Singh Sachdeva, Florida A&M, Department of Pharmacy & Pharmaceutical Sciences

Self-Assembly

SA-1 Olin Life Sciences 2nd Floor Atrium
Computational Study of Actin Polymerization Kinetics in Crowded Environments
Myeongsang Lee and Prof. Hyeran Kang, The University of Central Florida, Department of Physics

SA-2 Olin Life Sciences 2nd Floor Atrium
Molecular Crowding Modulates Actin Filament Structure and Mechanics
Nicholas Castaneda\textsuperscript{a,b,\ast}, Myeongsang Lee\textsuperscript{a}, Hector J. Rivera-Jacquez\textsuperscript{a}, Ryan R. Marracino\textsuperscript{a,b}, Theresa R. Merlino\textsuperscript{a}, and Prof. Hyeran Kang\textsuperscript{a,c,\ast}, University of Central Florida, UCF Nanoscience Technology Center

SA-3 Olin Life Sciences 2nd Floor Atrium
Analysis of Amyloid Fiber Gel by Transmission Electron Microscopy and Atomic Force Microscopy
Devadatta Gosavi\textsuperscript{1}, Hadeel Binomar\textsuperscript{1}, Sanil Dixit\textsuperscript{1}, Batool Albahrani\textsuperscript{1}, Sam Durrance\textsuperscript{2}, Dylan Bell\textsuperscript{2}, Shaohua Xu\textsuperscript{1}
\textsuperscript{1}Department of Biomedical, Chemical Engineering and Sciences, \textsuperscript{2}Department of Aerospace, Physics and Space Sciences, Florida Institute of Technology
Tissue Engineering and 3D Printing

TE-1 Olin Life Sciences 2nd Floor Atrium
**Rationally Designing a Tissue Engineered Electronic Nerve Interface (TEENI) for Improved Bionic Prostheses**
Abbas Furniturewalla, Erin Patrick, Paritosh Rustogi, Cary Kuliasha, Eric W. Atkinson, Benjamin Spearman, Ishita Singh, Elizabeth A. Nunamaker, Carlos Rinaldi, Kevin J. Otto, Christine E. Schmidt, and Jack W. Judy, The University of Florida, Departments of Electrical and Computer Engineering, Mechanical Engineering, Biomedical Engineering, Chemical Engineering, Materials Science and Engineering, and Neuroscience

TE-2 Olin Life Sciences 2nd Floor Atrium
**3D Printed Cornea using Corneal Epithelial Cells as a Potential Model for Wound Healing**
Paul Dinh, Shaluu Kuthleria, and Prof. Mandip Singh Sachdeva, Florida A&M, School of Pharmacy and Pharmaceutical Science

TE-3 Olin Life Sciences 2nd Floor Atrium
**Converting Tissue “Engineering” into an Engineering Discipline with 3D-Printable Bioreactors, Arduino-Based Sensors, and 3D Printers with Submicron Precision**
Adrien Hosking, Jonah Melegrito, Princess Akande, Nicole Bueno, Guochang (Nick) Ye, Timofey Broslav, Thomas Quaid, Thomas Ward, Kristen Brenner, Ziyad Al Hinai, Soha Patil, Dallas Nash, Megan Bass, Kyle Kercher, and Dr. Jim Brenner, Florida Tech, Department of Biological and Chemical Engineering and Sciences

TE-4 Olin Life Sciences 2nd Floor Atrium
**3D Printing with Submicron Precision**
Tanner Johnson, Filippo Mazzanti, Samir Kazi, Marlisa Lim, Daniel Hocheimy, Kenneth Verderber, Logan Johnson, Robert Koss, and Prof. Jim Brenner, Florida Tech, Mechanical, Aerospace, Chemical, and Biomedical Engineering Programs

Catalysis, Adsorption, and Thin Films

CA-1 Olin Engineering 2nd Floor Atrium
**Nano-Architectured Binder-Free Manganese Oxide Electrode for Wearable Supercapacitor**
Kowsik Sambath Kumar, Jayesh Cherusseri, Jayan Thomas
NanoScience Technology Center, University of Central Florida, Orlando, Florida 32826, USA
Department of Materials Science and Engineering, University of Central Florida, Orlando, FL
CREOL, College of Optics and Photonics, University of Central Florida, Orlando, Florida

CA-2 Olin Engineering 2nd Floor Atrium
**Composition-Dependent Photocatalytic Activity of Pd/m-BiVO4/BiOBr Nanosheets: Degradation of Polychlorinated Biphenyls**
Sophia Bachas-Daunert, Emily Williamson, Santiago Angaramo, Marc R. Knecht, Elsayed M. Zahran, Department of Chemistry, University of Miami, Coral Gables, FL, United States.
Rapid Degradation of Persistent Organic Pollutants Using m-BiVO4/BiOBr and m-BiVO4/BiOBr/Pd Nanocomposite Photocatalysts
Edward Miller, Elsayed Zahran, Marc Knecht, and and Prof. Leonidas Bachas, The University of Miami, BioNIUM

Quantum Chemical and Master Equation Study of OH + CH2O → H2O + CHO Reaction Rates in Supercritical CO2 Environment
Elizabeth E. Wait,1,2 Artêm E. Masunov,*,1,2,3,4,5 Subith S. Vasu6
1UCF NanoScience Technology Center, 2UCF Department of Chemistry
3Department of Physics, University of Central Florida, 12424 Research Parkway, Ste 400
4South Ural State University, Lenin pr. 76, Chelyabinsk 454080, Russia
5National Research Nuclear University MEPhI, Kashirskoye shosse 31, Moscow, 115409
6Center for Advanced Turbomachinery and Energy Research (CATER), Mechanical and Aerospace Engineering, University of Central Florida, Orlando, Florida, 32816, USA

Computational Study of the Adsorption of Bimetallic Clusters
Nusaiba Zaman, Karima Lasri and Abdelkader Kara
Department of Physics, University of Central Florida, Orlando FL 32816

Evaluating Defect Formation in Hexagonal Boron Nitride by Mechanochemistry for Heterogeneous Catalysis
Fernand Torres-Davila, Yi Ding, Katerina Chagoya, Alan Felix, David Nash, Richard Blair & Laurene Tetard, The University of Central Florida, Department of Physics

Synthesis of Fluorinated Tungsten (VI) Oxo-Alkoxide Precursors for the Chemical Vapor Deposition of WOx Films and Nanostructures
Nathan Ou*, Duane C. Bock, and Prof. Lisa McElwee-White, The University of Florida

Adsorption of DNA and RNA Nucleobases on Graphene
Johnathan von der Heyde, Walter Malone, and Prof. Abdelkader Kara, The University of Central Florida, UCF Nanoscience Technology Center

Micromachined 3D Microelectrode Arrays (MEAs), Functionalized Through Nanomaterial Electroplating for Tissue Culture in Space
Charles Didier, Avra Kundu, and Prof. Swaminathan Rajaraman, UCF Nanoscience Technology Center
Reliable Miniature Implantable Connectors with High Channel Density for Advance Neural Interface Applications
Paritosh Rustogi and Prof. Jack Judy, The University of Florida, NIMET

Optimization of Makerspace Microfabrication Techniques and Materials for 3D Printed Microelectrode Arrays
Crystal Nattoo1, Avra Kundu2, Swaminathan Rajaraman2
1The University of Miami, can32@miami.edu
2The University of Central Florida, UCF Nanoscience Technology Center

Characterizing the Induced Stress from the Infiltration of Volcanic Ash into a 7 Wt. % Yttria Stabilized Zirconia Thermal Barrier Coating by Means of Raman Spectroscopy and Nano-Mechanical Spectroscopy
Chance Barrett, Laurene Tetard, Seetha Raghavan, Ravisankar Naraparaju, The University of Central Florida, UCF Nanoscience Technology Center

Economic and Environmental Feasibility Assessment in Favor of Nanoparticle-Based Automotive Clear Coat
Illya Salinnyk1, Raha Gerami2, and Prof. Yinlun Huang2
1Florida Institute of Technology, Department of Chemical Engineering, 150 West University Blvd., Melbourne; 2Wayne State University, Detroit, MI

Efficient Energy Storage Device using Zinc Oxide Nanopillars
Jayesh Cherusseri, Basudev Pradhan, Kowsik Sambath Kumar, and Jayan Thomas
NanoScience Technology Center, University of Central Florida, Orlando, Florida 32826, USA
Department of Materials Science and Engineering, University of Central Florida, Orlando, Florida
CREOL, College of Optics and Photonics, University of Central Florida, Orlando, Florida 32816

Simulated Space Weathering Effects at the Surface of Thin-Film Aluminosilicate Model Regolith
Bijoya Dhar and Prof. William E. Kaden, The University of Central Florida, Department of Physics
Sensors

SE-1 Olin Engineering 3rd Floor Atrium
Bioluminescent Protein-Inhibitor Pair in the Design of a Molecular Aptamer Beacon Biosensor
Angeliki Moutsiopoulou, Eric Hunt, Hamdi Joda, David Broyles, Emre Dikici, Prof. Sylvia Daunert, Angel Kaifer, and Prof. Sapna K. Deo, The University of Miami, BioNIUM

SE-2 Olin Engineering 3rd Floor Atrium
Zinc Finger Proteins for the Detection of Pathogenic Bacteria
Prof. Sabrina Petrucci¹*, Aina Feliu², Hamdi Joda¹, Vineet Gupta³, Prof. Sylvia Daunert¹, and Prof. Sapna Deo¹
¹University of Miami Department of Biochemistry and Molecular Biology;
²Universidad Francisco de Vitoria;
³Rush University Department of Medicine

SE-3 Olin Engineering 3rd Floor Atrium
Design of an Electroactive Glucose Binding Protein Variant Using Global Incorporation of Non-Natural Amino Acids
Elnaz Zeynaloo, Trajen Head, Prof. Elsayed Zahran, Emre Dikici, Prof. Leonidas Bachas, and Prof. Sylvia Daunert, The University of Miami, BioNIUM

SE-4 Olin Engineering 3rd Floor Atrium
Highly Sensitive Lactate Sensors Based on Carbon MEMS (CMEMS)
Shahrzad Forouzanfar, Fahmida Alam, Nezih Pala, Chunlei Wang
Florida International University

SE-5 Olin Engineering 3rd Floor Atrium
Transdermal Alcohol Sensor for Monitoring BAC
Ahmed Jalal, Yogeswaran Umasankar, Ernesto A. Prettö Jr., and Prof. Shekhar Bhansali, Florida International University

SE-6 Olin Engineering 3rd Floor Atrium
Non-Invasive and Real-Time Monitoring of Drowsiness Using Solid State Sensor Array Targeting Breath Biomarkers
Chitvan Killawala and Sylvia Daunert, The University of Miami, BioNIUM

SE-7 Olin Engineering 3rd Floor Atrium
Carcinogen Exposure Monitoring in Firefighters using Passive Sampling Technology and Sensor Arrays
Umer Bakali, Jeramy Baum, Chitvan Killawala, Katerina M. Santiago, Johnathan Pangborn, Emre Dikici, Natasha Schaefer Solle, Kevin Moore, Erin N. Kobetz, Alberto J. Caban-Martinez, Prof. Sapna Deo, Prof. Leonidas Bachas, and Prof. Sylvia Daunert, The University of Miami, BioNIUM
Zinc Oxide Nanoflakes Based Immunosensor for Ethyl Glucuronide (EtG) Detection
Fahmida Alam, Shahrzad Forouzanfar, and Prof. Nezih Pala, Florida International University

Nanopore/Nanoelectrode Multifunctional Nanopipette for Probing Single Nanoparticle (NP) Events
Javier Garcia, Popular Pandey, Jin He, Florida International University

Split Deoxyribozyme Sensor for Detection of a Highly Structured Highly Modified Nucleic Acid: Transfer Ribonucleic Acid
Adam Reed, Ryan Sapia, Renan Peredes, Charles Dowis, Yulia Gerasimova, The University of Central Florida, Department of Chemistry

Interfacial Behaviours in a Nano-Domained Polymer-Derived Ceramic for High-Temperature Sensing Applications
Hao Li and Prof. Linan An
Department of Materials Science and Engineering, Advanced Materials Processing and Analysis Center, University of Central Florida, Orlando, FL 32816
Keynote Speaker

Friday, 2 - 3 pm, Olin Engineering Center, room 137
Lisa Friedersdorf, Director of the National Nanotechnology Coordination Office
lfriedersdorf@nnco.nano.gov

The NNI and You

The National Nanotechnology Initiative (NNI) is a U.S. Government research and development initiative involving 20 departments and independent agencies that invest approximately $1.5 billion annually in nanotechnology-related activities. This presentation will provide a brief overview of the NNI, its structure, and primary mechanisms for advancing research and technology in areas of national importance. Particular focus will be given to the opportunities to participate in and build communities of interest related to nanotechnology research and commercialization. A summary of the outreach activities of the National Nanotechnology Coordination Office will also be presented with an emphasis on ways to engage with the NNI.

Dr. Lisa Friedersdorf is the Director of the National Nanotechnology Coordination Office. She has been involved in nanotechnology for over twenty-five years, with a particular interest in advancing technology commercialization through university-industry-government collaboration. She is also a strong advocate for science, technology, engineering, and mathematics (STEM) education, and has over two decades of experience teaching at both the university and high school levels. Lisa earned her PhD and MSE in Materials Science and Engineering from the Johns Hopkins University and BS in Mechanical Engineering from the University of Central Florida.
Keynote Speaker

Saturday, 8:45 - 9 am, Olin Engineering Center, room 118
Chenzhong Li, Program Officer for the National Science Foundation
Professor, Biomedical Engineering, Florida International University
chli@nsf.gov, licz@fiu.edu

What does NSF support in Nanotechnology? Convergence Research and NSF 10 Big Ideas

The National Nanotechnology Initiative (NNI) is a U.S. Government research and development initiative involving 20 departments and independent agencies that invest approximately $1.5 billion annually in nanotechnology-related activities. This presentation will provide a brief overview of the NNI, its structure, and primary mechanisms for advancing research and technology in areas of national importance. Particular focus will be given to the opportunities to participate in and build communities of interest related to nanotechnology research and commercialization. A summary of the outreach activities of the National Nanotechnology Coordination Office will also be presented with an emphasis on ways to engage with the NNI.
**Keynote Speaker**

Saturday, 9 - 9:50 am, Olin Engineering Center, room 118  
Luke Roberson, Senior Principal Investigator, NASA Kennedy Space Center  
luke.b.roberson@nasa.gov  
**Flight Operations and Research at NASA Kennedy Space Center**

NASA’s vision for space exploration is turning towards building a sustainable plan for human exploration of our solar system. The Kennedy Space Center will play a huge role in accomplishing this new mission. As NASA gears up to return to the Moon, KSC is building a modern launch infrastructure to accommodate a large range of space vehicles. KSC is changing the way it operates through commercial resupply and crew missions. The International Space Station transitioned to a National Lab where payloads are being built to expand our knowledge in space. And advanced research is being performed to address a multitude of challenges that will address the difficulties of space exploration. Nanotechnology plays a vital role in each of these futuristic systems. This talk will set the foundation of NASA’s planned future and how research with nanotechnology and nanoscience can be used in space and terrestrially to help all mankind.

Luke B. Roberson, Ph.D. is a senior principal investigator for flight research at NASA’s Kennedy Space Center. Dr. Roberson’s research focuses on advanced composite materials for implementation into systems including chemochromic hazardous gas sensing materials, organic electronics, water purification chemistry, and chemical hazmat suits. Luke served as the payload developer for VEGGIE and Advanced Plant Habitat (APH); both plant growth chambers for the International Space Station. He has numerous published peer reviewed scientific journal publications and patents. He was recently awarded the 2016 NASA Invention of the Year Award, the 2014 R&D100, and was nominated to the 2018 Space Technology Hall of Fame. He received a B.S. (1999), M.S. (2002), and Ph.D. (2005) from the Georgia Institute of Technology. Dr. Roberson is also the co-founder of Gelwood, Inc. Spun-off from NASA inventions to solve Martian habitat structures, Gelwood creates an innovative approach to thermal insulation technologies for home applications. These nano-composite materials reduce thermal energy transport across materials by 20-50% with no effect on the base material’s application. This thermal transport advantage can be used in anything from containers to coolers to housing insulation.
Nanomaterials have been shown to effectively protect stainless steels from high temperature degradation. However, recently we discovered the unique antioxidant properties of the same rare earth nanoparticles, where it protects mammalian cells against damage caused by increased reactive oxygen or nitrogen species, and has been shown to act as effective SOD mimetic. This presentation will provide a brief overview of the applications of these nanostructures in treatment of disorders caused by reactive oxygen and nitrogen species. Materials manufacturing played an important role in manipulating the biomedical properties. I will end the talk by discussing pathways to transform research to technology commercialization.

Sudipta Seal, FASM, Trustee Chair, University Distinguished Professor and UCF Pegasus Professor, joined the Advanced Materials Processing and Analysis Center (AMPAC) and Mechanical Materials Aerospace Engineering at the University of Central Florida in Fall 1997 after a postdoctoral work at Lawrence Berkeley National Laboratory, University of California, Berkeley.

At UCF, he pioneered nanostructured cerium oxide and other metal/oxide platforms (micro to nano) and discovered its antioxidant properties and applied in various biomedical problems. He is also involved in plasma based large scale manufacturing of coatings and nano-energetics materials. He is funded by DOD, NSF, NIH, NASA, SBIR programs, and many industries.

At UCF, he served as Nano Initiative Coordinator for VP-Research. He is the Director of Nanoscience Technology Center (tenure unit) and Advanced Materials Processing Analysis Center and Professor till 2017, and now the Chair of Materials Science and Engineering and holds an appointment with College of Medicine. He oversees a large no staff, students and faculty in these academic units. He is the recipient of the 2002: Office of Naval Research Young Investigator Award (ONR-YIP), JSPS fellowship, Alexander Von Humboldt Fellow, ASM IIM Lecturer award, Royal Soc of Eng - Visiting Professor Distinguished Fellowship at Imperial College, UK, Academic Trail Blazor Award and Schwartz Tech award. He was elected to attend the Eng Symposium by National Academy of Engineering. Recently he got inducted World Academy of Ceramics and Florida Hall of Fame Inventors.

He is the recipient of Fellow of FASM, FAAAA, FAVS, FIoN, FAIMBE, FNAI, FECS. He has won multiple teaching and research awards from UCF and was awarded the UCF Dean's Advisory Board: Faculty Award for Excellence. He has more than 400 journal papers, conference proceedings papers, book chapters, and three books on nanotechnology (including one on Nanoscience and Technology Education). He received his BTech-Hons from Indian Institute of Technology (KGP) in Metallurgy and Materials Eng, worked for TATA Steel India, MMet, University of Sheffield, UK, and Ph.D. from U Wisconsin (UWM). He is an active member of ASM Intl and served on many ASM committees. He has > 70 issued patents (and many pending), and h index > 84 and his technology is responsible for various startups. He graduated more than fifty PhD, MS, postdoc/researchers and mentored many undergraduate students.
Session A: Nanomaterials Education, Characterization and Thin Films
Olin Engineering Center, Room 118

Saturday Morning Session Chair: Dr. Jim Brenner, Florida Tech

Nanomaterials Education, Characterization and Thin Films – Olin Engineering 118 – 10:00-10:40 Saturday

What Should a Hands-On Nanoscience & Nanotechnology Curriculum Look Like?

James R. Brenner, Kurt J. Winkelmann, Joel A. Olson, Yekaterina Lin, Shaohua Xu, Lisa M. Cole-Burnett, Benjamin J. Burnett, Kavitha Hari, Kyan Ali, Jack Kindred, Andres Phillips, Florida Tech, Department of Biomedical and Chemical Engineering and Sciences, 150 West University Blvd., 256 Olin Engineering Bldg., Melbourne, FL 32901, jbrenner@fit.edu

Florida Tech features the first nanotech program with multiple three-credit labs, as most students learn nanotechnology in "hands-on" mode. New Nanotech Lab II and Materials Characterization Lab courses have been pilot-tested to complement two existing courses and a freshman Nanotechnology Lab I course. In addition to a dozen syntheses, in the Nanotechnology Lab II course, students tracked the growth of ammonium hydrogen phosphate and zeolite crystals, the growth and misfolding of Alzheimer's disease proteins, and bone destruction from excessive acid concentrations associated with gouty arthritis. Materials Characterization Laboratory gets students from rookie to independent status quickly without significant cost or downtime. This class was composed of lectures, hands-on demonstrations, online testing prior to using the equipment, a mentoring program, and passing a hands-on practical test. Establishing a grading system that emphasizes independence, and even mentoring each other, ensures student progress when such teaching helps them earn an A.
An Overview of Modern Nanoparticle Characterization: Three Techniques

Jeff Bodycomb, Horiba Scientific Corporation
jeff.bodycomb@horiba.com

There are three common techniques for nanoparticle characterization: Laser Diffraction, Dynamic Light Scattering, and Nanoparticle Tracking Analysis. Laser diffraction is the use of variations in scattered light with angle to determine particle size distribution and is popular due to its speed and wide range. Dynamic Light Scattering (DLS) is the use of variation in scattered light with time to determine particle size distribution and is popular due to its ability to analyze the smallest particles. Nanoparticle Tracking Analysis (NTA) is the newest technique and, with the advent of multi-laser systems, can be used to analyze size distributions and particle concentration. High resolution distribution information and concentration information are NTA’s strengths. Here we give an overview of each technique along with a discussion of the relative merits of each.
Multicomponent Metal Oxide Semiconductors for Visible Light-Activated Catalytic Degradation of Polychlorinated Biphenyls

Elsayed M. Zahran*, Marc R. Knecht, Leonidas G. Bachas
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Metal oxide semiconductors, such as TiO$_2$ and ZnO have been established as photocatalysts in the degradation of organic compounds under UV irradiation. On the other hand, the activity of the majority of the visible light catalysts, such as Cu$_2$O, Fe$_2$O$_3$, and BiVO$_4$ is impacted by their sluggish charge transfer, photocorrosion, and fast electron hole recombination. Creating a p-n heterojunction in metal oxide semiconductors is an effective approach to decrease the electron hole recombination and enhance the photocatalytic activity. In this presentation, we describe a new approach to enhance the photocatalytic activity of BiVO$_4$ photocatalyst with Pd nanodomains and bismuth oxybromide nanosheets dual heterojunction. The p-n heterojunction $m$-BiVO$_4$/BiOBr nanosheets were prepared by a CTAB-assisted hydrothermal method at 80°C. Subsequently, Pd nanodomains were uniformly deposited on the surface of $m$-BiVO$_4$/BiOBr nanosheets from an ethanolic solution of palladium acetate. The pristine $m$-BiVO$_4$/BiOBr photocatalyst displayed substantially higher photocatalytic activity in degradation of the organic dye, Rhodamine B, than pure BiVO$_4$. Integrating Pd nanodomains on the surface of the composite demonstrated significantly enhanced photocatalytic activity. Furthermore, this novel ternary composite showed favorable light-activated degradation of polychlorinated biphenyls in comparison with other established metal oxide photocatalysts, such as TiO$_2$. This new photocatalyst is well suited as photoanode for oxygen generation in visible light activated water splitting and photocatalytic degradation of various persistent organic pollutants.
When nanoparticle tracking analysis (NTA) hit the commercial market some ten years ago, it didn’t take long for the nanoparticle community to realize the added value of this technique relative to Dynamic Light Scattering (DLS) and Transmission Electron Microscopy (TEM). Advantages versus DLS included the ability to work at lower concentrations for size measurements, obtain concentration data and in some instances, measure zeta potential. The question for biological applications quickly switched from how big and how much, to what exactly are those particles? Fluorescence NTA (F-NTA) helps to answer that question.
Determination of the Overall Antioxidant Strength of Teas Combining Metal Nanoparticles, Plasmonics, and Fluorescence: Designing New Experiments for Physical Chemistry Laboratory

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Herein we present a multidisciplinary experiment for undergraduate physical chemistry laboratory students. Based on plasmonics, this experiment also incorporates redox reactions, synthesis of metal nanoparticles, energy transfer, excitation processes and fluorescence emission and quenching of fluorophores. Especially impactful is the real world application of this experiment since the students' main goal is to compare the antioxidant strength of various store-bought teas. The relative antioxidant strength of three different teas (green, oolong and black tea) is determined by monitoring the fluorescence quenching effect of silver nanoparticles synthesized in a tea solution on a Rhodamine 6G (Rh6G) aqueous solution. By performing this experiment students can conclude that green tea (the least oxidized in manufacturing) is the strongest antioxidant compared to oolong and black tea since it has more antioxidants and thus can form more nanoparticles. Post-lab assessment showed that students could correctly discuss i) the relationship between the size of nanoparticles and the location of their Localized Surface Plasmon Resonance (LSPR) bands in an absorption spectrum, ii) transitions commonly illustrated by a Jablonski diagram (i.e. absorption, fluorescence, quenching) and iii) the role of reduction and oxidation in nanoparticle synthesis. Post-lab surveys show positive student perception of the experiment and their appreciation of current and topical laboratory experiments.
Nanomaterials Education, Characterization and Thin Films—Olin Engineering 118 – 2:00-2:20 Saturday

**Advanced Applications in Nanoscale Device Fabrication Enabled by Novel Focused Ion Beam Instrumentation**

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Nanofabrication techniques are enabling many advances in nanoscale science and engineering. Therefore, the expansion of the available nanofabrication techniques will have an immediate impact on our exploration of the nanoscale. We report on a myriad of different applications achieved through the use of state-of-the-art focused ion beam (FIB) nanofabrication instrumentation.

FIB-based nanofabrication is a viable and useful alternative to Electron Beam Lithography (EBL) for impressing patterns into, and otherwise directly physically and chemically modifying, material systems at the nanoscale. A key motivation for using FIB nanofabrication instead of EBL is the relative simplification of the overall nanofabrication process, especially for the direct processing at the nanometer scale of novel materials for which EBL processes have yet to be developed, or any material systems for which EBL processes do not exist or are otherwise difficult to access. Furthermore, FIB nanofabrication has direct, resistless, and three-dimensional patterning as advantages over EBL-centric nanofabrication.

The increasing availability of FIB-SEM instrumentation is also motivating FIB nanofabrication as a complement to EBL. However, traditional FIB-SEM instruments are lacking patterning resolution, stability, large, corrected fields-of-view, and laser interferometer stages, which are essential components in EBL instrumentation and are mandatory in some applications, such as plasmonics and nanophotonics, which often require high resolution nanolithography with tight dimensional control over areas much larger than a single field-of-view.

Here, we briefly introduce the VELION, a new FIB-SEM nanofabrication instrument concept containing these essential components of EBL instrumentation, but moreover review a wide range of FIB nanofabrication applications in nanoscale science and engineering. Over the last fifteen years, Raith has been pursuing its vision that nanofabrication has special requirements that should drive the development of FIB technology. This effort has culminated in the nanoFIB. Three, a state-of-the-art FIB column that produces record performance in stability and patterning resolution for Gallium-FIB. Furthermore, this technology opens the door to the stable delivery of non-Gallium nanobeams, such as Silicon-FIB, Gold-FIB, Germanium-FIB, and Cluster-FIB.

With the appreciation that an ion’s properties can have dramatic consequences on the physical and chemical nature of the resulting nanostuctures, we discuss the motivations behind applications employing either Gallium or non-Gallium species. We will survey the unique FIB nanofabrication applications that are enabled by this sub-10nm instrument, including maskless ion implantation for color center creation and nanomaterial synthesis, metasurfaces and other plasmonic and nanophotonic devices, quantum optics, nanopores for DNA sequencing, and compound semiconductor materials.
Sub-Molecular QSAR: Using Scanning Tunneling Microscopy Simulations for Rational Drug Design

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Tryptanthrins represent a class of compounds of interest for their anti-parasitic properties versus organisms that cause malaria, leishmania, trypanosomiasis, tuberculosis, and fungal infections. However, little is known of their mode(s) of action at the molecular level. To investigate their geometric and electronic behavior, scanning tunneling microscopy (STM) was used by our research group to observe monolayers of these compounds at the solution-graphite interface. Sub-molecular resolution has allowed the direct observation of individual lobes of the highest occupied molecular orbital (HOMO) and lowest unoccupied molecular orbital (LUMO), correlating very closely with density functional theory (DFT)-calculated MOs, thus providing a satisfying verification of DFT as a computational and theoretical method. Additionally, we performed tunneling barrier height spectroscopy studies, revealing that the origin of the relative apparent tunneling barriers for MO-mediated surfaces differ markedly from those of non-orbital mediated surfaces, representing a novel phenomenon. These MO-mediated tunneling barrier measurements were then used to develop a computational STM simulation based on the 3-dimensional convolution of a tip wavefunction with the MOs. The simulation displays remarkable agreement with experimental results. Furthermore, the simulation results were used to perform a first-ever tunneling barrier-based quantitative structure-activity relationship (QSAR) analysis of tryptanthrins. The results suggest a previously unknown pharmacophore for tryptanthrins versus P. falciparum, the pathogen that causes the lethal form of malaria. These initial results indicate that simulated tunneling barriers can be utilized in computer-aided drug design (CADD), or in the design of other important molecular structures of interest (i.e. catalysts, herbicides, pesticides, etc.).
Catalytic Performance of Defect Laden h-BN Revealed by Correlative AFM and ToF-SIMS Characterization

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CO$_2$ capture and conversion requires catalytic activation often involving metal surfaces. New solutions for high and tunable catalytic activities have emerged with the discovery of nanomaterials. For instance, recent studies reveal that hexagonal boron nitride (h-BN) can be used as catalysts by introducing defects such as vacancies and edges in the flakes. Processes such as ball milling and heat treatment have been considered to date.

In this study, we discuss approaches suitable for controllably introducing defects in h-BN powders and exfoliated layers. Functional atomic force microscopy (AFM) characterization reveals that the treatments affect the structural, mechanical, electrical and chemical properties of the pristine flakes. In addition, we monitor the changes in the affinity of selected molecules with defect-laden h-BN using functionalized AFM cantilevers. We complement our nanoscale findings with ToF-SIMS measurements, which support our hypothesis that defects become active sites for selected chemical reaction and long hydrocarbon chains form on the active defects. The study constitutes a new experimental approach to understanding the mechanisms of catalysis at the nanoscale, thus bridging the gap between molecular-level theoretical modelling and reactor-scale studies of the reactions.
Crystallinity-Transport Investigations of Nanoscale Ru Conductors at Al₂O₃ and/or SiO₂ Interfaces

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Enhanced scattering of charge-carriers at sufficiently small dimensions¹ (on the order of the mean free path of electrons), also known as the resistivity size-effect, leads to non-scalable increases in resistivity in conductors. As the trend of miniaturization continues in microelectronic fabrication, this size effect becomes a major challenge to current CMOS technology (Cu based) due to the loss of the majority of power at the interconnects due to their larger abundance. By using single-crystalline sub-nanometer metallic interconnects, room temperature ballistic conduction may be achieved. Within this general area of research, Ru has emerged as a promising candidate to replace Cu due to its weaker resistivity-thickness interdependence.² In practical applications, interconnects are necessarily in contact with isolating dielectric materials, and this work includes studies of Ru (0001) films epitaxially grown on c-axis sapphire, both with and without various silica capping layers in various states of crystallinity and chemical interaction with the underlying metal. The overall goal of the project is to measure the transport properties of the controllably different samples, while providing sufficient materials characterization to unequivocally establish correlations between changes in resistivity and changes in bulk/interface conductor properties.

Efforts within our group have centered on physical characterization of ruthenium films produced by collaborators and growth of SiO₂ on ruthenium thin-films via physical vapor deposition (PVD) within UHV. X-ray photoelectron spectroscopy (XPS) and low energy electron diffraction (LEED) have been used to demonstrate a high degree of both surface cleanliness and long-range crystal order following large-scale growth recipes. Further investigation has shown clear correlation between the extent of Ru oxidation and sheet resistivity following different annealing procedures during the film growth recipes. XPS, LEED, and low energy He⁺ ion scattering spectroscopy (ISS) have been used to characterize in-situ grown SiO₂ film, which is highly dependent upon both coverage and oxidative crystallization temperature. Further, ex situ measurement of resistivity of Ru (0001) films of different dimensions, with and without crystalline SiO₂ encapsulation will be made and additional atomically localized information will be collected using Scanning Tunneling Microscopy (STM).


Controlling Catalytic Hydrolysis at Gold Nanoparticle Surfaces

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Catalytic reactions, such as those involving hydrolytic mechanisms, are a critical research area for the development of new countermeasures against chemical and biological weapons of mass destruction. We are interested in controlling catalytic hydrolysis by taking advantage of the unique properties of gold nanoparticles (AuNPs). We will report a detailed investigation of the mechanism of hydrolysis of methyl parathion (MeP) and bis(4-nitrophenyl) phosphate (BNPP) as a function of surface coverage of a copper bipyridine catalyst attached to 10 nm AuNP and with laser excitation of the SPR band of the AuNPs. Using Michaelis–Menten kinetics, the 1st order catalytic rate constant ($k_{cat}$) and the Michaelis constant ($K_M$) have been analyzed as a function of catalyst surface coverage on the AuNPs. Our experiments suggest that laser excitation may be breaking inactive dimer Cu-OH-Cu bonds generating cooperative sites and giving rise to enhanced rates. Our laser enhancement result in which we can trigger catalysis at specific locations and time should be beneficial to broad applications for chemical remediation and threat reduction.

This work received support from the Defense Threat Reduction Agency-Joint Science and Technology Office for Chemical and Biological Defense (MIPR # HDTRA136555 and HDTRA1412658).
Organic molecules show a promising future as materials for organic devices e.g. light emitting diodes, field effect transistors, solar cells etc. The performance of these devices depends strongly on the atomic and electronic characteristics at the interface between organic molecule and the host substrate, which is necessary to provide support and/or conduction for the device.

To develop a working catalogue of established anchor-group-dependent trends in these characteristics, we have undertaken a joint computational/experimental research study of benzene and its derivatives (pyridine, thiophene) bound to Ru(0001), both with and without ultra-thin silica sheets inserted between the two. The selected molecules are simple models for the working materials of the device. The inserted silica sheets can be grown as either chemisorbed monolayers or physisorbed bilayers using different growth conditions and have been chosen to provide an experimentally accomplishable means of varying the degree of separation between the targeted adsorbate molecules and the conductive support.

Using Density Functional Theory (DFT) with the self-consistent inclusion of van der Waals (vdW) corrections, the above-mentioned materials will be modeled, and the preferred adsorption sites are determined by exploring a variety of adsorption geometries (adsorption sites and molecular orientation). For these energetically favorable configurations, electronic properties are extracted, which include changes upon adsorption in: i) the workfunction, ii) the charge density near the Fermi energy; iii) core level binding energies and iv) charge transfer between the molecule and the substrate.

Accompanying X-ray Photoelectron Spectroscopy (XPS) measurements will provide complementary experimental data sufficient to comparatively assess electronic predictions made from theory. These will include i) changes in the secondary electron kinetic energy threshold to establish changes in workfunction, ii) valence-band measurements to explore changes near Fermi charge density, and iii) conventional core-level XPS analysis with selective Auger Parameter analysis for improved deconvolutions of initial-state and final-state photoemission contributions to binding energy shifts.
Effect of Non-Uniform Electric Field in Microstructured (La$_{1-x}$Pr$_x$)$_{1-x}$Ca$_x$MnO$_3$ Thin Film

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Thin films of the hole-doped manganite (La$_{1-x}$Pr$_x$)$_{1-x}$Ca$_x$MnO$_3$ (LPCMO) grown on NdGaO$_3$ (NGO) substrates show coexistence of ferromagnetic metallic (FMM) and charge-ordered insulating (COI) phases and they undergo an insulator-to-metal transition as a function of temperature or applied magnetic fields. Using lift-off photolithography, we deposited micrometer scale gold contacts on LPCMO thin films. The geometry of these gold contacts allows us to apply non-uniform electric field across the sample. Two-probe voltage source measurements using these contacts show overall reduction in sample resistance with increasing applied voltages. This electroresistance behavior is due to the realignment of the fluid-like FMM regions embedded in COI background and has been observed before with uniform electric fields. However, unlike in the case of uniform field, the non-uniform field leads to significant increase in the insulator-to-metal transition temperature as a function of applied voltage. We also observed voltage dependent resistance breakdown at several temperatures. These behaviors are due to the electric field driven dielectrophoresis and percolation of the FMM regions in COI media.
Methanol Partial Oxidation Mechanisms on a Single-Site Catalyst Pt₁/ZnO(10-10): A First-Principles Study

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The rational design of single metal atoms anchored on non-metallic surface has the great potential to offer catalysts with high activity and selectivity [1]. Towards this goal, we have carried out density functional theory based calculations of the catalytic behavior of singly dispersed Pt atoms on ZnO, Pt₁/ZnO(10-10), as a model system for methanol partial oxidation. We find that methanol adsorption is favored at the surface Zn site whereas oxygen prefers to adsorb at the Pt-Zn site. The adsorption of reaction intermediates CO, CO₂, and H₂ are favored at the Pt site, whereas H₂O prefers to sit at the Zn site. Secondly, along the reaction pathways for methanol dehydrogenation, we will illustrate that the O-H bond scission from methanol is slightly exothermic (ΔE=−13 meV). The resultant methoxy then preferentially adsorbs at the Pt-Zn site, where C-H bond of methoxy can be easily activated. The dissociation of methoxy (CH₃O->CH₂O+H) is exothermic (ΔE=−0.42 eV) and that of formaldehyde (CH₂O->CHO+H) is endothermic (ΔE=+0.16 eV). The results suggest that Pt₁/ZnO(10-10) is a potential single-atom catalyst for methanol oxidation. We will compare our findings with those for the related system Pd₁/ZnO(10-10) [1] and available experimental observations to evaluate their relative advantages for methanol partial oxidation.

** The work is partially supported by DOE grants DE-FG02-07ER15842
Nanomaterials Education, Characterization and Thin Films – Olin Engineering 118 – 10:00-10:20 Sunday

Monte Carlo Simulation of Percolation Transport in Transparent, Conductive Metal Nanowire Networks

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There has been significant research interest recently in random networks of one-dimensional elements, such as carbon nanotubes, graphene nanoribbons, and metal nanowires, for next-generation transparent conductors. In particular, silver and copper nanowire networks exhibit high transmittance, low sheet resistance, mechanical flexibility, and fast deposition. These unique properties make metal nanowire networks promising candidates to replace indium tin oxide (ITO), which suffers from brittleness, scarcity, high cost, and slow deposition.

Monte Carlo simulations are employed to calculate the resistivity of metal nanowire networks, which is governed by percolation transport. Below critical dimensions, the network stops behaving like bulk and exhibits power-law resistivity scaling as nanowire and device parameters are reduced. In most computational work, nanowires in these networks have been modeled as straight "sticks". However, in real experiments, individual nanowires are not perfectly straight, but exhibit some degree of curviness. Furthermore, in most simulations, it is assumed that the resistance of the wire-to-wire junction is much larger than that of the nanowire itself, resulting in a junction resistance-dominated network. However, recent experiments have shown that the junction resistance can be significantly lowered by post-deposition treatments and the nanowire resistance can no longer be ignored. In this work, we perform systematic Monte Carlo simulations to study the effect of nanowire curviness on the scaling of percolation resistivity in nanowire networks. We generate the curved nanowires using 3rd-order Bazier curves. These curves are endowed with a curviness angle property that specifies how far away the two intermediate control points of the Bazier curve may lie, in the tangential sense, from a straight path connecting the two ends of the curve. The curviness angle is varied to obtain networks of differing values of curl ratio, which is defined as the ratio between the curved length of a nanowire and the straight distance between its two ends.

Furthermore, we study the effect of the wire-to-wire junction resistance on the resistivity of metal nanowire networks. In particular, we compute the network resistivity as a function of the wire-to-wire junction resistance over a span of six orders of magnitude, ranging all the way from a junction resistance-dominated to a nanowire resistance-dominated network. We study this effect when other nanowire/device parameters are also varied, namely nanowire density and length, device length and width, nanowire alignment, and nanowire curviness. We find that, for random networks, the resistivity of the network increases with increasing nanowire curviness and the resistivity exhibits an inverse power law dependence on the curl ratio. We also find that the value of the inverse power law critical exponent extracted is not universal, but depends on other nanowire and device parameters. We also find that the effect of curviness on resistivity decreases for nanowire resistance-dominated networks. These results show how the degree of curviness of individual nanowires and junction resistance affect to the macroscopic resistivity of the network. They also show that Monte Carlo simulations are an essential tool for providing insights into the percolation transport in transparent, conductive nanowire networks.
Sulfur Induced Embrittlement in Nickel: A Molecular Dynamics Approach

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The embrittling or strengthening effect of solute atoms at interfaces, commonly known as the embrittling potency, is an essential property for characterizing the effects of solute segregation on fracture. One of the more technologically relevant material systems related to embrittlement is the nickel-sulfur system where sulfur has a deleterious effect on fracture behavior in polycrystalline nickel. In this work, a nickel-sulfur embedded-atom method interatomic potential is developed considering the embrittling behavior of sulfur at nickel grain boundaries. The fitting was performed using colinear evolutionary and colinear pattern search algorithms with the software DAKOTA developed by Sandia National Laboratories. The quantities used in the fit are motivated by density functional theory (DFT) studies as well as experimental results and observations. For the validation of this interatomic potential, additional quantities are used which are not considered in the fitting process. After obtaining an adequate fit, this interatomic potential is utilized to compute embrittling potencies for a wide array of symmetric tilt grain boundaries.
Eddy currents produced in conductors and inductor cores operating at high frequencies heating and increase in resistance due to the skin effect. Traditional approaches for suppressing these eddy currents include the use of Litz wires and lamination of magnetic cores, both of which restrict the flow of eddy currents by decreasing the effective transverse cross-sectional area they may flow through. However, extending these techniques to improve performances at higher frequencies and reduced feature sizes, as well as integrating them into on-chip applications, has been challenging due to manufacturing limitations. In this research, nanocomposite structures are explored as a possible approach to producing conductors and inductor cores that can perform reliably at higher frequencies and also be manufactured on-chip alongside other traditionally micro-fabricated components.

The nanocomposite structures we are currently exploring are made up of electro-plated metal matrices surrounding inclusions of different shapes, materials, and orientations. Specifically, we are looking into the use of micro and nanofibers made from polymers, and nanoparticle spheres made from magnetic materials such as iron-oxide. Furthermore, combining these different inclusions, such as filling the polymer fibers with magnetic nanoparticles, are of interest due to the potential metamaterial effects that could be induced above certain frequency levels. To properly predict the performance of these different nanocomposite structures, we have developed various analytical solutions that take into account variables such as the density, the size and the packing order of inclusions. These models were compared to finite-element simulations in COMSOL.

Future steps in this work include the actual fabrication of these theoretical structures by a process developed in our lab and known as electro-infiltration. First, the inclusions are deposited onto a metal substrate, then the voids are filled by electroplating. Analysis of these structures would be performed via TEM in order to examine their internal ordering, as well as through electrical measurements to directly determine their properties. Conductors would be formed into transmission lines, and measured by collecting their S-parameters using a vector network analyzer, while inductor cores would be placed inside of air coils and measured using an impedance analyzer. Magnetic permeability measurements could also be made by shaping samples into toroids and by using a material analyzer.

By increasing the operating frequency range of conductors and inductor cores, more compact devices can be manufactured and used at frequency bands desired for use in 5G communication applications. Such advances are necessary as we begin to progress towards 5G communication systems, and as we seek to shrink the size of power electronic devices such as power blocks used for laptops and other portable computers.
Ocular drug delivery (ODD) presents unique challenges due to specific attributes of the eye and nanotechnology offers advantages to develop ideal ODD systems to overcome associated challenges and for effective therapies. Currently, our lab research is focused to develop drug delivery systems such as polymeric nanoparticles and NPs incorporated thermo-reversible gels for effective delivery of drugs in ocular diseases. Ocular biocompatibility and biodegradability are important characteristics in the selection of polymers for ODD system.

In our study, the model drugs triamcinolone acetonide (TA), Loteprednol Etabonate (LE) and Sunitinib Malate (SM) were encapsulated by PLA-PEG-PLGA nanoparticles (NPs) and further incorporated into a PLGA-PEG-PLGA thermo-reversible gel. PLGA NPs loaded with each drug individually were prepared by nano-precipitation method and were characterized to check their size, entrapment efficiency, in vitro drug release profile and in vitro cytotoxicity. The TA-loaded NPs showed an average particle size of 208.00 ± 1.00 nm and poly-dispersity index (PDI) of 0.12 ± 0.03 using DLS technique while for LE-loaded NPs, particle size was found to be 168.60 ± 23.18 nm and PDI was 0.08 ± 0.003 and for SM-loaded NPs it was 164.5 ± 5.8 nm and 0.09 ± 0.002 respectively. TEM images demonstrated nanoparticles of uniform size and were in concurrence with the DLS results and were spherical with smooth surface. The encapsulation efficiency of TA, LE and SM loaded PLGA NPs were found to be 26.3%, 82.6% and 72% respectively. The prepared PLGA NPs were further incorporated into a PLGA-PEG-PLGA thermo-reversible gel. For that 20% (w/v) thermo-reversible gel was prepared using cold method. In vitro release analysis demonstrated that free TA from TA solution was completely released within 24 hours; whereas 94% of TA was released from PLGA-PEG-PLGA thermo-reversible gel after 7 days. SM loaded nanoparticles PLGA-PEG-PLGA thermo-reversible gel also showed extended release profile with 15% release at the end of first day followed by slow release till 52% at the end of seven days, while nanoparticles without incorporating in gel exhibited 29% and 83% release at end of 1 and 7 days. Whereas, for drug solution more than 80% release was seen in 3 hours. Similarly, in vitro release results of LE loaded NPs gel also demonstrated sustained release profile at the end of 7 days in vitro release study. Cytotoxicity test (MTT assay) in human retinal pigmented epithelium (ARPE19) cell line indicated that the viability of cells was greater than 90% for gel loaded, as such and blank nanoparticles at 10 µM and 20 µM concentration tested whereas, for drug solution viability was found to be 72% and 54% respectively at above concentrations, thus indicating cell compatibility of the formulation. In vivo studies conducted in mice shown positive results in reduction of macular degeneration.
Target-specific treatment has become utterly important and immensely researched especially for cancer treatment in modern medicine. Most of the chemotherapeutic drugs and the radiotherapy treatments are not target-specific towards the affected cells or organs, therefore have adverse cytotoxic effects on normal healthy cells. This eventually results in side effects that could pertain to higher risks on a patient's quality of life. Carbon dots have emerged over time as a promising nano-carrier for drug delivery although specificity is not achieved by most of them. In addition, use of transferrin and folic acid receptors for transmembrane transport has achieved lower effective drug concentrations regardless of target. Therefore attention needs to be turned to other nanomaterials. Carbon nitride dots are another drug delivery material for which the biomedical applications have not being investigated much yet. Herein carbon nitride dots were synthesized with citric acid using two different N-precursors urea and selenourea separately. The prepared carbon nitride dots are found to have excellent photoluminescent properties and biocompatibility through studies using two cell lines, pediatric glioblastoma cancer (SJGBM2) and normal embryonic kidney (HEK293). Through fluorescence imaging carbon nitride dots were confirmed to selectively enter the cancer cell membrane while they barely penetrated into the normal cells. The proposed mechanism is that carbon nitride dots could be disguised as glutamine due to their functional groups on the surface, therefore cancer cells preferably take them up as an energy source needed for their rapid growth. In addition, carbon nitride dots are able to image with longer wavelength luminescence. Thus carbon nitride dots can have great potential for biomedical applications in target-specific drug delivery and imaging.
Nanomedicine – Olin Life Sciences 129 – 10:50-11:10 Saturday

**Design of Nanodrugs for Application in Biomedical Therapies**

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Our work is based on the development of carrier-free and non-toxic nanomaterials, i.e., nanodrugs, for efficient treatment of medical diseases and disorders. We designed innovative strategies to formulate nanodrugs that are solely derived from pharmaceutical drugs, with therapeutic agents embedded within the nanostructures. Nanodrugs exhibit intrinsic therapeutic properties and do not require a nanocarrier (e.g., polymers, liposomes) to transport the drug to the targeted receptor. The administration of these nanodrugs induces a highly efficient biological effect by delivering multiple units (therapeutic agents) per nanoparticle, without causing any unwanted side effects. Furthermore, the formulation of nanodrugs offers a bioavailability for an extended time in comparison to the free molecules counterparts, thus, avoiding the need for frequent dosing. Herein, we applied customized syntheses of nanodrugs, with different chemical compositions, for application in various biomedical therapies. For example, drug nanoformulations with cooling properties were prepared using vanilloid compounds, for application in therapeutic hypothermia. The nanomaterials will be administered via nasal spray as a useful treatment to secure neuroprotection in the case of brain trauma, cardiac arrest, spinal cord injury, stroke, and other acute traumatic conditions/injuries. Moreover, several formulations, derived from an antiviral drug, were prepared for targeting Zika virus (ZIKV). Following a self-assembly mechanism, the prepared formulations were made of nanovesicles that offer great benefits in biological sciences with a significant permeation ability through biological membranes. The synthesis of the nanodrugs in interest was performed using bottom-up approaches, which were assisted with ultrasound without/with soft templates. Characterization and optimization of the nanodrugs were performed with regard to controlling their size and morphology for an efficient performance. Transmission electron microscopy (TEM) and dynamic light scattering (DLS) showed the formation of various structures at nanoscale range, with most formulations being monodisperse. Zeta potential measurements indicated a high stability of the nanosuspensions, obtained upon optimization of the synthetic procedure. Various studies were done to evaluate the performance and efficiency of the nanodrugs at different pH's and experimental conditions. Current work focuses on development of biological assays suitable for testing the nanomaterials in each type of therapy. Overall, we believe that this research represents nanotechnology-based advances in the fields of nanomaterials design and preparation, localized and targeted delivery, as well as efficient therapies, which should have an impact in medicine and treatment of injuries and disease states.
Carbon dots (CDs), a novel class of carbon-based nanoparticles, have been widely developed and studied in terms of synthesis, characterization and applications. The syntheses of CDs could be divided into "top-down" and "bottom-up" approaches. Compared to the "top-down" approach, the "bottom-up" approach is more versatile with various starting materials and reaction conditions. Therefore, I will mainly present two types of CDs, gel-like CDs (G-CDs) and orange CDs (O-CDs), synthesized by the "bottom-up" approach. In addition, CDs prepared from raw carbon powder in the "top-down" route is also one focus of the presentation. The characterization methods of CDs will include UV/vis absorption, fluorescence and FTIR spectroscopies, XPS, AFM and TEM. Zeta potential and quantum yield are also two important parameters to reveal the electric and optical properties of CDs. In addition, solvent, temperature and pH effects on the optical behaviors are also worthy of further investigation. As to the application of CDs, we will present the unique use of CDs from carbon powder in the bone disease treatment. Also, zebrafish is used as the biological model to study O-CDs across the blood-brain barrier. Enhancement of thermoelectricity of Bi$_2$Te$_3$ by using G-CDs will also be illustrated. In the end, 3D printing by embedding O-CDs in superabsorbent polymer will be underlined.
One of the biggest challenges when engineering cancer nanomedicines is achieving efficient systemic delivery of nanoparticles into the tumor site. Stability and mobility of nanoparticles in complex biological environments remain largely unexplored because of the lack of techniques to assess nanoparticle diffusion in situ. In the case of magnetic nanoparticles, an alternative to monitoring nanoparticle stability and mobility in situ is to determine the rotational diffusivity obtained via dynamic magnetic susceptibility measurements. Here we report a systematic comparison of stability and mobility of magnetic nanoparticles coated with commonly used polymers for biomedical applications using dynamic susceptibility measurements. We synthesized cobalt ferrite cores modified covalently to have either a positive, negative or neutral surface charge. Then, we measured nanoparticle stability and mobility in phosphate buffered saline, blood, and tumor tissue explants. Our results suggest that polyethylene glycol (PEG) coated nanoparticles had the most favorable stability and mobility characteristics in all studied scenarios, whereas the positively charged polyethylene amine (PEI) coated nanoparticles were the least favorable. Understanding the mobility and stability of nanoparticles in complex biological environments such as blood and tumor tissue could improve particle design and stability so as to navigate biological milieu in vivo.
Advancements in nano-bio-technology revolutionized health care management via developing smart rapid diagnostic system and nanomedicine designed for targeted diseases. Due to easy tunable performance features these systems serves in a controlled manner and significantly useful for personalized health care. Our Laboratory is exploring magnetically guided delivery of nanomedicine to the brain for the treatment of neuro-HIV/AIDS. We have demonstrated successful safe delivery of drug-nano-carrier, i.e., magneto-electro nanoparticles (MENPs of 25 ± 5 nm size) to the brain of mice along with evaluation of bio-compatibility, structural integrity and motor coordination function. To develop a human compatible delivery system, MENPs were successfully delivered to the brain of non-human primates i.e., baboon using MRI as navigation tools. The MRI-assisted delivery methods were safe and MENPs presence baboon’s brain did not produce toxicity related with tissues and blood profile. The outcomes of our research have significance to develop future therapy for the treatment of neuro-HIV-infection in personalized manner.
Cyclosporine A (CsA) is one of the main immune-suppressant agents which has been used widely in organ transplantation against graft rejection. However, the low oral bioavailability and the associated adverse effects such as nephrotoxicity are the main drawbacks of current usage of CsA. Thus, purpose of this study is to formulate PLGA nanoparticles of CsA to improve its effectiveness and to reduce the nephrotoxicity induced by the plain drug. CsA-loaded PLGA nanoparticles were prepared by the oil-in-water (O/W) emulsion-solvent evaporation method. Briefly, Drug: Polymer ((PEG-PLGA) (50:50 DLG, mPEG 5000, 5 wt. % PEG)) were taken at optimized weight ratio (1:7) and dissolved in acetone as organic phase. This organic solution was slowly added in 1% w/v PVA solution using 23G syringe under continuous stirring. The resulting emulsion was stirred overnight at 700 rpm for evaporation of solvent. The nanoparticulate suspension obtained was centrifuged at 15000 rpm for 15 min at room temperature and pellet containing nanoparticles was collected, washed thrice with distilled water. Particle size and zeta potential of the formulation was determined by DLS using NanoZS90 particle size analyzer. Percent drug entrapment and loading efficiency were also determined. Quantitative estimation was carried out using validated UV spectroscopic method. The morphology of the nanoparticles was determined by Transmission Electron Microscopy (TEM). In vitro drug release profile was carried out utilizing dialysis method in pH 7.4 PBS. CsA loaded PLGA nanoparticles were successfully developed and characterized. In vitro cytotoxicity using MTT assay and in vivo toxicity studies are in progress and will be shared in the next presentations.
Drug traversal across the blood-brain barrier has come under increasing scrutiny recently, particularly concerning the treatment of sicknesses, such as brain cancer and Alzheimer's disease. Most therapies and medicines are limited due to their inability to cross this barrier, reducing treatment options for maladies affecting the brain. Carbon dots show promise as drug carriers, but they experience the same limitations regarding crossing the blood-brain barrier as many small molecules do. If carbon dots can be prepared from a precursor that can cross the blood-brain barrier, there is a chance that the remaining original precursor molecule can attach to the carbon dot surface and lead the system into the brain. Herein, tryptophan carbon dots were synthesized with the strategy of using tryptophan as an amino acid for crossing the blood-brain barrier via LAT1 transporter-mediated endocytosis. Two types of carbon dots were synthesized using tryptophan and two different nitrogen dopants, urea and 1,2-ethylenediamine. Carbon dots made using these precursors show excitation wavelength-dependent emission, non-toxicity, and have been observed inside the central nervous system of zebrafish (*Danio rerio*). The proposed mechanism for these carbon dots abilities to cross the blood-brain barrier concerns residual tryptophan molecules that have attached to the carbon dots surface, enabling them to be recognized by the LAT1 transporter. The role of carbon dots for transport open promising avenues for drug delivery and imaging in the brain.
Triple Molecule Conjugated Carbon Dots as a Nano-Drug Delivery Model for Glioblastoma Brain Tumors

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Brain tumors are the most common solid tumors found in children and the number one cause of childhood cancer death. The poor prognosis, especially for high-grade gliomas such as glioblastoma (GBM), is due to the difficulty in removing the entire tumor and the lack of effective chemotherapies able to cross the blood brain barrier (BBB) at therapeutic levels. Nano drug delivery is rapidly emerging as the most promising technology to deliver anti-cancer drugs to brain tumors as they can be conjugated with tumor-targeting ligands such as transferrin to increase the BBB and tumor cell penetration. Brain tumors are highly heterogeneous which reduces the chance that a tumor will be resistant to the treatment. Most nano drug delivery systems currently being evaluated are only single or dual molecule delivery systems. To develop a brain tumor targeted triple molecule delivery system, we utilized non-toxic Carbon dots (C-dots) as the nano-carrier, transferrin as the targeting ligand and the DNA damage-inducing chemotherapies epirubicin (epi) and temozolomide (temo) and tested their efficacy in vitro using brain tumor cell lines: SJGBM2, CHLA200, CHLA266 and U87.

The non-targeted (without transferrin) dual drug conjugated C-dots (C-dot-epi-temo) induced cell death in all cell lines compared to single drug conjugate. At the concentration of 10 µM C-dot-epi-temo showed the average cytotoxicity of around 86.5% for all cell lines. Furthermore, the cell death was more than additive suggestive of synergy, because C-temo and C-epi showed only 1.8 and 76.8% cytotoxicity, respectively. The conjugation of transferrin (targeted dual drug system) increased cytotoxicity by 100-1000x by the concentration. The dual drug transferrin conjugate (C-DT) increased the cytotoxicity of SJGBM2 cell lines to 86.0% at the concentration of 0.01 ppm, identifying the C-DT sample as a better therapeutic agent. The single drug conjugations with transferrin, C-dot-temo (C-TT) and C-dot-epi (C-ET), showed the cytotoxicity of the SJGBM2 at 8 and 35%, respectively, at the same concentration of 0.01 ppm.
Extended Delivery of Retina Drugs Through Injections of Oleogels

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Delivery of ophthalmic drugs to the back of the eye for treatment of retinal diseases is still a difficult challenge. For systemically delivered drugs the blood-retina barrier is an additional hurdle to overcome while diffusing across the blood capillaries in the retina. It is also a challenge to deliver drugs to the retina through eye drops due to the large physical distance between the tears and the retina which leads to transport barriers, and also clearance mechanisms that eliminate the drug both from tears and ocular tissue. Consequently, invasive approaches such as intravitreal injections through the eye ball are required to deliver retinal drugs. The intravitreal injections are invasive leading to reduced patient compliance, and repeated monthly injections can lead to serious complications including infections and retinal detachment. A reduction in the frequency of the injection through extended release of the drugs could have significant clinical benefits. We have designed oleogel formulations that can be injected into the vitreous through an intravitreal injection. The low solubility of the oil and the high viscosity of the oleogel ensures that the device remains in the vitreous for extended durations. The extended release of ophthalmic drugs can be achieved by adding the drug particles to the formulation at high concentrations, or by dissolving the drug within a water phase of a water-oil emulsion gel. There are many parameters that can be adjusted to alter the drug loading amounts and the release durations such as oil type, type and concentration of the gelling polymer, drug loading, size of the needle used, addition of surfactant, etc. The oleogel drug devices are unique because they can mimic the drug delivery of existing medicinal devices while mitigating some of the side effects. The devices are easy to manufacture, and are relatively low cost, dependent mostly on the price of loading the drug. Using the gel preparation proposed, various drug types can be loaded into the oleogels. Because the oleogels created are not dependent on the type of drug or concentration that will be used, each device can be customized based on the desired product. Experimental drug release trials performed with several types of drugs have shown release profiles of just a few days to over a year. These results were dependent on type of drug loaded and the method of preparing the device. Further experimental data can be collected on the physical and chemical properties of the gels after the drug preparation. Preliminary data suggests that in the future a wide variety of drugs can be delivered using this oleogel device, and the delivery regime may be tailored to the needs of the patient.
Sustained Release Formulation of Noscapine HCl using Hot Melt Extrusion (HME) Technique: Formulation and Pharmacokinetics

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Noscapine (Nos) HCl acts as a potent chemosensitizer for various anticancer drugs including docetaxel and doxorubicin. Sustained release formulation of Nos HCl could be useful in maintaining plasma Nos levels for a prolonged period of time, which is important for chemosensitization. However, weakly basic drugs like Nos HCl have pH dependent solubility. Therefore, the purpose of this study was to achieve pH independent drug release by developing sustained release dosage form of Nos HCl using biodegradable polymer eudragit RLPO and FDA approved pH modifiers by hot melt extrusion technique and to evaluate the pharmacokinetic characteristics of the formulation in Sprague-Dawley rats.

Nos HCl was extruded with various eudragit polymers and plasticizers blend above the glass transition temperature using hot melt extrusion equipment. Parameters related to HME equipment; barrel temperature, screw design, and screw speed were optimized to improve the quality of the extrudates. Different plasticizers that also act as pH modifiers were selected to achieve the pH independent drug release of Nos HCl. Recovery of Nos HCl and degradation was evaluated using HPLC. Extrudates were micronized using ball mill and filled into size ‘0’ HPMC capsules. Solid state characterization of extrudates were carried out using DSC. Nos HCl release was evaluated for 24 hrs using USP apparatus I, phosphate buffer pH 6.8 and HCl buffer pH 1.2 as dissolution medium at 100 rpm and 37°C. Pharmacokinetic characteristics of the optimized NOS formulation were evaluated in sprague dawley rats. Briefly, rats (n=5) were divided into two groups: control and Nos HCl formulation. Plasma samples were collected at 0.5, 1, 2, 4, 6, 8, 12 and 24 hrs after the oral dosage of Nos HCl. Further, the plasma samples were analyzed using HPLC to evaluate the pharmacokinetic parameters.

Sustained release dosage form of Nos HCl was successfully formulated using biodegradable polymer eudragit RLPO and a pH modifier citric acid with 91.2±1.34 drug recovery through the extruder. DSC results showed that there was no degradation of drug since the endothermic peak of both Nos HCl formulation and the active pharmaceutical ingredient (Nos HCl) were at the same temperature of 221°C. In-vitro drug release study showed that formulation containing citric acid released over 70 ± 2.51% drug in 24 hrs after initial burst release of 31 ± 3.24% drug release. However, all other formulations without pH modifier released below 40 ± 2.05% drug in 24 hrs. Further, in vivo pharmacokinetic data was in concordance with drug release profile which showed the sustained release plasma concentration-time curve with significant (p< 0.05) increase in AUC in contrast to control group.

Hot melt extrusion using hydrophobic polymers and pH modifiers could be a promising strategy to achieve reproducible sustained release dosage form of weakly basic drug Noscapine HCl.
Carbon dots (CDs) are classified as a new type of carbon-based nanomaterials with the diameter less than 10 nm. CDs attract tremendous attention because of their small size, biocompatibility, various surface functionalities and unique photoluminescence (PL) properties. None of the CDs have been reported the characteristic behavior in Langmuir monolayer technique. Herein we report stable Langmuir monolayers of CDs for the first time. We showed that saccharide-based CDs can reproducibly form Langmuir monolayers at the air-subphase interface. It is unexpected for the CDs to form Langmuir monolayers because of their highly hydrophilic surface groups and hence the great water dispersity. CDs prepared from carbon nano-powder or gel-like CDs did not form Langmuir monolayers, thus the amphiphilicity and ability to form Langmuir monolayer of the saccharide-based CDs is unique. Amphiphilic CDs were synthesized from glucose (GluCDs), galactose (GalCDs), and lactose (LacCDs) through a bottom-up route. The formation of CDs was confirmed with UV/vis, photoluminescence, and FTIR-ATR spectroscopy as well as transmission electron microscopy (TEM) and atomic force microscopy (AFM). UV/vis spectra of saccharide-based CDs have two absorption peaks in the range of 200-400 nm which can be attributed to $\pi-\pi^*$ transition (C=C) and $n-\pi^*$ transition (C=O). UV/vis absorption spectra of LacCDs in solution and in Langmuir monolayer at the air-subphase interface have the same peaks at 280 and 350 nm. The intensity of absorbance of at the peak maximum at the air-subphase interface increases with increasing surface pressure as the molecules come closer with increased compression. Also, no red-shift is observed in absorption peak with increased surface pressure showing that the aggregation in the 2D is not an important factor. PL emission in aqueous dispersions is excitation dependent whereas the close-packed Langmuir monolayer of CDs showed an excitation independent PL at the air-subphase interface. The specific and uniform alignment of the CDs in a close-packed, rigid Langmuir monolayer causes a uniform emission regardless of the excitation wavelength. Surface pressure-area isotherms of saccharide-based CDs showed all the essential phases of Langmuir monolayers starting from gas to liquid expanded, liquid condensed and solid. The maximum surface potential of about 100 mV is consistent with compact packing of CDs at the air-subphase interface. Compression-decompression cycle method showed minimum hysteresis (4.5%) confirming the retaining capacity of the CDs at the monolayer. Average diameter of GluCDs, GalCDs and LacCDs were obtained using the limiting molecular area from surface pressure-area isotherms. LacCDs have an average diameter of 1.3 nm in a close-packed Langmuir monolayer whereas the average diameter of GluCDs and GalCDs were calculated as ~0.8 nm. This result is consistent with the hypothesis that starting with a smaller precursor molecule, and keeping rest of the parameters of reaction constant, yields in CDs with smaller diameter. It furthermore confirms that CDs from glucose and galactose have same sizes as the precursors are isomers.
A Novel Conductive and Flexible Film for Neural Differentiation

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INTRODUCTION: Many disease processes of the nervous system involve neuronal loss, degeneration or damage. Therefore, it is of utmost importance to design new therapies and devices that promote nervous system regeneration. Bionanomaterials have the unique property of interacting with tissues and cells on a nanometric level, recapitulating a more natural cellular nanoenvironment. In this study, we designed a biocompatible, conductive and flexible bionanomaterial with several potential applications including biosensing, deep brain stimulation and as a platform of cellular regeneration.

METHODS: A poly (ethyl acrylate) film was synthesized through the free radical polymerization. The film was treated superficially with an acidic solution and then immersed in an aquosus solution of MWCNTs functionalized with COO⁻ groups, previously disperse by sonication. FTIR, TGA, TMA, AFM, FESEM, DSC and contact angle were conducted to characterize the material. Cytotoxicity and proliferation of human neural progenitor cells (hNPCs) from human induced pluripotent stem cells (hiPSCs) were tested with Alamar Blue. Differentiation was evaluated by immunofluorescence and pathway activation by Western blot.

RESULTS: The coated film shows conductivity of $9.76 \times 10^4\ \text{ohm}^{-1}/\text{m}$. Young modulus $0.2 \pm 0.03\ \text{MPa}$, and after two weeks of culturing hNPCs on glass (control), hNPCs stained predominantly with NeuN (neuron precursor) and DCX (glial). hNPCs cultured on the nanomaterial stained predominately for MAP2 (functional neurons) and Tuj1 (immature differentiated neurons). The presence of COO-MWCNTs activates FAK compare with NH₂-MWCNTs.

CONCLUSION: A novel material with high conductivity and flexibility was designed that is biocompatible and promotes functional neuronal differentiation.
Dielectrophoretic Manipulation and Electroporation of Vaccinia Virus Using Carbon Nanoelectrode Arrays

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Background: The current detection guidelines from CDC regarding viruses is by using Real-time polymerase chain reaction (PCR) and by detection of antibodies by enzyme-linked immunosorbent assay (ELISA). These testing are reliable but slow.

Purpose: The study reports the capture and detection of vaccinia virus particles based on AC dielectrophoresis (DEP) and electrochemical impedance measurements employing an embedded vertically aligned carbon nanofiber (VACNF) nanoelectrode array (NEA) versus a macroscopic indium-tin-oxide (ITO) transparent electrode in a “points-and-lid” configuration.

Method: The nano-DEP device was fabricated by bonding two SU-8 covered electrodes patterned using photolithography. The bottom electrode contains a 200 × 200 µm\textsuperscript{2} active region on a randomly distributed NEA and the top electrode contains a microfluidic channel in SU-8 spin-coated on ITO to guide the flow of the virus solution. The real-time impedance change was measured during DEP capture and validated with fluorescence microscopy measurements. The NEA was able to capture virus particles with a rather low AC voltage (~ 8.0 V peak-to-peak) at 1.0 kHz frequency as the particles were passed through the fluidic channel at high flow velocities (up to 8.0 mm/s).

Results and discussion: A concentration detection limit as low as ~ 2.58 × 10\textsuperscript{3} particles/mL were obtained via impedance measurements after only 54 sec of DEP capture. At the low AC frequencies (50.0 Hz or less), the high electric field at the exposed VACNF tips induced electroporation of the DEP-captured virus particles, which was validated by fluorescence emission from the dyes staining lipophilic membrane and internal nucleic acid, respectively. This study suggests the possibility of integration of a fully functional electronic device for rapid, reversible and label-free capture and detection of pathogenic viruses, with a potential of electroporation for the biochemical study of the virus particles.
Motivation and Aim: Cancer is one of the most common disease, which is the second leading cause of death. Surgery and chemotherapy cannot treat cancer efficient and selective. State of art technologies for cancer treatment are gene silencing therapies (GST), among them RNA interference, antisense therapy, CRISPR-Cas9, deoxyribozymes (DZ), but these approaches also have some challenges, such as off-target effects and poor efficiency. To address the aforementioned problems, we designed a DZ DNA nanomachine (DDM) based on RNA cleaving DZ and split DZ for the cleavage of housekeeping gene messenger RNA (mRNA) only in the presence of a cancer DNA marker. The main aim of this study is the optimization of DDM for efficient and selective cleavage of cancer cells mRNA.

Materials and methods: Housekeeping gene DAD1 (Defender Against Cell Death 1) mRNA have chosen as a target for cleavage. Its loss leads to apoptotic cell death. As biomarker sequence we have chosen the 31 nucleotides (nt) DNA sequence of the gene N-Myc, which is overexpressed in neuroblastoma cells. Short synthetic FAM-labeled RNA segments of DAD1 gene (RNA 46 nt length (RNA-46) and RNA 20 nt length (RNA-20)) were incubated with different constructions of DZ, split DZ or DDM in the presence or absence of the N-Myc sequence to study efficiency and selectivity of development nanomachine. Incubation was carried out at a temperature of 37 °C in buffer contains 2 mM MgCl2, 15 mM NaCl, 150 mM KCl and 50 mM HEPES (pH = 7.4). The cleavage of DAD1 mRNA was evaluated by denaturing polyacrylamide gel electrophoresis after 1, 2, 3, 5, 7, 10 and 24 of incubation.

Results: It was found that DZ is the best agent for RNA-20 cleavage. DDM and split DZ with the long RNA-binding arms is better for RNA-20 cleavage, while for RNA-46 cleavage DDM with short RNA-binding arms was the most efficient cleavage agent, because of secondary structure of RNA-46 that do it difficult target for DZ cleavage. Moreover, DDM and split DZ cleaved RNA target just in presence of N-Myc biomarker sequence, and a single base mismatch between DDM and RNA-46 or DDM and N-Myc DNA reduced the cleavage to the background level. These results indicate that DDM has high selectivity and can efficiently unwind and cleave RNA target. Using of long RNA-binding arms in DDM is good for short RNA cleavage, while short arms is better for long substrate cleavage.

Conclusion: We developed DNA nanomachine for selective and efficient cleavage of housekeeping gene in cancer cells. The integration of DZ into DNA nanomachine allows to increase efficiency of RNA secondary structure cleavage. Split DZ allows activate cleavage only in presence of biomarker sequence. Using of housekeeping gene as the target opens a possibility of damaging any cancer cell in case of change biomarker sequence. Optimizing DDM for working in cancer cell lines is the next step of our study.
Towards a Point-of-Care Test for Bacterial Vaginosis: Design and Development of a Rapid Test for Vaginolysin

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There is an ongoing need for an accurate, affordable, and simple point of care test to detect Bacterial Vaginosis (BV). This condition is characterized as a change from a Lactobacillus-dominant vaginal microbiota to an anaerobic and facultative bacterial dominance, leaving patients with vaginal discharge, vaginal malodor, and extreme discomfort. The effects of BV are substantial, and include increased risks of acquiring a sexually transmitted infection, and the increased likelihood of miscarriages associated with BV. These potential outcomes of BV negatively and acutely impact the patients' quality of life, while these individuals also often report physical discomfort, embarrassment, and social isolation as a result of undiagnosed BV. To date, the most commonly identified bacteria associated with BV is *Gardnerella vaginalis*. This work describes the design of a diagnostic test for the presence of vaginolysin, a toxin secreted by all 17 strains of *G. vaginalis*. Quantification of this toxin can be correlated with levels of this undesired bacteria, while elevated levels of *G. vaginalis* have been shown to lead to a toxic vaginal environment, facilitating BV. We report the recombinant expression and purification of vaginolysin, and the development of an ELISA assay for its detection. This methodology will, in turn, be adapted to a lateral flow assay (LFA) for use in a rapid, easy-to-use, cost effective paper-based point-of-care diagnostic for BV that does not require the use of any instrumentation for the visualization of the results of the test. The platform that we have devised is amenable for the incorporation of other assays, and, therefore, can be employed for the multiplex detection of other pathogens. Specifically, our approach and detection platform will be expanded to include tests for *Lactobacillus, Mobiluncus, Prevotella, Bacteroides, Peptostreptococcus*, and the seven other bacteria that leave the vagina in an unbalanced state, ultimately providing for a fully comprehensive point-of-care test to detect bacterial vaginosis.
Modeling and Optimizing DNA-Nanodevices for the Inactivation of Influenza A Virus

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5-15 per cent of the world population are infected by Influenza virus every year, resulting in 500 000 deaths all over the world. The most human pathogenic subtype is an influenza A that contains a strand of single negative-sense RNA as a genetic material, and belongs to the Orthomyxoviridae family. High mutagenesis of viral RNA complicates the treatment of the disease caused by Influenza A virus. The idea of our research is to damage a conservative part of viral RNA encoding a protein important for virus to interrupt the viral activity within the infected cell.

We have chosen as a target the RNA sequence encoding specifically PB1 subunit of RNA-polymerase complex of Influenza A virus. That means this subunit plays a key role in correct operation of viral RNA-replication enzymes, therefore the genetic sequence of PB1 is insusceptible to mutation process. The instrument that we decided to use to damage the part of viral RNA is deoxyribozyme 10-23 (Dz10-23, DNAzyme10-23) with RNA-cleavage catalytic activity. As known from the literature, this type of the cleavage agents has low therapeutic efficacy, and the important problem of our study is to increase the efficiency of the Dz10-23. In order to meet this issue, we use a DNA-nanomachines based on deoxyribozymes 10-23. This nanodevice consists from two logical parts: (i) catalytic core performed by two deoxyribozymes 10-23 and (ii) dsDNA platform serves as a link between two Dzs. Mg\textsuperscript{2+}-ions plays a crucial role in cleavage catalytic activity of two deoxyribozymes, and in generation of the complex between deoxyribozyme and RNA-substrate, which is very unstable under physiological [Mg\textsuperscript{2+}]. Therefore, we decided to use DNA-nanomachine to stabilize the RNA-DNAzyme10-23 complex and increase the rate of catalytic RNA-cleavage even in low concentration of DNA-nanodevice.

Designed DNA-nanodevice self-assembles from the ssDNA after annealing under 95°C and subsequent graduate cooling to the room temperature. In order to evaluate and compare the cleavage activity, DNA-nanodevice and separated deoxyribozymes were incubated with the synthetic 60-nucleotide RNA-substrate (PB1-60) in physiological buffer at 37°C to perform the cleavage reaction. A visualization and further analysis of an obtained result of reaction was performed with PAA gel electrophoresis.

The recent experiment demonstrates the cleaving efficiency of the 1000 nM target PB1-60 by 10 nM DNA-nanodevice in several times higher than in case with 10 nM free deoxyribozymes 10-23 after incubation during 10 hours.

The high cleavage activity of the DNA-nanomachine compared to single deoxyribozyme appear to be quite promising for testing obtained DNA-nanodevice on human cells infected by Influenza A virus.
DNA-Based Nano-Constructs for Visual Detection of Rifampin-Resistant Mycobacterium Tuberculosis

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Molecular diagnostics of drug resistant bacterial pathogens requires analysis of point mutations in their genomes, which is usually performed by trained professionals and/or by a sophisticated computer algorithm. At the same time, advances in DNA-nanotechnology and self-assembling DNA-nanostructures show promise to simplify drug susceptibility testing. Here, we developed a DNA-based logic system that autonomously analyzes mutations in the genome of Mycobacterium tuberculosis complex (MTC) species and communicates the output to a human user as alphanumeric characters to be read by the naked eye. Molecular logic gates comprised of split peroxidase deoxyribozyme probes were designed to interrogate fragments of the MTC genome containing resistance-conferring point mutations with colorimetric turn-on and turn-off properties. The five-gate system displays “O” (“no infection”) for the absence of MTC infection; and “P” or “F” for passing or failing the drug susceptibility test, respectively.
Synthesis of Nanodrugs for Targeted Therapeutic Hypothermia in Treatment of Traumatic Brain Injury

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Traumatic Brain Injury (TBI) is considered a public health concern because it results in disruption of the brain normal functioning, and accounts for over 30% of all injury deaths. Several TBI patients experience adverse effects including, but not limited to, increased intracranial pressure, edema, decreased tissue perfusion, hypoxia, and ischemia. Therapeutic hypothermia (TH) has shown to ameliorate the incidence of the injury mechanisms in patients who survived TBI, leading to an improved prognosis after treatment for the initial insult. Seminal research on TH has shown that this treatment method can provide neuroprotective effects, particularly at the acute stage (minutes to hours) following a TBI. However, current methods of TH such as use of ice packs and saline solution still suffer from ability to reach the target temperature within a short time window and in absence of side effects as patients often experience hypothermia-induced complications. Therefore, we propose to develop novel nanomaterials, comprised solely of the pharmaceutical compound Resiniferatoxin, to produce efficient TH.

Resiniferatoxin (RTX), a derivative of the Euphorbia resinifera plant, is a potent agonist of the chemo- and heat-sensitive transient receptor vanilloid type I (TRPV1) receptors in the central nervous system. It has been shown that this compound can induce a transient hypothermic state by stimulating fibers in the hypothalamus to activate heat-loss mechanisms and/or inhibit heat production in the brain. However, to date, pharmacological administration of RTX has yet to realize full therapeutic potential because the current methods of administration of this compound significantly limit the reception of similar compounds by the central nervous system. To overcome these challenges, we designed synthetic techniques to develop a nanoscale RTX-based drug delivery system to improve the properties of RTX at nanoscale, increase its bioavailability, and result in its rapid absorption (cellular uptake) by the brain. These nanomaterials, comprised of pure drug molecules, are synthesized using bottom-up approaches with/without assistance of soft templates, and do not require a nanocarrier to transport the drug molecules. Dynamic light scattering (DLS) and transmission electron microscopy (TEM) measurements demonstrated the hydrodynamic diameter, as well as size and morphology of these nanoparticles, respectively. Zeta potential measurements indicated that the nanoparticles are highly stable in aqueous suspensions, at approximately -45 mV. Preliminary data obtained from proliferation assays suggested that the nanoparticles are not cytotoxic to human embryonic kidney cells overexpressing the TRPV1 receptor (HEK-TRPV1), and do not interfere with cell proliferation.
Telmisartan Synergistically Enhances CFM 4.16 and Erlotinib Combination Therapy Through Enhanced Tumor Penetration

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**Background:** Non-small cell lung cancers (NSCLC) account for 85% of all lung cancers. Acquired resistance occurs in virtually all NSCLC tumors exposed to Tyrosine Kinase Inhibitors (TKIs) of epidermal growth factor receptor (EGFR). TKI-resistance reduces treatment efficacy and with poor outcomes. CFMs ([CARP-1 Functional Mimetics](#)) in combination with Erlotinib have been shown to inhibit cMet, Akt, and mToR kinases, which are known contributors to NSCLC cell survival and drug resistance. In order to achieve uniform intratumoral distribution of proposed CFM NLFs (nanolipid formulations of CFM) in fibrous tumors, we propose to use angiotensin II type 1 receptor blocker Telmisartan as a pretreatment, which has transforming growth factor beta 1 inhibiting antifibrotic effects that would allow for deeper tumor penetration thus enhancing the effects of treatment.

**Methods:** For cell viability assays, cells were treated with CFM4.16 overnight and then treated with Erlotinib for 48HRS. CFM-4.16 loaded NLFs were prepared by combining melt-emulsification and ultra-sonication techniques ([Patent Filed, 2436.19.PRC](#)). Renal and hepatic toxicities of CFM-4.16 NLF were evaluated in Sprague Dawley rats. CFM-4.16 NLF was administered orally (100 mg/kg) every second day for two weeks. PK studies were performed in SD rats with a dose of 40 mg/kg orally or 5 mg/kg intravenously. Oral formulations included free drug and NLC formulations. We pre-treated the tumor bearing animals with 10 mg/kg of telmisartan 3 times a week along with sorafenib (30 mg/kg) and CFM4.16 NLF (40 mg/kg), in combination.

**Results:** CFM-4.16 pre-sensitization significantly enhanced the anti-migration effect of erlotinib. In CFM-4.16 pretreated cells, 25 μM concentration of Erlotinib showed **77.8% bridging of the scratch area** (p<0.02 against erlotinib alone), while **erlotinib alone showed just 26.3 %** bridging of the scratch area (p<0.05 against CFM-16 alone). This significant reduction was due to downregulation of TGF-beta, Akt, Ras, Met, VEGF EGFR, Sox-2, Nanog and upregulation of E-cadherin. Our results also showed that oral pre-treatment with Telmisartan significantly reduced tumor burden for CFM4.16 NLF and sorafenib combination by several folds (P<0.05) at the end of 13 days. Oral administration of CFM-4.16 NLF resulted in a significant increase in the bioavailability when compared to CFM-4.16 Free drug (Figure 8A). The plasma Cmax concentration of CFM-4.16 free drug was found to be 1.19 ± 0.035 μg/ml. The Cmax concentration of CFM-4.16 NLF was 4.32 ± 0.23 μg/ml, which was a 3.63 fold increase when compared with CFM-4.16 free drug. The AUC for CFM-4.16 Free drug was 21.07±4.20 μg.h/ml, whereas for CFM-4.16 NLF it was 86.21±17.20 μg.h/ml. The AUC for CFM-4.16 NLF was 4.09-fold more compared to CFM-4.16 Free drug. A 2.48-fold increased plasma half-life (t₁/₂) of CFM-4.16 NLF suggests for a sustained release behavior of CFM-4.16 NLF.
Session C: Nanotechnology in Agriculture
Olin Life Sciences Building, Room 130

Saturday Morning Session Chair: Dr. Hyeran Kang, University of Central Florida

Nanotechnology in Agriculture – Olin Life Sciences 130 – 10:00-10:30 Saturday
Tracking Translocation of Model Therapeutics in Plant Tissue with Advanced Fluorescence Imaging

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Current and novel Ag materials such as antibiotics and Zinkicide\textsuperscript{TM} require updated approaches to track translocation in plant tissue. Although they are promising therapeutics for citrus diseases due to their assumed systemic action, direct confirmation of systemic action in the phloem is not straightforward. With chromatography (HPLC) and mass spectrometry (LC/MS) positive identification of pesticides in planta can be made but outputs from these methods lack the bactericides’ location in plant vasculature. So far evaluating efficacy of grove treatment with these bactericides has mainly relied on observed tree health and crop yield by growers. This brings confusion and uncertainty among growers about if money is being spent wisely, because observed increases in tree health or crop yield (few million boxes before hurricane Maria) could be due to weather or other factors.

Optical fluorescence imaging is a leading candidate to produce direct evidence for systemic translocation of engineered pesticides. The complication with doing this in planta is that endogenous chromophores such as chlorophylls, cinnamic acids, coumarins, and stilbenes fluoresce across most of the visible and near-infrared spectrum. Evidence is given by observed broad emission peaks around 440 nm, 520 nm, 690 nm, and 740 nm from plant tissue spectroscopy. This makes simple fluorescence imaging by filtering out plant background from dye-labeled bactericides and fluorescence nanomaterials unfeasible. Since spectral separation is not possible we show that separation by excited state properties of chromophores is needed and feasible.

Here, we discuss advanced fluorescence imaging tools to localize systemic surrogates for Ag pesticides in phloem tissue of trees. We demonstrate that, given the short excited state lifetime of endogenous plant chromophores (< 10 nanoseconds (ns)), long excited state lifetime dyes and nano-engineered particles (> 300 ns) can be detected in planta through Fluorescence Lifetime Imaging (FLIM). Furthermore, the plant fluorescence image can simultaneously be collected to observe cellular structure, serving as a confirmation of which tissue we are looking at. By showing that materials are reaching the intended target we can build grower confidence in systemic bactericide treatment schemes.
Development of Locally Systemic Pesticide (LSP) Particles Against Bacterial Spot Disease of Tomato

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Bacterial spot of tomato is caused by *Xanthomonas* strains. This disease is affecting tomato industry in Florida and many tropical and sub-tropical regions worldwide. Bacterial spot contributes to yield loss of marketable fruit up to 50% at peak conditions. *X. perforans*, which is the dominant factor for bacterial spot of tomato species in Florida has become tolerant to traditional Copper (Cu)-based bactericides. Cu in combination with Mn (such as Cu-mancozeb) is the only choice available to growers, making disease management extremely challenging. This demands design and development of novel bactericide for controlling the bacterial spot. In this research project, we introduce a concept of delivering locally more than one bactericidal agents through a nanoparticle delivery system (called hereafter Locally Systemic Pesticide, LSP). It is hypothesized that actives with different modes of killing will minimize development of bacterial resistance. The nanoparticle delivery system will improve rainfastness and deliver actives in a sustained manner locally. In LSP design, an inert silica nanoparticle core is coated first with a layer of Cu loaded silica gel. The Cu in this silica gel is in their mixed valence state (Cu0, CuI and CuII). Then a second layer of coating is fabricated using quaternary ammonium compound (Quat). Positively charged Quat molecules are electrostatically immobilized over the negatively charged silica layer. The entire synthesis process is done in a modular fashion, producing well-defined set of nanoparticles of three different sizes (~50 nm, ~200 nm and ~500 nm). Reagent grade tetraethyl orthosilicate is used as a precursor for the silica which undergoes through the base-catalytic hydrolysis and condensation processes. Particle size of these LSP particles were characterized using DLS, SEM and HRTEM techniques. HRTEM image at high-magnification revealed the formation of ultra-small size (~5 nm) Cu oxide/hydroxide particles in the silica shell. Plant injury potential (phytotoxicity) of LSP particles was evaluated using tomato plant (4.5-inch size). No sign of phytotoxicity was observed for LSP particles containing up to 500 ppm of metallic Cu and 125 ppm of Quat. Interestingly, Quat control itself showed phytotoxicity at and above 75 ppm. This suggests that silica serves as a diluent as well as a barrier for Quat minimizing their direct interaction with the plant tissue. *In vitro* antimicrobial efficacy was tested against both Cu susceptible and Cu tolerant strains of *X. perforans*. Minimum Inhibitory Concentrations (MIC) against both bacteria strains were found to be 2 ppm Cu /0.5 ppm Quat for LSP particles. MIC of Quat control was 1 ppm for both strains. Cu(OH)2 commercial standard exhibited MIC of 62.5 ppm for Cu susceptible strain and 250 ppm for Cu tolerant strains.
Nanotechnology in Agriculture – Olin Life Sciences 130 – 10:50-11:10 Saturday
Nanoscale Investigation of Mode of Antibacterial Activity of Multivalent Nanoparticles on Xanthomonas perforans

Briana Lee, Ali Ozcan, Mitsushita Doomra, Nicholas Castaneda, Parthiban Rajasekaran, Hyeran Kang, Swadeshmukul Santra, Laurene Tetard, The University of Central Florida, UCF Nanoscience and Technology Center, breelee@knights.ucf.edu, Swadeshmukul.Santra@ucf.edu, Laurene.Tetard@ucf.edu

The changing chemical and physical properties of bacteria developing resistance, in both humans and plants, are mostly unknown at the single cell level. However, biomechanical properties have been shown to contribute to the ability of bacteria in becoming infectious. Thus the ability to probe changes in stiffness, adhesion, binding interactions and molecular traits of individual bacteria resulting from their interactions with the treatment is of prime interest. In turn, the fundamental understanding of single cell response will support the development of a new generation of more potent, yet sustainable, drugs or pesticides aimed at eradicating bacterial diseases.

Our study aims to investigate the changes in mechanical and chemical properties of bacterial systems and their cell walls in presence of antibacterial treatments. More specifically, we investigate the physicochemical responses associated to multivalent nanoparticle-based bactericide treatments on bacterial systems identified as pathogens in plant diseases. Here we focus on developing a novel protocol to support the design and accelerate the development of pesticides and treatments against the bacteria, Xanthomonas perforans. X. perforans is the strain known to be responsible for bacterial spot in tomatoes, a contributing factor to the 50% losses in production observed in Florida. By comparing bacteria pre- and post-treatment with a multivalent silica core shell nanoparticles using a combination of Raman and infrared spectroscopy, as well as, atomic force microscopy (AFM)-based techniques, we identify attributes that can potentially serve as new markers to track the bacterial responses to the treatment. By exploring the local bacterial responses to treatment and correlating the results to conventional bioassays, we propose a new approach with exciting implications for the development of more potent treatments for the broader application of managing bacterial infections.
Evaluation of Novel Zinc-Based Nanomaterial to Control Growth and Biofilm Formation of *Xanthomonas citri* in Batch Cultures and Under Media Flow Conditions in Microfluidic Chambers

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**Zinkicide™** is a Zn-based nanomaterial developed for treating citrus bacterial pathogens *Candidatus Liberibacter asiaticus* and *Xanthomonas citri*. This study investigated the effects of Zinkicide™ on growth and biofilm formation of *X. citri* in batch cultures and under nutrient flow conditions using microfluidic chambers (MC) compared to Zn-based antimicrobial compound TSOL. *X. citri* and *L. crescens* were grown in SB and BM7 media, respectively, and treated with serial dilutions of Zinkicide™ and TSOL to test inhibition of growth, biofilm formation and viability. *X. citri* and *L. crescens* were also introduced to MC and inhibitory action of Zinkicide™ and TSOL on biofilm formation was recorded using time-lapse video imaging microscopy. The minimum inhibitory concentration (MIC) of Zinkicide™ and TSOL for *X. citri* was 35 ppm and 40 ppm, respectively. MIC of TSOL for *L. crescens* was 40 ppm. Both ZinkicideTM and TSOL have bactericidal effect on *X. citri* above 60 ppm and 150 ppm, respectively. Time-lapse video imaging showed that untreated *X. citri* grown in MC formed biofilm whereas *X. citri* treated with 50 ppm Zinkicide™ and 60 ppm TSOL did not form any biofilm. Furthermore, Zinkicide™ and TSOL inhibited further growth of already formed *X. citri* biofilm at 50 ppm and 60 ppm respectively in MC. Results confirmed that Zinkicide™ is more effective in controlling growth and biofilm formation of *Xcc* compared to TSOL *in vitro* and inhibits growth and biofilm formation under nutrient flow conditions in MC.
Antibiotics such as streptomycin while normally reserved for humans and animals are receiving emergency approval for use in agriculture to treat challenging plant pathogens. The need for improved delivery and tracking of these antibiotics to bacteria sequestered within the plant vasculature is needed to improve efficacy and prevent human consumption. Quantum dots (Qdots) have been widely studied due to their unique photoluminescent properties and capability for binding and targeted delivery of therapeutic cargo. However, the use of heavy metals precluded them from usage in agriculture and medicine. Herein we report the design and synthesis of a nontoxic, heavy metal free ZnS:Mn Qdots for the delivery and tracking of antibiotic compounds. The Qdots were synthesized in a one step, one pot synthesis with EPA approved reagents and coated with N-acetylcystine (carboxyl containing biomolecule). Drugs (streptomycin and kanamycin) were attached to the Qdot either covalently via EDC coupling or electrostatically using the negative charge of the Qdot coating and positive charge of the drugs. The Qdots were then characterized through spectroscopy (UV-Vis, fluorescence, and infrared) and electron microscopy. The antibacterial efficacy of the nanoparticles was evaluated against model plant pathogenic bacteria (E. coli, X. alfalfa, and P. syringae) and was found to have comparable activity to the free drug. The phytotoxicity was also tested with tomato plants and they were found to be nontoxic. Drug release kinetics of the particles show a slow sustained release of free antibiotic over a 96 hour period which shows this material could have applications as a topical antibiotic or agricultural biocide.
Agricultural practices for food or biofuel production subject plants to physical and chemical treatments. Pesticide application constitutes a prime example how important a thorough understanding of the effect of such treatment on plant systems is. For instance, residues of pesticides or their derivatives in consumable products should be carefully assessed for food safety. The emergence of nanoparticle-based treatments in the field of agriculture emphasizes the need for better tools to characterize such interactions of the nano-bio interfaces. On the other hand, multiscale analysis is critical to draw a detailed map of morphological and chemical changes taking place in the plant tissues as a result of external factors. While statistical response across multiple trees indicate the significance of changes observed, the micro- and nano-scale details of the morphology, structure and chemistry can reveal early signs of plant response.

In this talk, we will briefly review promising approaches that have been used to study plant tissues, with an emphasis on micro- and nanoscale characterization. In particular, we will discuss chemical, mechanical, thermal and structural properties of plant cell walls that have been measured with Atomic Force Microscopy. We will illustrate the importance of these tools to detect changes in plant cell walls for biofuel production and for disease management in crop production. Finally we will outline the importance of taking into account multiple scales in the interpretation of the findings for the benefit of sustainable agriculture.
Antimicrobial Magnesium Hydroxide Nanoparticles as an Alternative to Cu Biocide for Crop Protection

Ziyang Huang, Parthiban Rajasekaran, Ali Ozcan and Swadeshmukul Santra, The University of Central Florida, Department of Chemistry, hzyxuxiao@knights.ucf.edu, hzyf111@hotmail.com, Swadeshmukul.Santra@ucf.edu

Plant disease contributes to 10-16% of global harvest loss thus limiting food supply. Copper (Cu) based bactericides/fungicides are extensively applied to control a broad spectrum of crop diseases. Prolonged use of Cu biocides increases the risk of development of Cu resistance and their accumulation in soil. There is a strong need to develop Cu alternatives. Low cost, abundant and environmental friendly magnesium hydroxide (Mg(OH)₂) has been suggested has antimicrobial activity at certain concentrations. In this study, Mg(OH)₂ nanoparticles (NPs) were synthesized through alkaline precipitation method. In addition, water-soluble trisodium citrate or betaine were used as a capping agent to control particle size, surface charge, and to prevent particles aggregation. X-ray diffraction results showed all as-synthesized Mg(OH)₂ NPs were brucite Mg(OH)₂. The morphology of as-prepared Mg(OH)₂ were observed through Scanning electron microscopy and transition electron microscopy. Electron microscopy study confirmed the formation of ~10 nm size cubical NPs with citrate and ~ 100 nm size lamellar NPs with betaine. When screened for antimicrobial properties, as-prepared Mg(OH)₂ particles showed enhanced antimicrobial properties against model plant pathogens such as Xanthomonas alfalfae, Pseudomonas syringae, and Escherichia coli. In bacterial killing (CFU) assay, as-prepared Mg(OH)₂ NPs exhibited bacterial growth inhibition as early as 4 hours and by 24 hours post-treatment. Phytotoxicity studies on tomato plants indicated as-prepared Mg(OH)₂ NPs caused very little tomato plant tissue injury compared to Cu products. Thus, Mg(OH)₂ NPs synthesized by our method present themselves as potential Cu alternative biocides for crop protection.
Zinkicide™: A Systemic Bactericide for Managing Huanglongbing

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Huanglongbing (HLB, also known as citrus greening) is a destructive bacterial disease that affects citrus trees. It is caused by the phloem-restricted bacterium Candidatus Liberibacter asiaticus (CLas), which is introduced into the phloem tissue by the Citrus Asian psyllid (ACP, Diaphorina citri). In order to treat this disease, systemic antimicrobial is needed to reach bacteria in the phloem tissue. Using nanotechnology, Zinkicide™ was specially designed as zinc oxide-based ultra-small nanoparticles that are able to move into the plant vascular system and kill the bacteria. Despite size, Zinkicide™ was also designed to break down in zinc ions, an essential plant micronutrient, which participate in the plant metabolic pool. Since 2014, reagent grade Zinkicide™ has been evaluated in field trials against citrus canker, scab and melanose diseases. In early 2017, agriculture-grade Zinkicide™ was developed in collaboration with the industry partner. 2017 Zinkicide™ HLB field trial results have shown dose dependent effects on yield and bacteria titer reduction, confirming its efficacy against citrus greening.
Solid-Contact Paper-Based Zinc Ion Sensing Electrodes to Monitor Dissolution of ZnO Nanoparticles

Parth Patel, Stephanie M. Armas, Andrea Bances-Monard, Ali Ozcan, Karin Y. Chumbimuni-Torres, and Prof. Swadeshmukul Santra, University of Central Florida, Department of Chemistry, pkp26@knights.fit.edu, Swadeshmukul.Santra@ucf.edu

Citrus Greening Disease (CGD) or Huanglongbing (HLB) is a bacterial disease that affects citrus crops. This disease is transmitted by insects worldwide, affecting the citrus industry. The common symptoms of CGD/HLB are yellowish veins, asymmetric chlorosis, stained leaves, and immature fruits with green-stained seeds. It was found that the discoloring and stains of the leaves were linked to zinc deficiency. And, that the zinc concentrations was 10 times higher in healthy trees. [1] Consequently, to combat this zinc deficiency, current therapies are based on zinc supplements.[2] Some of the effective treatments are based on zinc oxide (ZnO) nanoparticles. However, these nanoparticles are toxic to humans. Therefore, it is essential to monitor the fate of such nanoparticles in citrus juices. Herein, we postulate a methodology to monitor, by potentiometric technique, the dissolution process of these ZnO nanoparticles to free zinc ions in an acidic medium as well as fresh citrus juice. The instrument used for this investigation is a solid-contact paper-based ion-selective electrode (SC-PB-ISE) that senses zinc ions, which was characterized by its Nernstian response of 25.51 ± 0.42 mV and detection limit of 0.311 μM. Likewise, dissolution process of 10 μM of ZnO nanoparticles in acid was monitored. Future results will demonstrate the dissolution of 200, 500, 750 and 1000 ppm ZnO nanoparticle levels in acid solution and citrus juices.

References


Tomato is one of the most significant among vegetable crops worldwide and US produces tomatoes worth > $2 billion annually. Tomato is an easy target to several pathogens that affect the yield of the crop. Bacterial spot, caused by *Xanthomonas perforans* in the one of most destructive among diseases of tomato. In Florida and other southeastern states in US where warm and wet weather conditions are present round the year, the conditions are ideal for bacterial spot. Effective strategies to manage the bacterial spot disease in tomato are currently limited. Overuse of copper-based bactericides on tomato have led to the development of *Xanthomonas sp.* strains tolerant to Cu since the 1980's, making Cu ineffective. In this study, we evaluated the antibacterial potential of a Cu/Zn hybrid nanomaterial *in vitro*, and *in vivo*. We also studied the interaction of this nanomaterial on a key bacterial pigment xanthomonadin, which helps in the bacterial survival on leaves. *In vitro* tests indicate the potential of the material to inactivate the bacterial growth. *In vivo* tests, performed in growth chamber showed the potential to decrease the number of lesions caused by the bacteria revealing no phytotoxicity. Bacterial cells exposed to the Cu/Zn nanomaterial showed significant impact in reducing the production of xanthomonadin. These preliminary results indicate that Cu/Zn could be a potential strategy to manage bacterial spot on tomato. Further field studies are in progress to understand field level efficacy of this hybrid nanomaterial.
Copper has been used traditionally as a main source of biocides for industrial scale agriculture, however copper accumulation leads to toxicity in soil. Bulk ZnO on the other hand is already been used in agriculture as a fertilizer. ZnO nanoparticles (NPs) exhibits antimicrobial activity. Thus, ZnO NPs has the potential to be used as an antimicrobial agent in agriculture as an alternative to copper. Zinc material comes in many forms such as salts, chelates, particles and composites. The size and surface chemistry of Zinc materials can play a large role in their antimicrobial properties. In this preliminary study, the antimicrobial activity of ultra-small ZnO NPs (≤ 10 nm) and the underlying mode of action was determined. We compared antimicrobial efficacy of ZnO NPs with ionic zinc (Zn(NO$_3$)$_2$), copper sulfate, and streptomycin was used as a positive control. ZnO NPs were synthesized using wet chemistry. Materials were characterized by Zetasizer for size and surface charge determination. In-vitro antimicrobial efficacy of ZnO NPs was evaluated against plant pathogens, Xanthomonas alfalfae subsp. citruminonis, Pseudomonas syringae pv. syringae and Clavibacter michiganensis subsp. michiganensis, and human non-pathogenic E. coli strain using Minimum Inhibitory Concentration (MIC) determination. To determine the mode of antibacterial activity, several E. coli mutants lacking in genes responsible for Zinc import mechanism (znuC mutant), Zinc export mechanism (zntA mutant), oxidative stress (katE and katG mutant), and zinc dependent enzyme (phoA mutant) were tested. The results indicated that nano-Zn demonstrated a stronger antimicrobial efficacy, which was comparable to ionic zinc. The antimicrobial mode of study on mutants showed increased MIC susceptibility of zntA mutant as compared to wild type parental (WT) strain in response to ZnO NPs and ionic zinc. Overall, the tested ZnO NPs demonstrated improved antimicrobial efficacies over copper and mode of action involved Zn efflux protein. MIC data suggest that the release of zinc ions appear to be the major mechanism of antibacterial activity of ZnO NPs.
Green Synthesis of Low-Cost, Facile, and Quick Nanosensors for the Detection of Inorganic Mercury in Water

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Mercury (Hg) is a dangerous neurotoxin that can enter ecosystems and municipal infrastructure through human industrial activities. Techniques and methods for monitoring mercury can be expensive, complicated, and time consuming. We demonstrate the development of low-cost, facile, and quick electrochemical nanosensors using flexible carbon circuits decorated with nanocuprous oxide recovered from recycled materials. Flexible graphene electrodes were fabricated with laser scribing, and then the electrode surface was decorated with copper nanoparticles synthesized from material liberated from waste electric cables. Copper nanoparticles were anchored to graphene electrodes using a novel magneto-hydrodynamic deposition process for creating carbon-metal nanohybrid structures. The material properties, electrochemical behavior and sensor performance were analyzed via scanning electron microscopy, cyclic voltammetry, and linear sweep stripping voltammetry. Mercury sensors were linear from 0.02-2.5 ppm, with a detection limit of 25 ppb, response time of < 3 min, and sensitivity of 10 nA ppm$^{-1}$. The methods shown here are facile, environmentally friendly, and economical. Green synthesis of flexible sensors and electronic devices with recovered waste represents a sustainable approach for next generation flexible carbon sensors for planetary health applications.
Special attention has been given to potential of polymeric nanocarriers for controlled release and site-specific delivery of pesticides/nutrients in agriculture. Research is needed to examine the efficiency of the smart nano-delivery systems in plants.

In this work, polysuccinimide (PSI)-based nanoparticles (NPs) were synthesized and characterized by dynamic light scattering (DLS). The loading capacity and pH-responsive release efficiency of the PSI-based NPs were determined with coumarine-6 (a fluorescent probe) using fluorescent spectroscopy. Grapefruit cells were used to determine the accessibility of NPs using fluorescence microscope. Soil microbial toxicity was also examined by counting microorganisms in plates and determining soil respiration rates, as affected by NPs spiking. DLS showed that the NPs had an average size of 20 nm with negative charges on the surface. The loading capacity of the PSI-based NPs for coumarin-6 could be up to 30%. Release of the loaded chemical increased with increasing pH from 5.5 to 8.5 and reached 85% at pH~8.5. Uptake of PSI-based NPs by grapefruit cells occurred within 10-30 min, indicating that the NPs are able to enter plant cells with the loaded effective components, and therefore, it is feasible to apply nano-delivery systems to crop production systems for enhancing use efficiency of pesticides/nutrients. In addition, the PSI-based NPs are environmentally friendly, as evidenced by minimal effects on soil microbial activities.
Currently, wearable electronic devices attract considerable attention due to its applications in communication, entertainment, on-body sensing, artificial skins and general health care. However, wearable devices capable of predicting plant health are rare. Since all these electronic devices require energy to operate, wearable energy devices are an integral part of all wearable devices. This presentation will focus on our recent initiatives in the direction of wearable energy devices which can be used to power human and plant wearables. The presentation will conclude with a discussion about the future prospects of plant wearables.
Copper (Cu) bactericides/fungicides are aggressively used in the agriculture industry in the U.S and worldwide on many crops. There is an increasing concern of Cu accumulation in field soil, Cu leaching potential into the surrounding ecosystem and development of bacterial resistance. Using nanotechnology, it is possible to reduce Cu amounts per application without compromising overall efficacy. This presentation will focus on laboratory, greenhouse and field efficacy outcomes of several nanoparticle composites, challenges towards developing industrially viable formulations and approaches to minimize regulatory challenges.
Utilizing Fluorescence Lifetime Imaging Microscopy to Monitor Small Molecule Translocation in Citrus Seedlings

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Nanotechnology plays a significant role in medicinal chemistry, with nanomaterial treatments becoming more prolific. Monitoring where these treatments are delivered and how they move through the host is a more difficult task. Fluorescence lifetime imaging microscopy (FLIM) is one method to track these target compounds. Antibiotics are currently the leading approach towards systemic treatment of plant systemic bacterial diseases. It is however difficult to truly localize them in plant vasculature with existing methods, due to their lack of spatial resolution. We show here that FLIM is a promising method for high-resolution localization and tracking of systemic pesticides in-planta.

Tris(bipyridine)ruthenium(II) chloride hexahydrate ([Ru(bpy)3]Cl2·6H2O) is a highly fluorescent dye molecule with an exceptionally long (~1 µs) lifetime that serves as a viable surrogate for systemic small molecule tracking. Direct systemic delivery was accomplished with a microneedle roller. After incubation and cross sectioning, the localization and kinetics of translocation of the ruthenium dye was determined by FLIM. We found that Ru(bpy) translocates within 3 hours of delivery, and was present throughout the plant within 24 hours. Interestingly, little translocation into the roots was observed even after a week from delivery.
Microneedles as Wearable Devices for Diagnostic and Therapeutic Monitoring of Citrus Trees

Avra Kundu, Cacie Hart, Charles Didier, Laboni Santra, Tariq Ausaf, and Prof. Swaminathan Rajaraman*, The University of Central Florida, UCF Nanoscience Technology Center, swaminathan.rajaraman@ucf.edu

In this work we demonstrate for techniques for the makerspace microfabrication of microneedle (MN) arrays for precise penetration of different parts of the citrus plant. Precise penetration is required so that drugs may be administered locally by brush or spray coating, for instance to the phloem where bacteria responsible for the disease ‘citrus greening’ reside. Two techniques were used to realize different types of MN arrays: additive manufacturing based on 3D printing of a photopolymeric resin and subtractive micro-manufacturing based on micromilling of stainless steel.

3D printed MNs were designed in Solidworks and directly 3D printed using a photopolymer resin. The printed microdevices were cured at a temperature of 60°C for 60 minutes in an oven to obtain high tensile strength. Such 3D printed needles are more suited for puncturing stem and leaves of citrus saplings as they have a fracture strength of ~ 100-150 MPa per tip. Both solid and hollow microneedles were fabricated using such a printing process. For the solid MNs the base diameter and height of each MN were designed to be 250 µm and optimized 3D printing conditions led to a tip radius of curvature down to ~30 µm. The solid MNs were used for creating controlled puncture sites through which subsequent delivery of compounds through mechanisms like spray/brush coating can be performed. Plant tissue in and around the penetration sites were additionally analyzed for testing the treatment efficacy. Hollow MNs combine the therapeutic and penetration functionality into a single structure. The fabricated hollow MNs have a port opening of 500 µm with a height of 2 mm and base diameter of 1.2 mm. Different arrays of both types of MNs were printed ranging from 5×5 to 5×1 to demonstrate the flexibility of 3D printing for rapid customization of the device based on the application. The pitch for the solid and hollow MNs were kept at 1 mm and 3 mm respectively.

For puncturing the barks of fully grown citrus trees stiffer MN arrays are required. Micromilling of 100 µm thick stainless steel (SS) sheet was carried out with a 90° pointed tool bits in a benchtop micromilling system. A 3D printed resin guided hypodermic needle array has also been custom fabricated for transitioning the micromilled SS out of plane. As the ultimate tensile strength of SS is ~ 500 MPa, they can be successfully used to carry out controlled, minimally invasive puncture of fully grown tree barks. The fabricated MNs have a base 3 mm wide and a height of 3 – 4 mm. SS MN arrays ranging in densities from 6×6 to 20×20 have been realized with a pitch of 6 mm and a tip having radius of curvature of ~ 80 µm have been obtained with the micromilled MNs. While the smaller arrays can be used for local diagnostic and therapeutic applications, the larger arrays were affixed on a paint roller for puncturing tree barks. Optical observations 7 days’ post treatment yielded no infections demonstrating the minimally invasive nature of the system.

Nutrient overloading such as runoff has promoted the incidence of harmful algal blooms (HABs) over many water bodies around the world. HABs are responsible of the production of toxins, oxygen depletion, and alteration of food web dynamics. Although chemical disinfectants have demonstrated to be effective for the control of microbial pathogens, the undesired formation of harmful disinfection byproducts (DBPs) has revealed an urgent need to reevaluate and innovate conventional methods. Quaternary ammonium compounds (QACs) are known as effective chemicals against a broad range of microorganisms. As a potential way to utilize the biocidal properties of QACs without directly releasing them into the environment, the synthesis of modified surfaces impregnated with QACs provides a potential alternative for water disinfection. In this work, an antimicrobial material was developed using fiberglass as an active surface coated with a composite of silica-modified QAC (Fixed-Quat) via sol-gel technique, and evaluated to control E. Coli (representing for pathogen) and Microcystis Aeruginosa (representing for HABs) in water. When using E. Coli as a model bacterial pathogen, Fixed-Quat coated fiberglass mesh showed effective microbial inactivation performance with a rate of $1.3 \times 10^{-3}$ log reduction cm$^{-2}$ min$^{-1}$. The synthesized material also showed effective mitigation of M. Aeruginosa with an 81% reduction of Chl-a contents within 9 hrs. Overall, by potentially eliminating regulated DBPs formation and minimizing release of nanomaterials (NMs) into the environment, the antimicrobial-nanocoated mesh technology could be a promising and sustainable alternative to conventional disinfection and HABs control methods in various water systems.
Development of Antimicrobial Active ZnS:Mn Nanoparticles

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Zinc sulfide nanoparticles (ZnS NPs) are extensively studied for their application in various fields including using their fluorescent property for bio-imaging. In this project, ZnS NPs were modified to be antimicrobial active in addition to their fluorescent properties through surface oxidation with hydrogen peroxide. A series of peroxide concentrations were studied and labelled HPT-1 to HPT-4 (hydrogen peroxide treated). The NPs were characterized with UV-Vis and Fluorescence spectroscopy; the least peroxide concentration treated sample (HPT-1) showed fluorescent intensity enhancement up to 1.4 times, however higher peroxide treatment (HPT-3) quenched the fluorescence. Minimal inhibitory concentration (MIC) study showed antimicrobial efficacy as low as 125 ppm of metallic Zn when ZnS NPs are treated with peroxide in contrast to no killing at 2000 ppm or less for untreated ZnS NPs. To evaluate their safe application in a biological system, Alamar blue assay on human dermal fibroblast cell (HDF) was performed which revealed that cytotoxicity increased with increasing peroxide treatment. Highest treated peroxide concentration (HPT-4) showed the most killing activity for both bacteria and human cell lines but at the expense of loss of fluorescent property. However, HPT-2 is a sample of interest since it showed 1.2 times increased in fluorescent intensity and antimicrobial efficacy at 250 ppm with minimal mammalian toxicity. Therefore, using its dual properties it can serve as a model system to understand the translocation and fate of similar antimicrobial NPs.
Evaluating Copper Uptake through Nanotechnology-Assisted Delivery to Combat Bacterial Spot Disease in Tomato Plants

Ahmad Khater$^{1,3}$, Briana Lee$^1$, Mikhail Soliman$^{1,2}$, Ali Ozcan$^{1,3}$, Swadeshmukul Santra$^{1,3}$, Laurene Tetard$^{1,4}$

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Bacterial spot disease in tomatoes is caused by Xanthomonas strains. This disease causes browning and black spots on the leaves and fruits. In turn, the bacterial infection results in the loss of foliar protection and decreases in fruit yield. The yield loss currently reaches up to 50% in Florida. To combat this infection, both antibiotics and copper (Cu)-based pesticide, such as Mancozeb, have been heavily used, and periodic treatment has led to increased bacterial resistance. Based on the challenges encountered in the field, new bactericide formulations are being designed that could bring about more efficient bacterial disease management in tomatoes. One such example is Locally Systemic Particles (LSP), a silica nanoparticle-based product designed for leaf spray application customized with an outer layer composed of mixed-valence copper and quaternary compound (Quat) for antibacterial activity.

The scope of this study is to quantify the uptake and translocation of copper in the tomato plants following foliar spray application of LSP at various concentrations. The formulations of LSP with varying content of Quat were compared. We developed a “nexus of characterization tools” to evaluate the responses of plants to the treatments. After applying foliar spray on plants with a LSP solution comprising of 500 ppm copper and 125 ppm Quat, we first characterized the uptake and translocation of copper using the elemental analysis technique of X-Ray fluorescence (XRF). Next, we evaluated changes in the leaves using Fourier transform infrared spectroscopy (FTIR). The IR data was further analyzed using principal component analysis (PCA) to identify potential variations and their nature, across the different groups. While the implications of this study were focused on LSP-specific treatments, this technique constitutes a proof-of-concept that can be applied to other treatments used in agriculture.
Zinkicide is a bactericidal nanoparticle that combats Citrus Greening with exceptional field efficacy. Bactericidal nanoparticle detection is important for surpassing EPA criteria and bringing biocide products to market; however Zinkicide degradation in particular is lacking in quantitative analysis. Here, we have developed a protocol using sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE) to monitor and track bactericidal nanoparticles in varying solutions, including water and acidic buffer mimicking citrus pH. The nanoparticle detection was performed using UV fluorescent imaging of polyacrylamide gels. This assay is a cost-effective and relatively simple approach for detecting and quantifying the intensity, concentration, and molecular weight change of nanoparticles. We observed intensity fluctuations of Zinkicide during time studies indicating that the capping agent of the material was affected. The molecular weight data shows that citric acid buffer induces the greatest degradation effect of Zinkicide. These findings are beneficial for general tracking and analysis of bactericidal quantum dots.
Session D: Photonics, SERS, FTIR, Simulation, Nanowires, and Self-Assembly
Olin Engineering Center, room 137

Saturday Afternoon Session Chair: Dr. Sung J. Kim, University of Miami

Photonics, SERS, FTIR, Simulation, Nanowires, and Self-Assembly – Olin Engineering 137 – 2:00-2:30 Saturday
Bioinspired Design of Next Generation Structural and Thermal Materials

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This talk focuses on the fundamental ideas arising from understanding the mechanisms behind the superior mechanical and thermal properties of biological materials through four specific examples of nacre, bamboo, cartilage, teeth, and lipid bilayers.

The mechanical behavior and toughening mechanisms of abalone nacre-inspired multilayered materials are explored. In nacre's structure, the organic matrix, pillars and the roughness of the aragonite platelets play important roles in its overall mechanical performance. A micromechanical model for multilayered biological materials is proposed to simulate their mechanical deformation and toughening mechanisms. The modeling results are in excellent agreement with the available experimental data for abalone nacre. The highly nonlinear behavior of the proposed multilayered material is the result of distributed deformation in the nacre-like structure due to the existence of nano-asperities and nano-pillars with near theoretical strength. Finally, tensile toughness is studied as a function of the components in the microstructure of nacre. Bamboo, a fast-growing grass, has higher strength-to-weight ratios than steel and concrete. The unique properties of bamboo come from the natural composite structure of fibers that comprises mainly cellulose nanofibrils in a matrix of intertwined hemicellulose and lignin called lignin-carbohydrate complex (LCC). Here we have experimentally and numerically studied mechanical and fracture properties of bamboo at multiple scale. We have utilized atomistic simulations to investigate the mechanical properties and mechanisms of the interactions of these materials in the structure of bamboo fibers. It is shown that a control hemicellulose model has better thermodynamic and mechanical properties than lignin while lignin exhibits greater tendency to adhere to cellulose nanofibril. Therefore, the role of hemicellulose found to be enhancing the mechanical properties while lignin provides the strength of bamboo fibers. Lastly, given the amphiphilic nature and chemical structure, phospholipids exhibit a strong thermotropic and lyotropic phase behavior in an aqueous environment. We performed non-equilibrium molecular dynamics simulations for a range of different temperature gradients. The results show that the thermal properties of the DPPC bilayer are highly dependent on the temperature gradient. Higher temperature gradients cause an increase in the thermal conductivity of the DPPC lipid bilayer. We also found that the thermal conductivity of DPPC is lowest at the transition temperature whereby one lipid leaflet is in the gel phase and the other is in the liquid crystalline phase. This is essentially related to a growth in thermal resistance between the two leaflets of lipid at the transition temperature. These results provide significant new insights into developing new thermal insulation for engineering applications.
Pigmented Contacts Lenses for Cystinosis and Photophobia Treatment

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Cystinosis is a rare genetic disorder caused by mutations of CTNS gene, a lysosomal transporter responsible for the cystine efflux pathway in cells. Mutations result in accumulation of cystine crystals in multiple organs including kidneys and eyes. 2-10 year old infants develop an abnormal sensitivity to light (photophobia) due to the build-up of these crystals. In severe cases, photophobia exacerbates ocular pain and contributes to frequent corneal erosions, thus complicating cystinosis treatment. Blocking a selected wavelength range from the light spectrum can have multiple benefits including photophobia management. Peripheral glares comprising of ultra-violet (UV) and near-visible light radiation have sufficient energy to induce photophobia, retinal damage and escalate corneal damage. This necessitates its blocking through sunglasses and contact lenses. In addition to managing complicated ocular symptoms, there are multiple challenges associated with cystinosis treatment. Cysteamine, an FDA-approved drug for cystinosis treatment readily degrades with oxygen, leading to a short shelf life of the formulation. Low bioavailability (<5%) of cysteamine drops along with a high frequency of application (eight or more doses per day) has led to low patient compliance. One alternative route of cysteamine delivery to the eye is topical application via p-HEMA and silicone hydrogel contact lens. Contact lenses, however, release the drug rapidly in a few minutes due to the small molecular weight, which can lead to adverse toxicity effects. A novel lens design approach involving integration of vitamin-E barriers along with a stable tint in the lens matrix is explored. Here, to achieve blocking, incorporation of pigments extracted from colored agro-products into contact lenses is demonstrated. Lens immersion in pigment/vitamin E concentrated ethanol is employed to facilitate swelling, allowing rapid pigment uptake. Pigment incorporation ensures the absence of visible light scattering, lens opacity, and leaching. The characterization of pigmented lenses is done through absorptivity and transmittance measurements. \textit{in situ} diffusion barriers are also created through vitamin E integration along with the tint into lab-made and commercial lenses. These highly hydrophobic aggregates form an effective barrier to highly hydrophilic drugs like cysteamine. p-HEMA and silicone hydrogels loaded with > 400 µg/g turmeric pigment act as class 1 UV blockers retaining > 90% visible light transparency and screening > 95% of the UVR and near-visible spectra. Spinach, paprika, and woad powder loaded silicone lenses mitigate > 20% visible light transmission from selective wavelengths finding applications in photophobia management. Commercial ACUVUE® TruEye® with > 400 µg/g turmeric pigment and > 20% vitamin-E loading can effectively treat Cystinosis induced photophobia and deliver therapeutic dosages of Cysteamine for 2-3 hours. Transparent lab-made, commercial ACUVUE® TruEye® and ACUVUE® OASYS® with > 400 µg⁻¹ mg/g pigment extracted from food colorants and > 20% vitamin-E loading commercial lens brands show > 95% UVR blocking along with > 2 hour of topical cysteamine delivery. These bioengineered SCL’s provide a threefold benefit including drug delivery at therapeutic dosages, cysteamine stability and, serve as ocular vehicles for effective photophobia management.
We explore multi-scale methods and generalized workflows to collect 3D surface and 3D volume reconstruction data. Scanning electron micro-photogrammetry, light optical photogrammetry, and x-ray computerized tomography (CT) is correlated in a combined dataset for 3D visualization. Initial studies are presented with application to characterizing the structural color exhibited by *Cotinis Nitida*, or more commonly, Green June Beetle. This species of the scarab family is distinguished by glossy iridescent colors in their elytra (wing case). The brilliant iridescence common to these beetles is due to complex selective geometric interferometric reflections from the multi-layer elytral cuticle structure. The scanning electron microscopy (SEM) micro-photogrammetric data provides nanoscale 3D surface detail and surface texture information. The CT yields micro-scale volume tric structural data, while the optical data allows correlation of the visible light coloration and elytra structure. Future studies will use SEM surface reconstruction and CT data acquired over entire specimen to guide FIB-SEM nanotomography to capture photonic cell volumes from selected regions. 3D surface reconstruction data and volumetric structural data may then be segmented and extracted to define 3D mesh structures suitable for physics-based models which propagate an electric vector through the structure and simulate the color response. Through the combination of these workflows we aim to develop both general and efficient methods to capture 3D structures over multiple length scales and ultimately simulate mechanisms of 3D structural color over a broad range of natural systems.
Here we report a novel anti-counterfeiting nanomaterial that allows for the repeatable and instantaneous concealing and revealing of an invisible pattern. This innovative approach employs principles drawn from two disparate fields: the photonic crystal and shape memory polymer (SMP) technologies. Macroporous photonic crystal membranes with 3-D ordered macropores are fabricated, utilizing a self-assembled colloidal crystal as sacrificial template. The photonic crystal membrane exhibits easily perceived iridescent structural color. The periodic macropores can then be deformed by submersion in water due to strong capillary force resulting in a loss of the iridescent color. A polydimethylsiloxane (PDMS) stamp placed on top of the deformed macroporous membrane allows diffusion of swelling oligomers and monomers to penetrate the polymer membrane, recovering regions in contact with the PDMS stamp and fixing the macropore open (original state) permanently. This is visibly apparent as the pattern from the PDMS stamp is now shown on the polymer membrane. The remaining deformed pores can be easily recovered by exposing the membrane to the vapor of a swelling solvent (e.g. ethanol or acetone). The pattern is now hidden as the entire polymer membrane is displaying the iridescent structural color; however, after submersion in water, the regions that contacted the PDMS stamp are no longer deformable. This allows for the uncovering of the programmed, hidden pattern. The pattern can be repeatably and instantaneously hidden and revealed with further exposure to vapor and submersion in water with little observable loss in resolution for more than 20 cycles.

Jing Guo and Prof. Jin He, Florida International University, Physics Department and Biomolecular Science Institute, jguo@fiu.edu, jinhe@fiu.edu

Single cell intra-cellular pH is very important in cell as it play an important role in transport processes and many cellular events. Functionalized nanoparticles-based surface enhanced Raman spectroscopy and fluorescence probe have been used for cell pH sensing, but those methods need cell labeling and lack of control of detection location inside a single cell. Here we developed a nanopipette sensor that can target at different spot inside a single cell and report the local pH based on surface enhanced Raman spectroscopy.
Multifunctional Nanopipette for Potential Sensing of Single Nanoparticle Collision Events

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Recently, single nanoparticle (NP) collision at nanoelectrodes have drawn significant attention due to its unique advantage in single entity electrochemical detection and analysis. Single NP collision is an exciting alternative to faradaic current response and has broad applications in many areas such as bio-electrochemistry, electrocatalysis, biosensing. Particularly, it is a powerful tool to study the properties of single NPs such as size, number density, aggregation and catalytic activity by using electrochemical signals. In this talk, I will demonstrate a novel method of detecting single nanoparticles (NPs) in electrolyte solution based on their polarizability via multifunctional nanopipette. Highly polarizable metallic gold NPs (GNPs) and non-polarizable polystyrene NPs with different sizes were used as the model NPs. The electrophoretic motion of GNP is faster than that of PS NP due to the higher conductivity and polarizability of GNP, which leading to a higher approaching speed of GNP before collision. The resulted first derivative of the potential changes detected by the CNE are distinctive between GNPs and PS NPs which enable us to differentiate GNP from PS NP in a mixture during single NP collision events.
Advanced Simulation Environment for the Study of a Plasmon FET as a Biosensor

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Surface Plasmon Resonance (SPR) is widely being studied due to its optical sensitivity to changes in refractive index of the host media. As novel devices utilizing SPR are being developed there is a need to effectively model these devices with their corresponding physical phenomena to allow for optimization and explore new geometries and materials quickly. We have developed a biological sensing platform, the Plasmon FET, using localized SPR (LSPR) that has experimentally shown a limit of detection (LOD) of 20 pg/mL while being insensitive to media absorption. The Plasmon FET is a thin film field effect transistor that uses functionalized nanostructures to inject current into the semiconducting channel. This direct conversion of plasmonic signals to electric signals allows for reduction of complexity of and size of the device enabling point of care diagnostics. Using commercial simulation software, we were able to develop an advanced computational environment illustrating key sensor properties such as resolution, sensitivity, and dynamic range. This work illustrates a comprehensive analysis of a direct plasmon-to-electric device designed to work in whole blood and furthering development of a device that already offers advantages in size, simplicity, and multiplexing capability.
Self-assembly of biomolecules and their deposition in our body are responsible for numerous human diseases, such as kidney stones and atherosclerotic plaques. Aggregation of amyloid beta peptide and the formation of fibers and plaques in the extracellular space of human brain is a characteristic of Alzheimer’s disease. Although we are still unclear whether the amyloid fibers and plaques are the cause of the neurodegeneration, nanoimaging techniques have played a vital role in providing landmarks allowing the research field to navigate in the right directions. I will present TEM and AFM images that have guided the Alzheimer’s disease research to where we are, and our new model on Alzheimer’s disease pathogenesis, that amyloid fibers can further aggregate and form gels, and the gels are capable of eliminating bulk flow and then the circulation of ions and molecules that are essential for neuronal function.
Dihydromotuporamine C (motu C) is a small molecule isolated from a New Guinea sea sponge that has demonstrated anti-metastatic and anti-migratory properties both in vivo and in vitro. Many cancers do not pose a threat to a patient’s life until they metastasize. Actin filament assembly plays a critical role in cancer cell metastasis, cancer cell movement, and force generation. In this study we investigate how motu C derivatives modulate actin filament assembly dynamics and kinetics in vitro, using biophysical and biochemical assays. The effect of motu C on average filament length was determined by direct visualization of actin filaments incubated with motu C derivatives by total internal reflection fluorescence (TIRF) microscopy. We demonstrate that one particular motu C derivative, motuCH$_2$33 reduces filament length significantly. Pyrene labelled actin assembly kinetics results indicate that motuCH$_2$33 also effectively decreases the amount of polymerized actin, potentially affecting cancer cell migration. Outcomes from this project can be used to further optimize the molecular design of anti-migratory small molecules.
Characterization and Printability of Polysaccharide Based Hydrogels to Study Self Assembly of Tumor Spheroids

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Three-dimensional (3D) bioprinting is a technology that can be used to develop a bio fabricated human tissue and organ with representative physiological functions. Bioinks are material used for bio fabrications of 3D tissues and organs. Bioinks are also important for cell support, adhesion, and differentiation. Polysaccharide-based bioinks are tunable hydrogel which proximately mimics the natural extracellular matrix (ECM) environment. Currently, this hydrogel is used for non-printed 3D culture models. The unique feature of this hydrogel is the nontoxic crosslinking with cell culture medium and rapid spheroid formation. The main aim of our project is to make this hydrogel bio printable with predefined rheology and higher cell viability.

For cytotoxicity screening, live-dead assay was performed by encapsulating non-small cell lung cancer (NSCLC) patient-derived xenograft PDX (T790M) cells with 0.5%, 1%, 1.5% and 2% (w/v) polysaccharide-based hydrogels before bioprinting. For printability screening, hydrogels were mixed with cell culture medium in the ratio of 1:1 up to 20:1 and kept for different incubation time (0 to 24 h) for further crosslinking. Printability of the crosslinked hydrogels were analyzed using INKREDIBLE bioprinter (Cell Link, Sweden). Hydrogel extrusion pressure, bioprinter line-width, scaffold pore size and swelling ratios were measured and considered as principal parameters for the printability. Printable hydrogel was prepared with 4% (w/v) polysaccharide hydrogel and printed with NSCLC PDX cells. The printed scaffolds were incubated at 37°C for seven days and live/dead and NucBlue/Actin Green staining was performed to determine cell viability and spheroid formation respectively. The scaffolds with spheroids were treated with 100 µM, 50µM and 25µM erlotinib for a period of 48hours and the cytotoxicity was checked by the live and dead assay.

Briefly, 4% (w/v) hydrogel was printable when mixed with media (hydrogel: culture medium) in the ratio of 6:1 after 10 minutes of incubation. The hydrogel extrusion pressure was observed between 33-45 kPa. The swelling ratio of the hydrogel was 600% after 5 hrs. The line width and pore sizes of the printed scaffolds were 113 ± 8 µm and 52821 ± 8.5 µm², respectively. Approximately 97% of cells were found viable in printed scaffold immediately after printing and ~98 percent of the cells were viable before printing in all concentrations. Further, 98.5 ± 2.65, 97.565 ± 3.98 and 88.35 ± 4.24 percent viable PDX cells were observed in the bio-printed scaffolds after 48, 72 and 96 h respectively. The cells formed spheroids after 7 days and decreased spheroid cell viability was observed in 50 µM and 100 µM of ERL (36 ± 11, and 22 ± 15, respectively)

Based on the printability, printed scaffolds morphology, cell viability and rapid spheroid formation ability, it can be concluded that this polysaccharide-based hydrogel can be helpful to develop a tumor scaffold with in vivo stromal characteristics.
Molecular Crowding Effects on Actin Filament Assembly Kinetics

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Actin assembly dynamics power cell movement and provide cells with mechanical strength. The cell environment contains high concentrations (up to 40\% of cell volume) of solutes including organic compounds, macromolecules, and proteins. Molecular crowding has been shown to affect actin filament stability and polymerization in bulk assays. In this study, we investigate how molecular crowding affects filament assembly kinetics by direct visualization using total internal reflection fluorescence (TIRF) microscopy. We measured the assembly rates of individual actin filaments for varying types and concentrations of molecular crowders. We demonstrate that a small molecule (sucrose), a polymer (polyethylene glycol), and a protein (bovine serum albumin) all have different effects on assembly rates during the elongation phase of filaments. TIRF microscopy results are consistent with those from pyrene fluorescence kinetics experiments. The effects of excluded volume, “soft” enthalpic interactions, and changes in viscosity may explain the observed crowding effects on actin polymerization in vitro. This study enhances our understanding of how crowded cellular environments modulate actin assembly at the molecular level.
Direct Evaluation of Single Hydrogel Nanofiber Mechanics Using Persistence Length Analysis

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Polyelectrolyte hydrogel nanofibers mimic extracellular matrix, create self-healing materials, and form a matrix that encourages high absorbance. These characteristics make them optimal for biomedical applications such as drug delivery, tissue scaffolding, and wound healing. Metal ions play a critical role in hydrogel fiber stability via electrostatic interactions, but knowledge of how they modulate mechanical properties of individual polyelectrolyte polymers is lacking. In this study, electrospun polyacrylic acid with chitosan is used as a model system to evaluate the effect ferric ions have on individual nanofiber mechanics. Using dark field microscopy imaging and persistence length analysis, we demonstrate that ferric ions modulate the bending stiffness of single nanofibers. Ionic conductivity of pre-electrospun solutions establishes the negligible influence of the electrospinning process on nanofiber fabrication regardless of ferric ion concentration. Calculation of the Young’s modulus of the fibers at values of a few kilopascals suggests that PAA nanofibers possibly exist in a hydrated state. Furthermore, Fourier Transform Infrared (FTIR) spectra display the effect of ferric ions on polyacrylic acid molecular bonds, while infrared nanospectroscopy (NanoIR) offers insight into nanofiber compositional changes. Taken together, this study suggests that metal ions can regulate single nanofiber stiffness, providing designs to fabricate hydrogels in a tunable fashion.
Effects of Macromolecular Crowding on Actin Bundles Induced by Actin Crosslinking Proteins

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The assembly of actin filaments into ordered bundles plays an important role in cell structure and mechanics. $\alpha$-actinin and fascin are essential actin binding proteins that induce actin bundles generating higher ordered structures including filopodia and lamellipodia. While the roles of both actin binding proteins in bundling have been well studied in dilute buffer conditions, how those in crowded environments affect actin bundling is not well understood. Here, we investigate the effects of molecular crowding on actin bundles crosslinked by $\alpha$-actinin and fascin in a filopodia-mimicking system. Time-dependent bundling by crosslinking proteins was monitored in the presence of a polymeric crowding agent polyethylene glycol (PEG) using total internal reflection fluorescence (TIRF) microscopy. Our preliminary data shows that PEG reduces $\alpha$-actinin-induced bundling whereas it enhances fascin-induced bundling. The amount of bundles quantified by fluorescence intensity decreases with $\alpha$-actinin in the presence of PEG. In contrast, PEG promotes the formation of thicker bundles induced by fascin. Overall, our work suggests that crowded environments may modulate actin bundling induced by actin binding proteins \textit{in vivo}. 
**Poster Topics and Locations**

Nanomedicine (NM)
Olin Life Sciences 1st Floor Atrium

Self-Assembly (SA)
Olin Life Sciences 2nd Floor Atrium

Tissue Engineering and 3D Printing (TE)
Olin Life Sciences 2nd Floor Atrium

Catalysis, Adsorption, and Thin Films (CA)
Olin Engineering Center 2nd Floor Atrium

Sensors (SE)
Olin Engineering Center 3rd Floor Atrium

**Nanomedicine**

NM-1 1st Floor Olin Life Sciences Atrium

**PCBA Polymer Nanoparticles Incorporating PhotoCORM to the Brain**

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Alzheimer’s is a type of dementia disease which causes problems in memory, thinking and behavior. It was found that level of CO increased in the brains of AD patients, and protected neuro cells from damage caused by amyloid related to AD. Our group are developing methods to incorporated carbon monoxide releasing molecules (CORMs) in poly(cyano buty lacrylate) (PCBA) nanoparticles, which has been widely used for delivering drugs to brain through blood brain barrier. The PCBA nanoparticles are prepared using both anionic emulsion polymerization and nano precipitation methods. The PCBA used for nano precipitation are prepared using unconventional free radical polymerization, which allows us to prepare copolymers of CBA and other acrylates. A novel photoCORM DK4 has been incorporated in the PCBA nanoparticles. The release of CO under 470 nm irradiation was confirmed by UV-Vis spectroscopy. Dynamic scattering light (DSL) has determined that the nanoparticle has an average size of 24 ± 3 nm with PDI of 0.44. A zeta potential of -42 mV indicated a high stability.
As the second leading cause of death of American men, prostate cancer is a disease that requires urgent attention. If caught early, prostate cancer (PCa) can be treated with surgery or radiation therapy. However, a subset of this cancer exists, known as castration resistant prostate cancer (CRPC), which is much more difficult to treat with currently available therapy due to their inherent recurrence, and resistance to conventional PCa chemotherapeutics. CRPC Is exacerbated by several factors including inflammation, bone metastases, drug resistance and altered metabolic profiles in cancer stem cells (CSC). Attempting to treat this disease with a singular mode of therapy is ineffective. We have developed a multifunctional, polymer based nanoparticle (NP) which can deliver a stoichiometric combination of a chemotherapeutic agent and an anti-inflammatory agent. Combined with fractionated radiation therapy (XRT), this NP system is able to effectively target the prostate-specific membrane antigen (PSMA), and deliver both drugs in a spatiotemporal targeted manner. This platform has the ability to load multiple drugs, in a predetermined ratio to co-deliver anti-inflammatory and chemotherapeutic agents to PSMA expressing cancer cells, and immune cells in the tumor microenvironment. We will be working on including additional moieties to the NP platform for bone metastasis therapy, as it is the major site of metastasis in PCa. The NP has shown the ability to inhibit mitochondrial respiration and ATP production in CSCs, forcing them into apoptosis. The efficacy of this model was tested in both in vivo and in vitro experiments.

**Modulation of Glioma Stem Cells with Targeted Nanoparticle Delivered Cisplatin Prodrug for Glioblastoma**

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Glioblastoma Multiforme (GBM) is one of the most lethal malignant primary brain tumors owing to their heterogeneity and self-renewal capacity (1). Glioblastoma stem cell (GSC) population is resistant to almost all the available conventional therapies which requires an urgent need to develop alternative therapeutic strategies. We recently discovered in patient derived GSCs of varied background that it utilizes fatty acid oxidation (FAO) as a major pathway for their growth and survival. Specific targeting of GSCs with chemotherapeutics also remains a major challenge in brain tumor. Cisplatin, the most widely used chemotherapeutic, is rarely used in the treatment of brain tumors
mainly due to the development of resistance, and toxicity associated with this drug (2). Thus, we embark on a journey to find a nano-therapeutic strategy which can inhibit FAO in GSCs and make this cell population vulnerable to apoptosis. Through a serendipitous discovery, we found that a cisplatin prodrug, has the ability to alter FAO in a series of cancer cells including GSCs. We also recently reported brain penetrating properties of a biocompatible polymeric nanoparticle which has the ability to load these cisplatin produgs (3-5). In this presentation, we will present the preliminary findings using this platform to set a stage for potential translation of a targeted nanoparticle delivered cisplatin prodrug to attack GSCs as an alternative treatment approach for GBM.

References

NM-4 1st Floor Olin Life Sciences Atrium

Gallium Combinations with Different Antibiotics Provide Alternate Treatment Options to Traditional Antibiotic Therapy for Pseudomonas aeruginosa and Acinetobacter baumannii Infections

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Highly contagious infections are increasing frequently in the hospital environment today. These bacterial infections can spread through medical equipment, cleaning solutions, and even food. These infections are prone to biofilm formation which leads to the development of their high resistance to standard antibiotic treatments. The objective of this study is to assess the efficiency of gallium (Ga) as a combinational treatment with traditional antibiotics in order to improve their efficacy against antibiotic resistant pathogens. The antibiotics chosen for this experiment were streptomycin, ampicillin,
colistin, and doxycycline. The potency of the gallium-antibiotic combinations was tested against Pseudomonas aeruginosa PAO1 and Acinetobacter baumannii 19606 and compared with the standard antibiotics. The efficacy of the gallium and antibiotic was assessed by determining the Minimum Inhibitory Concentration (MIC) and Minimum Biofilm Eradication Concentration (MBEC) of P. aeruginosa and A. baumannii against planktonic and biofilm cells were determined using broth micro-dilution assay as described in the guidelines of the Clinical and Laboratory Standard Institute (CLSI) and ASTM E-2799 assay. The safety of gallium and these combinations were screened by observing their toxicity against mammalian cells including Human Dermal Fibroblasts (HDF). The relationship of gallium and the antibiotics was assessed by determining the Fractional Inhibitory Concentration Index (FICI). This method indicated the relation between gallium and the antibiotic worked synergistically, additively, or indifferently. Results from this study showed that gallium combinations can have a positive cooperation and can potentially be used against antibiotic resistant bacteria. Future studies will include embedding these agents in a delivery vehicle.

NM-5 1st Floor Olin Life Sciences Atrium
New Microarray Data Analysis Techniques in Evaluating the Effect of Nanomedicine Treatment

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NM-6 1st Floor Olin Life Sciences Atrium
Multifunctional Therapeutic Nanoparticles for Atherosclerosis

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Macrophage derived foam cells contain high amount of cholesterol which promote atheroma expansion and disruption of arterial plaques [1]. Human atherosclerotic plaques are predominantly M2 macrophages, enriched with macrophage mannose receptor (MMR) on their cell surface in addition to classically activated M1 macrophages [2]. High-density lipoproteins (HDL) exerts its protective property against atherosclerosis by removing cholesterol from lipid laden foam cells. Earlier, we have reported the development of synthetic polymeric hybrid nanoparticle using Food and Drug Administration approved poly(lactic-co-glycolic acid) having favorable organ distribution and anti-atherosclerotic property [3]. Herein, we describe the systematic design of a dual targeted synthetic therapeutic NP with both mitochondria and MMR-targeting surface functionalities loaded with a hydrophobic MRI contrast agent, Mito-magneto (MM), to achieve target-specific MRI contrast and therapeutic outcomes in-vivo. Macrophage targeting surface functionality on the HDL-NPs is expected to add another dimension to the construct by targeting plaques and enabling better detection of
plaques and enhanced lipid reduction at the same time. In addition, the encapsulation of mitochondria acting coenzyme Q10 (CoQ10) into the core of these NPs is extremely crucial to improve the cellular bioenergetics and reduction of oxidative stress in the SMCs for better prevention and treatment of heart related disease.

NM-7 1st Floor Olin Life Sciences Atrium
Preparation and Intransal Formulation of Nanodrugs of Opioid Addiction Antagonists for Stroke Recovery

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Each day, more than 116 people die from opioid-related drug overdoses, over 40% of which are attributed to prescription opioids. The US Department of Health and Human Services has recognized the opioid epidemic as a public health emergency. Prescription opioids, used to treat chronic pain, are now linked to increased risk for stroke. Commonly prescribed opioids, including morphine, have been shown to breakdown the blood brain barrier (BBB) through the down regulation of tight junction proteins. Interestingly, there is also a strong correlation between stroke severity and the disruption of BBB. Consequently, protection of the BBB has been proposed as a therapeutic strategy for ischemic stroke. Annually, approximately 6 million people die from stroke with no drugs to promote recovery. Naloxone functions as a competitive antagonist that is commonly used to treat opioid overdose. More recently, naloxone has been shown to promote recovery from ischemic stroke and is beneficial in reversing related neurologic deficits. This may be attributed to naloxone’s anti-inflammatory properties. Naltrexone shares a similar structure and mechanism of action to naloxone and has also been observed to have neuroprotective effects. Naloxone and naltrexone have been reported to improve motor function following an ischemic stroke. However, oral delivery of naltrexone has limitations, namely, extensive first pass metabolism in the liver, which causes a short therapeutic action and lowered bioavailability. In order to overcome the bioavailability and drug delivery challenges associated with naltrexone, and to maximize naloxone and naltrexone as therapeutic agents for stroke recovery, a novel synthesis of “nanodrugs” based on carrier-free nanoparticles derived from pure naloxone and naltrexone drugs is proposed. Nanoparticles offer longer bioavailability compared to traditional forms of drug delivery thus decreasing dosage and frequency of dosage. Simultaneously, nanoparticles increase absorption, rate of absorption, and enhance adhesiveness to the cell surface due to particle diminution. Nanodrugs will be administered via the nasal route, in order to ensure localized drug delivery to the brain, as well as increased bioavailability in comparison to current available drug forms. To accomplish this goal, the following specific aims are devised: (1) Preparation, optimization, and characterization of the nanodrugs, i.e., nanoparticle formulations of naloxone and naltrexone drugs and assess any potential cytotoxicity of the nanodrug formulations by performing in vitro cell viability experiments; (2) Evaluation of nanodrugs in preserving BBB and cerebrovascular integrity in chronic prescription opioid use models; and (3)
Determination of the in vivo treatment efficacy of nanodrug formulations administered through the nasal route in attenuating stroke severity and promoting stroke recovery in animal models of chronic prescription opioid use. These nanodrug formulations are envisioned to (1) enhance the therapeutic efficacy of naloxone and naltrexone in relation to current drug formulations, and, thus, (2) as a result, promote stroke recovery.

NM-8 1st Floor Olin Life Sciences Atrium

**Determination of Polycyclic Aromatic Hydrocarbons (PAH) Exposure in Firefighters via GCMS Analysis of Urine**

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Polycyclic aromatic hydrocarbons (PAHs) are toxic organic compounds, which are usually formed by the incomplete combustion of organic matter, such as wood or coal. These highly toxic and persistent pollutants have been associated with mutagenic and/or carcinogenic properties. Exposure to PAHs can occur via multiple routes, such as inhalation, or consuming PAH-contaminated water or food, and certain occupational categories, such as firefighters are at higher risk of being exposed to PAHs. In this project we measured the levels of 5 PAHs in the urine of active firefighters, as PAHs are excreted in the urine. We performed Solid Phase Extraction to extract the PAHs and the analytes were then analyzed using Gas Chromatography Mass Spectrometry (GCMS) and a competitive enzyme immunoassay (RaPID Immunoassay). Our results show a higher incidence level of PAH concentration in the urine of firefighters that have responded to a fire event versus controls.

NM-9 1st Floor Olin Life Sciences Atrium

**Polymer Based Nanomedicine for Trans-Epithelial Oral Delivery of Ivermectin for Zika**

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Target specific delivery vehicles have emerged as important technologies to treat illness and develop preventive measures for various cancers and viral diseases. Polymer based nanomedicine can be used for the treatment of lethal viruses, such as the Zika virus, by facilitating oral drug delivery across the epithelial barrier. We have proposed that nanotechnology in combination with chemical biology can combat the catastrophic neurological complications caused by the Zika virus (ZIKV). ZIKV is known to be transmitted by an infected *Aedes* species mosquito [1]. The ZIKV outbreak in Florida and its association to microcephaly and other neurological conditions such as Guillain-Barre syndrome, myelitis, and meningoencephalitis pose a universal health emergency [2]. To understand and tackle this problem, we have developed Fc-Ivermectin-NPs, an oral
formulation composed of neonatal Fc receptor (FcRn) with decorated nanoparticles (NPs), that mediate the transport of Ivermectin across the epithelial barrier and release the drug in a controlled fashion to the Zika virus infected blood.

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NM-10 1st Floor Olin Life Sciences Atrium
Selective Targeting of Breast Cancer Brain Metastases by Cisplatin Prodrug Nanoformulation

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Breast cancer brain metastases (BCBMs) are common in patients with advanced breast cancer diseases. This is one of the breast cancer subtypes and its performance status are the major determinants of the course of the disease and survival time following a diagnosis of brain metastasis [1]. The unique challenges specific to the management of BCBMs includes, overcoming the blood-brain barrier (BBB) and resistance to conventional systemic therapies, as BCBMs typically occur in the pretreated patient population [2]. The development of new systemic and selective targeting nanoformulation based therapies for BCBMs has become increasingly important. In this work, we developed a cisplatin prodrug loaded brain accumulating nanoparticles to deliver the active drug cisplatin to the mitochondria of the cancer cells. Though the brain cell matrix is very complex and heterogeneous, we were able to show the selective targeting ability of these nanoparticles towards the BCBM cells over non-cancerous brain cells by crossing the BBB.

NM-11 1st Floor Olin Life Sciences Atrium
Dry Formulation of Ivermectin Nano-devices for Oral Delivery for Zika Virus

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Methods for targeted delivery of drugs have presented new opportunities for treating illnesses such as cancers and viral diseases. Infected mosquitoes of genus Aedes transmit
Zika virus (ZIKV), which leads to severe neurological complications [1]. We have proposed that nanotherapeutic solutions will be more effective than traditional therapies at treating ZIKV. We have developed Fc-Ivermectin-NPs, nanoparticles (NPs) decorated with neonatal Fc receptor and loaded with Ivermectin, to allow for the transport of Ivermectin across the epithelium and the controlled release of the drug in the ZIKV-infected blood. Oral delivery of this formulation to treat ZIKV will allow the encapsulated Ivermectin to enter the bloodstream and undergo gradual release to ensure all virus-infected cells are killed. To create a capsule formulation of the NPs, they must be freeze-dried and packed into the capsule in powder form. Maintenance of size and stability of Ivermectin-loaded NPs is key to their therapeutic effectiveness. To avoid aggregation and size changes as a result of the freeze-drying process, trehalose and sucrose were selected as lyoprotectants. The nanoparticle and lyoprotectant mixtures underwent freeze-thaw testing to test the ability of the lyoprotectants to maintain the NPs’ size and stability across various conditions.

NM-12 1st Floor Olin Life Sciences Atrium
Microneedle-Assisted Delivery of Model Therapeutics to Plant Tissue
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This project focuses on a potential treatment delivery method for the bacterial disease, huanglongbing (HLB), or citrus greening, which has devastated Florida's nine billion dollar citrus industry. HLB is caused by a phloem-restricted bacterium called Candidatus Liberabacter asiaticus. Florida growers are currently evaluating foliar-applied antibiotics as a potential tool to manage HLB, but there is a concern that it doesn't deliver at the concentration needed to kill the bacteria. Microneedles are a minimally invasive transdermal drug delivery system used in the biomedical industry and can be theoretically utilized for plant therapeutic deliveries. This project is believed to be the first of its kind to attempt this. It is hypothesized that therapeutics can be efficiently delivered to plant tissue using microneedles. A 3D printed microneedle-based stamp was designed and fabricated using CAD software. Water-soluble zinc sulfide quantum dots (ZnS: Mn Qdots) were used as a model for newly-emerging nanoparticle therapeutics. The procedure involves stamping citrus leaves with the microneedles, drop-casting Qdots on the treated surface, followed by analysis of zinc content using atomic absorption spectroscopy. Statistical analysis shows that the control measurements are extreme outliers compared to the treatment measurements. The 95% confidence interval constructed for the mean amount of zinc absorbed using the microneedles clearly shows higher absorption rates compared to the control. A four-fold increase of zinc content per unit gram of dry leaf sample was observed in treated leaves with respect to untreated control leaves. This novel idea shows that microneedles have the potential to be a more effective alternative than current delivery methods.
Formulation Development and Characterization of Herbal Drug Based Nutraceuticals

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Several nutraceuticals such as supplements, vitamins, herbal products, enhancers, and over the counter products with nutritional value are available in the market. However, poor solubility, rapid degradation and poor stability of these formulations limits their use. Hence there is a need to reformulate these formulations for maximizing their therapeutic effect. Herein, the strategy is to develop an oral tablet and capsule formulations of Kalmegh and Shatavari powders to enhance its solubility, dissolution profile and bioavailability. The Kalmegh and Shatavari powders were first mixed with varying quantity of lactose. The mixtures of diluent and an herbal drug powders were then filled in the clear gelatin size 1 capsule using capsule filling machine. The tablets were made using tablet mold by direct compression method using lactose as a diluent. To check the herbal drug and diluent compatibility plain herbal drugs, excipient (lactose) and physical mixture of drugs (kalmegh and shatavari) with lactose were subjected to thermal analysis using Differential Scanning Calorimetry and were analysed using Fourier Transform Infrared Spectroscopy system. Results of DSC and FTIR studies showed that both the drugs were compatible with lactose. To check the effect of diluent on release of herbal drug from preparation, both capsules and tablets were studied for disintegration profile. The disintegration for all two capsules started after 6 min of time and the complete disintegration was observed at 30 min of time when the capsule could release all the enclosed powder into disintegration test media. While the disintegration of for all two tablets started after 4 min of time and the complete disintegration was observed at 30 min of time when the tablets can release all the enclosed powder into disintegration test media. Dissolution profile of developed formulations are under experimentation and in vivo studies to check the bioavailability will also be done in future studies.

Development of a Novel Chitosan-Based Drug Delivery System

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The purpose of the project was to develop an improved drug delivery system through the manipulation of chitosan nanoparticles. The engineering goal was to synthesize chitosan particles that would have characteristics that fit the parameters of a nanoparticle and have the capability to encapsulate antibiotics. Conventional drug delivery systems require
several doses of antibiotics to maintain an average drug level in the blood, which is unethical and health-hazardous. Due to the instability of drug release in conventional drug delivery systems, a more optimized drug delivery system that would have a predetermined, stable drug release was the ultimate goal of the project. The synthesis of the chitosan nanoparticles was performed through hydrothermal treatment and lyophilization. Low molecular weight chitosan was dissolved in hydrochloric acid to ensure nanosized-particles. The synthesized chitosan nanoparticles underwent characterization. Dynamic-Light Scattering concluded the average size of the nanoparticles as well as the surface charges. IR Spectroscopy was also used to determine the interactions between the chitosan nanoparticles and attached drugs. Lastly, UV-Visibility Spectroscopy was used to determine the peak absorbance and fluorescence values. All in all, the synthesized chitosan nanoparticles were concluded to have the ability to encapsulate antibiotics effectively and act as a drug delivery system. The nanoparticles were small in size with an average diameter of 68.06 nanometers and had an average positive surface charge of 42.6 mV, allowing for them to interact with a negatively charged cell membrane. IR Spectroscopy led to the conclusion that chitosan nanoparticles comprise of several hydroxyl groups, which are negatively charged. Thus, chitosan can encapsulate positively charged antibiotics that contain amine groups. These characteristics led to the conclusion that chitosan nanoparticles can effectively carry antibiotics and act as an efficient drug delivery system.

NM-15 1st Floor Olin Life Sciences Atrium
Hydrogels for Tunable Affinity-Controlled Release of Carbohydrate-Binding Proteins

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Hydrogels are attractive vehicles for delivery of protein therapeutics because their high water content is ideal for maintaining drug activity. However, hydrogels often demonstrate a burst release of encapsulated proteins due to having large pores that permit rapid drug efflux. One strategy to extend the duration of release involves engineering hydrogels to reversibly bind to proteins with high specificity and tunable affinity. Here, we will present hydrogels for sustained release of a carbohydrate-binding protein, wheat germ agglutinin (WGA). These hydrogels are fabricated by photo-crosslinking poly(ethylene glycol) diacrylate (PEGDA) in the presence of self-assembled nanofibers of the carbohydrate-modified peptide N-acetylglucosamine-QQKFQFQFEQQ (GlcNAc-Q11). The extent of WGA binding and release can be tuned by simply varying the concentration of GlcNAc-Q11 nanofibers incorporated into the hydrogel network.

B-sheet fibrillizing peptides, GlcNAc-Q11 and the non-glycosylated variant Asn-Q11 (NQ11), were synthesized using solid-phase peptide synthesis and purified using high-pressure liquid chromatography. Hydrogels were prepared via photo-initiated radical crosslinking of prepolymer solution containing PEGDA (10% w/v) and NQ11/GlcNAc-Q11 nanofibers (total peptide = 0.5 mM in all hydrogels). GlcNAc content of the
hydrogels was changed by varying the molar ratio of NQ11 relative to GlcNAc-Q11. Each hydrogel was swelled with buffer for 24 hours and then soaked in buffer containing FITC-labeled WGA for another 48 hours. Protein release was measured by placing FITC-WGA loaded gels into phosphate buffered-saline solution (PBS) and analyzing the increase in buffer fluorescence as a function of time. The release profile was also measured by incubating hydrogels with a fixed molar ratio of NQ11/GlcNAc-Q11 in different volumes of PBS. Buffer fluorescence was converted to protein concentration on using a standard curve.

The amount of WGA bound to hydrogels tended to increase with increasing GlcNAc-Q11 mole fraction. However, at GlcNAc-Q11 mole fractions > 75%, binding was diminished likely due to steric hindrance. The rate and extent of release of WGA from hydrogels decreased with increasing GlcNAc-Q11 mole fraction. When the GlcNAc-Q11 mole fraction was held constant, the rate and extent of release of WGA from hydrogels increased as PBS volume increased. WGA was released faster from hydrogels incubated in PBS containing soluble GlcNAc suggesting that a binding inhibitor can disrupt specific association of WGA with GlcNAc-Q11 nanofibers in the hydrogel.

Collectively, these results demonstrate sustained release of carbohydrate-binding proteins from hydrogels fabricated from a photo-crosslinkable polymer and glycosylated self-assembled peptide nanofibers. Altering the nanofiber composition by varying the molar ratio of glycosylated to non-glycosylated peptide afforded control of the extent of WGA binding and its rate of release. We envision that this general approach will be broadly applicable for tunable, affinity-controlled release of therapeutic carbohydrate-binding proteins.

NM-16 1st Floor Olin Life Sciences Atrium
Design and Evaluation of Nabumetone Solid Lipid Nanoparticles Oral Formulation Using Hot Melt Extrusion (HME) Technology as a Continuous Manufacturing Process with Compritol® 888 ATO

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Solid lipid nanoparticles (SLN) have been formulated using various batch processes. However, in pharmaceutical industries, continuous production is always preferred over batch processes since it is more efficient and offer a better quality to the end product. Therefore, the aim of the present work is to develop Nabumetone (NBT) SLN for oral drug delivery by Hot Melt Extrusion (HME) technique.

Preliminary studies were performed to optimize the SLN-NBT. Various parameters related to formulation and HME; drug concentration, lipid concentration, surfactant concentration, different lipids, different surfactants, different barrels configuration, screw speed, temperature were considered for the process of optimization. Further, the
optimized formulation was analyzed for particle size, polydispersity, zeta potential, entrapment efficiency and drug assay. *In vitro* drug release study of NBT-SLN was performed for 24 hours by dialysis method using 14 KD MWCO dialysis bag. *In vivo* anti-inflammatory activity was evaluated on Sprague Dawley (SD) rats. The edema inhibition rate was measured using digital plethysmometer.

Optimized formulation of NBT-SLN showed a particle size of 44.23 ± 5.20 nm, polydispersity index 0.15 ±0.04, zeta potential -12.54 ± 0.61 mV, entrapment efficiency of 84.48 ± 2.31%. Drug assay revealed that there was 91.34 ± 2.64 % recovery of drug. *In vitro* drug release study demonstrated over 71.20 ± 3.24% drug released after 24 hours from NBT-SLN which was significantly (p˂0.05) higher in contrast to NBT-suspension. *In vivo* anti-inflammatory study revealed that NBT-SLN could significantly inhibit the rat paw edema in contrast to control.

NBT-SLN was successfully formulated using HME. This process demonstrates the novel application of Hot Melt Extrusion technology for continuous production of NBT-SLN.

**Self-Assembly**

SA-1 Olin Life Sciences 2nd Floor Atrium

**Computational Study of Actin Polymerization Kinetics in Crowded Environments**

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The essential protein actin polymerizes into a double-stranded helical filament through non-covalent interactions. Various cellular environmental factors such as ionic strength, pH, and molecular crowding affect the filament assembly kinetics. Specific crowding effects have been received much attention because it can mimic the crowded cellular environment. A recent experimental study indicates that molecular and/or protein crowders affect actin assembly rates. However, fundamental mechanisms of how crowded environment modulates actin assembly at the atomistic level has not been established yet. In this study, we carried out all-atom molecular dynamics (MD) simulations to examine the kinetic behaviors of actin monomer and its interaction with pre-formed filament in the presence of various molecular/protein crowders. Our preliminary results indicate that the diffusion coefficient of an actin monomer near a filament depends on different kinds of molecular or protein crowders, consistent with filament assembly rates obtained from a recent experimental study. Further, mean square displacement (MSD)s of water molecules near the monomer in the presence of crowders support the monomer's diffusion coefficients. This study may elucidate the molecular mechanism by which crowding affects actin polymerization *in vivo*. 
Molecular Crowding Modulates Actin Filament Structure and Mechanics

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The cellular environment is crowded with high concentrations of macromolecules that significantly reduce accessible volume for biomolecule interactions. Reductions in cellular volume can generate depletion forces that affect protein assembly and stability. Actin filament assembly and mechanics play critical roles in various cellular functions including structural support, movement, and intracellular transport. Although the effects of molecular crowding on actin polymerization have been shown, how crowded environments affect filament conformations, dynamics, and mechanical properties remain to be established. In this study, we investigate the effects of molecular crowding on the modulations of filament structure and mechanics both \textit{in vitro} and \textit{in silico}. Direct visualization of filaments in the presence of crowding agents is achieved by fluorescence microscopy imaging, allowing for the quantification of filament thermal bending dynamics and mechanics. Biophysical analysis indicate that molecular crowding modulates thermal fluctuations, enhances filament bending stiffness, and reduces average filament lengths. Utilizing all-atom molecular dynamics simulations, we demonstrate that molecular crowding leads to changes in filament conformation and inter-subunit contacts that are directly coupled to filament mechanics. Taken together, our study suggests that the interplay between excluded volume effects and non-specific interactions raised from molecular crowding may modulate actin filament mechanics and structure.

Analysis of Amyloid Fiber Gel by Transmission Electron Microscopy and Atomic Force Microscopy

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Alzheimer’s disease is characterised by the formation and deposition of amyloid fibers in the patient’s brain. Recently our laboratory reported that amyloid fibers continuously aggregate and form biogels. Lysozyme obtained from chicken egg white was used as a
model protein for the synthesis of the amyloid fibers that mimic those in human brain. Acidic pH and heat were used for inducing the conversion of lysozyme into amyloid fibers. Transmission Electron Microscope (TEM) and Atomic Force Microscope (AFM) were capable of imaging individual amyloid fibers. We applied TEM and AFM to examine the structure of the gel. When visualised under TEM, the amyloid fiber gels, that were crosslinked with glutaraldehyde, dehydrated and ultramicrotomed to thin sections (40-100 nm), showed the presence of pores or the spacing between fibers. Using AFM, we found better images of the amyloid fibers for the water diluted gels as compared to the undiluted ones. Our results suggest that the two nanoimaging techniques can provide valuable structure information when applied to the analysis of the amyloid fiber gels, especially in combination with different methods for sample preparations.

**Tissue Engineering and 3D Printing**

TE-1 Olin Life Sciences 2nd Floor Atrium

**Rationally Designing a Tissue Engineered Electronic Nerve Interface (TEENI) for Improved Bionic Prostheses**

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Microelectrodes are implanted into the brain, spinal cord, or peripheral nerves for bi-directional communication between the nervous system and external technology. However, even after decades of development, the resolution of signals that can be recorded or transmitted by microelectrodes has ultimately been insufficient for most neurotechnology applications. Prosthetic technology for amputees is one such application where neural interfaces are the bottleneck for communication, resulting in the lack of fine-tune prosthetic limb control and the inability to transmit accurate sensory information to amputee. Currently, there is a lack of understanding for the geometry, number, and arrangement of microelectrodes on a neural interface to selectively engage with individual nerve fibers with high resolution. Achieving a rational design for high-resolution neural interfaces faces two significant challenges: 1) fabricating a biocompatible neural interface that distributes microelectrodes throughout the nerve in a 3-dimensional fashion and 2) using accurate modeling methods to find an optimized arrangement of electrodes which maximizes the signal resolution. We have used tissue engineering, neuro-regeneration, and microfabrication techniques to develop a flexible neural interface that is integrated into the nerve. Our Tissue Engineered Electronic Nerve Interface (TEENI) can scale to 3 dimensions, enabling experimental studies of electrode arrangement for maximizing signal resolution. Additionally, we develop a method to simulate the electrochemical potentials transmitted between microelectrodes and peripheral nerves using a combination of biophysical and finite-element modeling software, which can be used to optimize electrode design.
Corneal epithelial cells require transplantation to restore ocular function (Bukowieski, 2017). Although keratoplasty is considered one of the most frequent types of transplantation, there is only an estimated 1 cornea available for every 70 needed (Gain, 2015). Three-dimensional printing has become an increasingly interesting field in biomedical sciences due to the success at which replicate organs, such as the human cornea, can be produced rapidly (Isaacson et al., 2018). Not only does this method of tissue engineering offer prospect in addressing the world shortage of corneal transplants, but also the growing demand for in vitro tissue regeneration studies. The corneal wound healing process is facilitated by various mechanisms involving cell death, migration, proliferation, and ECM remodeling. Upon injury, keratocytes are activated by transforming growth factor-β system to differentiate into myofibroblasts (Ljubimov and Saghizadeh, 2015). In our preliminary studies, a 3D culture of human corneal epithelial cells (HCEC) were grown in a VitroGel 3D matrix. HCEC were submerged in media for 7 days and were then allowed to grow by airlifting them on inserts to mimic the exposure of the epithelium in vivo. Live dead assays conducted on these cultures showed them to be more than 90 percent viable. In this study, we wish to investigate the tissue regeneration of a 3D bioprinted cornea matrix with human corneal epithelial cells and human keratocytes which will be 3D printed by using Inkredible printer (Cell Link, Inc) and collagen/alginate based bioinks.

Tissue “engineering” has not developed quickly for the following reasons: a) a lack of automation, meaning that students focus mostly on keeping cells alive rather than growing fully developed tissues capable of being transplanted; b) the time from a) prevents students from making enough samples to get statistically significant trends; c) taking measurements traditionally has meant that one takes the tissue out of incubation to see it, by which times cells are dying; d) a lack of ”patient monitors” to assess pH, glucose concentration, lactate concentration, dissolved oxygen concentration, temperature, liquid level, conductivity (salinity), cell mass, and in vivo imaging inside an incubated volume; e) insufficient mathematical modeling and experimental validation of
bioreactors; and f) the fiber diameter in 3D-printed objects is > 30 µm, whereas the fibers inside the body are typically 1-3 mm and cells range from 5-30 µm. This inconsistency in fiber diameter affects cellular adhesion biomechanics, which affects the cells’ ability to form tight junctions to form a leak-tight tissue, which in turn affects fluid transport and ultimately results in necrosis.

We are constructing a tissue engineering test bed with an array of 36 bioreactors in parallel, with all of the sensors listed in d) being Arduino-based and most being purchased from Open Aquarium and Atlas Scientific. Some of the concentration sensors are electrochemically-based and compatible with a CheapStat potentiostat. The primary competition is a group at Vanderbilt running eight bioreactors using LabSmith microfluidics hardware toward a simulation of entire organs-on-a-chip with automated feeding and with \textit{in vivo} imaging, but without all of the necessary instrumentation to do proper mass and energy balance accounting and with some side effects, often toxicity, from the dyes used for cell staining. After using a 3D printer to systematically dose suspensions of collagen, Bioglass, and crosslinking agent in controlled ratios, we will be able to control the mechanical, and ultimately, all properties of tissue engineered scaffolds. Once the scaffolds are prepared on glass slides, the scaffold-coated slides will be inserted into a custom-designed 3D-printable bioreactor, prior to systematic deposition of cells, glucose, dyes, etc. for maintenance, accounting, and imaging of tissues upon the scaffolds. Not only will we have the ability to mass produce candidate tissues at a fast enough rate to obtain statistically valid trends, by automating the \textit{in vivo} imaging and also developing a set of less harmful, reversible dyes, we will minimize the mundane, manual aspects of tissue culturing.

In the long term, to address the fiber diameter issue, 3D printing with submicron precision will be required. To that end, we are retrofitting an UpBox 3D printer. A set of servo motors will move the print head typical 3D printer distances. Because servo motors lack long term repeatability in returning to the origin, lasers will be used to estimate distances between reflectors spaced at calibrated distances to help estimate the positioning errors that Picomotor-based piezoelectric inchworm motors will be used to correct. In the short term, we are developing a single-axis system, but we have the equipment to eventually make this into a fully functional 3D printer with submicron resolution. Data acquisition and control use a combination of Arduinos and National Instruments (NI) hardware that are ultimately displayed in NI LabView.

TE-4 Olin Life Sciences 2nd Floor Atrium

\textbf{3D Printing with Submicron Precision}

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3D printers typically have a 20 x 20 cm printing area and use NEMA stepper motors to position the extruder with an accuracy of about 40 µm. These are currently used by
researchers in additive manufacturing to print scaffolds for tissue engineering, but tissue engineers would like to be able to print at a 1 μm resolution to have a higher control over the interaction between cells. We are demonstrating a proof of concept for a 3-dimensional positioning system with an accuracy in each direction of 1 μm or better using a combination of servo, stepper, and piezoelectric motors. While servo motors increase speed, servo motors struggle to return to home, or in x-y-z coordinates (0,0,0), consistently. To solve this issue, a laser and a piezoelectric motor will be used to reflect light off of transmission electron microscope (TEM) grids to optically determine the error between where the servo thinks is home position, and where home position actually is. After this error is found, the 24-bit servo motors can then apply the correction. Because we are using 24-bit motors instead of the standard 16-bit, our system could be as much as 2^8, or 256, times more precise, but at some point, other factors will limit the printing resolution.

Catalysis, Adsorption, and Thin Films

CA-1 Olin Engineering 2nd Floor Atrium

Nano-Architectured Binder-Free Manganese Oxide Electrode for Wearable Supercapacitor

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Integrating wearable energy storage devices into our daily outfits is becoming a trend these days since these devices can power the wearable electronics such as human body regulatory sensors. An integrated wearable energy storage device such as a supercapacitor should be safe in operation, light-in-weight and should have good charge/discharge capabilities. Flexible supercapacitors manufactured with electrochemically-active materials deposited onto flexible substrates such as carbon fibers attained great attention in the recent past, particularly for wearable devices. The present study includes the syntheses and characterizations of flexible and high-performance supercapacitors manufactured with nano-architected manganese oxides based flexible electrodes. Manganese oxides are low-cost transition metal oxides with excellent redox properties hence potential candidates for supercapacitor application. Highly flexible carbon fibers are used as substrates for the growth of nano-architected manganese oxides and electrochemical deposition is adopted for the electrode preparation. No binders are used during the electrode preparation hence the possible dead-weight of binders avoided. Nano-architected manganese oxides are characterized by scanning electron microscopy and Raman spectroscopy. The supercapacitor electrodes are tested by cyclic voltammetry, electrochemical impedance spectroscopy and
galvanostatic charge/discharge measurements. Nano-architected manganese oxide electrodes based supercapacitor exhibits a high areal capacitance of 997 mF/cm². The flexibility of the supercapacitor is tested by performing galvanostatic charge/discharge measurements while bending the supercapacitor at different bending angles and no capacitance degradation is observed at different bending angles. The present supercapacitor is a potential candidate, which can easily be integrated with wearable electronic devices.

CA-2 Olin Engineering 2nd Floor Atrium

Composition-Dependent Photocatalytic Activity of Pd/m-BiVO₄/BiOBr Nanosheets: Degradation of Polychlorinated Biphenyls

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Creating a p-n heterojunction in metal oxide semiconductors is an effective approach to enhance the electron-hole separation and improve the photocatalytic activity of materials. The ternary composite of Pd/m-BiVO₄/BiOBr has demonstrated substantial photocatalytic activity in the degradation of organic contaminants. To understand the correlation between the rational composition of the catalyst and the photocatalytic activity, we controlled the molar ratio of ammonium vanadate relative to bismuth nitrate in the reaction in order to tune the ratio of m-BiVO₄ to BiOBr. Changes in the morphology and composition of the material were characterized by scanning electron microscopy and energy dispersive spectroscopy. Pure BiOBr nanosheets were afforded from the reaction of bismuth nitrate and cetyltrimethylammonium bromide at 80°C. The gradual increase of the amount of ammonium vanadate added into the reaction resulted in the formation of the heterojunction composite of m-BiVO₄/BiOBr with a steady decrease in the ratio of BiOBr in the composite. Diffuse reflectance spectroscopic analysis of the composites showed a bandgap shifted from ~3.1 eV at 0 mol% vanadate to dual-band gaps of ~2.4 and 3.1 eV starting at 30 mole %. An m-BiVO₄ rich composite was achieved by increasing the ammonium vanadate to 100 mol% with a single band gap of ~2.45 eV. The change in the composition of m-BiVO₄/BiOBr demonstrated the significant influence on the photocatalytic degradation of rhodamine B. The amount of palladium nanoparticles was found to have a direct effect on the activity of the photocatalyst. The optimized Pd/m-BiVO₄/BiOBr ternary composite demonstrated high activity in the light-activated degradation of polychlorinated biphenyls. These results allow for an intuitive understanding of the material’s structure-related photocatalytic activity of metal oxide semiconductors.
Rapid Degradation of Persistent Organic Pollutants Using m-BiVO4/BiOBr and m-BiVO4/BiOBr/Pd Nanocomposite Photocatalysts

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Polybrominated diphenyl ethers (PBDEs) and polycyclic aromatic hydrocarbons (PAHs) represent two major classes of persistent organic pollutants that can have significant negative environmental impact. We recently reported on a composite material consisting of monoclinic BiVO4 and BiOBr decorated with Pd nanoparticles that was shown to perform as a tandem photocatalyst in the reductive dechlorination of polychlorinated biphenyls (PCBs). The present work applies this catalyst to the reductive degradation of BDEs. BDE-47, one of the most environmentally persistent of these pollutants, was completely and rapidly reduced to diphenyl ether. Solvent and scavenger studies were done to probe the mechanism of the reaction. The un-palladized m-BiVO4/BiOBr material was further shown to be an effective photocatalyst in the oxidation of PAHs. Here, a 20 uM aqueous solution of naphthalene was completely degraded within 4 h.

Quantum Chemical and Master Equation Study of OH + CH₂O → H₂O + CHO Reaction Rates in Supercritical CO₂ Environment

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Many chemical reactions can take advantage of supercritical CO₂ as solvent. But will this affect their kinetics? Here we predict the rates of the title reaction in CO₂ bath. Two mechanisms were investigated: one involves the hydrogen transfer in bimolecular complex alone (R1), and the other one includes CO₂ molecule in the reactive complex (R2). We applied DFT+D3 and ab initio CBS-M11 model chemistry levels to study potential energy surfaces and based on activation barriers ruled out the third mechanism where CO₂ participates covalently in the hydrogen transfer. CO₂ molecule stabilizes the transition state in mechanism R2 and reduces the activation energy from 3.04 to 0.16 kcal/mol. This indicates a possible catalytic effect of CO₂. We further applied Transition State Theory (TST), Rice-Ramsperger-Kassel-Marcus theory (RRKM) and solved master equations in steady-state approximation. We assumed equilibrium between reactants and
pre-reactive complexes (PRC) and calculated rates. The equilibrium constants for bimolecular PRC1 formation in R1 and trimolecular PRC2 formation in R2
\[ K_{\text{PRC1}} = \frac{[\text{PRC1}]}{[\text{OH}][\text{CH}_2\text{O}]}; \quad K_{\text{PRC2}} = \frac{[\text{PRC2}]}{[\text{OH}][\text{CH}_2\text{O}][\text{CO}_2]} \]
and the high-pressure rate constants \( k_{R1}^{\infty} \) and \( k_{R2}^{\infty} \) were computed by TST. Branching fractions for chemically activated isomerization were predicted with RRKM in order to account for pressure dependence. The unimolecular rate coefficients \( k_{R1} \) and \( k_{R2} \) were calculated by multiplying \( k^\infty \) and the forward reaction branching fraction. The reaction rates

rate R1 = \( k_{R1} \) [PRC1] = \( k_1 \) [OH][CH2O]; rate R2 = \( k_{R2} \) [PRC2] = \( k_2 \) [OH][CH2O]
and bimolecular rate constants were
\[ k_1 = k_{R1} K_{\text{PRC1}}; \quad k_2 = k_{R2} K_{\text{PRC2}} [\text{CO}_2] \]
so that \( k_2 \) depends on \( \text{CO}_2 \) pressure. Comparison found the catalyzed R2 mechanism is faster \((k_2 > k_1)\) at higher \( \text{CO}_2 \) pressures (300 atm) and lower temperatures \(<300 \text{ K}\), when pre-reactive complexes have non-negligible concentration. Therefore, this catalytic effect may be important for this reactive process in room temperature \( \text{CO}_2 \) solvent, but is unlikely to play a role during oxy-combustion.

CA-5 Olin Engineering 2nd Floor Atrium
**Computational Study of the Adsorption of Bimetallic Clusters**

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With the increasing demand for high energy density storage and the need to reduce \( \text{CO}_2 \) emission, Li-air battery is a potential option for future generation energy storage since it has the highest theoretical specific energy of any rechargeable battery. Although little is known about the reaction mechanisms that occurs in the battery, progress in Li-air battery technology requires the basic understanding of the charge and discharge processes. It was shown that small silver cluster can indeed control the rate of \( \text{LiO}_2 \) formation. The gap near the fermi energy was shown to control the oxygen reduction, an important reaction for \( \text{LiO}_2 \) formation [1]. Controlling the gap would ultimately control the rate of \( \text{LiO}_2 \) formation. One can vary the size of the cluster to vary the gap, however, this “knob” provides limited variance in the gap. Alloying, in combination with size variation offer a much wider control of the gap, hence the \( \text{LiO}_2 \) formation. Here, we investigate the effect of \( \text{Pd}_3\text{M}_2 \) (where \( \text{M} \) changes from Ag, Au, Co, Cu, Mn, Ni, Pt, and Ru) sub-nanometer transition alloy-clusters on the rate of oxygen reduction at the hydroxylated alumina coated graphitized carbon cathode during discharge process. Using Density Functional Theory (DFT), we determined the most stable geometry of the bi-metallic clusters and calculated the binding energies of these clusters on the alumina substrate which ranges from 0.4 to 2.5 eV, depending upon the composition of the alloy-cluster, its orientation and the adsorption site. We also find that Pd atoms bind strongly with the substrate oxygen atoms with a short bond-length of about 2.2 Å. We explore how the gap between
the HOMO of the cluster and the Fermi energy of the system varies as function of elemental composition. These preliminary results will open the door for more systematic studies of alloy clusters of different size and stoichiometry.

1. J. Lu et al, Nat. Comm. (2014); DOI: 10.1038/ncomms.5895

CA-6 Olin Engineering 2nd Floor Atrium
Evaluating Defect Formation in Hexagonal Boron Nitride by Mechanochemistry for Heterogeneous Catalysis

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The production of metal-free heterogeneous catalysts for reactions such as CO₂ capture and conversion is highly desired to achieve a more sustainable societal development. Previous studies have shown that defect laden hexagonal Boron Nitride (dh-BN) can be used for hydrogenation of catalytic reactions, in which defects including vacancies or edges play the role of catalytic active sites. However, a comprehensive study of the connections between ball milling process conditions, h-BN structure and the resulting catalytic properties remains uncharted. Such an understanding would accelerate the development of more optimal ball milling processes for economical and effective large-scale production of dh-BN.

In this study, we investigate how milling parameters, including composition of the bearings, number and size of the bearings and milling duration, affect the production of active sites and the subsequent molecule uptake for catalytic reactions. We compare the mass uptake to the morphological and structural properties of dh-BN. Based on the comprehensive sets of parameters, we identify some optimized conditions for defect creation which can serve as our benchmark. Lastly, we evaluate the performance of the dh-BN obtained for CO₂ and propene capture.

CA-7 Olin Engineering 2nd Floor Atrium
Synthesis of Fluorinated Tungsten (VI) Oxo-Alkoxide Precursors for the Chemical Vapor Deposition of WOₓ Films and Nanostructures

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Tungsten oxide (WOₓ) has been shown to be a promising material for lithium-ion batteries and gas sensors. Chemical vapor deposition (CVD) is an attractive technique for producing conformal and uniform WOₓ materials of various morphologies. Fluorinated tungsten oxo alkoxide complexes with 1,2-diketonate/1,2-ketoesterate ligands were synthesized, characterized and utilized as precursors for aerosol-assisted CVD of WOₓ.
materials. The morphology of the deposited films was dependent on growth temperature. Amorphous deposits were obtained at lower growth temperatures whereas nanowires were grown at higher temperatures. Effects of fluorination in the alkoxide and in the ß-diketonate/ß-ketoesterate ligand will be discussed.

CA-8 Olin Engineering 2\textsuperscript{nd} Floor Atrium

\textbf{Adsorption of DNA and RNA Nucleobases on Graphene}

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We explore the adsorption of DNA and RNA nucleobases on graphene sheets with and without defects using Density Functional Theory. To account for the van der Waals interaction, we employ the \textit{optB88b-vdW} functional. We find strong physisorption between graphene and the nucleobases, which is both moderately sensitive to the specific nucleobase and weakly sensitive to graphene's defects. Specifically, our exploration includes two common defects: divacancy and stonewall. We thus demonstrate a useful hierarchy for nucleobase adsorption energies and show how this hierarchy is sensitive to the different imperfections of graphene. Additional geometric data is also supplied, such as adsorption heights and buckling. By analyzing nucleobases on and around these defects, as compared to perfect graphene, we provide supportive evidence for the application of DNA and RNA sequencing technologies, as well as nanoscale molecular electronics in general.

CA-9 Olin Engineering 2\textsuperscript{nd} Floor Atrium

\textbf{Micromachined 3D Microelectrode Arrays (MEAs), Functionalized Through Nanomaterial Electroplating for Tissue Culture in Space}

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MEMS sensing technologies are important components in several consumer, biological and Internet of Things (IoT) applications and are becoming almost as ubiquitous as Integrated Circuit (IC) components [1]. In spite of this ubiquity, microsensor prototyping in deep space is non-existent. Additive manufacturing technologies such as 3D printing, can potentially fill the void for developing and creating microsensors during exploratory missions since 3D printing is already being implemented to fabricate macro-scale tools in zero gravity conditions [2]. Deep space exploration missions, such as the Mars Colony, will undoubtedly make use of custom biological culturing devices to study tissue, both with existing and new biosystems in this extraterrestrial environment [3]. We have recently introduced the concept of "Makerspace Microfabrication" for biological microdevices that is centered around cost effective and benchtop production of micro/nanosensors for biological applications minimizing the need for cleanrooms and bulky equipment [4]. In this paper, we report the development of a biological
microdevice, a 3D Microelectrode Array (MEA) utilizing a combination of "Makerspace Microfabrication" and soft lithographic techniques that can potentially be employed in space. Further, we demonstrate selective definition of nanomaterials atop these microelectrodes for elevating the effectiveness of these devices by creating more consistent electrode data, and allow 3D electrodes to more effectively probe and record deeper into tissue samples.

The 20mm x 20mm base structure of the device was 3D printed to be 1mm thick. A shadow mask was CNC micromilled from 50 µm stainless steel, and then was used to define the conductive traces with ink casting of 50 µm thick silver-ink. Stainless steel 3D microelectrodes were micromilled from a 1.8mm x 1.8mm base to be 400 µm (width) and 430µm (height) after manual conversion from 2D to 3D. A configuration of 3x3 electrodes with a pitch of 2 mm was developed. These needles were attached with silver-ink to the landing pads on the 3D printed device and cured at 60°C for 24 hours. The dielectrically tunable elastomer Polydimethylsiloxane (PDMS) was used for insulation, and encapsulation [5]. PDMS was drop cast to a target thickness of 400 µm. Wicking of PDMS in the Z-axis resulted in reducible microelectrode sizes. Lastly a printed culture well of 15 mm x 15 mm x 500 µm was attached, and cured at 60°C for 4 hours.

Full spectrum impedance of the 3D microelectrodes with an average tip radius of curvature of 200 µm, measured 2.77 kOhm and -23.9° at 1 kHz (impedance and phase respectively). For comparison, the smaller 3D electrodes with a tip radius of curvature of 70µm resulted in values similar to literature-reported microelectrode characteristics of 45.49 kOhm and -33.31° at 1 kHz [6]. Cyclic Voltammetry scans of steel were performed at standard intervals on the larger electrodes, and the resulting graphs were collated, from which the capacitance value of 2.79 µF was extracted. Nanomaterial electroplating improves the properties of these electrodes by reducing the impedance, and creating suitable cell-surface adhesion-promotion sites. With the comparable properties to commercial MEAs, and the fabrication method ideal for tissue studies, this work could be invaluable for extraterrestrial tissue culture device manufacturing.

CA-10 Olin Engineering 2nd Floor Atrium

**Reliable Miniature Implantable Connectors with High Channel Density for Advance Neural Interface Applications**

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As neural-interface technology has advanced to higher channel counts and higher channel densities to improve stimulation targeting and to minimize side effects, the benefits derived by patients have also typically increased. Leading examples would be such as nerve interfaces used in brain-machine-interfaces (BMI) to restore sensory and motor function, nerve interfaces for sensing and controlling state-of-the-art prosthetics limbs, and even next-generation deep-brain stimulation (DBS) systems. However, current implant-packaging technology of such high channel counts neural interfaces (>=100) are
permanently bonded (i.e., soldering, conductive epoxy bonding, thermocompression bonding etc.), which eliminates the ability to disconnect the interface from implanted electronics to perform needed battery changes, replacement, or upgrades without disturbing interfaces that have become integrated into delicate and sensitive neural tissue. In our work we seek to eliminate this barrier by greatly advancing implantable connector technology, which is used to link neural interfaces with packaged electronics. We use micro and nanofabrication processes to produce microelectrode arrays and leads that will be attached to high-channel-density microscale feedthrough arrays by high-channel-count microscale connectors. We will maximize the channel density while yet maintaining sufficient channel-to-channel isolation.

CA-11 Olin Engineering 2nd Floor Atrium

Optimization of Makerspace Microfabrication Techniques and Materials for 3D Printed Microelectrode Arrays

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For creating in vitro models of biological cells, reliability, biocompatibility and disposability are important factors for planar or 2D Microelectrode Arrays (2D MEAs). 2D MEAs are used as reliable devices for interfacing between electronic circuits and biological cells in these models. Conventional fabrication of 2D MEAs in prevailing literature involves long timeframes, has requirements for cleanroom and backend fabrication technologies such as packaging, and the MEAs need to be assembled from multiple parts to obtain the final packaged device. This is less than ideal since disposability is impeded when the device fabrication cost, and consequently end product cost, is too high. For MEAs to be “used and tossed”, manufacturing should be moved from the cleanroom to makerspaces. Makerspace fabrication involves cheaper equipment, advanced prototyping capability, and is more accessible to users from various backgrounds including science, engineering and even art. The main drawback is the precision available in makerspace fabrication is not as high as cleanroom microfabrication. In order to enable makerspace fabricated MEA devices to be comparable to conventional MEAs, the devices must be optimized to have similar electrical, electrochemical and biological characteristics. This work presents a makerspace microfabricated MEA having a 6x6 electrode density with a roadmap to a 8x8 grid of microelectrodes, which is the state of the art in cell-based electrophysiology. The fabricated device does not require assembly of multiple parts and the cell culturing well is monolithically 3D printed along with the device base structure. The metallic functionality of the MEA has been added by silver ink casting followed by pulsed electroplating of gold or platinum. The pulsed plating process is performed using a software executable created specifically to allow for adjustment of all the necessary process parameters involved in electroplating. Confined precision spin coating (CPSC) of SU-8 acts as a biocompatible insulation layer which can be selectively
laser micromachined to expose the electroplated microelectrodes of either nano-porous Platinum or nano-Gold with 50 μm x 50μm openings. The fabricated MEAs have an average 1 kHz impedance of 32kΩ/15kΩ with a double layer capacitance of 10.2μF/7.82μF for platinum/gold which is comparable to the state-of-the-art commercially available 2D MEAs.

CA-12 Olin Engineering 2nd Floor Atrium

Characterizing the Induced Stress from the Infiltration of Volcanic Ash into a 7 Wt.% Yttria Stabilized Zirconia Thermal Barrier Coating by Means of Raman Spectroscopy and Nano-Mechanical Spectroscopy

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Volcanic ash (VA) poses a threat to the operation of aircrafts around the world due to the thermochemical and thermomechanical degradation they cause on thermal barrier coatings (TBC). The thermomechanical degradation begins after the infiltrated molten VA cools, producing a gradient in stiffness across the TBC. The thermochemical degradation arises from the phase destabilization caused by VA in the TBC. This, in turn, leads to a volume expansion that can be detrimental to the TBC. Both forms of degradation lead to a build up of stress in the coating, which eventually leads to coating failure.

In this study, our primary interest is to study stress in terms of the shift in characteristic IR bands of the TBC using Raman confocal spectroscopy. In addition, finer details of the stress distribution, in sites with early signs of material degradation, will be investigated with nanomechanical spectroscopy. A method called Lorentz contact resonance (LCR) imaging will be used to determine stress distribution in the coating, with nanoscale lateral resolution. We will investigate whether connections can be established between the results from Lorentz contact resonance to validate the stress calculated with Raman spectroscopy. All measurements will be carried out on 7 wt.% yttria stabilized zirconia (7YSZ). Samples with VA ingestion annealed at a temperature of 1200°C for annealing times of 10 minutes, 20 minutes, 30 minutes, and 60 minutes will be compared.

CA-13 Olin Engineering 2nd Floor Atrium

Economic and Environmental Feasibility Assessment in Favor of Nanoparticle-Based Automotive Clear Coat

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The introduction of new technologies in manufacturing is often accompanied by severe capital costs due to the need to update or change the equipment required for the manufacturing process to begin. However, not all technologies may need this adjustment. In this paper, first-principle-based computer modeling strategies are applied to evaluate the economic and qualitative feasibility of introducing nanoparticle-enriched clear coats using the conventional curing ovens used in coating operations today. Using energy rates in the State of Michigan, the theoretical cost model can be used to approximate the economic net gain of use of nanopaints due to performance differences in the curing process. As such, the study approximates the coating process to the curing operation alone, taking an in-depth look at the repercussions of altering the energy use of the curing ovens to better suit the quality requirements set by the automotive industry. It is demonstrated that using the models provided, it is possible to predict that the introduction of nanopaint should not cause severe net loss per unit compared to conventional paint, and that the current industrial settings may yet still be optimized to improve the quality and quantity of units per shift.

CA-14 Olin Engineering 2nd Floor Atrium
Efficient Energy Storage Device using Zinc Oxide Nanopillars

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Fast growing flexible and wearable electronic industries necessitates extremely tiny and flexible energy storage devices that can power such devices. Batteries and supercapacitors are the two main choices. The present lithium-ion batteries are bulky as well as not safe due to the lithium-based electrodes and the flammable electrolytes used in their manufacturing. Supercapacitors, on the other hand, exhibit good power density but lower energy density. If the supercapacitors are manufactured with environmentally non-hazardous electrode materials along with aqueous electrolytes, it will have great potential in applications such as integrated wearable devices. Zinc oxide (ZnO) is a commonly available material, which is safe, environment-friendly and of low cost. The present study proclaims the development of an efficient, safe supercapacitor using ZnO nanopillars based electrodes and aqueous electrolytes. The ZnO nanopillars are synthesized on ITO substrate by wet-chemical method with high surface coverage and density. The ZnO nanopillars are characterized by scanning electron microscopy and X-ray diffraction. Symmetric supercapacitors are prepared with ZnO nanopillars based electrodes and tested by cyclic voltammetry, electrochemical impedance spectroscopy and galvanostatic charge/discharge measurements. The said supercapacitor exhibits excellent electrochemical behaviors and is an efficient candidate in the field of energy storage devices.
CA-15 Olin Engineering 2nd Floor Atrium

Simulated Space Weathering Effects at the Surface of Thin-Film Aluminosilicate Model Regolith

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A fuller comprehension of solar radiation's impact on the surfaces of the airless bodies can provide insights regarding our star-systems formation and ongoing evolution. More specifically, a detailed study of space-weathering effects on atmosphereless bodies can lead to improved understandings of the physical and chemical evolution of planetary systems. To this end, we are actively investigating space-weathering mechanisms, particularly solar-wind effects on volatile-rich (e.g. water) bodies under laboratory conditions. Our primary ambitions are to better understand how surface chemistry and materials properties depend on variation in radiation conditions.

To carry out this work, our group is leveraging established thin-film recipes to generate and characterize a well-ordered regolith simulant within our multi-purpose UHV system (1 X 10^-10 Torr). In this case, our targeted system consists of well-ordered, and atomically-planar aluminosilicate (Al<sub>x</sub>Si<sub>y</sub>O<sub>z</sub>) sheets. The Al<sub>x</sub>Si<sub>y</sub>O<sub>z</sub> film will be grown on ruthenium (Ru) (0001) substrates via sequential physical vapor deposition of Al and Si. The Ru is cleaned with repeated Ar⁺-sputtering/annealing. XPS and He⁺ ISS have been used for cleaned Ru to ensure surface cleanliness (no detectable contaminants) and LEED for long-range crystal order (sharp 1x1 hexagonal pattern). Initial silica (SiO<sub>2</sub>) thin-film growth has been employed to establish both coverage and oxidative crystallization temperature. Using the calibrated Si flux and relative XPS sensitivity factors, Al flux will be calibrated, and both will be used to create bilayer Al<sub>x</sub>Si<sub>y</sub>O<sub>z</sub> film. In addition to the XPS, ISS and LEED, atomic scale confirmation of planar/crystalline silicate layers will be provided by STM analysis.

The next step will be the solar wind processing of model regolith. To do so, the model regolith will be irradiated with ions and electrons using the radiation facilities, such as, an electron gun, an ion gun, and an X-ray source. We aim to carry out TPD experiments on aluminosilicate films with ice-covered and bare surface. The effects of energetic particles on aluminosilicate thin-films will demonstrate the role of impinging electrons on the degree of hydroxyl sequestration. By tracking the energy, flux, and ice-layer depth dependencies on this process we seek to better understand the mechanisms and parameter-space through which this isolated form of space-weathering may evolve such interfaces and potentially integrate water feedstock into the mineral composition of near surface-layers through hydroxylation. The atomic scale experiment of silicate minerals irradiated with high energetic particles under a well-controlled UHV chamber will ease to analyze and quantify the parameters of radiation chemistry. In addition to understanding the mineral processing under radiation mechanism, this study will also enlighten us with the idea about potential hazard from space radiation on future robotic or human exploration missions.
Sensors

SE-1 Olin Engineering 3rd Floor Atrium

**Bioluminescent Protein-Inhibitor Pair in the Design of a Molecular Aptamer Beacon Biosensor**

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The molecular aptamer beacon has a hairpin structure and consists of two regions: the loop region and the stem region. It includes two fragments: the aptamer sequence, a short sequence complimentary to the aptamer with a fluorophore and a quencher covalently attached to each end.

Our laboratory has shown that one end of a molecular beacon can be labeled with a bioluminescent protein and the other end with a quencher and the close proximity of the quencher to the bioluminescent protein quenches the bioluminescence emission due to bioluminescence resonance energy transfer (BRET) in the absence of the target in the closed conformation of the stem-loop probe. Upon binding of the analyte to the loop region of the stem-loop probe induces a conformational change that goes from a closed loop to an open conformation resulting in the bioluminescence signal. This conformational change due to the hybridization of the molecular beacon with the target of interest can be used for many applications including sensing.

Our laboratory has envisioned an alternative approach to reduce the background noise through the use of an inhibitor instead of a quencher. The inhibitor bears structural similarity to the native substrate of the bioluminescent protein, binds to the enzymatic pocket of the bioluminescent protein and prevents the biochemical reaction when the stem loop probe is in the closed conformation.

For this study, we have conjugated a molecular aptamer beacon to a bioluminescent protein, *Gaussia luciferase* (GLuc). The molecular aptamer beacon has two end functionalities for the bioconjugation steps: an azide functionality at the 3’-end, and a carboxyl at the 5’-end. The bioconjugation of GLuc was achieved through azide-alkyne click chemistry and the bioconjugation of the inhibitor through EDC/NHS chemistry. Using this stem-loop probe, an assay was developed to detect target analyte, interferon-γ. The assay was validated for its accuracy and precision as well as the applicability in human serum.

SE-2 Olin Engineering 3rd Floor Atrium

**Zinc Finger Proteins for the Detection of Pathogenic Bacteria**
The rise in food recalls, water contamination after natural disaster, and disease outbreaks caused by bacteria has highlighted the need for assays that can quickly detect these pathogens. More specifically, there has been an increase in food related outbreaks related to pathogenic *E. coli* strains. Current detection methods are time-consuming and often require expensive equipment and trained personnel. Results from current methods can take sometimes over a week to be received which is not ideal when faced with an outbreak. Zinc Finger Proteins (ZFPs) can bind to DNA with high specificity and affinity. Each individual finger domain recognizes three or four base pairs and typically two or three fingers together are needed to bind a specific sequence (1). This characteristic makes these proteins a good candidate to use in a nucleic acid assay. By appending a sequence that is recognized by a ZFP (Z-tag) to a product during amplification we can create a capturing mechanism for DNA that can be applied assays for nucleic acid detection. Previously, our lab demonstrated this through the detection of *Mycobacterium tuberculosis*. Currently, we have combined this capturing technique with an isothermal amplification system in the interest of on-site point of care diagnostics. Using strain O157 we were able to indicate that we can use ZFPs to detect a strain specific region of the pathogenic strain. Through the targeting of genomic regions that are strain specific, we aim to develop a multiplexed test that can differentiate between several strains to provide quicker insight on the bacteria causing a potential outbreak in a manner that is rapid, specific, and able to be done on-site.

membrane. The binding constant of this protein to its substrate is in the micromolar range, and GBP is highly selective and sensitive towards glucose, however, GBP also binds galactose to a lesser degree. In contrast with enzyme-based sensors, GBP-based biosensors are reagentless, which is an improvement from glucose oxidase-based sensors that has oxygen as a limiting reagent. GBP does not alter the structure of glucose; therefore, this protein preserves its activity for a long time even in solution. The GBP structure contains two globular domains that are connected by a short hinge region; upon glucose binding, GBP undergoes a large conformational change, which is the basis for converting this protein into a biosensor. GBP contains a centrally located binding pocket which has one of seven phenylalanine (PHE) residues and one of five tryptophan (TRP) residues. The non-natural amino acid (NNAA) 3,4-dihydroxyphenylalanine (L-DOPA), was chosen to design a new GBP protein as L-DOPA has similar structure to PHE. L-DOPA contains a catechol moiety that participates in a quasi-reversible, 2-electron redox process. The resulting modified GBP could exhibit an electrochemical response, and we detect change in electrochemical behavior of incorporated L-DOPA residues. Therefore, electroactive GBP based biosensor can be potentially used for the selective electrochemical detection of glucose. To the best of our knowledge, this represents the first report of electrochemical detection of glucose via inherently electroactive amino acids incorporated into the primary sequence of a protein.

SE-4 Olin Engineering 3rd Floor Atrium

Highly Sensitive Lactate Sensors Based on Carbon MEMS (CMEMS)

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L-Lactic acid is one of the important metabolites produced during the anaerobic phase of glycolysis, making its precise determination highly important in various fields such as clinical diagnosis, sport, and military activities. Lactate plays a crucial role in several areas of human health, including heart failure, hepatic dysfunction, shock, respiratory insufficiency and systemic disorders. In sports medicine, knowledge of optimal blood lactate levels is vital to ensuring the maximum performance of an athlete during intensive exercise and endurance-based activities.

Various methods have been developed for determining lactate levels, such as optical, nuclear magnetic resonance, liquid chromatography, fluorimetry, and amperometry. Among these methods, electrochemical ones possess advantages such as simple instrumentation, low detection limit, and wide dynamic range, as well as high selectivity and stability. A Carbon-microelectromechanical system (C-MEMS) is one in which Carbon is synthesized through pyrolysis of micro patterned photoresist polymer in an oxygen-free environment under high temperatures. Carbon possesses various remarkable properties such as a wide electrochemical window, low non-specific adsorption of biomolecules, excellent biocompatibility, and low cost. Furthermore, carbon-based materials exhibit good electrical conductivity, as well as good tolerance toward biofouling. The surface of the carbon can be functionalized efficiently via various physical,
chemical, or electrochemical treatments. C-MEMS devices circumvent the major drawbacks associated with commercialized screen-printed carbon electrodes such as low resolution and miniaturization.

We developed an electrochemical C-MEMS-based sensing platform to detect L-Lactic Acid. The sensing platform of the biosensor—interdigitated carbon micro fingers—was synthesized by pyrolyzation of photo-patterned photoresist polymer in oxygen-free and high-temperature conditions. The surfaces of the fingers were functionalized by an oxidation pretreatment technique involving oxygen reactive ion etching (RIE) to form –COOH on glassy carbon. Taking advantage of having high concentrations of this carboxylic group on the surface of the carbon, we immobilized Lactate Oxidase (LOx) on the surfaces of the interdigitated carbon micro fingers without any other surface pretreatments. We employed various analytical characterization methods such as Fourier-transform infrared spectroscopy (FTIR) and Scanning Electron Microscopy (SEM) for material characterization. Sensing capabilities were measured by cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS). The carbon capacitive sensor demonstrated detection of lactate over a wide dynamic range of 50 nM - 5 mM for the electrode area of 0.5×0.5 cm². The sensitivity of this linker-free lactate sensor was found to be 40 nM /cm², making it the first carbon capacitive L-lactate sensor with such high sensitivity.

SE-5 Olin Engineering 3rd Floor Atrium
Transdermal Alcohol Sensor for Monitoring BAC

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A micro-fuel cell sensor has been demonstrated for transdermal monitoring of blood alcohol content (BAC) in real-time. The fuel cell sensor can detect wide concentrations of alcohol, including physiological range (0.1 mg/dl to 100 mg/dl). A multivariate calibration model, principal component regression (PCR) was implemented to reduce standard errors in sensor measurements. The BAC values from the fuel cell sensor (30.2 to 48.94%) was substantially closer to the theoretical values compared to the readings from a breathalyzer (51.56 to 272.72%). The results from human studies show that the device can be used for accurate detection of BAC via transdermal measurements.

SE-6 Olin Engineering 3rd Floor Atrium
Non-Invasive and Real-Time Monitoring of Drowsiness Using Solid State Sensor Array Targeting Breath Biomarkers
The operation of vehicles while sleep deprived or drowsy is conventionally understood to lead to a greater risk of accidents. In detail, accidents involving drowsy drivers are responsible for an estimated 5,000 fatalities each year, with overall expenses from damages and loss of revenue arising from these accidents costing over $100 billion each year. Given the staggering human and economic cost that sleepy driving entails, we describe a novel real-time, non-invasive drowsiness monitoring system that acts on the presence of biomarkers in a person's breath. By employing arrays comprised of solid-state sensors tuned for biomarker identification, we show that it is possible to predict drowsiness by using an individual's breath profile. Using a matched-pairs design in which sleep-deprived subjects are compared to the same subjects while well-rested, we show that sensor readings are significantly different between the breath profiles of both groups. In addition, we include data from our latest test simulations performed at the BMW Research and Development Facility in Munich, in which tired drivers were tested in a state-of-the-art driving simulator designed to replicate real-world driving conditions with minimal risk to the driver and others.

Carcinogen Exposure Monitoring in Firefighters using Passive Sampling Technology and Sensor Arrays

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The presence of potentially carcinogenic compounds in the work environment poses a substantial threat to the long-term health outcomes of those individuals whose careers may compromise them to carcinogen exposure. Firefighters and first-responders comprise one such demographic that may be adversely impacted through their exposure to toxic volatile organic compounds (VOCs), specifically polycyclic aromatic hydrocarbons (PAHs). It is well documented that firefighters suffer a significantly greater incidence of cancer compared to the general population as a result, firefighters may benefit from the use of monitoring technologies to determine the type and intensity of carcinogen exposure. Silicone wristbands are treated with solvents to increase their ability to adsorb volatile compounds and are deployed to capture compounds present in the ambient air surrounding firefighters in various environments, including during fire responses. Compounds adsorbed to the wristbands are then extracted with solvent, concentrated, and analyzed using GC-MS. In addition, solid-state sensors are demonstrated to be capable of real-time ambient exposure measurement. Here, we showcase recent progress in the use of silicone-based passive sampling technology and solid-state sensor arrays as a means of
cataloging the route and intensity of VOC exposure in firefighters pre- and post-Hurricane Irma.

**SE-8 Olin Engineering 3rd Floor Atrium**  
**Zinc Oxide Nanoflakes Based Immunosensor for Ethyl Glucuronide (EtG) Detection**

Fahmida Alam, Shahrzad Forouzanfar, and Prof. Nezih Pala, Florida International University

Continuous monitoring of alcohol detection is imperative for the prevention of addiction, accidents, and undesired interactions with medicines as well as for point of care monitoring. The cutting-edge technologies are mostly focused to detect alcohol from the breath (e.g. breathalyzer), which is not compatible for the real-time monitoring. The relationship between the blood and breath alcohol concentrations and the improvement of the detection techniques of alcohol biomarkers from the sweat render an opportunity for continuous and for point of care monitoring. Due to its prolonged existence in sweat, Ethylglucuronide (EtG) is considered as one of the most promising biomarkers for alcohol detection. We report on label-free highly sensitive electrochemical immunosensor for the detection and quantification of EtG based on sonochemically synthesized two-dimensional (2D) zinc oxide (ZnO) nanoflakes (NFs) on flexible Au-coated polyethylene terephthalate (PET) substrate. Highly sensitive detection of EtG using cyclic voltammetry (CV) is achieved by immobilizing EtG antibody on the as-synthesized sensing electrodes of ZnO NFs.

**SE-9 Olin Engineering 3rd Floor Atrium**  
**Nanopore/Nanoelectrode Multifunctional Nanopipette for Probing Single Nanoparticle (NP) Events**

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Nanopore sensing-based technologies have made significant progress for single molecule and single nanoparticle (NP) detection and analysis. To improve the sensitivity and selectivity of the nanopore sensing methods and to add new functionality to the nanopore devices, it is desirable to detect single entity events using simultaneous multimode detection methods. In this presentation, I will show that two electric sensing modes could work cooperatively to detect the motion of nanometer size particles in solution by a multifunctional nanopipette. By combining current and potential measurements, it is possible to detect events such as collisions at the nanopore, collisions at the nanoelectrode, and the nanopore translocations. Moreover, utilizing the information of potential and its derivative during single NPs collisions at the CNE, we can differentiate the NPs based on their properties. The nanopore-nanoelectrode nanopipette is suitable for the highly sensitive, label-free analysis of protein, virus and various biological and synthetic nanoparticles.
Split Deoxyribozyme Sensor for Detection of a Highly Structured Highly Modified Nucleic Acid: Transfer Ribonucleic Acid

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Complementarity of a nucleic acid target to a probe forms the basis for many nucleic acid detection methods. However, the probe performance is affected by the affinity of the probe to the complementary target region. In many cases, the target possesses secondary structures that the sensor will have to overcome in order to bind. A potential solution to this problem is to decrease the energy of the probe-target associated state by increasing the length of the probe. However, increased affinity would decrease target recognition selectivity. An ideal sensor utilizing a hybridization probe should be able to overcome the energetics of intramolecular secondary structures without compromising selectivity.

This work utilizes the sequence for the catalytic core of the most efficient RNA-cleaving 10-23 deoxyribozyme (Dz) split in half. Each half contains a portion that is complementary to a nucleic acid target of interest (analyte-binding arm), as well as a portion that is complementary to a signal reporter molecule, and is inactive unless the two deoxyribozyme halves are brought in close proximity. The signal reporter is recognized by the split 10-23 Dz and cleaved at a ribonucleotide cleavage site. The reporter contains a fluorophore and a quencher at the opposite sides from the reporter cleavage site, so that the fluorescence of the intact reporter is minimal. In the presence of the analyte, the Dz catalytic core is formed, and the reporter molecule is cleaved, resulting in an increase in fluorescence due to physical separation of the fluorophore and the quencher. The split nature of the probe allows for increased affinity of the probe to the target without reduction of the selectivity. The two halves of the probe need to simultaneously bind the analyte for the signal to be observed. Therefore, by lengthening one of the binding arms to overcome the energy of the secondary structures, while keeping the other arm short to ensure high selectivity, it is possible to fine-tune the probe performance and balance affinity-selectivity dichotomy.

Here, we demonstrate the use of the split Dz sensor design with yeast phenylalanine transfer RNA (tRNA^{Phe}) as a model highly structured target. While many nucleic acids contain intramolecular secondary structures, tRNAs also have several stable stem-loop elements that interact to fold into an intricate tertiary structure, which further enhances tRNA stability. Temperature dependence, reaction kinetics, and limit of detection studies were performed with tRNA^{Phe}, as well as its synthetic DNA mimic and RNA transcript to demonstrate the versatility of the split Dz sensor.
Interfacial Behaviours in a Nano-Domained Polymer-Derived Ceramic for High-Temperature Sensing Applications

Hao Li and Prof. Linan An

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A nano-domained polymer-derived ceramic was synthesized with its microstructure and frequency-/temperature-dependent dielectric properties and impedance behaviors characterized. A major change in its dielectric constant is observed, most probably caused by a strong interfacial polarization process. The interfacial polarization induced dielectric loss peaks were found to move to higher frequencies with either increasing pyrolysis temperature or with rising testing temperature. The peak-shifting effect of the pyrolysis temperature is mainly attributed to the dominating increase in the conductivity of the nano-sized free carbon phase, causing shortened relaxation times. Testing temperature, in a similar manner, accounts for the rise in the conductivity of the free carbon phase thus the decreased relaxation times, with the relaxation process follows a band-tail hopping mechanism within the nano free carbon phase. Impedance analysis reveals two relaxation processes stem from the bi-phasic nature of the material, and also confirms the presence of accumulated space charge. Electric modulus, dielectric loss and impedance results support the hopping type of conduction mechanism between localized states due to interfacial polarization. The findings provide valuable information for the precision control of the electrical and dielectric properties of PDCs for high-temperature sensing applications.
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Zetasizer Nano ZS
Performance, simplicity, versatility.
The world’s most widely used system. It is used for the measurement of protein size, electrophoretic mobility of proteins, zeta potential of colloids and nanoparticles, and optionally the measurement of protein mobility and microrheology of protein and polymer solutions. The high performance of the Zetasizer Nano ZS also enables the measurement of the molecular weight and second virial coefficient, $A_2$, of macromolecules and $k_D$, the DLS interaction parameter. The system can also be used in a flow configuration to operate as a size detector for SEC or FFF.

Zetasizer Ultra
Advance with Confidence
The new Zetasizer Ultra is our most advanced system for the measurement of particle and molecular size, particle charge and particle concentration, and represents the most intelligent and flexible instrument in the Zetasizer range. This flagship instrument enjoys all the benefits afforded by ZS Xplorer software, in terms of ease of use, analysis speed and data confidence, and also offers two unique measurement capabilities: Multi-Angle Dynamic Light Scattering (MADLS®) and Particle Concentration, to offer even greater insight into your samples.
3Flex TCD Overview

Perform High Resolution TPR, TPO, and TPD Experiments

Micromeritics 3Flex, the industry’s most highly recognized and preferred instrument for physisorption and chemisorption, has been made even more powerful. With the addition of the integral thermal conductivity detector, dynamic chemisorption analyses are available to the user providing the ability to perform temperature programmed reduction (TPR), oxidation (TPO), desorption (TPD), and reactions (TPRx). The TCD option provides the capability to investigate temperature dependence of specific adsorption or desorption process profiles for catalyst and adsorbents, as well as pulse chemisorption in one, very capable, instrument.

Surface Area and Porosity Analyzer

The ASAP 2460 Surface Area and Porosity Analyzer incorporates a unique expandable system designed for high-performance and high sample throughput. The base ASAP 2460 is a two-port master control unit. For more throughput, additional two-port units can be connected to the master unit expanding the system to either a four-port or six-port analyzer. The instrument also includes intuitive MicroActive software that combines user-defined reports with the ability to interactively evaluate isotherm