greenUp

2013 Michigan Green Chemistry and Engineering Conference

Designing a Sustainable Michigan

October 23-24, 2013

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"In the same way that these chemicals and materials can be designed so they're of a particular color, whether it's red or blue, or whether a plastic is brittle or flexible, you can now have the beginnings of how to design these materials so they're not going to be toxic… The good news is that this is something being practiced by some of the most visionary companies, some of the real leaders in industry across many sectors. The better news is that all of those accomplishments so far represent a small sliver, a tiny fraction of the power of the potential of green chemistry. So for every one process or product that's being reinvented using green chemistry and green engineering, there may be a hundred or a thousand that have yet to be rethought under these terms. ***So the upside both for profitability and economic benefits, as well as environmental and health benefits, has yet to be realized and is on the horizon."***

- Excerpt from *Yale Environment 360* interview with Paul Anastas, Director of Yale's Center for Green Chemistry and Green Engineering

Welcome to the 2013 Michigan Green Chemistry and Engineering Conference: Designing a Sustainable Michigan.

The quote above from Paul Anastas says it best. "… The good news is that this is something being practiced by some of the most visionary companies, some of the real leaders in industry across many sectors." These leaders are right here at this conference, ready to share their innovations and lessons learned and provide the tools and resources we need to design a sustainable Michigan through green chemistry and engineering.

The objective of the Michigan Green Chemistry Program is to foster use and development of new chemicals and chemical products that reduce or eliminate the use or generation of hazardous substances while producing high quality products through safe and efficient manufacturing processes. This is our fifth annual conference, and we are just uncovering the potential for catalytic change. Here we are in beautiful downtown Grand Rapids, striving for environmental excellence, researching new solutions, and realizing the true potential of green chemistry and engineering. In the 21st century, continuous environmental improvement must involve looking upstream at the lifecycle and design of chemicals, products, and processes, and seeking new solutions to remove hazards.

We can't discuss green chemistry and engineering in Grand Rapids without mentioning sustainability and design. West Michigan has experienced a paradigm shift when it comes to sustainability. Businesses get it. They are designing our future with greener buildings, products, and processes. Municipalities get it and they are striving to reach sustainability goals. And the people get it – their spirit and "green" culture are contagious.

Take this spirit with you today and listen to the speakers, ask questions of the poster presenters, and network with the exhibitors and leaders who surround you. Bring the power of green chemistry back to your office and become part of the solution, part of that bigger picture of designing a sustainable Michigan through green chemistry and engineering.

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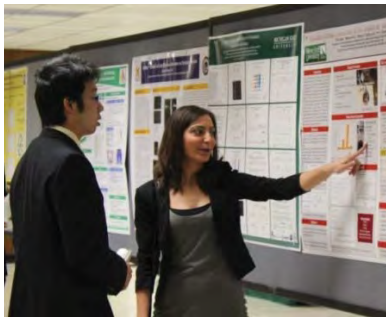
DEQ

2013 GreenUp Agenda

7:30 - 8:30	**Registration, posters, exhibitors and continental breakfast**		
8:30	**Welcome** - *Bryce Feighner, Chief of DEQ Office of Environmental Assistance and Grand Rapids Mayor, George Heartwell*		
8:45	**Governor's Award Presentation -** *Dan Wyant, DEQ Director*		
9:15 - 10:30	**Panel: *Green Chemistry's Place in the Sustainability Movement* - MaryEllen Mika**, Steelcase; **Deborah Steketee,** Aquinas College; **Robert Maleczka Jr**., Michigan State University (MSU); **Terry Collins**, Carnegie Mellon; Moderator: **Clinton Boyd**, Michigan Green Chemistry Clearinghouse (MGCC)		
10:30 - 10:45	**Networking Break - move to breakout sessions**		
Breakout Sessions	**I. Regulatory and voluntary drivers for green chemistry**	**II. Educating green chemists from K-12 to higher education**	**III. Applications in manufacturing**
10:45 - 12:15	*California's Safer Consumer Product Regulations* - **AnnMarie Sanford**, Pepper Hamilton LLP and **Pam Spencer**, The Dow Chemical Company *Sustainability and the building industry: the certification standard approach* - **Amber Dzikowicz** and **Mahya G.S. Wood**, NSF International	*The need for toxicology in chemistry education: the making of a green chemist* - **Dalila Kovacs**, Grand Valley State University (GVSU) and **Clinton Boyd**, MGCC *Michigan higher education: from self-evaluation to Green Chemistry Commitment* - **Kristina Mack**, GVSU *The Great Lakes Green Chemistry Student Network: creating a green chemistry community for students beyond the classroom* - **Lin Kaatz Chary**, Great Lakes Green Chemistry Network	*Sustainable manufacturing of polyurethane: InfiGreen Polyol for seat topper pads* - **Gerald Winslow**, InfiChem Polymers *Green innovation and sustainability practices for the automotive industry: progress report* - **John Bradburn**, General Motors *High functionality soy-based sustainable polyols for high solid coatings* - **Vijay Mannari** and **Chintankumar Patel**, Eastern Michigan University
12:15 - 1:30	**Lunch and Keynote Speaker: *Terry Collins, Carnegie Mellon Institute for Green Science and Professor Green Chemistry*** Keynote Introduction: Norm Christopher, GVSU Sustainability Director and Thomas Haas, GVSU President **Student Poster Award Presentation**		
1:30 - 2:00	**Posters, Exhibitors, and Networking**		

Breakout Sessions	**I. Making the case for green chemistry**	**II. Advancements in catalysis**	**III. Business tools and guides**	
2:00 - 3:00	*Using chemicals policy to drive green chemistry: children's car seats case study* - **Jeff Gearhart**, Ecology Center *Polybrominated diphenyethers: from your couch to your dinner table in three easy steps* - **Richard Rediske**, GVSU	*Great Lakes, great times: using hydrogen from water to fuel Michigan's future* - **Benjamin M. Klepser**, University of Michigan (UofM) *Discovery and development of catalytic deborylations* - **Robert Maleczka, Jr.**, MSU	*BizNGO Guide for Safer Chemicals* - **Eric Harrington**, Green Advantage Consutlants *Green chemistry checklist: a guide for businesses* - **Tracey Easthope**, Ecology Center and **Rich Helling**, The Dow Chemical Company	**2-hour teacher workshop** *Putting the green in next generation science*, **Julie Henderletter** and **Tom Pentecost,** GVSU
3:00 - 3:15	**Break**			
Breakout Sessions	**I. Green chemistry potential for the oil and gas industry**	**II. Roundtable discussions**	**III. Roundtable discussions**	
3:15 - 4:00	*Greener chemistry to reduce the impacts of drilling, hydraulic fracturing, and production* - **Brian Ellis**, UofM	*Green chemistry in higher education and the Green Chemistry Commitment* - facilitated by **Dalila Kovacs**, GVSU	*The bioeconomy in Michigan and the future of bio-based chemicals and materials* - facilitated by **Ramani Narayan**, MSU *Industry Implementation* - facilitated by **Gabe Wing**, Herman Miller	
4:00	**Closing Remarks**			

Check out the Poster Presentations!



Posters are on display to help deliver and demonstrate tools, resources, and content that drives green chemistry and engineering concepts into research, academics, industry, and advocacy arenas. Students are eligible for the Michigan Green Chemistry and Engineering Student Poster Award.

The winner of the student poster contest will be announced after the lunch keynote presentation.

Development of Environmentally - Friendly Novel Acrylated and Hydroxylated Soybean Oil and their Usage in 100% Solids Acrylic Urethane Coatings and Aqueous Hydrophobic UV-PUDs
Senthilkumar Rengasamy
Eastern Michigan University

Organic-Inorganic Hybrid Sol-gel Coatings as Ecofriendly Surface Treatment for Corrosion Protection of Aluminum Alloy
Mahshid Niknahad
Eastern Michigan University

Soy-based Polyols for "Green" Thermoset Coatings
Banafsheh Shabani
Eastern Michigan University

Synthesis and Characterization of Bio-based High-functionality Polyols in Coatings
Chung Hsuan Chen
Eastern Michigan University

Implementation of Microscale Chemistry in an Environmental Research Laboratory
Brian Scull
Grand Valley State University

Non-catalytic Conversion of Cellulosic Material
Aaron Marshall and Gerrit Rauch
Grand Valley State University

Recycled Paper: More than Meets the Eye
Erin Harbour and Kristen Wellman
Grand Valley State University

Bench-top Electrochemical Synthesis of Crystalline Inorganic Semiconductors in Water
Eli Fahrenkrug
University of Michigan

Denby's High School Garden
Leslie Ann Burleson, Instructor

Electrodeposition of Crystalline Si, Ge Nanomaterials Near Room Temperature: a novel approach via electrochemical liquid-liquid-solid growth mechanism
Junsi Gu
University of Michigan

Enhanced Oxidative Stability of Non-Grignard Magnesium Electrolytes through Ligand Modif cation
Emily Nelson
University of Michigan

The Green Manufacturing Industrial Consortium's GMIC Approach to Zero Waste To Landf ll ZWTL
Marylin N. Glass-Angeles
Western Michigan University

Renewable hydrocarbons from catalytic hydrothermal Treatment of Fatty Acids
Na Mo
University of Michigan

Development of Greener Surfactants from Renewable, Bio-Based Waste
Vishal Bavashi
University of Massechusetts, Lowell

Electrocatalytic Hydrogenation of Bio-Oil Components
Kelsey Longe
Michigan State University

Michigan Green Chemistry Governor's Awards

The Michigan Green Chemistry Governor's Awards recognize advances that incorporate the principles of green chemistry into chemical design, manufacturing, or use. The awards acknowledge efforts to design, implement, and promote safer and more sustainable chemicals, processes, and products.

The Awards program, which is Michigan specific, is guided by the following focus areas:

Greener Synthetic Pathways
This focus area involves implementing a novel, green pathway for a new chemical product or material. It may also involve using a novel, green pathway to redesign the synthesis of an existing product.

Greener Reaction Conditions
This focus area involves improving conditions other than the overall design or redesign of a synthesis.

Design of Greener Chemicals and Materials
This focus area involves designing and deploying chemical products or materials that are less hazardous than the products or technologies they replace.

Design and Implementation of Greener Processes
This focus area involves designing and deploying a process where hazardous and/or toxic chemicals are reduced or eliminated such that the resulting process will be environmentally benign, economically sound, and implementable, while still ensuring product quality.

Education or Advocacy of Green Chemistry
This focus area involves educating or advocating for the advancement of green chemistry in Michigan.

ACADEMIC AWARD

Stephen Maldonado
Assistant Professor of Chemistry
University of Michigan

Greening the Semiconductor Industry Electrochemically: Towards A Non-Energy Intensive Synthesis of Crystalline Semiconductor Materials

This research comprises a new method for making technologically important semiconductors such as silicon, germanium, and gallium arsenide. These materials are traditionally synthesized in processes that require extreme temperatures (> 1000 °C), are based on intensive instrumentation (e.g. electrical furnaces, vacuum pumps), and (particularly in the case of Si) are multi-stepped processes that yield toxic by-products. The method is a direct electrochemical strategy that avoids excessive temperatures and could be imagined to run under benign (i.e. bench top) conditions.

The objective of the ongoing work is to develop a novel, non-energy intensive process that can be used to synthesize important Group IV (e.g. silicon and germanium) and III-V (e.g. gallium arsenide) semiconductors and alloys that (1) operates in simple aqueous and nonaqueous solutions at low (ambient) temperatures, and (2) eliminates the need for further refining chemistry. The key advancement is the discovery of an electrochemical process that utilizes liquid metal electrodes that facilitate crystal growth at the liquid-liquid-solid interfaces. They dub this method an electrochemical liquid-liquid-solid crystal growth or 'ec-LLS' for short. The major premise is that certain types of liquid metals in an ec-LLS process can act simultaneously as a source of electrons for the reduction of dissolved oxidized precursors, as a separate phase for crystal nucleation and growth (i.e. solvent), and possibly as a chemical reactive species (i.e. reactant). An unintended but highly serendipitous finding in the results to date was that the ec-LLS process could be manipulated to make semiconductor materials tailored for specific applications. The results represent the initial development of this basic idea into a means for synthesizing crystalline silicon, germanium, and gallium arsenide. The continued focus of these efforts is to devise a disruptive technology that radically reduces the environmental impact and cost of the synthesis of technologically important semiconductors and their assembly into useful optoelectronic devices.

The achievements to date serve as the initial breakthroughs that demonstrate the concept that simple, low-tech, and non-toxic solutions are entirely compatible with crystalline semiconductor synthesis and preparation. They have shown that crystalline materials directly amenable to useful application like energy storage can be made without a large energy investment. Further, they have proven that the pre-existing dogmas against clean electrochemical routes for semiconductor manufacture are not universally true and can be bypassed altogether. The work thus far represents the first but necessary technological step in the re-envisioning of the semiconductor industry. A considerable amount of work is still needed to demonstrate scalability and (ultimately) marketability of the ec-LLS process as an economically competitive synthetic strategy. Nevertheless, the core scientific tenets have been demonstrated thus far and serve as the impetus for the systematic 'greening' of the semiconductor industry.

EDUCATION AWARD

Office of Campus Sustainability
University of Michigan

Advocating and Practicing Green Chemistry leading to Sustainable Laboratories at the University of Michigan

The Office of Campus Sustainability (OCS) at the University of Michigan (U-M) has developed a unique program to make teaching and research labs more sustainable, while keeping in mind the health and safety of students, faculty, and staff; economic and environmental impacts; university-wide goals; and general applicability to the scientific community. The OCS spearheaded a unique program called the Sustainable Lab Certification Program focused on standardizing greener practices in teaching and research laboratories. To date, OCS has evaluated nearly 60 labs through this unique program.

The OCS applied green chemistry and waste reduction principles along with operational, administrative, and behavioral controls to achieve short and long term sustainability goals in their campus laboratories. This program, developed through the participation of student groups, addresses two of the four broader University wide sustainability goals to reduce greenhouse gas emissions, and reduce waste being diverted to landfills. Metrics on the practice of green chemistry, reduction in waste generation, and energy usage are being tracked for the U-M Environmental Annual Report. In addition, OCS has been actively coordinating with the University teaching faculty to inculcate green chemistry and engineering principles in developing the curriculum. Consequently, many significant changes and improvements resulted leading to sustainability in carrying out research, teaching chemistry, biochemistry and engineering on the U-M campus.

Green chemistry, waste reduction, and pollution prevention principles have been applied effectively to achieve measurable results, including reduced consumption of energy and utilities, reduction in use and generation of hazardous materials, increase in reuse and recycling, implementing green chemistry and engineering practices, and improved safety for students, faculty, and staff. This achievement has general applicability that can be transferred to any research or teaching lab in the state of Michigan or across the globe to improve the health and safety of lab occupants while reducing impacts on the environment.

"We are pleased that the Office of Campus Sustainability, University of Michigan has been selected for a Michigan Green Chemistry Governor's Award this year. The Sustainable Lab Certification Program we have developed allows the lab users to implement standardized operations in their laboratories leading to safety while reducing impact on the environment. We thank Timothy Slottow, Executive Vice President and Chief Financial Officer and Henry Baier, Associate Vice President, Facilities & Operations for their support in developing this unique program." -Terrance Alexander, Executive Director, Occupational Safety and Environmental Health and the Office of Campus Sustainability and Sudhakar G. Reddy, Ph.D., Coordinator, Sustainable Labs

The Twelve Principles of Green Chemistry*

1. **Prevention**
   It is better to prevent waste than to treat or clean up waste after it has been created.

2. **Atom Economy**
   Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.

3. **Less Hazardous Chemical Syntheses**
   Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.

4. **Designing Safer Chemicals**
   Chemical products should be designed to effect their desired function while minimizing their toxicity.

5. **Safer Solvents and Auxiliaries**
   The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used.

6. **Design for Energy Efficiency**
   Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic methods should be conducted at ambient temperature and pressure.

7. **Use of Renewable Feedstocks**
   A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.

8. **Reduce Derivatives**
   Unnecessary derivatization (use of blocking groups, protection/ deprotection, temporary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste.

9. **Catalysis**
   Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.

10. **Design for Degradation**
    Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.

11. **Real-time analysis for Pollution Prevention**
    Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.

12. **Inherently Safer Chemistry for Accident Prevention**
    Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires.

* Anastas, P. T.; Warner, J. C.; Green Chemistry: Theory and Practice, Oxford University Press: New York, 1998, p.30.
By permission of Oxford University Press.

The Twelve Principles of Green Engineering*

1. **Inherent Rather Than Circumstantial**
   Designers need to strive to ensure that all materials and energy inputs and outputs are as inherently nonhazardous as possible.

2. **Prevention Instead of Treatment**
   It is better to prevent waste than to treat or clean up waste after it is formed.

3. **Design for Separation**
   Separation and purification operations should be designed to minimize energy consumption and materials use.

4. **Maximize Efficiency**
   Products, processes, and systems should be designed to maximize mass, energy, space, and time efficiency.

5. **Output-Pulled Versus Input-Pushed**
   Products, processes, and systems should be "output pulled" rather than "input pushed" through the use of energy and materials.

6. **Conserve Complexity**
   Embedded entropy and complexity must be viewed as an investment when making design choices on recycle, reuse, or beneficial disposition.

7. **Durability Rather Than Immortality**
   Targeted durability, not immortality, should be a design goal.

8. **Meet Need, Minimize Excess**
   Design for unnecessary capacity or capability (e.g., "one size fits all") solutions should be considered a design flaw.

9. **Minimize Material Diversity**
   Material diversity in multicomponent products should be minimized to promote disassembly and value retention.

10. **Integrate Material and Energy Flows**
    Design of products, processes, and systems must include integration and interconnectivity with available energy and materials flows.

11. **Design for Commercial "Afterlife"**
    Products, processes, and systems should be designed for performance in a commercial "afterlife."

12. **Renewable Rather Than Depleting**
    Material and energy inputs should be renewable rather than depleting.

* Anastas, P.T., and Zimmerman, J.B., "Design through the Twelve Principles of Green Engineering", Env. Sci. and Tech., 37, 5, 94A-101A, 2003.

THANK YOU

2013 Conference Steering Committee Members

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Mr. Chris Affeldt, Michigan Department of Environmental Quality
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