

Separation Science and Technology (SST) as a  
Convergence Platform for *SusChEM*,  
*Sustainable Chemistry, Engineering and Materials*

# Enabling The Sustainability of Critical Materials and Resources: The Role of Separation Science and Technology

Dr. Rosemarie D. Wesson, P.E.

National Science Foundation

August 12, 2014

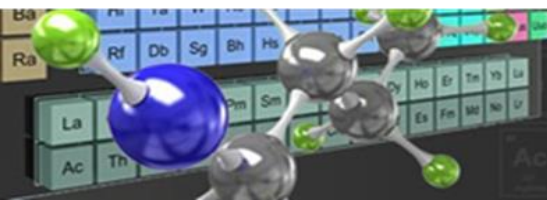


248<sup>th</sup> ACS National Meeting



# Previous ACS/AIChE Workshops

- 2012 National ACS Meeting, August 2012
  - Ensuring the Sustainability of Critical Materials and Alternatives: Addressing the Fundamental Challenges in Separation Science and Engineering
    - Catherine (Katie) T. Hunt
    - Mamadou S. Diallo
- 2013 AIChE Annual Meeting, November 2013
  - Advances in Critical Materials Research
    - Seyi A. Oduyungbo, Chevron, Chair
    - Annette A. Johnston, Abbott, Co-Chair

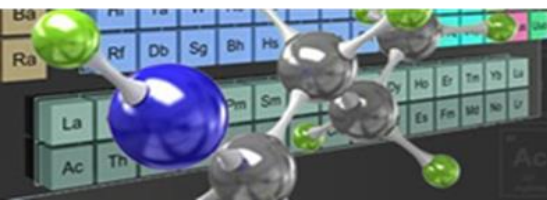


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# 2012 ACS Critical Materials Workshop

- Ensuring the Sustainability of Critical Materials and Alternatives: Addressing the Fundamental Challenges in Separation Science and Engineering
- One-day Workshop
- 2012 ACS Meeting, Philadelphia
- August 21, 2012



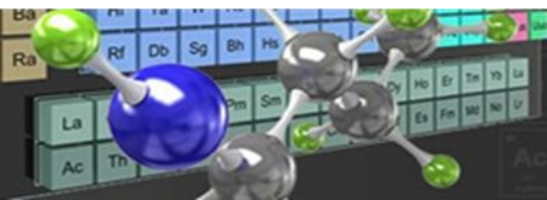
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# 2012 ACS Critical Materials Workshop

## Objectives

- Discuss the issues related to stresses in the global market and the key and enabling role of SSE in ensuring a sustainable supply and utilization of critical materials
- Bring into focus crosscutting research needs and Scientific Grand Challenges in SSE associated with the sustainable extraction, recovery, recycling and purification of *critical materials*.
- Communicate these research needs to the SSE and broader science/engineering community.



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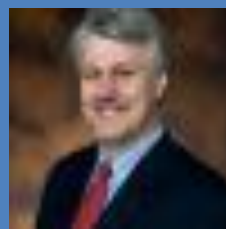


# 2012 ACS Critical Materials Workshop

## Featured Speakers (Academia)



**Ionic Liquids and Strategic Metals: Challenges & Opportunities, *Robin D. Rogers, University of Alabama***



**Developments in Alternatives to Critical Materials for Energy Applications, *Mark Johnson, ARPA-E, NC State***



**Sustainable Extraction of Critical Metals from Saline Water and Industrial Wastewater: Challenges & Opportunities, *M.S. Diallo, KAIST and Cal Tech***



**Findings and Opportunities from the 2012 NSF SusChEM Workshop, *Susannah L. Scott, UCSB***

**Sustainable Supply of Critical Materials: Addressing the Fundamental Challenges in Separation Science & Engineering, *M.S. Diallo***

Ensuring the Sustainability of Critical Materials and Alternatives: **Addressing the Fundamental Challenges in Separation Science and Engineering**



# 2012 ACS Critical Materials Workshop

## Featured Speakers



**Challenges for Extracting and Purifying Critical Materials,**  
*Bruce A. Moyer, Oak Ridge National Laboratory*



**Finding Alternatives to Critical Materials in Photovoltaics and Catalysis Part II: Industrial Perspective,**  
*James C. Stevens, Dow Chemical Company*



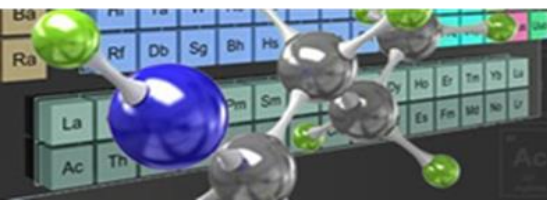
**Finding Alternatives to Critical Materials in Photovoltaics and Catalysis Part I: Academic Perspective,**  
*Henry A. Atwater, DOE*



**Extractions of Dissolved Organics and Metals,**  
*Paul L. Edmiston, College of Wooster, ABS Materials, Inc*



**Meeting the Global Rare Earth Challenge: Molycorp from Mine-to-Magnets,**  
*Andy Davis, Molycorp*

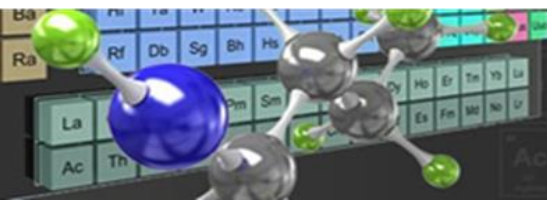


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# 2013 AIChE Critical Materials Sessions

- Advances in Critical Materials Research
- Two-half day Sessions
  - Morning Presentations
  - Afternoon Panel Discussion
- 2013 AIChE Annual Meeting, San Francisco, CA
- November 6, 2013



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# 2013 AIChE Advances in Critical Materials Research



US Dept of Energy  
Critical Materials  
Strategy and R&D,  
Michael McKittrick, DOE



Research Gaps and Needs:  
Critical Materials  
Separations R&D Workshop,  
Darlene Schuster, AIChE



Rare Earth  
Concentration,  
Extraction,  
Separation and  
Reduction, Corby  
Anderson,  
Colorado School of  
Mines



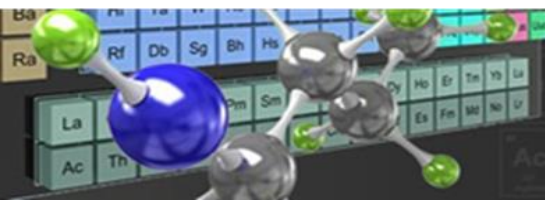
The Availability of  
Indium and Tellurium  
for Thin-Film  
Photovoltaic Materials,  
Roderick Eggert,  
Colorado School of  
Mines



Critical Materials  
Recycling for  
Resource  
Sustainability,  
Brajendra Mishra,  
Colorado School of  
Mines



Critical Materials Recycling & Substitutes  
for Critical Materials, Edwin Jones,  
Lawrence Livermore National Lab



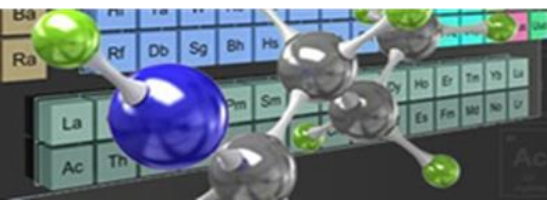
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# ACS/AIChE Critical Materials Key Findings

- SSE is a broad discipline
  - analytical, physical, inorganic, polymer and supramolecular chemistry,
  - chemical engineering (e.g. equilibrium thermodynamics and transport phenomena),
  - mining and materials engineering (e.g. mineral processing and extractive metallurgy), and
  - process and systems engineering.

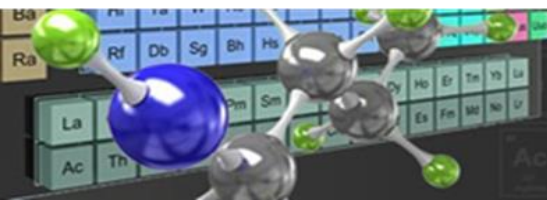


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# ACS/AIChE Critical Materials Key Findings

- Critical need to design and synthesize robust, recyclable supramolecular hosts that are capable of selectively extracting critical materials from complex, heterogeneous media that can be highly corrosive and damaging to many available materials.
- Seamless integration with existing separations equipment to be economically viable.

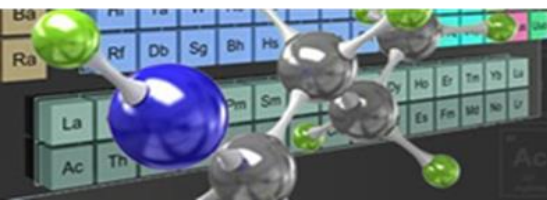


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# ACS/AIChE Critical Materials Key Findings

- Need for stronger collaborations between chemical engineers and chemists as to better understand the underlying physical and chemical processes that effect design and scale up of separation processes and systems for critical materials.
- Not all bench-scale processes can be easily scaled up due to technical and economic viability issues.

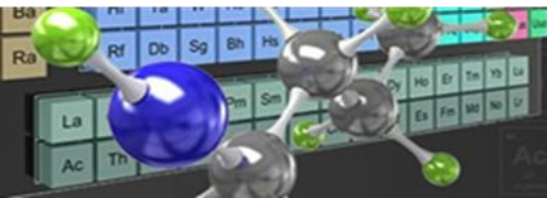


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# ACS/AIChE Critical Materials Key Findings

- Utilization of membrane technology in the extraction, recovery and purification of critical materials from solutions (e.g. mining leach liquors and industrial wastewater) has received limited attention to date.
- Fundamental research needed in the development of new membranes (e.g. nanofiltration and affinity membranes) for use in the extraction, concentration and purification of critical materials including rare earth elements (REEs) and platinum group metals (PGMs).

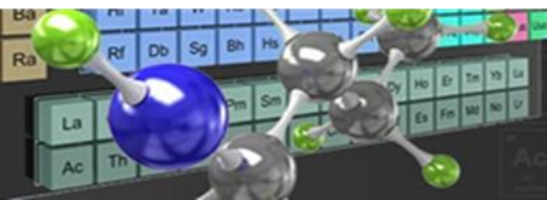


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# ACS/AIChE Critical Materials Key Findings--Education

- Science and engineering curricula should comprehensively integrate and emphasize separations science with a focus on sustainability-related applications
- A new and more unified education curriculum in SSE is needed that integrates
  - basic knowledge of the principles of separations science (e.g. thermodynamics and transport phenomena)
  - materials (e.g. supramolecular hosts, media and membranes)
  - engineering knowledge (e.g. unit operations and process/system design)

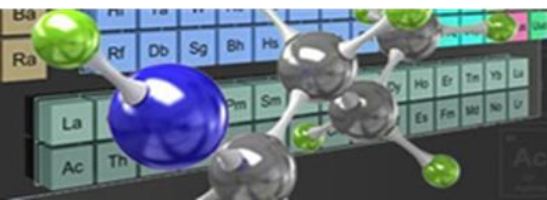


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# Current Workshop Objectives

- Discuss the key and enabling role of SST in SusChEM
- Bring into focus crosscutting research and education needs in SST associated with the sustainable recovery and recycling of critical materials and (e.g. metals) and resources (e.g. phosphorous) from liquid and solid wastes
- Communicate these research and education needs to the broader SST community of scientists, engineers, policy makers, business leaders and entrepreneurs.

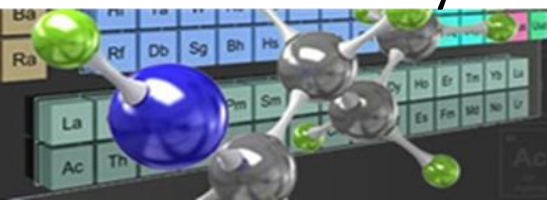


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# Current Workshop Anticipated Outcomes

- Promote interactions/networking to allow critical materials research to continue to expand
- Develop and publish comprehensive report summarizing the key contributions and findings of the symposium
- New website devoted to critical materials and resources.
  - serve as a repository for relevant materials from this symposium and potential future symposia.
  - The website can link to other sites with pertinent information.
  - make materials available to the research community
  - serve to inspire and engage the next generation scientists, engineers and policymakers.
- Provide focus and direction for future workshop series on aspects of separations science and technologies (SST) for critical materials specifically, by ACS and AIChE, and overall, by the scientific community.



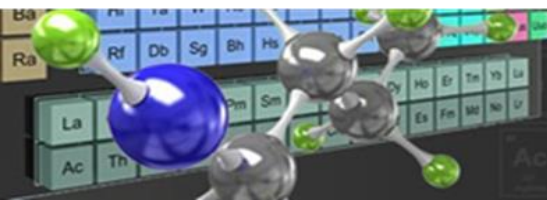
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# Workshop Co-Chairs

- Gretchen Baier, Dow Chemical Company
- Mamadou Diallo, KAIST and Cal Tech
- Catherine “Katie” Hunt, Dow Chemical Company(retired)

Thank you!!!



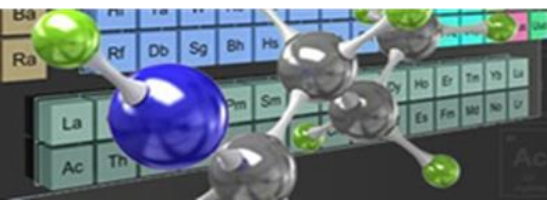
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# Questions

- How can we articulate sufficiently (and succinctly) specific grand challenges here?
- Are there groundbreaking new ideas and approaches?
- What is the nature of "convergence" in this area?



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