Type them into questions box!

“Why am I muted?”
Don’t worry. Everyone is muted except the presenter and host.
Thank you and enjoy the show.

Contact ACS Webinars® at acswebinars@acs.org

Benefits of ACS Membership

**Chemical & Engineering News (C&EN)**
The preeminent weekly digital and print news source.

**NEW! ACS SciFinder**
ACS Members receive 25 complimentary SciFinder® research activities per year.

**NEW! ACS Career Navigator**
Your source for leadership development, professional education, career services, and much more.


Contact ACS Webinars® at acswebinars@acs.org

https://www.linkedin.com/company/american-chemical-society

@AmericanChemicalSociety  @AmerChemSociety

ACS Webinars
Chemistry for Life®
How has **ACS Webinars** benefited you?

“A great presenter who blended high level information with some good details. I was reminded of many facts and concepts, and I learned several new things.”

**Fan of the Week**

Mark Petrich
Director, Single-Use Systems Engineering, Merck & Co.  
ACS member for 32 years strong!

Be a featured fan on an upcoming webinar! Write to us @ acswininars@acs.org

---

Learn from the best and brightest minds in chemistry! Hundreds of webinars on diverse topics presented by experts in the chemical sciences and enterprise.

**Recordings** are an exclusive ACS member benefit and are made available to registrants via an email invitation once the recording has been edited and posted.

**Live Broadcasts** of ACS Webinars® continue to be available to the general public on Thursdays from 2-3pm ET!

[www.acs.org/acswininars](http://www.acs.org/acswininars)
What is ACS on Campus?

ACS visits campuses across the world offering FREE seminars on how to be published, find a job, network and use essential tools like SciFinder. ACS on Campus presents seminars and workshops focused on how to:

- Publish in top journals
- Find a job
- Effectively use research tools like SciFinder® and ACS ChemWorx
- Communicate your science

- Write grant proposals
- Build industry partnerships
- Prepare for a changing employment landscape

http://acsoncampus.acs.org

#HeroesofChemistry
ACS Heroes of Chemistry Award

The ACS Heroes of Chemistry Award is the Annual award sponsored by the American Chemical Society that recognizes talented industrial chemical scientists whose work has led to the development of successful commercialized products ingrained with chemistry for the benefit of humankind.

2018 Winners:

www.acs.org/heroes
An individual development planning tool for you!

https://chemidp.acs.org

Explore Chemical & Laboratory Safety

https://www.acs.org/content/acs/en/chemical-safety.html
Upcoming ACS Webinar

www.acs.org/acswebinars

[Image of webinar poster]

FREE | Thursday, May 23 at 2pm ET

https://www.acs.org/content/acs/en/acs-webinars/popular-chemistry/heavy-elements.html

ACS Safety Programs

[Image of laboratory equipment]

WORKING SAFELY with NANOMATERIALS IN THE LABORATORY

THIS ACS WEBINAR WILL BEGIN SHORTLY...
Working Safely with Nanomaterials in the Laboratory

Slides available now! Recordings are an exclusive ACS member benefit. www.acs.org/acswebinars

This ACS Webinar is co-produced with the National Nanotechnology Coordination Office and ACS Safety Programs

Today’s Objectives

• Reinforce that safe and responsible lab practices enable nanomaterial research

• Discuss how an effective lab safety program and culture accommodates a wide range of research

• Build awareness of existing information resources

• Ensure that lab safety is a key element of good research

• Discussion and share experiences
Nanomaterials: Some Safety Basics

Debbie M. Decker
ACS Fellow and Safety Manager,
Department of Chemistry, University of California, Davis
dmdecker@ucdavis.edu

Administrative Controls

- Operating Procedures
  - Campus-wide template in development
  - Lab-specific Safety Plan
- NIOSH “Approaches to Safe Nanotechnology”
- Training and mentoring

Nanomaterials: Hazard Assessment

Hazard assessment needs to include:
- Assume nanomaterial is at least as toxic as the bulk material
- And it’s probably more toxic!
- Synthesis methods
- Solvents
- Particles vs. Pores
- Other hazards: lasers, pyrophoricity

AFM Imaging of sulfated cellulose nanocrystals
Photo Credit: Sulkannen

Engineering Controls

- Fume Hood
- Exhausted enclosure
- Glove Box

Atomic Force Microscope Photo Credit: Liu
Personal Protective Equipment

- Gloves
- Fire Retardant Gloves?
- Goggles vs. Safety Glasses

Handling and Synthesis Methods

- In suspension
  - Higher boiling solvent is better
- If using a substrate, make sure nanoparticles are well-stuck onto the substrate
- Cover surfaces with plastic-backed paper
  - Makes clean up easier
- Cautious about heat-generating equipment as it could provide an inadvertent ignition source
Analytical Methods

- AFM, SEM, NMR, Ramen, FTIR, UV/Vis, etc. — all require various sample preparation methods and different solvents

- For analysis, many times have to manipulate dry powder:
  - Drop dry onto substrate
  - Making sure material is well-stuck to substrate
  - Prep into a vial or similar

- “Large Amount” is maybe 10mg, dependent on molecular weight
  - Never working in gram scale

Characterization: XRD/ TEM

Increasing Bismuth levels leads in enhancing lattice parameter of Ge NCs up to 2 mol%  
Photo Credit: Kauzlarich

Storage

- Stored mostly in suspension
  - Materials can aggregate
  - Dry powders transferred in fume hood or glove box
  - Careful labelling is critical

Long-Term Stability After 13 Months – Aqueous Cellulose Nanocrystals  
Photo Credit: Sulkanen
Disposal

- Assume hazardous waste
- Within the laboratory, it may make sense for each researcher to have their own waste stream
- Labelling is important – identify solvent, if in suspension, and the identity of the nanoparticle
- Biggest hazard to hazardous waste workers may be the solvent

AQ-CNC aggregates showed alignment of individual fibers.

Photo Credit: Sulkanen

Acknowledgements

I wish to acknowledge Audrey Sulkanen, Matthew Owen, (Research Lab of Gang-Yu Liu) and Andrew Bernard (Research Lab of Susan Kauzlarich) for their input and advice.

Photo credits to Sulkanen, Owen, and Bernard.
In your opinion, which of the following does your lab do well regarding nanomaterial safety? (choose all that apply)

- Administrative controls
- Hazard assessment
- Engineering controls
- Personal Protective Equipment
- Storage and disposal

* If your answer differs greatly from the choices above tell us in the chat!

Managing Nanomaterial Safety in a Large and Diverse University Setting

Ken Kretchman, CIH, CSP
Director, Environmental Health Safety,
North Carolina State University
kwkretch@ncsu.edu
Presentation Objectives

• Identify Challenges and Potential Solutions to Assuring Safety with Nanomaterials at Large, Diverse, Research Environment

• Share One Approach – Emphasize Goal of Achieving Basic Awareness

• Provide Listing of Resources - https://www.nano.gov/LabSafety

• Building a Safety Program to Protect the Nanotechnology Workforce

• AIHA Nanotechnology Working Group

Systemic Translocation of Nanoparticles

“...non-cationic nanoparticles smaller than ~34 nm in diameter that do not bind serum proteins reach the regional lymph nodes within 30 min”

“Nanoparticles larger than ~34 nm are consistently retained within the lungs.”

Credit: Kreyling et al., Nat Biotechnol. 2010 28(12):1275
The Challenge for the EHS Professional for a Large, Diverse, Decentralized, and Ever-changing Lab Environment

- How to Build a **Lasting Infrastructure** of Processes and Tools to Capture and Educate this Population with 100% Capture as the Goal?

- **If You Build It ...They Won’t Come** - Just Because It is on your website does not mean you have accomplished your goal!

- Concern About Small Particles of Known Substances is **Not Intuitive** “*We already know about small particles...have been working with them for years*” …

- **You can’t drown Principal Investigators with Information at the Outset** – They are already on Information Overload

- **Sharing of Engineered Nanomaterials – Common** - Hazard Awareness Information Needs to Accompany the Material

- **Key People – Leaving Today**

- **New People – Starting Tomorrow** - Every Changing Workforce

---

Nanotechnology or Microelectronics?

**Got Gases?**

**Got TMAH?**
Plan, Do, Check, Act

- Strong Safety Culture Foundation
- Management Support (Accountability, Focus on Quality)
- Capture and Train
- Hazard Identification
- Hazard Assessment
- Hazard Abatement
- Critique and Adjust
- Management of Change

Drilling Deeper

Overall Company Health and Safety Program
- Management Leadership
  - Policies
  - Standards
  - Employee Participation
  - Planning
  - Implementation
    - Risk Management
      - Training
      - Communication
      - Safe Practices
    - Evaluation
    - Corrective Actions
    - Compliance Plan

Nanomaterial Risk Management Program
- Hazard Determination
- Process Review
- Exposure Evaluation
- Risk Characterization
  - Controls

Hierarchy of Controls
- Elimination
- Substitution
- Isolation
- Engineering Controls
- Administrative Controls
  - Biological Monitoring
  - Medical Screening and Surveillance
  - Personal Protective Equipment

Building a Safety Program to Protect the Nanotechnology Workforce - NIOSH 2016
Steps

- **Develop Strategy**  (Plan)
- **Provide Tools** - Awareness Training, SOPs
- **Implement Processes** - Incoming Material Reviews, Process Hazard Reviews, Communications  (Do)
- **Inspections, Self-Inspection, Reviews** with Collaborators  (Check)
- **Adjust as Needed**  (Act)

**Can’t Be Dependent on Strong Leadership** - **Can’t be Transient**

**Must be Integrated into Processes and Sustained by a Strong Culture**

---

Plan

- **Collaborate**
- **Capture**
- **Communicate**

- **Sustainable Infrastructure**
  - People
  - Processes
  - Assistance Tools

- **Goal** - Process that is 100% Capable and Addresses Management of Change
Got Collaborators? Some of Mine…Who are Yours?

Internal
- Key Process Collaborators – Onboarding, Purchasing...
- Research Safety Committee Leadership and Members
- Lab Safety Contacts
- Subject Matter Expert Collaborators (just to name a few- past or present at NC State)
  - Nancy Montiero-Riviere – Skin Nano Toxicology
  - James Bonner – Carbon Nanotube Toxicology
  - Jacob Jones – Director, Research Triangle Nanotechnology Network (RTTN)
  - Phillip Barletta – Operations Manager - Nanofabrication Facility (NNF)
  - Khara Grieger – Nanomaterial Risk Assessment and Communication (RTNN)
  - Dawn Mason – Eastman Chemical – Research Safety Culture

External
- National Institute for Occupational Safety and Health – Geraci, Hoover, etc...
- American Chemical Society – CHAS Division, SAP…other
- American Industrial Hygiene Association – Nanotechnology Working Group
- University Environmental Health and Safety Directors and Staff

One Capture / Communication Process

Onboarding – Everyone
- Includes General Safety Orientation - Online
- Includes Completion of Training Matrix
  - Includes Use of Nanomaterials Training – Get Tagged – Get Short Message Real Time
- Steered to One Page Summary
  - Take Awareness Training
  - Read N.C. State Requirements
  - Provide One Page Summary to those with whom you share materials

Principal Investigator Safety Plan – Initial and Updated Annually
- Includes Process Descriptions / SOP
- Includes Target Chemical Lists - Includes Nanoparticles – Key NP Message
- Includes Self Assessment Checklist – Includes Key NP Message
  - Includes Hazard Review Requirements - Includes NP requirement
Target Chemical Notice

I noted that you recently placed an order for *****

As you may be aware, this chemical is formulated as an engineered nanomaterial (<100nm). When working with engineered nanomaterial you need to take additional precautions, above and beyond normal safe chemical handling procedures. Additional training in the safe use of engineered nanomaterials is necessary and can be found at the following presentation:

http://wisha-training.lni.wa.gov/training/presentations/NanotechnologySafety.ppt

Please consult EH&S if there is a potential for nanoparticles to become airborne in your processes. Engineered nanomaterials must be disposed of via the HAZTRAK system, more information on waste disposal can be found here: https://ehs.ncsu.edu/home-page-info/environmental-affairs/chemical-waste/

For more information on Engineered nanomaterials and their safe handling, please see the following document:

https://drive.google.com/file/d/0Bwfv9WVwZC73Z2JDa0dUSDFFSVk/view

If you are not the person who intends to use this chemical, please forward this email to the person(s) who will be using it. Thank you.

If you have any questions, please ask.
Personal Responsibility in Hazard Assessment

*NIOSH and Other Agencies – Health Hazard Findings and Hazard Control Information

*ACS CHAS, AIHA, Other

EHS, Scientists Public

Principal Investigator

Lab Staff

Periodic Self Assessment!

*March/April 2019: Journal of Chemical Health and Safety – Published for ACS CHAS Division
- Evaluating Nanomaterial Safety Data Sheets – Hodson, Eastlake, Herbers -NIOSH
- Emissions from 3D Printers – Stefaniak et all - NIOSH

Personal Responsibility – Hazard Assessment - Check SDSs, literature, other Safety Resources along with site requirements before proceeding!

Got Engineering Controls?

NC STATE UNIVERSITY
Got Standard Operating Procedures (SOPs)?

https://www.safenano.org/knowledgebase/guidance/safehandling/goodnanoguide/


Got Personal Protective Equipment (PPE)?

Got Awareness Tools?

SELECTED CHEMICALS WHICH POSE A SKIN ABSORPTION HAZARD

The following listing contains common substances, which are listed in the 2005 TLV (Threshold Limit Values) Booklet by the American Conference of Governmental Industrial Hygienists (ACGIH) as having a “potential significant contribution to the overall exposure by the cutaneous route, including mucous membranes and the eyes, either by contact with vapors, or, of probable greater significance, by direct skin contact with the substance.”

The recommended airborne exposure limits (TLVs) for these materials is also listed. Please take special note of avoiding skin contact and using the proper glove and eye protection for each of the materials listed below, particularly those which also have a low TLV. Note that this listing is not all inclusive, does not address materials, which cause a direct irritant effect on the skin surface (acids, bases, etc), and does not address materials, which may cause allergic reactions or dermatitis due to skin contact. Consult the TLV term definitions at the end of the list. Please take special precautions in handling hydrofluoric acid (not listed below). Remember that some materials, which do not readily pass through the skin, may do so when mixed with a carrier, which is readily absorbed (e.g. DMSO) or may pass through skin through cuts, breaks, or other damage such as dermatitis. Please also note that materials listed below, or others, may be components of solvent mixtures, so be sure to read your MSDS and use proper skin protection.

Contact the Environmental Health and Safety Center at 515-4860 with additional questions you may have concerning skin protection.

<table>
<thead>
<tr>
<th>SUBSTANCE</th>
<th>ppm</th>
<th>mg/m³</th>
<th>STEL/CEILING°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetone cyanohydrin</td>
<td>-</td>
<td>-</td>
<td>C 4.7 (1.4)</td>
</tr>
<tr>
<td>Acetone</td>
<td>20</td>
<td>33.6</td>
<td></td>
</tr>
<tr>
<td>Acetonitrile</td>
<td></td>
<td>-</td>
<td>C 0.1</td>
</tr>
<tr>
<td>Acrolein</td>
<td>-</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>Acrylamide</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Try to Narrow the Field and Provide Focus

Inspection / Assessment

- **Exposure Assessment**
  - Mass Based Air Sampling is Not Appropriate
  - Particle size, shape, surface area, and surface chemistry are important
  - Particle size and number most achievable
  - Compare to background levels

- **Self Inspection – Key**

Plan  Do
Act  Check
Got Collaborators?

- Nano User lists
- Communications
- Seminars
- Sharing of Safety Information

- Process Safety Reviews
- New Chemical Reviews
- Emergency Response Training

Target Equipment Forwarding Lasers, Semiconductor Equipment, Radiation Producing Devices, other
Daily Chemical Order Forwarding
Real Time Compressed Gas Order Forwarding-Reviews and Approvals
Approved Electrical Equipment

Audience Survey Question

ANSWER THE QUESTION ON BLUE SCREEN IN ONE MOMENT

In your opinion, which of the following does your lab need guidance regarding nanomaterial safety? (Choose all that apply)

- Plan, Do, Check, Act process
- One capture or communication process
- Standard operating procedures
- Awareness tools
- Collaboration support

* If your answer differs greatly from the choices above tell us in the chat!
What is Most Important in Nanomaterials Laboratory Safety?

- **Individual Researchers**
  - Initial and ongoing safety training
  - Adherence to lab safety standards
  - Hazard identification and risk assessments
  - Analysis of near misses and Lessons Learned

- **SOPs**
  - Detailed SOPs prepared and followed

- **Controls**
  - Required use of PPE and engineering controls

- **EH&S**
  - Rigorous lab inspections
  - Active as a safety resource

*Answer – All of the above.  So how to improve upon these?*
Laboratory Safety Triad

Safety Outcomes
- What incidents occur?
- Where do incidents occur?
- When do incidents occur?

Safety Programs
- EH&S Actions, Using SOPs
- PPE Usage, Safety Training

Safety Culture
- Actions by researchers in labs.
- Safety leadership by everyone.

Safety Culture Survey

Safety Culture: Values, beliefs and behaviors resulting in a collective commitment to safety by everyone in an organization.

Safety Culture Survey
- Determine the state of laboratory safety culture
- Identify factors that influence the safety culture
- Determine strengths and weaknesses of safety programs
- Identify factors that correlate with injuries

GOAL: Use data to drive improvements in laboratory safety practices, culture and outcomes
Safety Culture Survey

- **Short:** < 10 minutes
- **38 questions;** 5-point Likert scale, 1 open-ended question
- **Bifurcated survey:** Students, postdocs & staff vs. Principal Investigators
- **Areas:**
  - Demographics
  - Safety communication
  - Safety attitude
  - Safety behavior
  - Lab incidents and near misses
- **4 Research universities**
- **> 1000 respondents**

Safety Culture Survey Highlights

**Trainees (graduate students & postdocs) and Staff:**

- **96%** Have access to all required PPE
- **96%** Regularly wear long pants in the lab
- **98%** Regularly wear close-toed shoes in the lab
- **93%** Regularly wear gloves in the lab

**PIs/Faculty:**

- **95%** Speak openly with EH&S about safety issues regarding work in their lab
- **97%** Would take immediate action if they saw a researcher in their lab act unsafely
Safety Engagement by Gender

People in my lab consider safety procedures before they conduct a new or scaled-up experiment

People in my lab incorporate safety measures into the protocols for their experiments

The time devoted to compliance with lab safety regulations is appropriate and valuable

Audience Survey Question

ANSWER THE QUESTION ON BLUE SCREEN IN ONE MOMENT

How often does your lab group discuss how to conduct experiments safely?

- Daily
- Weekly
- Monthly
- Quarterly
- Yearly

* If your answer differs greatly from the choices above tell us in the chat!
Perception Gap when Discussing Safety in Experiments

**PI:** I discuss with my lab group how to conduct experiments safely.
89% Agree/Strongly Agree

**Trainees/Staff:** My PI discusses with me how to conduct experiments safely
66% Agree/Strongly Agree

---

Perception Gaps

- **PI discusses with my lab group how to conduct experiments safely:**
  - 94% Agreed/Strongly Agreed

- **When there is a safety issue in my lab, the PI does a good job addressing it:**
  - 100% Agreed/Strongly Agreed

- **PI positively acknowledges trainee/staff for safe behavior:**
  - 94% Agreed/Strongly Agreed

---

UCLA
Correlating PI Safety Recognition with Trainee/Staff Safety Behavior and Attitudes

**PI Action:**
- Safety Recognized
- Neutral
- Safety Not Recognized

**Trainees/Staff Reaction:**

- People in my lab incorporate safety measures into their experimental protocols.
- Time devoted to compliance with lab safety regulations is appropriate and valuable.

**Safety recognition by PI correlates with safe lab practices**

Correlating PI Safety Recognition with Trainee/Staff Safety Behavior and Attitudes

**PI Action:**
- Formal Lab Safety Discussions:
  - Weekly / Monthly
  - Quarterly
  - Yearly / Never

**Trainees/Staff Reaction:**

- Trainees/staff would report to PI:
- A minor injury
- A near miss

**Regular and frequent lab safety discussions strongly correlate with higher incident reporting**
How many injuries (minor or major) has your immediate lab group had in the last two years?

- 0
- 1
- 2
- 3
- 4 or more

*If your answer differs greatly from the choices above tell us in the chat!

Do Faculty and Trainees Safety Attitudes and Behaviors Impact Safety Outcomes?

How Can Injuries be Prevented?

Correlating behavior with Safety Outcomes:

- Near misses
- Minor injuries
- Major injuries (see: *J Chem Health Safety* 2016, 23:12-23)
Fewer minor injuries are reported when PI includes risk assessment in experimental design

*My mentor/professor discusses with me how to conduct experiments safely.*

![Bar chart showing](chart1.png)

**Agree** | **Disagree**
---|---
0 | 45% | 12% | 0
1 | 33% | 23% | 12%
>1 | 31% | 23% | 0

Fewer minor injuries are reported when trainees/staff perform risk assessments

*People in my lab consider safety procedures before they conduct a new or scaled-up experiment.*

![Bar chart showing](chart2.png)

**Agree** | **Disagree**
---|---
0 | 48% | 7% | 0
1 | 36% | 10% | 15%
>1 | 23% | 15% | 23%
Key Findings and Recommendations

PI/Faculty Engagement to Improve Laboratory Safety

- PIs should discuss with students and staff how to conduct experiments safely.
- PIs should require students and staff to consider safety procedures before they conduct a new or scaled-up experiment.
- PIs should teach hazard identification and risk assessment.
- PIs should monitor students’ safety practices.
- PIs should regularly discuss safety in lab group meetings.
- PIs should discuss near misses and Lessons Learned.
- PIs should wear proper PPE.
- PIs should exemplify proper safety.

Think Safety

- What could go wrong?
- How can I prevent it?
- How can I prepare for the unexpected?

The End – Be Safe!

Thanks to my outstanding colleagues in the UC Center for Laboratory Safety:

Dr. Imke Schroeder - UCCLS Project Manager
Dr. Elizabeth Czornyj - UCCLS Researcher
Dr. Nancy Wayne - UCCLS Board Chair
Working Safely with Nanomaterials in the Laboratory

Slides available now! Recordings are an exclusive ACS member benefit.

www.acs.org/acswebinars

This ACS Webinar is co-produced with the National Nanotechnology Coordination Office and ACS Safety Programs

Explore Chemical & Laboratory Safety

Chemical & Laboratory Safety
ACS advocates for the safe practice of chemistry across disciplines, at every scale, and in every organization. We engage with like-minded professionals and entities to provide tools to foster a culture of safety in your classroom, campus, or lab.

https://www.acs.org/content/acs/en/chemical-safety.html
Upcoming ACS Webinar
www.acs.org/acswebinars

FREE | Thursday, May 23 at 2pm ET

https://www.acs.org/content/acs/en/acs-webinars/popular-chemistry/heavy-elements.html

Working Safely with Nanomaterials in the Laboratory

Chuck Geraci
Associate Director for Emerging Technologies, National Institute for Occupational Safety and Health

Debbie Decker
Safety Manager, Department of Chemistry, University of California, Davis

Ken Kretchman
Director of Environmental Health Safety, North Carolina State University

Craig Merlic
Professor of Chemistry, University of California, Los Angeles

Slides available now! Recordings are an exclusive ACS member benefit.
www.acs.org/acswebinars

This ACS Webinar is co-produced with the National Nanotechnology Coordination Office and ACS Safety Programs
“A great presenter who blended high level information with some good details. I was reminded of many facts and concepts, and I learned several new things.”

Fan of the Week

Mark Petrich
Director, Single-Use Systems Engineering, Merck & Co.
ACS member for 32 years strong!

Be a featured fan on an upcoming webinar! Write to us @ acswебinars@acs.org


Contact ACS Webinars ® at acswebinars@acs.org

@AmericanChemicalSociety

@AmerChemSociety

https://www.linkedin.com/company/american-chemical-society
ACS Webinars® does not endorse any products or services. The views expressed in this presentation are those of the presenter and do not necessarily reflect the views or policies of the American Chemical Society.

Contact ACS Webinars ® at acswebinars@acs.org
Upcoming ACS Webinar

www.acs.org/acswebinars

https://www.acs.org/content/acs/en/acs-webinars/popular-chemistry/heavy-elements.html