



THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

SOPs, SOCs, and Docs:

*Developing Peer-to-Peer Safety to Fight Complacency in
Synthetic Inorganic Chemistry*

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University of North Carolina at Chapel Hill

October 22nd, 2019

Safety in a Synthetic Laboratory

Compliance

Safety Culture



Safety in a Synthetic Laboratory

Compliance

- Rules or mandated actions
- Top-Down approach (EHS)
- Bottom-Up approach (lab initiatives)



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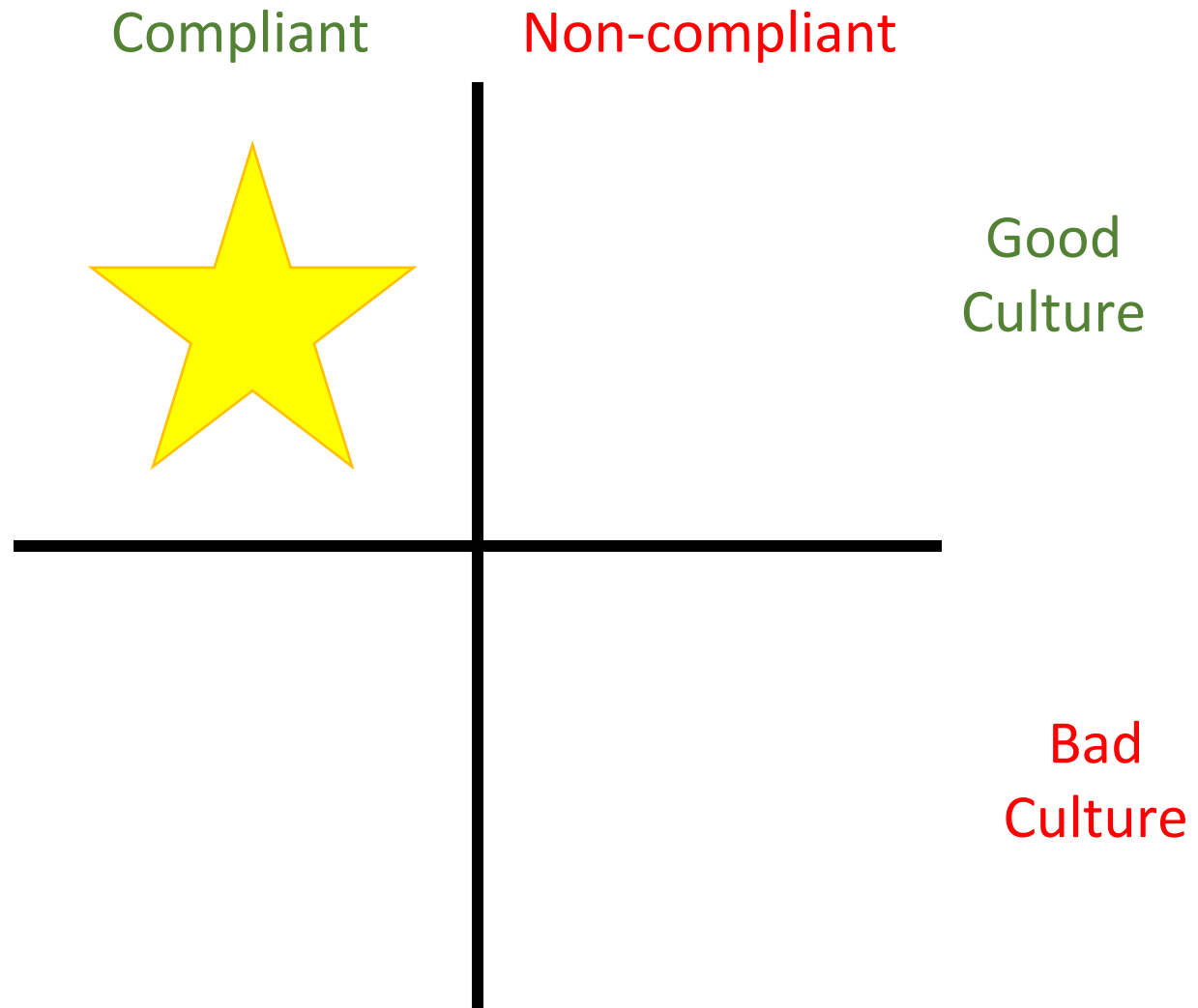


Safety Culture

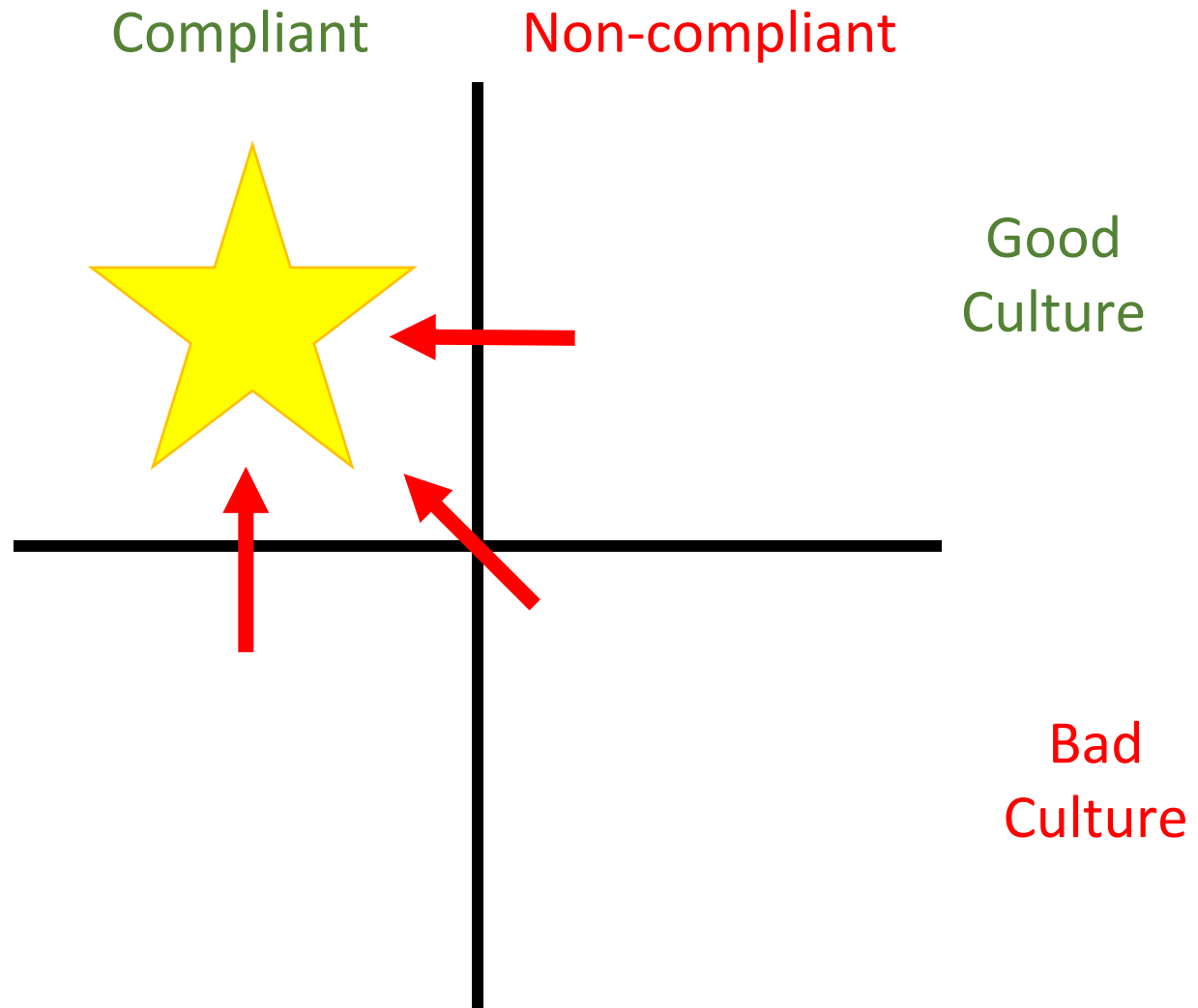
- Active engagement by students in thinking about safety



Safety in a Synthetic Laboratory



Safety in a Synthetic Laboratory

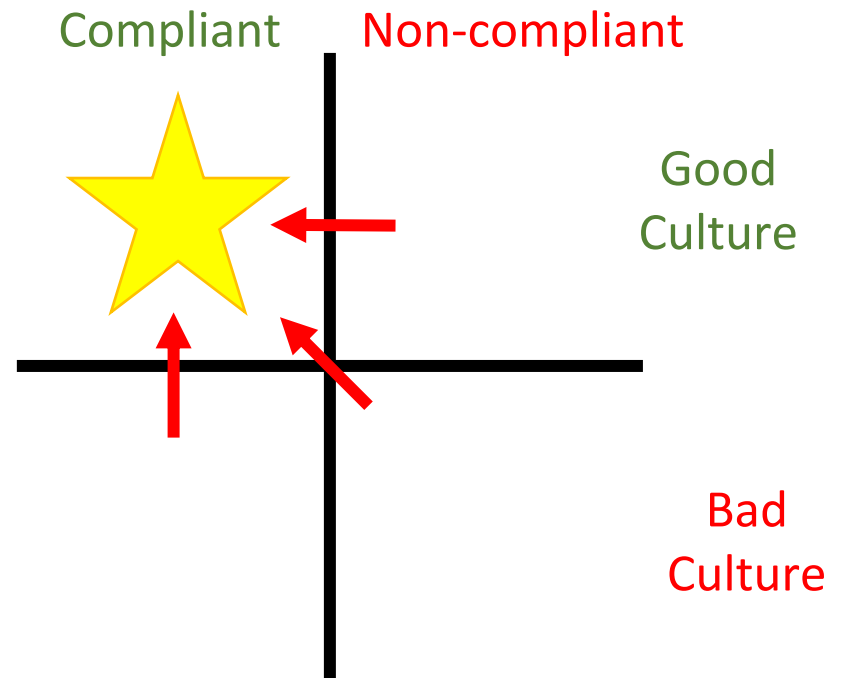


Initiatives in the Miller Lab

Fostering a grassroots safety culture

Safety Initiatives

Peer Teaching



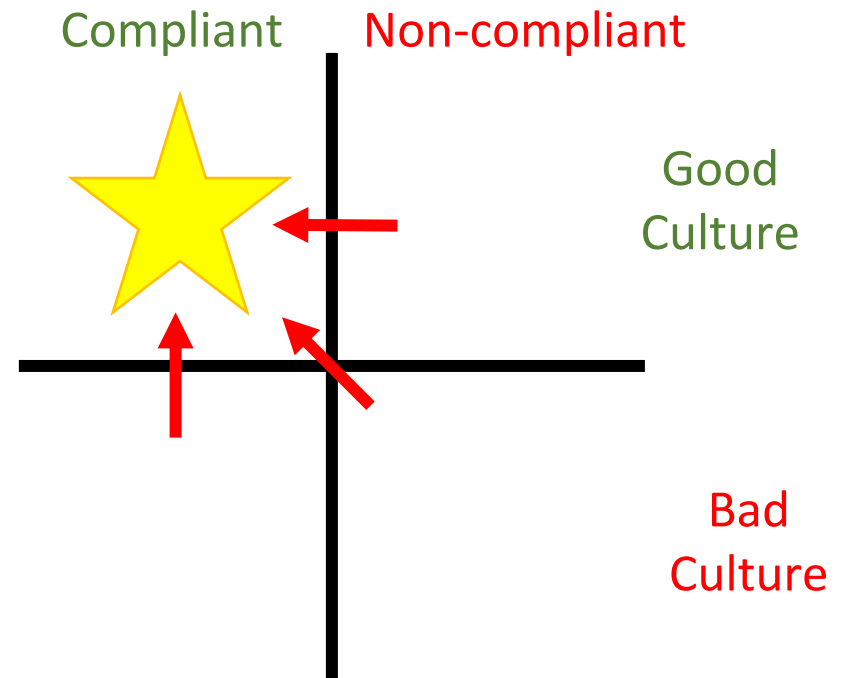
Initiatives in the Miller Lab

Fostering a grassroots safety culture

Safety Initiatives

- Standard Operating Procedures (SOPs)
- The Safety Net
- Safe Operating Cards (SOCs)

Peer Teaching



Initiatives in the Miller Lab

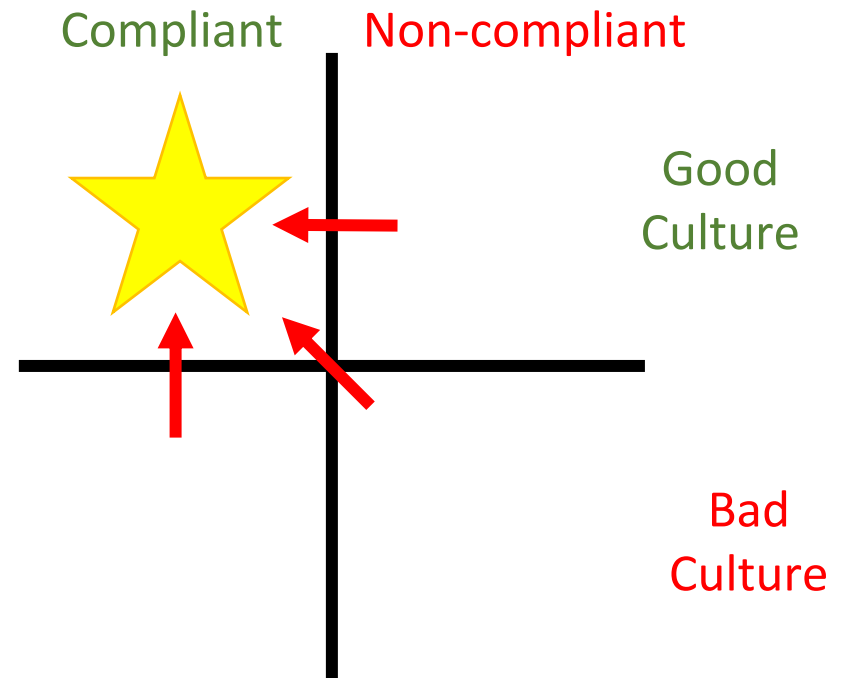
Fostering a grassroots safety culture

Safety Initiatives

- Standard Operating Procedures (SOPs)
- The Safety Net
- Safe Operating Cards (SOCs)

Peer Teaching

- Safety Minutes
- Safety Field Day



Standard Operating Procedures (SOPs)

Finding a place in the chemist's toolbox



- SOPs are widely used in industrial research and business to provide step-by-step instructions for routine tasks
- How can we adapt SOPs to fit a synthetic chemistry setting?

SOPs in the Miller Lab

Developing a teaching tool



- Provide baseline knowledge on a topic/procedure
- Serves as the starting point for trainings and discussions in the lab space

What Goes Into a SOP?

The first half is writing the SOP



- What would this SOP be about? Would a SOP be helpful?
- Student authorship helps foster ownership over safety
- How best to convey the information? Step-by-step, flow chart?
 - Being highly detailed is helpful

Example: Working with CO

Provide Information on Initial Risks

Training Requirements:

- Lab safety training
- Working with CO training
- Changing gas cylinder training

Potential Hazards:

- Inhalation of a toxic gas
- Injuries from failure of pressurized gas cylinder
- Backfilling glassware cooled in liquid nitrogen will condense >50 atm CO. Injuries may result from a possible explosion upon expansion of the gas.

Special PPE Requirements:

- CO detector

Materials Needed:

- CO gas cylinder
- Cylinder regulator CGA 350 (CGA 180 for lecture bottles: see SOP for lecture bottles)
- CO detector
- Schlenk line with a cross-over port connecting the gas and vacuum manifolds
- Crescent wrench
- Gas cylinder cart

Example: Working with CO

Provide Detail and Photographs

6.
Connect the regulator... Keep the front port (vacuum) shut at all times and only use the back port that corresponds to the back manifold (gas line).

7.
Check that the gas manifold is connected to a bubbler and will be venting towards the back of the hood.



What Goes Into a SOP?

The second half is revising



- Test and review as a group before implementation
- When should SOPs be used in training?
- SOPs are living documents, revise overtime

Adopting SOPs into Your Lab

- Determine what topics you want SOPs for
- Divide and Conquer Writing
- Revise as a Group
- Implement and distribute for training

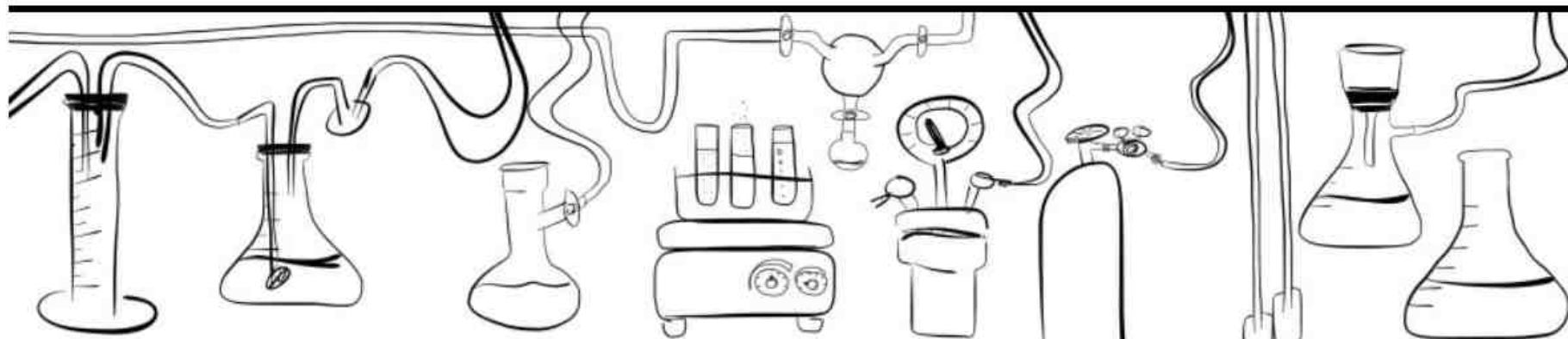


The Safety Net

<http://safetyweb.unc.edu/>

The Safety Net

Safety knows no season.



The Safety Net Standard Operating Procedures Lab Resources Synthetic Procedures Physical Properties Safety News Behind the Net

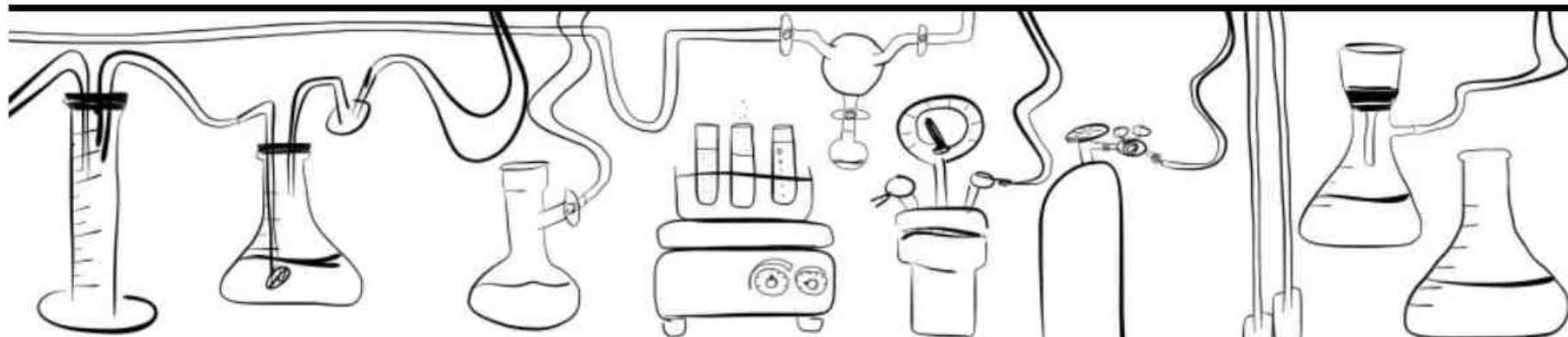
- A collaborative project started by Ian Tonks (U. of Minn.) and Alex Miller (UNC-CH)
- A site dedicated to providing tools to synthetic laboratories to improve safety and encourage critical thinking

The Safety Net

An online source of SOPs

The Safety Net

Safety knows no season.



[The Safety Net](#) [Standard Operating Procedures](#) [Lab Resources](#) [Synthetic Procedures](#) [Physical Properties](#) [Safety News](#) [Behind the Net](#)

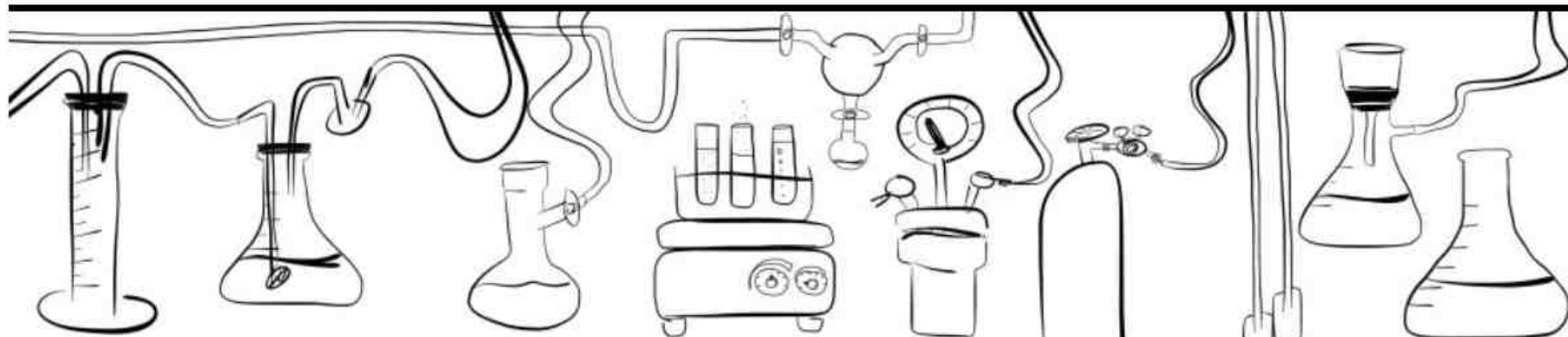
- ~50 SOPs available online
- Template also available for writing your own SOPs
- Open for submission and requests if you have a SOP to add!

The Safety Net

An online source of SOPs

The Safety Net

Safety knows no season.



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[SOCs \(Safe Operating Cards\)](#). Reusable placards that can be placed near a fume hood to provide details of ongoing reactions or processes.

[Lab Safety signs](#). Ready-to-print signs to clearly label the location of safety showers or other lab safety equipment, the presence of laboratory hazards, and other information.

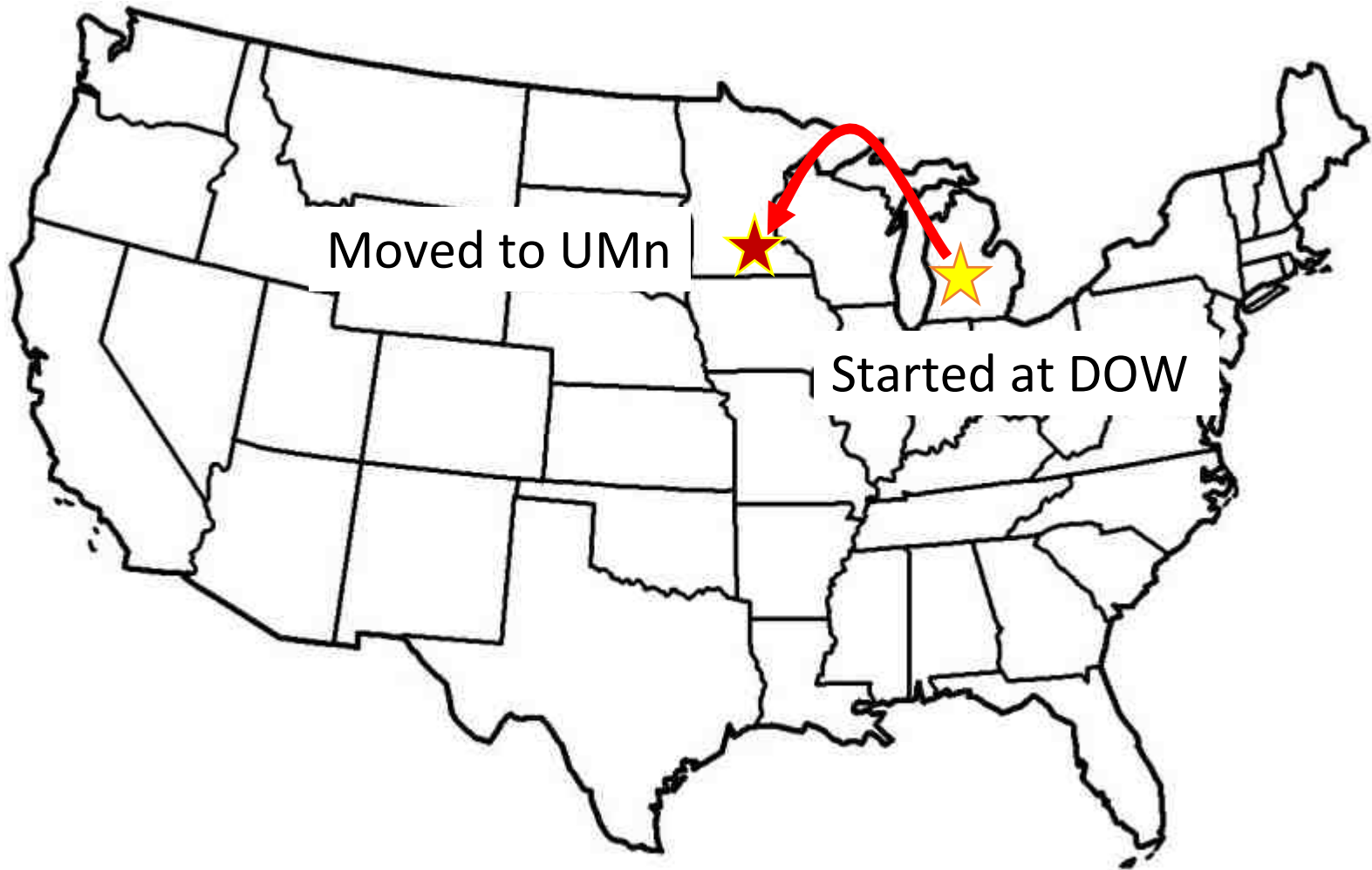
Safe Operating Cards (SOCs)

Started in industrial chemistry




Safe Operating Cards (SOCs)

Started in industrial chemistry



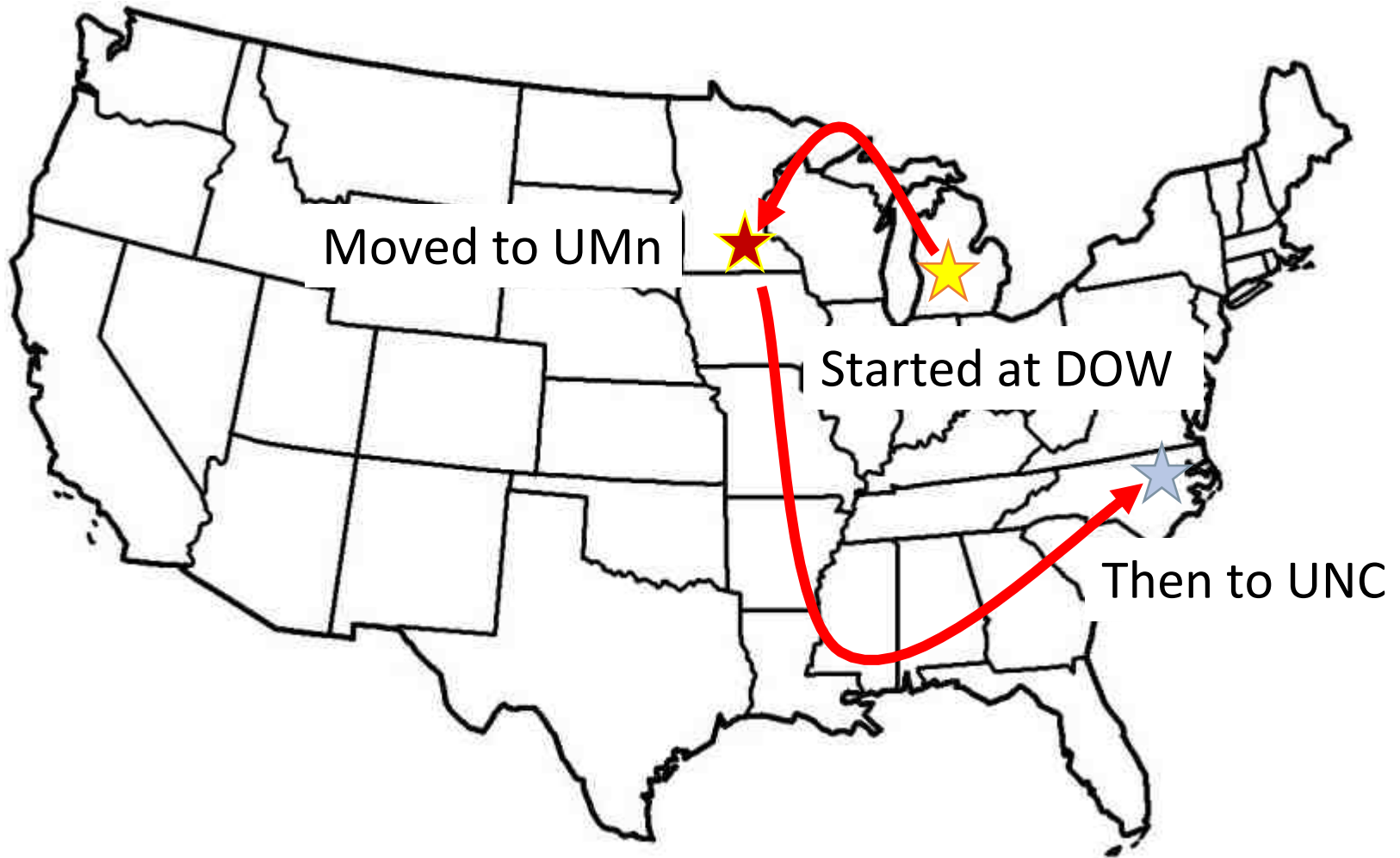
Safe Operating Cards (SOCs)

In the Tonks Lab

 <p>Safety Starts with U Reaction:</p>																	
<p>Contact: _____ _____ _____ _____</p>	<p>Intended Conditions: T: _____ P: _____ Stirring: _____ Other: _____ _____</p>																
<p style="text-align: center;">Hazards</p> <table border="0"><tr><td><input type="checkbox"/> <u>A</u>cid</td><td><input type="checkbox"/> <u>L</u>ow <u>H</u>azard</td></tr><tr><td><input type="checkbox"/> <u>B</u>ase</td><td><input type="checkbox"/> <u>B</u>iohazard</td></tr><tr><td><input type="checkbox"/> <u>O</u>xidizer</td><td><input type="checkbox"/> <u>R</u>adioactive</td></tr><tr><td><input type="checkbox"/> <u>F</u>lammable</td><td><input type="checkbox"/> <u>T</u>emp Hi/Lo</td></tr><tr><td><input type="checkbox"/> <u>M</u>ercury or Heavy Metal</td><td><input type="checkbox"/> <u>P</u>ressure Hi/Lo</td></tr><tr><td><input type="checkbox"/> <u>R</u>eactive <u>A</u>ir, <u>W</u>ater, <u>S</u>hock, <u>L</u>ight, <u>H</u>eat, halogens, _____</td><td><input type="checkbox"/> _____</td></tr><tr><td><input type="checkbox"/> <u>I</u>nhalation <u>H</u>azard</td><td><input type="checkbox"/> _____</td></tr><tr><td><input type="checkbox"/> <u>T</u>oxic</td><td><input type="checkbox"/> _____</td></tr></table>	<input type="checkbox"/> <u>A</u> cid	<input type="checkbox"/> <u>L</u> ow <u>H</u> azard	<input type="checkbox"/> <u>B</u> ase	<input type="checkbox"/> <u>B</u> iohazard	<input type="checkbox"/> <u>O</u> xidizer	<input type="checkbox"/> <u>R</u> adioactive	<input type="checkbox"/> <u>F</u> lammable	<input type="checkbox"/> <u>T</u> emp Hi/Lo	<input type="checkbox"/> <u>M</u> ercury or Heavy Metal	<input type="checkbox"/> <u>P</u> ressure Hi/Lo	<input type="checkbox"/> <u>R</u> eactive <u>A</u> ir, <u>W</u> ater, <u>S</u> hock, <u>L</u> ight, <u>H</u> eat, halogens, _____	<input type="checkbox"/> _____	<input type="checkbox"/> <u>I</u> nhalation <u>H</u> azard	<input type="checkbox"/> _____	<input type="checkbox"/> <u>T</u> oxic	<input type="checkbox"/> _____	<p style="text-align: center;">Emergency Shut Down:</p> <p>_____ _____ _____ _____ _____ _____ _____</p>
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Safe Operating Cards (SOCs)

Started in industrial chemistry



Safe Operating Cards (SOCs)

In the Miller Lab

Reaction

Expt# _____

Contact _____

Phone _____

Intended Conditions

T: _____ P: _____ Atm: _____

Stirring (Y/N), Dark (Y/N)

Other: _____

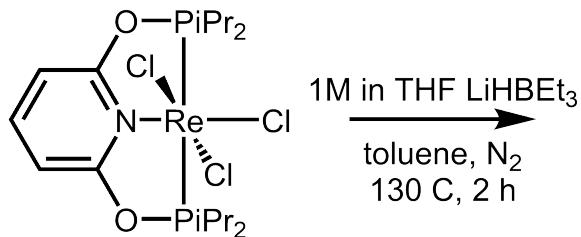
Hazards

- | | |
|---|--|
| <input type="checkbox"/> Acid | <input type="checkbox"/> Temp Hi/Lo |
| <input type="checkbox"/> Base | <input type="checkbox"/> Pressure Hi/Lo |
| <input type="checkbox"/> Oxidizer | <input type="checkbox"/> Heavy Metal |
| <input type="checkbox"/> Flammable | <input type="checkbox"/> Inhalation Hazard |
| <input type="checkbox"/> Air Sensitive | <input type="checkbox"/> Toxic |
| <input type="checkbox"/> Moisture Sensitive | <input type="checkbox"/> Biohazard |
| <input type="checkbox"/> Light Sensitive | <input type="checkbox"/> Radioactive |
| <input type="checkbox"/> Shock Sensitive | <input type="checkbox"/> Low Hazard |
| <input type="checkbox"/> Heat Sensitive | <input type="checkbox"/> _____ |

Emergency Shut Down

Using a SOC

Reaction



Expt#

QB 4-139-1

Contact

Phone

Hazards

- | | |
|---|--|
| <input type="checkbox"/> Acid | <input type="checkbox"/> Temp Hi/Lo |
| <input type="checkbox"/> Base | <input type="checkbox"/> Pressure Hi/Lo |
| <input type="checkbox"/> Oxidizer | <input type="checkbox"/> Heavy Metal |
| <input type="checkbox"/> Flammable | <input type="checkbox"/> Inhalation Hazard |
| <input type="checkbox"/> Air Sensitive | <input type="checkbox"/> Toxic |
| <input type="checkbox"/> Moisture Sensitive | <input type="checkbox"/> Biohazard |
| <input type="checkbox"/> Light Sensitive | <input type="checkbox"/> Radioactive |
| <input type="checkbox"/> Shock Sensitive | <input type="checkbox"/> Low Hazard |
| <input type="checkbox"/> Heat Sensitive | <input type="checkbox"/> _____ |

Intended Conditions

T: _____ P: _____ Atm: _____

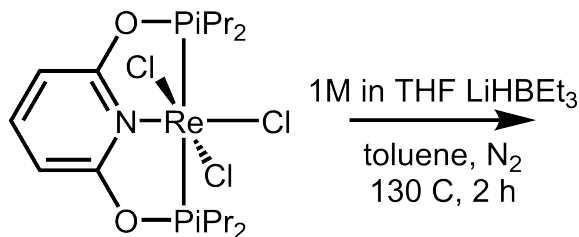
Stirring (Y/N), Dark (Y/N)

Other: _____

Emergency Shut Down

Using a SOC

Reaction



Expt#

QB 4-139-1

Contact Quinton

Phone 555-555-5555

Hazards

- | | |
|---|--|
| <input type="checkbox"/> Acid | <input type="checkbox"/> Temp Hi/Lo |
| <input type="checkbox"/> Base | <input type="checkbox"/> Pressure Hi/Lo |
| <input type="checkbox"/> Oxidizer | <input type="checkbox"/> Heavy Metal |
| <input type="checkbox"/> Flammable | <input type="checkbox"/> Inhalation Hazard |
| <input type="checkbox"/> Air Sensitive | <input type="checkbox"/> Toxic |
| <input type="checkbox"/> Moisture Sensitive | <input type="checkbox"/> Biohazard |
| <input type="checkbox"/> Light Sensitive | <input type="checkbox"/> Radioactive |
| <input type="checkbox"/> Shock Sensitive | <input type="checkbox"/> Low Hazard |
| <input type="checkbox"/> Heat Sensitive | <input type="checkbox"/> _____ |

Intended Conditions

T: _____ P: _____ Atm: _____

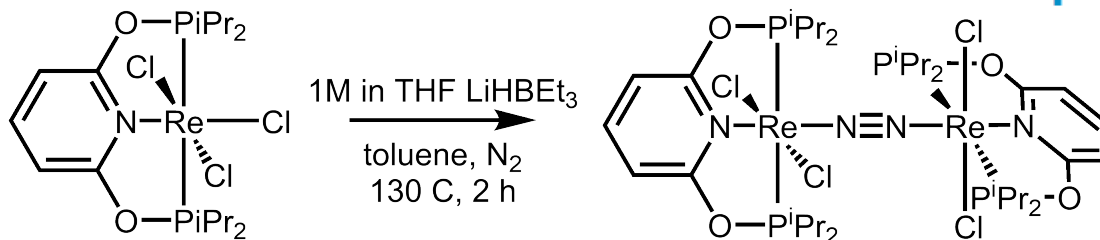
Stirring (Y/N), Dark (Y/N)

Other: _____

Emergency Shut Down

Using a SOC

Reaction



Expt#

QB 4-139-1

Contact Quinton

Phone 555-555-5555

Hazards

- | | |
|---|--|
| <input type="checkbox"/> Acid | <input type="checkbox"/> Temp Hi/Lo |
| <input type="checkbox"/> Base | <input type="checkbox"/> Pressure Hi/Lo |
| <input type="checkbox"/> Oxidizer | <input type="checkbox"/> Heavy Metal |
| <input type="checkbox"/> Flammable | <input type="checkbox"/> Inhalation Hazard |
| <input type="checkbox"/> Air Sensitive | <input type="checkbox"/> Toxic |
| <input type="checkbox"/> Moisture Sensitive | <input type="checkbox"/> Biohazard |
| <input type="checkbox"/> Light Sensitive | <input type="checkbox"/> Radioactive |
| <input type="checkbox"/> Shock Sensitive | <input type="checkbox"/> Low Hazard |
| <input type="checkbox"/> Heat Sensitive | <input type="checkbox"/> _____ |

Intended Conditions

T: 130 C P: 1 atm Atm: N₂

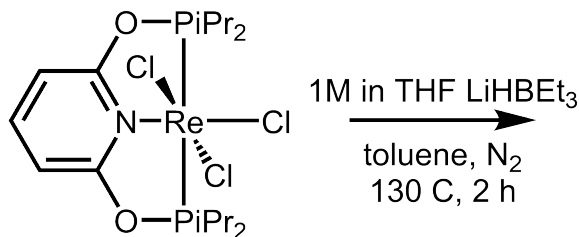
Stirring Y N, Dark Y N

Other: _____

Emergency Shut Down

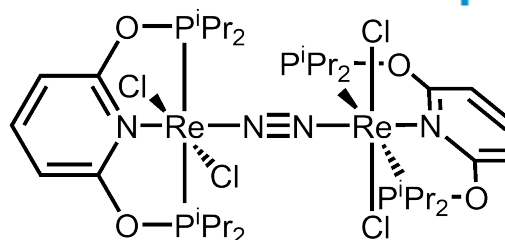
Using a SOC

Reaction



Expt#

QB 4-139-1



Contact Quinton

Phone 555-555-5555

Intended Conditions

T: 130 C P: 1 atm Atm: N₂

Stirring (Y/N), Dark (Y/N)

Other: _____

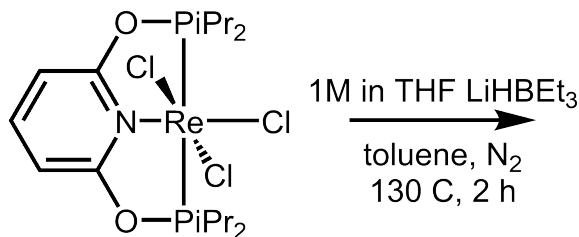
Hazards

- | | |
|--|---|
| <input type="checkbox"/> Acid | <input checked="" type="checkbox"/> Temp <u>Hi</u> Lo |
| <input checked="" type="checkbox"/> Base | <input type="checkbox"/> Pressure Hi/Lo |
| <input type="checkbox"/> Oxidizer | <input type="checkbox"/> Heavy Metal |
| <input checked="" type="checkbox"/> Flammable | <input type="checkbox"/> Inhalation Hazard |
| <input checked="" type="checkbox"/> Air Sensitive | <input type="checkbox"/> Toxic |
| <input checked="" type="checkbox"/> Moisture Sensitive | <input type="checkbox"/> Biohazard |
| <input type="checkbox"/> Light Sensitive | <input type="checkbox"/> Radioactive |
| <input type="checkbox"/> Shock Sensitive | <input type="checkbox"/> Low Hazard |
| <input checked="" type="checkbox"/> Heat Sensitive | <input checked="" type="checkbox"/> <u>Pyrophoric</u> |

Emergency Shut Down

Using a SOC

Reaction



Expt#

QB 4-139-1

Contact Quinton

Phone 555-555-5555

Hazards

- | | |
|--|---|
| <input type="checkbox"/> Acid | <input checked="" type="checkbox"/> Temp Hi Lo |
| <input checked="" type="checkbox"/> Base | <input type="checkbox"/> Pressure Hi/Lo |
| <input type="checkbox"/> Oxidizer | <input type="checkbox"/> Heavy Metal |
| <input checked="" type="checkbox"/> Flammable | <input type="checkbox"/> Inhalation Hazard |
| <input checked="" type="checkbox"/> Air Sensitive | <input type="checkbox"/> Toxic |
| <input checked="" type="checkbox"/> Moisture Sensitive | <input type="checkbox"/> Biohazard |
| <input type="checkbox"/> Light Sensitive | <input type="checkbox"/> Radioactive |
| <input type="checkbox"/> Shock Sensitive | <input type="checkbox"/> Low Hazard |
| <input checked="" type="checkbox"/> Heat Sensitive | <input checked="" type="checkbox"/> <u>Pyrophoric</u> |

Intended Conditions

T: 130 C P: 1 atm Atm: N₂

Stirring **(Y/N)**, Dark **(Y/N)**

Other: _____

Emergency Shut Down

1) Turn off hot plate

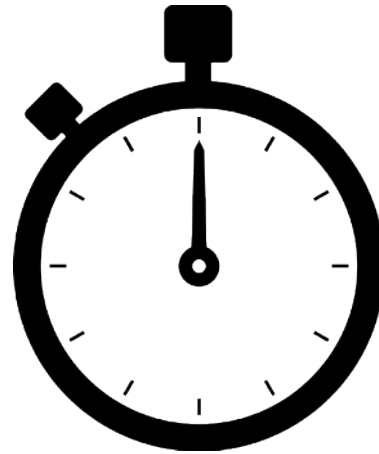
2) Remove reaction flask from hot plate and
allow to cool

A SOC's Success Story



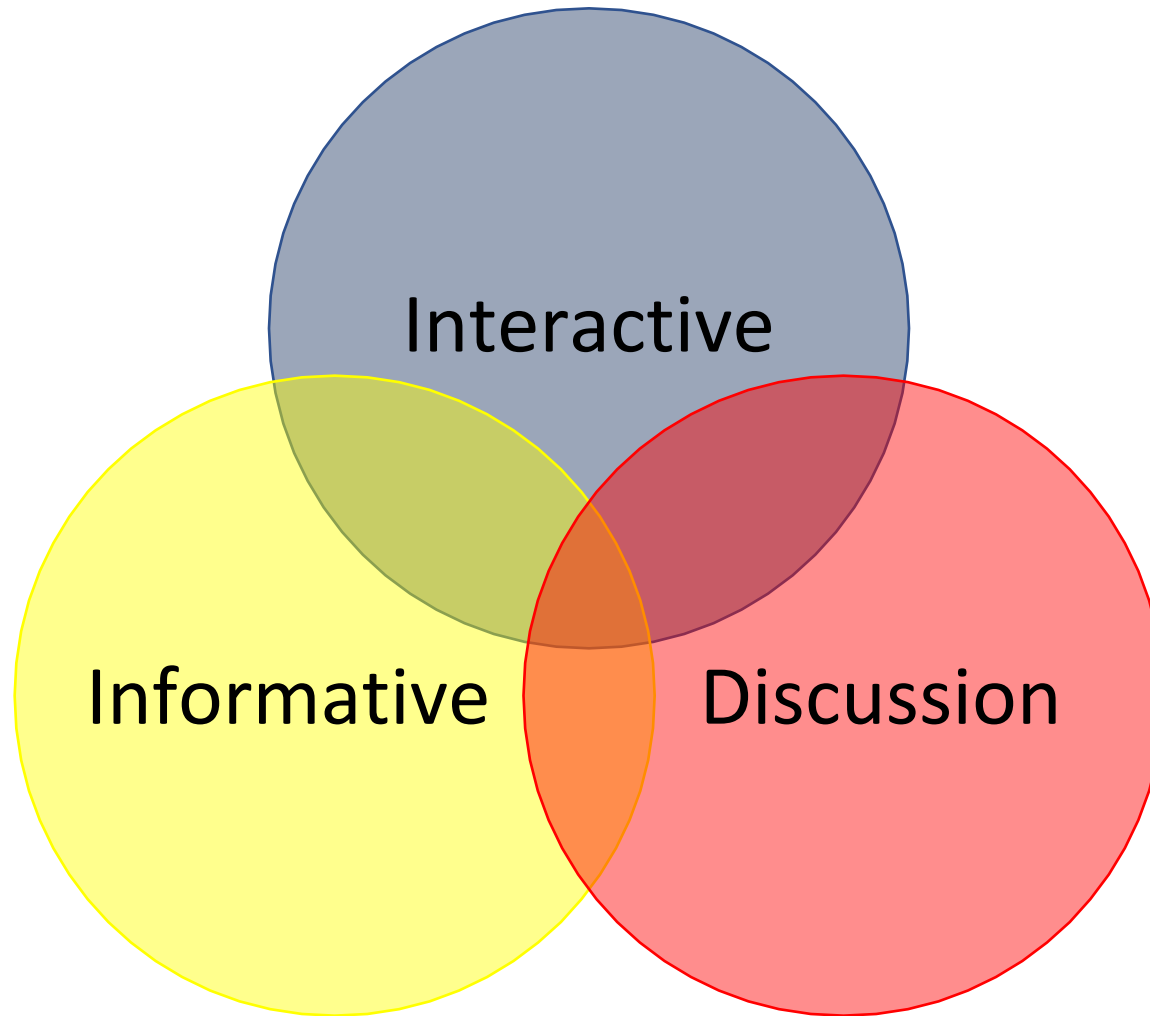
- Recently had a power outage in April of 2019
- Only a few people left in lab, but they were able to safely and efficiently shutdown the entire lab using SOC's

Peer Teaching: Safety Minutes



- A Safety Minute is a 10-20 minute interactive discussion on a topic presented by a researcher
- Can relate to a recent lab accident, a technique or procedure, a SOP, or hazard assessment
- It is a part of our weekly group meeting

Components of a Safety Minute

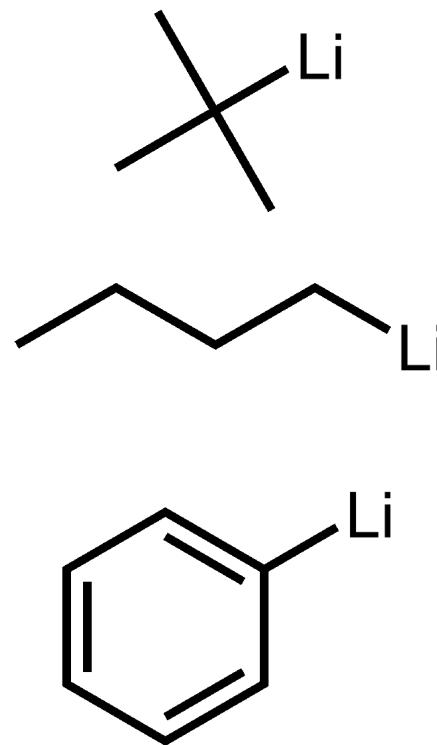


Example 1: Cradle-to-Grave Planning

A complete risk assessment of a reaction

Prompt: Design a complete cradle-to-grave plan for using an organolithium reagent

- Interactive:
 - Prompt requires students to create something
- Discussion:
 - Students will discuss best practices and options on tackling potential hazards
- Informative:
 - Students are either exposed to new knowledge or get a refresher



Example 2: Unexpected Lab Closure

Prepare for extreme weather events

Prompt: A hurricane is expected to hit campus, how do you prepare the lab for the storm?

- Interactive:
 - Prompt requires students to create a plan of action
- Discussion:
 - Students will discuss what must be done to shutdown the lab
- Informative:
 - Students are reminded very clearly of what actions must be completed



Getting the Most From Safety Minutes

- Incorporating examples of past work or ongoing research
- Engaging everyone in discussion
 - Creating environments where new students will participate
- Choosing a topic that requires critical thinking
- A great way to be proactive and not reactive
 - Run through weather scenarios before the hurricane/blizzard



Peer Teaching: Safety Field Day



- Annual requirement to review safety with PI
- Created a day of demos and hands-on activities
- Builds in time for discussion on the safety of activities

Implementing Safety Field Day

- Ask for people to submit ideas for activities while planning
 - Student-led process
- Design activities around two types:
 - Important for everyone to review annually
 - A rare technique that can be shared as a teaching opportunity
- Rotate through activities/demos in small groups



Cannula Transfers, 2017

Example Activities

Those in bold are perennial activities

Hands-on

- **Gloveboxes**
- Sealing Ampoules
- Cannula Transfer

Discussions

- Crystallizations
- NMR Data Analysis

Demos

- **Vacuum traps**
- **Moving gas cylinders**
- Vac Transfer
- Soxhlet extraction
- Quenching Pyrophorics
- Air-free filtrations

Designing a Successful Activity

- Pick a topic that you are highly knowledgeable in
- Ensure there is a clear demo/hands-on activity
- Explain why the activity/technique is important
- Engage groups in discussion



Air-free filtrations, 2017

Outward Impacts

- SOPs are available online at <http://safetyweb.unc.edu/>
- Additional resources and templates are also available
- SOC's have been passed onto EHS and distributed to the department as a whole
 - A few research labs have adopted them
 - Undergraduate teaching labs have used them in advanced synthetic laboratories
- Peer teaching initiatives (Safety Minutes and Safety Field Day)

Acknowledgements

People

Prof. Alexander Miller

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Henry Dodge

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Dr. Tianfei Liu

Dr. Scott Kolmar

Andrew Camp

Bethany Stratakes

Eric Assaf

Sebastian Acosta-Calle

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Joyanne Terry

Dean Bass



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