Supporting a prudent safety culture through job hazard analysis and information literacy skills

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Today's Topics

1. Risk Assessment and Minimization in a Laboratory Safety Culture
2. Professional Judgment and Information Literacy
3. Developing More Informationally-Literate Electronic Tools
4. Use Cases in the Lab Setting

Safety Considerations in Research Proposals

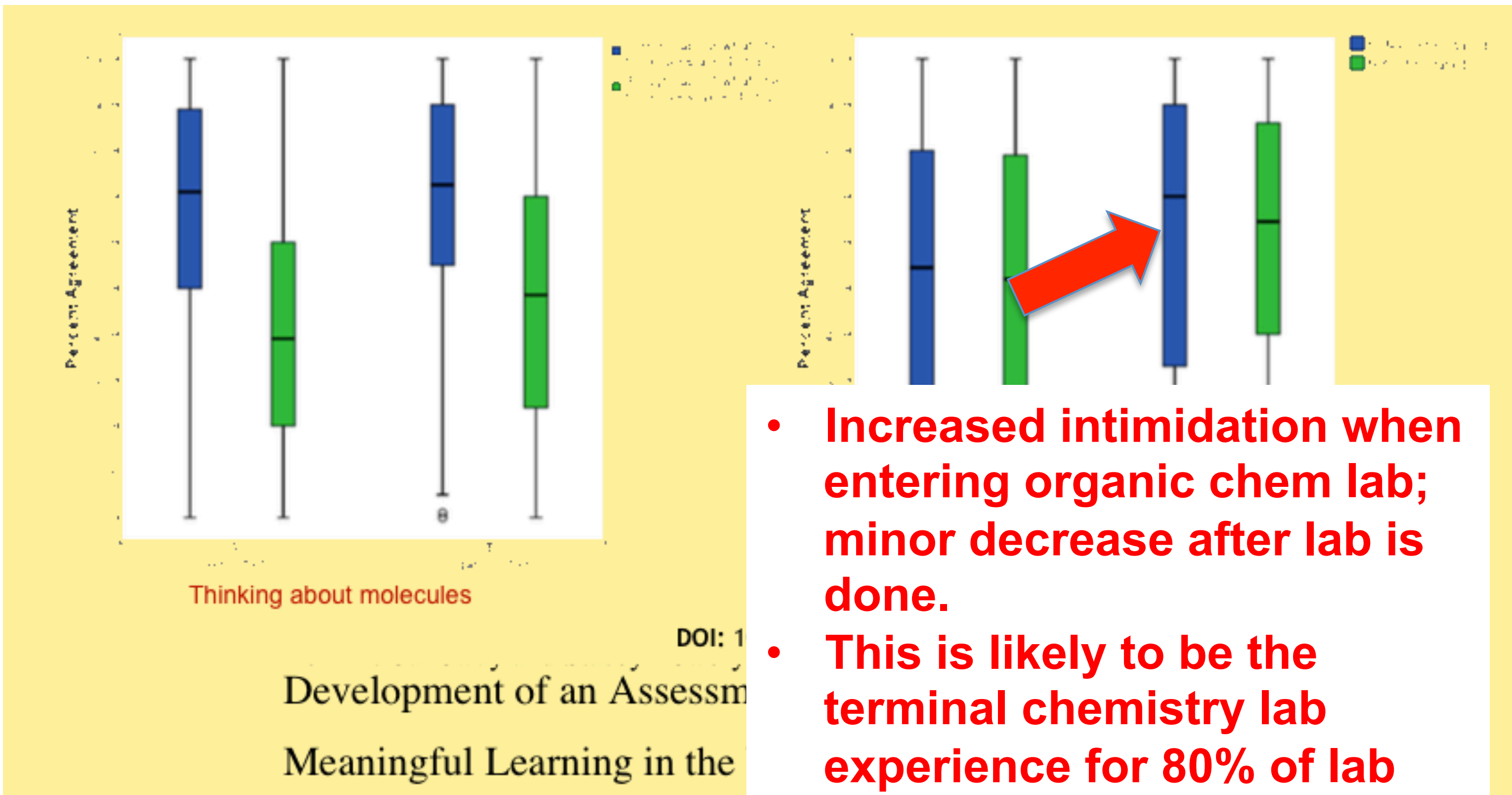
J Chem Ed, H.K. Livingston (1964)

- "Safety considerations are **mental processes** that determine if **hazards** are likely to be involved in a proposed course of action, and to evaluate the steps that can be taken to **minimize** those hazards…
- "***Hazard*** is the incurring of a possibility of loss or harm for the possibility of ***benefit***.
  "***Danger*** may have no compensating benefit.
  In ***risk,*** the possibility of loss is the chief thought.
- "***Legal requirements*** …are outside the competence of our committee…Certainly if humanitarian and ethical requirements are met, there are not likely to be any issues that will require legal action."
- **The last statement is an outdated approach to prudence, rooted in the laws and information tools of the time.**

H. K. Livingston was educated in the public high schools of San Benito, Texas, and at Schreiner Institute (Kerrville, Texas), the University of Texas, and the University of Chicago. He obtained his Ph.D. at the last-named institution in 1941. From 1941 to 1964 he was engaged in chemical research for the DuPont Company, holding a variety of positions including laboratory director in the Organic Chemicals Department and director of pioneering research in the Electrochemicals Department. He is currently professor of chemistry at Wayne State University, specializing in polymer chemistry.

What are students learning about lab safety culture in the Class Lab?

General chemistry | Organic chemistry | General chemistry | Organic chemistry



- **Increased intimidation when entering organic chem lab; minor decrease after lab is done.**
- **This is likely to be the terminal chemistry lab experience for 80% of lab scientists**

Blue = scores before labs began, Green = scores after lab ended

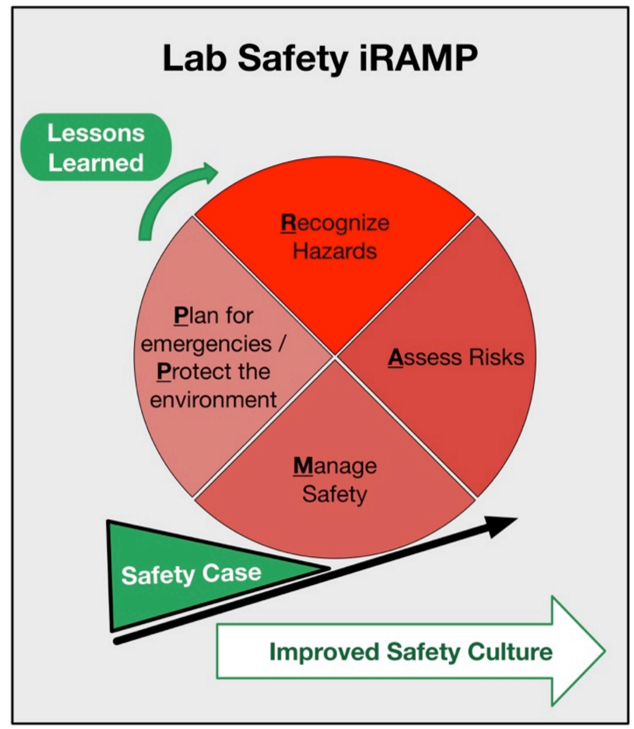
Kelli R. Galloway and Stacey Lowery Bretz*, Sept. 2015

The RAMP approach to Building a Lab Safety System for Chemicals

Enculturating students into a lab safety culture today requires information tools appropriate to the 21st Century.

Happily, there is an emerging paradigm that can support such tools. It has 6 components:

1. *Safety Culture*
2. *Hazard Identification*
3. ***Risk Assessment***
4. ***Managing Safety***
5. *Planning for Emergencies*
6. *Protecting the Environment*



What does *Assessment* Mean in this Model?

- A system can not address all risks equally, so the risk assessment process must **prioritize** the identified hazards in terms of:
  - *likelihood* of occurrence,
  - *amount* of associated damage, and
  - likely *benefit*
- This prioritization requires both **technical information** and **professional judgment**.
- Neither information or judgment is free, but they can be cheaper with the help of 21st Century electronic information resources

The *Management* Component: Getting Specific about Controls

1. Replacing the Hazard
2. Engineering Controls
3. Training and Oversight
4. Personal Protective Equipment
5. Emergency Planning and Response

Relying on a Solution rather than a System

Figure 3. Methanol igniting on the day of the incident[8]

An Assessment & Management Example: Classroom Demonstrations

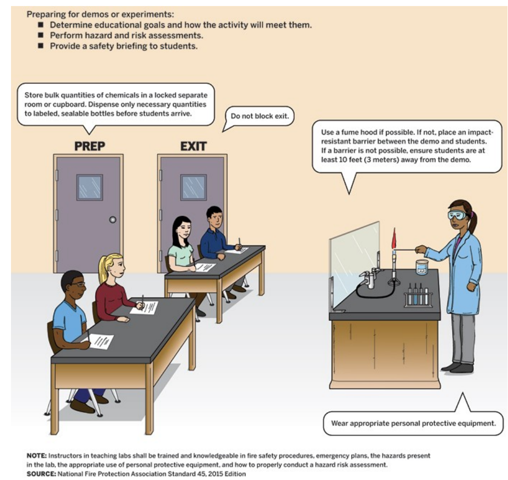
The Risk Question:

For a classroom demonstration, which of methanol's hazards are most important:

- For the demonstrator?
- For the students?

1 **GHS Classification**

Signal: Dgr
H225 - Highly flammable liquid and vapour
H331 - Toxic if inhaled
H311 - Toxic in contact with skin
H301 - Toxic if swallowed
H370 ** Causes damage to organs



1. Replacing the Hazard
2. Engineering Controls
3. Training and Oversight
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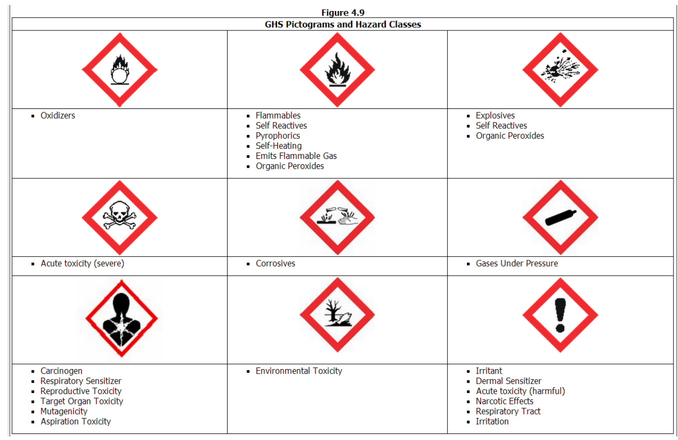
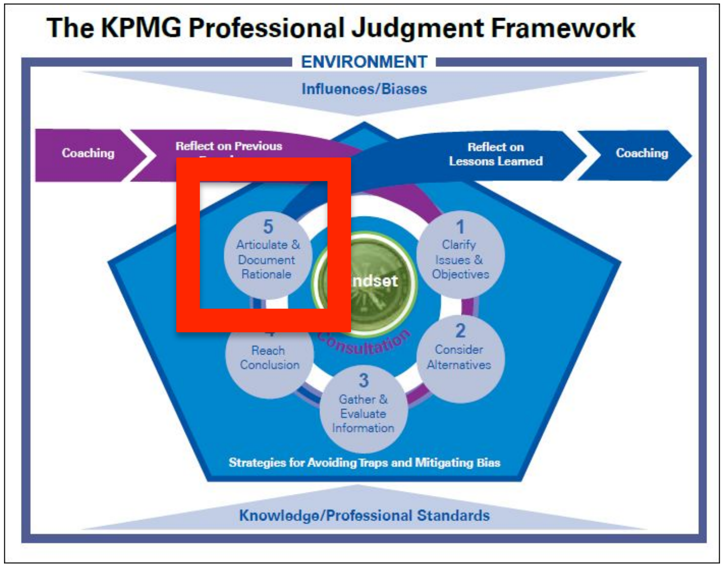
5. Emergency Planning and Response

Combining Information and Judgment

- The GHS signal words and hazard statements are a first step in collecting the **information** to develop a risk assessment
- However, they don't address chemical **reactivities, reaction conditions** or identify **variations in the risk level** for various participants or locations; this is where **professional judgment** comes in
- **Documentated** professional judgment is better understood and easier to share.

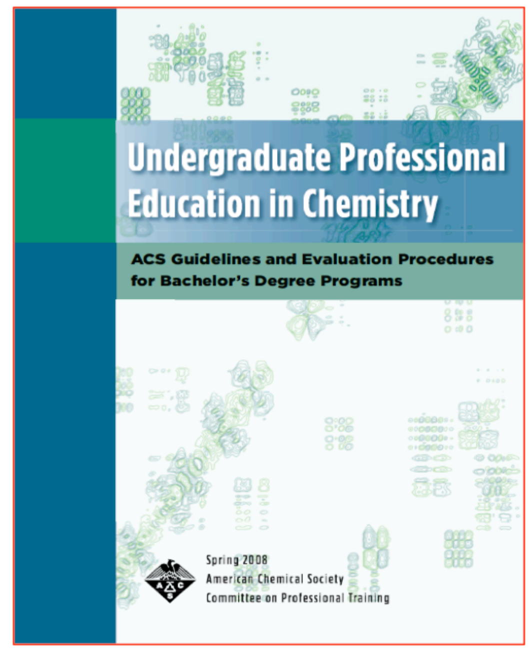




Professional Judgment and Information Literacy

Assessing information is a core piece of professional safety judgment

- **Evaluation Criteria** (the CRAAP test)
  - **Currency:** The timeliness of the information.
  - **Relevance:** The importance of the information for your needs.
  - **Authority:** The source of the information.
  - **Accuracy:** The reliability, truthfulness and correctness of the content.
  - **Purpose:** The reason the information exists.



Information Problems with traditional MSDS

Purpose: **regulatory compliance**

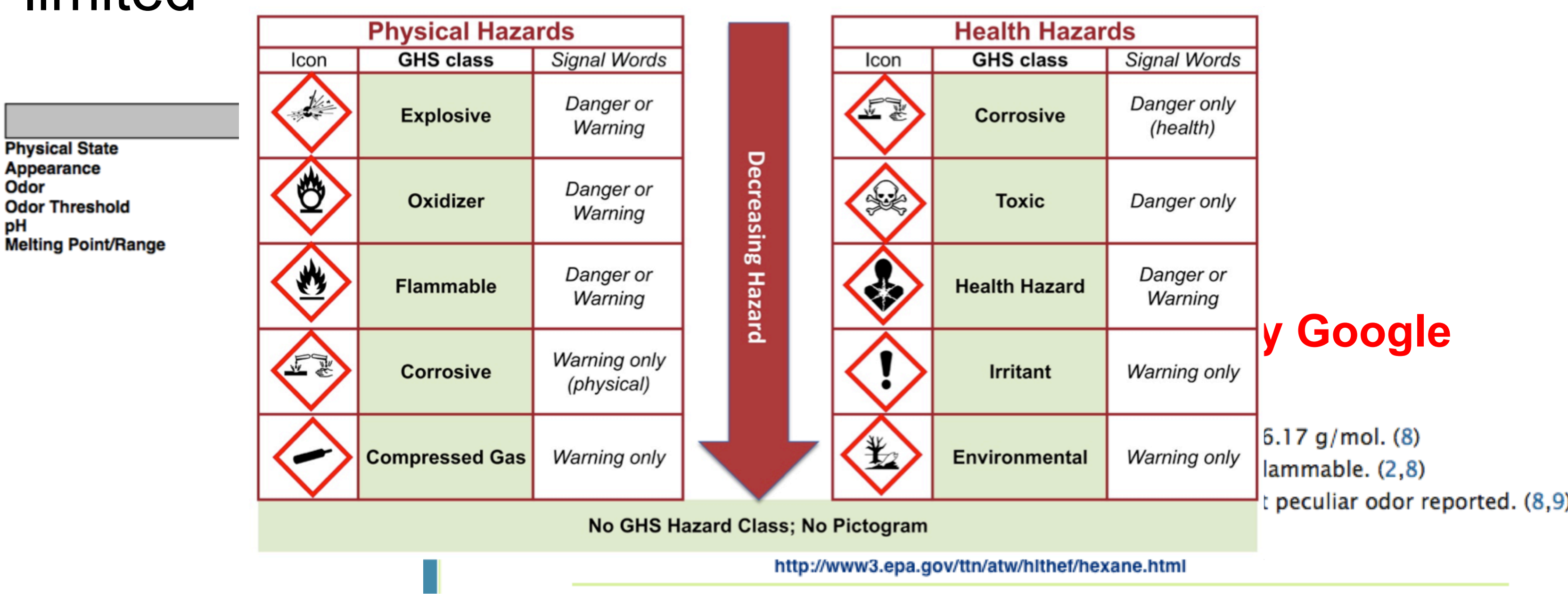
- Traditional MSDS's are written for legal purposes, so the ***currency*** and ***relevance*** of the information provided is constrained by commercial considerations such as *preparation costs, trade secrets, liability* and *legal jurisdiction.*
- The ***authority*** (provenance) of the information is not provided, so evaluating its ***accuracy*** is cumbersome, if possible.

Progress with GHS Information

Purpose: assist chemical users, increasing usability

Limitations:

- ***Relevance*** limited because SDSs are organized around specific chemicals and labs work with processes
- ***Currency*** is limited due to novel nature of chemicals
- ***Authority*** and ***accuracy:*** information provenance is still limited



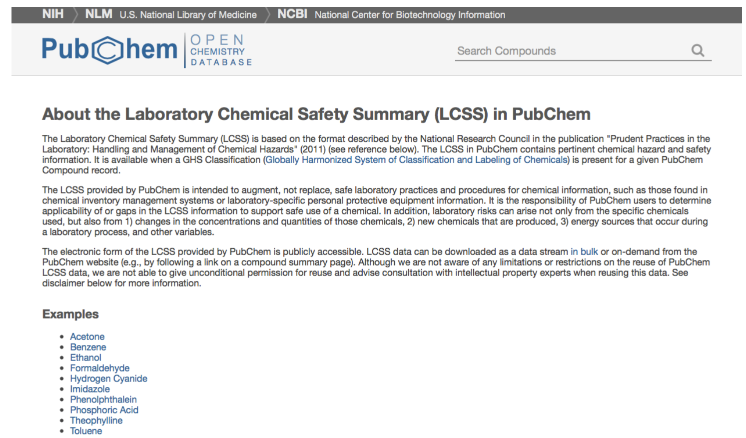
Physical Hazards		
Icon	GHS class	Signal Words
	Explosive	Danger or Warning
	Oxidizer	Danger or Warning
	Flammable	Danger or Warning
	Corrosive	Warning only (physical)
	Compressed Gas	Warning only

Health Hazards		
Icon	GHS class	Signal Words
	Corrosive	Danger only (health)
	Toxic	Danger only
	Health Hazard	Danger or Warning
	Irritant	Warning only
	Environmental	Warning only

No GHS Hazard Class; No Pictogram

Information Advantages of the PubChem LCSS

- **Purpose and Relevance**: sharing objective information for reuse in multiple processes
- **Currency:** Information updates as the source updates it
- **Accuracy and Authority:** Provenance is provided at a click
- **Relevance:** Additional information sources can be incorporated as needs are identified; the beginnings of process information are provided by sources in the Stability and Reactivity section



NIH NLM U.S. National Library of Medicine NCBI National Center for Biotechnology Information

PubChem OPEN CHEMISTRY DATABASE

Search Compounds

About the Laboratory Chemical Safety Summary (LCSS) in PubChem

The Laboratory Chemical Safety Summary (LCSS) is based on the format described by the National Research Council in the publication "Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards" (2011) (see reference below). The LCSS in PubChem contains pertinent chemical hazard and safety information. It is available when a GHS Classification (Globally Harmonized System of Classification and Labeling of Chemicals) is present for a given PubChem Compound record.

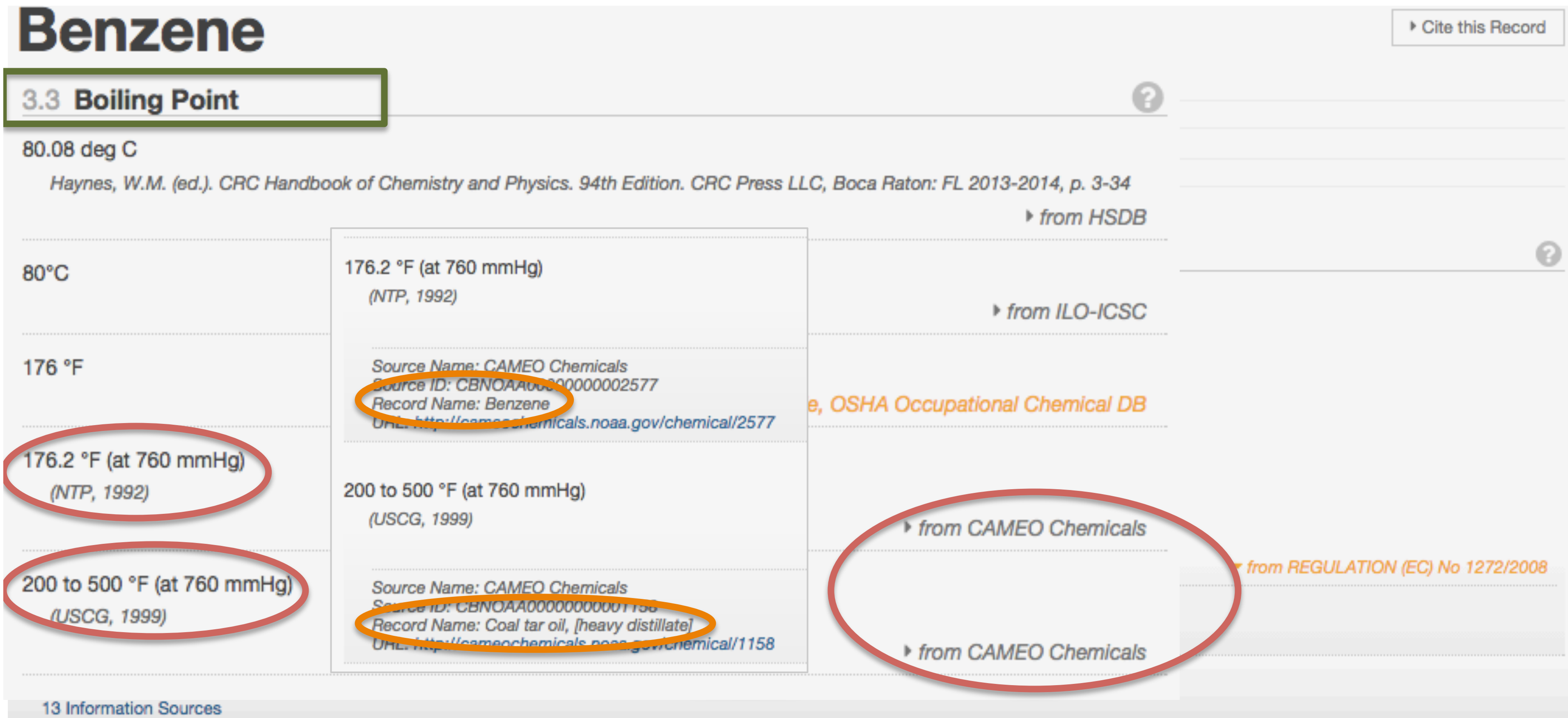
The LCSS provided by PubChem is intended to augment, not replace, safe laboratory practices and procedures for chemical information, such as those found in chemical inventory management systems or laboratory-specific personal protective equipment information. It is the responsibility of PubChem users to determine applicability of or gaps in the LCSS information to support safe use of a chemical. In addition, laboratory risks can arise not only from the specific chemicals used, but also from 1) changes in the concentrations and quantities of those chemicals, 2) new chemicals that are produced, 3) energy sources that occur during a laboratory process, and other variables.

The electronic form of the LCSS provided by PubChem is publicly accessible. LCSS data can be downloaded as a data stream in bulk or on-demand from the PubChem website (e.g., by following a link on a compound summary page). Although we are not aware of any limitations or restrictions on the reuse of PubChem LCSS data, we are not able to give unconditional permission for reuse and advise consultation with intellectual property experts when reusing this data. See disclaimer below for more information.

Examples

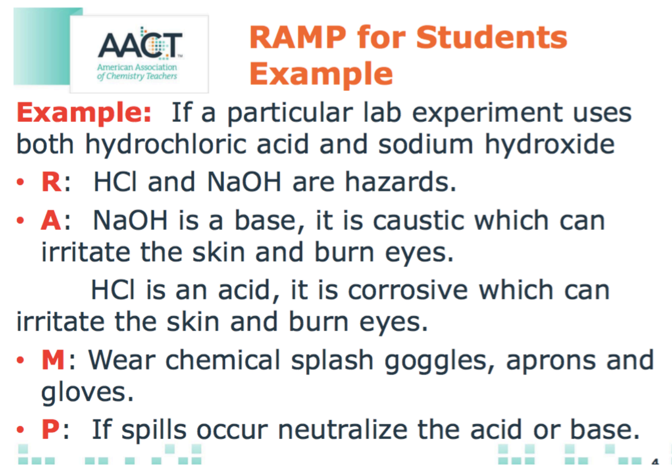
- Acetone
- Benzene
- Ethanol
- Formaldehyde
- Hydrogen Cyanide
- Imidazole
- Phenolphthalein
- Phosphoric Acid
- Theophylline
- Toluene

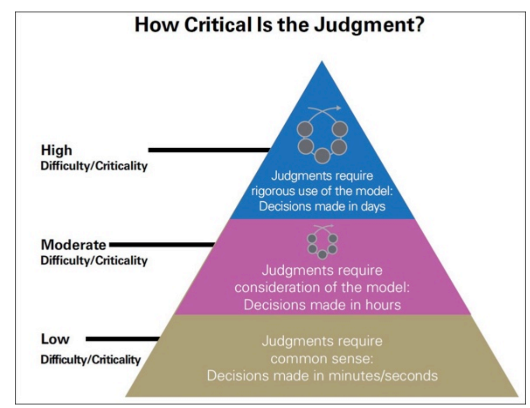
Support for Critical Thinking



Chemistry Educator Use Cases for the Risk Assessment Process

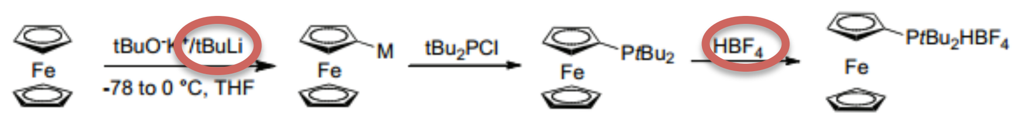
- Scalable chemical profiling for lab curricula; in **high school**, in simple GHS terms (hazard class and signal word)
- Teaching information literacy as part of the RAMP process; **at undergrad** introductory chemistry courses, in terms of analyzing GHS hazard statements provenance
- Analyzing procedures for chemical, equipment and process hazards; **for upper class research students** assess complicated chemistries and other process hazards





Researcher Use Case for the Risk Assessment Process

- Experimental planning
- Capturing lab risk assessments and lessons learned
- Publication of safety notes as part of Supplemental Information
- Use of safety info tools and documentation promotes safe research group culture



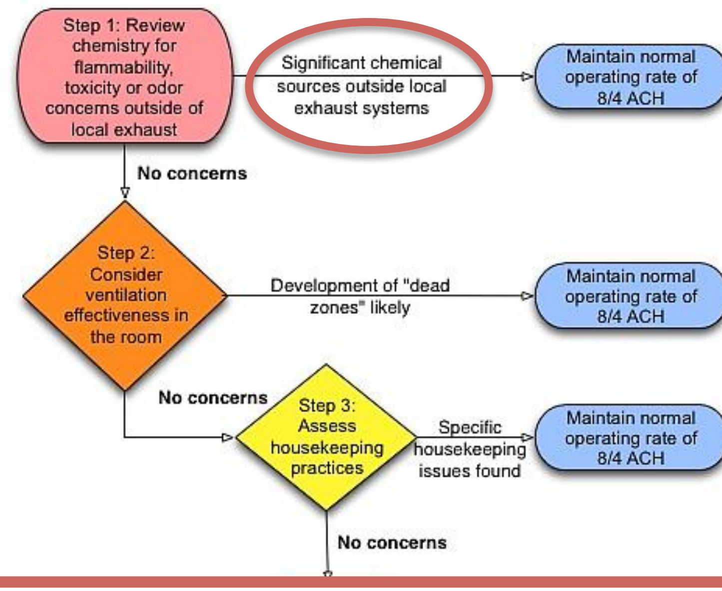
Caution! tert-Butyllithium is extremely pyrophoric and must not be allowed to come into contact with the atmosphere. This reagent should only be handled by individuals trained in its proper and safe use. It is recommended that transfers be carried out by using a 20-mL or smaller glass syringe filled to no more than 2/3 capacity or by cannula. For a discussion of procedures for handling air-sensitive reagents, see Aldrich Technical Bulletin AL-134.

Org. Synth. **2013**, *90*, 316-326
Published on the Web 6/10/2013

Need for Targeted Information:
- Identification of reagents, products
- Reactivity and associated hazard analysis
- Associated exposure control information
- Alternative reagents or reaction pathways
- Iterative over repeated experiments

Safety Office Use Case for the Risk Assessment Process

- Hazard inventory systems
- Safety planning
  - Training program
  - Emergency response
  - reactivity classifications
  - incident analysis
- Ventilation requirements
- These systems need to be *scalable, transferable* and *sustainable*



Information Requirements:

- GHS hazard statements and signal words
- SDS equivalent for 'house solutions' (piranha acid, aqua regia)
- Potentially deliverable with InChI identifiers, extensions

LRM

Opportunities Moving Forward

1. Improved information literacy will improve safety culture.

- **Question:** Is teaching safety information quality a safety role (institutional) or the chemist's(faculty) role?
- **Answer:** Both – it's a partnership catalyzed by the chemical information community.

2. **Use Case Commonalities**

- **Lab process descriptors** are needed to organize information beyond GHS information
- A **chemical safety ontology** is needed to organize management information beyond GHS Precautionary statements (e.g. *"P201: Obtain special instructions before use."*)

Questions?