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Development of Demonstrations:

a collaborative project between the Safety Office and Teaching Assistants

Presented by

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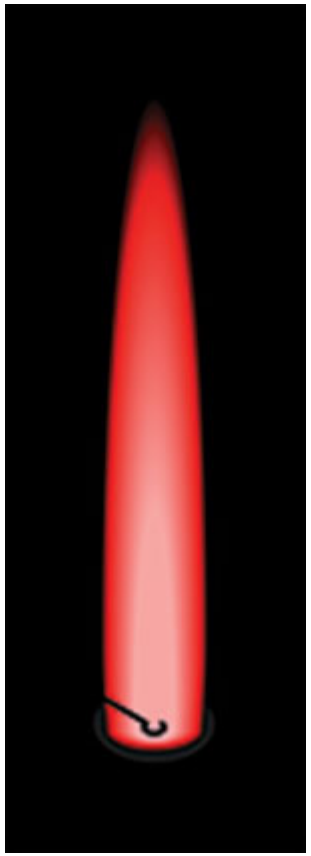
The "Rainbow Demonstration" at UC Davis

- *Multiple incidents with significant injuries*
- *We used the old, very dangerous version*
- *Dispensary staff asked to re-engineer demo*
- *Re-engineered version is featured in ACS video, available on YouTube at "***A Safer "Rainbow Flame" Demo for the Classroom***"*



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The "Magic Show" at UC Davis

- *Huge draw to the Chemistry Department*
- *Been presented for decades by the Chemistry Club – an undergraduate student-run organization*
- *Incident in 2013*
- *Management issues in 2015*
- *Brought under auspices of new faculty Education and Outreach Committee*

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Re-engineering Demonstrations

- *Goals:*
  - *Reduce overall hazard*
  - *Eliminate/Reduce hazardous waste production*
  - *Reduce use of flammable solvents*
  - *Simplify but still maintain the "wow" factor*

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Taking our show "On The Road"

- *Many shows performed during the year, both on-site and off.*
- *Very ad-hoc with no oversight or organization*
- *A system created to manage these outreach events*

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First Big Success

- *Invited to participate in a National Chemistry Week event at The Discovery Museum, Science & Space Center*
- *Table demonstrations and Hands-On science*
- *Interacted with over 300 children and adults on that day*
- *Enthusiastic invitation to return*

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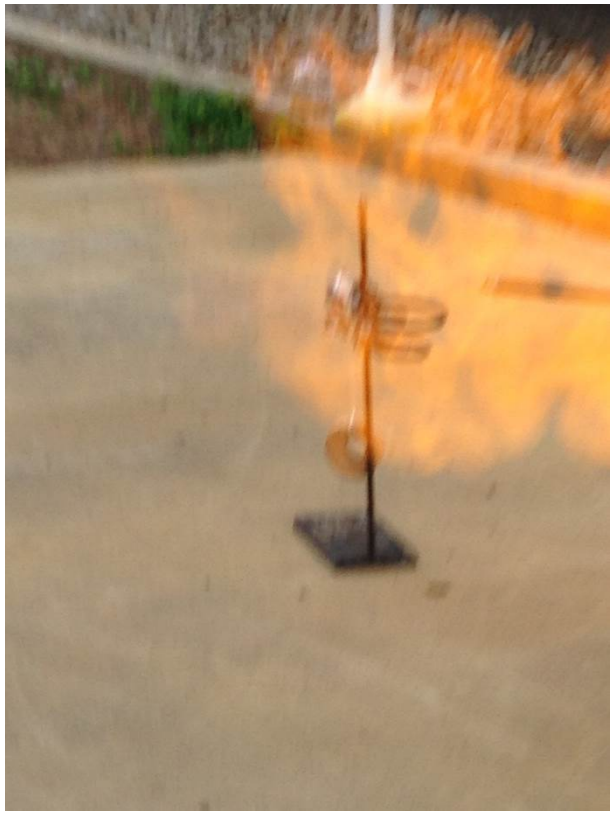
Re-Engineering Process

- *Review the desired outcome*
- *Review hazardous end products*
- *What are the hazards and risks?*
- *Is there literature to achieve outcome with less risk?*
- *Proof of concept*
- *Documentation*



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Re-Engineered Demo List

- *Balloon Explosions*
- *Bang in a Can*
- *Elephant Toothpaste*
- *Genie in a Bottle*
- *Liquid Nitrogen*
- *Silver Flask*
- *Bottle Rockets*
- *Gummy bear*
- *Luminol*
- *Borate Flame*
- *Instant Coke*
- *Instant Fire*
- *Mg/Dry Ice*

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An Example

- *Using "Green Borate Flame" (sometimes called "Fire Tornado"), as an example.*
- *Undergone several iterations to significantly reduce methanol hazard*
- *Current version is much safer and a cooler demonstration*

BORATE FLAME

Required Training	Required PPE
UC Lab Safety Fundamentals	Flame-resistant lab coat, safety glasses/goggles, nitrile gloves
Equipment	Chemicals
1-L Erlenmeyer flask with boiling chips	Boric acid ($B(OH)_3$)
Rubber stopper fitted with an S-shaped glass tube	Methanol (CH_3OH)
Hotplate with clamp for flask	Sulfuric acid (H_2SO_4), 18 M
BBQ-style butane lighter (≥ 6" long)	

Procedure:

1.) Add 2-3 mL of H_2SO_4 to 150 mL of CH_3OH in the 1-L Erlenmeyer flask. 2.) Add 30 g of $B(OH)_3$ to the mixture and stir until all solids have dissolved.

3.) Add a few boiling chips to the flask and place it in the clamp on the hotplate. Put the rubber stopper with the 'S'- shaped tube in the neck of the flask, and heat the mixture to a vigorous boil. This may take 5-10 minutes, and should be started slightly before the demo is to be performed.

4.) Ignite the vapor at the top of the 'S'-shaped tube with the lighter. If the vapor does not ignite, increase the heat from the hotplate. Ensure the mixture is boiling rapidly enough to maintain a flame ~4-6" in height, but not so rapidly that it boils over.

5.) When finished, turn off the hot plate. You may either blow out the flame or simply wait until the mixture has cooled sufficiently, as the flame will diminish and then self-extinguish as the boiling subsides.

Clean-up: The flask should remain clamped to the hotplate to minimize the chance of spilling methanol around any ignition sources. Once everything has cooled to room temperature, the mixture should be saved for future use by replacing the 'S'-shaped tube with a solid rubber stopper.

Hazards: Sulfuric acid is strongly oxidizing and corrosive, and will cause immediate chemical burns on contact. Methanol is toxic and highly flammable. Keep all solutions away from ignition sources until the demo is performed.

Principle: $B(OH)_3$ will react with CH_3OH in the presence of a dehydrating agent (H_2SO_4) to form trimethylborate ($B(OCH_3)_3$) and H_2O. This borate ester is volatile (b.p. = 68 °C) and burns with the green flame characteristic of all boron compounds. The color is due to broad band emissions in the green region of the spectrum from various molecular species as they relax from excited electronic states back to their ground states.

Notes: A freshly-prepared solution may be added to the flask whenever the volume of the solution becomes too low to perform the demonstration (<50 mL). Do not heat the flask with an open flame, as this may cause the mixture to bump and boil out of the flask, creating a fast-spreading methanol fire. Performing the demonstration without the S-shaped glass tube is not recommended; while this produces a larger flame, it is not self-extinguishing and there is a much greater risk of the solution boiling over if it bumps.

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Safety TA Model

- *Creation of a teaching assistant position to work on demonstrations*
- *Facilitate presentation of shows and prep of demos for shows*
- *Unique expertise*
- *Willingness to collaborate*

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Summary

- *Taking chemistry out into the community is a great way to introduce people to science as beautiful and crucial to our well-being.*
- *Teaching Assistants don't just have to slog away, teaching General Chemistry laboratory.*
- *Performing demonstrations is really fun.*

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