Chemical Demonstrations Exercise
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Workshop Summary

The terminal objective of this exercise is to have the participants witness and perform simple chemical exercises in a safe and repeatable way using household supplies. The chemical demonstrations follows immediately after a short presentation describing the supplies, materials, and the chemical concepts/definitions at each step in the hands-on activities.

This workshop is broken into four parts.

- Demonstration of sublimation, vapor expansion, and application of foam with dry ice.
- Demonstration of varying boiling points, vapor pressures, vapor densities, and solubilities of commonly encountered acids and bases using simple pH paper.
- Instructor facilitated hands-on training to demonstrate miscibility/solubility, specific gravity.
- Instructor facilitated hands-on training to visualize dispersion as a response technique.

Dry Ice Demonstration

Introduction

Using dry ice is helpful to understand the definition of sublimation, but it is also useful in understanding the effects that extreme temperatures have on container integrity during HM response risk evaluation. Dry ice when used in conjunction with warm water and detergent can also demonstrate vapor pressure, vapor expansion ratio, and the effectiveness of foam in vapor suppression.

Materials

- Large clear plastic container (≅ 1-2 L) half filled with warm water
- Paper towels or spill pads and aluminum cooking pan
- 1 lb of dry ice
- 1 L of water and detergent solution
- Metal tongs

Preparation, Procedures, and Discussion Points

Centrally locate the instructor and supplies listed above in the classroom where all students can clearly see the table. Place the clear container with water in the aluminum pan in anticipation of capturing any spilled material resulting from adding detergent to the water and dry ice.

Begin by discussing the sublimation as a physical change like melting, boiling, condensation, and deposition. Have a student use the NIOSH PG to look up the temperature (MP @ -109°F) and discuss if this meets the DOT definition of cryogenic materials (BP <-130°F). In addition to the obvious hazard of the extremely low temperature also ask the students to identify the any other hazards - it is a simple asphyxiant.

The students can witness the gas being released and demonstrating a vapor density or RgasD of > 1 (1.53). The instructor can explain that the actual gas coming off the dry ice is invisible, but the "smoke" they are witnessing is the condensation of moisture in the surrounding air.

Due to the extremely low temperature of dry ice the instructor can lead into the conversation the effects of temperature have on container material by taking the warm metal tongs and holding them on the dry ice and they can hear the metal contraction as it rapidly cools. It should be mentioned that the rapidly cooling metal become brittle allowing for cracks or breaks while super heating container materials allows for the stretching or thinning of container metal.

To speed the sublimation process up, the instructor can drop the dry ice in the warm water. By doing this the instructor can lead into the discussion of using materials to reduce a chemical's ability to vaporize or at least reduce responders’ exposure to chemical vapors and gases with the use of foam.

Summary

By using dry ice in class, the students will automatically conduct a hazard assessment by recognizing the extremely low temperature and with a little prodding by the instructor recognized it is a simple asphyxiant. The dry ice also demonstrates the definition of sublimation, condensation, vapor density, brittleness through metal contraction, vapor expansion, and vapor suppression.

pH Paper Demonstration

Introduction

This simple exercise can be used to demonstrate several simple chemical properties. It is a useful visual demonstration to reinforce concepts taught during hazard assessment sections of emergency response classes. The chemicals used are commonly available substances that are also major concerns for emergency responders ranging from clandestine labs to large scale incidents.

As previously mentioned, we use this in most classes after discussing hazard assessment – chemical and physical properties. Another suitable application of this demonstration is during our air monitoring class, specifically in the discussion of "Procedures." During air monitoring procedures discussion, it is important to mention that simple and cheap Ph paper can help them characterize air conditions as well as liquid releases and possibly alert them to vapors present that may otherwise damage delicate sensors.

This demonstration requires 20 – 30 minutes.

Materials and Methods

- pH paper (preferably full range paper)
- Glass sampling vials – qty 5 (20-40 ml)
- Protective eye wear and gloves for the demonstrator
- NIOSH Pocket Guides
- Sulfuric acid (10 ml)
- Muratic acid (10 ml)
- Sodium hydroxide solution (10 ml)
- "Sudsy" ammonia (10 ml)

Preparation & Procedures

Break the class into groups or tables and have someone at each group to be responsible for looking up chemicals in the NIOSH PG. If necessary, give a brief discussion on Ph & interpreting Ph paper results. Review common chemical and physical properties used as standards. (MW of Air is ≈ 29; BP of water is 212ºF; VP of water is ≈ 20 mm Hg @ ≈ 70ºF; 1 ATM = 760 mmHg) As you prepare to demonstrate each vial, ask the groups individually to look up the following properties:

- Boiling point
- Vapor pressure
- Molecular weight or Relative Gas Density

After the trainees have looked up the chemical/physical properties for the specified chemical, ask them to help determine the "attitude" of the chemical in question.

- Do they expect vapors to be given off?
- If not, why?
- If yes, a lot?
- If they expect vapors, where should they expect them – rising or falling?

After the groups have stated their answers, you may wet the paper with distilled water (not necessary, but helps increase the intensity of color change due to vapors) and perform the demonstration. Discuss the observations. Also, you may want to ask them "What environmental conditions may alter or influence the expected results?"

Repeat for the next chemical. The preferred order is to start with "sulfuric acid", then "hydrogen chloride" (muriatic), then "sodium hydroxide", then "ammonia". Depending on the context of the class, you should quiz them on where these chemicals may be encountered and under what conditions. You may also want them to look up synonyms or give you examples of common products or trade names these chemicals can found in. Some products are:

- Sodium hydroxide = Red Devil Lye drain opener or degreasing solutions
- Sulfuric acid = battery acid
- Hydrogen chloride = dilute hydrochloric acid = muriatic acid = concrete cleaner
- Ammonia = "sudsy ammonia" household cleaner

Main Points and Expected Results

- Sulfuric acid – no color change in vapor space, distinct positive acid response to liquid only (high BP, low VP, high MW or heavy VD)
- Muriatic acid – no color change in elevated vapor space, but distinct positive acid response inside the vial above the liquid, distinct positive acid response to the liquid (low BP, high VP, high MW or heavy RgasD)
- Sodium hydroxide – no color change in the vapor space, but distinct positive alkaline response to the liquid only (high BP, low VP, high MW or heavy VD)
- Ammonia – distinct alkaline response above the vial, and distinct positive alkaline response to the liquid (low BP, high VP, low MW or light RgasD)

Summary

This demonstration exercise is beneficial in illustrating properties of chemicals that are crucial in hazard assessment. It also helps them to realize such a simple technology can give them good information while possibly protecting expensive vapor detection equipment.

Specific Gravity Demonstration

Introduction

This is an instructor facilitated exercise conducted by the trainees in small groups of 4-5 people with one trainee assigned as the "chemist" for their group. The trainee functioning as the chemist should be wearing nitrile exam gloves and safety glasses. All SDS for the chemicals should be available on site by the instructor.

Objectives

- Define, compare, and contrast solubility and specific gravity of different liquids through demonstration given liquid samples and glassware.
- Draw conclusion to difficulties in describing crude oil shipments and crude oil cleanup as seen in the Gulf of Mexico BP Oil Spill Response

Required Materials

- Glass flat bottom vile – 40-50 ml
- Red or blue food coloring
- Water -5 ml
- Glycerin – 5 ml
- Blue (or red) lamp oil – 5 ml
- Mineral Oil – 5 ml
- 4 small cups
- 1 absorbent pad

Procedures

Setup (for Instructor):

1. Place absorbent pad on table.
2. Set 1 glass vial and 4 small cups on absorbent pad.
3. Pour 5 ml of water into first cup (far left)
4. Pour 5 ml of lamp oil into second cup (second from left)
5. Pour 5 ml of mineral oil into third cup (third from left)
6. Pour 5 ml of glycerin into fourth cup (fourth from left)

Demonstration (for Trainees):

1. Pour water from cup into vial
2. Add one drop of red food coloring (blue color if using red lamp oil - demonstrates miscibility/100% sol)
3. Pour lamp oil into vial (demos SpG < 1, insoluble/0% sol)
4. Pour mineral oil into vial (SpG < 1, but heavier than lamp oil, insoluble/0% sol)
5. Pour glycerin into vial (SpG > 1, low sol, also demo for viscosity)

Summary

With the use of household chemicals students can visualize the concepts of solubility and specific gravity. Even with chemicals that are miscible, unless they are agitated by mixing or dissociation, does not happen immediate. Other factors such as specific gravity, temperature, saturation, and/or viscosity can supersede a chemicals ability to dissolve or mix with another chemical. Knowing this fact can allow for response intervention if the properties and behavior of spilled chemicals to water is understood and anticipated.

Specific Gravity/Solubility/Dispersant Demonstration

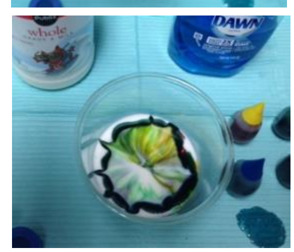
Introduction

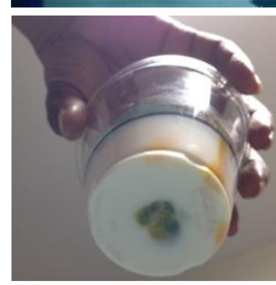
This is an instructor facilitated exercise conducted by the trainees in small groups of 4-5 people with one trainee assigned as the "chemist" for their group. The trainee functioning as the chemist will perform the steps as led by the instructor.
The technique of using dispersants in water-borne spills of hydrocarbon materials does not render the released material harmless, but rather speeds the process of chemical dilution by allowing it spread horizontally and vertically in a large body of water to reduce its specific concentration in the water in a given a location.

Objectives

- Compare and contrast solubility of the food coloring to the whole milk given the materials provided and observations
- After being told by the instructor that detergents are a form of "dispersant" the student will be able to describe the effects dispersants have on an "oil spill": breaks the spilled material into smaller "pieces" and allows it to mix with the water. Dispersants essentially change a material's SOL in water and increase the material's SPG and sinks the material to the bottom of the cup (body of water).

Required Materials





- 1 Absorbent pad
- 1 Clear plastic glass
- ≈100 ml of whole milk
- 1 Cotton swab
- Few drops of Dawn dishwashing detergent
- 1 Set of food coloring (Red, Blue, Green, Yellow)

Procedures

Setup (for Instructor):

1. Place the absorbent pad on table
2. Place the clear plastic glass, food coloring vials, cotton swab, and drops of Dawn on the pad
3. Pour ≈100 ML of whole milk in the cup

Demonstration (for Trainees):

1. Have the trainees place one drop of each color of food coloring into the center of the milk in the cup.
2. Take swab and saturate one end of it with the Dawn detergent provided
3. Touch the saturated end of the swab to the center of the food coloring in the middle of the milk.
4. The colors should immediately mix and disperse
5. Have the students lift the glass and look on the bottom to see if the food coloring has reached the bottom

Summary

With the use of household chemicals students can visualize the concepts of solubility and specific gravity and the response technique of using dispersants. Knowing this information can allow for response intervention if the properties and behavior of spilled chemicals to water is understood and anticipated.