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Flaming Vapor Ramp

Demonstration Kit

Introduction

Vapors from volatile, flammable liquids are generally heavier than air and can travel along a countertop to an ignition source. Once vapors have been ignited, the flames will quickly follow the vapor trail back to the vapor source and may result in a very large fire or explosion.

Concepts

- Flammable liquids
- Fire safety

Materials (for each demonstration)

Hexanes, 100 mL*
Aluminum angle bracket, 2.5 ft in length*
Candle, votive*
Materials included in kit.
Erlenmeyer flask, 1-L
Match or lighter
Ring stand and clamp
Stopper, 1-hole, to fit flask

Safety Precautions

Be very careful while performing this demonstration. Hexane is a flammable liquid and may be irritating to the respiratory tract. Do not use more hexane than is specified in the procedure—the flames may become too large and it will also increase the fire hazard should the flask fall and break. Do not substitute a more volatile liquid; many are dangerously combustible and the vapor trail may enter the flask and lead to an explosion. Ether (diethyl ether) or methyl alcohol for example, are far too volatile to use anywhere near an open flame or ignition source. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Preparation

1. Clear off a countertop before starting. Remove all combustible materials such as paper from the demonstration area.
2. Prepare a vapor ramp by elevating one end of the aluminum angle bracket using a ring stand and clamp. The ramp should be at a 20° angle or about 20 cm elevation (see Figure 1).
3. Place an unlit candle on the countertop directly below the lower end of the vapor ramp (see Figure 1).
4. Pour about 2–3 mL of hexanes into the 1-L Erlenmeyer flask.

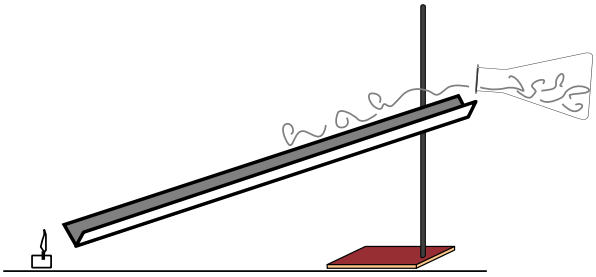

Figure 1.

5. Place a one-hole stopper on top of the flask and swirl the flask to evaporate the hexanes. Allow the flask to sit for a few minutes to allow hexanes vapors to fill the flask. Set the flask aside.

Procedure

1. Have entire class put on their safety goggles.
2. Light the candle and position it so that the flame is even with the bottom of the vapor ramp.

3. Remove the stopper from the flask containing the hexanes. Gradually pour the hexane ***vapors*** down the ramp for about three seconds. Tip the flask slightly and do ***not*** allow any unevaporated liquid hexanes to pour out. Be prepared to have the fumes catch fire.
4. Nothing will happen for a few seconds—be patient. The vapors will soon ignite and then race up the ramp.
5. After the flames race up the trough, the demo can be repeated.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. The hexanes solution may be treated according to Flinn Suggested Disposal Method #18a.

Tips

- Hexane, hexanes, and petroleum ether (not ethyl ether) are all similar materials and will work well in the demonstration. Do ***not*** substitute any other flammable liquids for this demonstration. ("Hexanes" denotes a mixture of isomeric hydrocarbons having the formula C_6H_{14}.)
- If the ramp cannot be adjusted using a ring stand and clamp, hold the ramp with one hand. Using an oven glove or a fire-resistant welder's glove. Hold the ramp from beneath, open-side up. Keep fingers and gloves away from any flames.
- Practice this demo beforehand to understand how long to pour the hexanes vapors. The flask should not be near the trough when the flames ignite. If you are still pouring when the flames start, take the flask away from the top of the vapor ramp to prevent the fire from going back into it. (If the flame does make it back into the flask, it is OK; it will just burn there for a while at the mouth of the flask, unable to burn the entire sample due to inadequate oxygen.)

Discussion

Many organic solvents have very low boiling points and hence are highly volatile at ambient temperatures. For example, the hexanes solution has a boiling point of 68–70 °C (154–158 °F) and a vapor pressure of 150 mm Hg at 25 °C. Most organic compound vapors are also colorless and therefore nearly impossible to see. Hexanes (C_6H_{14}) have a molecular weight of 86 g/mol. This gives hexanes vapors a density of nearly three times that of air (M.W. of oxygen is 32 g/mol). Thus hexanes vapors (and most other organic vapors) are heavier than air and will sink in air. Heavier-than-air vapors are also easy to pour.

When the hexanes vapors are poured down the vapor ramp and make their way to the lit candle, all three necessary ingredients for a fire are present; air containing oxygen, hexanes fuel, and a source of ignition or heat. The flame travels back up the ramp, leaving an impressive trail of fire as it goes.

What makes this an especially valuable demonstration is the safety lesson: using flammable liquids indoors can be a fire hazard even if you are nowhere near an open flame. Indeed, as any firefighter can attest to, volatile fumes can travel along the floor, even down steps and find an ignition source, such as the pilot light of a furnace or hot water heater or an electric switch. Outdoors, ignition sources are less common, and winds generally cause the fumes to dissipate and not reach combustible levels.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Systems, order, and organization
Evidence, models, and explanation
Content Standards: Grades 5–8
Content Standard B: Physical Science, properties and changes of properties in matter
Content Standard F: Science in Personal and Social Perspectives; natural hazards
Content Standards: Grades 9–12
Content Standard B: Physical Science, structure and properties of matter
Content Standard F: Science in Personal and Social Perspectives; natural and human-induced hazards

Answers to Worksheet Questions

1. Draw the set-up for this demonstration. Include an arrow indicating the movement of the flames that were created.
2. What properties do you think allowed the hexanes solution to evaporate so easily? It did not require any heating.

   The hexanes mixture probably has a low boiling point that is closer to room temperature than most other liquids, including water. Because of this, the liquid probably also has the ability to evaporate at lower temperatures than other solutions.

3. Why did the hexane vapors (C_6H_{14}) travel down the ramp when they were poured out of the flask, instead of just dispersing into the air? (*Hint:* Keep in mind that the molecular weight of oxygen is 32 g/mol.)

   Hexanes have a higher molecular weight, at 86 g/mol, than oxygen (32 g/mol). Therefore its vapor density is greater, as well. This forces hexane vapors to sink in air and travel along surfaces rather than rising into the air and dispersing.

4. What does this demonstration teach you about using flammable liquids in the laboratory?

   Using flammable liquids such as hexanes is dangerous in the lab for a number of reasons. First of all, many organic flammables have low boiling points and evaporate easily. These vapors can travel all over a lab or even a building. Should they encounter an ignition source, such as a furnace or an electrical switch, they will light on fire and spread quickly.

References

Becker, R. *Twenty Demonstrations Guaranteed to Knock Your Socks Off!,* Vol. 2; Flinn Scientific: Batavia, IL, 1997, pp 59–60.

The *Flaming Vapor Ramp—Demonstration Kit* is available from Flinn Scientific, Inc.

Catalog No.	Description
AP6154	Flaming Vapor Ramp—Demonstration Kit

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.

Name: _____

Flaming Vapor Ramp Demonstration Worksheet

Discussion Questions

1. Draw the set-up for this demonstration. Include an arrow indicating the movement of the flames that were created.

2. What properties do you think allowed the hexanes solution to evaporate so easily? It did not require any heating.

3. Why did the hexane vapors (C_6H_{14}) travel down the ramp when they were poured out of the flask, instead of just dispersing into the air? (*Hint:* Keep in mind that the molecular weight of oxygen is 32 g/mole.)

4. What does this demonstration teach you about using flammable liquids in the laboratory?