Flaming Vapor Ramp

Flammable Vapor Safety Demonstration

Introduction

Vapors originating from volatile, flammable liquids are generally heavier than air and can travel along a countertop to an ignition source. Once the vapors have been ignited, the resulting 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
- Combustion
- Fire safety

Materials

Hexane, 2–3 mL
Aluminum angle bracket, about 1 meter in length
Candle, tealight
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. Do not use more hexane than is specified in the procedure. Using more hexane many cause the flames to become too large and will also increase the fire hazard should the flask fall and break. Do not substitute a more volatile liquid for hexane; many volatile solvents are dangerously combustible, and the resulting 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 consult 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, tealight candle on the countertop directly below the lower end of the vapor ramp (see Figure 1).
4. Pour about 2–3 mL of hexane into the 1-L Erlenmeyer flask.
5. Place a one-hole stopper on top of the flask and swirl the flask to evaporate the hexane. Allow the flask to sit for a few minutes to allow hexane vapors to fill the flask. Set the flask aside.

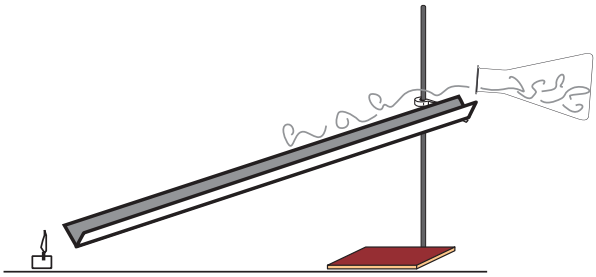

Figure 1.

Procedure

1. Have all of the students in the 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 hexane. Gradually pour the hexane vapors only down the ramp for about 3 seconds. Tip the flask slightly but ***do not allow any unevaporated liquid hexane 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. *Caution:* Do not continue to pour once the vapors have ignited at the candle source. Once the flames start, remove the flask from the top end of the vapor ramp.

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5. After the flames race up the trough, the demo can be repeated.

Tips

- A small, flat votive candle is ideal for this demonstration. If a taller candle is used, adjust the vapor ramp so the vapors can flow onto the top part of the candle flame and ignite.
- Hexane, hexanes, or petroleum ether (NOT ethyl ether) have a similar composition and boiling point and will work well in the demonstration. Do NOT substitute any other flammable liquids for this demonstration.
- 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.
- Shop at your local hardware store for aluminum angle brackets—we found our brackets as drop ceiling flashing. The sides of the bracket should be about 0.75–1.5 inch.
- Practice this demo beforehand to understand how long to pour the hexane 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, hexane has a boiling point of 68–70 °C (154–158 °F) and a vapor pressure of 150 mm Hg at 25 °C. The vapors of most organic compounds are colorless and therefore nearly impossible to see. Hexane (C_6H_{14}) has a molar mass of 86 g/mol. This gives hexane vapors a density nearly three times greater than that of air (nitrogen, 28 g/mole, and oxygen, 32 g/mol). Thus hexane 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 hexane 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), hexane fuel, and a source of ignition or heat. The vapors ignite and the resulting flames travel back up the ramp, leaving an impressive trail of fire in their wake.

What makes this an especially valuable demonstration is the safety lesson to be conveyed: *Using flammable liquids indoors can be a fire hazard even if you are nowhere near an open flame*. Indeed, as any firefighter can attest, 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 flammable vapors or fumes to dissipate before they 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

Evidence, models, and explanation

Constancy, change, and measurement

Content Standards: Grades 9–12

Content Standard B: Physical Science, structure and properties of matter, chemical reactions, interactions of energy and matter

Content Standard F: Science in Personal and Social Perspectives, personal and community health, natural and human-induced hazards

References

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

Materials for *Flaming Vapor Ramp* are available from Flinn Scientific, Inc.

Catalog No.	Description
H0046	Hexanes, 100 mL
AP6154	Flaming Vapor Ramp Demonstration Kit

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