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eLearning

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Methane Mamba

Flammability of Gases

Introduction

Methane gas is bubbled up through a funnel of soapy water and a buoyant column of suds grows gracefully upward like a large bubbly snake swaying elegantly to the air currents in the room. Igniting this methane mamba provides for a rather charming effect!

Concepts

- Combustion
- Density
- Hydrocarbons

Materials

Source of natural gas

Soap solution, 3% Dawn® by volume

Water, tap

Beaker, 400-mL

Buret clamp

Butane safety lighter

Candle (optional)

Funnel, made from the top half of a 2-L plastic soda bottle

Glass tubing, 6 mm diam to fit stopper, 9 cm long

Graduated cylinder, 10-mL

Meter stick (optional)

Pipet, Beral-type

Ring clamp, 5"

Rubber hose to fit gas jet nozzle, approx. 1 m long

Rubber stopper, #3, 1-hole

Stirring rod

Support stand

Tape (optional)

Safety Precautions

Wear safety goggles at all times, and keep a fire extinguisher on hand. Remove all combustible material from the vicinity of the demonstration. Perform this demonstration in a well-ventilated room. Do not perform this demonstration directly underneath smoke/heat detectors or sprinkler systems. A 10-cm high column of methane bubbles may produce a flame well over a meter tall. Let the height of your ceiling and the flame retardant capability of the ceiling tiles dictate how large a cluster can be safely ignited.

Preparation

1. Carefully, and with adequate lubrication, slide the rubber stopper over the glass tube stopping when it reaches the middle.
2. Insert the stopper securely into the mouth of the funnel.
3. Connect the protruding end of the glass tubing to the rubber hose. If the fit is too loose, wrap the end of the tube with some electrician's tape to make the hose fit more snugly.
4. Use the support stand, buret clamp, and large ring clamp to secure the funnel in a vertical position with the stoppered end down (see Figure 1 on page 2).
5. Run the hose up over the neck of the ring clamp (to avoid leakback) and then connect it to the gas jet (see Figure 1).
6. Prepare 300 mL of a 3% soap solution by adding 3 mL of Dawn dish soap to a 400-mL beaker. Add tap water to the beaker to the 300-mL mark. Stir gently to mix.

7. Tape a candle to the end of a meter stick.

Procedure

1. Pour 300 mL of the prepared 3% soap solution into the funnel. The top of the glass tubing should be submerged by about 1.5 cm (see Figure 1).
2. Then, with no open flames nearby, simply turn on the gas jet full throttle. A column of methane bubbles will begin to grow lazily upward, attaining a height of 2–3 meters in about 5 minutes.
3. An interesting effect can be achieved by using a pipet to place a few drops of water on the top of the growing column. Since the water increases the density, it causes the top to arch over—accentuating the snakelike appearance even more! But as the head of the snake drops down, water falls from its snout, the density decreases and the snake rears its head back up! Adding another drop or two repeats this cycle.

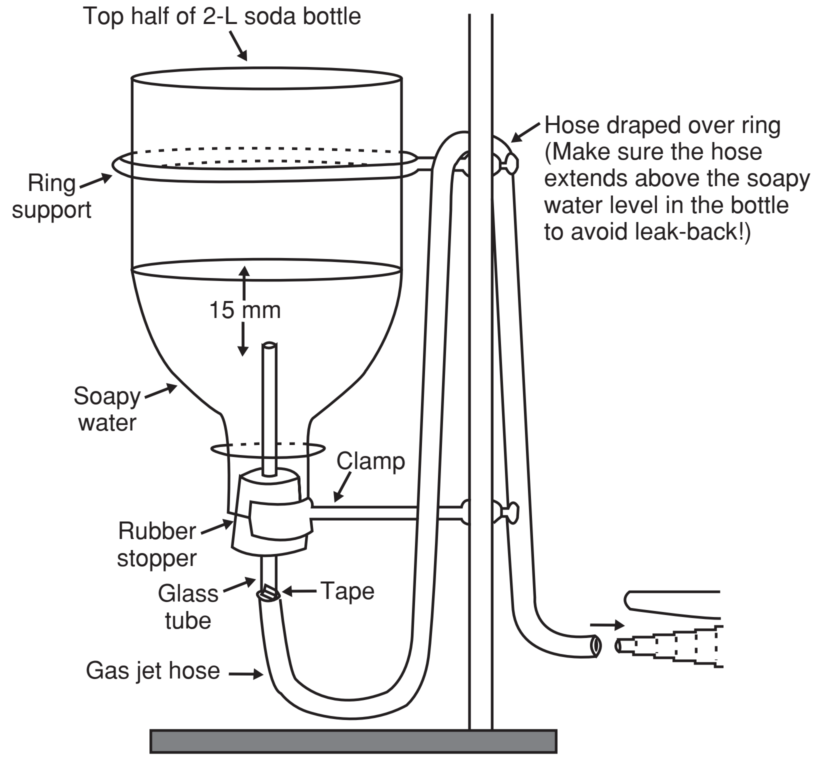

Figure 1.

4. Wet your hand, gently scoop the column of bubbles up off the funnel, and carefully walk around the room. (Wetting the hands first avoids popping too many bubbles.) Large sweeping motions make for a very graceful display! And with a quick jerk of the hand, the bubble column can be turned loose, free to snake its way up to the ceiling.
5. Perhaps most impressively, these bubble columns may be ignited. The safest manner for presenting this is to first turn the gas jet off. With a wet hand, scoop the column off the funnel, then set it down on the lab bench. Make sure all combustible materials have been removed from the vicinity. Stand about two meters away and light a candle taped to the end of a meter stick. Then ignite the bubbles with the candle. The column may be lit from the bottom (this produces the fastest burning and therefore the largest flame), from the top (this shows an interesting downward progression of the fire) or from somewhere in between.

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 soap solution may be rinsed down the drain according to Flinn Suggested Disposal Method #26b.

Tips

- Play snake charming music during the demonstration if available.
- If there are too many large bubbles, the column will be too buoyant and will tend to pinch off before reaching its full height. If there are too many small bubbles (suds), the column will be too dense and will simply spill over the rim of the funnel. The best results are obtained from a combination of large and small bubbles, producing a column that is just barely less dense than air—enough to support its own weight but not cause a substantial upward tug. This might require some "fine tuning"—adjusting the flow rate of the methane, the position of the glass tubing and the depth of the soapy water in the funnel. Humidity may also play a role, for the top of the column does tend to dry out.
- An arching effect similar to step 3 occurs naturally if the column is allowed to grow for a long enough period of time. The methane diffuses out of the top bubbles and air diffuses in at the same rate. Therefore the upper section increases its density and eventually bends over on its own.

- After scooping up the column and turning it loose (step 4), if the density is close enough to that of air, the column will ascend very slowly, allowing the opportunity to inject into it a drop or two of water. This causes the column to hover in mid-air—perhaps even descend downwards a little bit—but as the excess water then drips off, the column will start to float up again. With a little practice, it is possible to keep a column suspended this way for quite some time.
- An alternative way to light the column is to wet your hand well, scoop off the column, and ignite the bubbles near the bottom of the column with a butane safety lighter. The water on your hand provides a heat sink, and the flames travel quickly upward so your hand does not get scorched.
- The diffusion of the methane across the soap film can be demonstrated by setting a column of bubbles on the lab bench and holding the flame from the candle a few centimeters above the bubble column. After a few seconds the top of the column ignites, even though the flame never touches the column! Furthermore, a small cluster of bubbles may be flattened out on the lab bench and left there for about two minutes. When a flame is then held directly to the bubbles, nothing happens—they pop, of course, but they do not ignite—even though the cluster appears just as it did when the bubbles were blown. This indicates not only that the methane has diffused out of the bubbles, but also that air must have diffused in.
- Blow up a balloon, tie it off, and give it a charge by rubbing it against some wool or hair. Bring the negatively charged balloon near the top of the column and watch the snake "strike" at the balloon.

Discussion

Methane is about half as dense as air. You can approximate this by comparing their relative molecular weights. Methane (CH_4) has a molecular weight of 16 compared to air, a mixture of mostly nitrogen (N_2) with a molecular weight of 28 and oxygen (O_2) with a molecular weight of 32. Because of its lower density, pure methane rises rather rapidly in air. The soapy water adds significantly to the density, but with just the right proportions, you can achieve a soapy water/methane mixture that is just slightly less dense than the surrounding air, which ascends very slowly. The adhesive nature of the soapy water, due mostly to the H-bonding that occurs between the water molecules, helps to hold adjacent bubbles (suds) together in a snake-like cluster.

Following is a possible presentation lecture to go along with the Methane Mamba Demonstration.

"What I have here is a very simple set-up—natural gas (comprised mostly of methane, CH_4) being bubbled up through a funnel filled with soapy water. Right away, what are some physical properties you notice about methane? *[It is a gas at room conditions, it is colorless...]* But this is quite unusual (gesturing toward the growing column of bubbles). Does any one want to guess why the bubbles do that? (Give the column a quick karate chop and watch them float away). So what is another property of methane? *[It's less dense than air]*. Let me wet my hand, then carefully scoop off this new cluster of bubbles and just let it sit here on the wet table top—we'll come back to them later. Wetting my hand first decreases the likelihood of the bubbles popping when I reach for them. These bubbles stick to my wet hand and now to the wet table top and won't float away because of some important physical properties of water. It is very adhesive—it sticks well to certain surfaces, and it is very cohesive—it sticks well to itself. This is what holds the bubble column together in the first place, and it is the result of water's strong intermolecular forces—hydrogen bonding. In fact, it is water's strong intermolecular forces that make it a liquid at room conditions, whereas methane, a molecule of similar size, but having very weak intermolecular forces, is a gas. (Allow the bubble column to grow to some height).

"Now you can see that if I drip a little water on the top, it weights the column down a bit and gives it a serpent shape—hence the name "methane mamba." A mamba is a very venomous African snake, like a cobra, only without the hood. Note also how I can rub electrons off onto this balloon (rubbing it against hair or wool) and put a negative electrostatic charge on it. Now watch what the methane mamba does as I bring the balloon nearby (the mamba attracts to it quite noticeably, appearing like a snake striking at the balloon). It is actually the water, not the methane that causes this effect—water is quite able to be polarized. The negative charge on the balloon polarizes the water, pushing the negative charges away, and thus attracts to the remaining positive charges.

"You may also have noticed what appears to be yet another physical property of methane—its unpleasant odor. Actually, methane is completely odorless. What you smell is an additive that the gas company adds to make the gas smell that way. It is called a mercaptain, like the smell of rotten meat, and it is one that our noses are especially sensitive to. Can anyone tell me why they would add such an obnoxious odor to the methane *[so that we can easily notice if there is a gas leak]*. That's right, and I hope you all know what to do if you enter a building or a room and you smell that odor—leave immediately, and go somewhere else to call the fire department. One interesting side benefit of adding that smell is that when leaks are in the underground main gas lines that run through rural areas, the employees sent out to look for the leak will sometimes rely on buzzards circling overhead to help them pinpoint the exact location. The buzzards mistake the odor for that of some dead animal!

“So we have that methane is an odorless, colorless, low density gas. These are all physical properties. Can anyone describe any chemical properties of methane? *[It is combustible—that is, it reacts with oxygen in a very exothermic way, producing heat, along with* CO_2 *and* H_2O*.]* Now watch as I wet my hand again, scoop off a new bubble column and bring a flame to it *[WOW!]*.

“One other interesting thing to note: You might be curious to know how tall a column of methane bubbles we could grow. If the air in the room is not too dry (which causes the bubbles to pop prematurely), I may grow them about 3 meters tall in about ten minutes. But after that, an odd thing happens—the column starts bending over at the top, forming a huge arch. Could the methane inside have lost its buoyancy? Actually, the methane is no longer in the top bubbles. The soap film that the bubbles are made of is not an air-tight membrane. It allows the methane to gradually leak out. You do not see the bubbles shrinking because as the methane leaks out, air is leaking in at more or less the same rate. Thus the bubbles that were blown with methane ten minutes ago are now filled with air. Not only will they not float, but they also will not burn, as I will now demonstrate with this cluster that has been sitting on the table for some time now (a flame brought to the bubble pile only pops them; they do not ignite).

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
Content Standards: Grades 5–8
Content Standard B: Physical Science, properties and changes of properties in matter
Content Standards: Grades 9–12
Content Standard B: Physical Science, structure and properties of matter, chemical reactions, interactions of energy and matter

References

Boys, C. V. *Soap Bubbles and the Forces Which Mold Them;* Dover Publications: New York, **1959**.

Alyea, H. *Tested Demonstrations in Chemistry,* Journal of Chemical Education: Easton, Pennsylvania, **1965**; 6th ed.

Shakhashiri, B. Z. *Chemical Demonstrations,* University of Wisconsin Press: Madison, Wisconsin, **1983**; Vol. 1, pp 106–116.

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Methane Mamba* activity, presented by Bob Becker, is available in *Flammability of Gases* and in *Bob Becker’s Favorite Combustion Reaction Demonstrations,* part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Methane Mamba* are available from Flinn Scientific, Inc.

Catalog No.	Description
C0241	Cleaner, Dishwashing
AP1321	Ring, Support, with Rod Clamp, 5″
AP8284	Burner Tubing

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