Methane Can Explosions – Reaction Rates

Printed below are two references to the methane can explosion. The first is from the Teacher's Laboratory Guide for the 1982 Heath text Chemistry: Experiments and Principles, by O'Connor, Davis, McNab, and McClellan (P 144-145). The second is taken from the 1982 Camille and Henry Dreyfus Chemistry Institute Curriculum Module entitled Chemical Kinetics and Catalysis, (pp 64-66)

DEMONSTRATION 28 **A CHANGE IN REACTION RATE**

PURPOSE

To show a dramatic change of rate in a combustion reaction.

TIMING

About 5 minutes are needed during an introduction to Chapter 12.

MATERIALS NEEDED

A one-gallon, cylindrical paint can. The lid must have almost the same diameter as the can, and be the type that is pressed to fit. Punch a 0.5 cm hole in the center of the lid and a 1 cm hole near the bottom of a vertical curved side. A cardboard oatmeal box provides a satisfactory, but less spectacular result.

A source of lab gas. Propane gas (from a bottle) is unsuitable. It burns too fast. An explosion occurs as soon as it is ignited. Acetylene is EXTREMELY DANGEROUS. It detonates violently. DO NOT USE

CLASSROOM PRESENTATION

Put the lid on snugly. The tighter it fits, the higher it will blowl Use a rubber hose to fill the can with lab gas *via* the hole in the lid. Be sure the can is full of gas and that most of the air is driven out. Hold your fingers over each hole and move the can to a safe place. The lid should not blow up to hit a light fixture. Nor should it be accessible to students while it burns. Light the gas at the hole in the lid.

All of these operations can be accompanied by a patter about a convenient tent-warmer you have invented. Warm your hands over the flame in an appreciative manner. Move away and continue to talk about different kinds of reactions, and how they differ. Some are slow; some are fast. To the inevitable question "How long will the heater burn?" answer "Until it goes out," or point out that an experiment is being done right now to determine the answer to that question. About 3 minutes after being lit, the gas in the can will explode. This is the time to emphasize that the rate of a chemical reaction is a very important characteristic of the reaction.

Much of the explanation for this behavior can be drawn out of the class. The gas *inside* the can did not burn initially because there was not enough air in the can to support combustion. As some gas burned, air entered the can *via* the bottom hole. The air and lab gas mixed until the concentrations were suitable for combustion inside the can. The combustion released heat into a combustible mixture, which proceeded to react at a great rate. The effects of concentration and temperature on reaction rate are discussed in this chapter.

KINETICS DEMONSTRATION 14

TITLE Methane Explosion

DESCRIPTION

A coffee can sealed with its plastic lid is filled with natural gas. Bringing a match near a hole in the top of the can causes a flame to appear. The flame burns quietly for several minutes, growing smaller with time. When the flame dips inside the can, the can explodes. An orange flame appears at the mouth of the can as the lid flies off.

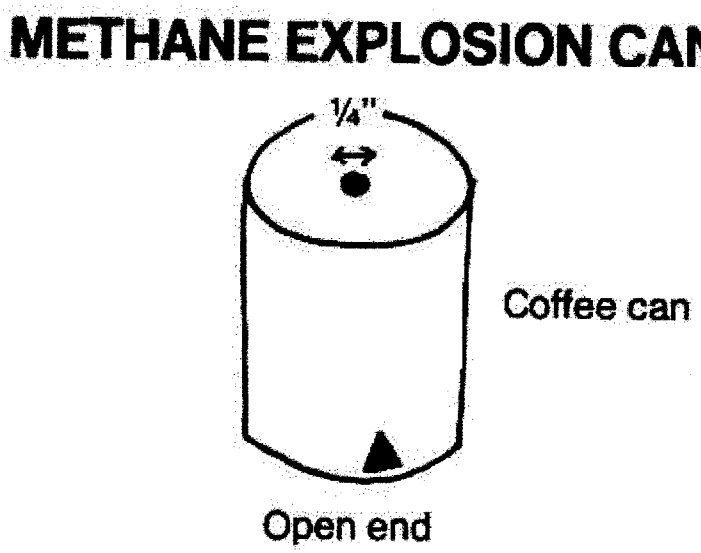
MATERIALS

3 lb coffee can with tight-fitting plastic lid
beer can opener
methane source
rubber tubing
matches

PROCEDURE

1. In metal end of coffee can, make a ¼—inch diameter hole. On side of can adjacent to open end of can, make a full-size can opener hole (about 3/4-inch diameter).

See diagram for hole placement.



2. Firmly attach plastic lid to open end of can. Put can on table so that it sits on plastic lid. Attach rubber tubing to gas source, and put free end of tubing into can opener hole on side of can. Turn on gas for 30-60 seconds. Remove tubing from can.

3. Bring lighted match near hole in top of can to ignite gas. Note: Drafts will blow out flame.

4. Variation: For louder explosions, use a paint can with tight—fitting metal lid—and watch overhead light fixtures.

DISCUSSION

1. Methane (CH_4) is lighter than air. Hence, it rises and can be ignited at the hole in the top of the can.

2. Initially the flame is large and orange. The gas mixture coming out of the can consists of a lot of methane and very little air. Combustion is incomplete because of the small amount of oxygen present.

3. As burning proceeds, the burned gases are replaced by air entering from the can opener hole at the bottom. The additional air allows combustion to be more complete, and the resulting flame gets bluer. However, since there is less methane inside the can, the pressure of the methane at the opening beneath the flame decreases. Therefore, the rate at which methane escapes becomes less, and the flame gets smaller.

4. Eventually, the pressure inside equals the pressure outside. At this point, the flame dips inside the can, igniting the remaining methane/air mixture. Because the burning occurs within an enclosed volume, enough pressure builds up to blow the lid off the can.

QUESTIONS

1. Will the flame burn from the hole on the side of the can?
2. Why does the side of the flame change?
3. Why does the color of the flame change?
4. Why does the explosion occur?
5. How are the changes in flame size and flame color related to the different kinds of flames you can make with a Bunsen burner?
6. What is the equation for the reaction?
7. Why doesn't the explosion occur as soon as the match is brought near the top of the can?

TOPIC CROSS-REFERENCES

Use of Bunsen burner, explosive limits, density of gases

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