Fun with Carbon Dioxide

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Materials:

- vinegar
- bicarbonate of soda (same as baking soda)
- two clear containers. (A size of 0.5-1 litre each works well.)
- matches

Suitable for: any number of students

Time required: 5-15 minutes, depending on pace

Topics discussed: composition of air, combustion, density, molecular weight.

Directions

Before trying this activity with your students you should practice it on your own, since the step of pouring the gas from one container into another takes some care.

Add a spoonful of baking soda and about 10 ml of vinegar into one of the two containers. The mixture will fizz.

(The white object on the bottom of the right jar pictured above is merely a price tag, which is unrelated to the experiment.)

If your two containers are of different sizes, you should mix the reactants in the larger container. Otherwise, you will not capture enough carbon dioxide in the first jar to fill the second one.

If the students have seen chemical equations, you might discuss the details of the reaction which is taking place:

The active ingredient in vinegar is acetic acid, also known as ethanoic acid. Its chemical formula is CH_3COOH, sometimes equivalently written $C_2H_4O_2$ or $HC_2H_3O_2$.

Baking soda is sodium bicarbonate = $NaHCO_3$.

$$CH_3COOH + NaHCO_3 \rightarrow \underbrace{CH_3COONa}_{\text{sodium acetate}} + H_2O + \underbrace{CO_2}_{\text{carbon dioxide}}$$

The bottom line is that the gas which is produced is carbon dioxide.

Tell the students that you will light a match and place it into the jar with the carbon dioxide. Ask the class for predictions as to what will happen. Have each student write down his or her prediction. (Research has shown that this step is extremely useful for learning, since it forces the pupils to think through the experiment and commit to their prediction.) Now light two matches, and simultaneously place one in each container. The flame in the baking soda and vinegar container will be extinguished, while the other flame will continue to burn:

Ask the students to explain the result. Answer: the emerging carbon dioxide has pushed the oxygen out of the left jar, and burning requires oxygen.

Next, pour the carbon dioxide into the empty jar, without pouring any of the liquid:

It should look as if nothing is happening, as if you are pretending to pour something invisible!

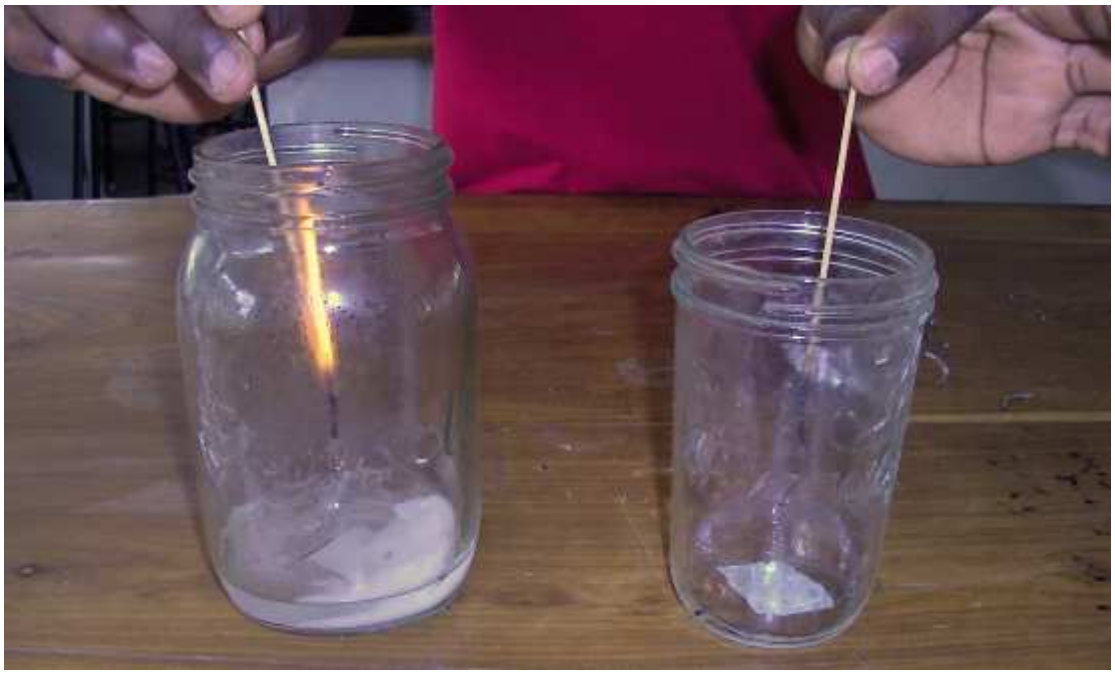
Again, tell the students that you will place a lit match in each jar, and ask the pupils to predict what will happen:

A. Both flames will go out
B. Neither flame will go out
C. Only the flame in the jar with the soda/vinegar will go out
D. Only the flame in the jar with NO soda/vinegar will go out

Again, after some discussion, each student should write down his or her prediction.

This next step may not work if there is any breeze in the room or if the containers were moved at all, since even a minor disturbance can cause the carbon dioxide to blow out of the containers. Therefore, at this point you may wish to add more baking soda and vinegar to the original jar and again pour it into the second jar.

Now, try sticking the lit matches into the containers:



The correct answer is D: the flame only goes out in the jar at right because all the carbon dioxide was poured into this jar.

Now ask the students why the carbon dioxide stayed in the jars rather than rising to the ceiling of the room. Answer: carbon dioxide is denser than air. Have the students compute the molecular weight of carbon dioxide and of the two primary components of air (N_2 and O_2):

Each N_2 molecule weights 28 atomic mass units.
Each O_2 molecule weights 32 amus.
Each CO_2 molecule weights 44 amus.

Thus, the carbon dioxide is heavier and denser than air, and so if you are careful to avoid mixing, the CO_2 will sink. This is why is stays in the first jar when you originally mixed the reactants, and why it pours downward into the second jar.

Next, mix up more baking soda and vinegar in the original container. Light just one more match, and pour the newly made CO_2 onto the flame. The flame will be extinguished. (This step takes practice).

Finally, ask the for 1-3 volunteers from the class to explain in their own words: "What was the point of this activity? What did you learn?"

Reference

http://www.stevespanglerscience.com/experiment/invisible-fire-extinguisher