Ocean Acidification Via Carbon Dioxide

Chris Lewis, City College of San Francisco

Introduction

In addition to contributing to global climate change, increasing atmospheric carbon dioxide also affects ocean chemistry. The term given to this change is ocean acidification, or OA (1). The following demonstration visually shows how this change takes place by using a non-toxic acid/base indicator and the naturally occurring CO_2 in human breath.

Materials:

Whole class:

About 0.5 cups chopped red cabbage
1 quart hot (just off boiling) water
White vinegar, or another dilute acid
Baking soda solution, or another dilute base (about a teaspoon dissolved in a cup of water)
Wire mesh strainer

Per group:

2 clear plastic cups, 8 ounce
1 drinking straw
1 sheet of blank white paper

Prepare the indicator solution in advance:

1. Steep the chopped cabbage in the boiling water for about 10 minutes.
2. Strain out cabbage and reserve the liquid.
3. Allow the liquid to cool. The reaction will take place faster in colder solutions as the solubility of carbon dioxide increases with decreasing temperature.
4. Dilute the indicator with water so that it is fairly transparent. You should be able to read text through the solution when it's in a plastic cup.

Pre-demo discussion:

1. Review the respiration reaction with the class, emphasizing that one of the products of the reaction is CO_2. The amount of CO_2 in human breath is typically around 4-5% (2), whereas the amount in air is only about 0.004%.
2. Demonstrate for the class how the indicator works by filling three beakers with indicator and adding a few milliliters of acid (vinegar) to one and a base to the other (baking soda solution). The acid will turn the indicator pink and the base will change it to blue.
3. Leave the three beakers in front of the class as references.

Run the demo:

1. Distribute the materials to each group
2. Label one of the cups "experiment" and the other "control"
3. Pour about 4 ounces of indicator in each cup (half full).
4. Place the cups on the sheet of paper. The color of the indicator will be easier to see on a white background.
5. Have one member from each group place the straw in the experimental cup and begin exhaling through the straw, causing the spent air to bubble through the solution.
6. Continue bubbling until a color change takes place.
7. Note the color, has it turned more pink, or more blue?
8. What does this color change indicate?

References:

(1) NOAA PMEL Carbon Program, 2013, *Ocean Acidification: The Other Carbon Dioxide Problem*, viewed online 6/9/2013 at:
http://www.pmel.noaa.gov/co2/story/Ocean+Acidification

(2) Jaffe, Michael B., 2008, *Infrared Measurement of Carbon Dioxide in the Human Breath: "Breathe-Through" Devices from Tyndall to the Present Day*, ANESTHESIA & ANALGESIA, Vol. 107, No. 3, International Anesthesia Research Society.
Viewed online 6/9/2013 at:
http://oem.respironics.com/wp/Infrared%20Measurement%20of%20CO2%20in%20the%20Human%20Breath_Jaffe.pdf