CarboSchools

Interaction at the Air-Water Interface II

Note: Seawater can not be used for this experiment, see note4 at the end of the document.

Introduction:
What happens to the surface of a body of water (e.g. lakes or the sea) when carbon dioxide is dissolved in it? There is a constant exchange of gases between the air and the water surface. One of the factors which may affect this exchange is temperature. In a large body of water, what happens to the gas that is dissolved at the surface and not transported to deeper layers? It will stay in the surface and equilibrate with the concentration of the gas in the atmosphere.

Aim:
To demonstrate gas exchange at the boundary layer between water and air. Relate this to what happens at the ocean-air interface. To show how temperature affects this process.

Preparation time:	15 minutes
Activity time:	15 - 45 minutes
Type of activity:	Hands-on experiment
This activity had been tested on students aged:	10-12 yrs., grades 5-7
Application:	Physics, Chemistry, After-school activity
Time for data analysis and discussion:	20 minutes
Prior knowledge required:	acid-base interaction, concept of "indicators"
Cost:	Indicator (12€/250 ml), Floating candles (3€)
Degree of difficulty:	Easy

Material:*
6 salad bowls with the same diameter
distilled water at room temperature
frozen distilled water (ice cubes)
matches (2 salad bowls are for control)
12 white floating candles
white paper background
universal indicator (McCrumb)

Figure 1. Materials needed for the experiment: Salad bowls, floating candles, indicator solution and white background

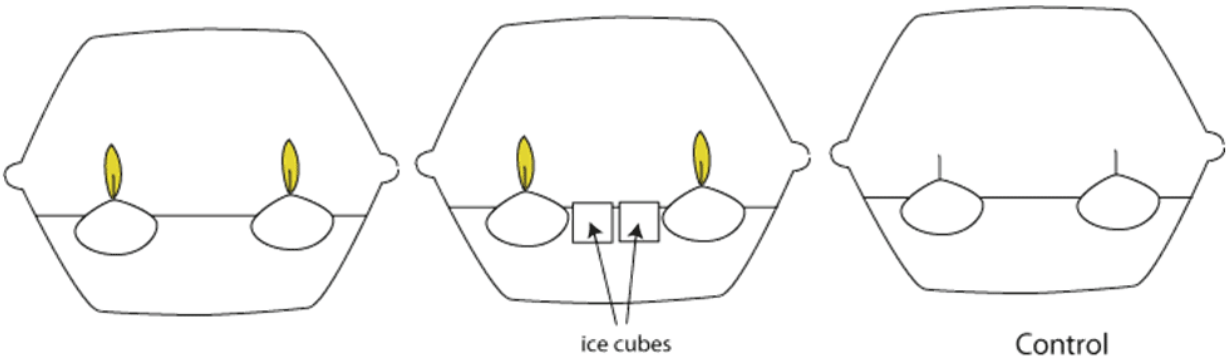
*To save on materials, you can do the experiments one at a time. In this case, you will just need two salad bowls and 4 candles.

Procedure:

1. Place three bowls on top of a white background. Fill these with the same volume of distilled water about ¾ full. Cool one bowl with the frozen distilled water (ice cubes). Add several drops of the McCrumb universal indicator to the bowls. Make sure that they have the same intensity of green color.
2. Light 8 floating candles and place four each in two bowls. Put the four unlighted candles in the third bowl. This will serve as your control. Cover the bowls with the remaining 3 bowls. Take note of the color of the water at the start of the experiment.
3. Observe the change in the color of the water in the bowls. To see any changes, look at the air/water interface (boundary between air and water).

Figure 2. Four lighted floating candles are placed in the bowl with water. Note the color of the water at the air-water interface

Figure 3. The bowl is covered with the other bowl. After some minutes, the candles are extinguished after they have used up all the oxygen inside. Control is the same set-up with candles unlighted.



The three set-ups

Results and Points for Discussion:

1. What color change did you observe? What does this indicate?
2. Where does the color change take place? Did all the water in the bowl change color? What does this imply in relation to the oceans?
3. In which bowl was the color change more visible? Why do you think is this the case?

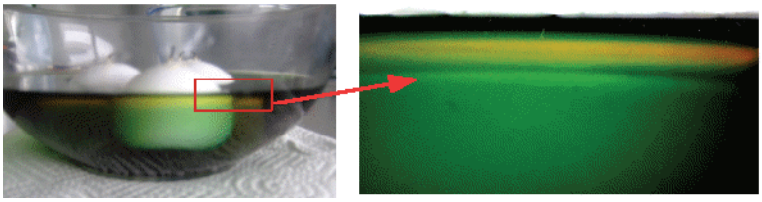
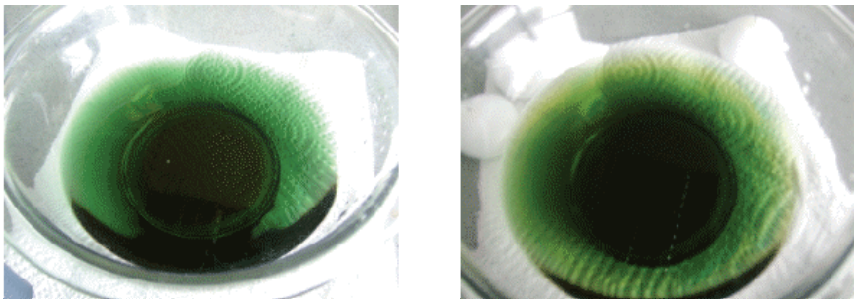


Figure 4. Some minutes after the candles are extinguished, a thin yellow layer of water forms at the surface. This indicates acidification of the surface layer because of dissolved carbon dioxide.



Before **After**

Figure 5. Color of the water before and after the experiment with the lighted candles.

Notes:

1. The color change from green to yellow (basic to acidic) occurs only at the surface of the water which has direct contact with the air above it. The carbon dioxide produced by the burning candles dissolves at the water surface making it acidic. Consequently, since there was no excess CO_2 (no lighted candles) introduced into the control bowl, there should be no chage in the color of the water here.
2. Without agitation, the color remains at the surface of the water and does not readily diffuse to the deeper part of the bowl. In the ocean, CO_2 dissolved at the surface is only effectively removed from the atmosphere if this CO_2 is physically transported to the deeper layers by convection.
3. The cooled water in one bowl should be more yellow because of a higher solubility of gases in cold water. However, since the water in the bowl has a uniform temperature, there is no transport of the acidic water to the bottom of the bowl.
4. In this experiment distilled water was deliberately used to show the pH change at the surface of the water using the McCrumb universal indicator. **Seawater can not be used for this experiment** because the indicator is not sensitive enough to a small pH drop. The buffering capacity of seawater will lead to a smaller change in pH compared to distilled water.

Additional Experiments:

1. Remove the covering bowl and let the set-up stand for a while. Observe the color change on the surface of the water. After several minutes, the yellow color will disappear because equilibration with the surrounding air, which has a lower concentration of carbon dioxide, has occured.
2. To demonstrate convection: Remove the covering bowl of the set-up without ice cubes. Add ice cubes and then replace the cover. This will cool down a part of the surface water and this will start to sink to the bottom of the bowl.

Developed for CarboSchools by S. Soria-Dengg, IFM-GEOMAR, Kiel, Germany. Mail: sdengg@ifm-geomar.de
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