APES Lab: Testing for Tropospheric Ozone Pollution

WHAT TO TURN IN:	Test Strips	Data Table	Questions #1-4

Objectives

- To prepare and carry out tests for tropospheric ozone pollution by making test strips
- To analyze the ozone pollution test results for local variation and possible impact on human health

Note: This activity works best in areas of low humidity and high ambient ozone concentrations. In some parts of the country, this activity may not be very conclusive.

Field testing ground level ozone is over a hundred years old and the test was developed by Dr. Christian Schoenbein in the early 1800s. The test paper he developed contains potassium iodide, corn starch and water. Distilled water is recommended to make the paper and for the final reading. Schoenbein's paper is placed in an area away from light for eight hours to allow for a reaction. This test is based on the oxidation capability of ozone.

Ozone in the air will oxidize the potassium iodide on the Schoenbein paper to produce iodine. The iodine reacts with starch and produces a purple color. The exact shade of purple correlates to the amount of ozone present in the air. The two reactions involved are

$$2KI + O_3 + H_2O \rightarrow 2KOH + O_2 + I_2$$

$$I_2 + \text{starch} \rightarrow \text{blue or purple color}$$

The color scale used is from http://teachertech.rice.edu/participants/lee/colorscale.html

There is a difference between ground level ozone and atmospheric ozone. Ground level ozone (O_3) is the tri-atomic form of molecular oxygen (O_2). Atmospheric ozone consists in the Ozone layer, which is the layer of ozone that protects the inhabitants of Earth from the harmful radiation of the sun (UV). Ground level ozone, however, is when a chlorine atom breaks apart an O_2 atom and joins it, creating O_3. A major contributor to ground level ozone is car emissions.

The way that cars contribute to ground level ozone is through car exhaust that contains nitrogen and carbon compounds. In the presence of sunlight, nitrogen compounds release oxygen atoms. The oxygen atoms combine with oxygen molecules in the air (O_2) and create ground level ozone (O_3). In total, there are five main exhaust emissions: carbon monoxide, carbon dioxide, hydrocarbons, nitrogen oxides (NO_x), sulfur oxides (SO_x), and suspended particulates (like soot that hangs in the air). One of the carbon compounds used in forming ground level ozone is carbon monoxide.

Materials

Hotplate	Scoopula	Corn starch
Graduated cylinder	Ceramic tile	Potassium iodide, KI
250 mL or similar-sized	Small brush	Distilled water
Beaker	Filter paper	Distilled water spray bottle
Beaker tongs	Plastic wrap	Microwave oven
Stirring rod	Plastic zip-top bags	Microwave-safe plate

Procedure

IN CLASS…

1) Preheat a hotplate to medium high.
2) Place 100 mL distilled water in a beaker, then add 5 g of corn starch.
3) On a hot plate with a magnetic stirrer heat the mixture until it gels and becomes somewhat translucent. This will take a few minutes.

(If you do not have a magnetic stirrer hotplate, stir the mixture carefully and constantly with a stirring rod while it heats. It will take a little longer to gel.)

4) Remove the beaker from the heat with tongs; place the hot beaker on the ceramic tile to cool.
5) Add 1.0 g KI and stir well; then let the mixture cool to a paste.
6) Obtain a microwave-safe plate. Lay a piece of filter paper down on the plate and brush the paste on it, being sure to cover it completely and uniformly.
7) Turn the paper over and repeat Step 6. The paper can now be used for testing, but it is better to allow the paper to dry in the dark. Keep away from direct sunlight.

Lab Hint: Fast drying can be accomplished in a microwave at low power for 30 to 60 seconds. Use a microwave-safe plate.

8) Cut the filter paper in strips of 1" width and store in an airtight container (such as a zip-lock bag or jar) in the dark. Potassium iodide is sensitive to moisture and light.

CAUTION: Wash your hands thoroughly when done. Potassium iodide, although not toxic, is a mild basic salt and can cause a skin irritation.

9) ONE PER CLASS: To test for ozone, spray a test strip with distilled water and hang it at a collection site out of direct sunlight for eight hours. Then seal it in an airtight container until you are ready to measure the results.

AT HOME…

10) Select sites near your school and/or home. Spray the test strips with distilled water and hang them. The test strips should be able to hang freely, but not in direct sunlight. Try sites like your classroom, rest rooms, gym, cafeteria, teacher copying room, garage, laundry room, parking lots, etc. You can hang them with a paper clip. **Check the humidity online** (http://weather.noaa.gov/weather/FL_cc_us.html, www.weather.com, etc.) **and record it when you hang the strips. Let the strips hang for eight hours.**

The equation below approximates the relative humidity within 0.6 % in the range of -25 to 45 ^{o} C or -13 to 113 ^{o} F. "T" is equal to the air temperature in degrees Celsius. "Td" is equal to the dew point temperature in degrees Celsius.

$$RH \approx 100 \left(\frac{112 - 0.1T + Td}{112 + 0.9T} \right)^{8}$$

11) Pack the test strips in separate plastic bags, properly labeled with each test strip's location, and bring them back to class.

BACK IN CLASS…

12) When you are ready to record your results, dip the paper in distilled water and observe the color. Use the color in the area of the most pronounced change. To determine the ozone concentration, you will need to determine the Schoenbein Number. Use the ozone color scale from http://teachertech.rice.edu/participants/lee/colorscale.html .

The EPA Air Quality Standard for O_3 is 0.08 ppm (80 ppb) over an 8-hour period.
1 ppm = 1000 ppb

DATA TABLE:

	Location of test strip	Schoenbein number	Relative humidity on testing day (%)	ppb O_3
1	_____	_____	_____	_____
2	_____	_____	_____	_____
3	_____	_____	_____	_____
4	_____	_____	_____	_____
5	_____	_____	_____	_____

Questions

1) What change in the test paper, if any, did you observe? (The color of the paper may not be uniform. Determine the Schoenbein Number by the color in an area with the most noticeable change.)
2) Compare your test paper to those of other students. Why do you think the test papers did not all appear the same?
3) Was the relative humidity for your test day higher or lower than usual? (Individual results will vary depending on the specific relative humidity of the site.)
4) Would the parts per billion of ozone be the same for Schoenbein Number of 4 at a relative humidity of 30 percent and 70 percent? (Hint: Refer to the Relative Humidity Schoenbein Number Chart.) What are both of those values, in ppb?

Relative humidity and ppb: Schoenbein number graph