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|  <b>Tropospheric<br/>Ozone</b> | <b>Activity 29: Making and Using Schoenbein Paper</b>       |  |   |  |
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## Making and Using Schoenbein Paper

### Background

Christian Friedrich Schoenbein discovered ozone in 1839 during his tenure as a professor at the University of Basel, Switzerland. He used the reactivity of ozone to measure its presence and demonstrate that it is a naturally occurring component of the atmosphere. He developed a way to measure ozone in the troposphere using a mixture of starch, potassium iodide, and water spread on filter paper. The paper, called Schoenbein paper, changes color when ozone is present. Ozone causes iodide to oxidize into iodine (I<sub>2</sub>).

This test is based on the oxidation capability of ozone. Ozone in the air will oxidize the potassium iodide on the test paper to produce iodine. The iodine reacts with starch, staining the paper a shade of purple. The intensity of the purple color depends on the amount of ozone present in the air. The darker the color, the more ozone is present.

The reactions involved are  $2KI + O_3 + H_2O \rightarrow 2KOH + O_2 + I_2$

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

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.

### Learning Goals

1. Students will understand that ozone is a gas found in the troposphere and other parts of the atmosphere.
2. Students will be able to demonstrate that by using Schoenbein paper, variations in the amount of ozone present in the troposphere can be determined from day to day and from place to place.
3. Students will be able to explain that the Schoenbein paper detects ozone by an oxidation reaction caused by the ozone in the surrounding air.
4. Students will be able to draw conclusions about ozone levels of the air based on test results.

### Alignment to National Standards

#### *National Science Education Standards*

- Science As Inquiry, Grades 5 to 8, pp. 143: "Content Standard A: As a result of activities in grades 5 - 8, all students should develop abilities to do scientific inquiry and understandings about scientific inquiry."

## Benchmarks for Science Literacy, Project 2061, AAAS

- Scientific Inquiry, all grades, pgs. 9-13.
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### Grade Level/Time

- **Grade level:** 7 to 9
  - **Time**
    - Will vary depending on the nature of the student experiment, but each exposure will take 8 hours
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### Materials

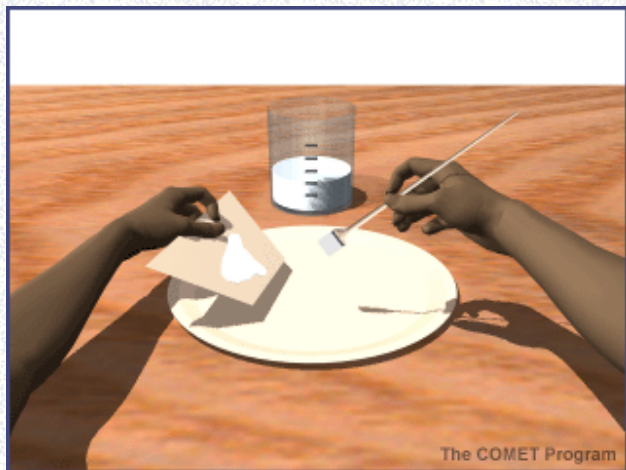
- Potassium iodide (a teaspoon will be plenty)
  - Distilled water (must use distilled water)
  - Spray bottle filled with distilled water (must use distilled water)
  - Filter paper
  - Heat source (preferably a hot plate)
  - Corn starch
  - Glass stirring rod (do not use metal)
  - Small paint brush
  - 250 ml beaker
  - Glass Pyrex plate
  - Hot pad or mitt for removing the beaker from the heat source
  - 8 1/2 x 11 inch paper for drying filter paper
  - Map of city or school building
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### Procedure

Schoenbein Paper Preparation (For safety, you may want to prepare the paper as a demonstration)

1. Place 100 ml of distilled water in a 250 ml beaker.
2. Add 1 1/4 teaspoon of corn starch.
3. Heat and stir mixture until it gels. The mixture is gelled when it thickens and becomes somewhat translucent.
4. Remove the beaker from the heat source and add 1/4 teaspoon of potassium iodide and stir well. Cool the solution before applying to the filter paper.

5. Lay a piece of filter paper on a glass plate, or hold it in the air, and carefully brush the paste onto the filter paper. Turn the filter paper over and do the same on the other side. Try to apply the paste as uniformly as possible.



6. Wash hands after applying the potassium iodide mixture. (Although potassium iodide is not toxic, it can cause mild skin irritation.)
7. Set the paper out of direct sunlight and allow it to dry. A low temperature drying oven works well if available.
8. Cut the filter paper into 1-inch wide strips.
9. To store the paper, place the strips in a sealable plastic bag or glass jar out of direct sunlight.

#### Testing Procedure

1. Each student should be given at least two strips to test.
2. Spray a strip of test paper with distilled water and hang it at a data collection site **out of direct sunlight**. Make sure the strip can hang freely.
3. Expose the paper for approximately eight hours. Note where each strip was hung.
4. After exposure, seal the strip in an airtight container if the results will not be recorded immediately.
5. To observe and record test results, spray the paper with distilled water. Observe the color.

Note: The xerographic process in most copy machines uses electrostatic charging of a cylinder. The accompanying ionization creates ozone in adjacent air, so a room containing a copy machine makes a good location for this experiment.

Teacher Note: Because relative humidity affects results, Schoenbein paper should not be left outside during periods of high humidity.

#### Qualitatively Determine Ozone Level

1. Have students compare their test strips. This is a qualitative comparison. While numbers cannot be attributed to this test, you can make relative comparisons. Those strips that show little or no change were in places with the lowest ozone concentrations. Those that have a lavender appearance were exposed to more ozone and, finally, those that look dark purple had high ozone exposures.

#### Questions and Observations

1. What change in the test paper, if any, did you observe? (The paper will vary in color depending on the amount of

the oxidation. The color of the paper may not be uniform.)

2. Compare your test paper to those of your fellow students. Do all the test papers appear the same? (The individual test papers will vary depending on the amount of oxidants at various sites. For example, sites near highways will show greater color change due to oxidants from car exhaust and nitrous oxides in heavy traffic areas.)
3. Was the relative humidity for your test day high or low? (The results of individual test papers will vary depending on the specific relative humidity of the site. See the reaction in the Background Information section. Notice that water is a reactant, so humidity will affect the reaction. Sites near lakes or streams may show greater change.)
4. Why do you think the various test papers did not all appear the same? (Student answers will vary. Tropospheric ozone levels vary widely due to the type and number of sources of ozone. Students measuring ozone in their home may report little color change of the paper, but if they live on a busy street, a measurement near the curb will register greater color change. Humidity and oxidants are present in varying levels depending on the time of day, the weather, the season, etc.)
5. Based on the data you collected, do you think this method is a good way to measure ozone in the troposphere? Why or why not? (Some students will point out the difficulty in interpreting the color accurately, while others will note the differences in how the paper was produced from group to group. It is important to stress that this is a good method for measuring relative amounts of ozone.)

## Extensions

1. Using a city or county map of your area, have students place sticky dots corresponding with the color of the Schoenbein paper from the location for which they collected data. Have students initial their dot.
2. Compare data your students collect with those from a local monitoring station. Also, if possible get information about the wind direction during your study.
3. Have groups of students collect daily ozone data for a week. These data can be plotted on a graph using parts per billion (ppb) on the vertical axis and the days on the horizontal axis. The students can see if there is any variability from day to day. By comparing the graphs, the students can see if there is any consistency in their data and if so, try to come up with a theory why. Students could also compare data to weather (temperature, relative humidity, clouds, wind, rain, etc.)
4. Contact your local Air Quality Control Board and request data for your test week. Do your readings agree with those from the control board?
5. It is always a good idea to get as many readings as possible. Incorporate other grade levels and other schools. Contact the state Air Quality Control Board for data during the test period. Compare data from students in different cities and states. Do you see correlations or patterns?

Research Project: Construct an Ozone Map of Your Area

## Procedure

1. Give each student two strips of Schoenbein paper in a sealed bag.
2. Have students moisten the paper with distilled water and hang the test strips at two sites in or near their home.
3. Students should record their data noting the color change they observe. Students can then plot relative ozone concentrations on a local map.
4. Have students contour the map indicating areas of high and low ozone concentration.

## Observations

1. Was there any variation in ozone levels on the map?
2. Where on the map were the concentrations the highest? The lowest?

## Conclusions

1. Looking at the area of highest concentration, does there appear to be any obvious explanation for the variation?
  2. Why do you think there were ozone level variations?
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## Assessment Ideas

- This would serve well as a scientific inquiry task and allow the teacher to assess student understanding of ozone distribution as well as the students' ability to design and conduct simple, independent experiments. A simple laboratory report on ozone distribution would be an appropriate assessment tool.
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## Modifications for Alternative Learners

- English Language Limited (ELL) students should be able to carry out this lab with little difficulty. If done as an inquiry task, all students should be given clear and specific directions on how to write up the lab. Students in general, and ELL students in particular, might benefit from a simulated report example prepared by the teacher as a guide (particularly if they have limited experience with inquiry lab reports).

**When you're finished with the activity, click on Back to Activities List at the top of the page to return to the activity menu.**

