

SUMMARY

Students check for the presence and relative amounts of ozone in the air using Schoenbein strips they make with filter paper, cornstarch, and potassium iodide.

ESSENTIAL QUESTIONS

- How can we find out if there is ozone in the air around our school?
- Where on campus can we find the most ozone?

TIME NEEDED

This activity, including the warm up and wrap up, should take about 90 minutes.

2012 North Carolina

ESSENTIAL STANDARDS

FOR EARTH/ENVIRONMENTAL SCIENCE

- EEn.2.5.1 Summarize the structure and composition of our atmosphere.
- EEn.2.5.5 Explain how human activities affect air quality.

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MAKING CONNECTIONS

It's always good to take any opportunity to remind students of the difference between ground-level ozone pollution and the ozone layer in the stratosphere. Ozone is a molecule made of three oxygen atoms. In the stratosphere, the ozone layer absorbs ultraviolet (UV) radiation, protecting plants and animals on Earth from its damaging effects. Near the surface of the Earth, ground-level ozone is a secondary pollutant that forms when nitrogen oxides and volatile organic compounds (VOCs) combine in the presence of sunlight and heat. In North Carolina, ozone tends to be a problem on sunny hot days during the week when there is a lot of vehicle traffic to produce nitrogen oxides.

BACKGROUND

If possible, do this activity during ozone season – on a day when it is hot and sunny and there is a lot of vehicle traffic in the area. If that's not possible, you can still do the activity because there's always some ozone in the air.

This activity also works best on days with lower humidity, 80% relative humidity or lower. Relative humidity is defined as the amount of moisture present in the air (specific humidity) compared to the amount of moisture the air can hold at the current temperature. The colder the air, the less moisture it can hold, which is why water condenses and dew appears

at the coldest time of day just before the sun rises. As the air warms, water is evaporated because the air can hold more. The more moisture there is in the air, the more likely the unstable ozone will lose an oxygen to become atmospheric oxygen (O₂). High humidity also makes Schoenbein strips more sensitive to ozone.

This activity checks for relative amounts of ozone; the measurements will not be exact. The test strips, that the students will make, turn purple in the presence of ozone, with darker colors representing relatively more ozone. Using the Schoenbein color scale and the relative humidity number chart, students will be able to determine an approximate amount of ozone in parts per billion. Students will be able to compare the relative amounts of ozone from different parts of campus.

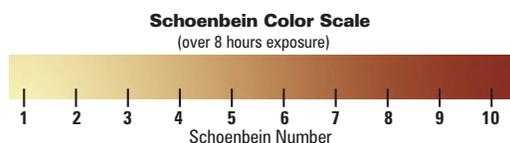
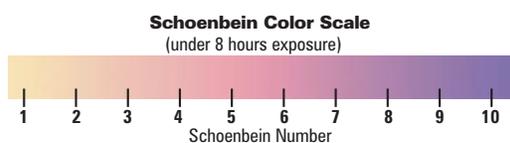
Students will make the indicator strips using cornstarch and potassium iodide. If there is ozone in the air, it will react with the potassium iodide in the presence of water to make molecules of iodine (I₂).



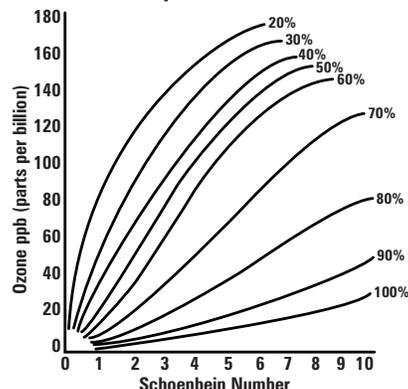
When the iodine reacts with the starch in the cornstarch, it turns blue or purple. So if the test strips turn blue/purple, it indicates the presence of ozone in the air.



For more information on ozone, see the activity "The Monitored Pollutants and a Closer Look at Ozone."



Relative Humidity Schoenbein Number Chart



NC Division of Air Quality

Ozone Air Quality Index with Cautionary Health Statements

Ozone Concentration	AQI Category	AQI Range	Cautionary Health Statement
0 to 59 ppb (8hr)	Good	0-50	No special precautions are suggested.
60 to 75 ppb (8hr)	Moderate	51-100	Unusually sensitive people should consider limiting prolonged outdoor exertion.
76 to 95 ppb (8hr)	Unhealthy for Sensitive Groups	101-150	Active children and adults, and people with respiratory disease, such as asthma, should limit prolonged outdoor exertion.
96 to 115 ppb (8hr)	Unhealthy	151-200	Active children and adults, and people with respiratory disease, such as asthma, should avoid prolonged outdoor exertion; everyone else, especially children, should limit prolonged outdoor exertion.
116 to 374 ppb (8hr)	Very Unhealthy	201-300	Active children and adults, and people with respiratory disease, such as asthma, should avoid all outdoor exertion; everyone else, especially children, should limit outdoor exertion.

MATERIALS

Making the Strips

- Potassium iodide
- White filter paper (coffee filters or Double Rings Filter Paper, 12.5 cm in diameter)
- Cornstarch
- Glass or plastic stirring rod (do not use metal)
- Measuring spoons (1 teaspoon, ¼ teaspoon)
- Masking tape
- String
- Hole punch
- Small paint brush
- Beaker, 250 ml
- Distilled water
- Aprons
- Hot plate
- Hot pad
- Safety goggles (optional)
- Low-temperature drying oven (optional)
- Heat-safe glass plate (optional)
- Microwave oven (optional)

Exposing the strips

- Distilled water in a spray bottle
- Supplies to hang the test strips (such as thread, scotch tape, paper clips, etc.)
- Psychrometer, preferably one without mercury (optional)

Interpreting the strips

- Schoenbein color scale (included)
- Relative humidity Schoenbein Number Chart (included)
- Distilled water

WARMUP

If necessary, review as a class the chemical structure of ozone (three atoms of oxygen) and that ozone in the stratosphere is good because it protects us from ultraviolet radiation, whereas ozone at ground level is a pollutant. The “ingredients” for ozone at ground level are nitrogen oxides (from vehicles and power plants), volatile organic compounds (man-made and natural), heat, and sunlight.

Discuss the scientific method, and emphasize the importance of using a consistent process for making, exposing, and interpreting the test strips. As a class, decide on locations to expose the test strips: near a parking lot or street, in or near a natural area, perhaps near a photocopy machine because they produce a lot of ozone. Ask students to generate hypotheses about what they will find with the Schoenbein strips.

Teacher Tips

Set-up Time: 15 mins.

Activity Time: 40–60 mins.

- Making the strips and hanging them will take about 20–30 minutes. The following day, it will take about 20–30 minutes to collect the strips and investigate the results.
- If you don't have access to a beaker and a hot plate, you can mix up the solution in a Pyrex measuring cup in a microwave.
- Assign three roles in each group: a lab manager responsible for gathering and putting away materials; a data recorder to write down notes and data; and a scientist responsible for performing the procedures.
- I like to make the solution myself in front of the class because the amount the instructions call for is more than enough for eight groups of students to make three strips each for a total of 24 strips. You can have each group make the solution so that they get to do the chemistry and make the three strips (one piece of filter paper cut into three strips), but you will have lots of chemical left to dispose of. I usually explain the chemistry and the reasons why the reaction works as an ozone detector while I mix up the solution, and the students prepare the strips.
- To save time, you can make the solution before class. It will keep for days at room temperature and for months in the refrigerator.
- Consistently saying “ground-level ozone” while teaching this activity will help avoid confusion between ozone at ground level and ozone in the stratosphere.

– Mark Townley



THE ACTIVITY

Note: Potassium iodide can be a mild irritant so either use gloves or wash your hands after working with it.

Part I: Make the test strips

- Makes 30-40 strips (each group should have 3 strips)
- In the 250-ml beaker, combine 100 ml of distilled water and 1 ¼ teaspoons of cornstarch.
- Heat and stir the mixture until you have a translucent gel.
- Remove from heat and add ¼ teaspoon of potassium iodide; stir.
- Cut the filter paper into one-inch-wide strips. Put tape on one end of the cut filter paper and punch a hole in the tape to make the hole for the string. Cut string into 2-foot lengths and attach to strips through the hole so that you have 2 loose ends to tie together.
- When the solution is cool, use a paintbrush to brush it evenly onto both sides of each piece of filter paper.
- If you are going to expose the test strips right away, skip the next two steps.
- Let the paper dry out of direct sunlight. You may dry it in a low-temperature drying oven, or in a microwave for about 30-45 seconds.
- When dry, store the strips in a sealed plastic bag or glass jar out of direct sunlight.

Part II: Expose the test strips

- If the test strips are dry, rewet them in distilled water using a spray bottle.
- Hang them outside in various locations, but not in direct sunlight, for several hours until dry, then retrieve the strips. They should all be exposed for the same amount of time for accurate comparison. Eight hours is an ideal length of time, but you can collect sooner if necessary or leave them for 24 hours. If they will not be read right away when collected, seal them in plastic bags to stop the reaction.
- When you hang the strips, use a psychrometer to determine the relative humidity of each location. If you don't have a

psychrometer, look up the relative humidity for the testing day in a newspaper or on the Internet.

- Place one unexposed strip in a sealed plastic bag as a control.

Part III: Interpret the test strips

- Rewet the paper in distilled water.
- Lavender and purple colors indicate the presence of ozone. If you expose the strips for a full day, the purple may fade to brown, as shown in the second color scale. The darker the color, the more ozone. Use the color scale to assign a Schoenbein number to each strip.
- Use the Relative Humidity Schoenbein Number Chart to find the ozone concentration or level in parts per billion: Go up from the Schoenbein number until you hit the appropriate relative humidity line, then read the ppb from the y-axis.
- Compare results of the strips from different locations. Can you explain the differences?
- Go to the website of the Division of Air Quality (www.ncair.org) and click on Air Quality Forecasts to find an official reading for ozone level for the day. Click on Today's Forecast to see current Ozone AQI levels. Click on Previously Observed to see the levels from the day before. Use the Ozone Air Quality Index chart to convert your results to the official reading. How does it compare to your results?

WRAP UP AND ACTION

As a class, discuss your results.

- Do the results seem accurate? Any surprises? Did they support the hypothesis?
- What are some strategies the community could take to lower ozone levels or keep them low?
- Is this technique a good way to measure ground-level ozone pollution? Why or why not?



ASSESSMENT

HAVE STUDENTS:

Write a letter to the editor of the school paper or the local paper describing their experiment and its results and making recommendations for lowering ozone levels or keeping them low.

EXTENSIONS

Give students strips to take home and expose outdoors near their homes. Compare the results the next day at school. Which parts of town appear to have the most and least ozone?

Plant a garden of plants that are known to display reliable effects of ozone pollution and monitor these effects regularly over a period of one to three months. To find out which plants are good indicators of ozone pollution and to find out how to recognize the effects of ozone pollution,

download the Ozone Monitoring Guide at this website: <http://www.handsontheland.org/environmental-monitoring/ozone-bio-monitoring.html>.

RESOURCES

A version of this activity is on the UCAR (University Consortium for Atmospheric Research) website: http://www.ucar.edu/learn/1_7_2_29t.htm

To check daily ozone levels for your community, go to the website of the Division of Air Quality (www.ncair.org) and click on Air Quality Forecasts. Click on Today's Forecast to see current Ozone AQI levels. Click on Previously Observed to see the levels from the day before.

It's Our Air Activity 1-3, Investigating Parts Per Million, Drop by Drop, is a good activity to help students understand the concept of part-per-million (ppm) and part-per-billion (ppb) measurements and appreciate the small scale of these measurements.



Making and Using Ozone Indicators

Student Page
#1

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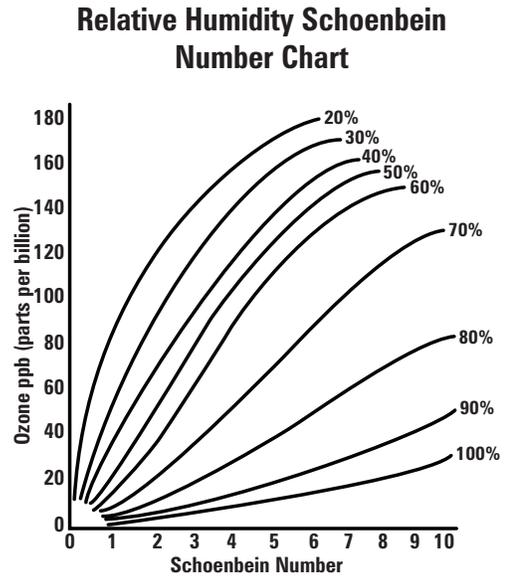
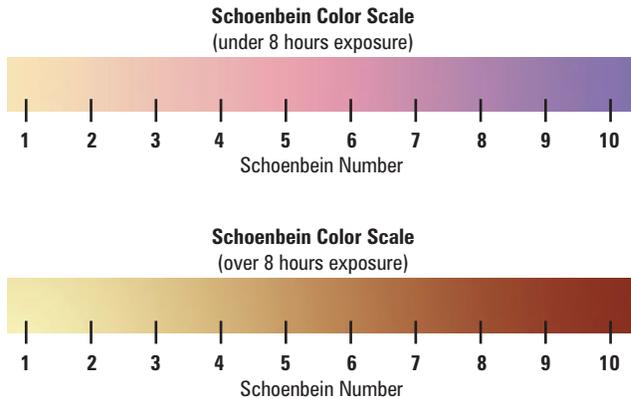
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