Ozone Test Paper

Introduction

We have become all too familiar with "smog-alerts" and television reports asking for us to reduce vehicle traffic due to high ozone levels. How can we test for ozone? Why is it so bad?

Concepts

- Ozone
- Parts per million/billion
- Air pollution

Background

Our atmosphere is divided roughly into two layers—the troposphere (between 0–9 kilometers above the Earth's surface) and the stratosphere (9–15 kilometers above the Earth's surface). About 90% of all natural ozone (O_3) gas exists in the upper stratosphere.

This so-called "ozone layer" plays a key role in the Earth's balance, by providing a protective shield for living things against harmful ultraviolet (UV) radiation from the Sun. The effects of high levels of UV radiation include risks of cancers, cataracts, immune deficiencies, damage to plants, and other genetic consequences. In the lower levels of the atmosphere (troposphere) ozone plays a destructive role as an irritant in smog.

In the stratosphere, ozone is usually found in concentrations of about 10–15 parts per *million*. Tropospheric ozone usually occurs at about 120 parts per *billion*. Tropospheric ozone is formed when hydrocarbons and nitrogen oxides from forests, industries and automobile exhaust react with heat and sunlight. In years past, tropospheric ozone didn't seem to be affecting human health. But the quantity of ozone that has been recently produced by certain human activities has caused us to rethink acceptable ozone levels. The concentrations have increased to such high levels that ozone has become a real irritant.

While stratospheric ozone shields us from UV radiation, ozone in the lower troposphere is irritating and destructive to forests, crops, nylons, rubbers and other materials. High concentrations of ground level ozone injure or destroy living tissue and can be harmful to individuals with respiratory problems. Thus, we have a dual ozone problem—pollution or smog in the troposphere ("bad ozone") and depletion of the ozone layer in the stratosphere ("good ozone"). These are two very different problems, both stemming from human industrial and other activities.

Since 1900, the amount of ozone near the Earth's surface has more than doubled. In urban areas in the Northern Hemisphere, high ozone levels usually occur during the warm, sunny summer months from May to September. Typically, ozone levels reach their peak late in the afternoon, after the Sun has had time to fully react with the exhaust fumes from cars. Tropospheric ozone is formed by the interaction of sunlight with hydrocarbons and nitrogen oxides which are emitted by automobiles and other industrial activities.

Christian Schoenbein discovered ozone in 1839. He established the presence of ozone in the air and demonstrated that it is a natural component of the air. He developed a way to measure ozone in the air using a mixture of starch and potassium iodide spread on filter paper. Schoenbein's paper can be made and his original test for ozone duplicated. The Schoenbein test is based upon the oxidizing ability of ozone—ozone is a stronger oxidizing agent than normal oxygen (O_2). Ozone in the air will oxidize potassium iodide on the test paper to produce iodine. The iodine in turn reacts with starch, staining the paper a shade of purple. The intensity of the purple color will depend upon the amount of ozone present in the air. The darker the color of the paper, the more ozone present at that location. Two reactions are involved:

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

$$I_2 + \text{starch} \rightarrow \underset{\text{(purple)}}{I_2\text{–starch complex}}$$

Materials

Corn starch, 5 g

Potassium iodide, KI, 1 g

Water, distilled or deionized, 100 mL

Glass plate or other flat drying surface

Graduated cylinder, 100-mL

Hot plate

- Bag, resealable type (optional)
- Beaker, 250-mL
- Envelope (optional)
- Chromatography paper, 8″ × 8″
- Paper clips
- Paint brush
- Sling psychrometer or other humidity measuring device
- Stirring rod

Safety Precautions

Wear chemical splash goggles, chemical-resistant gloves and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the laboratory. Follow all laboratory safety guidelines. Please review current Material Safety Data Sheets for additional safety, handling and disposal information.

Procedure

Part A. Ozone Test Paper

1. Weigh 5 g of corn starch and transfer the corn starch to a 250-mL beaker.
2. Measure 100 mL DI water in a graduated cylinder.
3. Add a small amount of DI water to the corn starch and stir well. Repeat this step several times until a thin paste is formed. Add the remainder of the 100 mL of DI water to the corn starch paste.
4. Heat the corn starch and water on a hot plate. Stir frequently with a stirring rod until the corn starch mixture starts to gel. The mixture is gelled when it thickens and becomes somewhat translucent.
5. Carefully remove the beaker from the hot plate and add 1 g of potassium iodide. Stir well. Let the solution cool.
6. Place a piece of filter paper on a glass plate or other flat, washable surface.
7. Using a paint brush, spread the starch/potassium iodide solution evenly on one side of the filter paper.
8. Turn the filter paper over and repeat. *Note:* Apply the paste as uniformly as possible.
9. The paper can be used for testing at this point (proceed to Part B) or it can be readied for storage as described below.
10. Allow the paper to dry. Do not set it in direct sunlight. It can be air-dried overnight or the process can be shortened by placing the paper in a low-temperature drying oven.
11. When the paper is completely dried, cut the filter paper into 1-inch strips.
12. Store the strips in an envelope placed inside a resealable bag. *Note:* Keep strips out of direct sunlight.

Part II. Testing for Ozone

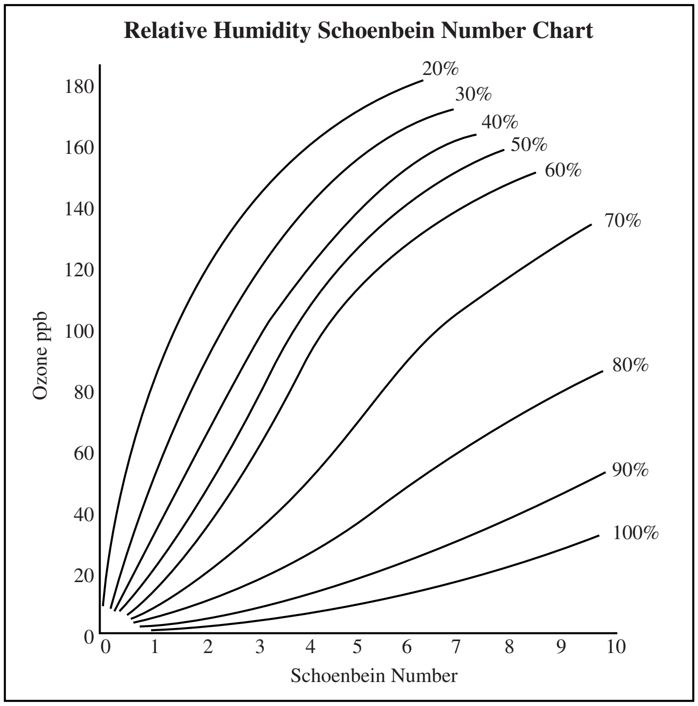
13. If the test strip is wet from Part A, continue on to the next step. If the paper was dried in Part A, dip a strip of the dried ozone test paper in DI water to reactivate before proceeding to the next step.
14. Unfold a paper clip to make a hook on which to hang the ozone test strip.
15. Select an area without drafts and direct sunlight where the ozone test strip can hang freely from the paper clip hook.
16. Determine the relative humidity at the data collection site using a sling psychrometer or other humidity measuring device.
17. Expose the ozone test paper for at minimum of eight hours or overnight.
18. When the strip is retrieved, either seal it in a resealable bag for testing back at the lab or proceed to the next step.

19. To observe the test results, dip the paper in DI water. Observe the color and determine the Schoenbein Number using the Schoenbein Number Scale below.

0–3	No change to little change
4–6	Pink to lavender hues
7–10	Blue to purple

Schoenbein Number Scale

20. Refer to the Relative Humidity Schoenbein Number Chart below. Along the bottom of the chart, find the point that corresponds to the Schoenbein number recorded above. From that point draw a line upward until it intersects the curve that corresponds to the relative humidity recorded above. To find the ozone concentration in parts per billion, draw a line perpendicular from the intersection point to the vertical axis on the chart. Record the ppb number for the test site.



Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. Excess starch/potassium iodide solution may be disposed of according to Flinn Suggested Disposal Method #26b.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Constancy, change, and measurement
Content Standards: Grades 5–8
Content Standard B: Physical Science, properties and changes of properties in matter
Content Standard D: Earth and Space Science, structure of the Earth system
Content Standard F: Science in Personal and Social Perspectives, natural hazards, risks and benefits

Content Standards: Grades 9–12

Content Standard B: Physical Science, chemical reactions
Content Standard D: Earth and Space Science, energy in the Earth system
Content Standard F: Science in Personal and Social Perspectives, personal and community health, environmental quality, natural and human-induced hazards

Tips

- Plan carefully for the ozone test sites. Select areas where the test strips can be hung inconspicuously and undisturbed during the test time frame. Locations should be convenient to reach during class time or after school. Obtain permission or clearance for all sites as needed.
- This activity works best in areas of low humidity and high ambient ozone concentrations. In some parts of the country (especially rural areas) this activity may not produce very conclusive or interesting results.
- Check with local authorities to secure ozone readings for the days you conduct this activity. Have students compare their data with the scientific data. The actual ozone number is not critical. The relative amount of ozone is interesting and the relative comparisons of various locations can be very revealing. (Near freeways, copy machines, electrical outlets, etc.)
- Ozone has an acrid odor. Older electronic equipment, ozone generating air cleaning machines, and small motors may provide interesting ozone results.

Materials for *Ozone Test Paper* are available from Flinn Scientific, Inc.

Catalog No.	Description
FB1619	Make Your Own Ozone Testing Kit
AP5069	Pocket Sling Psychrometer
S0124	Starch, Corn, 500 g
P0278	Potassium Iodide, 100 g
AP4299	Chromatography Paper, Pkg. of 100 sheets

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.