

Producing Ozone Using A Tesla Coil-by Mary Beth Leavitt

Purpose

- Demonstrate the production of ozone using an electric current from a Tesla coil.
- Qualitative identification of ozone using potassium iodide test strips.
- Create an investigative report on ozone.

Student Learning goals

- Facilitate a discussion on the sources of ozone, both man made and natural.
- Experience the production and qualitative determination of ozone using teacher prepared potassium iodide strips.
- Research a topic on ozone.
- Develop technical writing skills.

Time

- Preparation of potassium iodide strips: 15 minutes the day before
- Selection of research topics: 30-40 minutes
- Demonstration: 5 minutes
- Discussion: open-ended
- Report: open-ended

Level

Middle school and High school, grades 7-12

Educational Outcomes

- Identify and comprehend what produces surface ozone.
- Generate and understand the equation of the formation of ozone from oxygen.
- Generate and understand the equation of the qualitative test for ozone with potassium iodide.
- Observe the production of ozone by electricity
- Research a topic on ozone
- Collate facts about ozone into an investigative report

Skills

- Observing the production of ozone
- Writing the chemical equations
- Comparing the exposed potassium iodide strips with a control
- Discussing the sources of ozone
- Researching and writing an investigative report

Materials and Tools

- Tesla coil
- Filter paper
- Scissors
- Wooden splints or tongue depressors
- 10 % solution of potassium iodide
- Petri dish
- Glue stick

Preparation

- Prepare potassium iodide solution

Cut filter paper, soak in potassium iodide, dry, and glue to a wooden splint
Plug Tesla coil into a ground fault interrupter (GFI) outlet

Prerequisites

Able to understand and/or write chemical equations
Able to research a topic
Able to report results of research

Introduction

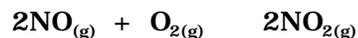
It is important that students understand ozone can be found in two distinct locations in the earth's atmosphere. Its effect on us can be either beneficial or harmful depending on which location the ozone is found. The troposphere is the lower band of atmosphere around the earth. It is the region that extends from the earth's crust to between 8 and 18 km above the earth's surface. The stratosphere lies in the region directly above the troposphere between 10 and 50 km above the earth's surface.

Stratospheric ozone is considered to be the "good ozone" that protects us from harmful ultraviolet (UV) radiation. It acts as a shield, absorbing harmful UV radiation. In recent decades, scientists have observed that there has been a reduction in ozone in the stratosphere due to the introduction of manmade pollutants. The largest contributors to this pollution are chlorofluorocarbons (CFCs), which were and to some extent are still used in refrigerants, aerosols, and cleaning solutions. These compounds are unusually stable in the troposphere and are not harmful to man. The problem with the CFCs begins as they migrate up into the stratosphere where the high energy UV radiation breaks them down and releases atomic chlorine. The atomic chlorine, which is very reactive, then attacks the ozone and starts a chain reaction of ozone destruction. We are very dependent on the ozone in the stratosphere to protect us. With a reduction in stratospheric ozone we are vulnerable to an increase in skin cancers, decreased immune systems, cataracts and damage to all plants and trees due to an increase in the UV radiation.

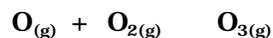
Tropospheric ozone is considered to be the "bad" ozone and is an air pollutant. It is a main ingredient in photochemical smog. The ozone is produced as a secondary reaction to the exhaust from fossil fuels. For example, in the extreme high heat and pressure in a car engine, diatomic oxygen and nitrogen molecules break down into atomic nitrogen and oxygen and reform as nitric oxide (NO).



This nitric oxide reacts with oxygen in the atmosphere to produce nitrogen dioxide. These are both referred to as NO_x (nocks).



When nitrogen dioxide is in the presence of UV radiation (from sunlight) it breaks down into nitric oxide and atomic oxygen. The atomic oxygen is very reactive and attaches to diatomic oxygen in the air to produce ozone.

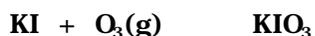


This reaction is especially prevalent in the summer when there is a lot of car exhaust, sunshine and slow moving high-pressure systems that trap the air and prevent it from mixing and removing the pollutants. These pollutants can rise to dangerous levels and cause severe health problems. The most dangerous pollutant is the ozone. Ozone is a strong oxidant. It causes respiratory distress, damage to rubber and paint, and the most important cause of plant destruction and loss. Besides automobile exhaust, biomass burning also produces a significant increase in ozone that threatens the tropics. Additionally ozone is produced during lightning or anytime there is an electrical arc in the presence of oxygen.



It is essential that the students understand that we have too much of the tropospheric ozone and not enough of the stratospheric ozone. Also it is vital for them to realize that ozone produced in photochemical smog stays in the troposphere and does not transfer into the stratosphere where it would be beneficial.

In the demonstration, the potassium iodide on the paper strips reacts with the potassium iodate. The strips turn brown when they react to the ozone produced by the electric arc. Also the pungent odor of ozone can readily be observed.



Lesson Design

The lesson is designed to facilitate:

- 1) the basic understanding of the production of ozone
- 2) the demonstration of the production of ozone
- 3) the qualitative determination of ozone with potassium iodide strips
- 4) a discussion of the causes and effects of ozone in our world
- 5) brainstorming on research topics by using clustering
- 6) an internet research project on ozone

How to Do It

The day before the demonstration, make the potassium iodide strips. To make the strips, cut filter paper into 2 cm by 8-cm lengths. Prepare a 10% solution of potassium iodide by dissolving 10g of KI into 100g of distilled water. Pour about 10 mL of the KI solution into a petri dish and allow the filter paper strips to soak. Remove the strips from the solution and allow them to dry overnight on a glass plate. The day of the demonstration, glue one of the KI strips to a wooden splint or tongue depressor.

For the demonstration, plug the Tesla coil into a GFI outlet near a metal source (like a faucet). Turn the coil on and hold it about 3 to 4 cm from the metal source so that it will arc. The electrical arcing will produce the ozone. Have a student hold the prepared KI strip (by the wooden end) about 2 cm from the arc for 3 minutes. Ask the student to describe the odor being produced. After 3 minutes, turn off and unplug the Tesla coil. Have the student show the KI strip to the class. Compare an exposed KI strip to an unexposed strip.

Student Assessment

Rubric for investigative report on ozone

Procedure

Introduce the topic of ozone by explaining the difference in stratospheric and tropospheric ozone. Explain the cause and effect of the depletion of the protective ozone in the

stratosphere versus the production of harmful ozone in the troposphere. Discuss all of the ramifications on health, agriculture and quality of life by too little ozone in the stratosphere and too much ozone in the troposphere.

Demonstrate the production of ozone with the Tesla coil and the qualitative test of ozone with potassium iodide strips. Discuss the chemical reaction and have the students write a chemical equation to represent the reaction of KI and O_3 . Show the chemical equations in the production of photochemical ozone and discuss each step.

Assign a research project on ozone. In teams of three or four, have the students brainstorm on ozone related research topics, by using clustering. Have them pick a recorder and allow them about 10 minutes. After 10 minutes, list on the board all of the different topics developed by the students. After the class reviews the topics, allow for more spontaneous brainstorming and record those topics. Have the students draw a number to determine the order in picking their research topic from the board. Cross out a topic as a student selects it. The assignment is to report the results of their research as if they were an investigative reporter. They should utilize at least five references listed in their bibliography (preferably from the Internet sources).

Helpful Hints

When conducting the demonstration, turn off the lights so that the students can clearly see the electrical arc produced by the Tesla coil. Do not allow the students to use the Tesla coil because the coil is a transformer used as a source of high-frequency voltage. Also, don't use the coil longer than 3 or 4 minutes at a time or it will damage the unit. The use of the wooden splint to hold the KI strip is to keep the student's fingers away from the electrical arc to prevent them from being shocked.

When the students are brainstorming, walk around to keep them on task and offer some suggested topics if they are having trouble.

Tell the students to be as creative as possible with their investigative report as long as they adhere to the facts. If they have the capability, tell them to use a newspaper format just as if they were a reporter. This should be fun for the students.

Educational Advantages of using this Activity

1. Enlightens students on the problems with ozone
2. Provides students an opportunity to smell and detect ozone
3. Utilizes an activity designed to meet the educational needs of multiple cognitive levels and different learning styles:
 - a) Interpersonal learner through cooperative group activity;
 - b) Linguistic learner through reading, researching, collating and writing a report
 - c) Visual learner through observations during the ozone demonstration;
 - d) Logical learner through interpreting research and generating chemical equations;
 - e) Naturalist learner through learning more about the problems of his or her own world.
 - f) Autistic learner through hearing explanation and discussion of the topic

INVESTIGATIVE REPORT ON OZONE OR RELATED TOPIC
Student Rubric for Assessing Report

Imagine that you are a reporter investigating an aspect of ozone. As a good investigative reporter, you must tell the “who”, “what”, “when”, and “how” on your topic. Try to be as creative with your report while sticking to the scientific facts. You will be graded on content, thoroughness, and creativity. The report should be 2 single-spaced typewritten pages long with a complete bibliography attached. Information reflected in a quality report:

- **Headline/byline**
- **Written in 3^d person**
- **Written in columns**
- **Reveals scientific information in a clever way**
- **Topic sentence hooks reader**
- **Typed**
- **Correct spelling, grammar and sentence structure**
- **Content rich, and thorough**
- **Illustrates the investigative method**
- **Impact on society and mankind with possible solutions**
- **Graphs, data tables, clip art if applicable**
- **One paragraph editorial on student’s personal views**
- **Complete bibliography with at least five sources**

Investigative Report on Ozone- Rubric for Assessment	
4 <u>EXPERIENCED REPORTER</u>	<ul style="list-style-type: none"> • Creative report that reveals information in a clever manner • Written in 3^d person • Uses columns • Has a headline and a byline • Typed with correct spelling, grammar and sentence structure • Good use of graphs or data table to clarify information • Content rich, and thorough • Shows impact on society and mankind with possible solutions • Interesting report that is enjoyable to read • Insightful editorial that demonstrates an understanding of the topic • Illustrates the investigative method • Complete bibliography with five or more sources
3 <u>COMPETENT REPORTER</u>	<ul style="list-style-type: none"> • Not as creative, clever or insightful as an experienced reporter • Written in 3^d person • Has a headline and a byline • Typed with correct spelling, grammar and sentence structure • Good use of graphs or data table to clarify information • Content rich and thorough • Shows impact on society and mankind with possible solutions • Editorial demonstrates an understanding of the topic • Illustrates the investigative method • Complete bibliography with four or five sources
2 <u>INTERMEDIATE REPORTER</u>	<ul style="list-style-type: none"> • Written in 3^d person • Has a headline and a byline • Typed with correct spelling, but has some trouble with grammar and sentence structure • No graphs or data tables, or labeled incorrectly or not at all

- Not as thorough as a competent reporter
- Shows some impact on society and mankind with possible solutions
- Editorial is weak and shows poor understanding of the topic
- Bibliography only has two or three sources

1 BEGINNING REPORTER

- Not in 3rd person, and poor organization
- Incorrect spelling, grammar and poor sentence structure
- Shows a lack of research
- Minimum effort
- No information on impact, possible solutions or editorial
- Bibliography only has one source

0 FIRED REPORTER

- Not in 3rd person, and no apparent organization
- Incorrect spelling, grammar and poor sentence structure
- Shows a total lack of effort
- No information on impact, possible solutions, editorial or bibliography