

## Supplemental Experiment 3

# Preparation and Properties of Pollutant Gases

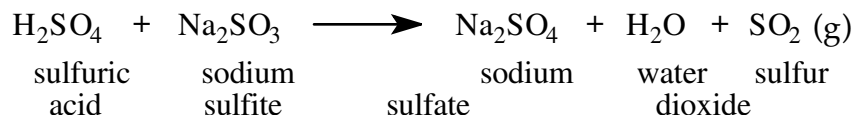
### Introduction

In *Experiment 1* the properties of gases in a typical breath were investigated. In this experiment you will investigate the properties of sulfur dioxide (SO<sub>2</sub>) and nitrogen dioxide (NO<sub>2</sub>), two gases that can pollute the air you breathe. These are also the gases that are responsible for acid precipitation (See chapter 6 in *Chemistry in Context*). Unlike oxygen and nitrogen, which have fixed concentrations and are major components in the air, the concentrations of sulfur dioxide and nitrogen dioxide are extremely small and they vary with location. Furthermore, both are highly toxic and have disagreeable irritating odors.

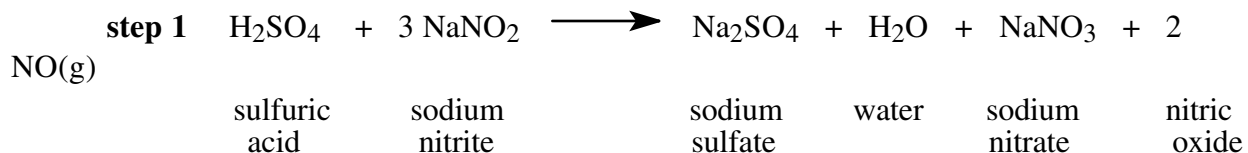
All of the gases will be generated in "zipper" plastic bags so that you will have an opportunity to make observations about the reactions. You will investigate the reaction of both gases with water to gain a better understanding of how acid rain is produced. Then you will observe the effect of the gases on *Blepharisma*, a common single-celled pond-dwelling organism.

### Background Information

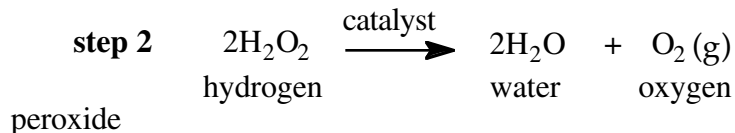
Sulfur dioxide will be prepared by the reaction of sulfuric acid with sodium sulfite to produce sodium sulfate, water, and sulfur dioxide.



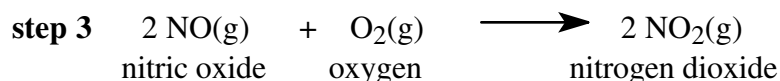
Nitrogen dioxide will be prepared by a multistep process. In *step 1*, nitric oxide (NO) will be formed by reaction of sulfuric acid with sodium nitrite to produce sodium sulfate, water, sodium nitrate, and nitric oxide.



In *step 2*, oxygen (O<sub>2</sub>) will be prepared by the reaction of hydrogen peroxide with yeast (as in Experiment 1).



Finally, in *step 3*, the oxygen and the nitric oxide will be combined to produce nitrogen dioxide.



As part of this experiment, you will test the pH of water containing each of these gases. The **pH scale** is discussed in the text, Section 6.4. A pH less than 7 means the solution is acidic; a pH greater than 7 means the solution is basic (alkaline); and a pH of 7 is neutral (neither acidic nor basic). Remember that the pH scale is logarithmic; thus for every decrease of one pH unit, the acidity increases 10-fold. For example, a solution of pH 4 is 10 times more acidic than one of pH 5, and 10 times less acidic than one of pH 3.

Change in pH can be determined by using a so-called universal indicator. This indicator is a mixture of pH sensitive dyes combined so that an aqueous solution of the dye shows a different color at each pH. You will make up a set of colored reference solutions by adding universal indicator to solutions of known pH. These reference solutions will be used to help you to estimate the change in acidity when each gas is mixed with water.

### Overview of the Experiment

1. Set up a 24-well wellplate for tests on the gases.
2. Prepare the “zipper” bag assemblies with reactant materials.
3. Generate gases in the “zipper” bags and record observations.
4. Test the properties of the gases and record observations.
5. Clean up and dispose of materials.

### Materials Needed

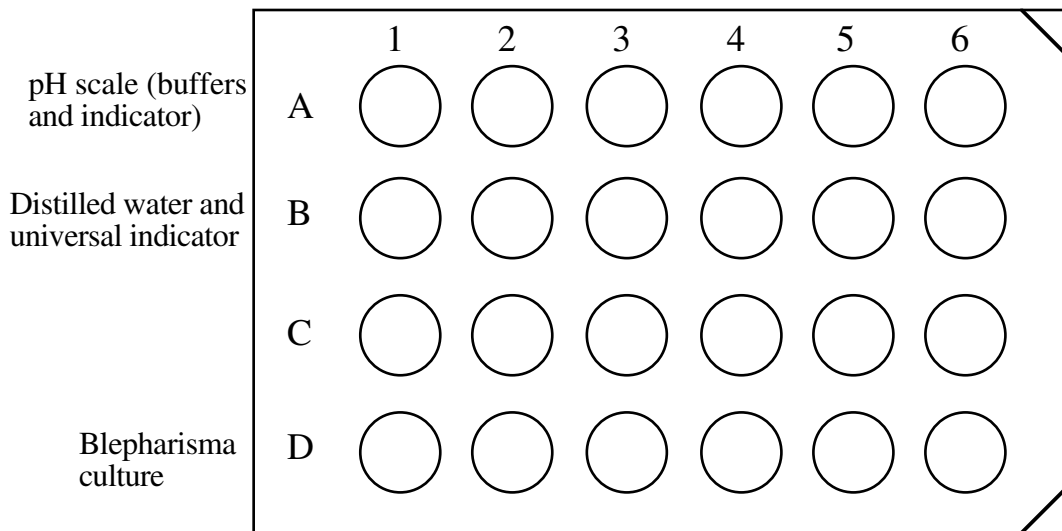
Chemicals	Equipment
<ul style="list-style-type: none"> <li>• 2 grams sodium sulfite (<math>\text{Na}_2\text{SO}_3</math>)</li> <li>• 2 grams of sodium nitrite (<math>\text{NaNO}_2</math>) (alternate: potassium nitrite, <math>\text{KNO}_2</math>)</li> <li>• 1/3 of a package of yeast</li> <li>• 6 mL of 6% <math>\text{H}_2\text{O}_2</math></li> <li>• 12 mL of 6 molar <math>\text{H}_2\text{SO}_4</math></li> <li>• pH reference solutions (pH 2 to 7)</li> <li>• universal indicator</li> <li>• supply of <i>Blepharisma</i> microorganisms</li> </ul>	<ul style="list-style-type: none"> <li>• 2 pint-size heavy duty “zipper” plastic bags</li> <li>• 1 quart-size heavy duty “zipper” plastic bag</li> <li>• 8 thin stem plastic transfer pipets</li> <li>• 24-well wellplate</li> <li>• 6 wood splints or toothpicks</li> <li>• cellophane tape</li> <li>• scissors</li> <li>• microscope (shared by whole lab class)</li> </ul>

#### SAFETY NOTES :

- Both of the liquids used in this experiment (6 molar sulfuric acid, and 6% hydrogen peroxide) are corrosive materials and should be handled very cautiously.
- Both  $\text{NO}_2$  and  $\text{SO}_2$  are toxic gases and should not be allowed to escape into the lab.
- This experiment should not be done by anyone who has a sensitivity to sulfites or has an asthmatic condition! Sulfites have been shown to cause severe asthma attacks in a few sensitive individuals.

## EXPERIMENTAL PROCEDURE

### I. Preliminary Work: Preparation of the Reaction Wellplate

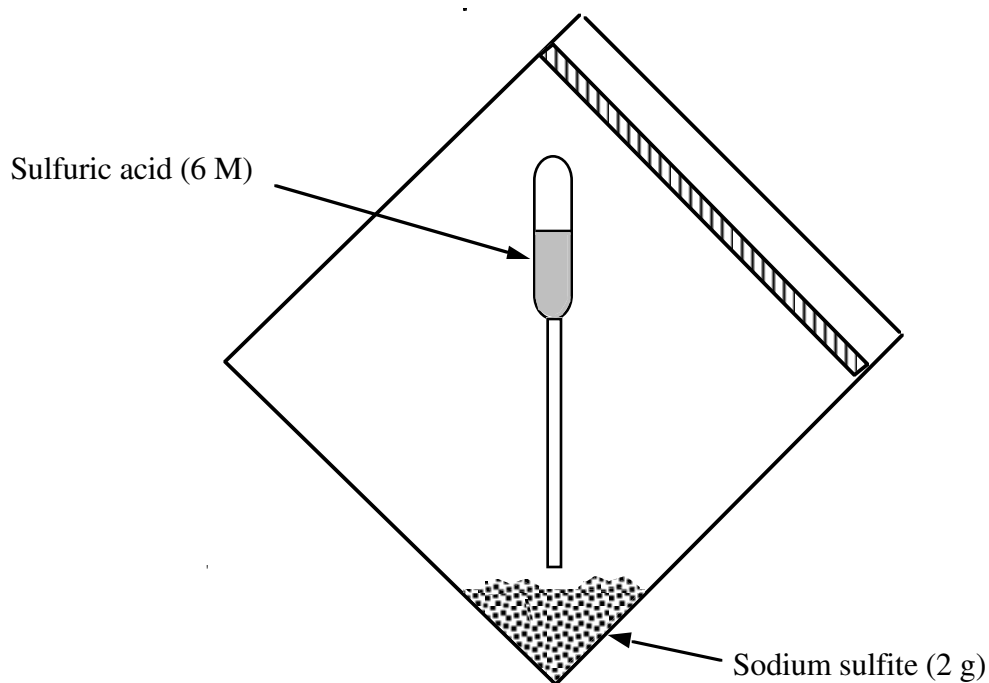


**Figure 1** The reaction wellplate setup

- Put 10 drops of pH 2 solution in well A1, 10 drops of pH 3 solution in A2, etc. up through pH 7 solution in well A6.
- Add 1 drop of universal indicator to each well containing a pH solution. Record the color of each solution in the data table. These solutions will serve as your comparison standards. To prevent accidental contamination of these comparison standards, seal them with a strip of cellophane tape.
- In row B of the wellplate place 10 drops of distilled or deionized water and 1 drop of universal indicator in wells B1, B2, and B3.
- In the fourth row of the wellplate add several drops of *Blepharisma* culture (or pond water) to wells D1 and D3. (Note: Since living cells will be in these wells, the wells should be clean and free from contamination.)

### II. Preparation of Sulfur Dioxide Gas

- Place about 2 grams (about 1/2 teaspoonful) of sodium sulfite ( $\text{Na}_2\text{SO}_3$ ) in the bottom corner of a 1 pint heavy duty “zipper” bag. (Figure 2, next page)
- Fill a plastic transfer pipet with 6 molar sulfuric acid. (**Caution: corrosive material.** Be careful not to spill any on yourself, your clothing, or the bench top.)
- Place the transfer pipet with the sulfuric acid in the plastic bag with the  $\text{Na}_2\text{SO}_3$ . Smooth out the bag so it contains a minimum amount of air, and then seal the bag. (Take care not to press against the pipet.)



**Figure 2.** The zipper bag setup for generating sulfur dioxide

4. Hold the sealed plastic bag as shown in *Figure 2* and slowly squeeze the transfer pipet so that the acid drops onto the sodium sulfite. **Keep the bag sealed.** What do you observe? Record your observations on the data sheet.
5. You should now have a sealed plastic bag partially filled with  $\text{SO}_2$ .

### III. Properties of Sulfur Dioxide

#### GENERAL INSTRUCTIONS FOR TESTING THE GASES.

1. Use a fresh plastic transfer pipet-full of gas to perform each test.
2. Since the gases is toxic and irritating, take the plastic bag to a fume hood to obtain the gas samples.
3. To get a pipet-full of the gas, squeeze the bulb of a dry transfer pipet to expel the air inside, then keep squeezing the bulb and slowly push the tip of the pipet against the zip seal at one corner of the plastic bag containing the sulfur dioxide gas. With a bit of practice you will be able to just push the pipet tip so that the seal opens around it. Push the pipet tip all the way into the bag and release the bulb so that the gas enters the pipet and withdraw the pipet. As the tip leaves the bag, reseal the bag along the "zip strip." *Take care not to contaminate the tip of the pipet by touching the solid or the liquid within the bag.*

**A. Distilled Water/Indicator Solutions**

1. Place the tip of an air-filled pipet into well B1, containing distilled water and universal indicator. Slowly bubble the gas through the solution by gently squeezing the pipet.
2. By comparing colors with the solutions in row A, determine the pH of the gaseous solution of air in B1. Record your results in the data table. This test using air will provide the reference point for comparison with the other gases.
3. Place the tip of the pipet containing sulfur dioxide into well B2 (which contains distilled water and universal indicator). Slowly bubble the gas through the solution by gently squeezing the pipet.
4. By comparing colors with the solutions in row A, determine the pH of the gaseous solution in B2. Record your results in the data table.

**B. *Blepharisma* Test**

1. Place the wellplate on the stage of a microscope and adjust the magnification and focus so that the *Blepharisma* in D1 are clearly visible. *Blepharisma* are pink, oval, one-cell organisms found in pond water.
2. Observe the nature and movement of the *Blepharisma*. Describe what you see on the data sheet.
3. Fill a plastic transfer pipet with sulfur dioxide gas and then gently squeeze a puff of gas at the water (do not bubble gas through the water) containing the *Blepharisma* while you observe. Record your observations on the data sheet.

**IV. Preparation of Nitrogen Dioxide Gas**

This gas will be generated in three steps. First you will generate, in separate containers, nitric oxide (NO) and oxygen (O<sub>2</sub>). Then these two gases will be mixed to form nitrogen dioxide, NO<sub>2</sub>. The complete reaction assembly is shown in *Figure 4*.

**SAFTEY NOTE:** Work with this gas *ONLY* in the fume hood. Do NOT open the bag containing the gases outside of the hood.

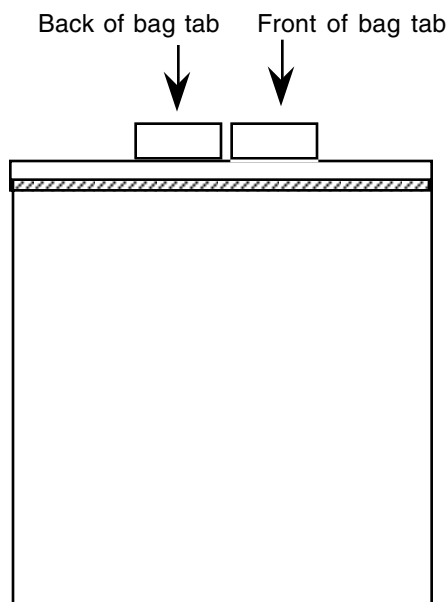
**A. Assembly of the Nitric Oxide Generating Bag**

1. Weigh about 1.5 grams (about 1/2 teaspoonful) of sodium nitrite (NaNO<sub>2</sub>) and place it in the bottom corner of the **larger** heavy duty “zipper” bag. (Alternate: Use potassium nitrite.)
2. Fill a plastic transfer pipet with 6 molar sulfuric acid.
3. Place the transfer pipet with 6 molar sulfuric acid in the plastic bag with the sodium nitrite, (NaNO<sub>2</sub>). This is the nitrogen oxide generating bag.

**B. Assembly of the Oxygen Generating Bag**

The bag that will serve as a container for oxygen must be opened *inside* another bag. This is not easy to accomplish. A suggested approach is to make pull tabs on the edges of the inner bag above

the zip strip, as shown in *Figure 3*. These should help make opening the oxygen bag easier. Use scissors to cut the smaller bag as shown. **Note:** It is *not* essential to create tabs as shown. Some people find that tabs do not help. But it is very important for you to *practice* opening the smaller bag inside the larger one, to be sure you can do it successfully, before proceeding with the following steps.

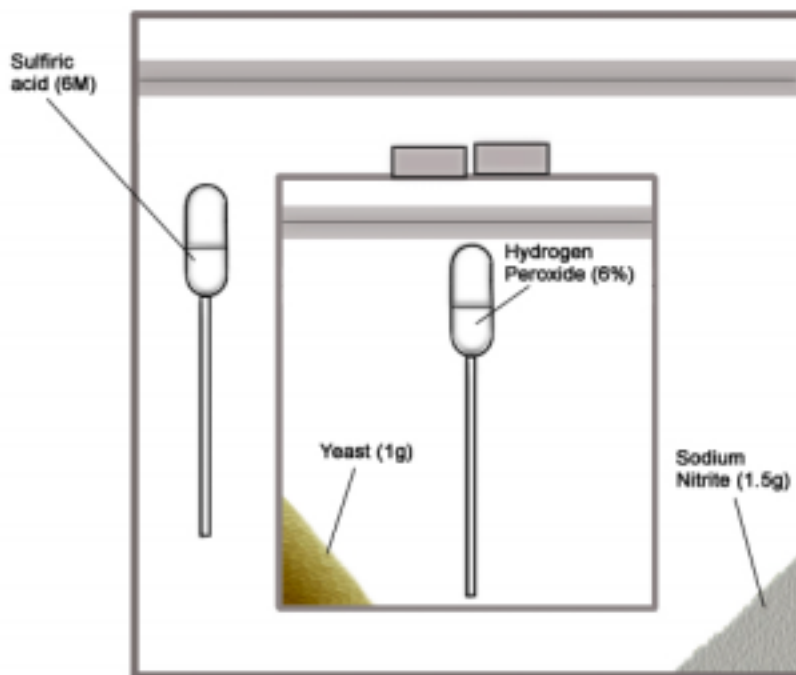


**Figure 3** The oxygen-generating bag.

1. Place about 1 gram (1/4 teaspoonful) of yeast in the bottom corner of the smaller heavy duty “zipper” bag. (The yeast can be replaced with 0.5 gram of potassium iodide if desired. See Experiment 1 in the printed Lab Manual.)
2. Fill a transfer pipet with 6% hydrogen peroxide ( $\text{H}_2\text{O}_2$ ).
3. Place the pipet with the hydrogen peroxide in the plastic bag with the yeast.
4. Smooth out the bag so it contains a minimum amount of air, and then seal the bag. (Take care not to press against the pipet.) This is the oxygen-generating bag.

### C. Reactions to Produce Nitrogen Dioxide

1. Place the smaller bag (oxygen-generating bag) inside the bag containing the transfer pipet with 6 molar sulfuric acid and sodium nitrite ( $\text{NaNO}_2$ ). (The nitrogen oxide-generating bag.)
2. Smooth out the bag so it contains a minimum amount of air; then seal the bag. (Take care not to press against the pipet.) Your assembled system should look like the diagram in *Figure 4*
3. Since nitrogen oxides are toxic and irritating gases, *take the plastic bag to a fume hood for steps 4-8.*
4. Without opening either bag, generate oxygen ( $\text{O}_2$ ) in the inner bag by slowly squeezing the pipet so that the hydrogen peroxide drops onto the yeast.



**Figure 4.** The complete assembly for generating nitrogen dioxide

5. Generate nitric oxide (NO) in the outer bag by slowly squeezing the transfer pipet so that the 6 molar sulfuric acid slowly drops onto the sodium nitrite. When the reaction is complete, you should have an outer “zipper” bag that is partly filled with NO (and possibly some NO<sub>2</sub>). Record your observations on the data sheet.
6. Now, *without opening the larger bag containing NO*, open the smaller bag containing oxygen and observe what happens. Record your observations.
7. The larger bag now contains mostly NO<sub>2</sub> to be used in the tests below.
8. The bag assembly should be kept in the fume hood since some of the nitrogen oxides slowly diffuse out through the plastic.

## V. Properties of Nitrogen Dioxide

Refer back to the general procedure used for sampling sulfur dioxide (beginning of Part III). The procedure for nitrogen oxides is identical.

### A. Distilled Water/Indicator Solutions

1. Place the tip of the NO<sub>2</sub>-filled pipet into well B3, containing distilled water and universal indicator. Slowly bubble the gas through the solution by gently squeezing the pipet.
2. By comparing colors with the solutions in row A, determine the pH of the gaseous solution in B3. Record your results in the data table.

**B. *Blepharisma* Test**

1. Place the wellplate on the stage of a microscope and adjust the magnification and focus so that the *Blepharisma* in D3 are clearly visible. *Blepharisma* are pink, oval, one-cell organisms found in pond water.
2. Observe the nature and movement of the *Blepharisma*. Describe what you see on the data sheet.
3. Fill a plastic transfer pipet with nitrogen oxide gas and then gently squeeze a puff of gas at the water (do not bubble gas through the water) containing the *Blepharisma* while you observe. Record your observations on the data sheet.

**VI. Clean Up**

1. Open the bags containing the nitrogen oxides and the sulfur dioxide in the back of the fume hood and allow all of the gases to be vented into the hood.
2. After the gases have been vented from the bags, fill the bags with water before removing them from the hood. Then carefully pour the water into the sink.
3. Rinse the bags with tap water and discard them in the trash.
4. The wellplates should be washed, rinsed with distilled or deionized water, and allowed to dry.
5. Your instructor will tell you what to do with the plastic pipets.

**Questions To Be Answered After Completing This Experiment**

Write out answers to the following questions on a separate sheet of paper and hand it in along with the data sheet.

1. Was the pH of water with air bubbled into it approximately what you expected? Explain.
2. Did addition of  $\text{SO}_2$  or  $\text{NO}_2$  cause a dramatic change in the pH of the water? Give a chemical explanation for what happened, either in words or with a chemical equation.
3. Considering your observations when sulfur dioxide was bubbled through the indicator solution, what are the implications for a lake that is downwind from a coal-fired power plant that emits fairly large quantities of sulfur dioxide?
4. Nitrogen oxide emissions occur primarily in cities. They are formed in the internal combustion engines of automobiles. Considering your observations with nitrogen dioxide, which urban pollution problems are likely to be made worse by nitrogen oxide emissions?



Name \_\_\_\_\_

Date \_\_\_\_\_

Partner \_\_\_\_\_

Lab Section \_\_\_\_\_

**Data Sheet – Pollutant Gases**

1. Observations regarding the generation of sulfur dioxide.

2. Observations regarding the generation of nitric oxide and nitrogen dioxide.

3. Colors of the universal indicator solutions.

pH	2	3	4	5	6	7
Color						

4. Properties of air, sulfur dioxide, and nitrogen dioxide.

	pH of water solution	Effect on Blepharisma culture
Air		
Sulfur dioxide SO <sub>2</sub>		
Nitrogen Dioxide NO <sub>2</sub>		

5. Conclusions. (Continue on reverse side if needed.)