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Teachers' Resource for Materials and Environmental Chemistry

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TEACHER'S RESOURCE FOR MATERIALS AND ENVIRONMENTAL CHEMISTRY

A Thesis
Presented to
The Faculty of the Department of Chemistry
Western Kentucky University
Bowling Green, Kentucky

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

By
Carnetta Charlotte Skipworth
April 2003
TEACHER’S RESOURCE FOR MATERIALS AND ENVIRONMENTAL CHEMISTRY

Date Recommended  April 15, 2003

Director of Thesis

Date Approved  4/29/03

Dean, Graduate Studies and Research  Date
Words cannot express the satisfaction that I feel for reaching this part of my life. I would first like to thank God for giving me the ability to achieve this goal and for the comfort during the more intense times. I would also like to thank my husband for supporting and helping me through this stressful time and my son, Tristan, for giving me a reason to finish and always making me smile. You both kept me going. Thanks to my mother for her lifelong praise. The encouragement has helped me throughout the completion of this goal. Thanks to my mother and mother-in-law for spending time away from their normal day to watch Tristan when I was working. Thanks to my father for being patient with me and for teaching me that hard work pays off. Thanks to my uncle Tony for always being interested in how close I was getting to completion. Thanks to Dr. Wei-Ping Pan for the professional advice given to me during my entire education at WKU. I would also like to thank Dr. Thandi Buthelezi and Dr. John T. Riley for their excellent advice. I would like to give my sincere gratitude to all of you mentioned above. You have made a difference in my life.
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In many secondary education chemistry classrooms, teachers have a difficult time introducing chemistry topics in a way that will be interesting to the high school student. The development of a materials and environmental chemistry teacher's manual will help teachers introduce a variety of selected topics in an interesting fashion to the students. This manual focuses on the subjects covered for freshman and sophomore level students. The manual uses five separate experiments to introduce topics such as the electromagnetic spectrum and solubility. The five experiments include a test on tennis shoe stiffness and energy dissipation ability, pesticides in water, grease in vent hoods, concentration of salicin in willow, and a paint adhering test on a vehicle bumper. The manual introduces several chemistry concepts by relating the subject to projects that the students can understand because they are useful to society and the environment. By presenting the material in this manner, students should be able to focus on the specific concepts longer, thus understanding the concepts better. Some of the lessons cover a topic that is required by the American Chemical Society (ACS) for postsecondary education materials chemistry classes. The inclusion of these topics will increase the
knowledge of future chemistry students in an area that will be required at multiple postsecondary education institutions. Each experiment topic includes background information, teacher information, lesson objectives, ACS topic and/or experimental subject covered, lesson, definitions, supplements, transparencies, and a worksheet.
I. INTRODUCTION

Materials and environmental chemistry are important for several reasons. Materials are incorporated in all of our lives. The knowledge of how these materials are formed, used, and disposed or recycled is the key to developing better materials. Environmental chemistry is important because, as in materials, the environment is part of all of our lives. Keeping our environment safe and healthy is the key to a better lifestyle. A materials and environmental chemistry teacher’s manual is used to show students that chemistry concepts are relevant to daily life. Some students find it difficult to grasp chemistry concepts when they are introduced to them in only a factual method. This teacher’s manual introduces several chemistry concepts by relating the subject to projects that the students can understand because they are useful to society and the environment. By presenting the material in this manner, students should be able to focus on the specific concepts longer, thus understanding the concepts better. The manual provides students a stronger basis for succeeding in the field of chemistry.

A. Purpose of Manual

The purpose of this teacher’s manual is to educate high school level students. It is written for freshman and sophomore level chemistry classes. The manual can be used in one of two ways. It can be used to reinforce a topic that has already been discussed in class or it can be used to introduce a new topic. The use of the manual is at the teacher’s discretion. Each lesson requires approximately twenty minutes of class time. Some lessons may require a few extra minutes, and some lessons may require a few less
minutes. The supplies needed are very minimal and are all household materials. The purpose of the manual is not to require more preparation time for the teacher. It is to enhance the time that the teacher has already spent in preparing the lesson.

B. Manual Background

Each lesson covers an area of environmental information or a requirement set by the American Chemical Society. The American Chemical Society specifies requirements that must be covered by college instructors who teach materials chemistry. A simplified list includes basic chemical and physical aspects of bonding, materials such as polymers and composite materials, specific properties and materials such as electrical conduction and magnetic materials, and structural materials and environmental aspects such as selection of structural materials, oxidation, and radiation damage. The entire list of requirements can be found on the American Chemical Society web page at www.acs.org.

The requirements covered in the manual include bonding, polymers, and composite materials. It is beneficial for high school students who may be future chemistry students to have a background in this type of information before entering college.

C. Manual Contents

Each lesson is divided into sections. The various sections include background information, lesson objectives, subject or standard covered, lesson, definitions, supplementary materials, worksheet, and transparencies. The manual is written in this format to provide teachers with the easiest access to the information. The first sections including background information, lesson objectives, subject or topic covered, lesson, and definitions are designed for the teacher's use. The supplementary materials and worksheets are materials for the students. The worksheets and transparencies are the last sections included with each experiment so that it will be easier for the teacher to tear
away these sections in order to make the appropriate number of copies and transparencies. The background information is written for the teacher’s knowledge of the individual experiment. The teacher may opt to read this information aloud to the class or he/she may find other ways of describing the experiment. The lesson objectives and subject or topic covered are also to be used by the teacher. The lesson objectives tell the teacher ahead of time about the information that the lesson covers. The lesson is written in a format so that the teacher can simply read each step and easily teach the subject with a minimal amount of preparatory work. The lesson is also written to ensure that the subject will be covered in an organized fashion. The definitions are included for easy assess to the teacher. The supplementary materials are to be copied for the student’s review. These materials are spaced appropriately in order for the teacher to copy. The worksheets are also given to the students. The worksheets can be graded or they can be completed as a class. The answers to the worksheets come directly from the lesson. Some lessons have transparencies. The transparencies can be used to aid the teacher in instruction.

The information that the students will learn covers various topics from several areas of chemistry. This variety will allow the teacher to use the manual at different times throughout the school term. This information will introduce the variety in classroom instruction that many students subconsciously require to succeed. The lessons include elasticity, comparing information on a graph, stress/strain, importance of clean water, structures and effects of a select number of pesticides, chemistry influence on the Environmental Protection Agency, initial understanding of organic chemistry, electromagnetic spectrum, oxidation/reduction reactions, solutes, solvents, solutions,
homogeneous/heterogeneous mixtures, major component of aspirin, importance of experiment repetition, scientific method, and polymers.

D. Goal of Manual

The goal of this manual is to provide a simple way for teachers to present factual chemistry information so that students can fully understand the concept. The goal is to help keep student’s attention focused on the subject. The experiments should provide an interesting solution to the above-mentioned goals. The manual has been tested at Greenwood High School in Bowling Green, Kentucky. After the manual was tested, a few small modifications were completed. One modification was developing a lesson that indicated a specific time during the class to introduce the details about the experiment. Another modification was to include a definition section in the manual. Three different types of classes were presented with the information in the manual. The three types of classes were a freshman general science class, sophomore general science class, and a sophomore chemistry class. The sophomore chemistry class asked more questions than did the other two classes. They were motivated to learn before the lesson began. The general science classes had to be motivated during the lesson; however, most of the students seemed to enjoy the material once it grabbed their attention. The students responded to the information after the lesson was presented. The responses were positive and suggested that the lesson helped to make the subject matter more interesting to learn; therefore, the goal of the manual was reached.
II. TEACHER’S MANUAL

A. Athletic Shoe Experiment

The technical definition of a shoe is a durable covering for the human foot, made of leather or similar material with a rigid sole and heel. A shoe (as shown in picture to the right) is a very important asset to everyone’s wardrobe. There are three important qualities that are desired in a pair of shoes. The qualities are comfort, longevity, and style. Comfort is determined by how soft the shoe feels to the consumer. Longevity is determined by the length of the shoe’s lifetime. Style is determined by the individual consumer. Comfort and longevity can be analyzed in a laboratory.

In a study performed by the Thermal Analysis Laboratory at Western Kentucky University, several different name brands of athletic shoes were studied. Thermal analysis is the general term given to a group of analytical methods (and types of instrumentation) that measure the properties of materials as they are heated or cooled. Seven different models of shoe sole components (interior and exterior) were examined using thermal analysis techniques. The qualities studied were stiffness, energy dissipation ability, and the ability to retain these properties over time. The equation used in the experiment was as follows:

\[
\text{Energy dissipation ability} = \frac{\text{loss modulus}}{\text{storage modulus}}
\]
The storage modulus measures the elasticity of a material. A material with a larger storage modulus is a harder material. Those with a lower storage modulus are softer materials. The loss modulus measures the inelasticity of a material. A material with a larger loss modulus is a softer material. Materials with a smaller loss modulus are harder materials. The equation shows the relationship that the energy dissipation ability has to the storage modulus and the loss modulus. The smaller the ratio of loss modulus to storage modulus, the lower the energy dissipation ability. A low value for the energy dissipation ability indicates that the sole is properly dissipating energy.

The results from the study can be determined by referring to transparencies 1-2. Transparency 1 shows the stiffness of the interior and exterior of the shoe sole at different time intervals. Transparency 2 shows the energy dissipation ability of the interior and exterior of the shoe sole at different time intervals.

On transparency 1 (stiffness), the lower values represent a softer material. An ideal shoe will have a soft internal sole for comfort and a soft external sole for longevity. A hard external sole does not have enough flexibility to withstand the abuse of wearing. Shoe G has the softest internal and external soles. The soles stay soft with an increase in time. Shoe B has the hardest internal sole. It even gets harder with an increase in time. Shoe C has the hardest external sole. This sole shows a dramatic increase in hardness with an increase in time.

On transparency 2 (energy dissipation ability), the lower values represent a better ability to dissipate energy. All of the shoe samples have similar values for the external soles; however shoe B and shoe C have slightly higher values. Shoe G has a low value for the internal sole at a short time interval, but it increases drastically with a long time
interval. The value for the internal sole of shoe D also increases drastically with an increase in time.

1. Teacher Information

The athletic shoe experiment covers several subjects that are important for students to understand. It also covers a topic that is listed as an American Chemical Society (ACS) topic for materials chemistry.

a. Lesson Objectives

Students will fully understand the concept of elasticity.

Students will learn how to compare information on a graph.

b. ACS Topic

The topic from the American Chemical Society covered in this lesson is composite materials.

2. Lesson

a. As an advance organizer, ask students to describe the one accessory that is put on daily that has the capacity to affect how a person feels at the end of the day. The answer will probably be shoes.

b. The teacher should provide visuals of different shoe types. Tell students that people wear several different types of shoes—sandals, dress shoes, boots, and athletic shoes. Which of the four previously mentioned is usually the most comfortable? The more common answer will be athletic shoes.

c. Ask the students if they can remember one pair of athletic shoes that was their favorite because of comfort. Why were some more comfortable than others? The actual reason for the shoes being more comfortable is elasticity.

d. Introduce the experiment by summarizing the background information.
e. Explain elasticity in general. An overview of elasticity is included as supplement 1. Supplement 1 should be copied for students to read. Using the material in the background information and showing students transparencies 1-2 explain the results. To make the results more interesting show transparency 3. The newspaper advertisement will show students the way that shoe companies “sell” their item. In the study performed by the Thermal Analysis Laboratory, the shoes were analyzed by cutting them similar to the sub-diagram on the advertisement.

f. Give students the worksheet listed as supplement 2.

3. Definitions

a. Energy dissipation – the irreversible loss of energy.

b. Elasticity – the degree to which a material returns to an initial form or state following deformation.

c. Storage modulus – the measurement of a material’s elasticity.
4. **Supplement 1 - Elasticity**

An important property of many structural materials is their ability to regain their original shape after a load is removed. This property of materials is called elasticity. Steel, glass and rubber have elastic properties; putty or modeling clay do not. The elasticity of the materials varies greatly depending on the material type. Steel and glass are both more elastic than rubber. The degree of elasticity or "stiffness" of a material is called its Modulus of Elasticity. Given the modulus of elasticity, possible deformations can be calculated for any material and loading.⁴

Robert Hooke experimented with springs, clocks and watches. During his investigation of the spring, he discovered that in elastic materials stress and strain are proportional. This discovery is known today as Hooke’s Law. Stress and strain are directly proportional: if the load is released the material will regain its initial dimensions, if the stress is doubled the strain is doubled, if the stress is tripled the strain is also tripled.

Steel cables over 1 m in diameter support a suspension bridge (as shown in the picture to the right).⁵ The load of the bridge causes a tensile force in the cable, setting up a tensile stress. This stress has the effect of stretching the cable, setting up a tensile strain.⁵
A tensile force is the stretching force pulling at both ends of a component along its length.\(^5\)

A tensile stress is an applied force per unit area of the cross-section of a body.\(^5\)

Tensile strain is defined as the increase in length per unit length of a body subjected to an applied stress.\(^5\)

The English physician and physicist Thomas Young noted that if stress is proportional to strain, then for any given material stress divided by strain would be a constant. This constant is known today as Young's Modulus or the Modulus of Elasticity. The Modulus of Elasticity = Stress / Strain. A higher value of the modulus indicates a more brittle material. Glass and ceramics have a high value. A very low value represents a ductile material. Rubber has a low value.\(^5\)
1. What is a material called when it can regain its original shape after a load is removed?

2. What is the law called that tells us that stress and strain is proportional in elastic materials?

3. In a dictionary look up the definitions for stress and strain.
   Stress-
   Strain-

4. Stress divided by strain is known as what constant?

5. What is the mathematical expression for Young’s Modulus?
Stiffness, MPa

- Exterior @ Short Time Period
- Exterior @ Long Time Period
- Interior @ Short Time Period
- Interior @ Long Time Period

Shoe A, Shoe B, Shoe C, Shoe D, Shoe E, Shoe F, Shoe G
$39

A superior walking shoe for men and women.

- Moving air for extra cushioning
- Advanced midsole for support
- Dynamic cushioning plus system
- Flex-grooved outsole for push off and traction
B. Pesticides in Water Experiment

Consider for a moment that a letter has been received from the local water utility. The letter explains that the water is unsafe to drink. Customers are advised to boil all drinking water before consumption. Should these letters be considered acceptable or should the water utility be expected to assure it’s customers that the water is always safe to drink? Water utilities hire chemists to test water supplies for contaminants.

In an experiment done by the Thermal Analysis Laboratory at Western Kentucky University, seven water samples were tested for twelve pesticides. The structures and harmful effects of each pesticide are listed in supplement 4. The water samples were retrieved from seven small and primarily rural water supply sources in Kentucky. Some of the samples were from springs, and others were from untreated water sources. Testing for pesticide presence is particularly important in Kentucky due to the agricultural runoff that takes place. This runoff is a major contributor to pesticides in drinking water. Pesticides are used in great volume in Kentucky. The twelve tested pesticides have somewhat similar structures. The pesticides are also possible carcinogens.

The United States Environmental Protection Agency (EPA) has guidelines for regulating a few of the twelve pesticides. The regulated pesticides are alachlor, atrazine, and simazine. Trifluralin has been listed for regulation, but no maximum contaminant levels have been set. Two of the seven water samples tested were found to contain one or more pesticide(s). Sample 1 contained trifluralin and metribuzin. Sample 2 contained trifluralin.
1. **Teacher Information**

The pesticides in water experiment covers information that students need to know in order to become productive citizens. The subject covered is environmental information. The answer to worksheet two #5 is 0.005 ppm, liver problems and increased risk of cancer, and discharge from factories and dry cleaners.

a. **Lesson Objectives**

Students will understand the importance of clean water.

Students will learn the structures and effects of a select number of pesticides.

Students will learn about the chemistry influence on the Environmental Protection Agency.

b. **Subject**

The subject covered in this lesson is environmental information.

2. **Lesson**

a. As an advance organizer, provide students with disposable cups and allow class to get a cup of water.

b. Discuss the importance of water. Ask students to name ways in which water is used.

c. Provide students with supplements 3 and 4. Allow students to read the supplements in class.

d. Have students write a letter to the water municipality in charge of the water from sample 1. This sample contained trifluralin and metribuzin. The letter should include a description of the dangers of each pesticide.

e. Show transparency 4. This transparency is an article from a small town newspaper. It is a quality water report from the local water department. Specific
concentrations of each contaminant is listed in ppm and ppb. Also the EPA’s MCL and MCLG’s are listed.

f. Give students worksheet listed as supplement 5.

3. Definitions

a. pesticide – any substance that is intended to prevent, destroy, repel, or mitigate any pest.

b. carcinogen – a substance that causes cancer.
4. **Supplement 3 – The Importance of Clean Drinking Water**

The United States Environmental Protection Agency (EPA) is a government agency formed to protect human health and safeguard the natural environment. The EPA regulates contaminants in drinking water. Keeping public water supplies safe has long been recognized as an important public health issue. In 1974, the U.S. Congress passed the Safe Drinking Water Act (SDWA) in response to public concern about findings of harmful substances in drinking water supplies. The aim of the SDWA is to provide public health protection to all Americans who get their water from public water supplies (over 200 million people). The SDWA requires the EPA to regulate contaminants. Realistic limits are set on contaminants depending on the concentration of contaminants likely to be present in drinking water sources and on the ability of water supply utilities to remove the offending contaminants by using available technology.

The EPA has established a goal for each contaminant. This goal is called the Maximum Contaminant Level Goal (MCLG). The MCLG is the level at which a person weighing 154 pounds could drink two liters of water containing the contaminant every day for 70 years without suffering any ill effects. The MCLG is not a legal limit for which water systems must comply; however, it is the limit that is based solely on considerations of human health. In fact, all carcinogens are given an MCLG of zero. This value suggests that any exposure to a carcinogen may cause cancer.

The Maximum Contaminant Level (MCL) is the legal limit within which water systems must comply. The EPA sets the MCL as close to the MCLG as possible. Carcinogens have an MCL and MCLG of zero. It is imperative to recognize that simple exposure to most contaminants will not cause harmful effects.
There are also contaminants that the EPA does not regulate. These contaminants are on the Unregulated Contaminants Monitoring List. This list means that each state must monitor these contaminant levels in drinking water and report the levels; however, there are no MCL's set.

In an experiment done by the Thermal Analysis Laboratory at Western Kentucky University, seven water samples were tested for twelve pesticides (refer to supplement 3 for the structures and harmful effects of each pesticide). The water samples were retrieved from seven small and primarily rural water supply sources in Kentucky. Some of the samples were from springs, and others were from untreated water sources. Testing for pesticide presence is particularly important in Kentucky due to the agricultural runoff that takes place. This runoff is a major contributor to pesticides in drinking water. The regulated pesticides are alachlor, atrazine, and simazine. Trifluralin has been listed for regulation but no MCL has been set. Two of the seven water samples tested were found to contain one or more pesticides. One of the water samples contained both trifluralin and metribuzin. Another sample contained only trifluralin. Neither trifluralin nor metribuzin is regulated by the EPA; therefore, there is no positive way of determining whether or not these water supplies are safe for drinking.
Structures and Harmful Effects

**Atrazine:**
- Eye and mucous membrane irritation; cardiovascular and reproductive complications; possible carcinogen

**Trifluralin:**
- Eye and skin irritation; abdominal cramps; nausea; diarrhea; headache; respiratory difficulty; possible carcinogen

**Acetochlor:**
- Probable carcinogen; probable mutagen

**Linuron:**
- Possible carcinogen

**Metribuzin:**
- Slightly toxic by oral route

**Pendimethalin:**
- Slight cancer risk
Alachlor:  **
skin and eye irritation; liver, kidney, spleen damage; damage to eyelids and lining of nose; carcinogen

Simazine:  **
weight loss; tremors; damage to testes, kidneys, liver, and thyroid; gene mutations; carcinogen

Propazine:
possible human carcinogen

Chloroneb:
low oral toxicity; moderately irritating to skin and mucous membranes

Metolachlor:
skin and eye irritation; cramps; nausea; anemia; convulsions; sweating; shock; possible carcinogen

Propachlor:
likely human carcinogen

** Pesticides regulated by the EPA.
6. **Supplement 5 – Worksheet 2**

1. Which one of the twelve pesticides does not contain nitrogen? Nitrogen’s elemental symbol is “N.”

2. Three of the twelve pesticides are regulated by the EPA. Name these three.

3. What is the difference between MCLG and MCL?

4. Do all regulated carcinogens have an MCLG and MCL of zero?

5. Go to EPA’s website (www.epa.gov/safewater/mcl.html) and find the MCL, harmful effects, and common location of tetrachloroethylene. (Teacher: refer to teacher information page for answer)

6. What did the U.S. Congress pass in response to public concern about findings of harmful substances in drinking water supplies?
The Scottsville Water Department consistently strive to produce water of high quality. We are pleased to report that we have not had any violations of a contaminant level. This brochure is a summary of the quality of water provided to our customers in 2001. It is a record reflecting the hard work by our employees to bring you water that is equal to or better than both state and federal regulations.

Included in this report are details of where your water comes from, what it contains, and how it compares to standards set by regulatory agencies.

The Scottsville Water Department is committed to providing you with information about your water, because customers who are well informed are our best allies in supporting improvements necessary to maintain the highest drinking water standards.

Plans for 2002

1. Working to maintain compliance with new EPA regulations.

Source of Your Drinking Water

Scottsville's source water comes from the Barren River Reservoir. It is considered a surface water source. As water travels over the land's surface or through the ground, it dissolves naturally occurring minerals and radioactive material, and can be polluted by animals or human activity. Contaminants that might be expected in untreated water include: biological contaminants, such as viruses and bacteria; inorganic contaminants, such as salts and metals; pesticides and herbicides; organic chemicals from industrial or petroleum use, and radioactive materials.

In order to ensure that tap water is safe to drink, the Environmental Protection Agency (EPA) prescribes regulations which limit the amount of certain contaminants in your drinking water. Food and Drug Administration (FDA) regulations establish limits for contaminants in bottled water which must provide the same protection for public health.

"Drinking water, including bottled water, may reasonably be expected to contain at least small amounts of some contaminants. The presence of contaminants does not necessarily indicate that water poses a health risk." More information about contaminants and potential health effects can be obtained by calling the U.S. Environmental Protection Agency's Safe Drinking Water Hotline at 800-426-4791.

The Safe Drinking Water Act Amendments of 1996 require every water system to prepare a source water assessment that addresses the system's susceptibility to potential sources of contamination. The final source water assessment is due for completion by May, 2003. A preliminary source water assessment may be available in the current county water supply plan that is available at the Allen County Local Area Development Office.

Special Info Available: "Some people may be more vulnerable to contaminants in drinking water than the general population. Immuno-compromised persons—such as persons with cancer undergoing chemotherapy, persons who have undergone organ transplants, people with HIV/AIDS or other immune systems disorders, some elderly persons and infants—can be particularly at risk from infections. These people should 'seek advice about drinking water from their healthcare providers. Environmental Protection Agency and Centers for Disease Control guidelines on appropriate means to lessen the risk of infection by Cryptosporidium and other microbial contaminants are available from the EPA's Safe Drinking Water Hotline (800-426-4791)."
## Treated Water Quality Summary

<table>
<thead>
<tr>
<th>Detected Substance</th>
<th>Highest Detected Level (Range of Detect)</th>
<th>Highest Level Allowed (EPA's MCL)</th>
<th>Ideal Goals</th>
<th>Sources of Contaminants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbidity</td>
<td>&lt;0.5 NTU (&lt;0.5 100%)</td>
<td>Treatment Technique: none</td>
<td>Natural river sediment</td>
<td></td>
</tr>
</tbody>
</table>

- Turbidity has no health effects, but it is used to monitor the effectiveness of the treatment process. However, turbidity can interfere with disinfection and provide an environment for microbial growth. The allowable level is < (less than) 0.3 NTU 95% or no more than 5 NTU. The test unit NTU actually is a measurement of the clarity of the water. A turbidity value of 5 NTU would be just slightly cloudy in appearance.

### Particulate Test Results

<table>
<thead>
<tr>
<th>Substance</th>
<th>(Sample Date)</th>
<th>Highest Detected Level</th>
<th>Range of Detect</th>
<th>Treatment Technique</th>
<th>Sources of Contaminants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barium</td>
<td>(01/01)</td>
<td>0.036 ppm (NA)</td>
<td></td>
<td>2 ppm</td>
<td>Erosion of natural deposits</td>
</tr>
<tr>
<td>Fluoride</td>
<td>(07/01)</td>
<td>1.45 ppm (0.85 - 1.45)</td>
<td>4 ppm</td>
<td>4 ppm</td>
<td>Natural geology/sediment</td>
</tr>
<tr>
<td>Mercury</td>
<td>(01/01)</td>
<td>0.6 ppm (NA)</td>
<td>2 ppb</td>
<td>2 ppb</td>
<td>Erosion of natural deposits</td>
</tr>
<tr>
<td>Nitrate</td>
<td>(01/01)</td>
<td>0.8 ppm (0.65 - 1.88)</td>
<td>10 ppm</td>
<td>10 ppm</td>
<td>Runoff from fertilizer use</td>
</tr>
<tr>
<td>Nitrite</td>
<td>(01/01)</td>
<td>0.01 ppm (NA)</td>
<td>1 ppm</td>
<td>1 ppm</td>
<td>Runoff from fertilizer use</td>
</tr>
</tbody>
</table>

### Regulated at the Treatment Plant

<table>
<thead>
<tr>
<th>Substance</th>
<th>(Sample Date)</th>
<th>Highest Detected Level</th>
<th>Range of Detect</th>
<th>Treatment Technique</th>
<th>Sources of Contaminants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>(07/00)</td>
<td>0.9 ppb (90th percentile)</td>
<td>15 ppb</td>
<td>0 ppb</td>
<td>Consumer plumbing and service connection</td>
</tr>
<tr>
<td>Copper</td>
<td>(07/00)</td>
<td>0.03 ppm (90th percentile)</td>
<td>1.3 ppm</td>
<td>1.3 ppm</td>
<td>Disinfection Interaction</td>
</tr>
</tbody>
</table>

### Regulated at the Customers' Tap

<table>
<thead>
<tr>
<th>Substance</th>
<th>(Sample Date)</th>
<th>Highest Detected Level</th>
<th>Range of Detect</th>
<th>Treatment Technique</th>
<th>Sources of Contaminants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>(07/00)</td>
<td>0.9 ppb (90th percentile)</td>
<td>15 ppb</td>
<td>0 ppb</td>
<td>Consumer plumbing and service connection</td>
</tr>
<tr>
<td>Copper</td>
<td>(07/00)</td>
<td>0.03 ppm (90th percentile)</td>
<td>1.3 ppm</td>
<td>1.3 ppm</td>
<td>Disinfection Interaction</td>
</tr>
</tbody>
</table>

### Regulated in the Distribution System

<table>
<thead>
<tr>
<th>Substance</th>
<th>Highest Detected Level</th>
<th>Treatment Technique</th>
<th>Sources of Contaminants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Trihalomethanes</td>
<td>51.3 ppb avg (39 - 91)</td>
<td>100 ppb avg (80 ppb)</td>
<td>Disinfection Interaction</td>
</tr>
</tbody>
</table>

### Unregulated Contaminants

<table>
<thead>
<tr>
<th>Substance</th>
<th>Highest Detected Level</th>
<th>Treatment Technique</th>
<th>Sources of Contaminants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haloacetic Acids</td>
<td>53.9 ppb avg (39 - 91)</td>
<td>60 ppb avg (in 2002)</td>
<td>Disinfection Interaction</td>
</tr>
</tbody>
</table>

**Definitions:**

- **Action Level:** The concentration of contaminant that triggers treatment or other requirement that a water system must follow.
- **NA:** No range available due to only one test result.
- **MCL:** The Maximum Contaminant Level (MCL) is the highest level of a contaminant that is allowed in drinking water. MCL's are set as close to the MCLG's as feasible using the best available treatment technology.
- **MCLG:** The Maximum Contaminant Level Goal (MCLG) is the level of a contaminant in drinking water below which there is no known or expected health risk. MCLG's allow for a margin of safety.

**NOT LISTED:** are the non-detected values of the other contaminants monitored for in 2001. The results of all monitoring performed are available at the water office.

1 Total Trihalomethanes: The current MCL is 100 ppb; however, in 2002 the MCL will be lowered to 80 ppb.
2 Haloacetic Acids: The MCL will be established at 60 ppb beginning in 2002.

This report is not being mailed to individual customers unless requested. A copy of this report can be obtained by calling the water office during regular business hours.

We at Scottsville Water work around the clock to provide top quality water to every tap. We ask all our customers to protect our water sources, which are the heart of our community and our children's future. For questions about quality of our drinking water, or of this report, contact Donnie Reels or Greg Cook at the Scottsville Water Plant. The telephone number is (270) 622-4440.

This CCR was prepared using information provided by the Scottsville Water Department. ©McCoy & McCoy Laboratories, Inc., 2002
C. Restaurant Vent Hood Experiment

Restaurants use ventilation hoods to trap vapors of fats and grease that are released during the cooking process. The hoods make the cooking area cleaner; however, there are still problems with the ventilation hoods. The fats and grease remain in the hood and can be very odorous. Also, the hoods are extremely hard to clean. The restaurant industry would like to find a ventilation hood that would reduce odor, reduce fats and grease, and reduce cleaning time.

The thermal analysis laboratory at Western Kentucky University has found that UV light is effective in accomplishing the previously mentioned goals. A UV light source is placed in a ventilation hood. The UV light causes the large components of grease to be broken into smaller components. These smaller components are converted to light gases (CO, CO₂, and H₂O) that can escape into the atmosphere; therefore, the UV light helps in reducing odor, reducing fats and grease, and reducing cleaning time.

Organic chemistry plays a significant role in this experiment. Organic chemistry is the branch of chemistry that deals with carbon compounds but does not imply that these compounds must originate from some form of life. Fats and grease are composed of large organic chains called alkyl chains.¹¹ The large alkyl chains consist of carbon and hydrogen. The large alkyl chains are broken down to smaller alkyl chains by an oxidation reaction. An oxidation reaction occurs when an element loses electrons in a chemical reaction.¹² The reaction occurs by UV light producing O₃ (ozone) which cleaves and oxidizes double bonds of one large alkyl chain into two smaller alkyl chains. In the following reaction, R and R' represent two different alkyl chains.

\[ R' + RH + O₃ \rightarrow R' = O + O = RH \]
The smaller alkyl chains are converted to CO, CO2, and H2O, which are gases that can escape into the environment.

1. **Teacher Information**

   The restaurant vent hood experiment covers information that makes it easy to introduce oxidation and reduction reactions. These reactions can be discussed in detail or a simple summary of the reactions can be introduced. It also covers a topic that is listed as an American Chemical Society (ACS) topic for materials chemistry.

   a. **Lesson Objectives**

      Students will obtain an initial understanding of organic chemistry.
      
      Students will have a basic understanding of the electromagnetic spectrum.
      
      Students will have an understanding of oxidation and reduction reactions.

   b. **ACS Topic**

      The topic from the American Chemical Society covered in this lesson is bonding.

2. **Lesson**

   a. As an advance organizer, show students two different pans. One of the pans should be covered with grease from cooking and the other pan should have a very small amount of grease on the surface. Ask students to decide which of the two pans would be easier to clean. Obviously, the students will choose the pan with just a small amount of grease. Use this introduction to explain the concept of restaurant vent hoods.

   b. Introduce oxidation reactions by telling students the difference between oxidation and reduction reactions. Oxidation reactions occur when the reactant loses electrons and a reduction reaction occurs when the reactant gains electrons. The detail of this discussion is to the teacher's discretion depending on the ability of the individual classes.
c. The background information can be copied as a supplement that explains how an oxidation reaction can help in decreasing the cleaning time of restaurant vent hoods.

d. UV light is used in the experiment. Since UV light is part of the electromagnetic spectrum, it is described in supplement 6. Supplement 6 should be copied for all students.

e. Use transparency 5 to further explain the electromagnetic spectrum.\textsuperscript{13}

f. Give students the worksheet listed as supplement 7.

3. Definitions

a. Organic Chemistry -- branch of chemistry that deals with carbon compounds but does not imply that these compounds must originate from some form of life.\textsuperscript{10}

b. Oxidation Reaction -- occurs when an element loses electrons.\textsuperscript{10}

c. Electron -- a subatomic particle that contains a negative charge.

d. Wavelength -- the distance between two identical crests on a wave.
The electromagnetic spectrum is the entire range of radiant energy. The light that we can see directly is called visible light. The visible light is only a narrow band compared to the entire electromagnetic spectrum. Each type of radiant energy differs in wavelength. The energy increases as the wavelengths get shorter. On the diagram below, the line represents one wavelength.\textsuperscript{14} The wavelength is the distance between two identical crests on a wave.

![Diagram showing electromagnetic spectrum]

On one end of the spectrum are radio waves with wavelengths billions of times longer than those of visible light. On the other end of the spectrum are gamma rays. These have wavelengths millions of times smaller than those of visible light. The following are the basic categories of the electromagnetic spectrum, from longest to shortest wavelength:\textsuperscript{14}

![Diagram showing electromagnetic spectrum categories]

Radio waves are used to transmit radio and television signals. Radio waves have wavelengths that range from less than a centimeter to tens or even hundreds of meters. FM radio waves are shorter than AM radio waves.

Microwave wavelengths range from approximately one millimeter (the thickness of a pencil lead) to thirty centimeters (about twelve inches). In a microwave oven, the
radio waves generated are tuned to frequencies that can be absorbed by the food. The food absorbs the energy and gets warmer.

Infrared is the region of the electromagnetic spectrum that extends from the visible region to about one millimeter in wavelength. Infrared waves include thermal radiation. For example, burning charcoal may not give off light, but it does emit infrared radiation that is felt as heat. Infrared radiation can be measured using electronic detectors and has applications in medicine, finding heat leaks from houses, and many other uses.

The rainbow of colors we know as visible light is the portion of the electromagnetic spectrum with wavelengths between 400 and 700 billionths of a meter. It is the part of the electromagnetic spectrum that we see.

Ultraviolet radiation has a range of wavelengths from 400 billionths of a meter to about 10 billionths of a meter. Sunlight contains ultraviolet waves that can burn your skin. Most of these are blocked by ozone in the Earth's upper atmosphere. A small dose of ultraviolet radiation is beneficial to humans, but larger doses cause skin cancer and cataracts.

X-rays are high-energy waves that have great penetrating power and are used extensively in medical applications. The wavelength range is from about ten billionths of a meter to about 10 trillionths of a meter.

Gamma rays have wavelengths of less than about ten trillionths of a meter. They are more penetrating than X-rays. Gamma rays are generated by radioactive atoms and in nuclear explosions, and are used in many medical applications.14
5. Supplement 7 – Worksheet 3

_______________________________________________ Name

1. Arrange these types of radiation in order of increasing wavelength.
   a. microwaves  b. ultraviolet  c. visible  d. infrared

2. What type of radiation was used in the restaurant vent hood experiment?

3. What type of reaction causes the breakdown of fats and greases in the restaurant vent hood experiment?

4. What type of radiant energy can humans see?

5. What is the distance between two identical crests on a wave called?

6. What type of radiant energy causes sunburn?

7. What is the charge of an electron?

8. What type of radiant energy is generated by radioactive atoms?

9. Which has the longer wavelength? FM or AM

10. What is the type of reaction called when a reactant loses an electron?
6. Transparency 5 – Spectrum
D. Willow Tree Experiment

The willow tree (pictured to the left) is a popular plant used in basketry and wickerwork. The bushes and their twigs used in basketry are often called osiers. Many varying shapes and types of baskets can be made from the willow tree. The willow tree is not only used in basketry and wickerwork but it is also used by rabbit owners to ensure the oral health of their pets. Rabbits have a need for chewing materials. If they are not given enough of these materials, the rabbit's teeth can begin to grow backwards into the jaw. This incorrect growth will cause pain and the rabbits will not eat. Willow is a substance for rabbits to chew on to help keep their teeth healthy.

Willow buds and bark have also been used medicinally. The active ingredient in willow bark is salicin. Aspirin, usually made synthetically now, was originally derived from salicin. Willow bark had been used for centuries in folk medicine in certain parts of the world. Acetylsalicylic acid was first prepared by the German chemist Felix Hoffman, an employee of Friedrich Bayer Co., in 1897. It is now the active ingredient in more than 50 over-the-counter preparations. Estimates put American consumption at 80 billion tablets annually.

Willow typically contains 0.1-2% salicin; therefore, it can be used to relieve pain. Over consumption of salicin is possible and is harmful to a rabbit's health. Over consumption may cause several side effects. The side effects may be as simple as a
headache or vomiting to as serious as central nervous system disturbances. The Thermal Analysis Laboratory at Western Kentucky University analyzed the concentration of salicin in a willow plant sample.

1. Teacher Information

The willow tree experiment covers a very important, yet common, compound. The experiment allows for the introduction of mixtures and solutions. The subject covered in the lesson includes environmental information.

a. Lesson Objectives

Students will learn the difference between solute, solvent, and solution.

Students will learn the difference between a homogeneous mixture and a heterogeneous mixture.

Students will learn about the major component of aspirin and how this component can sometimes negatively affect living things when overly consumed.

b. Subject

The subject covered in this lesson is environmental information.

2. Lesson

a. As an advance organizer, show students a bottle of aspirin. Ask the students about where they think the active ingredient in aspirin was derived. Show a picture of a willow tree and ask if they would have ever guessed a willow tree.

b. Introduce experiment to students. The active ingredient in aspirin is derived from salicin. Salicin is found in willow trees. Also explain the relationship between salicin and rabbits.

c. Provide students with copies of supplement 8. This supplement should help explain solute, solvent, homogeneous mixtures, and heterogeneous mixtures.
d. As a simple lab, give students a few supplies to mix together in order to determine whether the mixtures are heterogeneous or homogeneous. A few examples are food coloring and water, a piece of wood, oil and water, corn syrup and water, salt and water, flour and water, and beverage powder and water.

e. Ask the students to brainstorm more examples for homogeneous and heterogeneous mixtures. Have students write their ideas on slips of paper. Collect the slips of paper and review the examples with the class.

f. Give students the worksheet listed as supplement 9.

3. Definitions

a. osiers – willow bushes and their twigs used in basketry.

b. salicin – active ingredient in willow bark; aspirin is derived from this compound.

c. solvent – the substance present in the greater amount in a solution.

d. solute – the substance present in the lesser amount in a solution.

e. heterogeneous mixture – substance in which the composition is not identical throughout.

f. homogeneous mixture (solution) – substance in which the composition is identical throughout.
4. Supplement 8 – Solution: What is it Made of?

In the willow experiment, the concentration of salicin was determined from a given sample of willow. The willow sample was cut into small pieces. Methanol (used to help extract the salicin from the willow) was added to the cuttings. After approximately 1 hour, the willow was filtered from the solution. The solution was concentrated to an exact volume and analyzed. The solution contained 0.033% salicin by weight. The final solution contained several substances. Using the solution as an example, pretend that the solution contained only methanol and salicin. Methanol was present in the greater amount and salicin was present in the lesser amount. The solution contains a solvent and a solute. The substance present in the greater amount is the solvent (methanol). The substance present in the lesser amount is the solute (salicin).\textsuperscript{20}

Strawberry beverage powder can be used for another example. The powder is dissolved in water. The water is present in the greater amount. The powder is present in the lesser amount. Therefore, water is the solvent and the powder is the solute.

Another term important when dealing with solutions is mixture. There are two types of mixtures: homogeneous and heterogeneous. A homogeneous mixture is a solution, meaning that the composition is identical throughout. Conversely, in a heterogeneous mixture the composition is not identical throughout. Consider two substances: lemonade made from a powder and freshly squeezed lemonade. The lemonade made from the powder is a homogeneous mixture (solution) because the composition of the substance is identical throughout. The freshly squeezed lemonade is a heterogeneous mixture because the substance contains lemon pulp; therefore, the composition is not identical throughout.
1. In the willow experiment, a solution that contained salicin and methanol was used. Was methanol a solute or a solvent?

2. In the following list, identify which substance is the solute.
   - Carbonated drink with cherry flavoring added
   - Small amount of salt added to a glass of water
   - Chocolate syrup added to a glass of milk
   - Powdered milk added to glass of water

3. In the following list, determine if the substances are heterogeneous or homogeneous.
   - Granite rock
   - Freshly squeezed orange juice
   - Tea made from an instant powder mix
   - Bee's wax and candle wax ground together
   - Bee's wax and candle wax melted together, stirred, and allowed to solidify

4. What is the name of the active ingredient in aspirin?

5. What is another name for a homogeneous mixture?
E. Vehicle Bumper Experiment

Automobile manufacturers have the responsibility of manufacturing high quality automobiles with well-built motors and appealing bodies. These two qualities determine the fate of a vehicle's consumer demand. Consumers desire a motor that is reliable and a body that is appealing to the eye. The automobile manufacturers will sometimes acknowledge a problem with a particular automobile. These problems must be corrected before the automobile can be sold to consumers; therefore, the manufacturers may need assistance in determining how to fix the problem.

One example of a problem that has occurred is that the paint may not adhere properly to the center of the automobile bumper. This problem was sent to the Thermal Analysis Laboratory at Western Kentucky University for their chemists to study the problem and possibly find a solution. The laboratory conducted several experiments. A piece of the bumper (center part) where paint would not adhere was analyzed, as well as a piece of the bumper (top part) where paint would adhere. The bumper pieces were analyzed on two different instruments to confirm correct results.

The results of the experiment concluded that two of the bumper's materials were polypropylene and polyethylene. The pieces of the bumper were analyzed to determine whether the concentrations of polypropylene and polyethylene were different at the separate bumper sites. The experiment concluded that the part of the bumper to which paint would not adhere contained more polyethylene, and the part of the bumper to which paint would adhere contained more polypropylene. Both instruments that were used gave the same results. Therefore, the differences in the concentrations of polypropylene and polyethylene caused the difference in the paint adhering ability of the bumper pieces.
1. Teacher Information

The vehicle bumper experiment covers a very large topic—polymers. This experiment allows the introduction of a diverse range of topics such as the scientific method and recycling. The experiment covers environmental information, and it also covers a topic that is listed as an ACS topic for materials chemistry.

a. Lesson Objectives

Students will understand the importance of repeating experiments.

Students will understand the scientific method.

Students will understand synthetic and natural polymers.

b. ACS Topic and Experiment Subject

The topic from the American Chemical Society covered in this lesson is polymers. The lesson also covers environmental information.

2. Lesson

a. As an advance organizer, read this excerpt taken from *Chemistry in Context* published by the American Chemical Society.10 “I’m on my way to go hiking and camping this weekend. I am so excited about getting away from studying and doing my daily chores at home. I can just relax. The weather forecast is calling for the weekend to be cold and rainy; however, it doesn’t matter to me. I am well equipped for the trip. I’ve got new polyester and Lycra pants and a warm acrylic sweater. And of course if it really gets very cold I can put on my microfiber polypro thermal tights. My jacket will be perfect. It’s Gore-Tex so that the rain will not get through. The Thinsulate lining makes it warm, but it weighs almost nothing; therefore, I can still hike comfortably. My hiking boots are terrific. They are lightweight, waterproof, and they fit like a glove. I’m borrowing a tent made of nylon with plastic poles. It all folds up so I can stick the whole
thing into my backpack. Well, I'm out here with just Mother Nature and me. It's great
to get away from all that synthetic, artificial junk for a change. Catch you later."

Obviously, this camper was not getting away from things that were synthetic and
artificial. All of the equipment mentioned was synthetic polymers.

b. Give a small lecture on polymers. Poly means many. Mer means part. Give
examples of synthetic and natural polymers. A few examples of natural polymers are
wood, cotton, cellulose, hair, nails, natural rubber, and wood. Introduce experiment to
give examples of synthetic polymers. The two polymers mentioned in the background
information (polyethylene and polypropylene) are synthetic polymers.

c. Have a student stand in front of class and as a whole class, determine
everything on the student that is a polymer. Examples will be hair, skin, nails, plastic
pieces on eye glasses, plastic earring backs, cotton, nylon, polyester, shoes, etc.

d. There are six polymers that make up the bulk of the plastics that are
manufactured today. The six are polypropylene, polyethylene (HDPE and LDPE),
polystyrene, polyvinyl chloride, and polyethylene terephthalate. Show students an
example of a recyclable symbol from a plastic bottle. Each of these six have a specific
number associated with it. Refer to supplement 11 for more information. This
supplement can be copied for students. Transparency 6 is the chasing arrows symbol
found on recyclable products.

e. The background information can be copied for students to read themselves or it
can be read to the students.

f. This experiment is a good experiment to use when trying to explain or
reinforce the scientific method. Give students a copy of supplement 10.

g. Give students worksheet 5 listed as supplement 12.
3. **Definitions**

a. bias – a strong preference.

b. polymer – a compound with a large molecular mass.
4. Supplement 10 – The Scientific Method

In the bumper experiment, two instruments were used to confirm one result. Both instruments confirmed that there was a difference in the concentrations of polyethylene and polypropylene in the separate pieces of bumper. Since two instruments gave the same result, it is highly unlikely that the experiment could be incorrect. This repetition gives scientists confidence in the accuracy of the experiment. Chemists learn about the world by making observations and measurements. These observations and measurements are usually in the form of experiments. There is no rigid formula that chemists follow while making these observations and measurements; however, the general pattern that most chemists follow is called the scientific method. The scientific method includes the following.\footnote{22}

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. State the Problem:</td>
<td>Be specific about the questions that need to be answered.</td>
</tr>
<tr>
<td>2. Design Experiments:</td>
<td>Set up experiments so that correct data can be collected.</td>
</tr>
<tr>
<td>3. Gather Data:</td>
<td>Perform experiment and collect data.</td>
</tr>
<tr>
<td>4. Interpret the Data:</td>
<td>Understand the experimental results.</td>
</tr>
<tr>
<td>5. Plan Future Work:</td>
<td>Repeat experiment to assure accuracy.</td>
</tr>
<tr>
<td>6. Publish Results:</td>
<td>Publish results so that other scientists can view your results and test the results to assure accuracy.</td>
</tr>
</tbody>
</table>

The last step involves other scientists being able to test the results. This step is crucial for accuracy because it helps to prevent bias. Bias is a strong preference. A scientist can be biased toward a particular result, and he or she may change data to obtain that result. More than one scientist performing the experiment may help to prevent bias.
5. Supplement 11 – Recycling Plastics

The picture to the left is an example of a recyclable symbol. It is called the chasing arrows symbol. Each arrow represents a step in the recycling process. Step one in the recycling process is separating out recyclable materials from waste and setting them aside for collection. Step two involves businesses using the material as stock for making a new product. Step three represents consumers purchasing products made with the recyclable material.

"By using plastic in packaging, product manufacturers save enough energy each year to power a city of 1 million homes for 3 1/2 years."

American Plastics Council

The “Big Six” Plastics

There are six plastics that make up the bulk of the plastics that we regularly encounter. The following table identifies the “Big Six” plastics.

<table>
<thead>
<tr>
<th>Recycle Symbol #</th>
<th>Name</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Polyethylene terephthalate</td>
<td>Clothing, soft drink bottles, audio- and videotapes</td>
</tr>
<tr>
<td>2</td>
<td>Polyethylene (HDPE)</td>
<td>Milk and water jugs, gasoline tanks, cups</td>
</tr>
<tr>
<td>3</td>
<td>Polyvinyl chloride</td>
<td>Shampoo bottles, garden hoses, “bubble” package wrap, plumbing pipe</td>
</tr>
<tr>
<td>4</td>
<td>Polyethylene (LDPE)</td>
<td>Plastic bags, toys, electrical insulation</td>
</tr>
<tr>
<td>5</td>
<td>Polypropylene</td>
<td>Battery cases, carpet, bottle caps, auto trim</td>
</tr>
<tr>
<td>6</td>
<td>Polystyrene</td>
<td>Styrofoam insulation, drinking glasses, packing “peanuts”</td>
</tr>
</tbody>
</table>
6. Transparency 6 – Chasing Arrows Symbol
6. **Supplement 12 – Worksheet 5**

____________________________ Name

1. Name two synthetic polymers.

2. Name two natural polymers.

3. What are the three steps that represent the three chasing arrows in the recyclable symbol?

4. Which of the six steps to the scientific method helps to eliminate bias?

5. In the bumper experiment, what was the cause of the paint adhering to one part of the bumper and not adhering to another part of the bumper?

6. Why did the chemists in the bumper experiment use two different instruments?

7. How many different plastics make up the bulk of the plastics that we encounter?

8. There are two different types of polyethylene plastics listed in the plastics table. The types are HDPE and LDPE. Using the internet or the library, determine the difference between the two types of polyethylene plastics.
III. CONCLUSIONS

This teacher's manual has been previously used in a classroom setting; thereby proper revisions and changes could be made to better accommodate students and teachers. These revisions and changes were made to help the organization of the manual and to also increase the effectiveness of the manual content. Three types of classes were introduced to the content of the manual. The three types were as follows: freshman general science, sophomore general science, and sophomore chemistry.

A. **Subject Detail**

It was found that the introductory science classes needed only a short summary of each of the experiments. Details about the individual experiments seemed to be too complex for the students in these classes. The actual chemistry class wanted more details about the experiments. They were interested in details so that they would better understand the reasoning behind each experiment.

B. **Manual Organization**

The manual's contents are well organized. Reading the lesson and instructing the class simultaneously can be done with ease. The lesson is not too lengthy nor too impossible to read while teaching. This appropriate length allows the teacher to read each step as the lesson proceeds. Providing an accurate amount of information makes introducing the material easy for the teacher. Each step also provides a means of introducing the next step of the lesson. This feature also makes instructing easier.
C. Supplementary Material

The supplementary material in the manual is placed in a format that is easy to copy for the students. The supplementary materials provide an initial understanding of the experiments and subjects covered during the lesson. Students need the supplementary materials to actually see the ideas that the teacher is discussing. Worksheets are also a part of the supplementary materials. These worksheets reinforce the information presented in the lesson.
IV. BIBLIOGRAPHY


7. EPA, U.S. Environmental Protection Agency; *Drinking Water Standards*. Available online: http://www.epa.gov/safewater/mcl.html


14 NASA; Observatorium. Available online: http://observe.arc.nasa.gov/nasa/education/reference/emspec/emspectrum.html


18 Ginkgo Biloba is the Tree of Life. The Times, Mar 7, 2002, p 8.


