Future Fuels from Forest Teaching Unit

By Abbie Reed
Valley Lutheran High School, Saginaw, MI

Unit Overview: This unit would be used in an Advanced Chemistry course while the students are learning about combustion, and distillation of an alcohol. While studying these topics it would be a good time to share with the students the environmental effects of combustion, showing also the difference between renewable and nonrenewable resources. By making these biofuels, the students will then be able to form their own opinions about sustainability and the amount of carbon given off into the environment. The goal for this unit is to increase not only awareness of the problems with our energy consumption today, but also to get the students to develop their own theories about how these problems can be addressed.

Sources Consulted:

http://www.ag.ndsu.edu/pubs/ageng/machine/ae1240w.htm This website provided me with the figure of transesterification along with the information used in the lesson to make the biodiesel.

Soy Biodiesel Chemistry Education Kit Lesson Manual Indiana Soybean Board Bernie Y. Tao PhD. This manual provided all of the lab sheets, information and experiment itself for the production of biofuel.

Fran Schantz, chemistry teacher at St Charles High School, MI, provided the idea for the renewable and nonrenewable energy activity.

Dr. Barry Solomon and Nick Johnson, Dept. of Social Sciences, Michigan Tech University, for their presentation on sustainability.

www.**carbonfootprint.com** The students will go to this website to determine their carbon footprint.

http://rubistar.4teachers.org/index.php?ts=1220733334 This website provided the rubric for the final assessment tool.

http://www.michigan.gov/documents/CHEM_HSCE_168205_7.pdf This website provided the High School Content Expectations for the state of Michigan.

Learning Objectives:

Upon completion of this unit the students will be able to:

1. Define sustainability as used in energy resources.
2. Determine renewable and nonrenewable resources.
3. Discuss the benefits for using renewable resources.
4. Discuss some of the drawbacks to biofuel production at this time.
5. Define carbon emissions and determine their carbon footprint.

State Benchmarks Addressed

C1.1A Generate new questions that can be investigated in the laboratory or field.
C1.1C Conduct scientific investigations using appropriate tools and techniques (e.g., selecting an instrument that measures the desired quantity—length, volume, weight, time interval, temperature—with the appropriate level of precision).
C1.1E Describe a reason for a given conclusion using evidence from an investigation.
C1.1f Predict what would happen if the variables, methods, or timing of an investigation were changed.
C1.1g Based on empirical evidence, explain and critique the reasoning used to draw a scientific conclusion or explanation
C1.1h Design and conduct a systematic scientific investigation that tests a hypothesis. Draw conclusions from data presented in charts or tables.
C1.1i Distinguish between scientific explanations that are regarded as current scientific consensus and the emerging questions that active researchers investigate.
C1.2B Identify and critique arguments about personal or societal issues based on scientific evidence.
C1.2C Develop an understanding of a scientific concept by accessing information from multiple sources. Evaluate the scientific accuracy and significance of the information.
C1.2f Critique solutions to problems, given criteria and scientific constraints.
C1.2g Identify scientific tradeoffs in design decisions and choose among alternative solutions.
C1.2k Analyze how science and society interact from a historical, political, economic, or social perspective.
P3.p1A Explain that the amount of energy necessary to heat a substance will be the same as the amount of energy released when the substance is cooled to the original temperature.

C5.2d Calculate the mass of a particular compound formed from the masses of starting materials.
C5.2e Identify the limiting reagent when given the masses of more than one reactant.
C5.2g Calculate the number of atoms present in a given mass of element.
C5.8C Recognize that proteins, starches, and other large biological molecules are polymers.

Five Days of Classroom or Field Activities:

Day One

Renewable vs. Nonrenewable Energy Activity

This activity allows students to gain a better understanding of renewable energy sources compared with nonrenewable energy sources and the effects of usage on long-term. This will start the students thinking about sustainability and the energy reserves we now have.

Materials – Presorted bags of M&M's (92 one color, 8 another)

Procedure – M&M's will be used to represent renewable and nonrenewable energy in a simulation to show the depletion of nonrenewable energy over several years.

1. Divide into pairs and get a bag of exactly 100 M&M's. Verify that 92 are one color and 8 are another.
2. Blindfold one person to represent a population that is using energy without thinking about whether or not it can be replaced.
3. Predict how many trials (years) it will take to deplete the nonrenewable energy in the container. Record prediction on data sheet. (Students may make their own data sheet)
4. The blindfolded person will then start to "use energy." This is done by taking 15 units of energy from the container. After each trial, replace the renewable energy (put it back in the container.) Record number of nonrenewable energy units for each trial. Calculate the percentages of renewable and nonrenewable units that remain after each draw.
5. Continue procedure until all nonrenewable energy has been used up.
6. Answer the follow-up questions when finished.

Follow-up Questions

1. Name five types of renewable energy and five types of nonrenewable energy.
2. Because the renewable resources come from plants, why do we not use only renewable energy sources?
3. How did this activity explain the importance of using renewable energy along with nonrenewable?

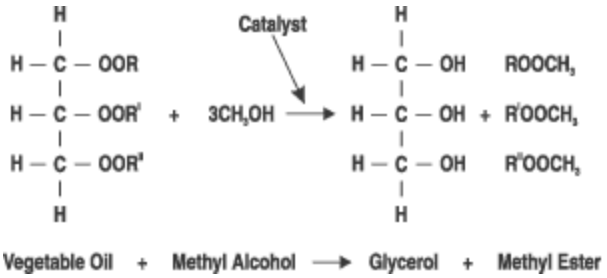
Day 2

Discussion/ Lecture on renewable and nonrenewable resources, sustainability, biofuels, and the transesterification of biodiesel.

Some of the key questions should include:

1. How do renewable and nonrenewable resources differ? Where does each come from? Which creates more useable energy?
2. Create a working definition of sustainability for the class to use.
3. What are biofuels? Brainstorm types of biofuels that the students have heard of before.
4. Explain the transesterification of biodiesel. (assuming that the students have already been introduced to esterification during the previous unit.)

   (Transesterification is the reaction that combines triglycerides (oils) with methanol to produce glycerol and Fatty Acid Methyl Esters which is also sometimes called FAME. FAME is what industry has now called biodiesel.



Day 3 and 4

Production of soy biodiesel.

Equipment

goggles
magnetic stir plate with bar
250 reaction bottle with cap
weighing dish
electronic balance
125 Erlenmeyer flask
100 ml graduated cylinder
25 ml graduated cylinder

Materials

Soybean oil
Methanol
Potassium hydroxide

Safety

1. Wear safety goggles.
2. Potassium hydroxide is corrosive and can cause severe injury. If you spill potassium hydroxide on yourself, flush the affected area with water for 5-10 minutes and notify the teacher.
3. Methanol is highly flammable and poisonous if ingested. Methanol can irritate the skin, and can cause dizziness and nausea when exposed to the fumes. Handle pouring methanol in the fume hood. If methanol should get in your eyes, begin flushing with water immediately and continue for 10 minutes. If you should spill methanol on yourself or in the laboratory, immediately notify the teacher.

Procedure

1. Record data on data sheet included.
2. Measure the mass of the reaction bottle without the cap and record the value to 0.01 grams (or the precision of the electronic balance.)
3. Measure out 150 ml of soybean oil using the graduated cylinder.
4. Pour the soybean oil into the reaction bottle and record the mass of the bottle and oil. Note the color of the soybean oil and how it behaved when poured.
5. Measure and record the mass of the 125 ml Erlenmeyer flask.
6. In the fume hood, measure 35 ml of methanol. Pour into the 125 ml and record mass.
7. Measure 75 g of KOH in the weighing dish.
8. Place magnetic stirrer bar in the Erlenmeyer flask containing the methanol and place it on the stir plate. Turn on the stirrer to a medium setting being careful not to splash.
9. Slowly pour the KOH into the methanol and continue stirring until ALL of the KOH has dissolved. Stop agitation and remove from stir plate.
10. Slowly pour mixture and stir bar into the soybean oil being careful not to splash. Note the two phases of liquid.

11. Place reaction bottle on the stir plate. Begin agitation at a medium setting. Describe any changes observed in color and phase behavior during the first 10 minutes of agitating and record. Continue mixing for 3 hours. (Instructor will remove) Record total time of reaction.
12. Let set until the next class period.
13. Examine and record the contents of the reaction vessel.
14. Measure the mass of the 100 ml beaker and record. Place cap on reaction bottle being careful not to squeeze the bottle.
15. Place the tip of the spout of the bottle in the 100 ml beaker. While tilting the bottle to keep the dark glycerol layer at the bottom, squeeze the bottle to decant glycerin layer. Release pressure on the bottle very slowly to avoid mixing the layers.
16. When all glycerin is gone, measure the mass of the beaker and glycerin. Record.
17. Measure the mass of the bottle and methyl esters.

Data Tables, Calculations, Results, and Questions

Item Weighed	Mass (grams)
Reaction bottle (without cap)	
Reaction bottle and soybean oil	
Empty Erlenmeyer flask	
Erlenmeyer flask with methanol	
Potassium hydroxide used	
100 ml beaker	
Beaker and glycerol	
Reaction bottle and methyl esters	

Step Number	Observations
4	
10 and 11	
13	

Substance	Mass	Calculation
Soybean oil		
Methanol		
Glycerin		
FAME		

Find the molecular weight of methanol.

Using the molecular weight of 875 g/mol for soybean oil, calculate the numbers of moles of soybean oil and the numbers of moles of methanol reacted.

Using a density of 785 g/L methanol, calculate the ratio of methanol: soybean oil used in the reaction.

Determine the theoretical molar ratio of methanol: soybean oil for the equation.

Why is more methanol added to the reaction than necessary?

Analysis

1. From the number of moles found determine the limiting reagent in this experiment.

2. Compare the theoretical molar ratio of methanol to soybean oil with the ratio used in the experiment. What is the difference? Why might this difference be useful in performing this reaction?

3. Compare the sum of the mass of the reagents to the sum of the mass of the products. Is there a loss of mass? How can this be explained?

Day 5

Discussion/ Lecture on corn ethanol and cellulosic ethanol, environmental concerns and carbon emissions.

Some key questions should include:

1. How is corn ethanol made? Why is it the only ethanol used at this time?
2. What is cellulosic ethanol? How does it differ from corn ethanol? What other steps need to be completed to create cellulosic ethanol?
3. How much energy is used to produce ethanol (corn or cellulosic)? Where does that energy come from?
4. Does the amount of energy used to make the ethanol outweigh the amount of energy produced by it?
5. How does carbon emission or the emission of other greenhouse gases affect the world? Where do these gases come from? How can we decrease this amount?

The students will then determine their "carbon footprint" on the earth as homework using http://www.nature.org/initiatives/climatechange/calculator/

Unit Assessment: At the end of this unit, students will write a two to four page paper about the pros and cons of biofuel production. In this paper, they will form an opinion able this process and use sources from the material presented and from other sources such as the internet. The rubric for this assignment, is below..

Persuasive Essay: Biofuels: Is this the solution?

Student Name: _____

CATEGORY	4 - Above Standards	3 - Meets Standards	2 - Approaching Standards	1 - Below Standards	Score
Position Statement	The position statement provides a clear, strong statement of the author's position on the topic.	The position statement provides a clear statement of the author's position on the topic.	A position statement is present, but does not make the the author's position clear.	There is no position statement.	
Grammar & Spelling	Author makes no errors in grammar or spelling that distract the reader from the content.	Author makes 1-2 errors in grammar or spelling that distract the reader from the content.	Author makes 3-4 errors in grammar or spelling that distract the reader from the content.	Author makes more than 4 errors in grammar or spelling that distract the reader from the content.	
Support for Position	Includes 3 or more pieces of evidence (facts, statistics, examples, real-life experiences) that support the position statement. The writer anticipates the reader's concerns, biases or arguments and has provided at least 1 counter-argument.	Includes 3 or more pieces of evidence (facts, statistics, examples, real-life experiences) that support the position statement.	Includes 2 pieces of evidence (facts, statistics, examples, real-life experiences) that support the position statement.	Includes 1 or fewer pieces of evidence (facts, statistics, examples, real-life experiences).	
Evidence and Examples	All of the evidence and examples are specific, relevant and explanations are given that show how each piece of evidence supports the author's position.	Most of the evidence and examples are specific, relevant and explanations are given that show how each piece of evidence supports the author's position.	At least one of the pieces of evidence and examples is relevant and has an explanation that shows how that piece of evidence supports the author's position.	Evidence and examples are NOT relevant AND/OR are not explained.	
Sources	All sources used for quotes, statistics and facts are credible and cited correctly.	All sources used for quotes, statistics and facts are credible and most are cited correctly.	Most sources used for quotes, statistics and facts are credible and cited correctly.	Many sources are suspect (not credible) AND/OR are not cited correctly.	