**Lesson Plan Template**

**Modified 5/08/13 from** [**LEARN NC**](http://www.learnnc.org/) **(**[www.learnnc.org](http://www.learnnc.org))

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For LEARN NC partners

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| **Title (Required)** | **Activity 3 – Biodiesel Basics and Production** |
| **Introduction (Required)** | In this activity, students will perform a transesterification reaction to produce biodiesel from various types of vegetable oil. The biodiesel that is prepared can then be tested in Activity 4 of this module. Students will also learn how the reactants, a triglyceride and methanol, along with a catalyst, undergo the reaction. Factors affecting the rate of reaction are learned as the reaction is set up. Background knowledge and students’ ideas about where biodiesel comes from can be discussed prior to lab. The reaction takes at least 90 minutes. As the reaction is happening, students will discuss why using biofuel is a good idea. Students are shown a real-world example of biodiesel production and use. The Catawba County landfill in North Carolina has an Ecocomplex that grows crops, produces biodiesel, and uses the fuel and its by-products in a sustainable operation. |
| **Learning Outcomes (Required)** | **Students will*** Develop a flow chart for producing biodiesel from vegetable oil.
* Produce biodiesel in a small-scale laboratory experiment.
* Compare and evaluate the usefulness of alternative fuel sources.
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| **Curriculum Alignment (Required)** | From the Next Generation Science Standards (<http://www.nextgenscience.org/>):

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| HS-ETS1-3. | Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. |

From the NC Essential Standards “unpacked” content for chemistry:* **2.2.1** Explain the energy content of a chemical reaction (interpret potential energy diagrams for endothermic and exothermic reactions including reactants, products, and activated complex-with and without the presence of a catalyst)
* **3.1.1** Explain the factors that affect the rate of a reaction (temperature, concentration, particle size and presence of a catalyst)
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| **Critical Vocabulary (Required)** | * Transesterification – a chemical reaction between an alcohol and a triglyceride to produce biodiesel and glycerin
* Triglyceride – oils or fats found in plants and animals; composed of a glycerol (3 carbon chain) backbone with three fatty acid chains (long straight chains of carbon atoms) attached
* Methyl ester – a compound formed from the reaction between an acid and an alcohol
* Biodiesel – a diesel fuel produced from organic sources, such as cooking oil, animal fat, or plant seeds (canola, sunflower, soybean)
* Catalyst – a substance used to speed up the rate of a chemical reaction without being used up during the process; similar to an enzyme in a biological system

The US Department of Energy maintains a full text glossary of terms related to the Biomass Program. The link is www1.eere.energy.gov/bioenergy/glossary\_full\_text.html |
| **Classroom Time Required (Required)** | **Activity 3** – Two hours with overnight separation of reaction. To make the biodiesel, allow one 45 minute period to warm the oil and add the alcohol and catalyst. The reaction then needs to proceed for at least one hour, followed by separation in a funnel (overnight is ideal). |
| **Materials Needed (Required)** | **Activity 3 Materials:**Teacher: computer with internet access, class monitor, Biodiesel for the Global Environment handouts, Biodiesel preparation lab handout, goggles, gloves, apronStudents: Biodiesel for the Global Environment handout, Biodiesel preparation lab handout, goggles, gloves, apron (if students perform lab activity)Lab Materials (per lab group):* 300 mL soybean oil or canola oil
* 6 g potassium hydroxide
* 60 mL methanol
* Thermometer
* Hot plate/stirrer
* 500 mL beaker
* 250 mL Erlenmeyer flask with stopper
* Glass storage bottle with lid
* Stir bar
* Separatory funnel (optional)
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| **Pre-activities (Required)** | **Activity 3 – Biodiesel Basics and Production**Equipment and starting materials need to be set up before class begins. The teacher can pre-measure reactants and begin warming the vegetable oil before class begins if time is an issue. Once the reaction has started, the teacher may have students do other work because of the long wait time. |
| **Activities (Required)** | **Activity 3 – Biodiesel Basics and Production**In this activity, students will learn basic information about biodiesel production and will perform a transesterification reaction to produce biodiesel. Factors that affect reaction rate and the effect of a catalyst on the energy diagram will be discussed.A Prezi presentation will guide students through biodiesel basic information. Each student needs to keep their KWL chart for additions. This activity begins with a slide that asks “Where does biodiesel come from?” The teacher can define biodiesel (see Critical Vocabulary section) and get students thinking about how it is different from petroleum-based fuels. The teacher can ask students which perception they have from the slide – do they just know it comes from the gas pump, do they picture a scientist in a messy garage lab, or do they think of the starting biomass materials? The second slide shows the transesterification reaction and begins the lab. Explain that the triglyceride and methanol are the reactants and that the potassium hydroxide is a catalyst. Review the energy diagram to point out activation energy and the effect of the catalyst on this graph. The teacher can also point out that this reaction uses heat and stirring to increase the rate of reaction by mixing reactants together more effectively than would occur if reactants were simply combined and left to sit at room temperature. Connections to biology can be made by reviewing that triglycerides are fats found in our blood and that cholesterol testing also tests the levels of triglycerides. We metabolize these triglycerides for energy, just like this reaction will use it to produce a fuel for energy. Also, glycerol is used in skin and hair care products, toothpaste and soap. It is also used to produce nitroglycerin, which is a component of dynamite and cordite.The teacher will have to determine how many lab set ups to have in each class. If safety concerns or lack of equipment are issues, the biodiesel production can be done as a teacher demonstration. Once the reactants are all added and the reaction is started, students can then go back to finish the Prezi presentation.Slide 3 asks “Why is this a good idea?” The image of the biodiesel cycle will begin a class discussion on economics, health concerns and global warming issues associated with both petroleum and biodiesel. A few thinking points are included and students can read the “Biodiesel for the Global Environment” handout. The teacher should point out some of the advantages and disadvantages from the handout. Remind students to continue to add their questions to the KWL chart they have been keeping for the unit. The final slide is a site map of the Catawba County landfill site and a link for a video clip with images from the site. Catawba County uses buffer land around its landfill to grow fuel crops for biodiesel. They harvest the seeds and press the oil out on site. The oil is then converted to biodiesel on site and is blended into diesel fuel to run the landfill machinery. The landfill also uses its methane to produce electricity and to heat water for the buildings and to power approximately 1500 homes in Catawba County. The Ecocomplex is a great example of a profitable waste management system. The link for more information on the site is <http://www.catawbacountync.gov/ecocomplex/index.asp>The remainder of the class will be for students to begin researching advantages and disadvantages of biodiesel. A list of student resources is included. Students will use their research to answer questions remaining on the KWL chart and to prepare their final assessment product. *Optional Community engagement:* The class may visit a biodiesel production facility if one is nearby. Locally, there are often small-scale facilities that may be available for a tour. |
| **Assessment (Required)** | Teachers can use a variety of formative assessments that are not graded, but will inform instruction after each activity. The following are some suggestions for these informal assessments.* Entrance/exit tickets – each student fills out a small ticket. The teacher can ask a content question, such as “Name two things you have learned about energy” or an open-ended question, such as “Write one question that you still have about calorimetry.” The teacher can then use the responses to guide future instruction.
* Starter question – The teacher can make a quick power point slide with a heat problem for students to work out.
* Thumbs up/thumbs down – A quick poll of understanding by a show of “thumbs up” or “thumbs down” can let the teacher know if students are confused. If students are not likely to give responses in this way, polleverywhere.com or gosoapbox.com are websites that have similar functions.
* Whiteboarding – students may work in small groups. The teacher assigns one problem from the homework sheet and the group puts the solution on the board and explains it to the rest of the class. This provides an easy way to uncover misconceptions.
* Electronic feedback – padlet.com allows teachers to build a wall and students to post comments. In this unit, a padlet could be created to post student questions or student feedback from each activity. Gosoapbox.com is a student management site where students can post questions, teachers can give quizzes or polls, and students can post discussion comments during class.

Summative assessments are more formal and are graded. A number of suggested assessments are listed below. Teachers may select work that is appropriate for their classes.* Heat Practice Problems – a power point with four heat problems with answers worked out on the last slide. Can be used as a quiz after Activity 2.
* Quiz – a short quiz can be given after Activity 3.
* Written test – a test with multiple choice, heat problems, graphs and short answer questions has been included. This test is best given once the entire unit has been completed.
* Lab report – students can write up formal lab reports for Activity 3 and 4. . A suggested format can be found on a prezi. The link is <http://prezi.com/lxl9c0rw81mv/?utm_campaign=share&utm_medium=copy>
* Student presentations – students can create a presentation to support or oppose biodiesel production in the United States. Options for formats include: power point; prezi.com; piktochart.com. Students can also make videos, posters or skits. This will be most effective after Activity 5.
* Class debate – students can be assigned roles (environmentalist, farmer, scientist, congressman, etc.) to help them focus research for the debate. The debate will be most productive if it is held after the completion of the unit.
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| **Community Engagement (Required)** | In North Carolina, there are several sites involved in biofuel production or research. These operations offer education outreach by offering tours or guest speakers to school groups. Teachers should brainstorm.* Piedmont Biofuels – Pittsboro, NC – free public tours on Sunday afternoons and the first Friday of each month
* Patriot Biofuels – Greensboro, NC
* Biofuels Center of North Carolina – Oxford, NC – tours are available or guest speakers can visit schools
* Catawba County landfill site – Newton, NC – free tours can be scheduled
* Guest speakers – North Carolina A&T bioenergy center, Greensboro; North Carolina Biotechnology Center, Research Triangle Park.
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| **Websites (Optional)** | **Introductory Articles** – these have basic information that you will want to read before you start looking at other aspectsA list of common FAQs* http://biodiesel.org/what-is-biodiesel/biodiesel-faq's
* http://www.patriotbiodiesel.com/category\_s/1820.htm

A great introduction to biodiesel* <http://biodiesel.org/what-is-biodiesel/biodiesel-basics>

History of Biofuels* <http://blog.hemmings.com/index.php/2013/07/10/a-brief-history-of-biofuels-from-the-civil-war-to-today/>

A basic dictionary of terms* http://www1.eere.energy.gov/bioenergy/glossary\_full\_text.html

NC State Energy report 2010 – overview of policies, regulations and energy statistics for NC* http://www.energync.net/Portals/14/Documents/Publications/ANNUAL%20NC%20ENERGY%20REPORT%20final%20feb%202010%20v2-1.pdf

**Biodiesel Production**A one-page schematic of how biodiesel is produced* http://biodiesel.org/docs/ffs-production/production-fact-sheet.pdf?sfvrsn=4

US Dept of Energy data – current prices of fuel in different areas of the country* http://www.eia.gov/petroleum/gasdiesel/

**Advantages and Disadvantages**Biodiesel Myths v. Facts brochure (pro-biodiesel)* http://biodiesel.org/docs/default-source/ffs-basics/biodiesel-myths-vs-facts.pdf?sfvrsn=10

Alternative Fuels Data Center – you can compare various types of fuel* http://www.afdc.energy.gov/

Create your own comparison chart for various fuels* http://www.afdc.energy.gov/fuels/fuel\_properties.php

A short article on renewable v. nonrenewable sources of energy* http://www.ecology.com/2011/09/06/fossil-fuels-vs-renewable-energy-resources/

Crunching the Numbers on Alternative Fuels – Popular Mechanics articles* http://www.popularmechanics.com/cars/alternative-fuel/news/2690341
* http://www.popularmechanics.com/cars/how-to/4314657?click=main\_sr

Ending the Food vs. Fuel Debate* http://www.renewableenergyworld.com/rea/news/article/2012/10/ending-the-food-v-fueldebate-researchers-define-surplus-land

Food vs. Fuel Debate – CNBC article* http://www.cnbc.com/id/48477352

**Video Resources –** Each video clip has the time listed at the end of the titleInvention Nation: Biodiesel video (3:38)* http://videos.howstuffworks.com/science-channel/5044-invention-nation-biodiesel-video.htm

Public service announcement – introduces the use of fuel from organic materials (0:30)* http://bcove.me/r6k4gt36

“Here, Now” commercial – use of biodiesel in Dallas (0:37)* http://bcove.me/rwararju

“Fast Track” commercial – a biodiesel truck breaks a land speed record (0:37)* http://bcove.me/9cdwh71s

Jay Leno’s Garage – Jay talks to a scientist about using biodiesel in some of his cars (1:31)* http://bcove.me/316xk1ki

Motorweek segment – interviews farmers and various industries using biodiesel (7:55)* http://bcove.me/3yzusjn6

Biofuel lesson from National Defense Education Program – brief description of how organic materials are being developed into gasoline, biodiesel, and jet fuel* http://www.ndep.us/Biofuel

CNN Story on the Catawba County landfill site* http://www.cnn.com/video/?/video/tech/2009/08/20/wolf.green.town.cnn

**Careers in Biofuels**A US Bureau of Labor Statistics report on biofuel associated careers with salaries and credentials* <http://www.bls.gov/green/biofuels/biofuels.pdf>

Biofuel and Biodiesel product development careers – lists job outlook, salaries, personality traits and has links to other related careers* <http://myfootpath.com/careers/science-careers/biofuel-and-biodiesel-product-developer-careers/>

Green Career Guide – basic information about school and expectations for various biofuel jobs* <http://www.greencareersguide.com/Cellulosic-Biofuels.html>
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| **Author Info (Required)** | Marci Harvey is a chemistry and physics teacher at West Forsyth High School in Clemmons, NC. She has been teaching in NC for 17 years. She has a BS in chemistry from the College of Charleston and a MS in chemistry from the University of South Carolina. Marci earned National Board certification in 2008. This lesson is part of a Kenan Fellowship “Pump New Life into the Classroom with Biofuels.” completed at North Carolina A&T University. |