From Algae to Oil

Objective:

The purpose of this lesson is to investigate the use of algae as an alternative fuel.

Keywords:

- Algae
- Photosynthesis
- Biodiesel
- Biofuels

21st Century Skills Represented:

- Environmental Literacy
- Economic Literacy
- Creativity & Innovation
- Critical Thinking & Problem Solving
- Information Literacy

National Science Education Standards:

- Physical Science: Matter & its Interactions, Energy
- Earth & Space Sciences: Earth & Human Activity
- Engineering, Technology & Applications of Science: Links among Engineering, Technology, Science & Society

feedstocks	processes	uses
Crop - algae	Mechanical – extraction/separation Chemical conversion	Fuel/energy - biodiesel

Background

Algae, a renewable source of biofuel, have great potential to be an alternative to non-renewable sources like crude oil.

Algae are a plant-like organism that needs water, carbon dioxide, minerals and light to flourish. They are mostly photosynthetic and float in surface waters (both sea and fresh). One of the key reasons that algae are considered a feedstock for oil is their yields. The Department of Energy has estimated that algae can yield 30 times more energy per acre than land crops and utilize resources that are widely available.

Once the algae are grown and harvested, there are different ways of getting the oil. Extracted oil is called “green crude” and is transformed into biodiesel through a process called transesterification. In this process, a catalyst such as sodium hydroxide and an alcohol, such as methanol, is mixed with the green crude resulting in biodiesel mixed with glycerol. Once the glycerol is removed, the result is algae biodiesel.

However, the current high costs of production create uncertainty about sustainability. Are there ways to reduce production costs and make algae fuels a reality?

Materials

Per group of 2-3 students:

- 100 ml stock algae (can also obtain from a local pond or water source)
- 2-liter bottle
- 1.5 liters of distilled water
- 10 g nitrogen-rich fertilizer
- 1 funnel
- 1 piece filter paper
- 2-3 paper towels
- Mortar and pestle
- 6-8 cm piece of wick
- Lighter
- Measuring tools:
  - 110 mL graduated cylinder
  - Gram scale
  - Plastic boats for gram scale

Continued on the next page...

From Algae to Oil

Pre-Lab Preparation

1. Have students research the life cycle of algae and the role of photosynthesis.
2. Have students record their answers to the following questions:
    a. How do algae grow?
    b. What is photosynthesis? What is its equation?
    c. How is photosynthesis involved in the growth of algae?
    d. What types of products use algae as an input source?
3. Have a class discussion about the preceding questions.
4. Break students into groups of 2-3.
5. Tell each group to bring in one empty 2-L bottle for the lab.

Lab Procedures

1. Have each group label the 2-L bottle using a permanent marker, including names, date and class period.
2. Thoroughly rinse out the 2-L bottle with distilled water.
3. Fill the 2-L bottle with non-tap water until it is 3/4 full.
4. Pour 10 g of fertilizer into the bottle and mix thoroughly.
5. Pour 100 mL of algae into the bottle.
6. Leave the cap off of the bottle and place it in an area where it can be exposed to sunlight.
7. Allow 3-5 days for algae to grow. Record observations in a lab notebook.
8. When the algae are ready to harvest, use a funnel, filter paper, beaker and paper towels to extract the algae from the water.
9. Place algae on the paper towel and blot excess water until it is dry.
10. Use the mortar and pestle to grind out the oil from the algae. If you are unable to harvest enough algae, plan to gather more from local ponds.
11. When oil is visible, soak a wick in it and leave it in the mortar.
12. Light the wick with the lighter.
13. Record observations in the lab notebook.

Post-Lab Discussion/Questions

Have the students answer the following questions:

1. Does the oil you extracted from the algae contain energy? How do you know?
2. Once the oil has been taken out of the algae, what biological molecules would be left?
3. What could the oil be used for?
4. What could the leftover biological molecules be used for?
5. What is a bio-based product or “bioproduct”?
6. What is a biofuel?
7. What is biodiesel?
8. How do you think algae are being used to produce biofuels and biodiesel?
9. What other bioproducts could be made from algae?

From Algae to Oil

Expansion Ideas

- Test the effects of varying sunlight, nutrient and CO_2 levels on the growth of algae.
- Have students develop alternative methods for harvesting oil from algae.
- Create business plans for algae biofuels and bioproducts. Consider different marketing approaches that highlight environmental/green angles.

Evaluation of Learning

- Students successfully grow algae and harvest oil from it.
- Students turn in results, observations and answers.

Resources

- Videos
    - Sustainable Fuel from Algae from YouTube by The Ohio State University-OARDC
    - Invention Nation: Algae Biofuel from The Science Channel
    - Next Big Bio-Fuel – Algae from YouTube
    - OBIC Alliance Member: NuVention Solutions from YouTube by OBIC

- Websites and Articles
    - Oilgae, algae energy information.
    - The Need For A New Oil by OriginOil, a company converting algae to renewable crude oil.
    - Green by Nature: Algae Research May Lead to New Alternative Fuel Industry in Ohio by Mauricio Espinoza, The Ohio State University-OARDC
    - Accelerating the commercialization of a novel bio resource resin (BR^2) by Crain's Cleveland Business

Contacts

- Algaeventure Systems, Marysville, OH: http://algaevs.com/
- Bioproducts and Bioenergy Research Laboratory at The Ohio State University-OARDC, Wooster, OH: http://oardc.osu.edu/bioenergy/
- Algae Producers of America, Inc., Madison, OH: http://www.algaeproducersinc.com/
- Beagle Bioproducts, Inc., Ohio: contact Dr. Stephanie Smith at stephanie.smith@beaglebioproducts.com
- NuVention Solutions, Inc., Valley View, OH: http://www.nuventionsolutions.com/

Project supported by a Secondary Education/2-Year Postsecondary Education/Agriculture in the K-12 Classroom grant from the United States Department of Agriculture - National Institute of Food and Agriculture under Award No. 2010-38414-21028. Any opinion, findings, conclusions or recommendation expressed in this publication are those of the author and do not necessarily reflect the views of the U.S. Department of Agriculture.