Oklahoma Ag in the Classroom

# Will Your Car Run on Gas?

## How biomass becomes alcohol

### Objective

Students will read about biomass and conduct experiments with yeast.

### Background

Unlike other renewable energy sources, biomass can be converted directly into liquid fuels, called "biofuels," to help meet transportation fuel needs. Biomass is organic (living or once-living) matter such as trees, grass, corn stalks, or even manure from humans or livestock. All living organisms get their energy from the sun, either directly or indirectly. They use the sun's energy to convert water and carbon dioxide into carbohydrates (sugars) and oxygen (and they also release water in the process). Because new plants can be grown, biomass is a renewable resource.

Most of the biomass used for energy production is products from wood—logs, bark, sawdust, etc. Wood products are used to generate electricity or heat ovens in wood-processing plants. This process alleviates disposal costs, saves landfill space, and cuts utility bills. Wood is also burned to heat homes in the form of logs or compressed wood pellets.

The two most common types of biofuels in use today are ethanol and biodiesel. Ethanol is an alcohol, the same as in beer and wine (although ethanol used as a fuel is modified to make it undrinkable). It is most commonly made by fermenting any biomass high in carbohydrates through a process similar to beer brewing. Today, ethanol is made from starches and sugars, but scientists are developing technology to allow it to be made from cellulose and hemicellulose, the fibrous material that makes up the bulk of most plant matter.

Ethanol is mostly used as blending agent with gasoline to increase octane and cut down carbon monoxide and other smog-causing emissions.

Biodiesel is a diesel fuel substitute that can be made from a variety of oils, fats, and greases. It is made by reacting vegetable oil or animal fat with an alcohol (usually methanol or ethanol) and a catalyst (usually sodium hydroxide or potassium hydroxide). The resulting product is thinner than the original oil or fat and thus works better in a diesel engine. Hundreds of governments, national parks, school districts and utility companies in the United States use biodiesel blends to run their fleets.

Biodiesel is of interest to farmers for a number of reasons:

- It can provide an additional market for vegetable oils and animal fats.
- It can allow farmers to grow the fuel they need for farm machinery.

Commonly-used crops for the production of biodiesel include soybean, rapeseed/canola, used (waste) vegetable oils, and tallow (animal fat).

Oklahoma State University, in cooperation with the Noble Foundation

### Oklahoma Academic Standards

GRADE 5
Physical Science: 1-1,4; 3-1; Life Science: 2-1

GRADE 6
Physical Science: 1-4. Physical Science: 3-3,4. Life Science: 1-6; 2-3. Earth Science: 3-3

GRADE 7
Physical Science: 1-1,2

GRADE 8
Physical Science: 1-3,6. Life Science: 1-7. Earth Systems: 2-1; 3-1,4

in Ardmore, is working on an alternative using switchgrass to make biofuels. Switchgrass is a native prairie grass that grows all over Oklahoma. Unlike corn and other crops, the current varieties of switchgrass grow without tillage and planting. Switchgrass is perennial and requires less water and fertilizer than crops such as corn. Switchgrass can produce between 300 and 700 gallons of ethanol per acre. In addition, more net energy is gained from switchgrass than from corn. Ethanol from corn yields 34 percent more energy than it takes to grow and process the corn into biofuel. Ethanol from switchgrass nets over five times more than that amount.

Background sources: The National Energy and Education Development Project, http://www.need.org; National Renewable Energy Laboratory, www.nrel.gov; U.S. Department of Agriculture, www.ars.usda.gov; The Noble Foundation, www.noble.org

## Vocabulary

**anaerobic**—without oxygen
**decomposers**—organisms that break dead organisms into their component parts
**enzymes**—proteins that speed chemical reactions; biological catalysts
**fermentation**—turning sugar into alcohol or lactic acid during anaerobic respiration
**fossil fuel**—nonrenewable energy sources from ancient life, e.g., oil, coal, natural gas
**greenhouse gas**—gases such as carbon dioxide and methane that trap warmth in the atmosphere and raise the earth's temperature over time
**perennial**—living over a period of many years
**photosynthetic**—an organism that derives its energy from the sun
**renewable resource**—energy resourcesthat are replaceable or not used up, such as trees, water power, solar energy
**tillage**—plowing the ground to make it ready for planting

## Materials

- hot water
- baking yeast
- clear plastic 500 ml water bottles
- stirrers
- measuring spoons
- flour
- salt
- sugar (Sugar is made from a plant—sugar beets or sugar cane)
- vinegar
- funnel
- balloons

## Procedures

1. Read and discuss background and vocabulary.
   —Ask how corn or switchgrass can be converted to a fuel for burning?
2. Bioethanol is most often produced by fermentation of sugars by yeast. The material used for bioethanol production includes sugar from sugar beet and sugar cane as well as starches from corn or grain. In this case the starches are first hydrolyzed with amylase enzymes to produce sugar that can be fermented by yeast.
   —Divide class into groups.
   —Hand out copies of the "Yeast Experiment" sheet and the "Scientific Method Format" included with this lesson .
   —Students will follow the directions on the instruction sheet to test different substances for their ability to promote fermentation.
   —Students will record their steps on the "Scientific Method Format."
3. Lead a discussion using these questions:
   —What is the evidence of reactions in any of the containers?
   —How are these observations related to fermentation?
   —Which of the substances tested was most helpful to yeast fermentation? Which of the substances was made from plants?

4. Students will design experiments with other substances associated with biofuels (corn syrup, flour from wheat, etc.) to test their ability to help yeast fermentation.
5. Students will use the same ingredients from Activity # 2.
   —Students will place the ingredients in small bottles and secure a balloon over the top of each one to observe the release of carbon dioxide.
6. In a large beaker place warm water, yeast, sugar, and flour as though making bread.
   —Make marks on the side of the beaker every 2 minutes so students can observe the growth of the mixture rising and the bubbles.

# Yeast Experiment

Materials:

- 1/2 c hot water
- baking yeast
- 4 clear 500 ml water bottles
- funnel
- stirrers
- measuring spoons
- flour
- 4 balloons
- salt
- sugar
- vinegar
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1. Number the bottles, 1-4.
2. Use the funnel to pour 1/2 cup hot water into each bottle.
3. Empty one packet of yeast into each bottle. Stir for one minute.
4. Add 10 ml (2 tsp) of flour to each bottle. Stir again.
5. Add ingredients to each bottle as follows:
    - Bottle # 1—Add 5 ml (1 tsp) of salt.
    - Bottle # 2—Add 5 ml of sugar.
    - Bottle # 3—Add 5 ml of vinegar.
    - Bottle # 4—control. Leave as is.
6. Stir each bottle again for one minute.
7. Place a balloon over each bottle.
8. Record observations in the table below after five, 10, and 15 minutes.
9. Predict what will happen to the solutions overnight. Let the solutions sit overnight. Record observations.

| Observations | After 5 minutes | After 10 minutes | After 15 minutes | Overnight |
|---|---|---|---|---|
| Bottle 1—salt | | | | |
| Bottle 2—sugar | | | | |
| Bottle 3—vinegar | | | | |
| Bottle 4—control | | | | |

Which of the substances tested was most helpful to yeast fermentation? Which substance is made from plants?

What evidence shows that a reaction is taking place?

Oklahoma Ag in the Classroom is a program of the Oklahoma Cooperative Extension Service, the Oklahoma Department of Agriculture, Food and Forestry and the Oklahoma State Department of Education.

Name_____

# Scientific Method Format

Title of Experiment or Study:

I. Stating the Problem:
   What do you want to learn or find out?

II. Forming the Hypothesis:
   What is known about the subject of problem, and what is a prediction for what will happen?

III. Experimenting: (Set up procedures.)
   This should include: materials used, dates of the experimental study, variables, both dependent and independent (constant and experimental); how and what was done to set up the experiment; fair testing procedures.

IV. Observations:
   Includes the records, graphs, data collected during the study.

V. Interpreting the Data:
   Does the data support/defend the hypothesis?

VI. Drawing Conclusions:
   Justify the data collected with concluding statements about what has been learned. Discuss any problems or concerns. Use other studies to support the conclusion. Give alternative ideas for testing the hypothesis.

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