Will Your Car Run on Grass?

How biomass becomes alcohol

Skills: Science, Math

Objective: Students conduct experiments with yeast to learn what substances promote fermentation.

Background

Biomass is organic (living or once-living) matter such as trees, rice plants, corn stalks, or even manure from humans or livestock. All living organisms get their energy from the sun, either directly or indirectly. Plants and other photosynthetic organisms, such as cyanobacteria and algae, get their energy from the sun. 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). Herbivores get energy from eating plants. Omnivores get energy from eating plants or other animals (which eat plants), etc. 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.

Solid waste (trash) can also be burned to generate electricity. However, most garbage is not biomass. A large portion of solid waste is plastic, which is made from natural gas and petroleum products. An American ton (2,000 pounds) of garbage has almost as much heat energy as 500 pounds of coal. It is not economical to burn garbage, compared with using other energy sources, but it does save landfill space.

Methane gas is colorless and odorless. It is produced as solid waste decays. Methane gas can cause explosions. Landfills are now required to collect methane gas. Most burn it off as it is collected, as it is not economical to collect and store it for fuel. Methane is mostly natural gas. Anaerobic digesters can be built to decompose biomass and collect the methane to burn it as fuel. Some waste treatment plants use the energy from the anaerobic digesters to run the plant.

Another biofuel is biodiesel, which is made by combining

P.A.S.S.

GRADE 6

Science Process—1.1,3; 3.1,2,3,4,5; 4.1,3,4,5; 5.1,3,4
Physical Science—1.1
Life Science—4.1
Math Process—1.1,3; 4.1
Math Content—4.3; 5.1

GRADE 7

Science Process—1.1,3; 3.1,2,3,4,5; 4.1,3,4,5; 5.1,3,4
Life Science—4.2
Math Process—1.1,3; 4.1
Math Content—4.2a

GRADE 8

Science Process—1.1,3; 3.1,2,3,4,5; 4.1,3,4,5; 5.1,3,4
Physical Science—1.1
Math Process—1.1,3; 4.1

Resources Needed

hot water

baking yeast

clear plastic 500 ml water bottles

stirrers

measuring spoons

flour

salt

sugar

vinegar

funnel

balloons

methanol with used cooking grease (animal fat or vegetable oil) or with oilseed crops like soybeans, sunflowers and canola. Biodiesel can also help decrease harmful emissions. It can be used as fuel for diesel engines.

One way to make biofuel is to ferment plants. Using processes similar to those used to make beer and wine, yeasts can be used to ferment starches in grain kernels (usually corn) to ethanol. Ethanol is usually added to gasoline and helps decrease carbon monoxide emissions. Currently the most common crop used in ethanol production is corn. One acre of corn can produce 300 gallons of ethanol.

Oklahoma State University, in cooperation with the Noble Foundation in Ardmore, is working on an alternative to corn—switchgrass. Switchgrass is a native prairie grass that grows all over Oklahoma. Unlike corn, 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.

In April 2007, Oklahoma had seven biodiesel stations and one ethanol station. Using biofuels helps the environment because the carbon dioxide released into the atmosphere from biofuels only replaces what the plants originally took out. This is in contrast to carbon dioxide harvested from underground fossil fuels and added to current atmospheric levels. (Carbon dioxide is one of the major greenhouse gases.) Use of biofuels also lowers our dependence upon other countries for fuel supplies.

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).

Activities

1. Read and discuss background.
   —Ask how corn or switchgrass can be converted to a fuel for burning?
2. One way to make biofuel is by using yeasts to ferment plants.
   —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?
4. Students design experiments with other substances associated with biofuels (corn, grass) to test their ability to help yeast fermentation.
5. Students use the same ingredients from Activity # 2.
—Students 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.

Extra Reading

Carless, Jennifer, *Renewable Energy: A Concise Guide to Green Alternatives*, Walker, 1993.

Peterson, Christine, *Alternative Energy*, Children's, 2004

Povey, Karen D., *Biofuels—Our Environment*, KidHaven, 2006.

Renewables Are Ready—A Guide to Teaching Renewable Energy in Junior and Senior High School Classrooms, Union of Concerned Scientists, 1994.

Vocabulary

anaerobic—without oxygen
cyanobacteria—blue-green algae
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 resources that are replaceable or not used up, such as trees, water power, solar energy
tillage—plowing the ground to make it ready for planting

Name _____

Yeast Experiment

1. Gather materials:

1/2 c hot water	baking yeast	4 clear 500 ml water bottles	funnel
stirrers	measuring spoons	flour	4 balloons
salt	sugar	vinegar	

2. Number the bottles, 1-4.
3. Use the funnel to pour 1/2 cup hot water into each bottle.
4. Empty one packet of yeast into each bottle.
5. Stir for one minute.
6. Add 10 ml (2 tsp) of flour to each bottle.
7. Stir again.
8. 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.
9. Stir each bottle again for one minute.
10. Place a balloon over each bottle.
11. Record observations below after five, 10, and 15 minutes.
12. Predict what will happen to the solutions overnight.
13. Let the solutions sit overnight.
14. Record observations.

Activity adapted from "Newton's Apple," http://www.newton'sapple.tv/TeacherGuide

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?

What evidence shows that a reaction is taking place?

Produced by Oklahoma Ag in the Classroom, a program of the Oklahoma Cooperative Extension Service, the Oklahoma Department of Agriculture, Food and Forestry and the Oklahoma State Department of Education, 2008.

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 or 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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