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Ethanol Production from Organic Matter

| SuperNOVA | 1 Hour | Grade 5/6

SUPERNOVA
DALHOUSIE UNIVERSITY | HALIFAX, NOVA SCOTIA

OVERVIEW

Description

Participants will learn about ethanol as a clean fuel and how it's produced. They will produce ethanol biofuels using different biomass sources and compare the sources' effectiveness at producing ethanol fuel.

***Students can bring their own organic biomass from home for this experiment. Examples of what to bring can be found in the "Materials" or the "Ethanol Experiment" section. ***

Learning Outcomes

- Ethanol as a clean fuel source.
- Ethanol fermentation as a means for ethanol production.

Outline *(with time indications/estimations)*

1. Clean fuels and Examples (5 mins)
2. Ethanol and Ethanol Production (5 mins)
3. Ethanol Experiment (30-40 mins)
4. Debrief (10 mins)

Materials:

Item (*be very descriptive*)	**Quantity Per Group** (*with units*)	**Quantity Per Camp** (*with units*)
• Kitchen Scale	• 1	• N/A
• Yeast	• 7 grams	• N/A
• Plastic Water Bottle (500mL) OR Erlenmeyer Flask (500mL)	• 1	• N/A
• Water	• 100mL	• N/A
• Balloon	• 1	• N/A
• Organic Material Containing Sugar *Examples include: cereals, sugar (granulated or powdered), fruits or*	• At least 8 grams	•

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vegetables, grass or outdoor plants, cookies (sugary snacks in general), candy, legumes, etc.
***Ask students to bring the nutritional facts of what they bring to compare sugar content.*

SAFETY CONSIDERATIONS

- Precautions for Instructor and Participants.
- Please use caution, and explain each safety measure to the participants. Ensure any incidents are reported appropriately.
- Indicate with an 'x' next to the items that apply to this activity.
- This activity will be messy, please prepare to clean up your mess, at multiple stages.

Material/Chemical Safety	
	SDS Required (*attach in write up)*
	Electrical Components
X	Food & / or Potential Allergens
	Other:
Equipment Precautions	
	Sharp Objects: Scissors / Staplers / Scalpel
	Burn Risk: Glue Guns / Hot Plate / Flame
	Tools
	Other:

Digital Safety [ ] Yes [ ] No	
Special Clean-up Required? (indicate below)	
	Yes
Safety Equipment or Protection	
	Goggles / **Gloves**
	Lab Coat
	Fire Extinguisher
	Other:
Other Safety Precautions? (indicate below)	

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KEY INFORMATION

Information on the activity topic(s) that is necessary for the Instructor to be familiar with.
(Suggested 300 words)

Clean Fuels: Clean fuels are any fuel source that produces less emissions than traditional fossil fuels throughout its life-cycle; the production and use of clean fuels leave a smaller carbon footprint compared to traditional methods. Clean fuels are commonly made from natural sources, such as plants. Examples of clean fuels include ethanol (alcohol), renewable diesel, synthetic fuels, sustainable aviation fuels, clean hydrogen gas, and renewable natural gas.

Ethanol and Ethanol Fermentation: Ethanol is a sustainable, clean, plant-based alternative fuel produced using ethanol fermentation. Ethanol contains ethyl alcohol, the same type of alcohol used in alcoholic beverages. Ethanol can be found as an additive in gasoline such as E10 (10% ethanol and 90% gasoline) and E85 (85% ethanol and 15% gasoline) to oxygenate the fuel, reducing air pollution, or as pure ethanol fuel. Ethanol fuel has a higher octane than gasoline which reduces engine knock and allows car manufacturers to run their vehicles more efficiently (run higher turbo pressures).

Ethanol fermentation is an anaerobic process which converts sugars (glucose, sucrose, fructose) into cellular energy, which produces ethanol and carbon dioxide as by-products. For ethanol found in gasoline or as a standalone fuel, it is produced using yeast fermentation of carbohydrate products or "cellulosic feedstocks"; all plant-based material can be used as an ethanol feedstock as all plants contain sugars. Common plants used to produce ethanol include corn (used in temperate regions) and sugarcane (used in warmer climates).

LESSON PLAN AND PROCEDURE

- *Should reflect Overview-Outline.*
- *Include any necessary inclusion and/or adaptation information.*
- *Refrain from including additional background information on the topic, instead refer back to the Key Information section, where necessary.*
- *Make note if anything needs to be prepared beforehand.*

Clean Fuels and Examples (5 minutes)

1. What are clean fuels? Clean fuels are any fuel source that produces less emissions than traditional fossil fuels throughout its life-cycle.
    a. Begin by discussing with students about how traditional fossil fuels produce harmful emissions in the form of carbon dioxide when burnt. A common one students can see

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are from internal combustion vehicles which produce exhaust gasses, contributing to global warming.

b. Ask students for alternative fuels that could be less harmful to the environment. Students may suggest examples of clean energy sources (rather than clean fuels) such as solar, wind, or hydro power. Help students understand that these sources of energy generate electricity, which is a clean fuel.
    i. Examples of clean fuels include ethanol (alcohol), renewable diesel, synthetic fuels, sustainable aviation fuels, clean hydrogen gas, and renewable natural gas.

2. Allow students to discuss what kinds of fuel we pump into our cars (ex. gasoline, diesel, electricity).
    a. Ask students if they believe the gasoline we pump into our cars is pure gasoline. In Nova Scotia, all gasoline sold is now mixed with ethanol.

Ethanol and Ethanol Production (5 minutes)

3. Ethanol is a sustainable, clean, plant-based alternative fuel. It is mixed into our gasoline fuel in Nova Scotia. It is a cleaner alternative to pure gasoline as it is renewable (produced from biomass) and burns more cleanly and completely than gasoline.
4. Ethanol is produced from biomass (plantstock or any organic material) through a process known as ethanol fermentation. This process will produce ethanol and carbon dioxide as by-products. The important factor to how much ethanol is produced is the sugar content present in the biomass.
    a. Ethanol fermentation involves using yeast to convert the carbohydrates (sucrose, glucose, and fructose) found in plantstock into cellular energy which produces ethanol and carbon dioxide as a by-product.
    b. Ask students if they have used yeast at home for baking. The carbon dioxide gas yeast fermentation produces is what causes bread to rise! The ethanol is driven off by the baking process so the bread is not alcoholic.

Ethanol Experiment (40 minutes)

5. Students will produce ethanol from familiar organic sources and compare the amount of ethanol produced.
    a. Ask students to each bring their own organic sources from home (should be done in advance of the experiment date to give students ample time to gather their resources).
        i. Examples include: cereals, sugar (granulated or powdered), fruits or vegetables, grass or outdoors plants, cookies (sugary snacks in general), candy, legumes, etc.
    b. Ethanol will be captured in a balloon and the size the balloon inflates to will indicate the effectiveness of the biomass source at producing ethanol.

Activity Procedure:

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1. Students will grind up their biomass source as finely as possible.
    a. Place the biomass into their plastic bags. Grind it using your hands or using a blunt object (a book or a water bottle could work).
        i. Grass or other organic materials gathered from outside can be hard to grind up finely, especially if it contains moisture. Look to gather materials ahead of time so they can be dry come experiment day.
    b. Make sure the bag does not explode!
2. Take turns using the kitchen scale to weigh out 8 grams of biomass material. Pour this material into the flask or plastic water bottle.
3. Add 7 grams of yeast into the mixture. This yeast is crucial in ethanol fermentation.
4. Repeat these steps until every student has 8 grams of biomass with 7 grams of yeast in their flask or plastic bottle.
5. Add 100mL of water into the mixture. Quickly stretch the opening of the balloon over the opening of the flask or bottle, ensuring no gas can escape. Swirl the mixture to mix it.
6. Leave the mixture for 20 minutes minimum (can leave it longer to ensure the fermentation is complete). While waiting, get students to predict which source will produce the most ethanol by comparing the sugar content of each source.
    a. Students can have a friendly competition to see who brought the "best" ethanol feedstock.
7. Once time is up, compare the size that each balloon grew by. Some sources will produce very little ethanol and the balloon will appear to not have any air in it, while other sources will inflate the balloon by a considerable amount.
8. To dispose of the gasses produced, make sure to do it outside where the gas can escape freely. The yeast mixture can be disposed of in the organics bin.

Debrief

- *Discuss how ethanol fermentation produces ethanol. What is the other by-product that is produced? What other applications do we see ethanol fermentation (baking, alcohol distillation).*
- *What factors contribute to more ethanol production?*
    - *Biomass with higher sugar content (more sucrose, glucose, and fructose) will have more carbohydrates for the yeast to react with.*
- *Why is ethanol a source of clean fuel?*
    - *Ethanol is renewable (can be grown and made from organic matter) and burns more cleanly than traditional fossil fuels.*

SuperNOTE

One sentence summary of activity, including basic learning outcomes. Remember to copy this into the SuperNOTES Spreadsheet!

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REFERENCES & RESOURCES

Clean Fuels and Sustainable Fuels

- https://natural-resources.canada.ca/our-natural-resources/energy-sources-distribution/clean-fuels/clean-fuels-fueling-the-future/23735
- https://www.who.int/tools/clean-household-energy-solutions-toolkit/module-7-defining-clean
- https://sustain-fuels.com/education/sustainable-fuels/
- https://reposenergy.com/understanding-clean-fuels/

Ethanol

- https://www.britannica.com/science/ethanol
- https://afdc.energy.gov/fuels/ethanol-fuel-basics
- https://natural-resources.canada.ca/energy-efficiency/transportation-alternative-fuels/alternative-fuels/biofuels/ethanol/3493

Ethanol Fermentation

- https://www.khanacademy.org/science/ap-biology/cellular-energetics/cellular-respiration-ap/a/fermentation-and-anaerobic-respiration
- https://en.wikipedia.org/wiki/Ethanol_fermentation#:~:text=Ethanol%20fermentation%2C%20also%20called%20alcoholic,carbon%20dioxide%20as%20by%2Dproducts.

Bioethanol Production Video

- https://www.youtube.com/watch?v=JBUubS9eBIk

DOCUMENT TITLE NAMING CONVENTION

Title

Be concise, but descriptive. The Title *must* reflect the title in the write up document itself, the SuperNOTE, and the camp schedule.