Seed to STEM

Kansas Corn: Ethanol vs. Fossil Fuels

This lab is made possible with the support and content contributions of the Kansas Corn Commission.

KANSAS CORN COMMISSION

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Kansas Corn: Ethanol vs. Fossil Fuels
Grade Level: Middle School

Overview
The purpose of the activities in this lab is to compare and contrast ethanol to fossil fuels. For each fuel, we will compare the amount of carbon dioxide produced, the amount of carbon soot produced and the amount of heat produced when burned.

Kansas College and Career Ready Standards
- **MS-ESS3-3.** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- **MS-ESS3-4.** Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

Learning Objectives
- Compare the difference of using ethanol and kerosene.
- Measure the amount of carbon dioxide produced after burning ethanol and kerosene.
- Measure the amount of heat produced when burning ethanol and kerosene.

Materials
- Ethanol vs. Fossil Fuels PowerPoint (available at www.kscorn.com)
- Student Worksheet (pg. S1-4 or at www.kscorn.com)

Which Fuel Burns Cleaner?
- Ring stand
- Clamp
- 2 250-mL beakers
- Digital scale
- Blue food coloring (if your kerosene is not already colored)
- 2 fuel burners
- 95% ethanol
- Kerosene
- Lighter
- Timer

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Which Fuel Produces More Carbon Dioxide When Burned?

- 2 alcohol burners
- 95% ethanol
- Kerosene
- Lighter
- RAE carbon dioxide gas detection tubes, 10-104-30
- 100-mL syringe
- Tubing
- Metal vent pipe and cover (This can be substituted with something comparable.)

Which Fuel Burns the Hottest?

- Ring stand
- Clamp
- Thermometer
- One-holed stopper
- Metal cup
- Graduated cylinder
- 100 mL of water
- 2 fuel burners
- 95% ethanol
- Kerosene
- Lighter
- Digital scale
- Timer
- Calculator

Safey Considerations

Students should wear safety goggles for each of the experiments. Use extreme caution when using an open flame and follow all fire safety guidelines. Students should know how to properly extinguish a flame as well as where the fire blanket and fire extinguishers are located. Students should not wear baggy or bulky clothing and long hair should be pulled back.

Procedures for Instruction

Length of Time for Preparation: 45 minutes
Length of Time for Classroom Teaching: 2 class periods

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Preparation Procedure
Each activity will take 15-20 minutes to setup. Allow about 45 minutes to set up all three activates. Color the kerosene with one drop of food coloring to help students tell the difference between the two burners.

Background Information
There are many claims that ethanol is cleaner burning, more energy efficient and better for our environment than burning fossil fuels. This lab is designed to compare ethanol and kerosene, a fossil fuel, to see if these claims are accurate.

Most energy used in the United States consists of burning a combustible material and harnessing the heat, or energy, produced. The burning of combustible materials releases harmful gases and soot into the air. Typically, fuels that produce more soot tend to be more harmful to the environment. About 50 percent of air pollutants come from transportation the burning of combustible fuels. Soot is the most visible form of air pollution and leaves a black coating on whatever it settles on. Also, when breathed in, the tiny particles can cause health problems. Carbon dioxide is a product of all carbon-based fuels when burned. Carbon dioxide is a greenhouse gas and plays a role in global warming. Environmental impacts can be measured by observing the particulate matter, or soot, released into the air and by measuring the amount of carbon dioxide produced.

Fuels that produce more heat per unit produce more energy. To determine efficiency, the heat released during the combustion process may be measured by heating a set volume of water. Students will collect both qualitative and quantitative data to compare the two fuel sources.

Classroom Discussion
Introduce the topic and assess students for prior understanding.

- Where does the energy we use come from? (The sun. Plants use photosynthesis to convert sunlight into energy stored in sugars. In the case of fossil fuels, this energy was stored by the plants millions of years ago. The energy was concentrated by heat and pressure within the Earth to form the fossil fuels we use today.)
- What are some of the issues of using fossil fuels? (Students may point out that fossil fuels release greenhouse gases and other pollutants. Fossil fuels are also a nonrenewable resource.)
- Discuss how ethanol is a biofuel. (Because the fuel comes from living plants like corn and the corn can be grown each year, ethanol is considered a renewable fuel source.)

Let students discuss their ideas, and guide the discussion without telling them if they are right or wrong.

- How can you determine which type of fuel source is better? (Students may bring up topics such as cost, which gives the most energy, and/or which is better for the environment.)

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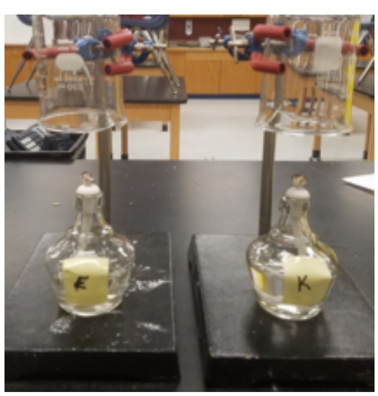
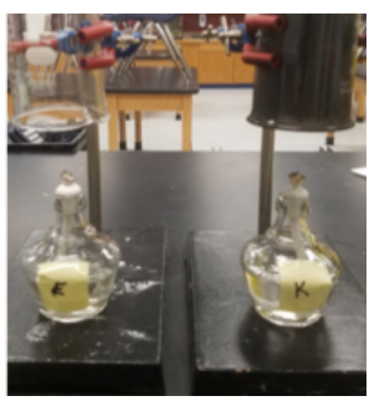
- When looking at which fuel is better for the environment, what does that mean? (Students may bring up greenhouse gasses, pollution renewable resources, and/or environmental damage to extract the fuel.)

- Let the students know that they are going to compare two fuels, a fossil fuel, kerosene, and a biofuel, ethanol. We will be looking at how much pollution in the form of soot each gives off, how much carbon dioxide is produced, and how much energy the fuel gives off, all when burned. This will help them to compare the fuels and draw conclusions about which fuel should be used in the future.

Procedure for Lab
This lab consists of three activities to compare ethanol and kerosene. Each activity can be done independently or collectively. Each activity can be done as a whole class demonstration or as lab stations. What you do and how you do it should be determined by your learning objectives and the needs of the students in the classroom.

Which Fuel Burns Cleaner?
1. Using a digital scale, find the mass of each of your two 250-mL beakers and record information on the data sheet.
2. Use two burners, one containing kerosene (blue) and one containing ethanol (clear). Make sure the wick of the burners is just barely above the metal casing. Light the burners and check to make sure the flame height is about 2-3 cm above the burner. Extinguish the flame and adjust the wick if necessary.
3. Set up two ring stands with clamps. Set an alcohol burner in front of each ring stand. Invert the 250-mL beakers and clamp them into place with the opening facing downward. Clamp the beakers directly over each burner, approximately 20 cm above the top of the burner. Make sure each beaker is at the same height.
4. Light each burner and start the timer. Let each fuel burn for 2 minutes. During this time, record any observations of what is happening as the fuels burn.
5. After 2 minutes, extinguish each flame. Give the beakers a couple of minutes to cool. Using a hot pad, or beaker tongs, carefully remove each beaker from its clamps. Set aside and make sure the beaker is completely cool before setting it on a digital scale. Use the digital scale to find the mass of each beaker and record the results. Subtract the final mass from the initial mass of each beaker to find the difference.





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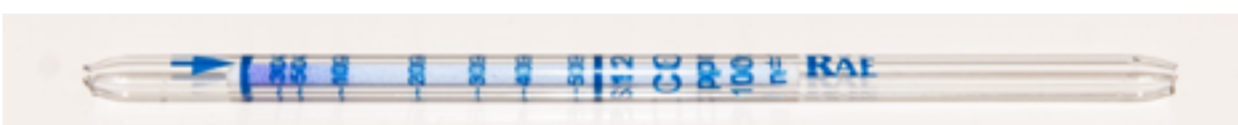
Questions

- What observations did you make as the two fuels were burning?
- Were you able to observe any difference between the two beakers after 3 minutes? What was that difference?
- What was the difference in mass for each beaker?
- What can you conclude about which fuel burns cleaner?

Which Fuel Produces More Carbon Dioxide When Burned?

1. Measure the carbon dioxide level of the classroom. Break off the ends of the gas detection tube. Insert the gas detection tube into the end of the tubing connected to your 100-mL syringe. There is an arrow indicating the direction of air flow on one side of the gas detection tube. The tubing goes on the end opposite of the arrow. Extract 100 mL of air from the room. This will take a couple of minutes. Pull back on the stopper as far as you can and hold. This creates a vacuum. Over time, this will fill with air. As this happens, you will be able to pull the stopper back further. Hold the stopper at the 100-mL mark until the stopper is no longer being pulled back into the syringe.

2. Read the carbon dioxide level of the classroom. Take your reading from where the solid purple band stops. There will be a gradient of lighter purple going further up the tube. The measurement is read from where the solid purple ends and the gradient begins. (Picture below read about 500 ppm.)



3. Break off the ends of another gas detection tube. Insert the gas detection tube into the end of the tubing connected to your 100-mL syringe. Set aside.
4. Burn a glass fuel burner of ethanol in the vent pipe for 2 minutes.
5. Extinguish the flame and cover the top of the vent pipe

6. Through the hole in the side of the pipe, insert the gas detection tube and extract 100 mL of air. Hold the stopper at the 100-mL mark until the stopper is no longer being pulled back into the syringe.
7. Read the carbon dioxide level.
8. Repeat the same procedure (steps 3-7) for the kerosene fuel.
9. Compare the carbon dioxide readings for all three tubes.

Which Fuel Burns the Hottest?

1. Give the students two burners, one containing kerosene (blue) and one containing ethanol (clear). Make sure the wick of the burners is just barely above the metal casing. Light the burners and check to make sure the flame height is about 2-3 cm above the burner. Extinguish the flame and adjust the wick if necessary.
2. Mass each burner and record the initial mass of each burner.
3. Use a graduated cylinder to measure and place 100 mL of room temperature water into the metal cup. (100 mL of water also has a mass of 100 g.)
4. Using a ring stand and ring clamp, position the cup 5 cm above the burner.
5. Use a clamp to suspend the thermometer in the water. The thermometer should not touch the bottom or side of the can. Measure and record the initial temperature of the water in the cup.
6. Light the burners and make sure the flame is centered under the cup. Set the timer for 5 minutes, then extinguish the flame. Measure and record the final temperature of the water.
7. Repeat this process for both fuels. Depending on the time you have in class, this can be done up to three times to develop an average. If you do this more than once, use room temperature water for each test and make sure to clean the soot off the bottom of the cup each time.
8. Find the mass of the burner and record that under the final mass.

During the 5-minute burn time, did the ethanol or kerosene use more fuel?

Teachers Tips

Visit www.kscorn.com for additional resources and teacher tips.

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Carbon Dioxide Concentration Level Reference Chart

Level	Reference
350-450 ppm	Typical outdoor CO2 level.
1,000 ppm	Recommended maintaining under 700 ppm CO2 differential between outdoor and indoor air. “This level is not considered a health risk but is a surrogate for human comfort.”
2,500 ppm	CO2 level of 2,500 ppm diminishes test subjects cognitive function to “dysfunctional” on the taking initiative and thinking strategically indexes.
30,000 ppm	OSHA allows less than 15-minute short-term exposure limit.
40,000 ppm	Immediately dangerous to life or health concentrations (IDLH) (greater than 5 minutes).
~50,000 ppm	30 minute exposure is a lethal concentration in humans, causes unconsciousness.
70,000-100,000 ppm	Few minute exposure is a lethal concentration in humans, causes unconsciousness.

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Lab Analysis

	Trial 1	Trial 2	Trial 3	Average
Initial mass of ethanol and burner				
Final mass of ethanol and burner				
Difference in mass (amount of fuel used)				
Initial mass of kerosene and burner				
Final mass of ethanol and burner				
Difference in mass (amount of fuel used)				

Ethanol	Trial 1	Trial 2	Trial 3	Average
Initial temperature of water				
Final temperature of water				
Change in water temperature				
Kerosene				
Initial temperature of water				
Final temperature of water				
Change in water temperature				

Calculate the amount of energy, measured in calories, given off during the burn and absorbed by the water.

Energy in calories = (100 g of water) x (average change in water temperature)
Divide the calories by the average amount of fuel used to get the amount of energy per g of fuel.

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	Ethanol	Kerosene
Energy absorbed by the water	cal	cal
Mass of the fuel burned	g	g
Energy per gram of fuel	cal/g	cal/g

Reflection and Conclusion
- What can you conclude about which fuel produces the most CO2?
- What can you conclude about which fuel produces the most soot?
- What can you conclude about which fuel produces the most energy?
- Which fuel would you conclude burns cleaner?
- Based off of the data collected, which fuel do you think we should use in the future?
- What additional information would you need to help you reach a more informed conclusion?

Science and Agriculture Careers
To learn more about agriculture careers, visit www.agexplorer.com. You can also find career profiles at www.kscorn.com.

Sources:
Lab-Aids Kit 359

CASE Activity 6.1.1 Clean Smoke

https://lukeskaff.com/measure-carbon-dioxide-co2-levels-test/

Any educator electing to perform demonstrations is expected to follow *NSTA Minimum Safety Practices and Regulations for Demonstrations, Experiments, and Workshops*, which are available at http://static.nsta.org/pdfs/MinimumSafetyPracticesAndRegulations.pdf, as well as all school policies and rules and all state and federal laws, regulations, codes and professional standards. Educators are under a duty of care to make laboratories and demonstrations in and out of the classroom as safe as possible. If in doubt, do not perform the demonstrations.

Which Fuel Burns Cleaner?

1. Using a digital scale, find the mass of each of your two 250-mL beakers and record the information on the chart below.
2. Use two burners, one containing kerosene (orange) and one containing ethanol (clear). Make sure the wick of the burners is just barely above the metal casing. Light the burners and check to make sure the flame height is about 2-3 cm above the burner. Extinguish the flame and adjust the wick if necessary.
3. Set up two ring stands with clamps. Set an alcohol burner in front of each ring stand. Invert the 250-mL beakers and clamp them into place with the opening facing downward. Clamp the beakers directly over each burner approximately 20 cm above the top of the burner. Make sure each beaker is at the same height.
4. Light each burner and start the timer. Let each fuel burn for 2 minutes. During this time, record any observations of what is happening as the fuels burn.
5. After 2 minutes, extinguish each flame. Give the beakers a couple of minutes to cool. Using a hot pad, or beaker tongs, carefully remove each beaker from its clamps. Set aside and make sure the beaker is completely cool before setting it on a digital scale. Use the digital scale to find the mass of each beaker and record the results. Subtract the final mass from the initial mass of each beaker to find the difference.

Initial mass of the beaker over the ethanol.			Initial mass of the beaker over the kerosene.	
Mass of the beaker after burning the ethanol			Mass of the beaker after burning the kerosene	
Difference in mass before and after burning fuel			Difference in mass before and after burning fuel	

What observations did you make as the two fuels were burning?

Were you able to observe any difference between the two beakers after three minutes? What was that difference?

What can you conclude about which fuel produces the most soot?

How might this affect the air quality in a city and human health?

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Which Fuel Produces More Carbon Dioxide When Burned?

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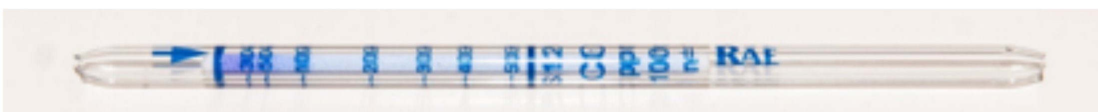

3. Break off the ends of another gas detection tube. Insert the gas detection tube into the end of the tubing connected to your 100-mL syringe. Set aside.
4. Burn a glass fuel burner of ethanol in the vent pipe for 2 minutes.
5. Extinguish the flame and cover the top of the vent pipe.
6. Through the hole in the side of the pipe, insert the gas detection tube and extract 100-mL of air. Hold the stopper at the 100-mL mark until the stopper is no longer being pulled back into the syringe.
7. Read the carbon dioxide level.
8. Repeat the same procedure (steps 3-7) for the kerosene fuel.
9. Compare the carbon dioxide readings for all three tubes.

Fuel	Carbon Dioxide Level
Classroom CO2	
Ethanol CO2	
Kerosene CO2	

What can you conclude about which fuel produces the most CO2?

Which Fuel Burns the Hottest?

1. Use two burners, one containing kerosene (orange) and one containing ethanol (clear). Make sure the wick of the burners is just barely above the metal casing. Light the burners and check to make sure the flame height is about 2-3 cm above the burner. Extinguish the flame and adjust the wick if necessary.
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7. Repeat this process for both fuels to develop an average. Use room temperature water for each test and make sure to clean the soot off the bottom of the cup each time.
8. Find the mass of the burner and record that under the final mass.

	Trial 1	Trial 2	Trial 3	Average
Initial mass of ethanol and burner				
Final mass of ethanol and burner				
Difference in mass (amount of fuel used)				
Initial mass of kerosene and burner				
Final mass of ethanol and burner				
Difference in mass (amount of fuel used)				

Ethanol	Trial 1	Trial 2	Trial 3	Average
Initial temperature of water				
Final temperature of water				
Change in water temperature				
Kerosene				
Initial temperature of water				
Final temperature of water				
Change in water temperature				

Calculate the amount of energy, measured in calories, given off during the burn and absorbed by the water.

Energy in calories = (100-g of water) x (average change in water temperature)
Divide the calories by the average amount of fuel used to get the amount of energy per g of fuel.

	Ethanol	Kerosene
Energy absorbed by the water	cal	cal
Mass of the fuel burned	g	g
Energy per gram of fuel	cal/g	cal/g

During the 5-minute burn time, did the ethanol or kerosene use more fuel?

What can you conclude about which fuel produces the most energy?

Which fuel would you conclude burns “cleaner”?

Based off of the data collected, which fuel do you think we should use in the future? What additional information would you need to help you reach a more informed conclusion?