

HEAT/THERMODYNAMICS:

Heat Content of Biodiesel

Georgia Performance Standards: SCSH1-9, SC2 a & b, SC6 b

National Science Standards: Content Standards A, B: structure and properties of matter, conservation of energy

Objective: Students will learn about the heat content of biodiesel. They will combust samples of the fuel and measure the heat given off. They will compare the biodiesel to petroleum diesel. (They may also compare biodiesels made from different feedstocks or blends.)

Essential Questions:

- Is biodiesel easily combustible?
- Does biodiesel or petroleum diesel give off more heat when it is combusted?
- Which fuel will give more energy for your engine? (Which fuel might have better mileage?)
- What is the value of having an oxygenated fuel?

Background: Combustion of fuel is very important to running a vehicle. Combustion is the reaction of the fuel with oxygen in the air which results in the release of much heat. The force of the explosion caused by the reaction is what drives the pistons down in the cylinder, turning the crankshaft, and eventually resulting in the wheels moving. If the fuel is more easily and evenly combusted, it will result in a higher cetane number (rating used for diesel, like octane for gasoline). Diesel fuels that have higher cetane numbers give easier starts, reduced smoke, less noise, fewer emissions and improved fuel economy. A diesel fuel that has more stored energy (often measured in BTU) gives more miles per gallon and more horsepower.

Principles of calorimetry can be used to calculate how much heat is contained in a fuel. The fuel is burned and the heat released from the combustion reaction can be used to increase the temperature of a known mass of water. Knowing that theoretically all the heat released from the fuel will be absorbed by the water, the equation $q = c \times m \times \Delta T$ can be used to calculate the heat stored in the fuel.

- Materials:**
1. Petroleum diesel
 2. biodiesel (made in lab #2)
 3. Ethanol or acetone for cleaning
 4. alcohol burners/oil lamps
 5. 250 mL beaker
 6. thermometer (preferably digital)
 7. water
 8. Optional: coffee can with the top and bottom cut out

*****Before you start the lab, state your hypothesis on what results you expect to see from doing this lab.**

- Procedure:**
1. Obtain an alcohol burner
 2. Pour about 10 mL of petroleum diesel into the burner. Make sure that the wick is completely soaked through with the fuel before you put the top back on.
 3. Find the mass of the 250 mL beaker.
 4. Fill the beaker $\frac{3}{4}$ full with water (can be from the tap) and find the mass of the water and beaker together.
 5. Set up a ring stand with a ring on it and place wire gauze over the ring.
 6. Place the full alcohol burner just below the Beaker and lower the ring so that the beaker sits about 6 inches from the top of the burner. (Optional: you can place a coffee can around the burner to keep the heat from escaping too far)
 7. Light the burner and record any observations about the flame.
 8. Monitor the temperature of the water, being sure to stir the water every minute.
 9. Record the highest temperature that the water reaches.
 10. Thoroughly clean out the alcohol burner and wick. You may use either ethanol or acetone (whatever your teacher has). You can blow air into the burner to dry it out.
 11. Repeat the procedure using biodiesel. Be sure to dump out the water from the beaker and get fresh water.
 12. Be sure to record any data and observations (notice any differences between the two fuels and the flames?).



- Questions:**
1. What is the mass of the water for each trial?
 2. Using the equation from the 'background,' calculate the amount of heat contained in each of the two diesels.
 3. Which contained more heat, the petroleum diesel or the biodiesel?
 4. Which fuel would probably have a higher cetane number?

Assessment: Lab rubric

Lab Data Sheet – Heat

Hypothesis:

Mass of 250 mL beaker empty: _____g

Mass of 250 mL beaker + water: _____g (for petroleum diesel)

Mass of 250 mL beaker + water: _____g (for biodiesel)

Highest temperature reached: _____°C (for petroleum diesel)

Highest temperature reached: _____°C (for biodiesel)

Observations:

Calculations: $q = c \times m \times \Delta T$

Don't forget to pay attention to units and significant figures!

HEAT/THERMODYNAMICS: Instructor Notes

For an extension activity you can also have the students calculate the heat content in the vegetable oil feedstock. They can compare to see if the energy content of the oil was changed any when it underwent the transesterification reaction to produce biodiesel.