ABSTRACT

In today’s society there is much emphasis on trying to find an alternative fuel source that is renewable and clean. Gasoline, Coal, and Natural gas are conventional fossil fuels that are either refined or directly mined and used. Supplies of these materials are finite, and in addition all produce the greenhouse CO₂ when burned. Alternative renewable fuels should ideally be clean, cheap, and have a high energy density, difficult criteria to meet simultaneously. In the present experiment, an adiabatic calorimeter is used to obtain values of combustion enthalpy for several conventional and alternative fuels.

INTRODUCTION

Bomb Calorimetry is a method for the determination of the enthalpy of combustion for a substance using the thermodynamic principle of energy conservation. The heat produced by the reaction is used to heat a known quantity of water. The heat capacity of the calorimeter is determined through a previous measurement using a standard sample (benzoic acid).

Calorimeter

In this experiment a Parr 1241 Adiabatic Calorimeter was employed. Combustion occurs rapidly and completely in approx. 30 atm of oxygen. Electrical energy is used to ignite the fuel.

Enthalpy of Combustion

The enthalpy of combustion is the energy change at constant pressure occurring when one mole of a substance reacts completely with oxygen. It is denoted as ΔHᵋ. This reaction is typically measured in units of energy J/K. For a substance to be useful as a fuel its value should be large and negative.

METHODS AND MATERIALS

Combustion

• A carefully weighed sample of each fuel was placed in the sample cup inside the Bomb and an iron wire (for ignition) was placed in contact with the sample. This was then placed inside the Bomb and about 30 atm of pure oxygen was pumped into the chamber. 1.5 liters of water was heated to 25 degree Celsius and placed in the calorimeter can together with the bomb. This was then put inside the adiabatic jacket and the ignition apparatus connected. Initial readings were taken for 4 minutes while the system was allowed to come to thermal equilibrium, whereupon the sample was ignited.

Measurements

Every thirty seconds a temperature reading was taken and recorded using a specialized thermometer ranging from 24.9 to 30.0 Celsius with a nominal precision on 0.001°C. These temperatures were then graphed to determine ΔT. The change in temperature was then used to determine ΔU, the change of internal energy, which can be converted to the enthalpy of combustion for the sample inside the bomb.

RESULTS

Fuel types and Enthalpy Values

- Biodiesel : -25.5661 kJ/g
- Gasoline : -29.6423 kJ/g
- Ethanol : -20.9703 kJ/g
- Peat : -16.2688 kJ/g

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CONCLUSIONS

The enthalpy of combustion values that were calculated from this experiment were somewhat surprising. The gasoline used was regular 87 octane obtained from the local gas station. When the gasoline sample was combusted, it generated a large quantity of soot inside the bomb, indicating incomplete combustion. This was not entirely unexpected, given that gasoline engines rely on a premixed fuel-air spray. The peat used was from the Isle of Lewis, cut by John Macleod in 2007. Combustion of the peat sample produced a small quantity of yellowish liquid together with pieces of some kind of reddish solid material. Further analysis of these residues is underway. The biodiesel used was made in the organic lab at Marian by AMES student Jim Foster. The biodiesel sample size had to be adjusted downwards by about a factor of two compared to the standard because of the larger amount of energy produced.

The numerical results indicate that all the alternative fuels underperform gasoline, with biodiesel being the closest in value. The lower values for biodiesel and ethanol can be attributed to the partially oxidized nature of these materials, while the poor value from peat is likely due to residual water content from cellular matter.

REFERENCES

1. Lab handout CHE 328, Spring 2008, Dr. Macrae, Marian University
2. www.chem.hope.edu/~polik/Chem345-2000/bombcalorimetry