Candidate 3 evidence

Relationship between size of an alcohol and the energy content

Aim: to compare the size of an alcohol to the energy content of the alcohol.

Underlying environmental science: A fuel is a chemical that undergoes combustion in oxygen to release energy. When a fuel undergoes complete combustion carbon dioxide and water are produced. These are greenhouse gases. Most fuels used by humans are derived from fossil fuels, oil, gas and coal. Fossil fuels were formed over millions of years, and the carbon contained in them was removed from the atmosphere millions of years ago. The combustion of these fuels releases stored carbon dioxide into the atmosphere and adds to the enhanced greenhouse effect.

Alcohols can be used as fuels and can be produced from biological sources as well as from fossil fuel based sources. When an alcohol is produced from a biological source the carbon it contains has only recently been removed from the atmosphere. Combustion of a biofuel does not add to the greenhouse effect. These biofuels are chemically identical to the fossil fuel version. Two of the more commonly used biofuels are bioethanol and biodiesel. Bioethanol is produced from the fermentation of plant sugars, and biodiesel is produced from oils. The USA is the largest producer of bioethanol, and the EU is the largest producer of biodiesel.

There are various social, economic, environmental and technical issues with biofuel production and use, which have been discussed in the popular media and scientific journals. These include: the effect of moderating oil prices, the "food vs fuel" debate, poverty reduction potential, carbon emissions levels, sustainable biofuel production, deforestation and soil erosion, loss of biodiversity, effect on water resources, the possible modifications necessary to run the engine on biofuel, as well as energy balance and efficiency.

Different alcohols release different amounts of energy when burnt, the reaction is exothermic. In an exothermic reaction the energy value is shown as a negative value as it represents the energy being released from the reaction.

Method: Different alcohols were combusted, and the energy used to heat water. The temperature change in the water was measured and compared. The mass burnt was measured. The energy content of the fuel was then calculated. The alcohols used were methanol, ethanol, propanol and butanol.

Results:

Fuel	Mass at start (g)	Mass at end (g)	Mass change (g)	Temp of water start (°C)	Temp of water end (°C)	Temp change (°C)
Methanol	13.12	11.02	2.1	21	45	24
Ethanol	18.62	17.14	1.48	21	77	56
Propanol	22.48	21.78	0.7	21	56	35
Butanol	18.16	17.05	1.11	21	89	68

The energy for fuel was calculated using the equation cmΔT, where c is the specific heat capacity of water (4.18), m is the mass of water heated in cm^3 (100) and ΔT is the temperature difference.

The energy per gram was calculated by dividing ,the energy released from the fuel (cmΔT) by the number of grams of the alcohol combusted.

Finally, this value was divided by 1000 to convert from Joules to kiloJoules. .

E.g for methanol: cmΔT = 4.18*100*24 = 10032
10032/2.1 = 47800
47800/1000 = 4.78

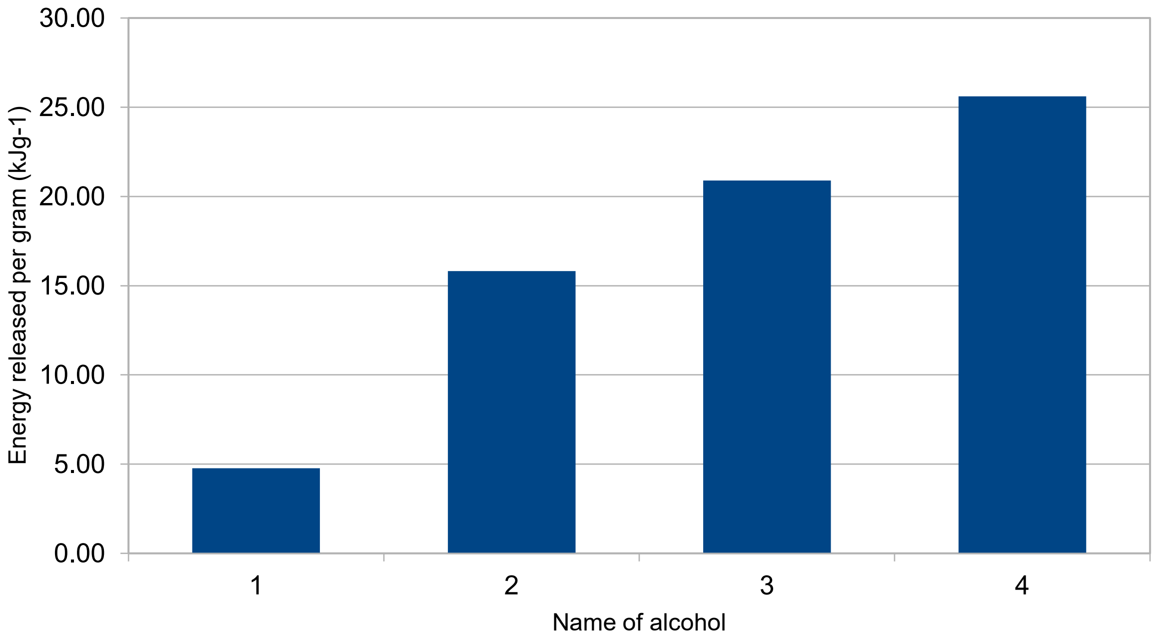
Name of alcohol	Mass burnt (g)	Temperature difference	cmΔT (J)	Energy released per gram (kJ g^{-1})
Methanol	2.1	24	10032	4.78
Ethanol	1.48	56	23408	15.82
Proponol	0.7	35	14630	20.90
Butanol	1.11	68	28424	25.61

Second source: SQA Higher Chemistry Data Book (https://www.sqa.org.uk/files_ccc/Higher-AH-Chemistry-Data-Booklet.pdf)

Enthalpies of Formation and Combustion of Selected Substances

Substance	Standard enthalpy of formation (kJ mol^{-1})	Standard enthalpy of combustion (kJ mol^{-1})
hydrogen	–	–286
carbon (graphite)	–	–394
sulfur (rhombic)	–	–297
methane	–75	–891
ethane	–84	–1561
propane	–104	–2220
butane	–126	–2878
benzene	49	–3268
ethene	52	–1411
ethyne	227	–1300
methanol	–239	–726
ethanol	–278	–1367
propan-1-ol	–303	–2021
methanoic acid	–425	–254
ethanoic acid	–484	–874

Graph:



Analysis: The second source is the expected values for the energy release from different alcohols. These values are much greater than my values, which suggests that there was energy loss to the surroundings. As the experiment was carried out in an identical manner for each fuel, it is likely that this heat loss would have been constant for all the fuels tested, and so whilst this shows a difference from the expected data from the second source, it would not have been different between different fuels in the experiment. This would mean that the experiment was not accurate, but was valid.

Conclusion: The energy released from each fuel increased when the size of the alcohol was increased.

Evaluation: Each alcohol was only tested once, which means the experiment was not reliable. Ideally each alcohol should have been tested 3 times to make the experiment reliable.

The energy released from my experiment was much lower than the published data (second source). Energy was lost to the environment. To reduce this happening, either a wind shield could have been used, or the experiment could have been done in a bomb calorimeter.

The second source did not have the standard enthalpy of combustion for butanol and so I could not compare my value to the correct value. However, the true value of propanol was greater than the actual value for butanol in my experiment, and the true value of butanol would be greater than the true value of propanol, as the value increases as the fuels increase in size, so the comparison I made (my enthalpy of combustion was lower than the expected value) still stands. To absolutely confirm this, the standard combustion of butanol would need to be researched. .

References:

https://en.wikipedia.org/wiki/Biofuel accessed: 8th December 2018

SQA Higher Chemistry Data Booklet https://www.sqa.org.uk/files_ccc/Higher-AH-Chemistry-Data-Booklet.pdf Accessed 10th December 2018