Fuels

Posted by Anonymous on Tue, 2015-09-08 13:08

We have received a few questions on this topic

- We are using toxic alcohols in spirit burners to test fuel efficiency. The students are provided with six alcohols in spirit burners to investigate the usefulness of different alcohols as fuels. Each class is provided with four sets of the spirit burners containing each of the six fuels. The fuels concerned are: methanol, hexan-1-ol, ethanol, propanol, butanol, and pentanol. I am concerned about the safety of using methanol and hexanol as they are both toxic. Is there an appropriate substitute or is it safe to proceed with the above? Can you please suggest any additional safety procedures to ensure this investigation is carried out as safely as possible?
- An IB student would like to investigate the effect in heat energy of mixing ethanol and methanol, ethanol and propanol, or ethanol and butanol. I read the SDS and it doesn't provide any information regarding this query. Is this safe?
- I have been asked to provide diesel, kerosene, methanol and ethanol to be used in spirit burners for an evaluation on different fuels. Is it safe to do so? I am particularly concerned about the diesel.

Voting:
☆☆☆☆☆
No votes yet

Year Level:
Senior Secondary
Laboratory Technicians:
Laboratory Technicians

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Submitted by on 17 September 2015

Answer reviewed 27 February 2023

Investigating fuel efficiency

Fuel efficiency can be investigated by determining the heat of combustion of fuels such as alcohols, using spirit burners. When alcohols are burnt in oxygen, a large amount of heat is released and the reaction is said to be exothermic.

Methanol, ethanol, propan-1-ol, butan-1-ol,pentan-1-ol and hexan-1-ol are all aliphatic [1]alcohols with the general formula $C_nH_{2n}+1$ OH where n is greater than or equal to 1. The functional group is the hydroxyl group (–OH). Alcohols [2] are good fuels as they burn in oxygen to give a large amount of heat. The standard enthalpy change of combustion of a compound is the heat change that occurs when 1 mole of a substance is completely burned in oxygen, under standard conditions (at 1 atmosphere pressure and at $25^{o}C$).

The equations for the combustion of methanol and ethanol are:

$CH_3OH_{(l)}$ + 1 1/2$O_{2(g)}$? $CO_{2(g)}$ + 2$H_2O_{(g)}$?HOC=-726 kJmol-1

$C_2H_5OH_{(l)}$ + 3$O_{2(g)}$? 2$CO_{2(g)}$ + 3$H_2O_{(g)}$?HOC= -1367 kJmol-1

A known mass of alcohol is burned in a spirit burner and the heat released is transferred to a metal can containing a known volume of water. From the resulting temperature rise, the enthalpy of combustion of ethanol can be calculated. As the number of carbon atoms increases, the enthalpy change of combustion becomes more negative.

?HOC= Mass X Specific heat capacity X Rise in temperature

= mc?T

During this experiment the volume of water used and the distance between the wick of the spirit burner and the bottom of the calorimeter should be kept constant.

Mixing of alcohols

Methanol, ethanol, propan-1-ol and butan-1-ol belong to the same homologous series, which means they have similar chemical properties because they possess the same functional group.[3] For alcohols, the functional group is the hydroxyl group (-OH). These are small simple alcohols, with only one functional group, and are compatible in mixtures and if heated or combusted. Therefore, mixtures are safe to use and can easily be made and Science ASSIST recommends the following:

- carry out a site specific risk assessment see the Science ASSIST Risk Assessment Template [4]
- refer to Safety Data Sheets (SDSs) of all the alcohols used in the experiment
- wear suitable PPE such as laboratory coat, gloves, safety glasses and closed in shoes
- conduct this experiment under an operating fume cupboard or in a well-ventilated room, investigating the enthalpy change of one mixture at a time.

Spirit burner safety

There are some important safety aspects to be considered when using spirit burners. There is a potential, if good practices are not observed, for the flame to travel back into the burner and/or an explosive air-fuel mixture may be generated.

Here are some safety instructions for the use of spirit burners:

- Observe standard laboratory safety practice such as long hair tied back and wearing safety glasses
- Check that the burner is a well-constructed clear glass vessel made of robust glass with no flaws, so that the level of the fuel can be seen. The shape should be a squat form that is not easily toppled.
- **Ensure that the wick fits tightly in the neck of the wick holder and that the wick holder fits firmly in the burner.** This should form a good seal with both the glass and the wick so that in the event of toppling, the spirit does not rapidly leak out and catch fire.
- **It should have a tight fitting extinguishing cap**: that fits over the wick and extinguishes the flame.
- Label the spirit burner with the fuel that will be used
- Fill the burner using a funnel, to avoid spills and do this in an operating fume cupboard with no sources of ignition. Students should **not** refill the burners.
- Wipe any excess fuel from the outside of the burner.
- **Burners should be filled to more than half full.** Keeping the volume of fuel in the bottle above 50% will help to avoid an explosive air fuel mixture in the bottle. To avoid having to use a larger volume of the fuel to maintain the less than 50% air ratio, an inert object like some glass beads or marbles could be added to the flask.
- Spirit burners should be upright when lighting and not be moved when alight
- **They should be used in a well-ventilated room**
- At the conclusion of the activity, empty the unused fuel into a labelled screw capped storage bottle and allow any residue in the spirit burner to evaporate in an operating fume cupboard.
- Do not store the spirit burners with fuel in them, because they do not provide a vapour tight seal
- Do not have the stock bottles of fuels in the classroom during the activity

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Methanol, ethanol and kerosene are all classed as flammable liquids, while diesel is classified as combustible. 5 Vapours from flammable liquids can form explosive mixtures with air. These vapours can also travel to a source of ignition and flash back to its point of generation. The lower the flashpoint the more easily these liquids can be ignited. The flashpoint of the fuel is the temperature at which sufficient vapour is produced to maintain a flame. The flash point for methanol is 12°C; methylated spirits 13°C; ethanol is 13°C, kerosene about 38°C, while for diesel it is about 56 °C.

Kerosene and diesel are both products of crude oil, generally separated by fractional distillation. Since they are not pure substances, an exact flash point cannot be given. Kerosene generally consists of carbon chains of 12 to 15 carbon atoms while diesel is in the next range being 16 to 19 carbon atoms.

Methanol is a highly flammable and toxic alcohol. It is toxic by inhalation, as well as ingestion and via the skin, so MUST be dispensed using an operating fume cupboard and wearing relevant PPE such as safety glasses, laboratory coat, gloves and closed in shoes. This is the most volatile out of all these fuels. Explosions have been reported using this fuel in spirit burners, but this appears to be when the above safety measures have not been observed.2

Ethanol is a highly flammable alcohol.

Methylated spirits is highly flammable. This is generally about 95% ethanol and commonly used in camping spirit burners. Note: some manufacturers include methanol in the composition of this fuel.

Kerosene is a well-established heating and lighting fuel that is usually coloured blue and has a distinctive smell. Combustion produces a complex mixture of gases, such as carbon dioxide and carbon monoxide, water, airborne solids and organic compounds.

The above fuels would be suitable for testing fuel efficiency; however, **it must be conducted in a well-ventilated room, following all the above mentioned safety instructions for using spirit burners. In addition, we recommend limiting the number of methanol and kerosene burners to one per class.**

Diesel: Due to the high flash point of diesel, it may not ignite under normal room conditions, where the temperature is around 20°C. Combustion of diesel also produces a complex mixture of products such as toxic and/or irritating fumes, smoke and gases including carbon monoxide, carbon dioxide and oxides of nitrogen as well as organic compounds, including benzene-derivatives and polycyclic aromatic hydrocarbons. In 2012, the International Agency for Research on Cancer reclassified diesel engine exhaust as carcinogenic to humans (Group 1).[6] Science ASSIST does not recommend the use of diesel in this activity.

References

1 ThoughtCo. website, Helmenstine, A., (2019, July 3), *'Aliphatic hydrocarbon definition',* https://www.thoughtco.com/definition-of-aliphatic-hydrocarbon-604763

2 Chem Supply website, (2022) *'Safety Data Sheet*'. Please search the product information page on the website for the latest version for each alcohol or fuel: https://shop.chemsupply.com.au/

3 ThoughtCo. website, Helmenstine, A., (2019, July 3), *'Functional groups definition',* https://www.thoughtco.com/definition-of-functional-groups-604473

4 Science ASSIST website, (2014, July), '*Risk assessment template'* https://assist.asta.edu.au/resource/2298/risk-assessment-template

5 Worksafe, Queensland, (2022), search document for '*A guide for flammable and combustible liquids'* https://www.worksafe.qld.gov.au/safety-and-prevention/hazards/hazardous-...

6 Victorian Trades Hall Council (2015) '*Diesel – declared carcinogen'* https://www.ohsrep.org.au/diesel_-_declared_carcinogen

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Submitted by VIC003 on 28 February 2025

Thank you for this information. I can always rely on ScienceASSIST to have thought of the things that come up from a Lab Tech's point of view.