**VCE Chemistry Unit 3**

**SAC 1: A report on a laboratory Investigation on Synthesis and analysis of Biodiesel**

Time allowed: TBA hours

Name : ...................................................................................................

Result : / 50

*Weighting*: This assessment will contribute 50 marks out of 100 marks allocated to school-assessed coursework for Unit 3. (The overall SAC result for Unit 3 contributes 16% to the study score.)

*Important Information:* Show your working for all questions, which require a numerical answer. Numerical answers **must** include units and be to the correct number of significant figures.

*Materials allowed*: (modify as required)

* Scientific calculator only
* Textbook
* Pen, pencil, ruler and eraser
* Spare blank sheets of paper

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**Theory**

Rudolf Diesel, inventor of the Diesel engine, stated in 1912 "*The use of vegetable oils for engine fuels may seem insignificant today. But such oils may become in course of time as important as petroleum and the coal tar products of the present time".* It is possible to operate a Diesel engine using a much wider range of fuels than for petrol engines without doing damage to the motor. One of Rudolf Diesel’s original engines ran on peanut oil, but modern Diesel engines would be difficult to start and might not perform very well if they were fuelled by vegetable oil.

In the century since these engines were first invented, they have been tailored significantly to make them particularly suited to the fuel that we now call “Diesel”. This substance is made from petrochemicals by distilling it from crude oil, to give a liquid that is much less viscous and less dense than peanut oil. Modern Diesel flows well at low temperatures and has components that give engines a long lifespan.

Vegetable oil is a triglyceride molecule, which is made up of a glycerol molecule connected via ester bonds to three fatty acid molecules. During this reaction, the ester bonds are broken (using potassium hydroxide as the catalyst) forming a molecule of glycerol and three fatty acid molecules. The methyl- group from the methanol then attaches itself to the fatty acid molecules to form biodiesel (an ester). The value of ‘n’ in the carbon chain depends on what type of vegetable oil is used in the production of biodiesel. The biodiesel made from vegetable oil might be suitable to run some older diesel engines.



**Aims**

To prepare a sample of biodiesel from vegetable oil

To measure some of the properties of the biodiesel and compare these to that of petrodiesel.

**Equipment**

Candle wick; crucible; distilled water; evaporating dish; glass jar with sealable lid; glass rod; mass balances; matches; measuring cylinders (10, 50 and 100 mL); methanol; plastic Pasteur pipettes; potassium hydroxide; stop watch; thermometer; test tubes (two) with rubber stoppers; and vegetable oil

**Safety**

*Risk assessment table*

|  |  |  |
| --- | --- | --- |
| **Material or procedure** | **Hazard** | **Management** |
| Potassium hydroxide pallets | Corrosive | Wear safety glasses, labcoat and gloves (PPE) |
| Methanol | Highly flammable, toxic and an irritant to the skin | Keep away from naked flames or sources of ignition and wear PPE |
| Biodiesel | Flammable, toxic and an irritant to the skin | Wear PPE |
| Petrodiesel | Highly flammable, toxic, an irritant to the skin, gives of pungent odour | Keep away from naked flames or sources of ignition and wear PPE |

*It should be noted that all the safety information regarding Biodiesel is not fully available at this stage.*

Complete and indicate by signing below that you have understood the information contained in the risk assessment table above

**Name:**

**Signature: Date:**

**Procedure**

**Part A: Synthesis of Biodiesel**

Biodiesel is made from vegetable oil by adding methanol and a potassium hydroxide catalyst and shaking the mixture in a glass jar. The mixture will eventually separate into two components. The top layer will be the biodiesel, and the bottom layer is glycerol, an important ingredient in soap.

1. Weigh an empty glass jar with it’s lid.
2. Weigh out 0.4 g of KOH pellets and add this to the glass jar.
3. Add 10 mL of methanol to the jar and swirl the solution until the KOH pellets dissolve.
4. Add 50 mL of vegetable oil to the jar, screw the lid on securely and shake the mixture vigourously for 10 minutes.
5. Let the flask sit for at least 30 mins (overnight better) and record your observations.
6. Remove the glycerol (bottom layer) using a plastic Pasteur pipette and keep the biodiesel (top layer).
7. Add 5 mL of saturated NaCl solution to the jar, shake gently 2-3 times and allow the mixture to separate (at least 30 mins) recording your observations.
8. Remove the salt water (bottom) layer using a Pasteur pipette.
9. Weigh the glass jar, lid and biodiesel.
10. Determine the mass of biodiesel made and record this in the results table.

**Part B: Properties of Biodiesel**

**(a) Density**

1. Weigh a 10 mL measuring cylinder
2. Add 10 mL of the biodiesel to the measuring cylinder
3. Reweigh the measuring cylinder and the biodiesel

**(b) Effect of temperature on flow rates**

1. Fill one test tube with Biodiesel nearly filled up to about 1.0 cm from the top
2. Fill another test tube to the same level with petrodiesel (*do this step in a fume cupboard*)*.*
3. Securely place a rubber stopper in each test tube.
4. Measure the temperature of the room and invert each test tube, recording the time it takes for the air bubble to reach the top of the test tube in your results table.
5. Place each test tube into an ice/water bath and allow the temperature to equilibrate (around 10 mins), then repeat step 4 at the lower temperature (record the temperature of the ice/water bath).
6. Place each test tube into a beaker of warm water (around 35˚C) and allow the temperature to equilibrate. Measure the temperature of the water, then repeat step 4.

**(c) Energy content of Biodiesel**

1. Weigh an empty crucible and record its mass
2. Add about 1 mL of the biodiesel to the crucible
3. Reweigh the crucible and the biodiesel
4. Insert a wick into the crucible
5. Weigh an empty evaporating dish, then add 100 mL of water to the evaporating dish.
6. Place the crucible (containing the biodiesel) into the evaporating dish and record the temperature of the water
7. Place the evaporating dish into a fume cupboard onto a heatproof mat and light the wick with a match (start timing at this point).
8. Stir the water gently with a glass rod and record the temperature of the water every 30 sec in your results table.
9. Once the flame has extinguished itself, keep recording the temperature of the water until the temperature starts to decrease.

**Results/Calculations**

**Part A: Synthesis of Biodiesel**

*Table of mass results*

|  |  |
| --- | --- |
| **Item** | **Mass in grams** |
| mass of empty glass jar and lid |  |
| mass of glass jar, lid and biodiesel |  |
| mass of biodiesel synthesised |  |

Observations from part A:

**Part B: Properties of Biodiesel**

**(a) Density**

*Table of mass results*

|  |  |
| --- | --- |
| **Item** | **Mass in grams** |
| mass of empty measuring cylinder |  |
| mass of measuring cylinder plus 10 mL biodiesel |  |
| mass of 10 mL of biodiesel |  |

(i) Determine the density of biodiesel in g mL-1

**(b) Effect of temperature on flow rates**

*Table of time taken (sec) for bubble to reach top of test tube when inverted for biodiesel and petrodiesel at various temperatures.*

|  |  |  |
| --- | --- | --- |
| **Temperature (˚C)** | **Biodiesel** | **Petrodiesel** |
| Ice/Water bath |  |  |
|  |  |
| Room temperature |  |  |
|  |  |
| Warm water |  |  |
|  |  |

**(c) Energy content of Biodiesel**

*Table of mass results*

|  |  |
| --- | --- |
| **Item** | **Mass in grams** |
| mass of empty crucible |  |
| mass of crucible plus 1mL biodiesel |  |
| mass of biodiesel used |  |
| mass of empty evaporating dish |  |
| mass of evaporating dish plus 100 mL water |  |
| mass of water in evaporating dish |  |

*Table of temperature of water (˚C) at time intervals after biodiesel lit*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Time (sec)** | **Temp (˚C)** | **Time (sec)** | **Temp (˚C)** | **Time (sec)** | **Temp (˚C)** |
| 0 |  | 210 |  | 420 |  |
| 30 |  | 240 |  | 450 |  |
| 60 |  | 270 |  | 480 |  |
| 90 |  | 300 |  | 510 |  |
| 120 |  | 330 |  | 540 |  |
| 150 |  | 360 |  | 570 |  |
| 180 |  | 390 |  | 600 |  |

(i) Initial water temperature =

(ii) Final water temperature =

(iii) Change in temperature of water: T(H2O) =

(iv) Given that the specific heat capacity of water is 4.18 J g-1 ˚C-1, determine the amount of energy (in J) gained by the water:

 (v) Hence, determine that amount of energy released by the combustion of the biodiesel (in kJ):

(vi) Using the mass of Biodiesel burned, determine, the energy content of the biodiesel in kJ g-1:

(vii) Using the density of biodiesel, calculate the volume (in litres) of biodiesel that was burned in this experiment.

(vi) Hence, determine the energy content of Biodiesel in kJ L-1:

**Questions**

1. Given that the Australian Standard for the density of petrodiesel to be in the range of 0.820 to 0.850 g mL-1, how does the density of the Biodiesel compare to that of petrodiesel?

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1. How did the flow rate of biodiesel change with temperature and how did this compare with that observed for petrodiesel?

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1. Given that the energy content of petrodiesel is around 40 MJ L-1, how did the energy content of the biodiesel compare to this?

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1. If the diesel tank of a car can hold a maximum of 55 L, how much total energy (in kJ) would be available from the car if it were run on the biodiesel produced in this practical?

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1. Assuming that 40% of the energy of the biodiesel is converted into energy to move the car (i.e. kinetic energy), how much of the energy of the biodiesel would be converted to kinetic energy?

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1. Petrodiesel contains about 75% saturated hydrocarbons (i.e. alkanes) ranging from C10 to C15, with an average of 12 carbons in the hydrocarbon chain. Draw the structure of the alkane with 12 carbons in the chain and also indicate what type of intermolecular forces exists between molecules of petrodiesel.
2. Given that the biodiesel you have produced is a fatty acid ester molecule (structure given in the introduction), discuss the similarities and/or differences of the intermolecular forces, polarity and melting points between petrodiesel and biodiesel.

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1. If a substance is hygroscopic it absorbs water over a period of time as the water molecules are attracted to that substance. In reference to their structures, would diesel or biodiesel be more hygroscopic and how would this affect the efficiency of the fuel when burned?

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**Discussion**

1. The analysis of errors is important in any practical activity/investigation that is undertaken. Discuss the errors associated with this practical investigation and suggest improvements to the experimental method.

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1. How pure is the biodiesel made from this experiment and what contaminants might it contain? Discuss also the impacts that any impurities would have on the efficiency of which biodiesel burns.

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1. Compare the suitability of petrodiesel and biodiesel as transport fuels in different climates.

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1. Compare the environmental impacts (of sourcing and also burning) petrochemical and biodiesel.

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**Conclusion**

Write a conclusion briefly summarizing the results of this practical investigation.

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