Fractional distillation of crude oil

Learning objectives

1. Distil a crude oil substitute to simulate industrial fractional distillation of crude oil.
2. Observe and record the different properties of the fractions produced.
3. Describe how the different fractions are formed and link this to their physical properties.
4. Explain why different fractions have different properties.

Introduction

Crude oil is a **mixture** of chemical **compounds**, mostly **hydrocarbons**, which are molecules consisting of **carbon** and **hydrogen** only. It is an incredibly useful **resource**. The molecules within the mixture have different physical and chemical properties which can then be used in a wide variety of ways.

To separate the **mixture** into its separate parts (or **fractions**), a process known as **fractional distillation** must be used.

In this experiment, you will use a crude oil substitute to **model** the fractional distillation process. After collecting four fractions at different temperatures, you will test each one for **viscosity**, colour, smell and **flammability**.

Equipment

- Safety glasses
- Bunsen burner
- Heat resistant mat
- Side-arm hard glass test tube
- Bent delivery tube and rubber connection tubing
- Small sample tubes, at least 20 mm x 5 mm (or small test tubes), x 4
- Thermometer, 0–360°C, with cork to fit side-arm test tube
- Teat pipette
- Beaker, 100 cm^3
- Hard glass (borosilicate) watch glass
- Mineral or ceramic fibre
- Wooden splint

Chemicals (per group)

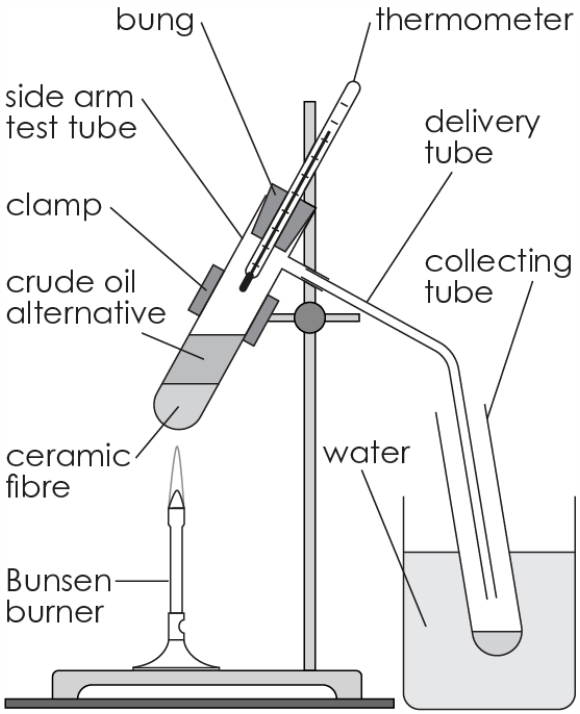
- Crude oil substitute (HIGHLY FLAMMABLE and HARMFUL), about 2 cm^3



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Method

1. Place about a 2 cm^3 depth of ceramic fibre in the bottom of the side-arm test tube. Add about 2 cm^3 of crude oil substitute to this, using the teat pipette.



2. Set up the apparatus as shown in the diagram. For the first fraction only, make sure that you place a beaker of cold water around the collecting tube. The bulb of the thermometer should be level with, or just below the side-arm. Heat the bottom of the side-arm test tube **gently**, with the **lowest Bunsen flame**. Watch the thermometer.
3. When the temperature reaches 100°C, replace the collection tube with another empty one. The beaker of water is no longer necessary.
4. Collect three further fractions at the following temperatures:
    - Room temperature to 100°C
    - 100–150°C
    - 150–200°C
    - 200–250°C
5. A black residue will remain in the side-arm test tube. Test the four fractions for viscosity (how easily do they pour?), colour, smell and flammability, and record what you observe in your results table.
    - To test the smell, gently waft the smell towards you with your hand.
    - To test for flammability, pour the fraction onto a hard glass watch glass and light the fraction with a burning splint.
6. Keep one set of fractions and combine them to show that they form a mixture very like the original sample.

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Results

Fraction temperature range (°C)	Viscosity *how easily does it flow?* 1 = least viscous 4 = most viscous	Colour	Smell	Flammability *how easily does it set on fire?* 1 = least flammable 4 = most flammable
Room temperature to 100				
100–150				
150–200				
200–250				

Questions

Complete the following sentences using the words provided in bold:

1. Describe what crude oil is.

hydrogen **mixture** **hydrocarbons** **carbon**

Crude oil is a _____ of compounds called _____.

These contain _____ and _____ only.

2. Explain why crude oil is a valuable resource.

lubricants **mixture** **fuels** **heating**
feedstock **plastics** **transport**

Crude oil is a valuable resource as it contains a _____ of compounds including _____ that we can use for _____ and _____ as well as chemicals that act as a _____ to manufacture solvents, _____ and _____.

3. State the order of viscosity as the boiling point range increases.

_____

4. State the order of flammability as the boiling point range increases.

_____

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Further questions

Complete the following sentences by deleting the wrong word from the brackets:

5. Describe what type of resource crude oil is. Explain why this is.

Crude oil is an example of a **[renewable/non-renewable (finite)]** resource. This is because it is being used **[more quickly/more slowly]** than it is being replaced.

6. Explain the process of distillation.

During distillation, the liquid is first **[heated/cooled]**. It then turns into a **[gas/solid]**. This process is known as **[freezing/evaporation]**. When it **[cools/heats]** it begins to **[melt/condense]** back into a **[liquid/solid]**.

7. Explain why the flammability of the fractions changes in the way you observed.

Fractions with **[higher/lower]** boiling points contain larger molecules. Larger molecules are **[more/less]** volatile (they do not evaporate easily into a gas at room temperature), making it much **[harder/easier]** for them to catch fire compared with light, highly volatile molecules.

8. Explain why the viscosity of the fractions changes in the way you observed.

Fractions with **[higher/lower]** boiling points contain longer hydrocarbon chains. These longer chain molecules easily tangle together and have **[weaker/stronger]** intermolecular forces between them, making the liquid thicker and **[easier/harder]** to pour.

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