EXPERIMENT: CATALYTIC CRACKING OF PARAFFIN OIL

INTRODUCTION

Catalytic cracking is mainly used to split large crude oil components into smaller, more useful molecules. In this experiment we will crack paraffin oil by using glass wool (SiO_2) as a catalyst and test the nature of the gaseous products.

Background to catalytic cracking

Catalytic cracking differs from thermal cracking in the type of molecules that are reacted. Thermal cracking is normally used on small to medium-sized hydrocarbon molecules such as ethane to produce ethene, which is used as a precursor to a number of useful substances. A typical thermal cracking reaction is shown below:

$$C_2H_{6\,(g)} \xrightarrow{\text{Heat}} C_2H_{4\,(g)} + H_{2\,(g)}$$

Catalytic cracking is used on larger hydrocarbon molecules to produce smaller saturated and unsaturated molecules some of which, can undergo thermal cracking to produce ethene while others are used to blend fuels such as gasoline.

The conditions used in catalytic cracking can be manipulated so as to have some control over the products obtained by the reaction. A typical catalytic cracking reaction can be as shown below:

$$C_{14}H_{30\,(g)} \xrightarrow{\text{Catalyst}} C_{12}H_{26\,(g)} + C_2H_{4\,(g)}$$

Testing for the presence of unsaturated hydrocarbons:

1. Unsaturated hydrocarbons burn with a smoky flame while saturated hydrocarbons burn with a clean flame.

2. Unsaturated hydrocarbons decolourise (remove the colour) from a solution of bromine almost immediately while saturated hydrocarbons will do so more slowly and only if exposed to strong light or when heated.

AIM

1. To perform catalytic cracking on a sample of paraffin oil.

2. To determine whether the gaseous products from the cracking are saturated or unsaturated molecules.

MATERIALS

- 4 X 18 mm test tubes on a rack
- 3 X Rubber stoppers
- Retort stand, boss head and clamp
- 25 mm diameter “Pyrex” glass test tube
- 25 mm 1-hole rubber stopper fitted with short glass delivery tube and 30 cm rubber tubing
- 10 mL measuring cylinder
- Glass wool
- 500 mL beaker
- Boiling chips
- Bromine in trichloroethane solution
- Matches
- Bunsen burner and mat

METHOD AND SAMPLE RESULTS

1. Pack some glass wool into the Pyrex glass tube to a depth of about 2 cm. Slowly transfer 2 mL of the paraffin oil into the glass wool using a dropper and three quarter fill the rest of the tube with boiling chips. Connect the gas delivery system to the glass tube as shown in the diagram below.

2. Fill the 500 mL beaker with water and then invert the 4, 18 mm test tubes already filled with water into the beaker, making sure that no air enters the water filled tubes.

3. Clamp the Pyrex tube horizontally and set up the apparatus as shown in the diagram below:

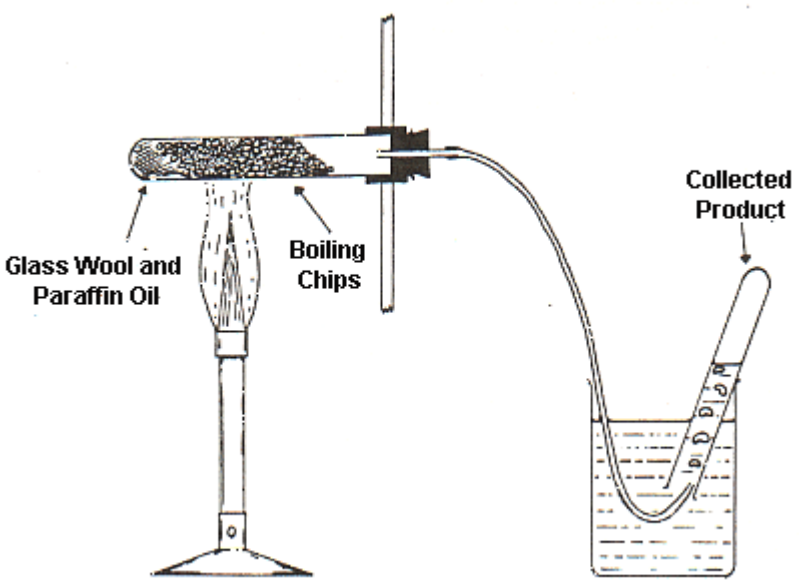

Diagram modified from "Year 12 Chemistry Prac Manual" Presentation College, Moe. 1986. Page 37.

4. Heat the Pyrex tube around the boiling chips but not directly at the glass wool.

5. Collect the first two test tubes of gas by displacement of water and discard. Collect gas in the next two tubes and stopper while still under water.

6. Remove the stopper of the last tube filled with gas and ignite with a match. Record observations.

SAMPLE RESULTS

Gas will ignite with a smoky, smelly flame.

1. Add 2 drops of bromine solution to the other test tube and record observations.

   Sample result
   The bromine solution is decolourised immediately

2. Allow equipment to cool down, disassemble and discard glass wool and boiling chips as instructed by teacher.

SAFETY

- Safety goggles should be worn at all times during the experiment.
- Check the gas collecting assembly thoroughly for leaks as the gas produced is highly flammable.
- Do not heat the glass wool directly as the reaction will proceed too quickly or a pressure build-up in the collecting assembly may result.

DISCUSSION QUESTIONS

QUESTION 1
Suggest why the first two collecting test tubes were discarded during the experiment.

QUESTION 2
Assuming that the formula for a major component of paraffin oil is $C_{16}H_{34}$, write an equation for a possible reaction during the cracking of paraffin oil.

QUESTION 3
Write an equation for the combustion of the gas produced during the cracking reaction.

QUESTION 4
Write an equation for the reaction between the gas produced by the cracking of paraffin oil and bromine.

SOLUTIONS TO DISCUSSION QUESTIONS

QUESTION 1

The top section of the Pyrex tube as well as the rubber tubing contained air. As the product gases were being produced during the reaction, this air would have been pushed ahead into the collecting tube. Two tubes were discarded to make sure that the gas collected from then on contained no air.

QUESTION 2

A number of reactions are possible, below are a couple of examples:

I. $C_{16}H_{34}(l) \rightarrow C_{14}H_{30}(l) + C_2H_4(g)$

II. $C_{16}H_{34}(l) \rightarrow C_{13}H_{28}(l) + C_3H_6(g)$

QUESTION 3

The gas produced is an alkene, either propene or ethene and like other hydrocarbons they burn in air to produce carbon dioxide and water according to the following equation:

$$C_2H_4(g) + 3O_2(g) \rightarrow 2H_2O(g) + 2CO_2(g)$$

QUESTION 4

$$C_2H_4(g) + Br_2(l) \rightarrow CH_2BrCH_2Br(g)$$