CHEMISTRY

Reactions of Hydrocarbons with Bromine Water

❖ *Aim*

To determine and compare the reactivity of saturated and unsaturated hydrocarbons with bromine water solution.

❖ *Hypothesis*

The unsaturated hydrocarbons will prove to be more reactive with bromine water than the saturated hydrocarbons.

❖ *Method*

1. Five test tubes were arranged on a test tube rack and numbered accordingly.
2. A series of hydrocarbons, including cyclohexane, toluene, 1-hexene and cyclohexene, were assembled in a fume cupboard and each was allocated a separate pipette for use. The laboratory was cleared for sources of ignition prior to the conduction of the experiment and safety glasses were worn.
3. Each hydrocarbon was systematically designated a corresponding numbered test tube, which was recorded.
4. 2mL of each hydrocarbon was measured, using a pipette, and transferred to its corresponding test tube.
5. 2mL of bromine water solution was then added, using a pipette, to each test tube. 4mL of bromine water was transferred to the fifth test tube.
6. Each test tube was carefully shaken and observed over a period of approximately 10 minutes.
7. The waste material was stored in a beaker for a subsequent safe disposal (as opposed to being drained down a sink).

❖ *Results*

Hydrocarbon	Observations prior to addition of Br + H_2O	Observations immediately after addition of Br + H_2O	Observations after shaking for 10 minutes
Cyclohexane	Clear, colourless	Light yellow layer forms at the base of test tube, clear layer develops on top.	Opaque yellow layer develops on top, transparent yellow layer forms at the base
Toluene	Clear, colourless	Light yellow layer forms at the base of test tube, clear layer develops on top.	Clear layer forms on top, transparent yellow layer forms at base.
1-hexene	Clear, colourless	Light yellow layer forms at the base of test tube, clear layer develops on top.	Opaque yellow layer forms at the top, transparent yellow layer develops at base
Cyclohexene	Clear, colourless	Light yellow layer forms at the base of test tube, clear layer develops on top.	Clear, colourness layer forms on top, slightly yellow, transparent layer develops underneath.

❖ *Discussion*

The colour change undergone by each hydrocarbon with the bromine/water solution indicates that a reaction occurred between the substances present. This reaction transpired between the alkenes and the bromine water as a consequence of the double bond present in each hydrocarbon molecule. The double bond, being a site of high electron density, reacted readily with the highly electronegative atoms of bromine. This type of reaction is called halogenation due to the dihalogeno addition products it generates, shown below:

Cyclohexene + Bromine ⟶ 1,2 - dibromocyclohexane

1-hexene + Bromine ⟶ 1,2-dibromohexane

The exposure of the substances to UV light was also sufficient to override the activation energy for the reaction between bromine water and the other two hydrocarbons (toluene and cyclohexane). Consequently, both hydrocarbons underwent a substitution reaction in which a C-H bond is broken and a new C-Br bond is formed. These reactions are shown below:

Cyclohexane + Bromine ⟶ bromocyclohexane + hydrogen bromide

Toluene + Bromine ⟶ (bromomethyl)benzene + hydrogen bromide

Halogenation is an important reaction that is used frequently in the industrial production of various valuable substances. It is used to make the extremely important chloroethane, which is the starting material for the manufacture of polyvinyl chloride (PVC). Similarly, bromine and ethane will produce a product that was also used in leaded petrol as a lead scavenger. This product (1,2 – dibromoethane) was also used as a potent insecticide, but its use has decreased due to its carcinogenic properties.

❖ *Conclusion*

All of the hydrocarbons underwent a reaction with the bromine water. Cyclohexene and 1-hexene underwent an addition reaction and halogenation occurred. However, toluene and cyclohexane underwent substitution reactions due to UV exposure and similarly, halogenation occurred as a result.