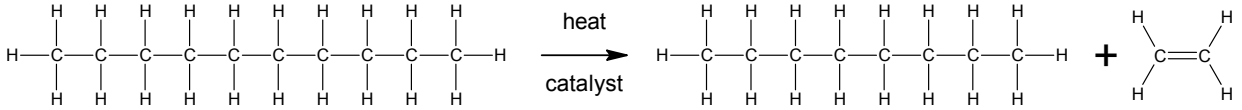
Topic C1.4: Products from oil

Summary

Crude oil is a mixture of mainly **saturated hydrocarbons** (*i.e.* no C=C double bonds) known as alkanes, which can be separated into **fractions** by the process of **fractional distillation**. There is much greater demand for the low boiling point fractions from crude oil as they make better fuels. The higher boiling fractions are generally processed further to produce more useful products. This process by which this is achieved is known as **cracking.** The usual method is to heat the fraction to a high temperature in the absence of air but in the presence of a catalyst in a process known as **catalytic cracking**. The reaction which occurs is a **thermal decomposition** (*i.e.* large molecules are broken down by the action of heat into simpler ones). The products of thermal decomposition of a saturated hydrocarbon can be complex but must include at least one **unsaturated hydrocarbon** (*i.e.* at least one C=C double bond) as in the example below. The product mixture from cracking is separated by further fractional distillation and refining (purification).



decane octane ethene

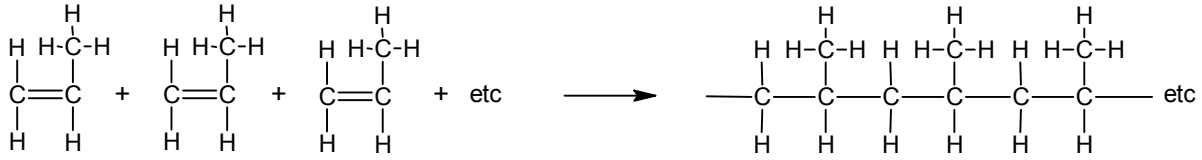
Hydrocarbons containing a single C=C double bond are known as **alkenes** and have the general formula $\mathbf{C_nH_{2n}}$.

A test for an unsaturated molecule is that it will decolourise orange bromine water.

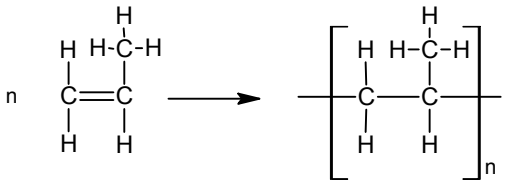
Alkenes are very useful products because they are more reactive than alkanes. They burn in air with a smokier flame than alkanes. More importantly, they undergo **addition reactions** (in which two or more molecules combine to form a single product).

Ethene undergoes an addition reaction with steam in the presence of a catalyst to form ethanol (alcohol), which has many uses including as a fuel. Ethanol can also be produced (in a less pure form) by fermentation.

A particularly useful example of an addition reaction is **addition polymerisation** in which many small molecules (**monomers**) join together to form a single long chain **polymer**. The double bond in one monomer opens up and a new single bond is formed to the next monomer leading to a chain reaction. For example ethene (C_2H_4) polymerises to form poly(ethene); propene (C_3H_6) polymerises to form poly(propene) as in the example below:



or alternatively,



where n is a very large number

Plastics are materials which are made up of polymers. The **properties** of a plastic depend on many things: the type of monomer, the conditions under which polymerisation occurs (temperature, pressure, type of catalyst, etc.) and the use of additives. The properties of a plastic determine its uses. For example LDPE (low density poly(ethene)) is used in carrier bags whilst HDPE (high density poly(ethene)) is much tougher and is used for making milk containers. Poly(alkene) plastics comprise a jumble of long polymer chains rather like a plate of spaghetti. The bonds within these chains (**covalent bonds**) are very strong, but the forces between neighbouring chains (**intermolecular forces**) are much weaker. This means that, when the plastic is heated the increased energy causes the chains to move past one another and the plastic softens. It is called a **thermosoftening plastic**. When softened, such plastics can be remoulded and hence thermosoftening plastics are **recyclable**. In other types of plastic, chemical reactions occur between the chains and join them together with covalent bonds. These are known as **thermosetting plastics**. When heated, the increased energy is not sufficient to break these covalent bonds so the chains cannot move past one another and the plastic does not soften. Hence thermosetting plastics cannot be recycled. Examples include the glue Araldite, melamine (plates) and Bakelite (pan handles).

New polymers are constantly being developed with novel properties. Whilst poly(alkenes) are not degradable (because they are very unreactive), new plastics have been developed which have similar properties but are **biodegradable** or **photodegradable**. **Shape memory polymers** are used in stitching wounds so that a loose stitch will tighten when it is heated by the body.

The use and disposal of plastics is a contentious environmental issue. The raw material for plastics is crude oil which is a finite (non-renewable) resource. Disposal in landfill sites is not advisable because most plastics do not degrade even over hundreds of years. Burning plastics produces useful energy but also greenhouse gases and toxic fumes such as carbon monoxide, hydrogen cyanide and hydrogen chloride. **Recycling** of plastics is to be encouraged but this also consumes a good deal of energy.