



## Understanding materials, their properties, and their selections for specific purposes

### Properties and classifications of materials

**Ferrous metals** contain iron and are magnetic. They are also prone to rust and need a protective finish to prevent corrosion.

- **Cast iron** is brittle if thin, can be cast in a mould, has strong compressive strength, good electrical and thermal conductivity, but has poor resistance to corrosion. It is used for products such as gates, manhole covers and drains.
- **High carbon steel** is also known as tool steel. It is hard and brittle and is less malleable than mild steel. It is an effective electrical and thermal conductor. Uses include tools, screwdrivers, and chisels.
- **Low carbon steel** is also known as mild steel and is ductile and tough, easy to shape, braze and weld. It is a good conductor of heat and electricity, but also corrodes easily. Commonly used for nuts and bolts, screws, bicycle frames and car parts.

**Non-ferrous metals** do not contain iron and are not magnetic. They do not rust.

- **Aluminium** is lightweight, malleable and strong. It is a good conductor of heat and electricity. It is used in drinks cans, cycle frames and saucepans.
- **Copper** is very malleable and an excellent conductor of electricity and heat, which makes it perfect for plumbing and central heating applications. It is orange/brown when polished but will oxidise to a green colour.

## Differences between thermoforming and thermosetting polymers

**Thermosetting polymers** will strengthen when heated and cannot be re-moulded or heated after the initial forming. Thermoplastic can be reheated, remoulded without causing a chemical change.

**Thermoforming polymers** can be heated and shaped repeatedly and are readily recyclable.

- **Acrylic** is hard with good plasticity when heated, can be bent and folded easily but scratches and can be brittle. It is a popular material in the production of car headlights, protective visors and baths.
- **High density polythene (HDPE)** is a stiff and lightweight polymer that provides excellent chemical resistance. It has good plasticity when heated; it is perfect for buckets, bottles, pipes and washing up bowls.
- **Polyvinyl chloride (PVC)** is available in a range of colours as well as transparent. It can be used for vacuum forming.
- **Thermosetting polymers** are materials that are formed once and cannot be recycled. **Melamine formaldehyde** has excellent resistance to heat, moisture, scratching and staining, making it perfect for kitchen worktops and tableware.
- **Urea formaldehyde** is a hard, stiff polymer with excellent insulation properties, making it suitable for switches, plugs and electrical fittings.

## Smart and composite materials

**Smart materials** can display a physical change due to external stimuli.

A smart material is a category of materials that react to a change in temperature or light, for example.

- **Photochromic pigments** or film are used to change colour in ultraviolet (UV) light. This is used in spectacles that automatically darken as the sunlight gets brighter. It is useful in office blocks windows to dim sunlight.
- **Thermochromic pigments** are useful when used in baby products like spoons, bottles and bath toys. This allows the product to change colour to indicate temperature.
- **Shape memory alloys** are materials that change their shape when heated. Spectacle frames and dental braces made from Nitinol can be returned to their original shape.

**Composite materials** are relatively new and have specific working properties and performance characteristics.

- **Carbon fibre** has high stiffness and tensile strength, with low weight. Carbon fibre is created by bonding carbon atoms together in crystals. It is then woven into fabric and combined with other materials to form a composite.
- **Kevlar** is a heat resistant and strong synthetic fibre with the ability to stop bullets and knives from penetrating it. Kevlar is often described as being five times stronger than steel.