

# FACTFILE: GCSE



# Technology and Design

## UNIT: 1.2 – MATERIALS AND THEIR GENERAL PHYSICAL, AESTHETIC AND STRUCTURAL CHARACTERISTICS



### Thermoplastics

#### Learning Outcomes

You should be able to:

- demonstrate understanding of the main properties and applications of the following plastics:
  - thermoplastics (acrylic, polyvinyl chloride (PVC), acrylonitrile butadiene styrene (ABS), nylon and rigid polystyrene).

#### Course Content

Plastics can be divided into two groups:

1. Thermoplastics
2. Thermosetting plastics

#### Thermoplastics

Thermoplastics can be re-heated, re-shaped and recycled. Most commercial plastics are thermoplastics. They can be easily thermoformed when heated at temperatures around 70-260°C depending on the type of plastic. Thermoplastics have molecules that move apart when heated and then return to their original position allowing all sorts of shapes to be created multiple times without changing their properties. They are easy to cut, shape and finish to a high aesthetic standard and are readily available in sheets, blocks, tubes, rod, bar, pellets, powder etc. Although thermoplastics are very versatile and widely used, they are not always suitable for high heat applications in which case thermosetting plastics are preferred owing to their more heat resistant properties.



Figure 1

#### Acrylic

Acrylic has several commercial applications but is often used for display signs. It is also highly popular in schools as a material used to fabricate products for several reasons. Acrylic is available in a wide variety of colours and as a transparent plastic. It is ten times more impact resistant than glass making it a good substitute for glazing applications. It is cost effective, easy to cut, shape and finish. It can be easily machined, cut or engraved with CAD/CAM equipment such as a laser cutter. Acrylic can be thermoformed at 160°C making it useful for line bending (using a strip heater) and resulting in products similar to the display stand shown in Figure 1. Acrylic can also be press formed and blow moulded. It is not as tough as many other plastics meaning that it can crack if subjected to a fair degree of force.



Figure 2

### Rigid Polystyrene

Products such as disposable cups and cutlery are often made from rigid polystyrene since it is food hygienic. As well as being widely used in the food industry, schools also make use of rigid polystyrene for product manufacture since, like acrylic, it is cost-effective and available in many colours (gloss and matt). Rigid polystyrene is however lighter and more flexible than acrylic and is especially useful as it can be easily vacuum formed at temperatures around 130°C. The model car shown in Figure 2 has been vacuum formed using 1.5mm rigid polystyrene giving the product good definition in terms of form and aesthetic detail. Rigid polystyrene is often referred to as High Impact Polystyrene (HIPS) as it is relatively tough although it can be easily scratched.



Figure 3

### ABS (Acrylonitrile Butadiene Styrene)

ABS is a much tougher, harder and durable alternative to acrylic and rigid polystyrene albeit at a slightly higher price. Figure 3 shows a picture taken on an aeroplane of a fold-up tray which is made from ABS using the vacuum forming process. ABS can also be injection moulded and 3-D printed. As well as having very good mechanical properties, ABS has also a high level of resistance to corrosive chemicals compared to most plastics.



Figure 4

### PVC (Polyvinyl Chloride)

PVC is a widely used thermoplastic having many commercial applications. It is produced in two forms and it is easy to tell the difference. PVC which is soft and flexible has been plasticised and is commonly used for clothing and electrical cables. PVC which is hard and rigid is unplasticised (uPVC) and is used for window frames and piping as shown in Figure 4. PVC is widely used in the construction industry since it is tough and durable but is less common in school workshops as it can give off toxic gases when being thermoformed.



Figure 5

### Nylon

Nylon can be manufactured in different ways making it commonplace in products ranging from cars to clothes. Nylon is a very strong material especially in terms of tensile strength. For this reason, Nylon is often used to for ropes and to reinforce rubber in cars tyres. Nylon is also self lubricating making it ideal for gears, it has a melting point of 220°C making it very useful for engine components owing to its resilience to heat.

Manufacturers will select certain thermoplastics for a range of applications based on specific properties as outlined in the table below.

Thermoplastic	Properties	Application
Acrylic	Coloured or clear (excellent clarity) Machines, lasers and polishes well Relatively hard and durable Limited toughness Good electrical insulator Good chemical and weather resistance	Safety glazing, visors, display signs, lighting fixtures, bathtubs
Rigid Polystyrene (HIPS)	Easy to thermoform and machine Relatively tough, and durable Easy to cut, join and paint Food hygienic (natural white)	Disposable plates, cups, cutlery, yogurt pots, toys, model kits
ABS	Easy to thermoform and machine Very tough, durable and hard Easy to cut, join and paint Very good chemical resistance	Keyboards, office chairs, airplane trays, power tool housing, lego, 3-D printing
PVC	Very strong, tough, durable Highly versatile – rigid/hard or flexible/soft (when plasticised) Excellent electrical insulator Excellent flame and chemical resistance	Window frames, guttering, pipes, credit cards, electrical cables, clothing
Nylon	Very strong (tensile strength) Good temperature resilience Easily machined Very tough, durable and hard Self lubricating Moisture wicking (pulls moisture away from the skin)	Gears, tyres, castor wheels, ropes, cable ties, carpets, power tool housing, airbags, clothing, umbrellas

### Student Task

Identify **three** products found in the home, garden or garage which are made from or which use thermoplastic plastic parts.

Carry out some research into which type of thermoplastic they are made from. Explain how each product benefits from the chosen thermoplastic by identifying key properties. The link shown below may act as a starting point.

<http://www.robotoid.com/appnotes/construction-plastics-in-household-items.html>

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## Revision questions

1. Suggest a suitable thermoplastic for each of the following:

a. Biscuits tray insert.

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b. Motorcycle helmet visor.

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c. Tow rope for a car.

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2. A designer wants to design a display sign for the check out area of a shop. Give **one** advantage and **one** disadvantage of using acrylic.

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3. Give **two** reasons why PVC is commonly used for electric cables.

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4. For each application shown below, select a suitable plastic and give **two** reasons for your choice.

a. Housing for an electric drill.

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b. Gears.

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