Make the most of your plastics

This resource aims to help people with plastics in their care make the most of them. It is intended for those with little or no prior knowledge of plastics and as a starting point for further exploration. It will help you identify and look after objects made of plastics whatever the subject of your museum. It also demonstrates how plastics have increasingly become significant for how life is lived with the intention of suggesting stories about plastics relevant to museums of widely different subject areas.

Contents

PLASTICS STORIES

Plastics have infiltrated almost everything to do with life and living from aviation to zip fasteners. They are found in art and design, social history and technological collections and are also among the ethnographic materials of the 20th century. They are a significant part of our cultural heritage. The stories that can be told about plastics are infinite. The Plastics timeline introduces different plastics in a way that it is hoped will make clear the relevance of plastics to museums of diverse subject matter and suggest themes for research and display about plastics.

Plastics Timeline

1712	John O'Brisset moulds snuff boxes from horn.
1823	Macintosh uses rubber gum to waterproof cotton and the 'mac' is born.
1839	First deliberate chemical modification of a natural polymer produces vulcanised rubber, see vulcanite.
1851	Gutta percha used to insulate submarine telegraph cables between England and France.
1854	Shellac mixed with wood flour patented in USA as moulding material for making 'union cases', protective frames for daguerreotypes and ambrotypes, early forms of photographs on glass.
1855	Soccer ball with vulcanised rubber panels, glued at the seams, designed and produced by Charles Goodyear.

1861-87	Queen Victoria's mourning for the Prince Consort fuels the production of imitation jet mourning jewellery in such materials as cellulose nitrate, hard rubber and horn.
1862	A range of toiletry and household objects, some imitating the appearance of tortoiseshell and ivory, made of an early form of cellulose nitrate, is displayed at the International Exhibition in London. The material was called Parkesine after its inventor Alexander Parkes. Ultimately Parkesine fails as a commercial venture.
1870	In USA Hyatt brothers in search of substitute material for ivory billiard balls turn cellulose nitrate into a commercially viable material. Dental palates are one of their good sellers. They register the name 'Celluloid' for their material in 1873.
1884	Cellulose nitrate modified to make artificial silk, called Chardonnet silk.
1889	Dunlop Rubber Company founded and motor industry revolutionised.
1888	First commercially successful celluloid (cellulose nitrate) photographic film introduced by George Eastman Kodak.
1890	Thermoforming introduced and used to make babies' rattles from cellulose nitrate.
1892	Cellulose acetate modified to make a form of artificial silk, called viscose. By 1904 this was known as rayon.
1898	Beginning of mass-production of 78 rpm gramophone records from shellac, for which it remains the most common material until the 1940s.
1899	Casein formaldehyde patented as Galalith in Germany.
1905	Laminated safety glass, first with gelatine but then with cellulose nitrate inter-layer introduced.
1907	First synthetic (lab made) plastic, phenol formaldehyde, better known as Bakelite, later known as 'the material of a 1000 uses' introduced.
1910	Viscose stockings begin to be manufactured.
1913	Formica invented.
1915	Queen Mary orders casein jewellery at the British Industries Fair.
1916	Rolls Royce boasts about use of phenol formaldehyde in its car interiors.
1920	Hermann Staudinger publishes his realisation that plastics are made up of polymers. Only in 1953 was the value of his work properly recognised when he was awarded the Nobel Prize for Chemistry.
1926	Harrods, the London store, mounts a display of Beetle products, made from a form of thiourea-urea formaldehyde. It is a huge success.
	National Grid for electricity is established, fuelling the desire for consumer goods that plug in and switch on, often with plastic housings.

1929	Bakelite Ltd receives its largest ever order of phenol formaldehyde for the manufacture of the casing of the Siemens Neophone Number 162 telephone.
1930	Scotch Tape, the first transparent (see cellulose acetate) sticky tape, invented.
1933	The British Plastics Federation, the oldest national organisation in the world with plastics in its name, set up.
1935	Couturier, Elsa Schiaparelli, begins to use zips made of cellulose nitrate and cellulose acetate in her garments.
1936	Acrylic (polymethyl methacrylate) canopies used in Spitfire fighter planes. From 1940 it becomes the most widely used material for aircraft glazing.
1938	First toothbrush with plastic tufts manufactured. The tufts were made of nylon (polyamide).
	Introduction of plastic contact lenses. The lenses were made of acrylic (polymethyl methacrylate).
1939	First polythene factory opens in Britain. Polythene plays a crucial role in the insulation of British radar cables during World War II. Entire production for military use.
	Plastic Man, a fictional comic-book hero, first appears.
1945	End of the war releases a range of plastics developed to support the war effort on the commercial market looking for uses.
1947	First acrylic (polymethyl methacrylate) paint (dissolved in turpentine) becomes available. Appreciated by artists such as Roy Lichtenstein for its intensity and rapid drying properties.
	Tupperware, with flexible seals made possible by the invention of polythene, patented in the USA.
1948	Introduction of long playing vinyl copolymer gramophone records
1949	Charles and Ray Eames glass reinforced plastic shell chair showed that plastic could be more than a furniture covering or veneering material.
	First Airfix self-assembly model produced. It was made of polystyrene.
	Kartell, the Italian firm associated with plastic objects of desire for the home, founded.
1950	Silly Putty, made from silicon, launched at the New York Toy Fair.
Early 1950s	The ubiquitous polythene bag makes its first appearance.
1951	First polythene bottle made by Sqezy.
1953	Commercialisation of polyester fibre introduces the concept of 'wash and wear' for fabrics.

	Chevrolet Corvette, the first mass-produced car with a glass reinforced plastic chassis, begins manufacture.
1954	Synthesis of polypropylene.
1956	Reliant Regal 111, first commercially successful all glass reinforced plastic bodied car, goes on sale.
	Eero Saarinen's Tulip chair, the seat consisting of a glass reinforced plastic moulded shell, launched.
1957	Invention of polyacetal, the first 'engineering' plastic.
	The Monsanto Company's House of the Future with 100% plastic structural parts built at the entrance to Disneyland's Tomorrowland.
	Polyvinyl chloride road cones used in the construction of the M1 motorway.
1958	Invention of the silicon chip.
	American Express launches first plastic credit card in US.
	Lego decides to concentrate exclusively on plastic toys and patents its stud-and-block coupling system. Originally made of cellulose acetate, it has been made of ABS (acrylonitrile-butadiene-styrene) since1963.
1959	Birth of the Barbie doll, made mainly of PVC (polyvinyl chloride) and the Lycra (copolymer of polyurethane) bra.
Early 1960s	Acrylic (polymethyl methacrylate) paint (diluted with water) comes on market and is soon widely used by artists such as Warhol, Rauschenberg and Hockney.
1962	Silicon gel breast implants pioneered successfully.
1963	Mary Quant launches her 'Wet Collection" made of plasticised PVC (polyvinyl chloride). It had taken two years to work out how to bond the seams successfully.
	Robin Day polypropylene one-piece injection moulded chair shell begins manufacture.
1965	Twiggy models John Bates's plasticised PVC (polyvinyl chloride) dress.
1967	Inflatable PVC (polyvinyl chloride) 'Blow' chair designed by DePas, D'Urbino., Lomazzi and Scolari for Zanotta SpA, launched.
1969	Neil Armstrong plants a nylon (polyamide) flag on the moon.
1969	Beatles' song 'Polythene Pam', the kind of a girl that makes the *News of the World* released on Abbey Road album.
1970	Verner Panton's cantilevered stackable chair, the first whole chair to be made out of a single piece of injection-moulded plastic becomes a reality. He had been working on the design since 1960. The first pilot production models were made of glass-reinforced polyester resin in 1967. It has since been made of polyester integral foam, polyurethane, styrene acrylonitrile (SAN) and polypropylene.

1976	Plastic, in its great variety of types, said to be the material with the most uses in the world. Concorde with its nose cone of purpose-made plastic goes into service.
1977	PET (Polyethylene terephthalate) drinks bottle introduced.
1978	PolyStyrene, lead singer of the Punk band X-Ray Spex, bursts on the scene with 'the day the world turned day glow'.
1980	During this decade ICI and Bayer launch PEEK, PES and PPS as the new engineering thermoplastics, Costs are enormous but specialist applications make a lasting market even after ICI retreats from the plastics market.
1982	First artificial heart made mainly of polyurethane implanted in a human.
1983	The slim Swatch watch launched, its case of ABS (acrylonitrile butadiene styrene) and strap of PVC (polyvinyl chloride). Authentics Ltd., British firm renowned for its sharp, modern designs in various plastics for domestic use, founded.
1988	Triangular recycling symbols identifying different types of plastics introduced.
1990	First biodegradable plastics launched by ICI
1993	Alessi designs its first all plastic product: the Gino Zucchino sugar pourer designed by Guido Venturini.
1994	Smart car with lightweight flexible integrally coloured polycarbonate panels introduced.
1998	Amorphous free standing Zanussi Oz fridge, with insulation and outer-skins made in one process from polyurethane foam, launched.
2000	Issues relating to sustainability and the creation of plastics from renewable sources start gathering momentum.
2005	Nasa explores the advantages of a polythene-based material, RXF1, for the space-ship that will send man to Mars.
2007	Tate Britain's Christmas tree decorated with plastic Airfix planes.

PLASTICS IDENTIFICATION

Clues to get you started

There will always be something you can glean from an object itself to help you decide what material it is made of or how it was manufactured. If you have any thoughts to contribute to the questions below click on them and find out how what you know may help. The notes attached to each question aim to help you make the most of what you know about the object to narrow down the options. Once you have done that you can go to the particular materials in the A –Z of plastic materials or the particular manufacturing processes in the A - Z of manufacturing processes to look in more detail at what you have decided are the probabilities.

When was it made?
What does it look like?
What does it feel like?
Does it smell?
What signs of deterioration can you see?
What marks are on it?

When was it made?
If you have an idea when the object was made, use the information under the relevant date span to narrow down the probabilities. Bear in mind though what you are getting are probabilities not certainties. Many plastics have had long periods of gestation and, as more and more plastics are invented, some become outmoded but nonetheless stay in production. And, although some materials are used most often with a particular manufacturing process, they may also be used from time to time with another. If you have a hunch that an object is made of a particular material outside the dates given or manufactured in a different process go to the material or process in the A – Z guides to check out what is possible in greater detail.

1840-1880
1880-1915
1915-1925
1925-1940
1940-1950
1950-1965
1965-onwards

1840 -1880

Materials	Manufacturing processes
Bois durci	Compression moulding
Celluloid (see cellulose nitrate)	Compression moulding, fabrication
Gutta percha	Compression moulding, extrusion
Parkesine (see cellulose nitrate)	Compression moulding, fabrication
Shellac	Compression moulding
Vulcanite	Compression moulding

1880 -1915

Materials	Manufacturing processes
Cellulose nitrate	Blow moulding, fabrication, thermoforming
Shellac	Compression moulding
Vulcanised rubber	Compression moulding, fabrication, turning

1915 -1925

Materials	Manufacturing processes
Casein formaldehyde	Fabrication, extrusion
Cellulose nitrate	Blow moulding, fabrication, thermoforming
Phenol formaldehyde	Compression moulding; casting
Shellac	Compression moulding
Vulcanite	Compression moulding, fabrication, turning

1925 -1940

Materials	Manufacturing processes
Casein	Extrusion, fabrication, thermoforming
Cellulose acetate	Compression moulding, fabrication, injection moulding
Cellulose nitrate	Blow moulding, fabrication, thermoforming
Phenol formaldehyde	Compression moulding; casting
Urea formaldehyde	Compression moulding
Shellac	Compression moulding

1940 -1950

Materials	Manufacturing processes
Cellulose acetate	Fabrication, injection moulding
Phenol formaldehyde	Compression moulding; casting
Polyamides	Casting, extrusion, injection moulding
Polymethyl methacrylate	Casting, extrusion, fabrication, thermoforming
Polythene	extrusion, blow moulding, injection moulding
Urea formaldehyde	Compression moulding

1950 -1965

Materials	Manufacturing processes
Acrylonitrile butadiene styrene	Injection moulding
Glass reinforced plastic	Compression moulding, fabrication,
Melamine formaldehyde	Compression moulding
Phenol formaldehyde	Compression moulding
Polyamides	Casting, extrusion, injection moulding
Polymethyl methacrylate	Casting, extrusion, fabrication, injection moulding, thermoforming
Polypropylene	Blow moulding, injection moulding, casting
Polystyrene	Extrusion, foaming, injection moulding
Polythene	Extrusion, blow moulding, rotational moulding
Polyurethane	Blow moulding, extrusion, injection moulding, foaming
Polyvinyl chloride	Blow moulding, extrusion, injection moulding, foaming, rotational moulding
Silicones	Injection moulding

1965 onwards

Materials	Manufacturing processes
Acrylonitrile butadiene styrene	Injection moulding
Glass reinforced plastic	Compression moulding, hand lay-up, fabrication, pultrusion, vacuum laminated
Polyamides	Casting, extrusion, injection moulding
Polycarbonate	Blow and injection moulding, extrusion, foaming
Polythene	Blow moulding, extrusion, injection moulding, rotational moulding
Polypropylene	Blow and injection moulding, casting (film)
Polyethylene terephthalate	Blow moulding, extrusion, injection moulding
Polymethyl methacrylate	Casting, extrusion, fabrication, injection moulding, thermoforming
Polystyrene	Extrusion, foaming, injection moulding

Polyurethane	Blow moulding, extrusion, foaming, injection moulding
Polyvinyl chloride	Blow moulding, extrusion, injection moulding, foaming, rotational moulding
Silicones	Injection moulding

What does it look like?

Transparent ?
Pale or bright coloured?
Amber, ivory, tortoiseshell or pearlised?
Shiny?

Transparent
Relatively few plastics are transparent like glass. All transparent plastics can be made translucent or opaque by the addition of pigments or fillers. Some plastics are only transparent in sheet form. If it is moulded and transparent it is probably made of one of the following:

Phenol formaldehyde as liquid resin not with filler
Polycarbonate
Polylactide
Polyethylene terephthalate
Polymethyl methacrylate
Polyurethane

The following plastics can also be clear in sheet or film form but are translucent or opaque when injection-moulded:

Cellulose acetate
PVC
Polypropylene

Is it translucent? If so, it can be any of the above and also:

Polythene
Silicones

Pale or bright coloured
If so it is unlikely to be made of one of the following as they usually come in dark colours. However plastics that can be light or bright in colour also come in dark colours.

Bois durci
Gutta percha
Vulcanised rubber
Horn
Phenol formaldehyde as liquid resin not with filler
Shellac

Amber, ivory, tortoiseshell, or pearlised
If it imitates one of these it is likely to be made of one of the following:

Casein formaldehyde
Cellulose acetate

Cellulose nitrate
Phenol formaldehyde as liquid resin not with filler

Shiny
If it has a hard glossy surface it is likely to be one of the following but bear in mind that nowadays almost any plastic can be made glossy:

Acrylonitrile butadiene styrene (ABS)
Casein formaldehyde
Melamine formaldehyde
Phenol formaldehyde
Polycarbonate
Polymethyl methacrylate
Polystyrene

What does it feel like?

Soft?
Flexible or rigid?
Sticky?

Soft
Some plastics have such a soft surface that they can be indented with a finger nail. If the object feels as if that is likely it is probably made from one of the following:

Polythene
Polyurethane
Polyvinyl chloride (when in flexible form)
Silicones

Flexible or rigid
Many plastics can be rigid or flexible however a few are always rigid. These are:

Acrylonitrile butadiene styrene (ABS)
Bois durci
Gutta percha
Phenol formaldehyde
Vulcanite

Sticky
Stickiness is a sign of degradation. The following can go sticky:

Cellulose acetate
Cellulose nitrate
Polyvinyl chloride
Polyurethane foam

Does it smell?

The following smells are sometimes given off by the plastics listed:

Carbolic acid:	phenol formaldehyde
Formaldehyde:	casein formaldehyde

Milky, if rubbed	casein formaldehyde
Mothballs (camphor):	cellulose nitrate
Plasticky (new car smell)	polyvinyl chloride
Sweet:	polyvinyl chloride but only when degrading
Sulphurous:	hard rubber
Vinegar:	cellulose acetate
Vomit /rancid butter:	cellulose butyrate, cellulose acetate butyrate
Waxy:	polythene

What signs of deterioration can you see?

The following signs of deterioration are associated with the materials listed:

Bloom
This takes the form of a white powder that can be wiped off or a pale mistiness.

Cellulose acetate
Cellulose nitrate
Polyvinyl chloride

Cracks and splits

Casein formaldehyde
Cellulose nitrate
Phenol formaldehyde
Polycarbonate
Polystyrene
Polyvinyl chloride
Shellac
Urea formaldehyde

Crazing

Casein formaldehyde (surface crazing)
Cellulose nitrate (internal crazing)
Gutta percha (network of small cracks on surface)
Polymethyl methacrylate
Polystyrene
Urea formaldehyde (an orange peel effect)

Crumbling

Gutta percha
Polyurethane foam

Embrittlement

Polyvinyl chloride

Fading and discolouration
Pigments can fade independently, leading to complete changes of colour.

Phenol formaldehyde, also dulls
Polyamide, tendency to yellow
Polymethyl methacrylate, sometimes discolours in light
Polyvinyl chloride: yellows and goes brown

Polyurethane: yellows
Urea formaldehyde, also dulls
Vulcanite, often has a yellowish brown tinge

Physical distortion, warping

Cellulose acetate

What marks are on it?

A small bird's wing was used to indicate the use of the material bois durci

An infinity sign is the logo of Bakelite and thus frequently indicates the material phenol formaldehyde but the company made many other plastic materials. It only appears on Bakelite promotional mouldings. Bakelite did not make mouldings for the general market.

Recycling triangles were introduced in 1988 so any object with these on must date from that year or later.

Smooth circular marks are a sign of the use of ejector pins to push the moulding from the mould and thus of injection moulding.

An imperfection on an otherwise smooth surface may be a residue left at the spot the material has been forced into the mould and thus indicate the use of injection moulding. Such marks can be extremely hard to detect and they may not be where you might expect to find them, for example centrally placed on the base or on the edge. They can be polished off so their absence does not tell you anything.

The following are trade names that frequently appear on mouldings. They are associated with the materials indicated:

Bandalasta	Thiourea-urea formaldehyde
Beetleware	Urea formaldehyde
Carvacraft	Phenol formaldehyde
Gaydon	Melamine formaldehyde
Linga Longa	Urea formaldehyde
Melaware	Melamine formaldehyde
Melmex	Melamine formaldehyde
Xylonite	Cellulose nitrate

Materials: the basics

- o Why identify the material?
- o What are plastics?
- o What are additives?

o Why identify the material?

It is good practice to identify the material of which an object is made because it enables you to understand more about the object. But it is vital for objects made of plastics as it will help you know how best to look after them. All plastics degrade over time but some are much less stable than others. It makes sense to concentrate limited resources on providing objects made of these plastics with optimum environments or you might even decide not to collect such objects at all. To find out which materials these are go to Problem plastics.

The best way to learn to identify different plastics is to study a group of objects that already have the plastic from which they are made identified. That way you can get to know what they look, feel and smell like. Clues to help you know what to look for can be found at Identification: clues to get you started.

Identification can also involve sophisticated analytical equipment of which the Fourier Transform Infrared Spectrometer (FTIR) is the most widely used. Such machines can be brought to your museum at a cost. It does however require experts to carry out the analysis and opinions differ on its value. For information on this and other forms of instrumental analysis please refer to Anita Quye and Colin Williamson ed., *Plastics collecting and conserving*, part two: analytical methods, pp.70 -73.

o What are plastics?

Plastics are materials that can be moulded into required shapes by the application of heat and /or pressure. Most plastics are derived from organic material, that is substances made from things that have lived, including oil, cotton, sugar cane, coal, corn and many others. There are however exceptions such as silicon which is derived from sand.

At the point of processing plastics consist of granules, pre-formed tablets, powders, syrups or pastes.

Plastics have been traditionally classified as:

- Natural, a material that can be moulded in its natural form. Examples are amber, gutta percha, horn, rubber, and tortoiseshell.
- semi-synthetic, that means, made of a chemically altered natural material. Examples are casein, cellulosic plastics and rubber.
- synthetic, that is entirely laboratory made, as for example is the case with phenol formaldehyde, polymethyl methacrylate and the many poly-plastics.

Plastics are based on polymers. That is a material made up of many smaller base units. The simplest plastic is polythene consisting of base units of carbon atoms with two hydrogen atoms to each carbon. The base unit is referred to as a monomer. Many monomer units linked together create a polymer, through a chemical process known as polymerization. Polymerization can be demonstrated by hooking together hundreds of paper clips (base units) to form chains. Chains in different configurations make plastics with different properties.

Plastics are divided into two distinct groups:

- thermosets, plastics that on being heated and moulded set permanently, and thus cannot be re-melted and re-formed.
- thermoplastics, plastics that can be re-melted after moulding again and again, and thus can be recycled by melting and reforming

Thermosets referred to on this site are:

Bois durci
Casein formaldehyde
Glass reinforced polyester
Hard rubber
Melamine formaldehyde
Phenol formaldehyde
Polyester (some types)
Polyurethane foam
Shellac (sometimes)
Silicones (sometimes)

Urea formaldehyde

Thermoplastics referred to on this site are:

Acrylonitrile butadiene styrene (ABS)
Cellulose acetate
Cellulose nitrate
Gutta percha
Horn
Polyamide
Polycarbonate
Polyester (some types)
Polyethylene terephthalate
Polylactide
Polymethyl methacrylate
Polypropylene
Polystyrene
Polythene
Polyurethane (some types)
Polyvinyl chloride
Shellac
Silicones (sometimes)

Recognising whether plastics are thermosets or thermoplastics is relevant for the curator as certain production techniques, for example those that rely on reforming plastic sheet, can only be done with thermoplastics.

Increasingly plastics are copolymers, that is made up of two or more polymers, in order to increase the range of performance of the resulting material, e.g. Lycra.

o What are additives?

The performance, appearance and stability of a specific plastic can be greatly modified by a mix of additives in its recipe. They are used for a wide range of reasons including to:

- give additional strength or dimensional stability
- act as plasticisers or lubricants
- provide decoration or pigmentation
- improve chemical resistance
- act as fire-retardants
- protect against ultra-violet degradation
- as fillers to reduce cost

Commonly found additives include:

- calcium carbonate
- camphor and phthalates (as plasticisers)
- pigments
- cotton flock
- gas/air in foams (as expanders)
- glass and other fibres
- mica
- minerals
- stabilisers
- talc

- wood flour

It would be impossible to process most polymers into useful objects without additives. Additives can be added in different quantities and can affect the long term stability of the plastic. It is as likely to be the additive contributing to a plastic object's degradation as the plastic itself. Please go to Degradation for more information.

For information on particular plastics please go to the A - Z of plastic materials or to an individual letter within it.

A – Z of plastic materials

Acrylonitrile butadiene styrene	ABS
Group:	thermoplastic
Developed:	from 1948
Trade names:	Cycolac
Manufacturing process:	injection moulding; extrusion (sheet); thermoforming
Cost:	low
Colour:	any
Transparency:	almost always opaque
Rigidity:	rigid
Feel:	hard
Smell:	none
Other:	glossy
Typical uses:	domestic appliance and computer housings; Lego
Degradation:	relatively stable but has tendency to yellow

Alkathene™ see polythene

Alketh™ see polythene

Argosy™see melamine formaldehyde

Bakelite™ see phenol formaldehyde

Bandalasta™ see thiourea-urea formaldehyde

Beatl™ see urea formaldehyde

Beetle™ see urea formaldehyde

Bexoid™ see cellulose acetate

Bois durci	blood albumen and powdered wood
Group:	thermoset
Developed:	patented in Paris 1855, exhibited 1862 and 1867 International Exhibitions, London; commercial production ceased in 1875
Trade names:	
Manufacturing process:	compression moulding
Cost:	high
Colour:	black and dark brown, but sometimes has a lacquered finish
Transparency:	always opaque
Rigidity:	always rigid
Feel:	hard
Smell:	none

Other:	can sometimes be identified by the moulding of a small bird's wing or by the name 'Bois Durci'
Typical uses:	desk accessories; plaques with reliefs of notable people or mythological scenes
Degradation:	relatively stable

Casein formaldehyde	milk curds hardened with formaldehyde
Group:	thermoset (but can also be thermoplastic to a certain extent)
Developed:	patented 1899; little used since the1980s
Trade names:	Lactoid, Erinoid, Galalith
Manufacturing process:	extrusion; fabrication, usually machined to shape from sheet, rod or block; textures achieved by laminating sheet on sheet
Cost:	medium
Colour:	any, including mottles, pearls and special effects
Opacity:	usually opaque but some translucency when imitating tortoiseshell, horn and all the many decorative affects that could be achieved
Rigidity:	firm but can flex
Feel:	hard
Smell:	occasionally of the formaldehyde used in its production
Other:	accepts surface dyeing; polishes to a brilliant lustre
Typical uses:	buttons, knitting needles, fountain pens, jewellery, dressing table sets, manicure sets, inlay in furniture
Degradation:	Surface crazes and cracks

Cast phenolic see phenol formaldehyde

Celanese™ see cellulose acetate

Cellophane™ see cellulose acetate
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Celluloid™ see cellulose nitrate

Cellulose acetate	
Group:	thermoplastic
Developed:	invented 1894, but only developed as a material for commercial use from 1918 (although to form cellophane from 1908); not common until late 1920s. Use fell off in1970s but interest currently reviving, as made from wood based cellulose, a renewable resource.
Trade names:	Celanese, Estron, Plastacele, Bexoid, Tenite, Clarifoil
Manufacturing process:	early examples compression moulded; from c.1928 injection moulded
Cost:	medium
Colour:	any, usually plain but occasionally marbled
Transparency:	transparent to opaque
Rigidity:	strong but slightly soft, may be flexible in thin sections
Feel:	hard
Smell:	vinegar (when degrading)
Other:	will accept surface colouring
Typical uses:	as liquid to stiffen and waterproof fabric wings and fuselage of early aircraft. In solid form in spectacle frames; type-writer keys; negatives and film; toys; fancy goods e.g. by Lalique; sculpture e.g. by Naum Gabo; hair brush handles, especially Addis Ltd; also as supports for archival material from 1940s
Degradation:	shrinks, crazes, becomes 'sugary' and cracks. Acidic droplets; white bloom on the surface; and distortion (warping), a result of plasticiser migration

Cellulose nitrate

Group:	thermoplastic
Developed:	displayed at 1862 International Exhibition, London; first common domestic plastic; turned into an artificial fibre like silk in 1884 called Chardonnet silk; use of all kinds almost ceases in 1940s but it is still used for ping pong balls.
Trade names:	Parkesine 1862 – 68; Xylonite (British) and Celluloid (USA) from 1870s
Manufacturing process:	blow-moulding; fabrication, made into blocks that are sliced into thin sheets; thermoforming of thin sheets
Cost:	medium
Colour:	any, including mottles, pearls and special effects such as imitations of tortoiseshell and ivory
Transparency:	transparent to opaque
Rigidity:	Wide range
Feel:	hard
Smell:	camphor (used as plasticiser), easiest to smell in containers with lids
Other:	blade marks from the slicing into sheets sometimes visible; flammable, hence its early demise
Typical uses:	collars and cuffs; dressing table sets and combs; billiard and ping pong balls; knife handles; jewellery and costume accessories; spectacles; toys; false teeth; sculpture e.g. by Naum Gabo; in mortars ; also as support for film and still photography and from 1940s archival material
Degradation:	internal cuboid crazing, becomes 'sugary' and cracks. Decomposition of the polymer releases nitrogen oxides, generating acidic wet bloom and ultimately breakdown

Chardonet silk see cellulose nitrate

Clarifoil™ see cellulose acetate

Corian™ see polymethyl methacrylate

Crimplene™ see polyester

Cycolac™ see acrylonitrile butadiene styrene

Delrin™ see polyacetal

Diatite™ see shellac

Erinoid™ see casein

Ebonite see hard rubber

Estron™ see cellulose acetate

Fibreglas™ see glass-reinforced plastic

Florence compound see shellac

Formica™ see melamine formaldehyde and phenol formaldehyde

Galalith™ see casein

Gaydon™ see melamine formaldehyde

Glass reinforced plastic	GRP, a composite material made of glass fibres and plastic usually polyester
Group:	thermoset
Developed:	during World War 2; first used in civilian life in 1950s
Trade names:	Fibreglas
Manufacturing process:	compression moulding or fabrication: hand-laying in an open mould
Cost:	low
Colour:	any
Transparency:	translucent to opaque
Rigidity:	Rigid
Feel:	hard
Smell:	None
Other:	
Typical uses:	very large containers, boat hulls, car panels, sculptures e.g. by Claus Oldenburg and Philip King
Degradation:	Relatively stable, can go brittle and crack

Gutta percha	hard substance exuded from tropical tree that softens in hot water
Group:	thermoplastic
Trade names:	
Developed:	introduced from Far East in1843; wide range of products shown at 1851 Great Exhibition, London; use falls off in 1930s
Production techniques:	compression moulding; extrusion
Cost:	low
Colour:	dark, but sometimes painted
Transparency:	always opaque
Rigidity:	normally rigid
Feel:	old material is hard; modern gutta percha is often softer; dry-ish
Smell:	none
Other:	can look woody
Typical uses:	golf balls; dentistry; insulation for submarine telephone cables; household uses similar to those of tin; fancy mouldings
Degradation:	oxidises and embrittles, as a result mouldings are now scarce

Hard rubber see vulcanite

Horn	
Group:	thermoplastic
Developed:	moulding technology from early 17th century
Trade names:	
Manufacturing process:	compression moulding; thermoforming
Cost:	medium
Colour:	natural horn colour, typically dyed black; also imitations of tortoiseshell
Transparency:	translucent or opaque
Rigidity:	rigid but when thin flexes
Feel:	sometimes textured
Smell:	none
Other:	fibrous texture sometimes visible
Typical uses:	drinking vessels; buttons; combs; imitation jet jewellery; snuff boxes; cutlery handles; small translucent panels used e.g. in windows and lanterns
Degradation:	stress cracks; some distortion and shrinkage but otherwise stable

Ivoride™ see cellulose nitrate

Kematal™ see polyacetal

Lacqrene™ see polystyrene

Lactoid™ see casein

LingaLonga™ see urea formaldehyde

Lucite™ see polymethyl methacrylate

Lycra™ see polyurethane

Makrolon™ see Polycarbonate

Melamine formaldehyde

Group:	thermoset
Developed:	commercially, post World War II; heyday late 50s and early 60s; still in use for picnic ware and ashtrays
Trade names:	Argosy; Gaydon; Melaware; Melmex
Manufacturing process:	compression moulding
Cost:	low
Colour:	any, often two-toned
Transparency:	always opaque
Rigidity:	always rigid
Feel:	hard
Smell:	none
Other:	porcelain-like; capable of high gloss
Typical uses:	colourful table and picnic ware; ashtrays; a component of Formica™
Degradation:	relatively stable but scratches and stains

Melaware™ see melamine formaldehyde

Melmex™ see melamine formaldehyde

Mouldrite™ see phenol formaldehyde

NatureWorks™ see polylactide

Nestorite™ see phenol formaldehyde

Nylon see polyamide

Oroglas™ see polymethyl methacrylate

Parkesine™ see cellulose nitrate

Peck™ see shellac

Perspex™ see polymethyl methacrylate

Plantic™ see polylactide

Plaskon™ see urea formaldehyde

Plastacele™ see cellulose acetate

Plexiglass™ see polymethyl methacrylate

Phenol formaldehyde	with wood flour or other filler as powder or pre-formed tablets and as liquid resin. Often called cast phenolic
Group:	thermoset
Developed:	with filler 1907: not widely used until after 1915; still used for electrical moulds and saucepan handles as liquid resin: 1927.
Trade names:	with filler: Bakelite; Mouldrite; Nestorite; Roanoid as liquid resin: Bakelite; Catalin; Carvacraft
Manufacturing process:	with filler: compression moulding as liquid resin: casting, often cut sections of rod, tube etc; often carved
Cost:	medium
Colour:	with filler: usually dark in colour: black, shades of green, red and brown, often mottled sometimes in wood effects As liquid resin: any, but frequently amber and green, seldom blue
Transparency:	with filler: always opaque as resin: seldom transparent; often translucent and marbled; sometimes opaque
Rigidity:	always rigid
Feel:	hard
Smell:	carbolic acid
Other:	good electrical and heat resistance
Typical uses:	with filler: domestic items: radio, clock and hair dryer casings, ash trays, boxes; electrical fittings; car components, aircraft and military components; cooker knobs; kettle handles; As liquid resin: napkin rings and bangles; desk accessories; wireless cabinets, especially American; jewellery; laminate surfacing, e.g. Formica™.
Degradation:	with filler: relatively stable but colour darkened by exposure to light, green becoming brown, also goes dull As liquid resin: brittle but relatively stable; discolours

Polyacetal	also referred to as polyoxymethylene (POM) and polyformaldehyde
Group:	thermoplastic
Developed:	1957
Trade names:	Delrin; Kematal
Manufacturing process:	extrusion; injection moulding
Cost:	medium
Colour:	naturally white, but any
Transparent:	translucent to opaque
Rigidity:	always rigid
Feel:	hard
Smell:	none
Other:	strong; recognised as the first ‘engineering’ plastic
Typical uses:	gear wheels and mechanisms; disposable lighters; bathroom taps; plectra and guitar picks
Degradation:	Stable

Polyamide	PA
Group:	thermoplastic
Developed:	1933; nylon trade name given in 1938
Trade names:	Nylon
Manufacturing process:	extrusion; injection moulding
Cost:	medium

Colour:	all
Transparency:	transparent to opaque
Rigidity:	rigid to flexible depending on type
Feel:	varies; can be waxy
Smell:	none
Other:	
Typical uses:	toothbrush tufts, combs, kitchen utensils, zips, Velcro; as textile fibres: carpets stockings, tents; glass-reinforced moulding compounds
Degradation:	discolouration, especially yellowing, and embrittlement

Polycarbonate	PC
Group:	thermoplastic
Developed:	from 1958
Trade names:	Makrolon
Manufacturing process:	blow moulding; extrusion; injection moulding
Cost:	medium
Colour:	injection moulding
Transparency:	transparent to opaque
Rigidity:	rigid
Feel:	hard
Smell:	none
Other	can be outstandingly strong
Typical uses:	safety and space helmets; compact discs and DVDs; as copolymer as mobile phone housings; car components; large bottles; glass substitute
Degradation:	stable but can crack

Polyester	a category of polymer often used to describe its fibre form; a huge family of ‘plastics’; more limited, see also polyethylene terephthalate
Group:	thermoplastic
Developed:	1941
Trade names:	Crimplene, Dacron, Terylene
Manufacturing process:	as a fibre: extrusion
Cost:	low
Colour:	any
Transparency:	transparent to opaque
Rigidity:	flexible
Feel:	varies
Smell:	none
Other:	resilient, quick-drying, flammable
Typical uses:	clothing and upholstery; also from 1955 in sheet form as support for archival material
Degradation:	relatively stable

Polyethylene terephthalate	PET, a polyester
Group:	thermoplastic
Developed:	1941 announced as a commercial polymer; widely used in blow-moulded form from1980s
Trade names:	related film Melinex and Mylar
Manufacturing process:	especially blow moulding; injection moulding
Cost:	medium
Colour:	any
Transparency:	transparent to opaque
Rigidity:	rigid

Feel:	varies
Smell:	none
Other:	strong
Typical uses:	carbonated drinks bottles; video and audio tape
Degradation:	stable

Polyformaldehyde see polyacetal

Polylactide	PLA, made from corn starch
Group:	thermoplastic
Developed:	since 2000
Trade names:	NatureWorks; Plantic
Manufacturing process:	all
Cost:	medium
Colour:	any
Transparency:	transparent to opaque
Rigidity:	rigid to flexible
Feel:	varies
Smell:	none
Other:	made from renewable resources
Typical uses:	disposable plates and cutlery, trays in confectionary industry, but suitable for anything from toys to car parts
Degradation:	intended to biodegrade; crucial to keep it dry

Polymethyl methacrylate	PMMA, often called acrylic
Group:	thermoplastic
Developed:	1932, in commercial use from 1934, fashionable in 1960s
Trade names:	Oroglas, Perspex, Plexiglass, Lucite; Corian
Manufacturing process:	initially thermoforming from cast sheet and fabrication; now also casting; extrusion; injection moulding
Cost:	medium
Colour:	any
Transparency:	transparent to opaque; better optical properties than glass
Rigidity:	rigid
Feel:	hard
Smell:	none
Other:	takes a high gloss; dull sound when struck
Typical uses:	aircraft glazing; containers fabricated from sheet, e.g. handbags; blocks with embedded objects, jewellery, display stands, artists 'paints
Degradation:	relatively stable; crazing resulting from stress; physical damage, especially scratches

Polyoxymethylene see polyacetal

Polypropylene	PP
Group:	thermoplastic
Developed:	from 1956; increase in use from 1976 when initial patents ran out; became fashionable in translucent sheet form in 1990s; now one of the most used plastics
Trade names:	Propathene
Manufacturing process:	blow moulding; extrusion (as a fibre); injection moulding
Cost:	low
Colour:	any

Transparency:	translucent, but can have clarifying agents added making it transparent; also comes as clear film (modern cellophane)
Rigidity	fairly rigid but flexible
Feel:	varies
Smell:	none
Other:	can be moulded to create an integral hinge; can achieve reasonably glossy surface scratches with fingernail
Typical uses:	chair shells and garden furniture; luggage; car bumper; petrol cans; food wrappings; microwaveable meal trays; margarine tubs; netting; household goods; carpets; packaging; rope
Degradation:	relatively stable

Polystyrene	PS
Group:	thermoplastic
Developed:	became a usable material in 1930s but not used commercially until after World War II
Trade names:	Lacqrene; Polystyrol; Styron
Manufacturing process:	usually injection moulding; also extrusion; fabrication: especially cutting and sticking; foaming; thermoforming
Cost:	very low
Colour:	any, including streak and pearlised effects
Transparency:	transparent to opaque
Smell:	none
Rigidity:	always rigid
Feel:	hard, except when foamed
Other:	can be brittle but can be toughened, e.g. high impact polystyrene (HIPS); metallic ring when tapped; good for bonding
Typical uses:	disposable pens and razors; cutlery and vending cups; CD cases; yogurt pots; model kits; insulation and packaging food trays, hamburger and egg boxes, electronic equipment, when foamed
Degradation:	crazing and discolours

Polystyrol see polystyrene

Polythene	PE, low and high density: LDPE and HDPE
Category:	thermoplastic
Developed:	1933 low density but used for military purposes until 1945; 1953 high density
Trade names:	Polythene; Alkathene; Tyvek
Manufacturing process:	blow moulding; extrusion; injection moulding; rotational moulding
Cost:	very low
Colour:	any
Transparency:	naturally translucent but can be opaque
Rigidity:	semi-rigid to flexible depending on density
Feel:	varies depending on density
Smell:	wax
Other:	scratches with fingernail; currently LDPE is the plastic with the highest volume of use
Typical uses:	replaced enamelled kitchenware: bowls and other domestic wares, first squeezable bottles (e.g. for washing up liquid) and airtight food containers; road cones; 'poppit' beads; packaging film, e.g. carrier bags
Degradation:	yellows, stiffens, and embrittles

Polyurethane	PU
Group:	thermoset as foams; thermoplastic as fibres and surface coatings
Developed:	from 1937; still widely used

Trade names:	in adapted form: Lycra; Spandex
Manufacturing process:	all
Cost:	medium
Colour:	any
Transparency:	transparent to opaque
Rigidity:	any
Feel:	varies
Smell:	none
Other:	surface scratches with fingernail
Typical uses:	furniture; paint; shoe soles; synthetic leather-like fabrics; bicycle seats; as foams, seating, large mouldings
Degradation:	discolouration followed by crumbling, the result of oxidation; foams deteriorate faster due to their greater surface area

Polyvinyl chloride	PVC
Group:	thermoplastic
Developed:	known from 1870 but suitable plasticisers not discovered until 1933; wide use from 1940s, ongoing
Trade names:	
Manufacturing process:	all thermoplastic processes
Cost:	low
Colour:	any
Transparency:	transparent to opaque
Rigidity:	basically rigid but made soft with the use of plasticizers
Feel:	varies, can be sticky
Smell:	none
Other:	in flexible form scratches and indents with fingernail
Typical uses:	shiny leather-like fabric; fashion belts; flexible toys; inflatable furniture; cables e.g. computers and other electrical items; credit cards; blood bags; flooring; in unplasticised form: guttering, window frames, flooring; as co-polymer LP gramophone records from 1952
Degradation:	yellowing and darkening; migration of additives to the surface creating either a bloom or sticky surface, which may lead to embrittlement.

Propathene™ see polypropylene

Rayon see cellulose acetate

Roanoid™ see phenol formaldehyde

Rubber see vulcanite

Scarab™ see urea formaldehyde

Shellac	excretion of tropical beetle mixed with fillers such as cotton flock, powdered slate, wood flour
Group:	thermoplastic or set depending on heat used in manufacture
Developed:	known for thousand of years; used to make products from 1860s to 1940s
Trade names:	Diatite; Florence compound; Peck
Manufacturing process:	compression moulding
Cost:	medium
Colour:	dark brown, black and occasionally paler dull shades
Transparency:	always opaque
Rigidity:	rigid
Feel:	hard

Smell:	sealing wax
Other:	brittle; capable of reproducing very fine detail
Typical uses:	cases for daguerreotypes and ambrotypes (early forms of photographs on glass); dressing table sets; 78 rpm records until 1948; as stiffening for bowler and riding hats; also used as lacquer
Degradation:	relatively stable

Silastic™ see silicon

Silicon	derived from sand
Group:	usually thermosets
Developed:	discovered in 1934; used commercially from 1942
Trade names:	Silastic
Manufacturing process:	injection moulding
Cost:	high
Colour:	any
Transparency:	translucent to opaque
Rigidity:	flexible
Feel:	soft and bouncy
Smell:	none
Other:	water-repellent; can be subjected to high heat without damage; bouncy; feels sensuous; softer than fingernail
Typical uses:	baking and ice trays; oven gloves; breast implants; baby teats; silly putty; micro-chips
Degradation:	relatively stable

Spandex™ see polyurethane

Styron™ see polystyrene

Tenite™ see cellulose acetate

Terylene™ see polyester

Tyvek™ see polyethelene

Urea formaldehyde	
Group:	thermoset
Developed:	patents taken out 1915 but only becomes practical for commercial use as thiourea urea formaldehyde in 1925; Improved to urea formaldehyde in 1929; role taken by other plastics by 1950s
Trade names:	Beetle; Beatl; Bandalasta; LingaLonga; Plaskon; Scarab
Manufacturing process:	compression moulding
Cost:	medium
Colour:	naturally white but any slightly muted or pastel colour; also speckled and marbled effects.
Transparency:	opaque or translucent; never transparent
Rigidity:	rigid
Feel:	hard
Smell:	usually none but occasionally a faint smell of urine
Other:	brittle; less than a high gloss
Typical uses:	domestic wares, picnic sets; jewellery; electric fittings and casings
Degradation:	dulls, discolours, cracks; acquires an orange peel effect on the surface; badly affected by hot water; otherwise reasonably stable

Vulcanite	also known as ebonite and in USA as hard rubber. It is made from chemically altered natural rubber. The process involves heat and sulphur
Group:	thermoset
Developed:	reaction when heated with a large percentage of sulphur to make it rigid discovered in 1839; still in use in 1930s
Trade names:	
Manufacturing process:	compression moulding; fabrication; turning
Cost:	medium
Colour:	typically black (fades to brown) but can also be red
Transparency:	always opaque
Rigidity:	rigid
Feel:	hard
Smell:	sulphurous rubbery
Other:	
Typical uses:	match boxes; combs; fountain pens; imitation jet jewellery; denture palates (with pigmentation to resemble gums); pipe stems
Degradation:	often faded to a greyish greenish brown shade

Viscose see cellulose nitrate

Xylonite™ see cellulose nitrate

Manufacturing process: the basics

The principal manufacturing processes are: blow moulding, casting, compression moulding, extrusion, fabrication, foaming, injection moulding, rotational moulding and thermoforming of sheet. These processes are described in the A – Z of manufacturing processes.

The clue to the manufacturing process can lie in the number of the particular product. Some processes can be used at home and others involve high tooling investment. Low investment processes tend to be craft based and thus slower than high investment ones. Injection moulding is only economically viable if a very high output is required. For example an injection moulding machine can convert plastic granules to a safety helmet in 40 seconds, that is 2160 in 24 hours, 15,120 in a week and 786,240 in a year. The sharing of the tooling cost across so many units results in a relatively low unit price. It is not, however, cost efficient to injection mould small runs (e.g. 5000) of products. On the other hand, casting, fabrication and rotational moulding cost less to set up but are slower in the making. Currently, excluding plastic bags, far more plastic objects are made by injection molding than by any other process.

Certain processes leave marks behind on the finished product. The most frequently encountered are the marks left by what is now the most widely used process: injection moulding. There are two kinds of marks: that left by the 'sprue', the tail of plastic that is broken off at the point it enters the mould, and the ejector pin marks, smooth and circular, which assist with the removal of the moulding from the mould. For more information please go to what symbols, marks and words are on it?

As certain plastics are only used with certain processes, identifying the process can assist in the identification of the particular plastic. It is helpful to bear in mind when considering manufacturing processes that thermosetting plastics were not injection moulded before about 1960 and they cannot be thermoformed.

A – Z of manufacturing processes

Blow moulding	
Process:	hot air is blown into a pre-formed tube, a parison, of semi-molten plastic

	which expands to fill a cavity formed by a two part, usually metal, mould. The tube can be injection moulded allowing a thread for a lid or some other detail to be formed. It can also be extruded as a tube, pinched at one end, and again expanded to fill the cavity of a two part metal mould. Textures can be formed on the mould walls.
Introduced:	1881 for use with cellulose nitrate
Plastics:	commonly high density polythene and polyethylene terephthalate
Marks:	a line where the mould parts have met is often visible
Tooling cost:	relatively high
Production volume:	high
Uses:	hollow articles, usually with openings of smaller diameter than the body, such as bottles or containers.

Casting

Process:	plastic in liquid form is poured into an open mould itself often moulded from plastic
Introduced:	long history with traditional materials, like metals
Plastics:	commonly phenol formaldehyde as liquid resin, polymethyl methacrylate, and polyurethane
Marks:	frequently trapped air bubbles, or their remains on the surface
Tooling cost:	low
Production volume:	low, essentially a craft process; objects can be placed in the liquid as it solidifies; the cast form can be carved; open casts allows manipulation of the finished result throughout the curing process
Uses:	preformed shapes: sheets, rods, tubes; jewellery; radio housings; designer furniture; paperweights

Compression moulding

Process:	a measured amount of material is added to a two part mould and subjected to heat and pressure
Introduced:	before 1900
Plastics:	usually thermosets, especially melamine formaldehyde amd phenol formaldehyde with filler
Marks:	mould lines but these can be polished off by hand
Tooling cost:	medium
Production volume:	relatively slow and labour intensive
Marks:	sometimes, especially on complicated mouldings
Uses:	radio and telephone housings; plugs and sockets; tableware; ashtrays; bowls and boxes

Extrusion

Process:	plastic pellets are fed into a heated cylinder and driven forward by a turning screw which compacts and melts them and forces the melt through a die at the end, creating continuous lengths of shapes with the desired profile. It is a system much like that of a mincing machine except for the addition of heat. Once the plastic shape is formed it is cooled by air or water
Introduced:	first experiments in the 1840s, widely used from late 1930s
Plastics:	any, especially high density polythene; polystyrene and polyvinyl chloride; all synthetic fibres
Marks:	none
Tooling cost:	moderate
Production volume:	high but restricted to minimum order lengths
Uses:	anything with a constant cross section: fibres; tubing; pipes; sheets; films; cable sheathing; profiles e.g. curtain rails or window frames

Fabrication

Process:	a catch-all term for a variety of processes, including bonding, carving, cutting, sticking, turning and welding. Go to the different materials to see how they are fabricated.
Introduced:	a traditional means of making
Plastics:	cellulose acetate; cellulose nitrate; glass reinforced plastic; phenol formaldehyde as liquid resin; polymethyl methacrylate; polystyrene
Marks:	none
Tooling cost:	low
Production volume:	slow
Uses:	varied; see materials concerned

Foaming

Process:	there are a number of different processes but they share the release of air/ gas into the plastic so that it fills with bubbles and foams within a two part metal mould of the desired shape
Introduced:	Post World War 1
Plastics:	most, especially polystyrene, polyurethane, polyvinyl chloride
Marks:	none
Tooling cost:	medium
Production volume:	high
Uses:	packaging; sponges; soles of shoes; steering wheels; vending cups, insulation; foam furniture

Injection moulding

Process:	similar to extrusion except that the plastic is injected into a metal mould often with branching for multi-impression tools
Introduced:	first used successfully with cellulose acetate after 1928; since 1946 it has been the most widely used method of processing thermoplastics; since 1960 it has also been used for processing some thermosets
Plastics:	commonly all thermoplastics
Marks:	the plastic enters the mould through what is known as a gate which leaves a 'sprue' which is then broken off but leaves a slightly rough, often circular area; there are sometimes also smooth circular marks left by the ejector pins used to help release the warm moulding from the mould
Tooling cost:	high
Production volume:	high
Uses:	precision technique capable of complicated shapes: e.g. medical components; Airfix kits; cheap products produced in very large numbers: Lego; plastic cutlery; machine housings; washing-up bowls

Rotational moulding

Process:	a measured amount of material is placed in a mould which is rotated on two axes at low speed within an oven. The molten plastic then covers and adheres to the inner surface of the mould. The mould is then cooled while still rotating and the product is released
Introduced:	1940s
Plastics:	most commonly low or medium density polythene; polypropylene can be used if end product needs to withstand high temperatures; polyamides may also be used but rarely because they are expensive
Tooling costs:	relatively low
Production volume:	medium
Uses:	only for products with uniform wall thickness and where the inner surface of the product can be inferior to its outer surface which replicates the surface of the mould. Usually large simple forms: storage tanks; traffic

	bollards

Thermoforming

Process:	uses preformed sheets which are warmed and sucked (vacuum forming) or pushed into a mould. Neither high heat nor pressure is required so moulds can be made from cheap materials such as MDF or cast aluminium. Also used to shape rod and tube.
Introduced:	1890 for use with cellulose nitrate
Plastics:	most sheet thermoplastic materials
Marks:	none
Tooling cost:	low
Production volume:	suitable for low quantities or even one offs, but can be mechanised to speed up process
Uses:	shallow forms: baths and boat hulls, bowls, margarine and yogurt pots

PLASTICS CARE

How a plastic object is looked after (combined with its chemical make-up about which nothing can be done) is the factor that has the most impact on its life-expectancy. It is unfortunate that objects may have had adverse experiences that are not visible at the time they enter your care but may impact on their future. But good care will slow down most forms of degradation.

Plastics differ from each other in their care needs. The exact recipe of each plastic, including its range of additives, influences how it will age. Even the pigment used to colour an otherwise identical object can cause objects to age differently. That said, most plastics are relatively stable if looked after appropriately but degradation, when it does occur, is irreversible making good care in the first place vital.

There are four plastics that are especially problematic. These are cellulose acetate, cellulose nitrate, polyvinyl chloride and polyurethane. Objects made of these materials should be identified and managed separately, according to their special needs. For more information please go to Problem plastics.

Handling

Gloves of some inert material, such as latex, should always be worn. Cotton gloves are not recommended as they may leave specks of lint on plastics that have become tacky.

Otherwise good practice is the same as for other objects: always use both hands and hold the object in a manner that puts as little strain on any part of it as possible. Do not hold objects by their handles.

Numbering

Barrier coatings as often applied to objects and adhesive tapes are not appropriate for plastics as they may react adversely with the surface. Rubber bands should also be avoided. The options are

- labels tied on with cotton tape

or

- writing directly on the plastic surface with a soft pencil, ideally inside the object.

Which method is the most appropriate will depend on the characteristics of the object.

Environmental requirements

Environmental conditions impact dramatically on the life-expectancy of plastic objects. Appropriate environmental conditions are therefore vital. What follows is good practice for the majority of plastics. For cellulose acetate, cellulose nitrate, polyvinyl chloride and polyurethane foam please go to Problem plastics.

Plastics should be kept in a dark, cool, dry room. Whether in store or on display the temperature should be restricted to 20° centigrade and relative humidity to 30 to 50%. Sharp fluctuations of heat and RH are especially damaging.

UV should be filtered out from any light to which plastics are exposed. However even UV-filtered light is bad for plastics so when stored plastics must be kept in the dark and when on display light should be limited. Plastic objects should not be on permanent display. The damage is cumulative and dependent on the overall amount of light whether a short blast of very bright light or a very low light for a long time. It is for each curator/conservator to decide what is appropriate for any particular object at any particular time. Recommended good practice varies from a maximum of 50 to 150 lux.

Storage and display guidelines

Objects should be stored and displayed in and on inert materials, in such a way as to minimise handling. Polypropylene is a good material to use as trays on which to store objects. Avoid especially materials that could off-gas organic vapours, such as painted materials, wood and MDF. Plinths should be left for at least 72 hours for paint to dry completely before covering. Plasticisers are drawn out by contact with absorbent materials so they too should be avoided.

Objects should never touch each other and air should be able to flow freely around them. Ideally the space should be dust free, but it must not be airtight.

Ideally each type of plastic should be stored separately.

Try to store objects supported as you would wish them to be on display. Should degradation take place this will enable them to be displayed without leading to further degradation as they are opened, unfolded or otherwise handled in order to make them appropriate for display. This is especially important for objects made of polyvinyl chloride and polyurethane foam (see Problem plastics).

Chemical degradation

The onset of degradation is unpredictable and rapid. It can manifest itself in an advanced state apparently almost overnight. It is irreversible and in most cases, once started, unstoppable. The best that can be achieved is to slow down the process.

Degradation products from objects (e.g. acidic vapours) can contaminate other objects in the vicinity. Collections should be checked regularly, ideally at least once a year, and any object showing signs of degradation should be separated from the rest of the collection.

Causes and effects of degradation:

- light, leading to darkening, loss of flexibility and embrittlement of the plastic and fading of pigments.
- excessive humidity can lead to chemical breakdown of certain plastics.
- fluctuating temperature and humidity, leading to shrinkage and expansion which in turn result in crazing and cracks.
- migration and loss of plasticizers, leading to surface bloom and /or surface tackiness and then to loss of flexibility and embrittlement.
- pollutants and exhaustion of stablisers leading to chemical break down of the material's structure and, ultimately, collapse
- bad handling, leading to chips, cracks and breaks.

Early signs of degradation can include

- bloom, a white powder of the surface.
- corrosion of metal parts or surrounding objects.
- crazing and cracking.
- discoloured or even shredded packaging materials.
- distortion of the shape of the object.
- smells: mothballs (camphor), sweetness vinegar, vomit, rancid butter.
- Surface stickiness.
- Haze, wet acidic deposit on the surface.

If you think an object may be degrading wrap it in charcoal cloth and store it away from other objects.

Problem plastics
The most likely plastics to suffer chemical degradation are cellulose acetate, cellulose nitrate, polyvinyl chloride and polyurethane. Try to identify objects made of these materials before deterioration is visible and store them separately according to the guidelines given below. If degradation has begun you cannot reverse it or stop it. If however you move it into storage as outlined below you will slow down its progress.

Cellulose acetate

Deterioration: how it happens
Moisture causes the loss of acetate groups and the subsequent production of acetic acid. The presence of acetic acid accelerates the process of deterioration. As this happens a smell of vinegar is given off. Plasticisers can also migrate to the surface leaving a white powdery deposit and resulting in shrinkage which itself often causes distortion ad further stress. As degradation proceeds, crazing and cracking may occur. The acetic acid fumes from deterioration corrode metals.

Storage guidelines

- Temperature ideally 2- 5 centigrade.
- RH ideally 20 to 30 %.
- Do not wrap.
- Keep away from absorbent materials.
- Isolate from metals and other materials if possible.
- Use air filtration or vapour scavengers.
- Use indicators (for more information got to Useful material and products).

Cellulose nitrate

Deterioration: how it happens
Light and moisture cause the loss of nitrate as nitrogen oxides. Water and oxygen then turn this into acids and that accelerates the process of deterioration making the object brittle and prone to crazing and cracking, as well as forming sticky droplets on the surface. The emanations from deterioration corrode metals.

Storage guidelines
- Temperature 2- 5 centigrade.
- RH 20 to 30 %.
- Do not wrap.
- Keep away from absorbent materials.
- Isolate from metals and other materials if possible.
- Use air filtration or vapour scavengers.
- Good ventilation desirable.
- Use indicators (for more information got to Useful material and products).

Polyvinyl chloride

Deterioration: how it happens
Light causes yellowing and darkening and can lead to the giving off of hydrochloric acid. Oxygen is also harmful. Plasticisers have a tendency to migrate to the surface causing bloom and tackiness which attracts dirt. The weeping is accompanied by a sweet smell. The loss of plasticiser causes the plastic to shrink and thus to warp and also to become more rigid.

Storage guidelines
- Temperature 5° centigrade.
- RH 20 to 30%.
- Enclose in non-absorbent material such as glass or polyester bags to prevent loss of plasticiser
- Ideally oxygen free, using products such as oxygen scavengers.
- Do not wrap.
- Keep away from absorbent materials.
- Store with future display requirements in mind.

Polyurethane foam

Deterioration: how it happens
Oxidation causes discolouration and loss of strength. The result can be catastrophic loss of structure leading to collapse.

Storage guidelines
- Temperature 20° centigrade
- RH at the low end of 20 – 30%
- Ideally oxygen free, using products such as oxygen scavengers.
- Store with future display requirements in mind.

Specialist subject areas
The key to the care of all plastics is identification of the specific material and then looking after it appropriately. Once you know what it is (or its trade name) you can look it up in the A – Z of materials to find out more about it. Plastics that are essentially the same can manifest themselves

in unexpectedly different ways. Under the subject areas that follow are a few pointers to get you started.

- o Architectural drawings and other archival material
- o Composite objects
- o Film and photography
- o Packaging and containers
- o Textiles and fashion

o Architectural drawings and other archival material

Translucent synthetic supports made from cellulose acetate and cellulose nitrate film were introduced in the 1940s and became wide spread in the 1950s. Coated with light-sensitive compounds they were also used to make photo-reproductions. The care of such film is the same as that for other objects made of these materials. For more information go to Problem materials.

There was during the 1960s a fashion for protecting architectural drawings and other large paper objects with a cellulose butyrate or cellulose acetate butyrate varnish. Overtime, this has had a tendency to darken and obscure the image. A by-product of the degradation process, which will help you recognise it, is the smell of vomit caused by the emission of acidic gases. The varnish may also have become acidic itself and thus be weakening the paper. The environmental requirements for such documents are the same as those for objects made of cellulose nitrate and acetate. For more information go to Problem materials. A treatment strategy depends on the composition of the paper, drawing process, coating and degree of deterioration. It might be possible to remove the coating in a solvent bath but again this will depend on the degree of deterioration of the
coating, the composition of any inks that are present because these could be removed. It might also be the case that removing the coating only removes one source of deterioration and thus, it may not actually be worth putting the object through such intensive treatment. Only a professional conservator should attempt this and only after some deliberation. Suitable conservators can be found at www.conervationregister.com.

Polyester film as a draughtsman's support and as means of reproducing drawings was introduced in 1955. Polyester is an inert material good also for encapsulating drawings or as use as a barrier to prevent cross-contamination between drawings. For more information go to Useful materials and products. Polyester film requires the same care as outlined for all but problem plastics.

o Composite objects

These are objects made from more than one material. Ideally plastics should be kept separately from other materials to prevent cross-contamination. However greater damage can result to an object by taking it apart. The care of composite objects is therefore likely to be a compromise between maintaining the integrity of the object and looking after its different components. Particular attention should be paid to plastic and metal objects as each can cause the other to degrade. They are the priority for segregation.

o Film and film-based photographic negatives

All film (motion and still) was made of cellulose nitrate until1923 when cellulose acetate was introduced. In 1937 this was replaced by cellulose diacetate, which was in turn replaced in 1947 by cellulose triacetate. However cellulose nitrate film continued to be manufactured into the early 1950s.

Life expectancy is affected by precise composition at manufacture and storage conditions since. Nitrate and acetate have long been recognised as problematic and relatively recently it has been realised that the diacetate and triacetate adaptations are too. All benefit from even more stringent conditions than those recommended in Problem materials. Temperatures of at or below 0 degrees centigrade in a moisture free environment will extend their life in good condition by factors of ten or more. For more information refer to Canadian Council of Archives, Basic conservation of archival materials, 2003, chap 6, pp. 59-60 available at www.cdncouncilarchives.ca/RB and the Cellulose Acetate Project: www.nla.gov.au/anica/natstratnew.html.

Cellulose nitrate film is extremely flammable and once on fire very difficult to quench. Storage or transport of such film is extremely risky and the best course of action is to have it transferred by a licensed laboratory to safety film. For more information on the associated hazards, recommended actions and useful contacts please go to www.hse.gov.uk/pubns/cellulose.pdf.

o Packaging and containers

If you wish to keep the packaging of plastic goods or plastic packaging of non-plastic goods the same guidelines should be followed as is given for the materials concerned. Those most often encountered in this use are:

Polyethylene terephthalate	Fizzy drinks and water bottles
Polypropylene	Petrol cans; microwaveable meal trays; margarine tubs
Polystyrene	CD cases; yogurt pots
Polystyrene foam	Food trays, hamburger and egg boxes; protective packaging especially for electronic goods
Polythene (high density)	Milk and washing-up liquid bottles
Polythene (low density)	Carrier bags
Polyvinyl chloride	Sandwich boxes; blood bags

Contents of containers, for example juice, shampoo, sweets or food should be removed unless, of course, it is the contents rather than the container you are collecting. Ideally non-liquid contents should also be stored separately but whether this is feasible will depend on the availability of storage space.

o Textiles and fashion

The plastics most commonly used in the manufacture of fabrics are polyamide, polyester, polypropylene, polyvinyl chloride and polyurethane. Information on their introduction and early uses can be found in the Plastics timeline. Trade names such as Crimplene, Lycra, Nylon, Rayon, Terylene, and Viscose are given in the index of the A to Z of Plastic materials. From there you will be led to the material from which they were adapted.

The best way to store semi-synthetic and synthetic materials is dependent on the size of the garment or textile. Large objects should be rolled to avoid creases. Normal size garments may be stored on hangers with proper support for the shoulders, inside Tyvek™ covers. Bear in mind that it is a good idea to remove as many separate materials for examples belts as you can and to isolate others such as buttons and foam shoulder pads by placing a barrier between them and the fabric (Melinex™ can be used for this purpose) to prevent cross-contamination.

Some semi-synthetic or synthetic fabrics or garments can be washed, depending on the composition of the fibres and the finish of the textile. Conservation advice should be sort before washing such materials. Suitable conservators can be found at www.conervationregister.com.

Cleaning

Cleaning tends to cause both chemical and mechanical damage so keep a balance between the risk of damage and your wish for the object to look pristine.

The best way to clean plastic objects is with cotton swabs and lint-free cloths, ideally of microfibre, a mix of polyester and polyamide. If more in depth cleaning is essential dampened but never wet cloth using deionised water can be used but the dampness should be kept to a minimum and make sure that the object is completely dry after treatment. Water is especially bad for casein formaldehyde, cellulose acetate and cellulose nitrate. Never immerse a plastic object in water. Do not use solvents: severe damage that could ensue may not show immediately.

Conservation

Once an object needs treatment for anything other than mechanical damage it is likely to be too late. The best conservation treatment for plastics is preventive conservation as outlined in Environmental requirements and Storage and display. Storing plastics at low temperatures and relative humidities and keeping them away from harmful substances and vapours will however slow down the rate of harmful reactions.

There are no standard interventive processes for plastic materials. Interventive treatments present risks of further damage to objects due to potential reaction between treatment and object. More damage than good can be done by interventive conservation of plastics. Do not consider mending plastics or doing other interventive work without the advice of a specialist conservator. Suitable conservators can be found at www.conervationregister.com.

Useful materials and products

Materials that are safe to use in direct contact with all plastics are:

- acid free paper for wrapping.
- acrylic (polymethyl methacrylate)is an acceptable material to use for display stands.
- Charcoal cloth for wrapping objects that have the potential to offgas acidic fumes, e.g. cellulose acetate and cellulose nitrate objects
- microfibre, a blend of polyester and polyamide, useful as cloth for cleaning.
- Tyvek™, a form of polythene, useful for protecting objects from dust.
- Plastazote™, a form of polythene foam, useful for securing objects within storage spaces. It is easy to cut and carve to shape.
- Melinex™, a form of polyethylene terephthalate, an inert material to lay over degraded objects to protect them from dust and to put between them to discourage cross contamination. Also good as a buffer on painted surfaces.
- Polyester wadding useful for providing padding for example on hangers for costumes.
- polypropylene, appropriate for trays to hold objects.
- silicon release paper, useful for objects with potentially tacky surfaces.

Products that help you maintain a good environment are:

- Ageless oxygen scavengers for an oxygen free environment. This is suitable for preventing the crumbling of polyurethane foams.
- Silica gel, as a buffering agent moderating the effects of change in relative humidity.
- Scavengers such as charcoal cloth and molecular sieves to remove polluting vapours.
-

Products that help you detect trouble are:

- indicator strips and chemical - impregnated string which change colour in the presence of acidic gasses.

For more information on these please go to Web resources: Care.

CONTACT US
Please contact modip@aib.ac.uk if you have any comments on or corrections to this resource, find it hard to use, misleading or if it does not answer your needs. Corrections and improvements will then be made.

Also please contact us if you think you would use a plastics chat room or would like to contribute to a plastics blog.

SOURCES OF INFORMATION

Selected further reading
No attempt has been made to be comprehensive. The aim is to provide a selection of obtainable books to which it would be useful for someone collecting or looking after plastics to have access. The list is short enough for you to read it through and decide which are appropriate for your needs and then to order them. Those not in print are readily available on the second-hand market, for example via Amazon.

The books are arranged in order of publication.

E G Couzens & V E Yarsley, *Plastics*, Pelican, 1941; updated edition 1968; no ISBN
Clear and concise on plastics and their use to date but of special interest as a pioneering attempt to bring to a wide public through paperback a little known and difficult technological subject.

John Gloag, *Plastics and industrial design*, George Allen Unwin, 1945; no ISBN
Historically interesting, giving an insight into the 'state of plastics' at the beginning of the post-war period. Gloag sets out some ground rules for the newly emerging role of industrial designer. Includes useful section on plastics, their properties and uses, and on manufacturing processes by Grace Lovat Faser. 50 photos and 10 distinctive line drawings.

V E Yarsley (Ed.), *Plastics Applied,* National Trade Press, 1945; no ISBN
A comprehensive survey of the British plastics industry in 1945. Separate sections on plastics in domestic appliances, electric lighting, medicine and surgery, etc. etc.

British Plastics Federation, *The world of plastics*, 1962; no ISBN
96 pages on raw materials to plastic products and their impact on the environment, presented as a primer. Excellent introduction to the facts and issues.

M Kaufman, *The first century of plastics,* The Plastics Institute,1963; no ISBN
Comprehensive coverage of the history of early synthetic and semi-synthetic plastics, particularly Parkesine and Xylonite. One of the most authoritative books on the subject.

John Briston, *The Pegasus book of plastics*, Dennis Dobson, 1969; SBN 234 77186 0
Accessible introduction to what plastics are and their impact on the world we live in up to the 1960s.

Dietrich Braun, *Simple methods for the identification of plastics*, Carl Hanser Verlag,1982; ISBN 0029492602
Just what it says it is and includes a plastics identification table.

Andrea DiNoto, *Art Plastic,* Abbeville, 1984; ISBN 0 89659 437 8

Coffee table style with over 300 superb illustrations accompanied by sparse but interesting text. International selection of artefacts.

Sylvia Katz, *Plastics: design and materials*, Studio Vista, 1978; ISBN 0 289 70783 8
Fulfils its title brilliantly bringing out the impact of the capabilities of different plastics on the evolution of form in design. A must for any museum with a design remit whether concerned with plastics or other materials.

Sylvia Katz, *Classic plastics from Bakelite to high-tech*, Thames & Hudson, 1984; ISBN 0 500 27390 1
Authoritative history with good pictures of products made of plastic. Conservation advice aimed at private collectors rather than museums.

Sylvia Katz, *Early plastics*, Shire album 168, 1986; ISBN0 85263790 X
32 pages of essential information. Images black and white but nonetheless helpful. Care and repair section more suitable for private collectors than a museum.

J A Brydson, *Plastics Materials,* Butterworths, 1989; ISBN 0 408 00721 4
Over 800 pages of plastics. Perhaps a little technical for the layman in places but still an essential reference book.

Penny Sparke ed.,*The plastics age, from Bakelite to beanbags and beyond*, The Overlook Press,1993; ISBN 0 87951 471 X
First published as the book of an exhibition held at the V&A in 1990 but hard to find in that version. Includes key texts by a wide range of thinkers and plastics experts including Reyner Banham, Jean Baudrillard, Roland Bathes, John Gloag, Sylvia Katz, Enzio Manzini and Susan Mossman. Maps the intellectual territory.

Jeffrey L Meikle, *American plastic, a cultural history*, Rutgers University Press1995; ISBN 08135 2234 X
Extensive (403 pages) text written by an art historian on the contexts of and attitudes aroused by American plastics. Thought-provoking.

Stephen Fenichell, *Plastic: the making of a synthetic century*, Harper Collins, 1996; ISBN 0 88730 732 9
Irreverent look at the social and economic revolutions brought about by plastic and how it has moulded and been moulded by scientists, artists, politicians and shoppers.

Susan Mossman ed., *Early plastics,* Leicester University Press, 1997; ISBN 0 7185 00202
Chapters by Morris Kaufman, Susan Mossman, Roger Newport and Mark Suggitt approaching the subject from a variety of perspectives. Very readable and full of useful historical information. Large section devoted to a catalogue of the Science Museum plastics collection. 20 colour plates and numerous black & white illustrations.

Pete Ward, *Fantastic plastic, the kitsch collector's guide*, Quintet Publishing, 1997; ISBN1 85076 794 7
Good for images of, in its own words, the 'wacky, crazy, eccentric, gaudy, tasteless' from the 1950s onwards.

Mel Byars, *100 designs / 100 years, innovative designs of the 20th century*, RotoVision SA, 1999; ISBN2 88046 442 0
Not a history of plastics but half the designs happen to be made of plastics or have plastic components.

Anita Quye and Colin Williamson ed., *Plastics collecting and conserving*, NMS Publishing Limited, Edinburgh, 1999; ISBN1 901663 12 4

Key to the creation of this information resource. Encompasses its subject comprehensively but succinctly with contributions from the key figures working in the field in the UK. A must have.

Holly Wahlberg, *1950s Plastics Design*, Schiffer Publishing, 1999; ISBN0 7643 0783 5
Good for images of plastics in context but limited to plastics in the USA.

N. Odegaard, S.Carroll, and W.S.Zimmt, *Material characterization test for objects of art & archaeology*, Archetype Publications, 2000; ISBN 1-873132-12-3
Places plastics in the context of other materials. Provides detailed information on tests available. Perhaps for the more scientifically inclined.

Chris Lefteri, *Plastic materials for inspirational design*, Rotovision SA, 2001
and
Chris Lefteri, *Plastics 2 materials for inspirational design*, Rotavision SA 2006; ISBN 2 940361 0 1
Aimed at budding designers rather than those with plastics in their collection but features a range of fascinating products that have defined and pushed out the boundaries of plastics manufacture plus basic information on a wide range of plastics and processes.

Thomas Wessel ed., *Plastic art – a precarious success story*, AXA Art Versicherung AG, 2007; no ISBN
Useful short introduction to the issues relating to and care of the plastics used in art and the high-end of design from about 1950 onwards.

Yvonne Shashoua, *Conservation of plastics, materials science degradation and preservation*, Elsevier, 2007; ISBN 978950664950
Source for all that is required to keep plastic objects in prime condition and includes a history of plastics. Excellent for curators as well as conservators.

Web resources
There are hundreds, if not thousands, of really useful websites. Any website will lead you to many others. Only the most significant in terms of plastics in the museum context are given here. These are listed alphabetically under the following subjects according to what is their greatest strength. They are often also a source of information under the other subjects:

- Care
- Materials and processes
- Objects

Care
www.conservation-by-design.co.uk
Good for information on and products relating to absorbents and buffers.

www.conservationregister.com/careplastics.asp?id=4.
Succinct account of plastic conservation issues with access to practicing conservators.

www.nla.gov.au/anica/natstratnew.html/
Outlines a national strategy for Australian cellulose acetate collections, a strategy that could be applied to plastics more generally.

www.preservationequipment.com/
Site of Preservation Equipment Limited (PEL) on which ordering of anything you might needs is made easy.

www.spnhc.org/files/supplies_cdn.htm

Excellent account of useful products for the care of objects with explanations of what they do and how to use them.

Materials and processes
www.bpf.co.uk
Site of leading trade association of the UK's plastic industry, especially good on materials and their histories and capabilities.

www.plasticsresource.com
American Plastics Council site, with succinct history of particular plastics up to 1950.

www.plastiquarian.com
Excellent information packed site of the Plastics Historical Society, especially good on the history and uses of plastics and their inventors/manufacturers (up to 1965). Includes useful index of tradenames/materials/manufacturers. If you are only going to look at one site, this is likely to be the most useful.

Objects
www.kunsthoff-museums-verein.net
Site of the German Plastics Museum. Objects grouped by materials and themes with good images and texts. A little hard to navigate but worth the effort.

www.museo.cannon.com
Site of the first Italian Museum of Plastics, founded 1985. 2500 well-catalogued objects presented informatively through a range of themes.

www.plasticsmuseum.org
Site of the National Plastics Center & Museum, Massachusetts, USA. Currently developing an on-line collections database: excellent so far as it goes but currently limited, plus useful timeline.

www.plasticsnetwork.org
A site created by the Bakelite Museum, Design Museum Collection (now the Museum of Design in Plastics), National Plastics Museum, and Plastics Historical Society in partnership. Includes the complete catalogue of the Museum of Design in Plastics and interesting case studies on a range of design related themes.

CONTRIBUTORS

This resouce is the product of a collaborative project funded by a Museums, Libraries and Archives Subject Specialist Network Implementation Grant.

The information in it has been derived principally from papers given at four regional workshops organised by the Plastics Subject Specialist Network, coordinated by the Museum of Design in Plastics based at the Arts Institute at Bournemouth.

The workshops were held at the:

- Design Museum, London, in partnership with the 20th Century Society
- Scottish National Gallery of Modern Art, Edinburgh, in partnership with the Modern Materials in Collections: Scotland
- Tate Liverpool in partnership with the UK Centre for Materials Education, University of Liverpool
- Wakefield Museum in partnership with the Social History Curators Group.

Each workshop followed the same pattern with three speakers in the morning on:

- Milestones in the development and use of plastics.
- Identification: plastic materials and production techniques.
- Care of plastics.

And in the afternoon, four sessions:

- venue and/or partner specific plastics.
- open discussion of delegates objects.
- group discussion with speakers.
- feedback.

The workshops were independently evaluated by Liverpool University. A copy of the evaluation is available from modip@aib.ac.uk.

The speakers were different at each workshop. Their briefs were based on comments from delegates on what they wanted to learn. Each speaker on a certain subject had the same brief but they interpreted it in their own and very different ways thus providing a wonderfully rich resource for the resource's content. In addition, texts given in Sources of further information were drawn upon, and in particular, Anita Quye and Colin Williamson ed., *Plastics collecting and conserving*, NMS Publishing Limited, Edinburgh, 1999.

The resource has been drafted by Susan Lambert, Museum of Design in Plastics. Its structure and content has been discussed in an ongoing process with all those involved. Thus delegates, as well as speakers and chairs, have played a major role in its shaping. Additionally the content has been reviewed by 6 specialist reviewers with complementary knowledge in the field of plastics, and again amended. Any errors that remain are, however, entirely the fault of Susan Lambert. If you find errors please send them to modip@aib.ac.uk and they will be corrected. She is most grateful to everyone involved for the generosity with which they have given of their expertise, ideas, and time, and for the marvelous support she has received throughout.

Information on those involved is given on the following pages:

Chairs

Each chair brought to the workshop their particular expertise and observations, and created an atmosphere that enabled free-exchange between speakers and delegates. Their participation is greatly appreciated.

Design Museum workshop	**Catherine Croft**, Director of the 20th Century Society
Scottish National Gallery of Modern Art workshop	**Ray Bush**, President of the Society of Plastics Engineers, UK and Ireland
Tate Liverpool workshop	**Colin Williamson**, Managing Director of Smile Plastics, founder member of the Plastics Historical Society, writer, lecturer and collector

Wakefield Museum workshop	**Zelda Baveystock**, Lecturer in Museum Studies, Newcastle University; Treasurer of the Social History Curators Group

Speakers
The speakers' papers, in their wonderful variety, provided the content of this resource. It is extremely generous of the speakers to have given of their expertise and scholarship so freely and to have allowed it to be used in this way. Their involvement is greatly appreciated.

Steve Akhurst	Editor of the *Plastiquarian*, Plastics Historical Society, collector and formerly plastics design consultant
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Colin Williamson	Managing Director, Smile Plastics; Plastics Historical Society; writer, lecturer and collector
John Whitaker	Curator, Wakefield Museum

Delegates
All delegates had input to this resource through what they said they wished to learn from the workshops and through their participation at them, their questions, observations and feedback. Those with an asterisk * beside their name brought objects for discussion to the workshops. Those in bold contributed to this manual during the drafting process. The participation of all delegates in the development of this resource is very greatly appreciated.

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Sam Gatley	Graduate Student
Sarah Gerrish	National Museums Scotland
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Laura Gray	Harris Museum and Art Gallery , Preston
Tate Greenhalgh	Thackray Museum, Leeds
Rachel Hammond	Museum of Science and Industry, Manchester
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Hannele Hentula	Burrell Collection, Glasgow
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Specialist reviewers
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