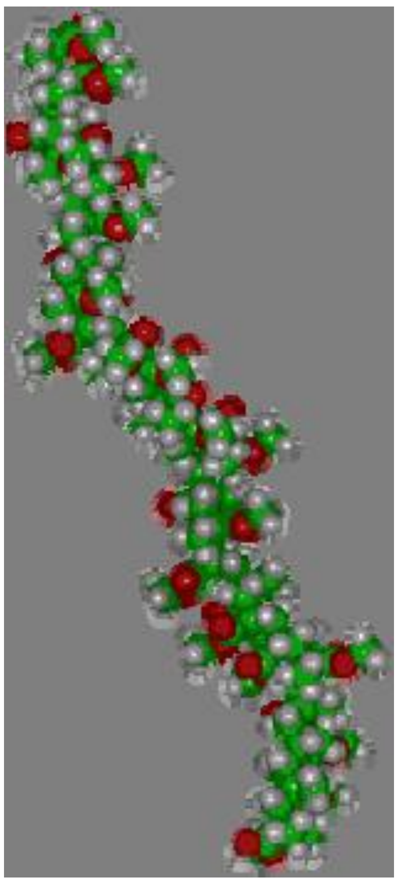
NEDRON POLYMERS

Partners in Progressive Plastics

Plastics

Introduction



Humans have taken advantage of the versatility of polymers for centuries in the form of oils, tars, resins, and gums. However, it was not until the industrial revolution that the modern polymer industry began to develop. In the late 1830s, Charles Goodyear succeeded in producing a useful form of natural rubber through a process known as "vulcanization." Some 40 years later, Celluloid (a hard plastic formed from nitrocellulose) was successfully commercialized. Despite these advances, progress in polymer science was slow until the 1930s, when materials such as vinyl, neoprene, polystyrene, and nylon were developed. The introduction of these revolutionary materials began an explosion in polymer research that is still going on today.

Some degree of compromise is almost always necessary in designing plastic parts. Arriving at the best compromise usually requires satisfying the mechanical, thermal, and electrical requirements of the part, utilizing the most economical resin or compound that will perform satisfactorily and be attractive, and choosing a manufacturing process compatible with the part design and material choice.

Probably no plastic will provide 100% of the requirements for the desired performance, appearance, processibility, and price. Selecting the best qualified material is not based simply on comparing numbers on published data sheets; such values can be grossly misleading. For example, choosing the most economical material for a part by comparing the cost per pound of various plastics is a mistake. Some plastics weigh twice as much per cubic inch as others and so would require twice as much to fill a given cavity and cost twice as much to ship.

Polymers have a wide range of mechanical properties. Network polymers are often quite strong and stiff (high yield strength and modulus of elasticity), although they have poor ductility. Linear polymers have much lower strength but quite high ductility, and elastomers have very large values of ductility and a variable modulus of elasticity. Polymers are generally classified according to their structure, properties and use as:

- **Thermoplastic**
- **Thermosetting**
- **Elastomers**

Thermoplastics

Thermoplastic materials are melt processable, that is they are formed when the are in a melted or viscous phase. This generally means they are heated, formed, then cooled in their final shape. Depending upon their chemistry, thermoplastics can be very much like rubber, or as strong as aluminum. Some high temperature thermoplastic materials can withstand temperature extremes of up to 600 F, while others retain their properties at -100 F. Thermoplastics do not oxidize and some materials have no known solvents at room temperature. Most thermoplastic materials are excellent electrical and thermal insulators. On the other hand thermoplastic composites can be made to be electrically conductive with the addition of carbonor metal fibers.

In general the combination of light weight , high strength, and low processing costs make thermoplastics well suited to many applications. The most common methods of processing thermoplastics are injection molding, extrusion , and thermoforming.

Thermoplastics include:

- ABS (Acrylanitrile Butadiene Styrene)
- ABS Polycarbonate Alloy
- PPO Modified Polyphenylene Oxide (Noryl)
- PPS Polyphenylene Sulfide
- ASA (acrylic-styrene-acrylonitrile) Alloys
- Polystyrene High Impact HIPS
- Polystyrene Medium Impact MIPS
- EVA Ethylene Vinyl Acetate
- LCP (Polyester Liquid Crystal Polymer)
- PVC Polyvinyl Chloride Rigid
- PVDF Polyvinylidene Fluoride (Kynar)
- SAN Styrene Acrylonitrile
- TPE Thermoplastic Elastomers
- TPR Thermoplastic Rubbers
- Nylon amorphous
- Nylon impact modified
- Polyallomer
- PBT Polyester (Polybutylene Terepthalate)
- Polycarbonate
- PEEK Polyetheretherkeytone
- PEI Polyetherimid (Ultem)
- Polyethersulfone
- Polyethylene High Density
- Polyethylene Low Density
- Polyethylene Medium Density
- PET Polyester (Polyethylene Terepthalate)
- Polyimide Thermoplastic (Aurum)
- Polypropylene
- Acetal
- Acrylic
- Polystyrene Crystal
- Cellulose Butyrate
- ETFE (Tefzel)
- Nylon 6
- Nylon 4-6
- Nylon 6-6
- Nylon 11
- Nylon 12
- Polysulfone
- Polyurethane
- PVC Flexible

Thermoset Plastics

Thermoset plastics such as amino, epoxy, phenolic, and unsaturated polyesters, are so named because they experience a chemical change during processing and become "set", hard solids. Thermosets are highly cross-linked polymers that have a molecular mesh or network of polymer chains like a three-dimensional version of a net. Thermosets undergo a chemical as well as a phase change when they are heated. Once cured they cannot be melted or remolded and are resistant to solvents - that is once they are formed they are 'set' (hence the name).

Thermoset plastics, because of their tightly crosslinked structure, resist higher temperatures and provide greater dimensional stability than do most thermoplastics. Thermosets are tough, durable with high temperature performance, and have found applications in a wide variety of fields including electronic chips, fibre-reinforced composites, polymeric coatings, spectacle lenses and dental fillings.

For more specific examples of thermoset resins and their uses browse the following pages.

1. **Alkyds / Polyester**

   Uses - Thermosetting polyester resins are commonly used as casting materials, fiberglass laminating resins, and non-metallic auto-body fillers. Polyester is used for car body panels and fender walls (SMC - sheet molding compound), tool housings (BMC - bulk molding compound) brackets, and industrial equipment housings.

2. **Urea Formaldehyde (UF) & Melamine Formaldehyde (MF) / Aminos**

   Urea formaldehyde (UF) thermosets are strong, glossy, and durable. They are not affected by fats, oils esters, ether, petrol, alcohol or acetone, nor by detergents or weak acids, and they exhibit good resistance to weak alkalis. Their high mechanical strength, heat and fire resistance, and good electrical arc and tracking resistance make them an ideal plastic for numerous industrial and household applications, from doorknoobs and toilet seats to electrical components and cosmetics enclosures.

   Melamine formaldehyde (MF) thermoset plastics are similar to urea molding compounds, but melamine has even better resistance to heat, chemicals, moisture, electricity and scratching.UFs and MF plastics that have high surface hardness and gloss, brilliant and precise colors, and light fastness.

Uses - Melamine formaldehyde (MF) thermosets are ideal for dinnerware, kitchen utensils, bathroom accessories, and electrical components. Some uses include electrical breakers, receptacles, closures, knobs and handles, appliance components, adhesives, coatings and laminates. Melamine was formerly used for dishware.

3. Epoxy

Epoxies have several advantages over other plastics including excellent electrical, thermal, and chemical resistance. Their strength can be further increased with fibrous reinforcement or mineral fillers. There is a huge variety of combinations of epoxy resins and reinforcements which allows a wide range of possible properties in the finished molded parts.

Generally, parts molded from epoxy are hard, rigid, relatively brittle, and have excellent dimensional stability over a broad temperature range. The combination of high mechanical strength and excellent electrical properties make them ideal for electrostructural applications.

Uses

Coatings, casting compounds, encapsulating for electrical components, laminates, and adhesives

4. Phenolic (Bakelite)

History

The first truly synthetic plastic was invented by Leo Baekeland - a Belgium chemist living in New York. Baekeland was already very rich as he had invented the first commercially successful photographic paper and sold it to George Eastman in 1898 for $1 million. With such money, Baekeland could engage himself in whatever research he decided to do.

In 1905, he found that when he combined formaldehyde and phenol, he produced a material that bound all types of powders together. He called this material Bakelite - after himself - and it was the first thermosetting plastic in the world. This was a material that once it set hard would not soften under heat. It had so many uses and so many potential uses, that it was called "the material of a thousand uses".

Bakelite was water and solvent resistant; could be used as an electrical insulator; was rock hard but could be cut by a knife and was used in 78 rpm records and telephones. It was a naturally brittle material in pure form, but it could be strengthened with fillers such as wood pulp and cellulose.

Uses

PF was used in early consumer electronic products such as telephones, radios, records. Phenolics are little used in general consumer products today due to the cost and complexity of production and their brittle nature. An exception to the overall decline is the use in small precision-shaped components where their specific properties are required, such as molded disc brake cylinders, saucepan handles, electrical plugs and switches, and electrical iron parts. Today, Bakelite is manufactured under various commer cial brand names such as Micarta. Micarta is produced in sheets, rods and tubes for hundreds of industrial applications in the electronics, power generation and aerospace industries.

5. Polyimide

When compared to most other organic or polymeric materials, polyimides exhibit an exceptional combination of thermal stability (>500°C), mechanical toughness and chemical resistance. In addition, they have excellent dielectric properties.

Uses

Used a lot in wear applications, machined gears, bushings and bearings, aerospace and aircraft parts, ring seals, thrust washers, wear strips. Also, because of their high degree of ductility and inherently low CTE, polyimides can be readily implemented into a variety of microelectronic applications. Multilayer thin and thick film applications on large silicon or ceramic substrates can be readily achieved.

6. Polyurethane

Polyurethanes are widely used in flexible and rigid foams, durable elastomers and high performance adhesives and sealants, fibers, seals, gaskets, condoms, carpet underlayment, and hard plastic parts. Polyurethane products are often called "urethanes".

Uses

Over three quarters of the consumption of polyurethane products is in the form of foams, with flexible and rigid types being roughly equal in market size. Polyurethane materials are also used in coatings and varnishes used in furniture manufacture, carpentry or woodworking. Polyurethane is also used as an adhesive, especially as a woodworking glue. Its main advantage over more traditional wood glues is its water resistance. It is also used in making solid tires. Modern roller blading and skateboarding became economical only with the introduction of tough, abrasion-resistant polyurethane parts.

7. Silicone

Silicones are odorless, colorless, water resistant, chemical resistant, oxidation resistant, stable at high temperature, and have weak forces of attraction, low surface tension, low freezing points and do not conduct electricity. They find many uses in oils, greases, and rubberlike materials. Silicone oils are very desirable since they do not decompose at high temperature and do not become viscous.

Uses

Silicones are use for lubricants, adhesives, sealants, gaskets, pressure compensating diaphragms for drip irrigation emitters, dishware, Silly Putty, and many other products. Silicones have a number of medical applications (e.g. breast implants) because they are chemically inert. Other silicones are used in hydraulic fluids, electrical insulators and moisture proofing agent in fabrics.

Elastomers

Elastomers and rubber are differentiated from polymers by the mechanical property of returning to their original shape after being stretched to several times their length. The rubber industry differentiates between the terms "elastomer" and "rubber" on the bases of how long a deformed material sample requires to return to its approximate original size after a deforming force is removed, and of its extent of recovery. Synthetic materials such as neoprene, nitrile, styrene butadiene (SBR), and butadiene rubber are now grouped with natural rubber. These materials serve engineering needs in fields dealing with shock absorption, noise and vibration control, sealing, corrosion protection, abrasion protection, friction production, electrical and thermal insulation, waterproofing, confining other materials, and load bearing.

As with almost any material, selecting a rubber for an application requires consideration of many factors, including mechanical or physical service requirements, operating environment, a reasonable life cycle, manufacturability of the part, and cost.

Manufacturing rubber parts is accomplished in one of three ways: transfer molding, compression molding, or injection molding. The choice of process depends on a number of factors, including the size, shape, and function of the part, as well as anticipated quantity, type, and cost of the raw material.

Elastomers are classified as follows:

- **Nonoil-resistant rubbers**
- **Oil-resistant rubbers**
- **Thermoplastic elastomers**