International Journal of Composite and Constituent Materials
eISSN: 2456-5237
Vol. 3: Issue 1
www.journalspub.com

Study on the Properties and Applications of Thermoplastic

*Garima Tripathi**
Department of Chemical Engineering and Technology, Indian Institute of Technology, Banaras Hindu University, Varanasi, Uttar Pradesh, India

ABSTRACT

Hot-applied thermoplastic is prepared for road deposition in a melting apparatus where the granular or block material is introduced and heated until it liquefies at temperatures exceeding 400F. When applied on asphaltic concrete, thermoplastic material develops a thermal bond via heat- fusion. A thermoplastic is a material, usually a plastic polymer, which becomes soft when heated and hard when cooled. Thermoplastic materials can be cooled and heated several times without any change in their chemistry or mechanical properties. When thermoplastics are heated, they melt to a liquid. A thermoplastic, or thermosoftening plastic, is a plastic material, a polymer, which becomes pliable or moldable above a specific temperature and solidifies upon cooling. Most thermoplastics have a high molecular weight. Thus, thermoplastics may be reshaped by heating and are typically used to produce parts by various polymer processing techniques such as injection molding, compression molding, calendaring, and extrusion. They are useful for a variety of applications, including consumer goods, machine parts, medical equipment and packaging and storage materials. Each type of material offers different properties, benefits and strengths; and today, we are going to focus on the importance of thermoplastic materials.

Keywords: molding and remolding of plastics, thermoplastic, thermoplastic application, thermosoftening, polymer

Corresponding Author
E-mail: tgarima245@gmail.com

INTRODUCTION

Plastics are synthetic resinous substances that can be molded with the help of heat or pressure. There are two main classes of plastics: Thermosetting – plastics that can only be heated and be molded once. If re-heated they cannot soften. Thermoplastics – plastics that are molded by heating and can be remolded if heated again [1]. Thermoplastics soften when heated and can be shaped when hot. The plastic will harden as it cools down. A thermoplastic is a material, usually a plastic polymer, which becomes soft when heated and hard when cooled. Thermoplastic materials can be cooled and heated several times without any change in their chemistry or mechanical properties. When thermoplastics are heated, they melt to a liquid [2]. The primary physical difference is that thermoplastics c an be remelted back into a liquid, whereas thermoset plastics always remain in a permanent solid state. Think of thermoplastics as butter – butter can be melted and cooled multiple times to form various shapes [3].

Types of Plastics

Acrylic

Acrylic, a polymer called poly (methyl methacrylate) (PMMA), is also known by trade names such as Lucite, Perspex and Plexiglas. It serves as a sturdy substitute for glass for such items as aquariums, motorcycle helmet visors, aircraft

windows, viewing ports of submersibles, and lenses of exterior lights of automobiles. It is extensively used to make signs, including lettering and logos. In medicine, it is used in bone cement and to replace eye lenses. Acrylic paint consists of PMMA particles suspended in water [4].

Nylon

Nylon, belonging to a class of polymers called polyamides, has served as a substitute for silk in products such as parachutes, flak vests and women's stockings. Nylon fibers are useful in making fabrics, rope, carpets and strings for musical instruments. In bulk form, nylon is used for mechanical parts, including machine screws, gear wheels and power tool casings. In addition, nylon is used in the manufacture of heat-resistant composite materials [4].

Polyethylene

Polyethylene (or polyethene, polythene, PE) is a family of materials categorized according to their density and molecular structure. For example, ultra-high molecular weight polyethylene (UHMWPE) is tough and resistant to chemicals, and it is used to manufacture moving machine parts, bearings, gears, artificial joints and some bulletproof vests. High-density polyethylene (HDPE) is used to make milk jugs, margarine tubs and water pipes. Medium-density polyethylene (MDPE) is used for packaging film, sacks and gas pipes and fittings. Low-density polyethylene (LDPE) is soft and flexible and is used in the manufacture of squeeze bottles, sacks and sheets [4].

Polypropylene

Polypropylene (PP) is useful for such diverse products as reusable plastic containers, diapers, sanitary pads, ropes, carpets, plastic moldings, piping systems, car batteries, insulation for electrical cables and filters for gases and liquids. In medicine, it is used to repair hernias and to make heat-resistant medical equipment. Polypropylene sheets are used for stationery folders and packaging and storage boxes [4].

Polystyrene

Polystyrene is manufactured in various forms that have differing applications. Extruded polystyrene (PS) is used in the manufacture of disposable cutlery, CD and DVD cases, plastic models of cars and boats, and smoke detector housings. Expanded polystyrene foam (EPS) is used in making insulation and packaging materials, such as the "peanuts" and molded foam used to cushion fragile products. Extruded polystyrene foam (XPS), known by the trade name Styrofoam, is used to make architectural models and drinking cups for heated beverages. Polystyrene copolymers are used in the manufacture of toys and product casings [5].

Polyvinyl Chloride

Polyvinyl chloride (PVC) is a tough, lightweight material that is resistant to acids and bases. Much of it is used by the construction industry, such as for vinyl siding, drainpipes, gutters and roofing sheets. It is also converted to flexible forms with the addition of plasticizers, thereby making it useful for items such as hoses, tubing, electrical insulation, coats, jackets and upholstery. Flexible PVC is also used in inflatable products, such as water beds and pool toys [5].

Teflon

Teflon is the brand name given by DuPont Corp. for a polymer called polytetrafluoroethylene (PTFE), which belongs to a class of thermoplastics known as fluoropolymers. It is famous as a coating for non-stick cookware. Being chemically inert, it is used in making containers and pipes that come in contact with reactive chemicals. It is also used as a lubricant to reduce wear from friction between sliding parts, such as gears,

bearings and bushings (Tables 1 and 2) [5].

Table 1. *Types of thermoplastics, properties and uses.*

Thermoplastic	Thermoplastic properties	Thermoplastic uses	Example outcomes
Acrylics or perspex (polymethyl methacrylate)	Stiff, hard, shiny, brittle in small sections, durable, scratches easily, available in different colors, good electrical insulator	Used for signs, key rings, lighting, storage containers	
High impact polystyrene (HIPS)	Light but strong plastic, available in sheets in a variety of thicknesses and colors and softens at about 95 degrees	Used for vacuum forming and making outer casings and packaging for products	
Expanded polystyrene (styrofoam)	White, lightweight and crumbly	Used for protective or insulating packaging	
Polypropylene (PP)	Light, hard, flexible but can scratch easily. Durable to wear and has good resistance to chemicals	Used for different kinds of packaging, chairs, gadgets, textiles and automotive components	
Low density polyethylene (LDPE)	Soft, flexible, good resistance to chemicals, good electrical insulator, tough	Used for packaging film, carrier bags, bottles, toys	
High density polyethylene (HDPE)	Hard, stiff and strong. Able to be sterilized	Used for plastic bottles, tubing and household equipment	
Corrugated plastic	Lightweight, rigid and weatherproof	Used for sign boards and folders	
Low-tack masking film	Flexible and transparent	Used to position sticky-backed vinyl letters or images onto a chosen surface. Used for creating signs, stencils and vehicle signage	
Polyvinyl chloride (PVC)	Stiff, hard wearing, brittle but can be treated to make it softer and more rubbery	Used for blister packs, window frames, records and clothing	

Some types of thermoplastics are expensive, strong and used in place of metal, while the others are used in common everyday products. They are easy

to mold and shape when they are hot. They can turn to liquid at high temperatures. When they are cooled, they turn into hard and solid plastic. The keyboards and compact disc cases are made of the thermoplastics (Figure 1). The most popular methods of processing thermoplastics are injection molding, extrusion, and thermoforming. The thermoplastics can be like rubber or as strong as aluminum depending on their chemistry. They are light weight, with densities of 0.9 to 2 gm/cc. Some thermoplastic materials can withstand the temperature extremes up to 600 F, while the others retain their properties at –100 F. Some thermoplastic materials have no known solvents at room temperature. The thermoplastic composites can be made to be electrically conductive with the addition of carbon or metal fibers. The combination of light weight, high strength & low processing costs make the thermoplastics well suited to many applications. They are used as thermal insulators and electrical insulators [6].

Fig. 1. *Thermoplastic – heated and remolded 100's of times can be recycled.*

Table 2. *Properties and uses of thermoplastics.*

Name	Properties	Principal uses
Polyamide (Nylon)	Creamy color, tough, fairly hard, resists wear, self-lubricating, good resistance to chemicals and machines	Bearings, gear wheels, casings for power tools, hinges for small cupboards, curtain rail fittings and clothing
Polymethyl methacrylate (Acrylic)	Stiff, hard but scratches easily, durable, brittle in small sections, good electrical insulator, machines and polishes well	Signs, covers of storage boxes, aircraft canopies and windows, covers for car lights, wash basins and baths
Polypropylene	Light, hard but scratches easily, tough, good resistance to chemicals, resists work fatigue	Medical equipment, laboratory equipment, containers with built-in hinges, 'plastic' seats, string, rope, kitchen equipment
Polystyrene	Light, hard, stiff, transparent, brittle, with good water resistance	Toys, especially model kits, packaging, 'plastic' boxes and containers
Low density polythene (LDPE)	Tough, good resistance to chemicals, flexible, fairly soft, good electrical insulator	Packaging, especially bottles, toys, packaging film and bags
High density polythene (HDPE)	Hard, stiff, able to be sterilized	Plastic bottles, tubing, household equipment

Two types of thermoplastics are high-temperature thermoplastics and engineering thermoplastics. Examples of high-temperature thermoplastics contain popular materials such as polypropylene and PVC; they are commonly used for the pipes, the bottles and the plastic containers. Engineering thermoplastics are typically flame-retardant and they can withstand the temperatures of up to 100°C, engineering plastics cost much more to produce than these popular materials, they contain the materials such as the nylons and the polyesters. One type of the thermoplastic which is called polyester resin, it is used for the car bodies and the garden furniture. Another type of thermoplastics is polymethyl methacrylate, it is used for the lenses and the windows [7].

Advantages of Thermoplastics

- Thermoplastics are energy efficient both in their manufacture and processing.

- Thermoplastic components can be made in very high volume with high precision and low cost.
- They can replace the metals with a considerable weight savings, proper care is taken in design.
- Most thermoplastics have better fatigue properties than the metals and they can tolerate larger deflections than the metals without deforming.
- The thermoplastics can be remolded and recycled without negatively affecting the material's physical properties.
- They can soften when they heated and they become more fluid as additional heat is applied.
- The curing process is completely reversible because no chemical bonding takes place.
- Thermoplastic materials resin and they offer many performance benefits. But most thermoplastic materials offer high strength, shrink-resistance and easy bendability.
- Depending on the resin, they are used in the low-stress applications such as the plastic bags or high-stress mechanical parts.
- Thermoplastics materials have high strength. They are lightweight and they come with relatively low processing costs. Manufacturing of the thermoplastic components easily in high volumes with high precision. The engineers use the thermoplastics instead of the metals because of their much lighter weight.
- Thermoplastics materials are highly recyclable. They offer aesthetically-superior finishes. They have High-impact resistance. They contain remolding/reshaping capabilities. They offer a chemical resistant. They have hard crystalline or rubbery surface options and they have Eco-friendly manufacturing.
- The thermoplastics can soften or melt when they heated and returning to solid when they cooled. The process is repeatable and it does not change the chemical nature of the polymer. Heating provides the thermal energy to allow the long polymer chains to move freely past one another and take on new shapes. Cooling reduces molecular motion to the level where the chains no longer move freely.
- The thermoplastics, with the exception of polyester and polyimide film, have only recently gained popularity, particularly for microelectronic structures in the recent times. Advanced thermoplastics can now provide high melting points and exceptional stability early generation polymers could not offer [8].

Disadvantages of Thermoplastics

- Many thermoplastic materials, especially the composites, tend to fracture rather than deform under high stress levels. They suffer from creep where the thermoplastics materials relax or weaken when they exposed to long-term loading.
- The primary drawback of using the thermoplastics instead of the materials such as the metal is that the thermoplastics can melt. Some types of low-quality thermoplastics melt, some thermoplastics degrade when they're exposed to direct sunlight or ultraviolet light levels for the extended times.
- Thermoplastics are more expensive than thermoset materials and they can melt if they heated, many materials have poor resistance to hydrocarbons, organic solvents and highly polar solvents but the others have excellent resistance to these materials [9].

CONCLUSION

The flexible nature of thermoplastics means that they are a top choice for

applications where both high-tensile strength and extremely thin gauge (or wall thickness) are necessities. Think of uses like packaging film or plastic bags – with a small amount of force, they can be easily broken (often as intended), but they hold up to normal use and impact. Thermoplastics are receptive to surface finishing. With thermoset materials, although they typically yield a pleasing final appearance, they are more difficult to apply custom finishes to, for instance ink or paint. Thus, for products or pieces where logos or decorations must be applied, thermoplastics are the better choice. They lend themselves to a broad range of surface-finishing methods and materials, making them an extremely versatile choice for consumer products and the like. Thus, from the above points represent the benefits of thermoplastics. A major effort focuses on producing parts utilizing processes without an autoclave. Composites reinforced with thermoplastic polymers provide designers and production engineers a variety of processes that make parts rapidly and reliably. With recent developments in automation and qualities such as room temperature storage, weldability, superior toughness, and almost unlimited shelf life together, thermoplastic composites will be useful in more applications.

REFERENCES

[1] http://www.lgschemistry.org.uk/PDF/Thermosoftening_and_thermosetting_plastics.pdf.

[2] S.A. Baeurle, A. Hotta, A.A. Gusev. On the glassy state of multiphase and pure polymer materials, *Polymer*. 2006; 47: 6243–53p. doi:10.1016/j.polymer.2006.05.076.

[3] A.V. Shenoy, D.R. Saini. *Thermoplastic Melt Rheology and Processing*. New York: Marcel Dekker Inc.; 1996.

[4] C.P. MacDermott, A.V. Shenoy. *Selecting Thermoplastics for Engineering Applications*. New York: Marcel Dekker Inc.; 1997.

[5] D.R. Saini, A.V. Shenoy. Melt rheology of some specialty polymers, *J Elastom Plast*. 1985; 17: 189–217p.

[6] https://www.azom.com/article.aspx?ArticleID=7983#12.

[7] http://onlinelibrary.wiley.com/doi/10.1002/masy.19910480115/abstract.

[8] http://sciencing.com/uses-thermoplastics-2457.html.

[9] https://www.slideshare.net/pratikchaudhari3/thermoplastics-introductionclassificationprocessing-applications