Polymeric Engineering Materials

an Overview

Craig E. Nelson - Consultant Engineer

Nelson Research, Inc. 2142 – N. 88th St. Seattle, WA. 98103 USA 206-498-9447 Craigmail @ aol.com

Plastics and Elastomer Terminology

The terms "THERMOSETTING" and "THERMOPLASTIC" have been traditionally used to describe the different types of plastic materials. A "THERMOSET" is like concrete. You only get one chance to liquify and shape it. These materials can be "cured" or polymerized using heat and pressure or as with epoxies a chemical reaction started by a chemical initiator.

A "THERMOPLASTIC", in general, is like wax; that is, you can melt it and shape it several times. The "thermoplastic" materials are either crystalline or amorphous. Advances in chemistry have made the distinction between crystalline and amorphous less clear, since some materials like nylon are formulated both as a crystalline material and as an amorphous material.

Again, the advances in chemistry make it possible for a chemist to construct a material to be either thermoset or thermoplastic. The main difference between the two classes of materials is whether the polymer chains remain "LINEAR" and separate after molding (like spaghetti) or whether they undergo a chemical change and form a three dimensional network (like a net) by "CROSSLINKING."

Generally a crosslinked material is thermoset and cannot be reshaped. Due to recent advances in polymer chemistry, the exceptions to this rule are continually growing. These materials are actually crosslinked thermoplastics with the crosslinking occurring either during the processing or during the annealing cycle. The linear materials are thermoplastic and are chemically unchanged during molding (except for possible degradation) and can be reshaped again and again.

As previously discussed, crosslinking can be initiated by heat, chemical agents, irradiation, or a combination of these. Theoretically, any linear plastic can be made into a crosslinked plastic with some modification to the molecule so that the crosslinks form in orderly positions to maximize properties. It is conceivable that, in time, all materials could be available in both linear and crosslinked formulations.

Nelson Research, Inc. 2142 – N. 88th St. Seattle, WA. 98103 USA 206-498-9447 Craigmail @ aol.com

Families of Plastics and Synthetic Resins

Acetal resins
Acetate cellulose (plastics) Acrylic resins
Acrylonitrile-butadiene-styrene resins
Alcohol resins
polyvinyl Alkyd resins
Allyl resins Butadiene copolymers, containing less than 50 percent butadiene
Carbohydrate plastics
Casein plastics
Cellulose nitrate resins
Cellulose propionate (plastics)
Coal tar resins
Condensation plastics
Coumarone-indene resins
Cresol resins
Cresol-furfural resins
Dicyandiamine resins
Diisocyanate resins
Elastomers, nonvulcanizable (plastics)
Epichlorohydrin bisphenol
Epichlorohydrin diphenol Epoxy resins

Ester gum
Ethyl cellulose plastics
Ethylene-vinyl acetate resins
Fluorohydrocarbon resins Ion exchange resins
Ionomer resins
Isobutylene polymers
Lignin plastics
Melamine resins
Methyl acrylate resins
Methyl cellulose plastics
Methyl methacrylate resins
Molding compounds, plastics
Nitrocellulose plastics (pyroxylin)
Nylon resins
Petroleum polymer resins
Phenol-furfural resins
Phenolic resins
Phenoxy resins
Phthalic alkyd resins
Phthalic anhydride resins
Polyacrylonitrile resins
Polyamide resins
Polycarbonate resins
Polyesters Polyethylene resins
Polyhexamethylenediamine adipamide resins

Polyisobutylenes
Polymerization plastics, except fibers
Polypropylene resins
Polystyrene resins
Polyurethane resins
Polyvinyl chloride resins
Polyvinyl halide resins
Polyvinyl resins
Protein plastics
Pyroxylin Resins, synthetic Rosin modified resins
Silicone fluid solution (fluid for sonar transducers)
Silicone resins
Soybean plastics
Styrene resins
Styrene-acrylonitrile resins
Tar acid resins
Urea resins
Vinyl resins

Chemical Resistant Resin-Polymer Families

Fluoropolymer - Hard Plastic
- Teflon - Vespel
- PVDF
- Polycarbonate

Fluoroelastomer - Rubbers – Very Soft Plastic - Paste
- Viton, Kalrez, Chemraz
- Elastomeric Bisphenol A Epoxy Vinylester
- Dow 730

Thermoplastic Rubbers
- Santoprene

Vinylester Resin – Hard Plastic
- Methacrylated
- Novalac – methacrylated Epoxy Vinylester
- High Cross Linked Bisphenol A Epoxy Vinylester
  - Vipel F083
- Bisphenol A Fummareate Polyester
  - Derakane 411
  - Vipel F282

Chlorendic Polyester Resin – Hard Plastic
- Hetron 197-3

Hydroxyl-Terminated Polybutadiene Resin

Furfuryl Alcohol Resin

Isophalic Polyester Resin

Parylene – Conformal Coating
- poly-para-xylylene

Polyamide-imide (PAI)
- Solvay TORLON

Polyamide Film
- Dupont Kapton

Polyphenylene Sulphide

- HPV PPS   Techtron

UHMW-PE Ultra High MW Polyethylene

HD-PE High Density Polyethylene

Nelson Research, Inc.   2142 – N. 88th St. Seattle, WA. 98103   USA   206-498-9447   Craigmail @ aol.com

Fluoropolymers, Fluoroelastomers, Perfluoroelastomers Comparison

Fluoropolymers (also referred to as Fluorothermoplastics and Fluoroplastics)

Fluoropolymers are high-performance polymers containing atoms of fluorine and are unique because they perform well in a wide range of applications. They are defined by their unusual resistance to chemicals & corrosion and their ability to withstand a wide range of high temperatures. Fluoropolymers are extremely flexible and have excellent anti-stick properties.

Disadvantages of Fluoropolymers
Application specific due to cost

Advantages of Fluoropolymers
Chemical resistant, operates in high temperatures, UV resistant, non-leaching, FDA approved, USP Class VI compliant

Examples of Fluoropolymers

PTFE PVDF
FEP PEEK
PFA ETFE
ECTFE

Nelson Research, Inc. 2142 – N. 88th St. Seattle, WA. 98103 USA 206-498-9447 Craigmail @ aol.com

Fluoropolymers, Fluoroelastomers, Perfluoroelastomers Comparison

Fluoroelastomers (FKM)

Fluoroelastomers are a family of synthetic rubbers that can be stretched extensively, and still return to their original shape once the stretching is released. It is actually a fluoropolymer that does not crystallize.

Disadvantages of Fluoroelastomers
very expensive

Advantages of Fluoroelastomers
chemical resistant, resistant to automotive and aircraft fuel, FDA approved

Examples of Fluoroelastomers

Viton®
Dyneon®
Aflas®

Fluoropolymers, Fluoroelastomers, Perfluoroelastomers Comparison

Perfluoroelastomers –(FFKM)

Perfluoroelastomers polymers are made up of three or more monomers, in which all hydrogen positions have been replaced by fluorine, the principal monomer being tetrafluoroethylene, or TFE. This is the most chemically resistant elastomer available and is effectively a rubber form of TFE

Disadvantages of Perfluoroelastomers
only available in O-ring and sheet form
very expensive

Advantages of Perfluoroelastomers
most chemically resistant of all elastomers
resistant to acids, caustics, amines, aldehydes, steam, and salt water

Examples of Perfluoroelastomers

Kalrez®
Chemraz®
Aflas®

Fluoropolymers, Fluoroelastomers, Perfluoroelastomers Comparison

Thermoplastics – sometimes referred to as Petroleum resins

Most of the worlds plastics are thermoplastics. Thermoplastic polymers melt when heated and return to their original state when cooled again, unless they were heated to a point above their decomposition temperature.

Disadvantages of Thermoplastics
higher creep

Advantages of Thermoplastics
less expensive due to fast cycle times
more complex designs are possible
wider range of properties due to copolymerization

Examples of Thermoplastics

PVDF
PTFE
PVC

Nelson Research, Inc. 2142 – N. 88th St. Seattle, WA. 98103 USA 206-498-9447 Craigmail @ aol.com