

## Resins - Reference

### Polyolefins

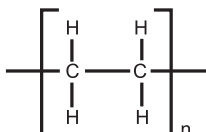
Polyolefins are high-molecular-weight hydrocarbons. They include: low-density, linear low-density and high-density polyethylene; polypropylene copolymer; polypropylene, and polymethylpentene. All are nontoxic and non-contaminating and exhibit varying degrees of break resistance. These are the only plastics lighter than water. They easily withstand exposure to nearly all chemicals at room temperature for up to 24 hours. Strong oxidizing agents eventually cause embrittlement. All polyolefins can be damaged by long exposure to ultraviolet light.

**Polyethylene** The polymerization of ethylene results in an essentially straight-chain, high molecular-weight hydrocarbon. The polyethylenes are classified according to the relative degree of branching (side chain formation) in their molecular structures, which can be controlled with selective catalysts.

Like other polyolefins, the polyethylenes are chemically inert. Strong oxidizing agents will eventually cause oxidation and embrittlement. They have no known solvent at room temperature. Aggressive solvents will cause softening or swelling, but these effects are normally reversible.

**Low-density polyethylene (LDPE)** has more extensive branching, resulting in a less compact molecular structure.

**High-density polyethylene (HDPE)** has minimal branching, which makes it more rigid and less permeable than LDPE.

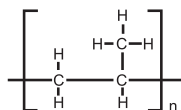


HIGH-DENSITY POLYETHYLENE

**Linear low-density polyethylene (LLDPE)** combines the toughness of low-density polyethylene with the rigidity of high-density polyethylene.

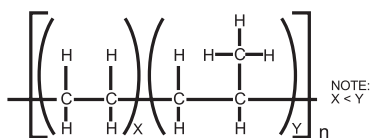
**Cross-linked high-density polyethylene (XLPE)** is a form of high-density polyethylene wherein the individual molecular chains are bonded to each other (using heat, plus chemicals or radiation) to form a three-dimensional polymer of extremely high molecular weight. This structure provides superior stress-crack resistance and somewhat improves the toughness, stiffness and chemical resistance of HDPE. XLPE is a superior material for molding very large storage tanks.

**Polypropylene (PP)** is similar to polyethylene, but each unit of the chain has a methyl group attached. It is translucent, autoclavable and has no known solvent at room temperature. It is slightly more susceptible than polyethylene to strong oxidizing agents. It offers the best stress-crack resistance of the polyolefins. Products made of polypropylene are brittle at 0°C and may crack or break if dropped from benchtop height.



POLYPROPYLENE

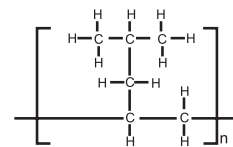
**Polypropylene copolymer (PPCO)** replaces polyallomer (PA) and is an essentially linear copolymer with repeated sequences of ethylene and propylene. It combines some of the advantages of both polymers. PPCO is autoclavable and offers much of the high-temperature performance of polypropylene. It also provides some of the low-temperature strength and flexibility of polyethylene.



POLYPROPYLENE COPOLYMER

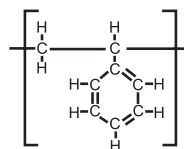
**Polymethylpentene (PMP or TPX-)** is similar to polypropylene, but it has an isobutyl group instead of a methyl group attached to each monomer group of the chain. Its chemical resistance is close to that of PP. It is more easily softened by unsaturated and aromatic hydrocarbons, and chlorinated solvents. PMP is slightly more susceptible than PP to attack by oxidizing agents. Its excellent transparency, rigidity and resistance to chemicals and high temperatures make PMP a superior

material for labware. PMP withstands repeated autoclaving. It can withstand intermittent exposure to temperatures as high as 175°C. Products made of polymethylpentene are brittle at ambient temperature and may crack or break if dropped from benchtop height.



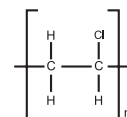
POLYMETHYLPENTENE

**Polystyrene (PS)** is rigid and non-toxic, with excellent dimensional stability and good chemical resistance to aqueous solutions, but limited resistance to solvents. This glass-clear material is commonly used for disposable laboratory products. Products made of polystyrene are brittle at ambient temperature and may crack or break if dropped from benchtop height.



POLYSTYRENE

**Polyvinyl Chloride (PVC)** is similar in structure to polyethylene, but each unit contains a chlorine atom. The chlorine atom renders it vulnerable to some solvents, but also makes it more resistant in many applications. PVC has extremely good resistance to oils (except essential oils) and very low permeability to most gases. Polyvinyl chloride is transparent and has a slight bluish tint. Narrow-mouth bottles made of this material are relatively thin-walled and can be flexed slightly. When blended with phthalate ester plasticizers, PVC becomes soft and pliable and can be extruded into flexible tubing.



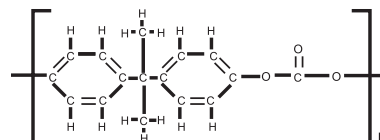
POLYVINYL CHLORIDE

**Thermoplastic elastomer (TPE)** is a type of polyolefin which, due to structure, molecular weight and chemistry, can be molded into autoclavable parts which are rubber-like in application and performance. It is used for several small caps and plugs on filtration products.

### Engineering Resins

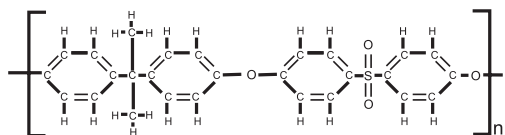
These resins offer exceptional strength and durability in demanding lab applications. For specific uses, they are superior to the polyolefins. Typical products are centrifuge ware, filterware and safety shields.

**Polycarbonate (PC)** is window-clear, amazingly strong and rigid. It is autoclavable, nontoxic and the toughest of all thermoplastics. PC is a special type of polyester in which dihydric phenols are joined through carbonate linkages. These linkages are subject to chemical reaction with bases and concentrated acids and hydrolytic attack at elevated temperatures (e.g., during autoclaving). This makes PC soluble in various organic solvents. For many applications, the transparency and unusual strength of PC offset these limitations. Its strength and dimensional stability make it ideal for high-speed centrifuge ware. Spectrophotometric analysis shows that the polycarbonate used in NALGENE safety products is essentially opaque to ultraviolet light from 200 to 380 nanometers (nm): 0% transmittance from 200-300 nm, 0.2% transmittance up to 380 nm. This covers the wavelengths emitted for germicidal applications such as laminar flow hoods (254 nm) and for fluorescence detection of dyes in electrophoresis or chromatography developing (350-360 nm).



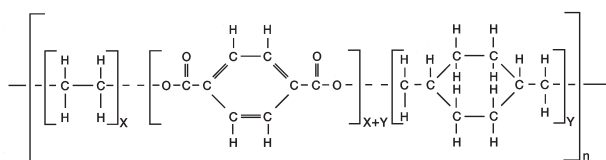
POLYCARBONATE

**Polysulfone (PSF)** Like polycarbonate, PSF is transparent, strong, non-toxic and extremely tough. PSF is less subject to hydrolytic attack during autoclaving than PC and has a natural straw-colored cast. PSF is resistant to acids, bases, aqueous solutions, aliphatic hydrocarbons and alcohols. PSF is composed of phenylene units linked by three different chemical groups – isopropylidene, ether and sulfone. Each of the three linkages imparts specific properties to the polymer, such as chemical resistance, temperature resistance and impact strength.



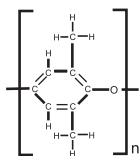
POLYSULFONE

**Polyethylene Terephthalate G Copolyester (PETG)** is similar to many other engineering resins. However, its glass-like clarity, toughness and excellent gas-barrier properties make it an outstanding choice for storing biologicals. Tests have shown PETG to be biologically equivalent to, or better than, Type 1 borosilicate glass bottles for cell culture applications. In tests using a wide variety of cell lines, PETG was determined to be non-cytotoxic, and media stored in PETG bottles demonstrated proliferative and morphological characteristics comparable to control media. In fact, the PETG bottles allowed growth of good monolayers directly on the surface of the bottle. PETG can be sterilized with radiation or compatible chemicals but cannot be autoclaved. Its chemical resistance is fair.



POLYETHYLENE TEREPHTHALATE G COPOLYESTER

**Polyphenylene Oxides (PPO)** A patented process for oxidative coupling of phenolic monomers is used to formulate Noryl<sup>®</sup> phenylene oxide-based thermoplastic resins. This family of engineering materials is characterized by outstanding dimensional stability at elevated temperatures, broad temperature-use range, outstanding hydrolytic stability and excellent dielectric properties over a wide range of frequencies and temperatures. Among their design advantages are: (1) excellent mechanical properties over temperatures from below -40°C (-40°F) to above 148°C (300°F); (2) self-extinguishing, non-dripping characteristics; (3) excellent dimensional stability and low water absorption; (4) resistance to aqueous chemical environments, and (5) excellent impact strength.



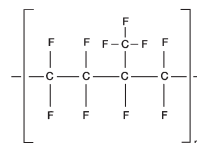
POLYPHENYLENE OXIDE

## Fluorocarbons

Typical fluorocarbons are Teflon tetrafluoroethylene (TFE)<sup>+</sup> and Teflon fluorinated ethylene propylene (FEP)<sup>+</sup>. Both have remarkable chemical resistance.

**Teflon TFE<sup>+</sup>** is opaque white and has the lowest coefficient of friction of any solid. It makes superior stopcock and separatory funnel plugs.

**Teflon FEP<sup>+</sup>** is translucent, flexible and feels heavy because of its high density. It resists all known chemicals except molten alkali metals, elemental fluorine and fluorine precursors at elevated temperatures. It should not be used with concentrated perchloric acid. FEP withstands temperatures from -270°C to +205°C and may be sterilized repeatedly by all known chemical and thermal methods. It can even be boiled in nitric acid.

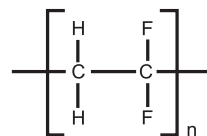


TEFLON FEP

**Tefzel ETFE<sup>+</sup>** is translucent white and slightly flexible. It is a close analog of Teflon<sup>+</sup> fluorocarbons, an ethylene tetrafluoroethylene copolymer. ETFE shares the remarkable chemical and temperature resistance of Teflon TFE<sup>+</sup> and FEP<sup>+</sup> and has even greater mechanical strength and impact resistance.

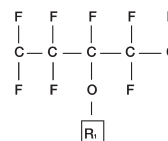
**Halar ECTFE<sup>\*\*</sup>** is an alternating copolymer of ethylene and chlorotrifluoroethylene. This fluoropolymer withstands continuous exposure to extreme temperatures and maintains excellent mechanical properties across this entire range (from cryogenic temperatures to 180°C). It has excellent electrical properties and chemical resistance and has no known solvent at 121°C. It is also non-burning and radiation-resistant. Its ease of processing makes it suitable for a wide range of products.

**Polyvinylidene Fluoride (PVDF, best known as Kynar<sup>\*\*\*</sup>)** is a fluoropolymer with alternating CH<sub>2</sub> and CF<sub>2</sub> groups. PVDF is an opaque white resin. Extremely pure, it is superior for non-contaminating applications. Mechanical strength and abrasion resistance are high, similar to ECTFE. It resists UV radiation. The maximum service temperature for rotationally-molded PVDF tanks is 100°C. Up to this temperature, PVDF has excellent chemical resistance to weak bases and salts, strong acids, liquid halogens, strong oxidizing agents and aromatic, halogenated and aliphatic solvents. However, organic bases and short-chain ketones, esters and oxygenated solvents will severely attack PVDF at room temperature. Fuming nitric acid and concentrated sulfuric acid will cause softening. At temperatures approaching the service limit, strong caustic solutions will cause partial dissolution. Autoclavable if tanks are empty and externally supported.



POLYVINYLIDENE FLUORIDE

**Teflon PFA<sup>+</sup>** is translucent and slightly flexible. It has the widest temperature range of the fluoropolymers – from -270°C to +250°C – with superior chemical resistance across the entire range. Compared to TFE at 277°C, it has better strength, stiffness and creep resistance. PFA also has a low coefficient of friction and outstanding antistick properties and is flame-resistant.



TEFLON PFA

<sup>+</sup>Registered trademark of Mitsui & Co., Ltd.

<sup>1</sup>Registered trademark of General Electric

<sup>\*</sup>or equivalent. Teflon and Tefzel are registered trademarks of DuPont.

<sup>\*\*</sup>or equivalent. Halar is a registered trademark of Solvay Solexis.

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