Beluns® Plastic

PVDF Sheet, Rod & Films

Property

Product Name:	PVDF.
Chemical Name and Synonym:	Polyvinylidene fluoride.

Material Names

PVDF is sold under a variety of brand names including KF (Kureha), Hylar (Solvay), Kynar (Arkema) and Solef (Solvay).

PVDF

Polyvinylidene fluoride or polyvinylidene difluoride (PVDF) is a highly non-reactive thermoplastic fluoropolymer produced by the polymerization of vinylidene difluoride.

PVDF is a specialty plastic used in applications requiring the highest purity, as well as resistance to solvents, acids and hydrocarbons. PVDF has low density 1.78 g/cm3 in comparison to other fluoropolymers, like polytetrafluoroethylene.

It is available in the form of piping products, sheet, tubing, films, plate and an insulator for premium wire. It can be injected, molded or welded and is commonly used in the chemical, semiconductor, medical and defense industries, as well as in lithium-ion batteries. It is also available as a cross-linked closed-cell foam, used increasingly in aviation and aerospace applications, and as an exotic 3D printer filament. It can also be used in repeated contact with food products, as it is FDA-compliant and non-toxic below its degradation temperature.

As a fine powder grade, it is an ingredient in high-end paints for metals. These PVDF paints have extremely good gloss and color retention. They are in use on many prominent buildings around the world, such as the Petronas Towers in Malaysia and Taipei 101 in Taiwan, as well as on commercial and residential metal roofing.

PVDF membranes are used in western blots for the immobilization of proteins, due to its non-specific affinity for amino acids.

PVDF is also used as a binder component for the carbon electrode in supercapacitors and for other electrochemical applications.

Property

In 1969, strong piezoelectricity was observed in PVDF, with the piezoelectric coefficient of poled (placed under a strong electric field to induce a net dipole moment) thin films as large as 6–7 pC/N: 10 times larger than that observed in any other polymer.

PVDF has a glass transition temperature (T_g) of about −35 °C and is typically 50–60% crystalline. To give the material its piezoelectric properties, it is mechanically stretched to orient the molecular chains and then poled under tension. PVDF exists in several forms: alpha (TGTG'), beta (TTTT), and gamma (TTTGTTTG') phases, depending on the chain conformations as trans (T) or gauche (G) linkages. When poled, PVDF is a ferroelectric polymer, exhibiting efficient piezoelectric and pyroelectric properties. These characteristics make it useful in sensor and battery applications. Thin films of PVDF are used in some newer thermal camera sensors.

Unlike other popular piezoelectric materials, such as lead zirconate titanate (PZT), PVDF has a negative d_{33} value. Physically, this means that PVDF will compress instead of expand or vice versa when exposed to the same electric field.

Thermal

PVDF resin has been subjected to high-heat experiments to test its thermal stability. PVDF was held for 10 years at 302 °F (150 °C), and following measurements indicated no thermal or oxidative breakdown occurred. PVDF resin has been recorded stable up to 707 °F (375 °C).

Chemical compatibility

PVDF exhibits an increased chemical resistance and compatibility among thermoplastic materials. PVDF is considered to have excellent / inert resistance to:

- strong acids, weak acids,
- ionic, salt solutions,
- halogenated compounds,
- hydrocarbons,
- aromatic solvents,
- aliphatic solvents,
- oxidants,
- weak bases.

Chemical sensitivity

PVDF, similar to other fluoropolymers, exhibits chemical sensitivity, in general, with the following chemical families:

- strong bases, caustics,
- esters,
- ketones.

Intrinsic properties and resistance

Polyvinylidene fluoride expresses inherent resistance characteristics in certain high-focus applications. Namely these are: ozone oxidation reactions, nuclear radiation, UV damage, and microbiological, fungus growth. PVDF's resistance to these conditions is fairly distinctive among thermoplastic materials. PVDF's carbon and fluoride elemental stability contributes to this resistance, as well as the polymeric integration of PVDF during its processing.

Process

PVDF may be synthesized from the gaseous vinylidene fluoride (VDF) monomer by a free-radical (or controlled-radical) polymerization process. This may be followed by processes such as melt casting, or processing from a solution (e.g. solution casting, spin coating, and film casting). Langmuir–Blodgett films have also been made. In the case of solution-based processing, typical solvents used include dimethylformamide and the more volatile butanone. In aqueous emulsion polymerization, the fluorosurfactant perfluorononanoic acid is used in anion form as a processing aid by solubilizing monomers. Compared to other fluoropolymers, it has an easier melt process because of its relatively low melting point of around 177 °C.

Processed materials are typically in the non-piezoelectric alpha phase. The material must either be stretched or annealed to obtain the piezoelectric beta phase. The exception to this is for PVDF thin films (thickness in the order of micrometres). Residual stresses between thin films and the substrates on which they are processed are great enough to cause the beta phase to form.

In order to obtain a piezoelectric response, the material must first be poled in a large electric field. Poling of the material typically requires an external field of above 30 megavolts per metre (MV/m). Thick films (typically >100 μm) must be heated during the poling process in order to achieve a large piezoelectric response. Thick films are usually heated to 70–100 °C during the poling process.

A quantitative defluorination process was described by mechanochemistry, for safe eco-friendly PVDF waste processing.

Application

PVDF is a thermoplastic that expresses versatility for applications similar to other thermoplastics, particularly fluoropolymers. PVDF resin is heated and handled for use in extrusion and injection molding to produce PVDF pipes, sheets, coatings, films, and molded PVDF products, such as bulk containers. Common industry applications for PVDF thermoplastics include:

- chemical processing,
- electricity, batteries and electronic components,
- construction and architecture,
- healthcare and pharmaceutics,
- biomedical research,
- ultra-pure applications,
- nuclear waste handling,
- petrochemical, oil and gas,
- food, beverage processing,
- water, wastewater management.