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White Paper

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PVDF: An Excellent Alternative to THV

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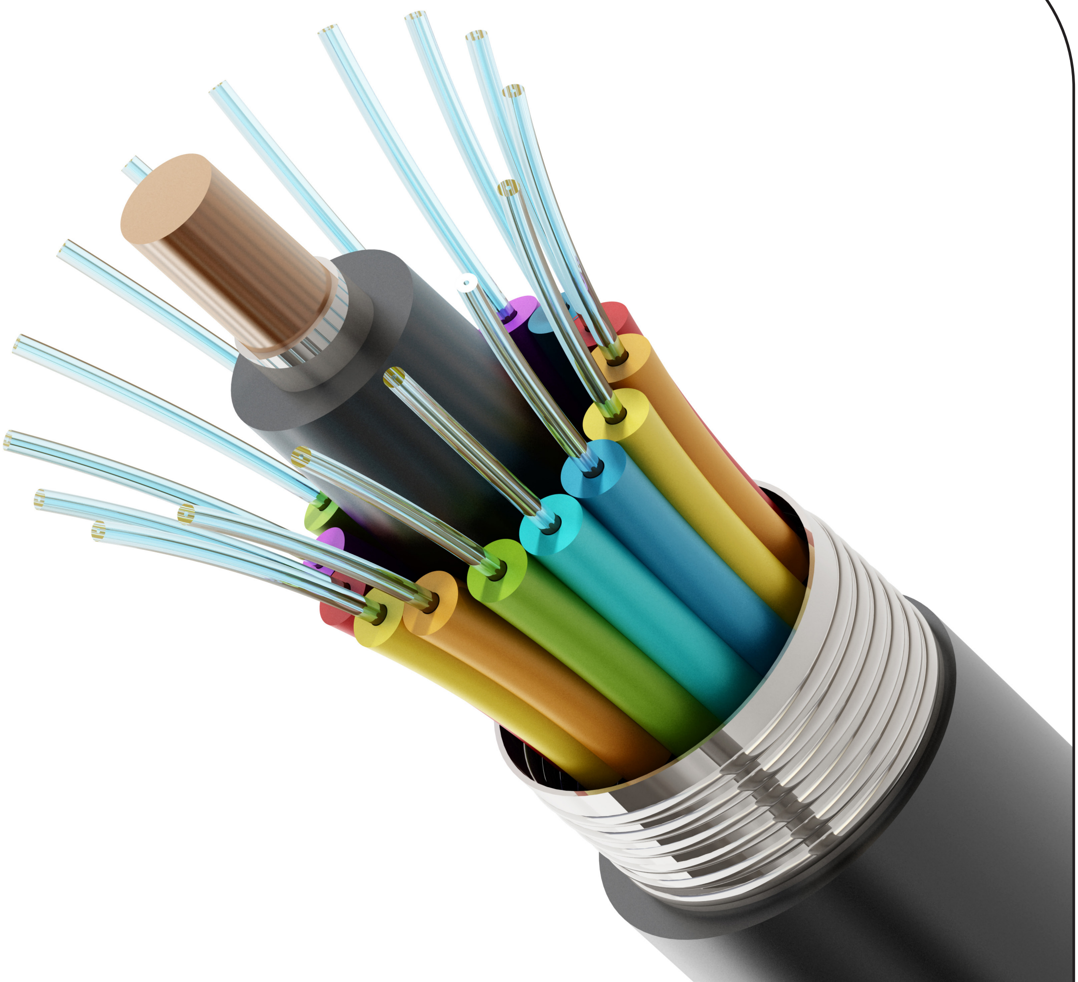

Kynar® PVDF

Demand for high performance materials in the engineering industry is continually on the rise. A project designer must have excellent knowledge of available materials and their properties in order to design systems with long service lives. This high demand, combined with concerns about material availability may leave many confused and unsure about how to best protect their systems. Engineers and system designers often look to fluoropolymers in order to provide optimal protection from harsh environments in many industrial areas. Fluoropolymers are valued for their outstanding chemical resistance and performance at high temperatures, and several fluoropolymers can also include high abrasion resistance and strong mechanical properties in their portfolio. One such polymer is polyvinylidene fluoride (PVDF), a partially fluorinated polymer that has been a highly utilized material since its introduction in 1965[1].

PVDF, a polymer composed of repeating vinylidene fluoride (VF2) units, is commonly used in industries that require excellent chemical resistance to acids, halogens, oxidants, and much more. Common industries that rely on PVDF's broad range of properties include mining, oil and gas, metal plating, food and beverage production, automotive applications, and many more. PVDF is an easily melt-processable fluoropolymer that can be processed on standard polyolefin processing equipment. For applications that require more flexibility or higher impact resistance, VF2 can be copolymerized with hexafluoropropylene (HFP), a monomer that lowers the polymer's crystallinity while increasing chemical resistance. HFP content can be controlled during polymerization, providing a wide array of varying flexible copolymer grades. This wide range of flexibility allows PVDF and its copolymers to be used in a large number of markets in the chemical processing industry. PVDF-HFP copolymer grades have been a mainstay in the wire and cable industry since the early 1970s in use as protective jacketing. These grades are also often used in tubing and tank lining applications. Copolymer grades are also used in flexible tubing applications for the food and beverage industry as well as fluid transport chemical processes that require high purity. Flexible PVDF-HFP copolymers have been proven to show longer lifespans than commodity plastics in the same applications and are often the material of choice when maintenance and downtime must be minimized[2]. These copolymers also display impressive smoke and flame resistance, and naturally char instead of igniting when exposed to flame. Smoke and flame suppressant additives can also allow these copolymers to reach stringent (UL 94 V0) criteria for materials in plenum spaces. PVDF grades can also meet other important regulatory requirements for smoke and flame such as FM 4910, ASTM E84, and UL 723.

In a similar vein, many systems engineers choose THV for its protective properties. THV is a fluoropolymer that is made from three monomers: VF2, HFP, and tetrafluoroethylene (TFE), the monomer is used to make polytetrafluoroethylene (PTFE). THV is present in the automotive market and is often used as a solar backing film [3]. THV displays many of the properties that fluoropolymers are known for, including chemical inertness and performance at high temperatures. THV is also valued in the wire and cable market due to its low flexural modulus.

In a changing and dynamic market, knowing how a material's properties differ from other similar materials is essential. Thanks to continual research and development in PVDF technologies, PVDF copolymer grades can often be used in the same applications as THV, even providing additional advantages in some areas. Table 1 shows a comparison of properties between two grades of commercial THV and two grades of commercial PVDF copolymers.

Figure 1: Flexible PVDF tubing.

Table 1: Comparison of properties between two THV grades and two flexible PVDF copolymer grades.

Property	Test Method	Unit	THV Grade 1	THV Grade 2	PVDF Flex 1**	PVDF Flex 2
Melting point	ASTM D591	ºC	115	130	117-125	160-168
Melt Flow Index (265ºC/5kg)	ASTM D1238	g/10 min	20	25	Not comparable	Not comparable
Glass transition	ASTM D4591	ºC	5	7	-42	-40
Specific gravity	ASTM D792	g/cm^3	1.93	1.98	1.80-1.82	1.78-1.82
Tensil strength at break	ASTM D368	MPa	20	23	14-31	19-24
Tensil elongation at break	ASTM D638	%	700	535	500-800	>500
Flexural modulus	ASTM D790	MPa	80	32	192-276	240-380
Limiting oxygen index (LOI)	ASTM D 2868	$\%O_2$	65	/	~42	~42
Refractive index	ASTM D542	nD	1.36	1.35	1.4	1.4
US-Vis light transmission (1mm)*	300nm 600nm	% %	75 90		10 67	
Product form			Pellets (GZ) Agglomertes (AZ)	Pellets (GZ)	Pellets	Pellets

* All values are from published TDSs, except for light transmission, which was measured at Arkema's R&D center at King of Prussia, PA.
** Counterpart developmental PVDF grades exist with higher transparency.

Several properties here should be noted. First, flexible PVDF copolymers display similar melting points, elongation properties, and flex moduli to THV. The two PVDF Flex grades listed in the table are examples of copolymers with higher HFP content. The melting points of PVDF Flex grades are higher than many THV grades, allowing them to function in higher temperature environments. PVDF-HFP copolymers show a lower melting point than other fluoropolymers, but radiation cross-linking technology has shown considerable improvement in this field, showcasing increased melting temperatures even up to 200 C[4]. Another important detail is that some THV grades may contain certain additives to improve electrostatic properties or to improve smoke and flame resistance, and many similar PVDF-HFP copolymer grades contain no such additives[5]. PVDF copolymer materials are made via chemical reaction and not by physical blending, thereby retaining their flexibility over time.
For these reasons, many engineers who have previously only utilized THV have chosen to now use PVDF copolymers in a market that is forecasting less and less THV capacity. In this uncertain market, PVDF can be a trusted and proven go-to for demanding engineering applications.

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