Fungal, Chemical, and Fire Resistance of PVDF Foams and Polymers

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Today's cleanroom environments in the pharmaceutical and semiconductor markets require the highest level of material performance across a broad spectrum of requirements. New, sophisticated medicines are made using advanced manufacturing technologies and materials. High technology cleanroom environments often contain polymeric sheets, coatings, wall coverings, and polymeric foam for insulation. These are used to create lightweight structures, walls, partitions, ceilings, and pipe and ducting insulation.

In general, fluoropolymers and, in particular, films, coatings, and insulating foams made from polyvinylidene fluoride (PVDF) do not support the growth of mold. Covering exposed surfaces with PVDF polymer provides a high-purity "inert" surface which does not support the growth of microorganisms and provides the resistance needed to withstand the harsh chemicals used for cleaning and sterilization. Fluoropolymer-based paints and solution coatings offer another option for cleanroom designers because these coatings resist fungal growth as well.

Fungal and microbial growth resistance is very important in cleanroom environments, but also important are fire resistance and low smoke generation, low moisture absorption, insulating properties, abrasion resistance, and non-shedding properties to prevent the introduction of contaminants into the manufacturing process.

ANTIFUNGAL PROPERTIES

Low surface energy makes it difficult for mold to grow on the surface of foam insulation. Tested according to *ASTM G21-96 (2002), Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi*, such foams showed no observed growth after the required 28-day exposure. This result was also confirmed by microscopic examination.

Pure synthetic polymers are usually fungus-resistant because they offer no carbon source for the growth of fungi. Unfortunately, polymer additives such as plasticizers, cellulosics, lubricants, stabilizers, and colorants often permit fungal attack of plastic materials. PVDF contains no plasticizers or other process additives, is inherently very pure, hydrophobic, and resists microbial attack, even under conditions favorable for such attack, namely, temperatures from 2–38 °C (35–100 °F) and relative humidity from 60 to 100%.

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FUNGUS	Fungus Sources Identification No.			
	NRRL	DSM Germany	ATCC USA	IMI Strain No.
Aspergillus niger	3536	63263	9642	091855
Aureobasidium pullulans			15233	045533
Chaetomium globosum	1870	1962	6205	045550
Gliocladium virens	2314	1963	9645	045553
Penicillium funiculosum			11797	211742

Table 1: ASTM G21-96 (2002) Standard practice for determining resistance of synthetic polymeric materials to fungi. Testing was conducted by Zoteofoams Plc.

Table 1 shows the organisms that were used for the testing.

FIRE RESISTANCE

Today's pharmaceutical companies have large investments in development, testing, FDA approval, and production of drugs. Even slight delays in production can result in financial losses. The financial impact of fire or smoke damage to a manufacturing facility can be very significant.

In order to limit the risk due to fire and smoke, Factory Mutual (FM), Underwriters Laboratories (UL), ASTM, and other testing agencies have developed fire-testing methods to characterize the fire performance of materials. For cleanroom materials, FM has established a fire and smoke standard called FM 4910 (Cleanroom Materials Flammability Test Protocol). This standard was developed to reduce the risk of fire and the resultant financial impact should one occur.

Many polymeric materials will readily burn, provide fuel to a fire, and produce large amounts of smoke. However, PVDF is inherently flame retardant without additives.

PVDF, in general, is characterized by the following:

- High auto ignition temperature
- Low caloric value
- Self extinguishes when a direct flame is removed
- Minimal fire propagation and minimal smoke generation
- Resistance to most chemicals, including typical sterilization methods
- High purity
- UV and gamma radiation resistant
- Toughness and cut-through resistance

ZOTEK® F42 HT LS foam, based on Kynar® PVDF resin, is the only polymeric foam to have achieved the 'Specification Tested' status against the FM 4910 test protocol. The foam has a high auto ignition temperature, minimal fire propagation and smoke generation, and low fuel load. The foam self-extinguishes when a direct flame is removed. It is hydrophobic and does not wick moisture, retaining its insulating properties in wet areas (unlike insulations which lose R value when they get wet). This specific grade of material is used to make T-Tubes® insulation, an insulation system specifically developed for cleanroom stainless steel process lines and equipment that also meets FM 4910 standards.

CHEMICAL RESISTANCE

Fluoropolymers exhibit exceptional chemical resistance and can withstand the harshest cleaning chemicals. PVDF is commonly used in solid sheet, as a foamed material, or in a solution coating.

PVDF resins are resistant to a wide range of chemicals, including most acids and acid mixtures, weak bases, halogens, halogenated solvents, hydrocarbons, alcohols, salts, and oxidants. At ambient temperatures, PVDF homopolymers are generally resistant to chemicals with a pH up to 12.

INSULATION PROPERTIES

For piping or process insulation, it is important that the materials used maintain their insulating properties over a wide range of temperatures and resist water absorption. Table 2 (on the next page) shows the R values for a specific foam insulation.

CONCLUSION

Materials should be chosen for the construction of cleanrooms that have excellent chemical and fire resistance and do not support the growth of fungi and other microbial

Grade	Testing Temperature [˚C]	Thermal Conductivity		Thermal Resistance	
		***k* value metric** [W/m.K]	***k* value imperial** [Btu.in/ft2.h.˚F]	***R* value metric** [m2.K/W]	***R* value imperial** [ft2.h.°F/Btu]
Zotek F42 HT LS	10	0.032	0.222	0.79	4.51
	50	0.037	0.256	0.69	3.9
	83	0.041	0.284	0.62	3.52
	130	0.053	0.367	0.48	2.72

Table 2: R value performance

species. Fluoropolymers offer many of these properties; PVDF has shown excellent fungal resistance and fire performance. Stringent cleaning and disinfection procedures are critical to controlling fungal contamination in the cleanroom environment. PVDF has inherent chemical resistance that withstands most aggressive chemical cleaning methods. It also provides excellent mechanical properties, abrasion resistance, and does not easily produce particulate contamination. Cleanroom surfaces can be coated with PVDF resin as a film laminate or solution coating.

Note: Kynar® PVDF and Kynar Flex® are registered trademarks of Arkema Inc. ZOTEK® F is a registered trademark of Zotefoams Plc. T-Tubes® is a registered trademark of UFP Technologies, Inc.

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