Stabilization Technologies LLC

ALTERIN FRP100™

A New Technology Flame Retardant For Nonwoven Thermoplastic Polyethylene Terephthalate (PET)

Thermoplastic polyester fibers are used extensively in automotive interior, construction, and industrial applications, and are also widely used in upholstery and housewares.

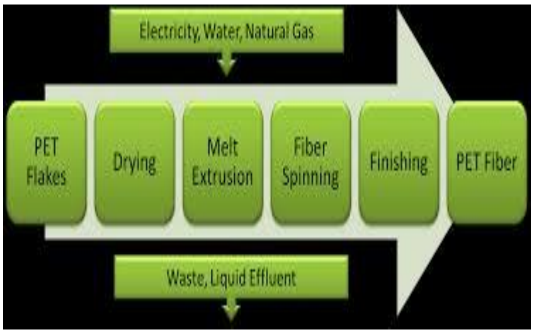
The need for consistent and reproducible flame retardant polyesters has never been more urgent. Over the last fifteen years the nature of flame retardants used by industry has changed dramatically, and these changes have created new problems. Many of the existing flame retardants adversely affect short and long term mechanical properties, and others create major 'smoking' problems during spinning operations or break down during processing. The variability in performance of many of these additives has created opportunities for vendors to introduce reactive additives added during the polymerization of thermoplastic polyesters. In all cases, the level of flame retardant added ranged from 5% to 7% to achieve performance. Since most FR systems were provided in masterbatch form, the fiber producer could not confirm the actual final levels used in needle punch nonwovens, and therefore experienced variable performance. Cost and performance changes and the requirements for tougher and cheaper performing additives dominated the market globally. Pressure on cost, and complying with ever more stringent flame retardant specifications, added to the demands by the market.

Now the requirements for a flame retardant non-woven product mean it should not adversely affect the color of natural fiber, is non-smoking during production of the fiber, and with no adverse effects on short and long term properties. There must also be minimum effect on UV durability, and it must pass stringent standards in a global market.

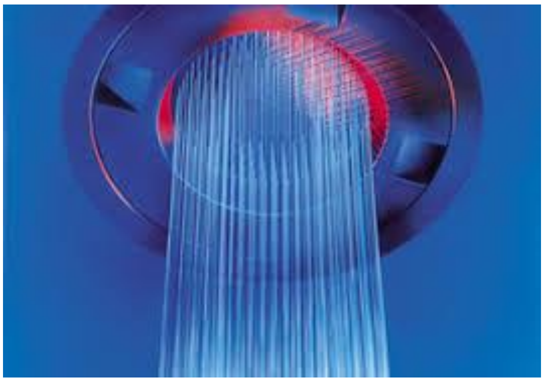
After many years of research and development, and extensive analytical testing of both the active additives and masterbatches used in the final polyester fiber and non-woven product of the textile producer, we have finally determined those key factors that affect performance. These include those parameters which permit lower levels of additives in the nonwovens, to achieve a cost benefit performance which makes the product competitive in the global market today. Today two test methods prevail: the NFPA-701 vertical burn, and the more difficult FAA standard Vertical Flammability Test in Accordance with FAR 25.853a. Both tests call for self-extinguishing flame out in less than two seconds, no drip and no smoking during testing. Burn length, Burn time, and Dripping time in the FAA standard, are less than 8 inches, 15 seconds and 5 seconds, respectively.

Today a new technology flame retardant system exists that can be used at less than 3% by weight final in the polyester fiber that passes both FAA and NFPA-701 vertical burn, that does not smoke or drip and provides instantaneous flame out. It has no adverse effect on short or long term physical properties, no adverse effect on UV durability, no discoloration, no antagonism with colorants used in polyesters, and no restrictions on use for the majority of applications for a flame retardant polyester in a Global market. The price and economics and cost benefit performance are higher and more consistent than any flame retardant system in use today. The technology for producing this product is the result of over five years of extensive testing at many global textile producers and real world testing. The results are reproducible and with Stabilization Technologies LLC Analytical Testing Services, the product is tested and certified as to its activity and concentration prior to being shipped to the customer.

The product is sold under the trade name ALTERIN FRP100™ and is available from Endex International. See page 4 below for contact details.



Non -woven PET fiber **Extrusion of PET Fiber**



Markets: In recent years, the nonwoven market has been one of the most developing markets in the world, as well as in European and especially Asian BRICS economies. This is due to the growing demand for nonwovens, especially for nonwoven geotextiles, the market size of which in Europe, Middle East, Africa, and Asia Pacific was estimated at USD 4.12 billion in 2017. The demand for nonwovens is generated by many sectors of the economy, especially due to their wide application in agriculture and horticulture, in the road and bridge construction sector, in the sports services sector, e.g., for long-term maintenance of ski slopes and other similar solutions.

World exports of nonwovens achieved the level of almost USD 14 billion in the past few years and were characterized by an upward trend, especially in 2017 compared to 2016. The dominant position (>53% of world exports) on the world export market is occupied by exporters from four countries: China, Germany, the USA, and Japan, but countries such as Italy, France, Turkey, Belgium, the Czech Republic, the Netherlands, South Korea, Spain, Luxembourg, Israel, Great Britain, Sweden, Malaysia, Poland, and Denmark also were the major exporters.

History: Man-made fibers have a long history. Robert Hooke first brought up the idea to create silk-like fibers in 1665, followed by René-Antoine Ferchault de Réaumur, who actually produced the first artificial filaments from different kinds of varnish in 1734. In 1883 Joseph Swan injected dissolved nitro-cellulose into a coagulation bath and thus obtained filaments for light bulbs. In 1938 DuPont de Nemours (Wilmington, DE, USA) launched the production of Nylon® (PA 6.6), the first commercial melt-spun fiber, invented by Wallace Carothers. In the same year Paul Schlack developed Perlon® (PA 6), a fiber declared vital to the war by Nazi Germany. The first polyester fiber, Terylene® (PET), was created in 1941 by Imperial Chemical Industries (ICI). The commercial production of polyolefin fibers started in 1957, based on the Ziegler-Natta catalyst recognized by a Nobel Prize in 1963. Today, chemical fibers are spun by drawing a melt or solution of a polymer or an inorganic material from a spinneret into a medium (quenching or solvent removal by air/gas, water or coagulation bath) where it solidifies. Drawing can either be applied by godets (rollers) and winders, by a high-velocity air stream, or by an electrostatic or centrifugal force. Table 1 lists fiber spinning methods used to produce filaments, staple fibers and nonwovens.

Table 1. List of fiber spinning methods.

Spinning Method	Material	Product
melt-spinning	polymer or inorganic melt	filaments, staple fibers, textured yarns
wet-spinning, dry-spinning	polymer solution	filaments, staple fibers
gel-spinning	polymer gel (polymer and solvent)	filaments
preform drawing	polymer or inorganic melt	filaments
film-split spinning	polymer melt	slit-tape filaments
spun-bonding, melt-blowing	polymer melt	nonwovens
electrospinning, centrifuge spinning (force-spinning)	melt or solution of polymer or inorganic material	nonwovens
flash-spinning	polymer solution	nonwovens

Table 2. Typical properties of selected polymers used for melt-spinning [18–27]. Density, T_g and T_m are average values (exact data depend on degree of crystallinity and molecular weight). In the case of PLA, 98:2 L to D lactic acid is assumed [28]. The decomposition temperature T_d is defined by 5 wt% loss in N_2, measured by thermogravimetric analysis (own unpublished data). Properties: TP = tensile properties, Res = resilience, ChR = chemical resistance, AR = abrasion resistance, UV = UV resistance, FR = flame retardancy. Performance: ++ = very good, + = acceptable, - = poor.

Polymer	Density [g/cm^3]	T_g [°C]	T_m [°C]	T_d [°C]	TP	Res	ChR	AR	UV	FR
PA 6	1.14	50	225	387	++	++	+	++	+	+
PA 6.6	1.14	50	260	407	++	++	+	++	+	+
PET	1.39	75	260	402	++	+	+	+	+	+
PBT	1.33	50	220	373	++	++	+	+	+	+
PLA	1.25	60	165	321	+	+	+	-	+	+
PP	0.91	−15	170	399	++	-	++	+	-	-
LDPE	0.92	−125	110	440	+	-	++	-	-	-
HDPE	0.95	−125	130	436	++	-	++	+	-	-
PVDF	1.78	−40	170	431	-	++	++	-	++	++
PEEK	1.32	145	335	569	++	++	++	++	++	++
PPS	1.34	85	285	494	++	++	++	++	-	++
PEI	1.27	215	-	515	++	++	++	++	++	++
PMMA	1.18	110	-	334	-	+	-	+	++	-
PC	1.20	150	-	471	-	+	-	-	++	+

Function of Additives

Additives are considered to facilitate processing, to provide additional functions, or to improve properties and durability of the final fiber (Table 3). The additive should exhibit thermal stability and good processability. As additives also can lead to blockage and fluctuations in processing, their quantity and variety should be kept as low as possible. The maximum tolerable amount depends on miscibility in the case of polymers, and solubility in the case of liquids.

Table 3. Typical additives used in melt-spinning.

Type	Function	Examples
Processing aids	Antioxidant	Hindered phenols and amines, phosphites
	Hydrolysis stabilizer	Carbodiimide
	Nucleating agent	Talcum powder, boron nitride, organic phosphate salts
	Lubricant	Stearates, low molecular wax
	Polymer processing aid	Fluoropolymers
	Surfactant	Stearates, PEG
Enhancing additives	Plasticizer	Tributylcitrate, acetyltributylcitrate
	Chain extender	Difunctional acid derivatives, anhydrides and epoxides
	UV-stabilizer	HALS, TiO_2, ZnO, carbon black
	Flame retardant	Phosphorous and halogen derivatives, HALS
	Thermal protection	Zirconia
Functional additives	Colorant	Pigments and dyes, carbon black
	Delustrant	TiO_2, ZnO, mica, optical brightening agents
	Antistatic	Carbon black, carbon nanotubes, graphene, ZnO
	Antimicrobial	TiO_2, ZnO, Ag^+, Cu^{2+}, Zn^{2+}, plant extracts, phenol
	Water/oil repellent	Silicone and fluorine compounds

For more information, contact:

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and

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