MICHELMAN®

Hydrosize®

Fiber Sizings & Composites

Enhancing composite performance through optimized fiber-polymer interface adhesion

Role of the Sizing

Sizing formulations are a mixture of various chemicals, typically, but not necessarily, diluted in water. Fiber producers use sizings to coat, or "size" their fibers.

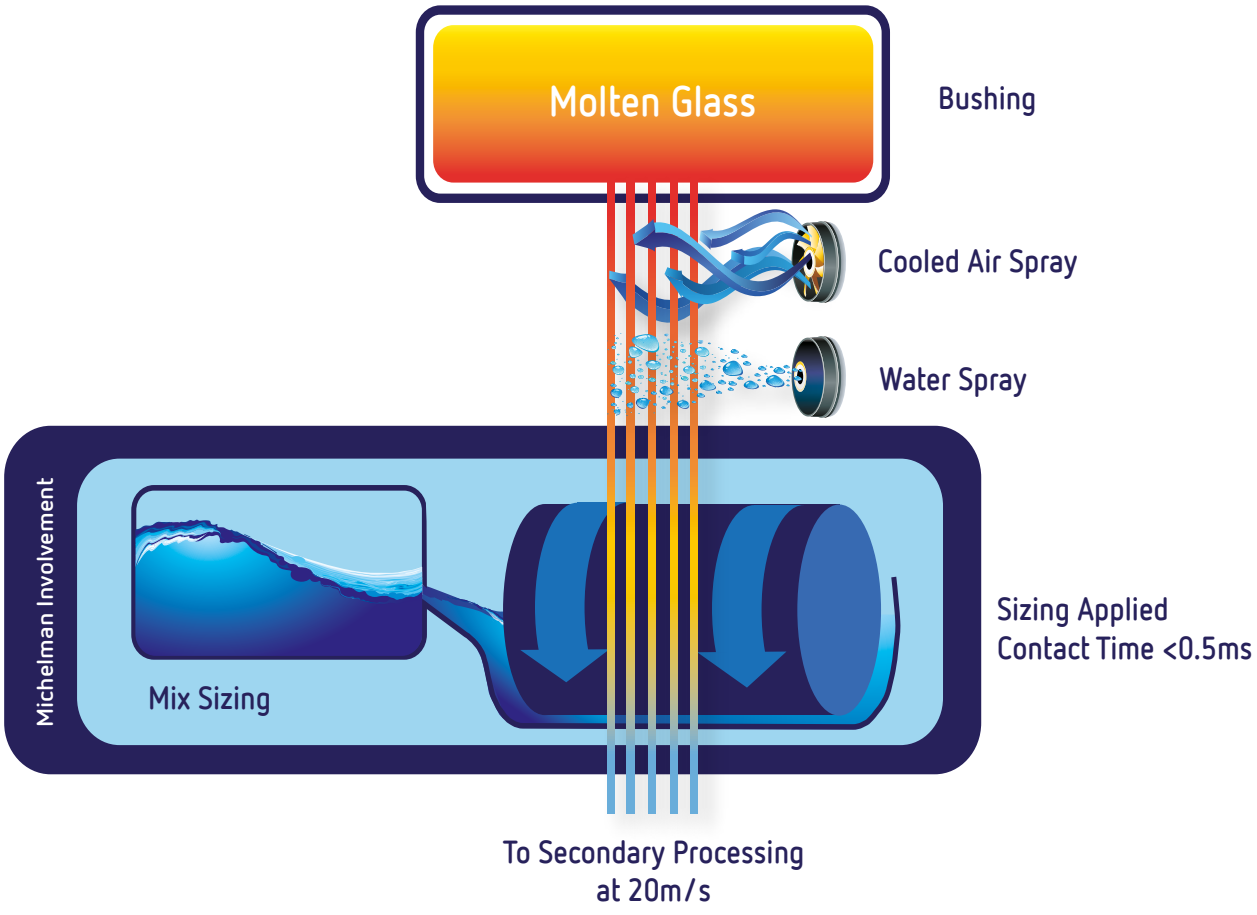
Sizing chemistry plays a significant role in a composite's mechanical properties including impact resistance, tensile strength, and fatigue resistance, as well as its material and chemical properties such as corrosion, hydrolysis, heat and oil resistance.

Every fiber producer develops their own sizing know-how and applies it to the fiber to best suit the needs of the targeted applications.

Sizings are composed of one or several film forming polymeric components in dissolved, emulsified, or dispersed form, as well as a coupling agent, a lubricant, and a range of additives including surfactants, plasticizers, anti-static agents, adhesion promoter, antifoams, and rheology modifiers.

With Hydrosize®
Optimized Adhesion

Without Hydrosize®
Inferior Adhesion



Hydrosize® used for Glass Fiber Sizing

The Film Former

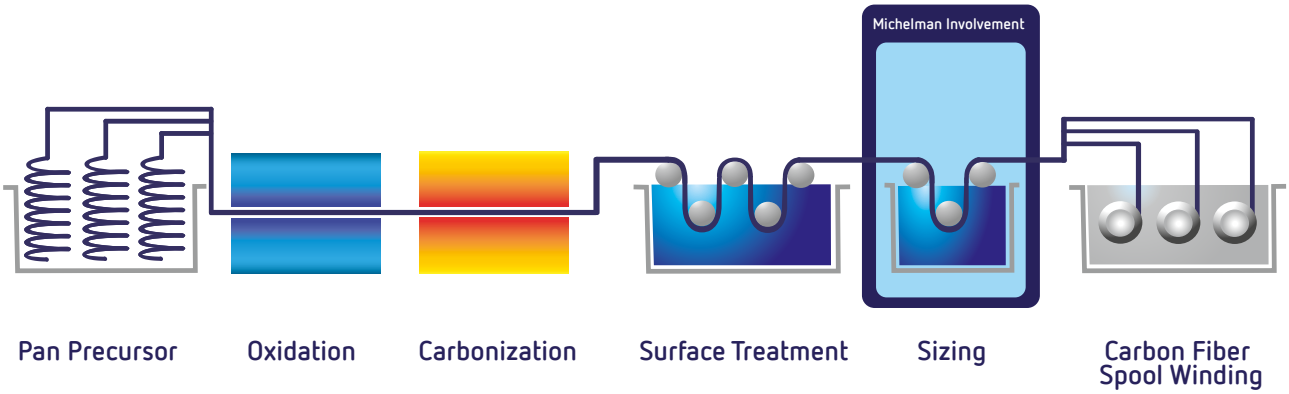
In a typical glass fiber sizing formulation, the film former makes up over 70% of a sizing recipe based on solids content, and must be stable in the final sizing formulation.

It should then improve the manufacturability of the fiber. When the fiber is being manufactured, every contact point is a possible fiber break point. As these contact points are inherent to the process, the ability of the film former to protect the fiber from damage allows for maximum process efficiency.

On the fiber surface, the film former plays an important role in determining the properties of the final composite, such as improved adhesion between the fiber and the matrix, mechanical properties, chemical or water resistance, and thermal stability.

Michelman has developed families of film formers, binders, and lubricants formulated specifically for the fiber manufacturing process that address the unique challenges the industry faces.

We have solutions for fiberglass, carbon fiber, natural fiber, and specialty fibers in chopped or continuous form.



Hydrosize® used for Carbon Fiber Sizing

Choosing the right Sizing Chemistry: Hydrosize®

If sizing's only function was to improve processability of the treated fiber, then it would be possible for one sizing to "fit all".

However, sizing ultimately affects the production and the processing of the fiber, and has a significant impact on the interface properties between the fiber surface and the composite matrix. The "right" sizing must render the fiber and matrix compatible. This is accomplished in large part by controlling the surface chemistry of the sized fiber.

Composites are quickly changing the way we drive, transport goods, generate energy, and more generally, how industry tackles problems that involve a maximum strength/minimal weight contradiction, oftentimes with a regulatory factor.

The role sizing plays in the manufacturing of composites is critical and complex.

Michelman has the sizing formulation expertise and understanding of end-use applications needed to handle all your fiber sizing needs.

Our Hydrosize® line of products includes sizing solutions designed for use in the manufacturing of glass fiber, carbon fiber, and natural fiber, using chopped strand or continuous strand fiberglass. In turn these are used to manufacture composite products and components.

Reinforcement Fibers

The structural properties of composite materials are derived primarily from fiber reinforcement. In a composite, the fiber contributes high tensile strength, enhancing properties in the final part, such as strength and stiffness while minimizing weight.

There are many different types of fibers that can be used to reinforce polymer matrix composites. The most common are glass fibers (E-glass, S-Glass, etc.) and carbon fibers. As with the matrix, the fiber chosen will be determined by the end application.

Fiber Type	Description	Sub Type	Density	Tensile Strength Mpa	Young Modules Gpa
Glass	Glass fiber is the most common reinforcement used in composite applications. It is based on silicate, with varying amounts of oxides of calcium, magnesium, and boron. Although it is not as strong and stiff as composites based on carbon fiber, it is less brittle and has a better impact resistance. Depending upon the glass type, filament diameter, sizing chemistry, and fiber form, a wide range of properties and performance levels can be achieved.	**E-Glass** **S-Glass**	**2.55** **2.49**	**3500** **4200**	**72** **84**
Carbon	There are two main types of carbon fibers. One is polyacrylonitrile (PAN)-based and the other is pitch-type. PAN-based carbon fibers are the most versatile and widely used. They offer an amazing range of properties, including excellent strength – to 1,000 ksi (6,900MPa) – and high stiffness. Carbon fiber is available in "tow" form, essentially a bundle of untwisted carbon filaments. 12K tow has 12,000 filaments and is commonly sold according to "modulus" category.	**Carbon HS** **Carbon IM** **Carbon HM**	**2.49** **1.78** **1.76**	**3500-5000** **5200-6000** **3500-4000**	**230** **290** **400**
Basalt	Based on basalt igneous volcanic rock, basalt fiber claims to offer performance similar to S-Glass fibers at a price point between S-Glass and E-Glass, and may offer manufacturers a less-expensive alternative to carbon fiber for products in which the latter represents over-engineering.		**2.70**	**3000-4800**	**100**
Aramid	Aramid fiber is a man-made organic polymer (an aromatic polyamide) produced by spinning a solid fiber from a liquid chemical blend. The bright yellow filaments produced have a high strength and low density giving very high specific strength. All grades have good resistance to impact, and lower modulus grades are used extensively in ballistic applications.	**Aramid LM** **Aramid HM**	**1.44** **1.44**	**3500** **2900**	**60** **120**
Natural	The use of natural fibers for technical composite applications has recently been the subject of intensive research. Many automotive components are already produced in natural composites, mainly based on polyester or PP and fibers like flax, hemp, or sisal. The main motives to use natural fibers are price, weight reduction, and environmental aspects ('processing renewable resources').	**Flax** **Hemp** **Jute**	**1.4-1.5** **1.4-1.5** **1.4-1.5**	**500-900** **300-800** **200-500**	**50-70** **30-60** **20-55**
Other	Numerous types of high performance fibers are commercially available. These fibers range from polymeric fibers such as extended chain polyethylene to boron fibers, and ceramic fibers such as silicon carbide and alumina. Those fibers are generally used for specific applications and need to be treated with the right type of sizing in order to translate their performance in the final composite part.				

Sizing for use in Polypropylene Composite

The first sizings for polypropylene reinforcement were dispersions of low MW PP-g-MA (maleic anhydride grafted polypropylene) copolymers. These dispersions were relatively easy to make, and showed good compatibility with both the PP matrix and the PP-g-MA coupling agents used in PP compounds.

In recent years fiberglass producers tend to prefer the highest molecular weight possible, especially for chopped strands.

In general, the higher the molecular weight of the PP-g-MA copolymer, the better mechanical properties can be obtained.

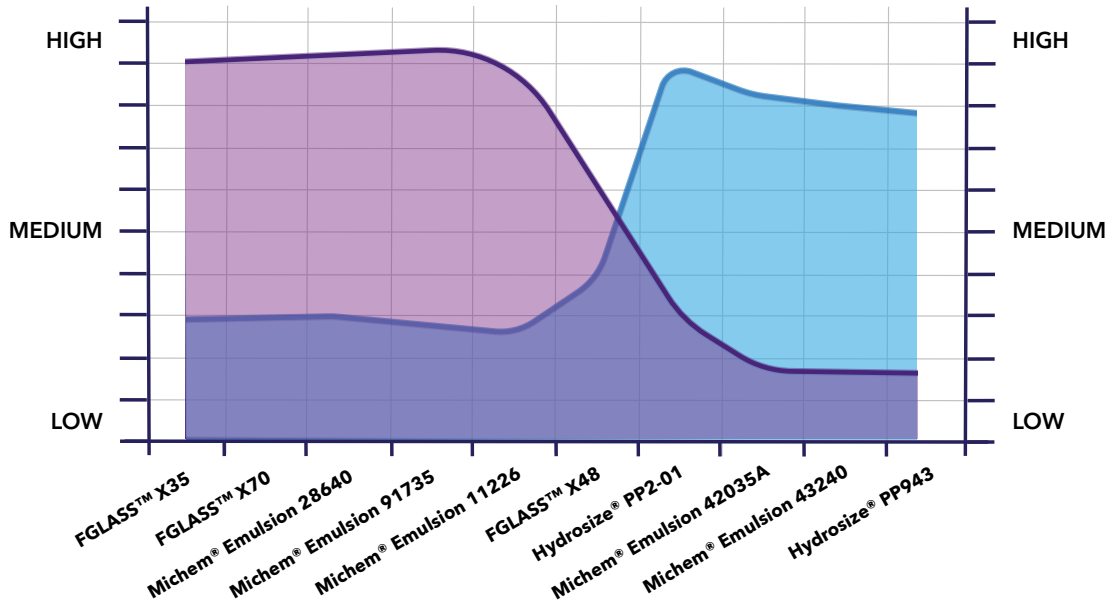
Michelman emulsions have also been developed to offer excellent hydrolysis resistance.

Michelman offers several grades that have a low VOC content to accommodate the latest emission restrictions requested by automotive OEMs.

Product Name	Mechanical Performance	Detergent Resistance	Color	Odor Performance	MW	Grafting Level	Chopped	LFT
FGLASS™ X35	●●●	●●●	●●	●●●	●●●	●	●●●	●
Hydrosize® PP2-01	●●●	●●	●●	●●	●	●●●	●	●●●
Hydrosize® PP247	●●	●●●	●●●	●	●●●	●	●●	●
Michem® Emulsion 91735	●●	●●	●●●	●●	●●●	●	●●	●●

A full list of products can be found on Michelman.com

Key Characteristics of Maleated PP Dispersions



Formulation for LFT PP Fiberglass

% by Weight..... 5%
Batch..... 100 Kg

Ingredients	Non volatiles (%)	% by Weight	Weight (kg)
Organosilane coupling agent	62%	5%	0.40
FGLASS™ X48	35%	80%	11.43
Hydrosize® PP2-01	40%	15%	1.88
DI water	0%	0%	86.29
		100%	100.00

Formulation for Direct Chopped PP Fiberglass

% by Weight..... 10%
Batch..... 100 Kg

Ingredients	Non volatiles (%)	% by Weight	Weight (kg)
Organosilane coupling agent	62%	10%	1.61
FGLASS™ X35	35%	85%	24.29
Lubricant	100%	5%	0.50
DI water	0%	0%	73.60
		100%	100.00

Sizing for use in Polyamide Composites

Michelman's Hydrosize® waterborne polyurethane dispersions are film formers used in sizing formulations that will be incorporated into the production of polyamide and PBT composites. Michelman has chosen aliphatic specific isocyanates as building blocks that provide the best color and color stability possible.

Hydrosize® polyurethane dispersions are compatible with polyamide, and are formulated to react with the resins during compounding.

They remain stable in the presence of silane, and many other additives and grades are available with soft segments to maximize hydrolytic and thermal stability. All Hydrosize® polyurethane dispersions are solvent and APE free.

We have the experience and breadth of products to solve your next PA / PBT challenges.

Hydrosize®	Mechanical Performance	Glycol Resistance	Thermal Resistance	EU Food Compliance	Strand Integrity	Chopped Strand	Long Fiber Reinforced Thermoplastic	PA
U2023	●●	●●	●●●	Yes	●●	●●●	●●	●
U5-01	●●●	●●●	●●●		●●●	●●●	●	●
U5-02	●●	●●●	●●●	Yes	●●	●●●	●●	●
U6-01	●●	●●	●●		●●●	●●	●●●	●
U8-02	●●	●●	●●	Yes	●●	●●	●●●	●
Link U470	●●●	●●●	●●●		●●●	●●●	●	●
Link U480	●●●	●●●	●●●		●●●	●●●	●●●	●

A full list of products can be found on Michelman.com

Formulation for Direct Chopped PA Fiberglass

% by Weight..... 10%
Batch..... 100 Kg

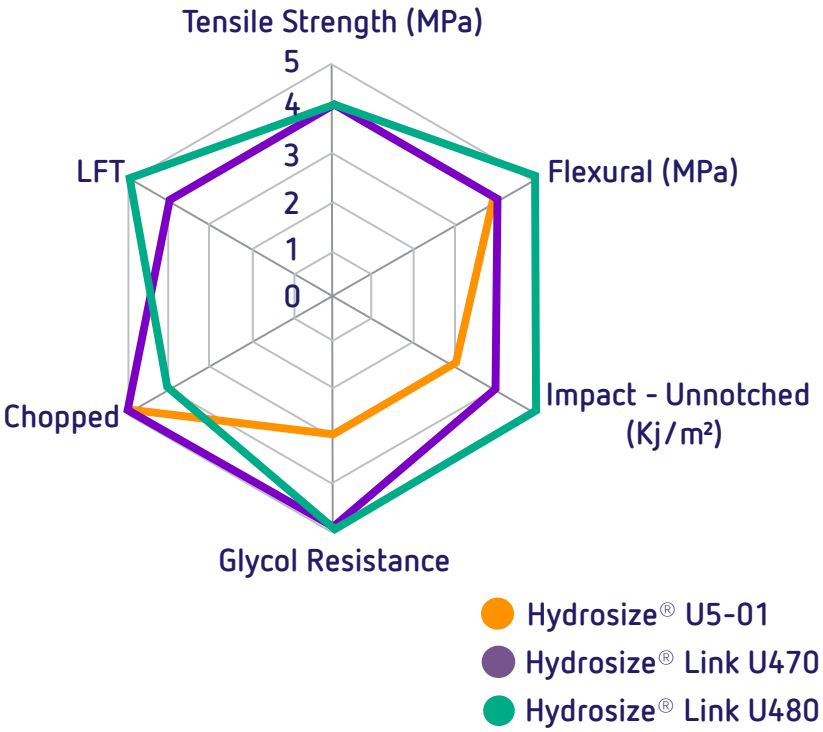
Ingredients	Non volatiles (%)	% by Weight	Weight (kg)
Organosilane coupling agent	62%	10%	1.61
Hydrosize® U5-01	55%	85%	15.45
Lubricant	100%	5%	0.50
DI water	0%	0%	82.43
		100%	100.00

Sizing for use in Polyamide Composites: Hydrosize® Link

Hydrosize® Link is a family of polyurethane film formers designed to offer enhanced reactivity with polyamide resin matrix. These high performance sizings are added during the fiber manufacturing process and activate during compounding.

Hydrosize® Link products are testaments to Michelman's intense focus on the development and manufacturing of specialized polyurethane sized fiber that improves composite performance in applications where materials are exposed to water, ethylene glycol, and high temperature.

RESIN COMPATIBILITY		
PPA/PPS	PET	EPOXY
	●	
●		
●		
		●
●		
●		



Formulation for LFT PA Fiberglass

% by Weight..... 10%
Batch..... 100 Kg

Ingredients	Non volatiles (%)	% by Weight	Weight (kg)
Organosilane coupling agent	62%	5%	0.40
Hydrosize® U6-01	30%	85%	14.17
Lubricant	100%	10%	0.50
DI water	0%	0%	84.93
		100%	100.00

Sizing for use in High Temperature Resins

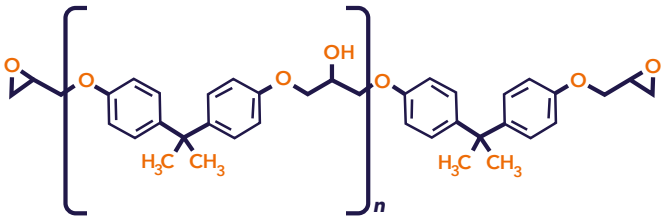
For the most demanding applications, many composites require high temperature processing, or require high temperature performance. These applications typically require the use of high temperature polyamide, polyimide, PPS, PEEK, or PAEK resin.

If no high temperature sizing is used on the fiber to manufacture the composite, then the sizing will likely degrade during composite fabrication or during use.

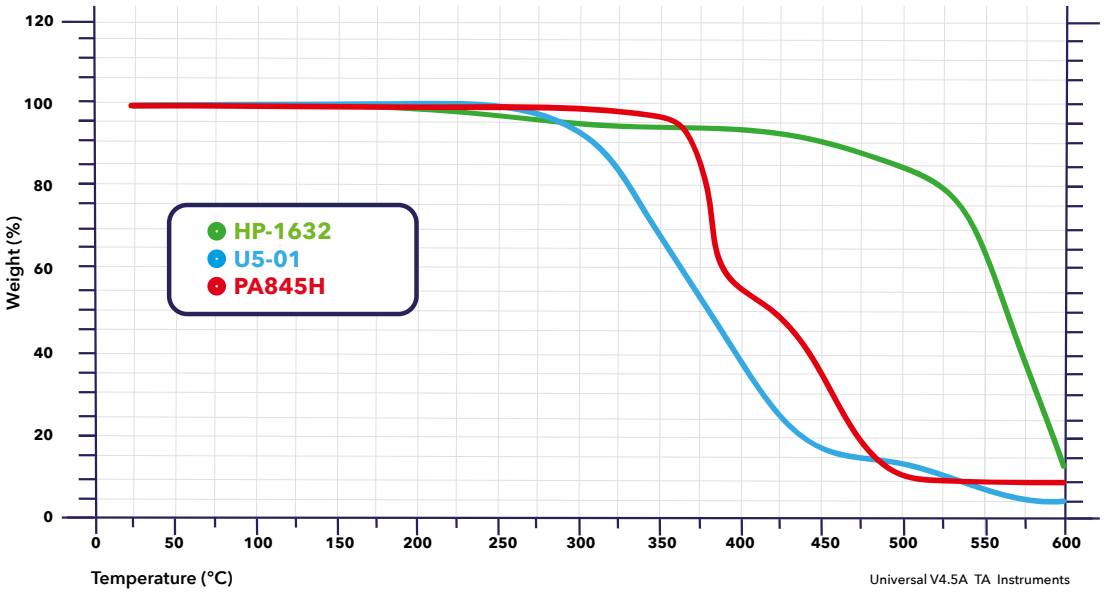
This results in a poor interface and microvoids caused by outgassing. Both of these situations will result in a decrease in mechanical properties and composite failure.

Polyimide-based Hydrosize® HP-1632 has been designed specifically for high temperature applications. Its onset of degradation is >500 °C and it is as thermally stable as most high performance resins.

	RESIN COMPATIBILITY			
Hydrosize®	PEEK	PEI	PPS	PPA
HP-1632	●	●	●	
PA845H	●			●
U5-01	●		●	●



Thermogravimetric Analysis



Sizing for use in Thermoset Resins

Using a proprietary process, Michelman can make high molecular weight epoxy dispersions without any solvent. The epoxy dispersions can be used as fiber sizing for epoxy resins, thermoplastic polyester and/or unsaturated thermoset polyester applications. They can be applied to the fiber or the fabric prior to the part consolidation and/or pre-preg.

	RESIN COMPATIBILITY	
Product Name	EPOXY	ESTER
Hydrosize® EP834	●	
Hydrosize® EP876	●	
Hydrosize® EP871	●	
Hydrosize® HP-302	●	●
Hydrosize® U2022		●
Hydrosize® U2023		●
Hydrosize® U2-04		●
Hydrosize® U10-01	●	
Hydrosize® U6-01	●	
Hydrosize® PA845H	●	
U-Nyte™ Set 201	●	

Sizing for Recycyled Carbon Fiber

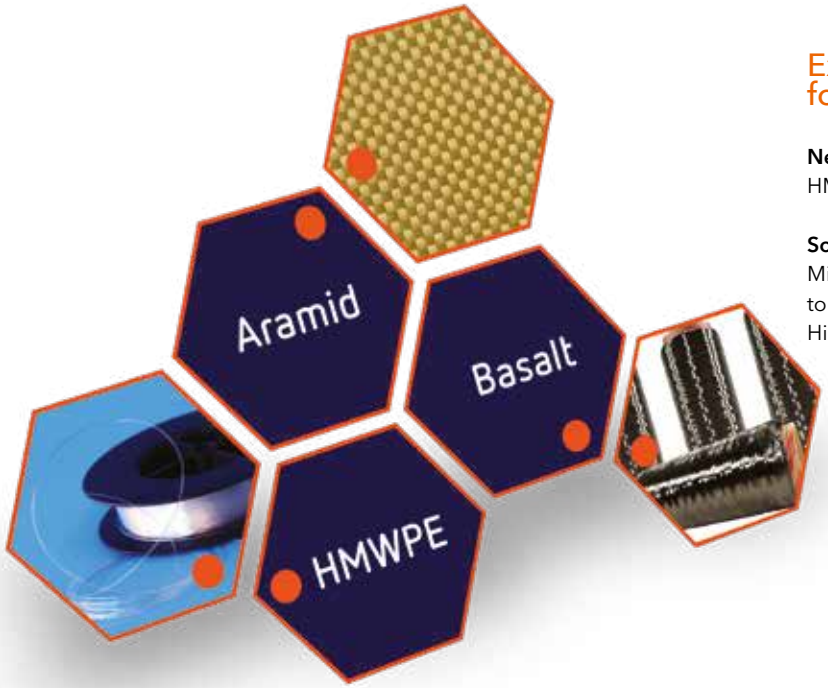
Increased use of carbon fiber in aerospace application generates scrap fiber previously sized with epoxy **+** Recycling initiative and environmental sustainability **=** MICHELMAN Hydrosize® Solutions

Hydrosize®	Resin Compatibility	Can be oversized (on epoxy based sizing)	Key Characteristics
U2-04	PA, PC and Esters	Yes	Compatible with epoxy, this polyurethane dispersion can be applied on a fiber already sized to improve adhesion with polyamides or polyesters and vinylesters.
HP3-02	PA, PC and Esters	Yes	This phenoxy dispersion is particularly designed to improve the compatibility of the carbon fiber with polycarbonate and PBT.
PA845H	PA, PC and Esters	Yes	This unique dispersion performs very well in applications using high temperature resistant polyamides (PPA).
HP-1632	PA, PC and Esters	Yes *(but not ideal to achieve the best performance)*	The best solution on the market for high temperature resistance.

Sizing for Specialty Fibers

Michelman also manufactures a wide range of acrylic based dispersions, and natural and synthetic wax dispersions, which provide a variety of properties and are suitable for synthetic fibers such as HMWPE, basalt or pararamid fibers.

For example, polyethylene (PE) and paraffin wax emulsions offer adhesion control. Paraffin and microcrystalline wax emulsions can enhance water, moisture, vapor and ozone barrier properties and carnauba wax emulsions can be used as slip and anti-block additives.



Example Production Solution for HMWPE Synthetic Fiber

Need: Better adhesion between HMWPE fiber and TPU.

Solution: Michelman recommends Michem® Prime 2960 and Michem® Prime 5931 to improve the interface between High Molecular Weight PE and TPU resin.

Sustainability for both natural and business environments.

Solutions for Technical Textiles / Pre-preg Fabrics

What are the Fiber Types?

- With the exception of cellulosic, fibers can be continuous or staple (chopped).
- Multiple fiber types can be used in one textile fabric. Example: carbon for strength and aramid for flex.
- Each fiber type has its own unique sizing and bonding needs.

NATURAL **SYNTHETIC (STRUCTURAL)**

BAMBOO FIBER GLASS CARBON

Market / Customer Benefit

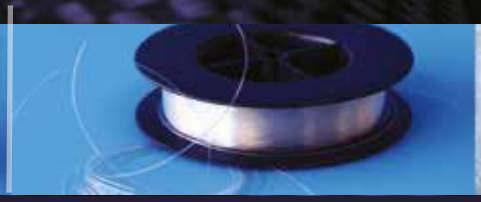
- Surface modification of fibers and fabric can quickly address dynamic needs for improved performance in nearly all technical textile applications.
- Surface modification can solve problems like improved air quality in filtration and provide effective light weight nonwovens that ultimately lead to fuel consumption reduction.
- Michelman's core competency around fiber sizing and surface modification is a direct fit with market/customer needs.
- We are well-positioned to use our expertise to accelerate innovation with our customers' fabric consolidation and/or pre-preg.

Surface Coating Effects

- Chemical Resistance
- Water Resistance
- Rub & Abrasion Resistance
- Lubricity / Slip
- Anti-slip
- Strength
- Adhesion
- Flexibility / Drapability
- COF Adjustment
- Hand / Soft touch

POLYMERIC


BASALT


POLYAMIDE (NYLON)


POLYESTER


ARAMID

Key Industries We Serve

MICHELMAN®

Innovating a Sustainable Future with Expert Materials℠

As a global developer and manufacturer of environmentally friendly advanced materials for industry, Michelman offers solutions for the coatings, printing & packaging, and industrial manufacturing markets. Motivated by unwavering values, and ingrained with a passion for environmentally conscious innovation, we help companies around the globe establish and achieve their product development goals. With access to Michelman's expert materials resources, a compelling combination of world-class talent and specialty chemistries, our customers are excelling in the diverse range of markets they serve with sustainable and responsible solutions.

Michelman Core Values

Integrity • Respect • Success • Collaboration • Curiosity • Giving

Please contact our interface experts in your region for further information.

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