

E7[®] Glass Fiber

Optimal Cost-Performance Solution for
High Performance Composite Materials



E7[®]

New High Performance Glass Fiber

Company Profile

Jushi Group specializes in the production of glass fiber. The company has attained the leadership position in the global glass fiber industry in terms of Output, Technology, R&D, Quality and Market share. Jushi Group is a Chinese national, key high technology enterprise, operating a distinguished Post-Doctoral program.

Jushi Group always adheres to its fundamental Management principles:

- "Apply science and technology for development,
- Build the brand name to expand market share,
- Emphasize management to improve efficiency and
- Employ talented people to enable future growth".

The company owns proprietary, world-class core technologies for large E-glass fiber furnaces, C-glass fiber furnaces and waste fiber recycling furnaces. The company has its own core technology of world-class and achieved certifications to ISO9001, ISO14001, ISO18001, ISO12001 and ISO17025. Its testing center has been certified by both China National Accreditation Board for Laboratories (CNAS) and Germanischer Lloyd (GL). The glass fiber rovings and chopped strand mats under the "Jushi" brand have been listed as "China Top Brand" products and the trademark "JUSHI" has been recognized as "China Famous Trademark". The principal products of Jushi Group have been approved by China Classification Society (CCS), DET NORSE VERITAS (DNV), Lloyd's Register (LR), Germanischer Lloyd (GL) and Attestation De Conformité Sanitaire (ACS).

Jushi Group produces E-glass and C-glass glass fiber products including rovings, chopped strands, chopped strand mats, woven rovings and electrical yarns and fabrics in over 20 product categories and 1000 specifications. The products are sold in all provinces in China and exported to over 100 countries. The key regions include North America, Middle East, Europe, Southeast Asia and Africa with export accounting for 50% of the total sales volume.

Jushi people adhere to our core values of "Behavior, Innovation, Responsibility, Learning, Enthusiasm" to build the company into an international group with leading manufacturing scale, advanced technology, talented team, excellent management, powerful execution, great achievements and fast growth. Jushi Group strives to lead the modernization of China's glass fiber industry and maintain the leadership position in the global glass fiber industry through endless pursuit of innovation and excellence.



E7[®] New High Performance Glass Fiber



GOALS

Provide Optimal Cost-Performance Solution for High Performance Composite Materials

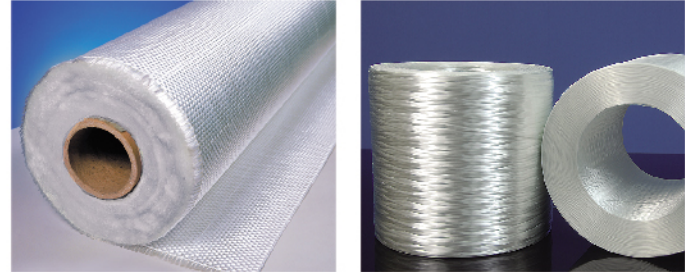
With scientific and technological progress, the 21st Century has seen the rapid development of glass fiber-reinforced composite industry. Due to limitations in mechanical properties, it has become more and more obvious that E glass fiber, including boron-free E glass fiber, can not meet the requirements of various high performance composite materials, such as large wind blades, high performance pultruded profiles and high pressure vessels, all of which require higher strength, stiffness, and fatigue-resistance. In the meantime, although the production of S glass fiber has been widely known, its production cost has exceeded the range that most composite industries can bear. To meet the requirements of high end markets, as well as to protect our environment and achieve clean production, after successfully launching E6[®] glass fiber in 2009, Jushi Group has developed E7[®] High Strength and High Modulus Glass Fiber with even better performance in 2010. The volume production of E7[®] glass fiber with large refractory furnaces makes it possible to meet the large demand for high performance glass fiber from the manufacturers of large wind blades, high pressure vessels and pultruded products and offer customers in the composites industry an optimal cost- performance solution.

E7[®] is a high strength and high modulus glass fiber which is produced using a special low-calcium glass formulation with less than 11.5% of calcium oxide content, and improves the product performance significantly. The chemical composition of E7[®] falls outside the range of standard E glass according to ASTM D578-00, but inside the category of R glass according to ISO 2078 standard. While having all the advantages of traditional E glass, E7[®] features technological breakthroughs in modulus, strength and softening point and can meet special needs of the high end markets. E7[®] provides a brand-new technological platform for Jushi Group products. The product lines developed on the basis of this new platform have wide applications and offer brand new solutions to the various needs of demanding customers.



E7[®] GLASS FIBER

Boost the High Performance of Composite Materials



Compared with traditional E glass, E7[®] delivers the following unique advantages:

- Higher strength, 30% higher than traditional E glass;
- Higher modulus, 23% higher than traditional E glass;
- Higher softening point, about 80% higher than traditional E glass.

Therefore, E7[®] is suitable for use in composite materials which require higher mechanical properties.

Mechanical and Electrical Properties of E7[®] and Traditional E-glass:

Property	Testing method	Unit	E	E7 [®]
Density	ASTM C693	g/cm ³	2.60	2.60-2.61
Refractive Index	ASTM C1648	/	1.566	1.562
Expansion Coefficient	ASTM D696	10 ⁻⁶ K ⁻¹	6.1	5.5
Softening Point	ASTM C338	°C	838	921
Elastic Modulus	ASTM E1876	GPa	72	89
Dielectric Constant (23°C, 1MHz)	ASTM D150	/	6.7	7.0

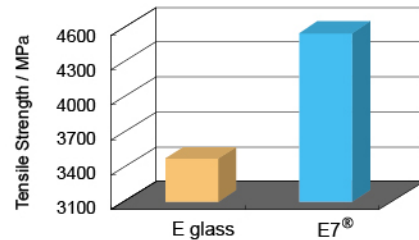
E7[®] has a reasonable chemical composition which has not only obviously increased mechanical properties, but also offers better corrosion resistance than boron-free E glass fiber in neutral, acidic or alkaline solutions, ensuring long-term stable performance of E7[®]-reinforced composites in special environments.

Corrosion Resistance Properties of E7[®] and Traditional E-glass:

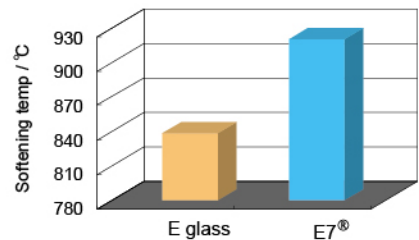
Item	Testing method	Unit	E	E7 [®]
Weight loss in acidic solution	Soaking in 10% HCl solution at 23°C for 24 hours	%	18.39	0.07
Weight loss in alkaline solution	Soaking in 0.025M Na ₂ CO ₃ solution at 23°C for 24 hours	%	0.16	0.14
	Soaking in 0.5M NaOH solution at 23°C for 24 hours	%	0.46	0.22
Weight loss in boiling water	Boiling in water at 100°C for 24 hours	%	0.53	0.23

Note: The above tested products have a uniform filament diameter.

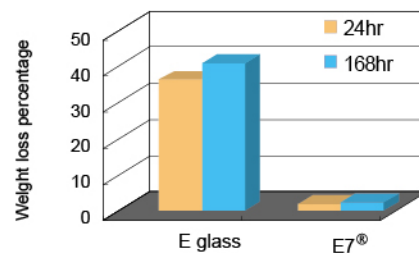
Comparison of Tensile Strength between E7[®] and E glass Fiber:



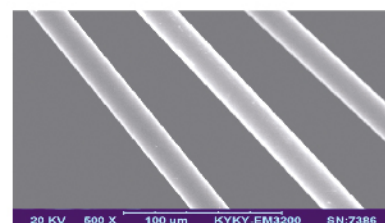
Comparison of Softening Point between E7[®] and E glass Fiber:



Comparison of Weight Loss in 10% H₂SO₄ at 96°C after 24 and 168 hours between E7[®] and E glass fiber:



SEM picture of E7[®] in 10% H₂SO₄ solution at 96°C after 24 hours:



E7[®] REINFORCEMENTS

Open New Space for High End Applications of Composites

The use of glass fiber reinforcements allows customers to design high performance composites beyond the limits of the polymer material itself. Jushi E7[®] glass fiber enables even higher composite performance. Compared with E-glass, composites based on E7[®] reinforcements have better mechanical properties including higher strength, modulus and fatigue resistance. E7[®] reinforcement will expand the use of high performance composites in large wind blades, high pressure vessels, pultrusion profiles and many other applications.

The exiting production technology with large refractory furnaces can be used to manufacture E7[®] at lower cost. The volume production of E7[®] glass fiber with large refractory furnaces makes it possible to meet the large demand for high performance glass fiber from high end industries such as the wind energy industry. The excellent mechanical properties and volume production with refractory furnaces make E7[®] an optimal cost- performance solution for the composites industry.

E7[®] - Reinforced wind blades are longer and more durable and reduce power generation cost

As a clean and inexhaustible energy source, the wind power can be generated at relatively low cost with mature technology. Due to environment issues related to thermal power and nuclear power more and more countries are setting up wind energy programs aggressively. The generation cost of wind power depends very much on the length of wind blades - longer blades lead to higher power generation efficiency. Longer blades require glass fiber reinforcements with higher strength and modulus since the use of carbon fiber in this industry is restricted due to its high price.

The fact that E7[®] can be volume produced with refractory furnaces makes it possible to meet the demand of the wind energy industry for a large quantity of high strength and high modulus glass fiber. By using E7[®], the manufacturers can make lighter, longer and more durable wind blades, which will lead to lower power generation cost in the end.

Take for instance Jushi UD1200 fabric which is widely used in spar caps of windmill blades. Compared with the boron free E glass based 398, the E7[®] based 380 products have a 30% increase in tensile strength, 11% increase in tensile modulus and significant increase in shear and compressive properties. Meanwhile, the fatigue resistance test shows that UD1200 laminates made from E7[®] based 380 has a 15% longer life time (in Log cycles) than boron free E glass based 398 under the same load.

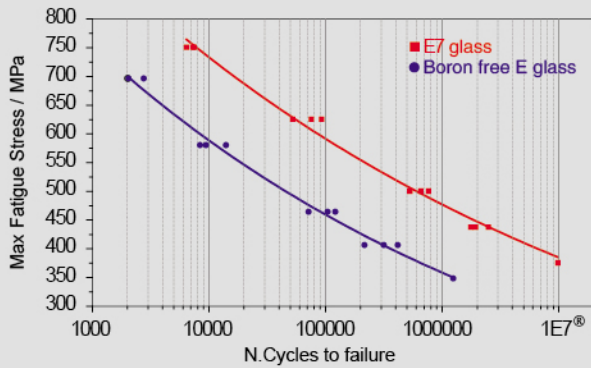
Test Sample	Property	Standard	E	E6 [®]	E7 [®]
Tensile property of impregnated roving, Epoxy resin	Tensile strength (MPa)	ASTM D2343	1900~2000	2500~2700	2800~3000
	Tensile modulus (MPa)	ASTM D2343	73~75	81~83	89~91
1200 g/m ² UD fabric, (tested in 0° direction), Infusion process, Epoxy resin	Tensile strength (MPa)	ISO 527-5	/	1120.6	1309.8
	Tensile modulus (MPa)	ISO 527-5	/	42.6	47.9
	Fiber Volume Content (%)	ISO 1172	/	53.6	53.9
	Tensile strength (MPa)	ISO 14126	/	805.5	900.5
	ensile modulus (GPa)	ISO 14126	/	42.9	48.2
	Fiber Volume Content (%)	ISO 1172	/	54.3	53.5



New High Performance Glass Fiber



Fatigue test result based on UD1200 laminate:



Test conditions for fatigue resistance:

- Tested per ISO 13003:2003
- Laminates made with 3 layers of UD1200 fabric by using epoxy vacuum infusion process.
- Roving inputs are boron free E glass based 398 for and E7[®] glass based 380.
- Tensile-tensile fatigue test at R=0.1 with a test frequency of 3 Hz

E7[®] - Reinforced pultrusion materials have higher strength, stiffness and performance.

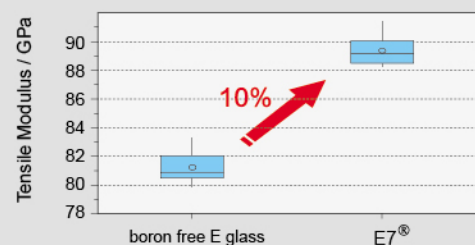
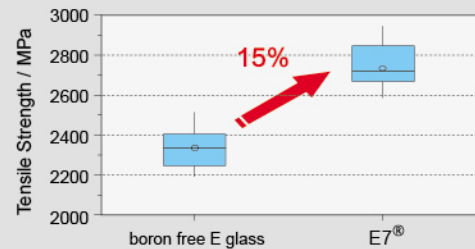
Pultrusion is a common production technology for producing glass fiber reinforced composites and features high production efficiency, high strength of finished products, low processing cost and consistent quality. It now has more and more applications including, for instance, pultruded sucker rods, FRP bridges and other construction profiles, which have longer service life, lower manufacturing cost and good corrosion resistance. With the expansion of the applications of pultruded FRP products, customers are getting more demanding and require lighter and thinner pultruded FRP products which have higher strength, stiffness and fatigue resistance as well as good weatherability and corrosion resistance.

E7[®] glass fiber for pultrusion inherits the advantages of E7[®] glass and offers higher strength, modulus and fatigue resistance, thus making it possible to manufacture various strong but light final products, which are lighter and thinner with the same strength, and have longer fatigue life and hence longer service life under the same stress. In addition, E7[®] glass fiber has corrosion resistance equivalent with that of ECR glass fiber in various environments, ensuring long-term stability in use of the pultruded final products.



Take for instance the new generation 312T for pultrusion. Compared with the boron free E glass based 312T, the E7[®] based version has 15% higher tensile strength and 10% higher tensile modulus.

Test Performance Comparison between boron free E glass 312T and E7[®] 312T (Glass content: E7[®] 58.6 wt%, boron free E glass 59.1 wt%, resin: UP, Test standard: ASTM D2343)



TEST SAMPLE	ITEM	UNIT	BORON FREE E GLASS	E7 [®]
DR23-4400-312T	Tensile strength	MPa	2350.6	2720.4
	Tensile modulus	GPa	81.5	89.5

ENVIRONMENTAL PROTECTION

Become A Model for Clean Production

Jushi Group is committed to improving our environmental footprint. We have invested heavily in the most modern technologies available to reduce pollutant emissions into our environment. Improved oxygen firing technology reduced total waste gas emissions from the furnace by 80% and the nitrogen oxide emissions by over 90%. State of the art glass recycling technology ensures zero discharge of process waste glass fiber. Modern waste purification technology enables zero discharge of industrial waste water from our production process.

E7[®] Glass Fiber is produced by more scientific production technology and process which not only improve the product performances, but also significantly reduces air pollutants. The development of E7[®] Glass Fiber is consistent with our constant commitment to social responsibility and sustainability. Not only have we achieved the goal of improving our glass fiber products, but we also have improved our environmental footprint at the same time.

CUSTOMER AND TECHNICAL SUPPORT ORGANIZATION

Jushi Group possesses world class core technologies and advanced testing and analysis capabilities for glass, organic chemistry, glass fiber and composites. We have established a global network and technical service professionals to help customers solve problems in materials development and process optimization. We collaborate closely with customers to address market challenges and promote the growth of the composites industry.

We will share with you all the information on E7[®] glass fiber reinforcements as well as our considerable knowledge of compounding and molding technology and processes.



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All the data given in this brochure is preliminary and we reserve the right to update or modify this data without notice.





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