

Carbon Fibers

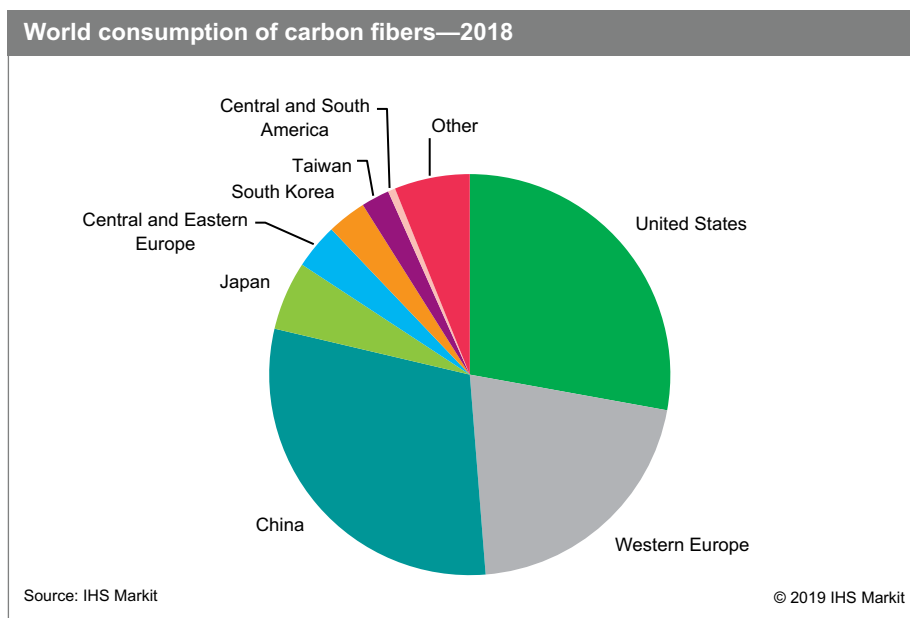
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Abstract

The term *carbon fiber* refers to organic materials that have been heat-treated at temperatures of 1,000–3,000°C and generally contain 92–99.99+% carbon. *Graphite fiber* refers to carbon fiber precursors that have been processed at temperatures exceeding 2,500°C for an extended period of time; for the purposes of this report, however, graphite fibers will not be distinguished from carbon fibers. Carbon fibers are noted for their high strength and stiffness. These properties are quantitatively measured by tensile-strength and tensile-modulus tests. The tensile strength of a material is the rupture strength per unit area as the material is subjected to a specified dynamic load. Tensile modulus is the ratio of stress to strain of the material as it is deformed under a specified dynamic load.

Carbon fibers are used primarily as reinforcing agents in high-performance composites with synthetic resin matrices such as epoxies, polyimides, vinyl esters, phenolics, and certain thermoplastics. High-performance composites, also referred to as advanced composites, are generally defined as very strong fiber-reinforced matrices having at least 60% fiber loading; composites having a fiber loading of 12–35% are used more frequently in industrial applications such as construction panels, pipes, or boats. Carbon fibers are used mainly in applications requiring high stiffness properties exceeding the tensile modulus of glass or aramid fibers. They are also used in applications where aramid fibers' poor compression resistance and susceptibility to moisture regain have caused lamination failures. In recent years, the price of carbon fiber-reinforced composites has dropped, making them more attractive for use in more applications.

The following pie chart shows world consumption of carbon fibers:



Contacts

Koon-Ling Ring • Koon-Ling.ring@ihsmarkit.com
Maria deGuzman • Maria.deguzman@ihsmarkit.com

Carbon fiber use has continued to grow strongly because of increasing carbon fiber composite use in the production of aircraft, as well as growing demand in industrial applications such as pressure vessels, automotive uses, and wind turbine blades. In 2011–12, aircraft/aerospace applications surpassed sporting goods/recreation as the second-largest market for carbon fibers.

Major advances in technology and processing have expanded the demand for high-performance carbon fibers. The introduction of higher-volume and lower-cost fibers, coupled with gains in productivity, has reduced the manufacturing costs of carbon fibers. Since cost is a major factor affecting demand, continued improvements in performance, along with increased availability, are expected to support growing consumption in all regions and applications. However, cost will remain a challenge in applications such as widespread automotive use.

In the United States, industrial use in pressure vessels will benefit from alternative fuels usage such as natural gas, gas transport, and the growing use of fuel-cell and electric vehicles. Use in wind energy will continue because of lower costs, longer turbine blades, larger wind turbines, and the growing number of offshore installations supporting this market. Carbon fiber composite use will potentially increase in mass-produced automobiles, providing lower weight, more fuel efficiency, and lower emissions; however, higher costs will continue to limit widespread use.

In recent years, the Chinese carbon fiber industry has grown and made improvements in its product offerings and quality. However, challenges still remain, such as the need for producers to have greater collaboration with downstream consumers, the need to establish product standardization, and precursor supply and quality issues. For the aircraft and aerospace market segments, Chinese carbon fiber use will have very high growth (albeit from a small base) but product certification issues could delay widespread use. Carbon fiber use for sporting goods will continue to grow well, but perhaps at a lower rate than in previous years as these markets are gradually becoming saturated.

Japan remains the largest exporter of carbon fibers, largely exporting to the United States, Western Europe, and Asia. Other Asian countries, including South Korea, Taiwan, and India, will experience continued growth in carbon fiber consumption. For example, future consumption in South Korea will be higher, led by industrial applications such as wind turbine blades and automotive use, and in sporting goods and recreation.

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IHS Markit Customer Care

CustomerCare@ihsmarkit.com

Americas: +1 800 IHS CARE (+1 800 447 2273)

Europe, Middle East, and Africa: +44 (0) 1344 328 300

Asia and the Pacific Rim: +604 291 3600

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