# Carbon Fiber

Here is a detailed introduction to carbon fiber:

## Basic Information

- **Definition**: Carbon Fiber is a high-molecular fibrous material with a carbon content of over 90%, produced by high-temperature carbonization and other treatments of carbon-containing raw materials under specific conditions.
- **Appearance**: Typically black and fibrous, with a diameter of about 5-10 micrometers, extremely slender.

## Development History

- In 1850, British scientist Swan trial-produced carbon filaments. In 1880, American inventor Edison carbonized cotton and bamboo fibers for use as incandescent light bulb filaments.
- In 1950, the Wright Patterson Air Force Base in the U.S. began researching rayon carbon fibers for ablative materials in rocket nozzles and nose cones.
- In 1959, Japanese scientist Asao Kondo invented polyacrylonitrile-based (PAN) carbon fiber, laying the foundation for the PAN-based carbon fiber route.

- In 1963, British scientist Watt improved the production process of PAN-based carbon fiber, obtaining high-performance carbon fiber, marking the rapid development of PAN-based carbon fiber.
- From 1971 to 1983, Japanese companies like Toray industrialized carbon fiber production. Since then, carbon fiber has been widely used in aerospace, sports equipment, and other fields.

## Raw Materials and Manufacturing Process

- **Raw Materials**: Mainly include polyacrylonitrile, pitch, viscose, lignin, phenolic, and other organic fibers. Currently, industrial products are mainly two categories: polyacrylonitrile (PAN)-based carbon fiber and pitch-based carbon fiber, with PAN-based carbon fiber being the most widely used.
- **Manufacturing Process**: The main steps include stabilization treatment (pre-oxidation treatment), carbonization heat treatment, and graphitization heat treatment. The specific process is as follows:
    - **Spinning**: Mix the precursor with other materials, spin into fibers, and wash and stretch them.
    - **Stabilization**: Heat the fibers in air at 200-300°C to change linear atomic bonds into ladder bonds.
    - **Carbonization**: Heat the fibers at 1000-3000°C in an oxygen-free environment to expel non-carbon atoms.

- **Surface Treatment**: Slightly oxidize the carbonized fibers to improve their bonding properties.
- **Sizing**: Coat the fibers with polyester, nylon, or other materials to prevent damage during subsequent processing.

## Performance Characteristics

- **High Strength and Modulus**: Carbon fiber is much stronger than steel, with excellent modulus, offering good tensile and deformation resistance to maintain stability under large external forces.
- **Low Density**: With a density about one-fourth that of steel, it is lightweight, effectively reducing the weight of products, which is crucial in aerospace, automotive, and other fields.
- **High and Low Temperature Resistance**: It maintains stable performance in high-temperature environments without deformation or melting, and does not become brittle or lose strength in low-temperature environments.
- **Corrosion Resistance**: It shows good tolerance to chemicals such as acids, alkalis, and salts, making it suitable for use in harsh chemical environments.
- **Good Fatigue Resistance**: After repeated stress and deformation, it still maintains good performance, with low risk of fatigue failure.

- **Good Electrical and Thermal Conductivity**: It has certain electrical and thermal conductivity, meeting the requirements of special fields for such properties.

## Application Fields

- **Aerospace**: Used to manufacture structural components such as aircraft wings, fuselages, tail wings, and rocket casings and engine parts, reducing the weight of aircraft and improving fuel efficiency and flight performance.
- **Automotive**: Applied to automotive body, frame, engine covers, wheel hubs, etc., reducing vehicle weight and enhancing acceleration, fuel economy, and handling.
- **Sports Equipment**: Commonly used in bicycles, golf clubs, tennis rackets, fishing rods, skis, etc., improving the strength, toughness, and comfort of equipment while reducing weight to enhance athletes' performance.
- **Construction**: Used for reinforcement, repair, and seismic retrofitting of buildings. For example, pasting carbon fiber cloth on concrete structures can improve their bearing capacity and seismic performance.
- **Energy**: Used to manufacture wind turbine blades. Its high strength and low density enable blades to remain stable in strong winds and improve power generation efficiency.

- **Electronics and Electrical**: Used to manufacture casings, radiators, circuit boards, etc., of electronic devices. It has good electromagnetic shielding and thermal conductivity, protecting devices from electromagnetic interference and enabling effective heat dissipation.