

Future of Carbon Fibre- A Short Review

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Abstract: This paper will discuss the previous studies related to carbon fibre. Carbon fiber is five times stronger than steel but it is still lighter than aluminum. Low weight reduces friction, and this is good for the consumers. Carbon fiber provides several other advantages, including corrosion resistance which is caused by carbon-carbon bonds, and it is naturally resistant to oxidation, moisture and heat stability, and high energy absorption. Carbon fiber is also resistant to corrosive situations. The detail about phone case applications, carbon fiber, the materials of carbon fiber, resin used and heat treatment will be reviewed. The topics will be discussed deeply in this paper and more information will be stated in it

Keywords: Carbon fiber, Phone casing, Electronics, Resin, PAN

1. Introduction

A phone case is a cover that protects the outside of your phone and protects it from scratches, grime, and other hazards. That is, it protects your electronics and extends the device's lifespan rather than shortening it. Phone cases, regardless of material, serve the same purpose: to protect your phone from being dropped, scratched, or brushed against unwanted texture. Not only that, but because a phone case is considered an accessory, it can be used with a variety of beautiful designs. A phone case is similar to a mobile phone's home. A phone case, like a house, protects humans from various types of damage and dirt. It shields the entire body of the phone from external damage and shields it from any scratches or nicks that may occur on its surface. Even if the phone is dropped accidentally, the phone case may absorb the shock and keep the phone from being severely damaged. There are now numerous mobile cases and covers available that not only protect your phone but also enhance its appearance.

2. Carbon Fibre as Phone Casing

The investigation of mechanical properties of carbon fiber for consumer products has been well researched. Although some research found that carbon fibre as a phone case had some disadvantages (Claire, 2016), several studies showed that making a phone case using carbon fibre is better than others. For example, a study of the mechanical properties of carbon fibre resulted in a very strong and ultra-lightweight material, Carbon is powerful but surprisingly it is a thin substance. It seems light when using the cases and even if it falls, the damage it sustains is negligible.

Carbon fibre will safeguard your phone from ordinary drops and scrapes while adding no extra bulk (Arthur, 2020). The Young Modulus of a material is used to determine its rigidity or stiffness by evaluating how much it deflects under stress. Carbon fibre-reinforced plastic is

more than four times as stiff as glass-reinforced plastic, more than twenty times as stiff as pine, and 2.5 times as stiff as metal (Pooja & Alka, 2017). It also gives a versatile unique look for phone cases that make the phone cases a luxury material. A carbon fibre phone case will elegantly frame your phone. The excellent moulding creates a clean, modern, high-tech aesthetic that will set you apart from the competition (Roberts, 2006).

Carbon fiber is five times stronger than steel but it is still lighter than aluminum. Low weight reduces friction, and this is good for the consumers. Carbon fiber provides several other advantages, including corrosion resistance which is caused by carbon-carbon bonds, and it is naturally resistant to oxidation, moisture and heat stability, and high energy absorption. Carbon fibre is also resistant to corrosive situations. In chemically infused sectors and circumstances where other materials are prone to corrosion, the composite is ideal.

Even though carbon fiber is a conductive material because of phone case is not a complete enclosure, so Faraday's principle does not apply. The back and sides of a cell phone are protected by a phone case. It does not cover the front of the screen. This still leaves a lot of open space for cell phone signals to flow through. A carbon fibre case could theoretically interfere with your cell phone reception.

However, this is a rare occurrence in practice where carbon fibre's characteristics are determined by its unique microscopic crystalline structure (Rock West, 2020). Carbon fibre can be relatively soft depending on the production method and the precursor material, and it can be produced into or more commonly integrated into protective garments for firefighting. A good example is nickel-coated fibres. Because carbon fibre is chemically inert, it can be employed in situations involving fire and corrosive materials. It is largely made up of carbon atoms bonded together in small crystals that are linearly aligned and parallel to the fibres' long axis.

Carbon fibre is also valuable in medical applications because of these characteristics. The utilization of prostheses, implants, and tendon repair, as well as X-ray accessories and surgical instruments, are all in the works. Thousands of thin carbon strands are twisted together to form a thread to make carbon fibre. After that, the yarn is weaved into a flexible fabric that can be moulded into a variety of shapes. These recent studies have begun to provide insight into the mechanical properties of carbon fibre for consumer products.

3. Polyacrylonitrile (PAN) Carbon Fiber

Carbon fibres made of polyacrylonitrile (PAN) dominate the market today, with pitch carbon fibres and a small amount of rayon carbon fibre textiles trailing behind. Carbon fibres can be created from several different precursors, each with its unique set of characteristics. The most extensively utilized precursor for carbon fibres is PAN, which contains 68 per cent carbon.

Linear PAN molecules contain polar nitrile groups, resulting in strong intermolecular interactions. PAN has a high melting point due to this strong intermolecular contact, and as a result, it tends to break down before the temperature reaches its melting point. Solution

spinning appears to be the only viable option for spinning PAN precursor fibres. PAN copolymers are extensively used as precursors in a range of industries. Internal plasticizers (such as methyl acrylate and vinyl acetate) are frequently used in the quantity of 5 mol% to boost PAN polymer solubility and processibility of PAN precursor fibres by minimizing intermolecular interactions (Chung, 1994).

Because of the improved molecular orientation in precursor fibres and the resulting carbon fibres, the addition of a comonomer can also improve the mechanical properties of carbon fibres. Some comonomers, particularly those with acidic groups (such as acrylic acid or itaconic acid) or acrylamide, aid the cyclization reaction in the stabilization step, and 0.4–1 mol per cent of the copolymer is commonly used for this reason (Donnet & Bansal, 1990).

Traditional wet spinning has been widely utilized to manufacture PAN precursor fibres, but newly developed dry jet wet spinning has demonstrated the ability to spin a dope with greater polymer concentrations and make carbon fibres with improved mechanical qualities. PAN is dissolved in a highly polar solvent, such as dimethyl formamide, dimethyl acetamide, sodium thiocyanate, or their combinations, to form a 10–30 wt% solution in wet spinning. The filtered and extruded PAN solution follows.

When the solvent diffuses away from the precursor, the extruded PAN goes through a coagulation bath containing a PAN solvent and a non-solvent, and the fibres are consolidated. To achieve molecular alignment, fibre bundles are stressed in the coagulation bath. The higher the non-solvent concentration and the higher the coagulation bath temperature, the faster the coagulation rate. A low coagulation rate is recommended in the wet spinning process to avoid flaws both inside the fibres and on the fibre surfaces. A low coagulation rate can also prevent the unfavorable skin-core structure from forming.

The most common carbon fibre precursor is polyacrylonitrile (PAN). A lot of work has gone into linking fibre structure to qualities and transferring that relationship into production to lower production costs or improve fibre attributes. However, issues like cost reduction, increased tensile and compressive strength, and the development of alternate precursors remain. Carbon fibre strength can be improved by reducing defect sensitivity by optimizing the microstructure. The microstructure of carbon fiber is determined by the precursor morphology and processing conditions. Carbon fibers with higher performance will be developed as a result of research in these areas.

4. Processing of PAN Carbon Fiber

The raw materials, known as precursors, are drawn into long strands of fibers during the manufacturing process. The fibers are then woven together to make fabric. They can also be combined with other materials to form desired shapes and sizes when filament wound or molded. The PAN-based carbon fiber manufacturing process includes fiber spinning, thermal stabilization, and carbonization stages.

Carbon fiber properties are heavily influenced by the quality of PAN precursor fiber

and the thermal stabilization process parameters (Lee et al, 2012). The spinning process is important because it forms the internal atomic structure of the fiber. Furthermore, the final fiber quality is affected by process parameters such as dope composition and coagulation bath temperature and concentration. Following the formation of the fibers, they are stretched, stabilized, carbonated, and graphitized.

Before carbonization, the fibers must be chemically altered to change their linear atomic bonding to a more thermally stable ladder bonding. This is accomplished by heating the fibers in air for 30-120 minutes at 390-590° F (200-300° C). As a result, the fibers absorb oxygen molecules from the air and reorganize their atomic bonding pattern. The chemical reactions that stabilize the environment are complex and involve several steps, some of which occur concurrently. A variety of equipment and techniques are used in the stabilization process. Fibers are drawn through a series of heated chambers in some processes.

After the fibers have been stabilized, they are heated for several minutes in a furnace filled with an oxygen-free gas mixture to approximately 1,830-5,500° F (1,000-3,000°C). In extremely high temperatures, the lack of oxygen prevents the fibers from burning. To prevent oxygen from entering the furnace, the gas pressure inside the furnace is kept higher than the outside air pressure, and the points where the fibers enter and exit the furnace are sealed. As the fibers heat up, non-carbon atoms and a few carbon atoms begin to escape in the form of various gases such as water vapour, ammonia, carbon monoxide, carbon dioxide, hydrogen, nitrogen, and others. Two furnaces operating at different temperatures are used in some processes to better control the rate of heating during carbonization (Zafar et al., 2012).

The fibers have a surface that does not bond well with the epoxies and other materials used in composite materials after carbonization. The surface of the fibers is slightly oxidized to improve bonding properties. The addition of oxygen atoms to the surface improves chemical bonding properties as well as etches and roughens the surface for improved mechanical bonding properties. To avoid the formation of tiny surface defects such as pits, which could cause fiber failure, the surface treatment process must be carefully controlled.

The fibers are coated after surface treatment to protect them from damage during winding or weaving. This is referred to as sizing. Coating materials are selected so that they are compatible with the adhesive used to form composite materials. Epoxy, polyester, nylon, urethane, and other common coating materials are used.

5. Resin

Composites manufacturers combine epoxy resins and carbon fiber because these materials complement each other. Many other composite manufacturing options lack the necessary adhesive properties, making epoxy one of the few materials that can adhere to carbon fiber. The complementary nature of the fiber/resin combination is one of its major advantages. Most polymer resins, on the other hand, have low tensile strength but are extremely tough and malleable. When combined, however, the fiber and resin balance each other out,

resulting in a material that is far more useful than either of its individual components.

Epoxy resins improve a composite's strength, durability, and chemical resistance. They perform well at high temperatures, with hot/wet service temperatures reaching 121°C. Epoxies are available in liquid, solid, and semisolid forms and are typically cured through a reaction with amines or anhydrides. Epoxies, unlike polyester resins, are cured with a hardener, which is also known as a curing agent. In a "addition reaction," the hardener (part B) and the base resin (part A) co-react in a fixed ratio. As a result, it is critical to use the correct resin-to-hardener mix ratio to ensure a complete reaction. Otherwise, the resin will not cure completely or achieve its full properties (Xiaosong, 2009).

First, by deposition from polymer solutions, epoxy-based sizing was applied to the carbon fiber surface. Sizing could not only protect the surface of the carbon fiber from damage during processing, but it could also improve its wettability to the polymer matrix. A thorough investigation was carried out into the effect of the ratio of epoxy and amine curing agents in the sizing formulation. The concentration of polymer solutions was varied to control the sizing level on the fiber surface.

6. Heat Treatment

Carbon fiber surface properties are likely to change during the molding process of carbon fiber reinforced matrix composite, and these changes may affect carbon fiber infiltration and resin adhesion (Diefendorf & Tokarsky, 1975). The fibre was heat-treated in the curing process of high-performance carbon fiber reinforced epoxy matrix composites. Activated carbon atoms, defined as carbon atoms in conjunction with oxygen and nitrogen, can be detected using X-ray photoelectron spectroscopy (XPS). Surface chemistry analysis reveals that the content of activated carbon atoms on the surface of treated carbon fibers, particularly those connected to the hydroxyl, decreases with increasing heat treatment temperature. The surface properties of carbon fibers and the fiber/epoxy interfacial adhesion change dramatically during heat treatment. The carbon fiber surface was modified using heat treatment in a gas mixture at 600- 750 °C. Heat treatment is another type of surface treatment for carbon fibers that changes the surface properties of the fiber to improve fiber/matrix adhesion. The impact of gas mixture composition, treatment time, and temperature on the interface was thoroughly investigated. Researchers (Feih & Mouritz, 2012) investigated the effect of fire on carbon fiber tensile properties, providing new insights into the tensile performance of carbon fiber-polymer composite materials during fire. Due to the lack of surface oxidation, the fiber modulus was unaffected when heated in nitrogen, indicating that the stiffness loss of carbon fiber composites in fire was sensitive to the oxygen content.

Researchers thoroughly investigated the reaction of functional groups between the carbon fiber surface and the fiber surface sizing during heat treatment (Dai et al., 2012). The results showed that the concentration of epoxy groups decreased with increasing heat-treatment temperature in both the fiber surface sizing and the extracted sizing, but it was lower in the extracted sizing compared to the fiber surface sizing after heat treatment under the same conditions. It showed that the reaction rate between the functional groups of the fiber surface

was faster than that of the sizing system.

The heat treatment at 150 °C increased the content of C-O bonds and activated carbon atoms on the surface of the desired carbon fibers, demonstrating the reaction between the functional groups on the surface of carbon fibers and the sizing materials. Moisture, in addition to heat treatment, has an effect on the interface between a carbon fiber and an epoxy matrix. Zafar et al. created single fiber model composites with high modulus carbon fibers based on an epoxy resin and investigated the long-term effects of moisture on the interface between a carbon fiber and an epoxy matrix. The results showed that after moisture absorption, the glass transition temperature decreased. Using Raman spectroscopy, the effects of moisture on the axial strain of the carbon fiber within the composite and stress transfer at the interface as a function of exposure time were observed, and it was discovered that the decrease in mechanical and interface properties of the model composites under seawater immersion was greater than under demineralised water immersion.

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8. References

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