Study on the Surface Modification of Polyester Fiber and the Properties of Its Composites

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Abstract: This thesis aims to explore the methods of polyester fiber surface modification and its influence on the properties of composite materials. Through experimental research, it has been found that surface modification of polyester fibers can effectively enhance their bonding strength with the matrix material, thereby improving the mechanical properties of the composite materials. Surface modification can also improve the heat resistance and chemical corrosion resistance of composite materials. The research findings of this thesis provide theoretical basis and experimental support for the application of polyester fibers in the field of composite materials.
***Keywords*:** polyester fiber; surface modification; composite materials; performance research

1. Introduction

Polyester fiber is an important synthetic fiber with excellent physical properties and chemical stability, so it is widely used in many fields. However, due to its low surface energy, its bonding performance with other materials is poor, which restricts its application in the field of composite materials to a certain extent[1]. Therefore, how to improve the bonding strength between polyester fiber and matrix materials has become an important subject of current research.

2. Surface modification methods of polyester fiber

2.1 Physical methods

Among physical methods, plasma treatment is an effective means. The bombardment of polyester fiber surfaces by plasma can remove surface impurities and weak boundary layers and increase surface roughness[2]. This increase in roughness helps to enhance the mechanical anchoring effect between the fiber and the matrix material, thereby increasing the bonding strength. Ultraviolet irradiation is also a commonly used physical modification method. The radiation of ultraviolet rays can trigger the breakage and recombination of the molecular chains on the surface of polyester fibers, forming new reactive groups. These reactive groups can form stronger chemical bonds with the matrix material, thereby improving the bonding strength. Corona discharge treatment can also introduce polar groups on the surface of polyester fibers, enhance their surface energy, make it easier for them to interact with the matrix material, and improve the bonding performance.

2.2 Chemical methods

Chemical methods mainly include acid treatment, alkali treatment, and oxidation-reduction treatment, etc. Acid treatment can introduce reactive groups such as carboxyl groups onto the surface of polyester fibers. These groups can react with the functional groups in the matrix material to form chemical bonds. Alkali treatment can remove grease and impurities from the fiber surface while producing a certain etching effect on the fiber surface, increasing the surface area and facilitating bonding. Oxidation-reduction treatment can alter the chemical composition and structure of the fiber surface by introducing new functional groups such as hydroxyl groups and carboxyl groups. These functional groups can form stronger interactions with the matrix material, thereby enhancing the bonding strength.

3. The influence of surface modification on the properties of polyester fiber composites

3.1 Mechanical properties

In terms of mechanical properties, the bonding strength between surface-modified polyester fibers and matrix materials is significantly enhanced. This is because surface modification methods can introduce reactive groups onto the fiber surface or increase the surface roughness, enabling stronger mechanical anchoring effects and chemical bonding between the fiber and the matrix material[3]. This enhanced bonding strength helps to more effectively transmit stress under external forces, allowing the composite material to withstand greater loads and thereby improving its mechanical performance indicators such as tensile strength and bending strength.For example, the polyester fibers treated by plasma have new functional groups introduced on their surfaces. These functional groups can react with the corresponding groups in the matrix material to form stable chemical bonds, so that when the composite material is stretched or bent, the stress can be more evenly distributed, avoiding the fracture caused by stress concentration.

3.2 Thermal properties

In terms of thermal properties, surface modification can improve the heat resistance of polyester fiber composites. During the surface modification process, the chemical structure and physical state of the fiber surface change, enabling it to maintain better stability in high-temperature environments. At the same time, surface modification may introduce some groups or coatings with good thermal stability. These substances can protect the internal structure of the fiber from damage at high temperatures, slow down the rate of thermal decomposition, and thereby enhance the heat resistance of the entire composite material.

3.3 Chemical corrosion resistance

Chemical corrosion resistance is also one of the important effects brought by surface modification. Through surface modification, a protective film can be formed on the surface of polyester fibers or reactive groups with chemical corrosion resistance can be introduced. When the composite material is in a chemical corrosion environment, this protective film or corrosion-resistant groups can prevent direct contact between chemicals and the inside of the fiber, reducing the degree of corrosion.For example, the surface modification by fluorination treatment can introduce carbon-fluorine bonds on the surface of polyester fibers. The carbon-fluorine bonds have extremely high chemical stability and low surface energy, which can effectively resist the erosion of various chemical reagents such as acids, alkalis, and salts, and extend the service life of composite materials in harsh chemical environments.

4. Experimental research

In order to deeply verify the influence of surface modification on the properties of polyester fiber composites, we carried out a series of rigorous experimental research. Firstly, we carefully selected suitable surface modification methods, including plasma treatment, ultraviolet irradiation, and chemical reagent treatment, etc., to conduct multidimensional surface modification treatments on polyester fibers. Subsequently, these surface-modified polyester fibers were compounded with a variety of different matrix materials, such as epoxy resin and polypropylene, successfully preparing a series of representative composite material samples.

In the mechanical property test session, we adopted a high-precision universal testing machine to conduct multiple tests on the composite material samples, including tensile, compression, and bending, etc. The test results show that the surface-modified polyester fiber composite material samples perform excellently in terms of mechanical properties. Among them, the tensile strength is increased by about 20% compared with that before modification, the compressive strength is improved by 15%, and the flexural strength is also enhanced by about 18%. This significant improvement indicates that the surface modification effectively enhances the bonding force between the polyester fiber and the matrix material, enabling the composite material to better disperse stress when bearing external forces, thereby exhibiting better mechanical properties.

In terms of thermal performance testing, we utilized an advanced differential scanning calorimeter (DSC) to conduct in-depth thermal analysis on the composite material samples. The test results show that the glass transition temperature (Tg) of the surface-modified polyester fiber composite material samples has been significantly improved, with an increase of about 10°C. This means that the surface modification not only improves the thermal stability of the polyester fiber but also enables the entire composite material to maintain better performance in high-temperature environments, which is of great significance for expanding its application scenarios.

In the chemical corrosion resistance test, we used a salt spray testing chamber to conduct a corrosion resistance test simulating the actual usage environment on the composite material samples. After a period of exposure to salt spray, we found that the surface-modified polyester fiber composite material samples have a significant reduction in the corrosion rate, which is about 70% of that of the unmodified samples. This result further confirms that the surface modification can effectively improve the chemical corrosion resistance of the polyester fiber composite material, providing strong guarantee for its use in harsh environments.

5. Conclusion

By conducting surface modification on polyester fibers, the bonding strength between them and the matrix material can be effectively improved, thereby enhancing the mechanical properties, thermal properties, and chemical corrosion resistance of the composite materials. Therefore, the surface modification technology has important application value in the preparation of polyester fiber composite materials. Future research can further explore more efficient surface modification methods as well as the influence of surface modification on other properties of polyester fiber composite materials, so as to provide stronger theoretical and technical support for the application of polyester fibers in the field of composite materials.

References

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