Application of New Materials in Sports Equipment

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Abstract. The excellent properties and applicability of graphene composite, nylon fiber composite, unsaturated polyester composite, carbon fiber composite and epoxy resin composite in sports equipment are introduced. It is pointed out that while developing competitive sports, we must attach great importance to the development, modification and utilization of new high-tech materials, so as to achieve faster and better development of sports. In the future, sports equipment will develop towards personalized, intelligent and environment-friendly materials.

1. Introduction

At present, the traditional sports equipment mostly uses wood or metal materials, the physical characteristics of these materials make the strength of sports equipment is greatly limited. With the development of science and technology, new materials are widely used in various sports equipment, and even become the key factor in competitive sports. Based on the excellent characteristics of various new materials, such as high specific strength, specific modulus, light weight, wear resistance, good damping performance, and strong designability and so on, it significantly improves the performance of sports equipment, making it widely used. In this paper, some new materials, such as nylon fiber composites, unsaturated polyester composites, carbon fiber composites and epoxy resin composites, which have been widely used in sports equipment, are introduced in detail. At the same time, the hot new materials in the 21st century, the structural characteristics of graphene composites and the excellent characteristics in sports equipment are introduced.

2. New materials for sports equipment

2.1. Graphene Composites

Graphene structure was considered to be a theoretical model because of its excessive surface tension, and it was difficult to exist independently until 2004, when physicists Andre Heim and Constantine Novosholov of the University of Manchester in the United Kingdom "tore" a single layer from the surface of graphite by a simple "mechanical peeling method" using "tape". The carbon material, graphene, confirms that it can exist alone. The two scientists also won the 2010 Nobel Prize in Physics for their outstanding contributions to two-dimensional graphene materials. Graphene, which can be as thin as a single carbon atom, is the world's thinnest, strongest, best thermal conductive and most flexible nanomaterial known; it is 100 times stronger than steel; and has excellent electrical conductivity. The size stability, toughness, heat resistance and mechanical properties of graphene polymer nanocomposites can be significantly improved by adding proper amount of graphene. Compared with commercial AZ31 magnesium alloy, the wear volume of graphene composite...
decreased by 89% at 20 °C. Compared with WC-Co composites for gears, the thermal fatigue life of the samples increased by 209% after adding 10 vol% graphene. A large number of theoretical and experimental results show that the graphene polymer nanocomposites depend on its high strength and high strength. The characteristics of high wear resistance and high heat resistance have important potential application value in the field of sports equipment.

2.2. Nylon fiber composites
Aromatic polyamides were developed around 1960 by DuPont to improve the heat resistance of nylon. There are two main products, one is polyisophthalic m-phenylenediamine (Nomex fiber), and the other is poly Terephthaloyl p-phenylenediamine (Kevlar fiber). The presence of benzene ring in Nomex fibers prevents the molecular chain from rotating internally. Strong polar amide groups form hydrogen bonds between the molecular chains, which enhances the interaction between the molecular chains and forms conjugated systems between benzene ring and amide group. Therefore, polymer molecular chains have great rigidity, which can make the polymer have the following excellent performance characteristics: high heat resistance, high strength, high stiffness, chemical corrosion resistance, high energy radiation resistance, flame retardant, moisture resistance and so on. In Kevlar fibers, the molecular chains are composed of phenyl group and polar amide group alternately, and all of them are distributed in high density. The amide group and benzene ring can form conjugated system, especially the phenyl group has more influence on the rigidity of the molecular chain than the metaphenyl group. Rigid benzene ring and high density hydrogen bond make the glass transition temperature of the polymer above 345, thermal decomposition temperature reaches 560, modulus is 3.5 times of steel, but density is one fifth of it, fracture strength is also far higher than other materials; at the same time, the polymer has light weight, strong impact resistance, high temperature resistance, corrosion resistance, flame retardant. It is characterized by small expansion coefficient and high toughness. Three-dimensional textile fabric composites made of aromatic nylon have the advantages of high strength and good impact resistance, and are widely used in sports protection tools, such as protective clothing, protective gloves, leg guards, knee guards and so on. The rope made of aromatic nylon is widely used in water skiing rope, parachute rope, parachute and climbing rope, etc. The main application is the high strength of aromatic nylon, super toughening nylon by EPDM toughened PA66, a kind of elastomer from 0.1 to 1.0 micron diameter uniformly distributed in the PA66 matrix, composed of dispersed two-phase structure. Its impact strength reaches 900 J/m~1 020 J/m, which is more than ten times that of PA66. At the same time, it retains the chemical resistance, flexibility and wear resistance of nylon itself. It is also widely used in sports protection tools. Besides high strength, not easy to creep and wear resistance, the protective tools made of flexible elastomer are comfortable to wear. The utility model has the advantages of light weight, good air permeability and shockproof function.

2.3. Unsaturated polyester composites
In the early 1940s, J.R. Whenfield and J.T. Dikeon of the United Kingdom consulted Dupont's paper on the synthesis of polyester from aliphatic dicarboxylic acid and glycol. Using terephthalic acid and glycol as raw materials, polyethylene terephthalate was successfully synthesized in the laboratory and polyester fibers were prepared. In 1946, it published the world's first patent for producing polyester fibers. Unsaturated polyester resin is a kind of polyester polymer with unsaturated bonds (such as double bonds) on the molecular chain. The linear polyester is prepared by esterification reaction of dibasic acid and diol, and then is dissolved in a certain amount of cross-linked monomer (such as styrene) for cross-linking and solidification. The somatotype unsaturated polyester is a thermostetting resin. Unsaturated polyester casting products can be used in a variety of sports equipment, including tennis rackets, parallel bars, horizontal bars, jumping board, rowing, props, fishing poles, bowling and so on.
2.4. Carbon fiber composites
Carbon fiber is a kind of special fiber mainly composed of carbon elements. Its carbon content varies with different types, generally more than 90%. Carbon fiber has the characteristics of common carbon materials, such as high temperature resistance, friction resistance, electrical conductivity, heat conduction and corrosion resistance, but different from ordinary carbon materials, its shape has significant anisotropy, soft, can be processed into various fabrics, along the direction of fiber axis shows high strength. Carbon fiber has a small specific gravity and therefore has a high specific strength. Now the F1 (world class one equation Championship) racing car, most of the body structure is made of carbon fiber material. One of the top selling points of top sports cars is the use of carbon fibers all over the body to improve aerodynamic and structural strength. Today's fourth generation of struts are mainly made of carbon fiber composites, which can ensure that the struts are flexible and strong without breaking and twisting, greatly improving the performance of athletes. Carbon fiber composites with high damping properties are also widely used in golf clubs, reducing dead weight by 10% ~ 40%, which can prolong the batting time and further hit the ball. Large tennis rackets need to be made of lightweight, high specific strength and large specific modulus carbon fiber composites, so that tennis can get a greater initial speed. Many parts of bicycle, such as frame, crankshaft and seat bracket, are made of carbon fiber composites, which give the bicycle body good rigidity and shock absorption performance.

2.5. Epoxy resin composites
Epoxy resin is a kind of important thermosetting resin which contains two or more epoxy groups in the molecular structure and can cross-link into three-dimensional reticulated cured structure under the action of appropriate reagents. More than 90% are bisphenol an epoxy resin, which is the product of condensation of bisphenol A and epichlorohydrin. Aliphatic hydroxyl groups, ether bonds and epoxy groups exist in the molecular structure of epoxy resins. These polar groups interact strongly with the polar surfaces of metals and silicates. In particular, epoxy groups can form chemical bonds with the surface of materials containing active hydrogen. At the same time, the presence of ether bonds makes the molecular chain of the resins flexible. It is good for diffusion in the surface layer of materials. Therefore, epoxy resin has strong adhesion and is called "all-purpose adhesive". Epoxy runway can improve the strength of the athletes to kick the ground, speed up the pace and stride frequency, thereby improving the performance of athletes. Epoxy resin coatings for indoor venues laying, with good flexibility, elasticity and cushioning, to a certain extent, can slow down the ground on the athletes' ankles, knees and other parts of the impact, greatly protecting the athletes' body, and the material also has a certain degree of silence, reducing the noise in the competition process. Interference.

3. Conclusion
There is still a big gap between China's R & D and utilization of new materials and developed countries in Europe and the United States. With the development of science and technology, new materials will be recognized and accepted by more people, and the price will also be reduced. At the same time, the application of new materials in sports equipment will be more common. Therefore, while developing competitive sports, the state must attach great importance to the development, modification and utilization of new high-tech materials, so as to achieve faster and better development of sports. With the increasing demand for individualization, the future sports equipment will develop to the direction of personalization and intelligence. At the same time, people will pay more and more attention to the environment-friendly and biodegradable sports equipment with new materials.
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