Study on the Application of Graphene Polymer Material in Sports Equipment

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Abstract: With the continuous development of science and the level of modern sports, scientists and sports workers all over the world have realized the importance of the application of new materials in sports equipment. Through the analysis of graphene rubber and graphene fiber, we have found the function of graphene rubber and graphene fiber in some fields. These materials include graphene rubber composites, graphene fiber composites and graphene magnesium matrix composites which can be used in the field of sports equipment. So we should further explore the application prospect of graphene polymer materials in sports equipment. By using the methods of literature, comparison and qualitative analysis, this paper takes the graphene rubber composite polymer material and the graphene fiber composite polymer material as the research object, and applies the graphene technology to the sports equipment such as shoes, rackets, bicycles, etc. The analysis of existing graphene technology can theoretically explore the application of graphene technology in sports equipment, realize the organic combination of graphene field and sports field at the theoretical level, and promote the application of graphene technology in sports field.

1. Introduction
Graphene is a kind of two-dimensional carbon nano material, which is composed of carbon atoms with SP² hybrid orbital and hexagonal honeycomb lattice. That is to say, graphene is a two-dimensional planar crystal structure composed of only carbon atoms, so the thickness of graphene is very thin, only one layer of carbon protons [1]. Andre Heim and Konstantin Novoselov, Nobel Laureates in physics in 2010, have isolated graphene from graphite and have successfully proved that graphene can exist alone. Since the first discovery of graphene in 2004, graphene and its application in various fields of materials have been a hot topic in the field of polymer materials. Graphene and its derivatives have many properties that other materials do not have [2]. For example, graphene is light, solid and tough. Graphene is the thinnest, the strongest and the best in conductivity and thermal conductivity among many nano materials, so it is called "black gold" by scientists. Graphene has excellent optical, electrical and mechanical properties, and has an important application prospect in materials, micro nano processing, energy, biology, medicine and sports engineering. It is considered as a revolutionary material in the future [3].

Competitive sports inseparable from high technology. We can say that in all fields of competitive sports, from the selection and training of athletes to the completion of the competition can't do without the support of high technology. Electronic timers, high-tech swimsuits, stadium buildings, blood lactate, stimulant detectors and so on in competitive sports almost contain all fields of high-tech such...
as electronic science, material science, architecture, biochemistry and so on. That is to say, there are a lot of contents closely related to advanced science and technology in competitive sports, which need to be developed urgently [4]. The development of science and technology will bring convenience to sports, and promote sports of all countries to develop better in the direction of science and technology and green. Based on the application of graphene polymer in sports equipment, this paper studies the application scope, content, application mode and application prospect of graphene polymer in sports equipment from theory and practice, in order to pave the way for the application of material science in sports in the future [5].

Sports equipment is an indispensable material condition for sports activities. Sports equipment general bag include supplies, appliances, instruments, equipment, etc. It necessary for sports activities. In terms of mass sports and school sports, the quality of sports equipment is directly related to the quality of sports activities. In competitive sports, advanced sports equipment will directly affect the effect of sports competition. In sports, the existence of sports equipment is indispensable. Sports equipment can ensure the safety of athletes, improve competitive performance and ensure fair competition [6]. The goal of the development of sports equipment is to ensure the fairness, improve the performance of athletes and reduce the risk of injury. To ensure the safety of athletes requires sports equipment to have higher strength and anti-fatigue. In order to improve sports performance, sports equipment should conform to the rules of improving sports performance of its applicable items, such as sprinting items requiring lighter weight of sprinting shoes, tennis items requiring better shock absorption performance of tennis racket and lighter weight of tennis racket [7].

In order to ensure the fairness of the competition, sports equipment must also meet the requirements of the applicable items. Nowadays, with the development of sports more and more dependent on science and technology, graphene material as a new field of science and technology, has a broad application space in the field of sports [8]. Based on this point, I decided to explore the application of graphene technology in sports equipment, theoretically explore the application scope, application mode and application feasibility of graphene technology in sports field, so as to pave the way for future practical application [9].

The main research object of this paper is that the sports equipment field and graphene technology are more closely applied items: tennis, bicycle, badminton, golf, basketball, sportswear, sports shoes and other equipment. Graphene technology refers to the technology of graphene materials, mainly including graphene, graphene natural rubber composite (GNR) [10], graphene styrene butadiene rubber composite (GSBR) [11], graphene butyl rubber composite (GIIR) [12], graphene fluororubber composite (gfkm), graphene nylon fiber composite, graphene carbon fiber composite and graphene magnesium base compound material. This paper studies the application of graphene technology in sports equipment in theory, mainly on the way of application value and feasibility. Taking sports equipment as the starting point, with the help of the existing experimental results at home and abroad, through the analysis of the existing graphene technology, to find its application scope, application method and application value in sports equipment, and discuss the feasibility of application [13].

The main research contents are: the application of graphene technology in sports clothing, basketball, tennis, badminton, golf and cycling. The research scope of this paper is limited to the material technology of graphene technology, the research of material characteristics and application research, only through the characteristics of materials to find the corresponding application scope and application value, and discuss the feasibility, does not involve the deep-seated physical principles, chemical principles and biological principles of research [14].

2. Manufacturing and application of graphene polymer

2.1. Graphene rubber

Rubber is an important material, which is indispensable and irreplaceable in the national economy and high technology. It has the characteristics of reversibility and high elasticity. It can produce large deformation under the action of external force, and can recover quickly after removing the external
force. It has been widely used in many fields. In recent years, the traditional rubber industry has been difficult to meet the high-tech industry, transportation, aerospace and other high-performance requirements. Nano fillers and rubber composites manufacturing nano fillers have become an effective way to obtain high-performance rubber compounds, which also led to the development of graphene rubber [15]. At present, graphene rubber can be divided into two kinds: general rubber material and special rubber material.

Table 1. Main properties of graphene general rubber materials

| Graphene general rubber | Main characteristics 1 | Main characteristics 2 | Main characteristics 3 |
|------------------------|-----------------------|-----------------------|-----------------------|
| GNR                    | High conductivity     | Mechanical            | Lower fatigue heat generation |
| GSBR                   | Low heat generation, high wear resistance | High thermal stability | Gas barrier |
| GIIR                   | Mechanical            | Gas barrier            |           |
| GEPDM                  | Mechanical            | Electrical property   |           |
| GNBR                   | Insulation            | Tribological properties | Wear resistance |
| GXNBR                  | High dielectric constant | Mechanical             |           |

2.2. Graphene fiber

In recent years, the successful synthesis of graphene fiber and its important role in some special applications have aroused people's interest. One dimensional graphene fiber is not only a supplement to two-dimensional film and three-dimensional graphene block, but also plays a very important role in the development of textile functional materials and devices. Zheng Bingna and others used graphene carbon nanotube composite fiber wet spinning [16]. The composite fiber not only has good mechanical properties (377mpa), but also can be used to manufacture super capacitor (32.6m / F · cm - 2). Li Yali's team used CVD method to make graphene and carbon nanotube composite, and extracted the ribbon material, and obtained graphene carbon nanotube composite fiber through torsion, with tensile strength of 300mpa. By combining graphene with carbon nanotubes and reinforced polyvinyl alcohol fibers, Kim's team found that graphene and carbon nanotubes can synergistically strengthen polymer fibers, and the composite fiber has good toughness. Graphene like shell fiber has better tensile strength and toughness than shell and pure graphene fiber, and has the characteristics of conductivity and chemical resistance, which can be widely used in many fields [17].

3. The application of graphene polymer in the field of sports equipment

3.1. Gym shoes

In theory, the components of shoes (such as insole, midsole and outsole) can improve the jumping ability of athletes and reduce leg fatigue. The cushioning parts made of soft and high energy feedback materials can get the maximum feedback value after being compressed by human feet. It prevents foot injuries and makes athletes and other wearers comfortable. The insole or midsole of the new basketball shoes is laminated, which includes two layers of supporting materials (top layer and bottom layer). The top layer is covered by 1,4-polybutadiene rubber or semi-rigid material, acting as an additional layer or covering layer. Each layer can be about 80% cis-1,4-polybutadiene rubber and about 20% natural rubber, and it is about 7.9MM thick 1,4-polybutadiene rubber layer, which is separated by covering layer. The liner is more suitable for inserting into the EVA / graphene natural rubber composite insole. Because the rubber material used in vamp is less, it will not be described here. The rubber material formula of the new basketball shoes is as shown in table2. Other materials can also be
used in shoe parts to provide additional functions. These extra materials do not reduce the amount of energy returned [18].

3.2. Clubs and rackets
With the continuous improvement of living standards in China, golf has gradually entered the country and become popular. The steel bars of 1930s are American standard golf clubs. The steel bars developed in 1942 (true temper's dynamic steel shaft) are still on the market. Carbon fiber golf clubs appeared in 1972, and the share of carbon fiber golf clubs was still small in 1986. Until 1998, 80% of golf tee clubs were made of carbon fiber, and only 20% of golf tee clubs were made of steel. The golf club consists of a handle, a club and a club head. The weight of the golf club made of carbon fiber composite material can be reduced by about 10% - 40%. According to the law of conservation of momentum, the reduction of the total weight of the club is also convenient to improve the swing speed of the club, so that the ball can get a larger initial speed; in addition, carbon fiber composite materials have high damping characteristics, which can make the hitting time longer, the ball is hit further, so that the better kick-off effect can be achieved. Carbon fiber golf clubs are made of different specifications of carbon fiber [19]. For example, the carbon fibers used by aldira include the standard modulus, medium modulus and high modulus carbon fibers of large tow (45k) and small tow (12-24k). There are three kinds of mature carbon fiber golf clubs: filament winding, blade assisted molding and pre rolling.

In order to make the racket get more hitting power, the first principle is to use "racket string" (commonly known as "net wire"). In addition, the rigidity, length and size of the racket also affect the strength of the racket. The greater the hardness of the frame, the longer the racket length, the larger the area of the tennis racket surface, and the greater the strength of the racket. The main influencing factors of tennis racket control are racket frame weight, torsional stability, racket head size, etc. the smaller the weight of racket, the smaller the area of racket head and the higher the torsional resistance of frame material, the better the control of racket; the larger the weight of racket, the larger the area of racket head, the worse the torsional stability of frame material, the worse the control of racket. In order to improve the comfort of tennis racket, it is mainly considered to increase the area of sweet zone, improve the torsion resistance of racket frame, improve the vibration absorption performance of racket frame material and change the weight of racket string. Compared with the common carbon fiber, the graphene carbon fiber composite is the graphite dispersed in the epoxy resin, which has higher strength and higher elastic modulus than the common fiber. It can greatly improve the rigidity of the racket and the strength of the tennis racket. The density of graphene carbon fiber composite is generally smaller than that of aluminum, its strength is comparable to that of steel, its elastic modulus is higher than that of aluminum alloy, and its fatigue strength is higher. It has higher strength and higher elastic modulus under the same weight, so it has the advantage of designing and manufacturing tennis racket more than ordinary carbon fiber material.

4. The prospect of graphene polymer materials in the field of sports equipment
Graphene carbon fiber composite and glass fiber composite can also be made into high jump crossbars, which will not produce bending deformation, nor easy to break, more accurate and safe. Adding graphene carbon fiber composite to the sole of running shoes can further reduce the weight of the sole. The bow arm made of carbon fiber reinforced composite is not only light in weight, but also has high bending strength and modulus, which can bear the greater bending stress imposed by athletes. Graphene carbon fiber composites can also be used to make bows and arrows, and higher bending strength and modulus can be obtained. Graphene carbon fiber composite can also be used to make arrow shaft. In the past, arrows were mostly made of bamboo, fiberglass, aluminum alloy, etc., but because of their low specific modulus and specific strength, it is not easy to make light, thin, rigid and small bending deflection arrows. Therefore, in order to improve the initial speed and hit rate of arrows, it is advisable to use graphene carbon fiber composite to make high-performance arrows [20].
Graphene carbon fiber composite materials can also be used in yachts, rowing and other ships as follows: ship hull (mostly used for paste or patching reinforcement) gangway, mast, paddle, communication room shielding materials. These parts are not only light in weight, but also improve the performance. The addition of graphene antirust coating on the hull can also increase the antirust performance of the hull, protect the hull from the erosion of sea water, and enhance the safety and performance of the sailboat.

| Table 2. Typical events of application of graphene technology in sports |
|-------------------------------------------------|
| **Category** | **Project** | **Equipment** | **Application prospect** |
| Wearable | Ice and snow | Ski suit and shoes | Heat, ventilation and warmth |
| Go fishing | Fishing rod | Excellent bending strength |
| Competition | Bicycle | mountain biking | More stable, high-speed controllability and comfort |
| Rock Climbing | Climbing rope | Lighter, harder, more flexible |
| Detection | Drift | Hull, rowing | Can withstand greater impact and protect athletes |
| Outdoor adventure | Expanding appliance | Real time monitoring effect |

5. Conclusions
This paper aims to analyze the application of graphene polymer in sports equipment and the conclusions are as follows: 1) We discussed the application of graphene rubber composite in the field of sports equipment. 2) The theoretical assumption of the application of graphene rubber composite material and graphene fiber composite material in sports events is elaborated in detail. 3) It is found that with the development of graphene rubber composites and graphene technology can be extended to sports equipment.

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