Frontier Analysis of the Application of New Materials in Competitive Sportswear

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Abstract. Under the social background of national fitness, the sportswear industry has also developed rapidly. In order to improve the performance of sportswear, people have developed a series of new materials. Today, with the rapid development of textile materials, the use of high-tech materials can increase the added value of competitive sportswear. This paper briefly describes the new sports technical materials currently on the market, and classifies them according to design requirements, and discusses the application prospects of new materials in competitive sportswear. This paper proposes an intelligent phase change temperature control material; it is a new type of functional material, it is a product that combines phase change materials and textile weaving technology, it has two-way temperature regulation function, and this paper explores the application of this material competitive sportswear.

Keywords: New materials, sportswear, application.

1. Introduction
There are three basic states of matter in nature: solid, liquid, and gas, under certain temperature conditions, these three states can be transformed into each other, this transformation process is called phase change. The physical phenomena of endothermic and exothermic occur in matter during the phase change of the three states, and change the phase or state by absorbing, storing and releasing energy, this kind of material is called phase change material. Combining phase change material technology with textile weaving technology can develop an intelligent phase change temperature-control textile, which has a two-way temperature regulation function after being made into clothing. At present, phase-change temperature-control textiles have become a research hotspot of textile functional products at home and abroad, but the application research in the field of sportswear is still rare. According to the characteristics of heat emission and temperature changes during human exercise, this material will have greater application value in the field of sportswear.

2. The Important Influence of Materials on Competitive Sportswear
Material is the most basic element of thermal and humid functional design in competitive sportswear, which is a platform to realize clothing technology and beauty; designers can achieve various functional requirements through materials. Generally speaking, the materials are divided into woven materials, knitted materials and non-woven materials; the fiber composition of the materials determines the
properties and functions of competitive sportswear. Knitted materials have more elasticity than woven materials, so they have advantages in the design of competitive sportswear, they can realize the thermal and moisture functional design of various parts of the body according to the physiological needs of the human body, such as moisture permeability and ventilation. Woven materials have obvious advantages in coating treatment than knitted materials, they can be treated in wind, water, and wear resistance according to the needs of specific sports, and therefore, they are more used in the design of protective clothing, jackets and so on.

The heat and moisture transfer performance has an important influence on the wearing comfort of textiles and clothing. When the human body is exercising, the surface of the skin will experience a cycle of drying → sweating → evaporation → drying, and the material will correspondingly undergo a cycle of drying → moisture absorption → moisture release → drying. The physiological experiments of athletes show that sweat in clothing with strong hygroscopicity in high temperature environment is more difficult to evaporate, namely it hinders sweat evaporation and heat dissipation, and therefore, we should consider choosing hydrophobic fiber fabric in high temperature environment. Table.1 lists the main materials currently used in competitive sportswear.

| material           | characteristic                                                                 | impact on sports                                      |
|--------------------|--------------------------------------------------------------------------------|-------------------------------------------------------|
| CoolMax fiber      | good moisture conductivity, the sweat produced by human activities can be quickly discharged to the material surface to evaporate in the shortest time | good breathability and comfort strong perspiring function |
| Lycra fiber        | elastic fiber, 4-7 times extensibility and resilience sportswear can reduce the resistance generated by clothing | improve the permeability of sportswear reduce the fatigue of athletes' muscles |
| Gore-tex waterproof| adhere to the surface of polyester fabric, durable                            | provide protection in windy, low temperature environments effectively improve athletes' endurance and sports performance |
| Clima TechFit material | reduce oxygen consumption and muscle energy output                      | delay the fatigue of the body                                  |
| Sphere React Dry material | combine unique three-dimensional woven structure and functional fabric | keep human skin dry reduce the discomfort caused by sweat and moisture provide more space to speed up the evaporation process and effectively reduce the body temperature |

3. The Action Mechanism of Intelligent Phase Change Temperature-control Material

Taking advantage of the material phase change characteristics, phase change materials that adapt to changes in human body temperature during the preparation of textiles are introduced, and give textiles the function of absorbing or releasing heat at a set temperature. When the body surface temperature rises, the phase change material in the textile changes from solid to liquid, absorbs heat, thereby reducing the body surface temperature; on the contrary, when the body surface temperature decreases, the phase change material in the textile changes from liquid to solid, releases heat, thereby increasing the body surface temperature and keeping the body temperature within a comfortable range.

The temperature-control mechanism of intelligent phase change thermoregulation textiles is different from traditional thermal insulation clothing: traditional clothing mainly uses the principle of extremely low air thermal conductivity and uses the method of increasing the amount of still air inside the fabric
to isolate heat conduction, the thermal insulation effect mainly depends on the density and thickness of the fabric; while the smart phase-change temperature-control textile uses the heat absorbed or released by the phase-change material during the phase-change process to keep the temperature constant, which is a kind of thermal regulation. This is reflected in the fact that when the internal and external environmental temperature changes suddenly, the textile can keep the human body temperature basically constant for a certain period of time, thereby preventing heat stress. Applying this feature of intelligent phase-change temperature-control textiles to the field of sportswear can prevent athletes from injuries caused by heat peak after exercise.

4. Characteristics of Material in Intelligent Phase-Change Temperature-control Sportswear

There are many kinds of phase change materials, mainly including inorganic phase change materials, organic phase change materials and composite phase change materials. The temperature change range of phase change materials is relatively wide, but because the human body surface and the ambient temperature have a relatively stable range, coupled with the special requirements of clothing textile processing and application, the selection range of phase change materials for sports is reduced. Therefore, the materials of intelligent phase-change temperature-control sportswear should have the following characteristics:

4.1. Suitable phase transition temperature.
The phase change materials used in competitive sportswear should be selected according to the season and climate of the sports, the environmental temperature and the specific application. The competitive sportswear used in severe cold climates should select materials whose phase change temperature is between 18.33°C and 29.44°C; the competitive sportswear used in warm climates should select materials whose phase change temperature is between 26.67°C and 37.78°C; the competitive sportswear used in hot areas or under large amount of exercise, should select materials whose phase change temperature is between 32.22°C and 33°C.

4.2. Strong heat storage capacity.
The selected phase change material should not only have a large phase change latent heat, but also have a large amount of heat stored in unit mass and unit volume of the material.

4.3. The volume and hardness of the material change little when it changes phase
If the volume and hardness of the phase change material increase during the phase change process, the physical properties of competitive sportswear will change, and it will affect the performance of athletes.

4.4. Fast heat conduction and good reversibility during phase change
The phase change material should have strong heat transfer ability; fast heat absorption and heat release, and must can melt and solidify well at a constant temperature.

4.5. Safe and reliable.
The selected phase change material sometimes comes into direct contact with the skin of the human body, so its chemical properties must be stable and non-toxic and harmless to the human body.

4.6. Strong reusability.
Sportswear is generally worn and used many times and must be resistant to washing.
5. Preparation Methods of Intelligent Phase Change Temperature-control Sportswear

At present, there are mainly two methods for preparing intelligent phase-change temperature-control sportswear: fiber spinning method and coating method.

5.1. Fiber spinning methods

Fiber spinning methods are mainly divided into microcapsule spinning method, composite spinning method and hollow fiber filling method. It should be noted that the phase change material is added when the fiber spinning method is used, which results in the low strength of the spun fiber, it is difficult to spin and weave directly, and so the blending process with other fibers is usually used.

5.1.1. "Microcapsule spinning technology. Microcapsule spinning is one of the most advanced methods for processing phase change fibers. Adding microcapsules containing phase change substances with 1 to 5 μm diameter into the solution spinning of polyacrylonitrile fibers (Fig.1), we can obtain phase change fibers with significantly improved heat storage capacity. The Outlast Technology Company uses the patent of microcapsule technology to develop heat storage and temperature control textiles that meet the requirements for the production of knitted fabrics and woven fabrics, its fiber linear density can reach as low as 2.2 dtex.

![Fig.1 Microcapsules containing outlast technology coated on the fabric surface](image)

5.1.2. Composite spinning technology. The composite spinning method is to extrude the high polymer spinning solution containing the phase change material through the spinneret plate, obtain the composite fiber with the parallel structure, the phase change material is directly embedded in the fiber, so that the fiber can absorb and release heat. The Outlast Company used composite spinning technology to prepare phase-change temperature-control polyacrylonitrile fibers, its linear densities reaches 2.2, 3.3 and 5.0 dtex.

5.1.3. Hollow fiber filling technology. Before fiber weaving, in order to prevent the phase change material from leaking and reduce the temperature control effect, the micro-phase change material is encapsulated and filled into the hollow part of the hollow fiber, and the fiber is covered with resin to achieve the purpose of long-lasting temperature control. Taking advantage of the melting and crystallization characteristics of the phase change salt at room temperature, the hollow part of the hollow fiber is filled with inorganic salt with crystal water to obtain phase change fiber with heat absorption and heat release function.
5.2. "Coating method"

The intelligent temperature-control microcapsule phase change material with 5μm particle diameter of (Fig.2) is mixed with deformer, adhesives to form a coating liquid, put it on the surface of fabric or non-woven fabric with thermal transfer coating technology, drying at a certain temperature can obtain fabrics with intelligent temperature control function (Fig.3).

![Scanning electron microscope photo of phase change material microcapsules](image1)

**Fig.2** Scanning electron microscope photo of phase change material microcapsules

![Scanning electron microscope photo of coated fabric](image2)

**Fig.3** Scanning electron microscope photo of coated fabric

6. Applications of Phase Change Temperature Control Materials in Competitive Sportswear

The exercise environment and body heat emission during exercise are different for different sports, so the requirements for clothing are also different. Winter sports require good thermal insulation, sportswear require clothing to have a certain thickness; summer sports require good cooling effects, thin clothing, and good moisture wicking effects. Therefore, it is very necessary to develop intelligent phase change temperature-control sportswear suitable for different sports. Moreover, it is necessary to strengthen the test and research on the heat storage and temperature control performance of phase change temperature control material, and determine the degree of temperature change and the durability of the phase change effect when the phase change material absorbs heat, and its influence on sports. This is one of the important foundations for expanding the application of smart phase change thermoregulation textiles for sports in more series of sportswear.
7. Conclusion
As a new type of material, intelligent phase change temperature control materials can absorb or release heat, and keep the temperature of the human body surface relatively constant, their application in the field of sportswear will help athletes exercise better and prevent injury to the human body caused by high or low temperature of competitive sportswear. Therefore, the author believes that it is very important to study the phase change materials used in the field of competitive sportswear and their preparation methods, which will provide references for the application of other new materials in competitive sportswear.

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