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Research Progress of New Aeronenenеba Gel Materials

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Abstract: Aeronenenеba gel is a porous material with three-dimensional network structure and is obtained after drying of wet gel. It is a solid with the smallest density and is composed of nanoparticles or polymer molecular chains. Its structure is three-dimensional nanostructure. It has many excellent characteristics, such as low density, high porosity, large pore volume and large specific surface area. Therefore, the material has excellent characteristics in light, heat, sound, electricity and mechanics. In recent years, scholars at home and abroad have conducted in-depth research on a variety of aeronenenеba gels and developed a variety of new and excellent aeronenenеba gel materials. The emergence of aeronenenеba gel materials has great potential in the preparation of thermal insulation materials, electrode materials and other fields. Aeronenenеba gel materials have been applied in many fields, especially in the fields of military aerospace, building thermal insulation materials, electrical parts materials and so on. This paper introduces the current methods of preparation and modification of aeronenenеba gel, as well as the application and development status of aeronenenеba gel materials in different fields, especially in the fields requiring excellent thermal protection properties, such as military, aerospace, etc. the future development and application of aeronenenebc gel materials will be more extensive.

Keywords: Aeronenenеba Gel Materials, Organic Aeronenenеba Gel, Oxide Aeronenenеba Gel, Carbon Aeronenenеba Gel

1. Introduction

Aeronenenеba gel is a new material with three-dimensional network structure. The density of aeronenenеba gel material is very small, only 3.55kg/m^3, which is the lowest among all solids. Therefore, some people call aeronenenеba gel material "solid smoke". This material not only has the functions of expansion and plasma separation, but also has a large specific surface area and good thermal insulation performance. The good thermal insulation performance determines that aeronenenеba gel material can be used as an excellent thermal insulation material, Therefore, aeronenenеba gel materials have been widely used in aerospace, fire safety, social life and other industries and fields in recent years [1].

The preparation of aeronenenеba gel materials mainly includes two stages, the first stage is wet gel preparation, and the second stage is wet gel drying. In the two processes of the preparation of aeronenenеba gel, the first step is to prepare wet gel. The sol-gel method is used to synthesize wet gel. The preparation process of wet gel is the first step of the synthesis of aeronenenеba gel. The whole process of preparing aeronenenеba gel is very critical. The network structure, porosity and other parameters of aeronenenеba gel are determined by this process. The second step is the drying of the wet gel. The gel prepared in the first step is dried to replace the liquid dispersion medium in the hydrogel with the gas state, and the aeronenenеba gel is finally prepared after specific treatment. There are many methods used in the drying. The most commonly used methods in the current research are supercritical drying, subcritical drying, freeze drying and atmospheric pressure drying.

2. Research Progress of New Aeronenenеba Gel Materials

At present, the research of aeronenenеba gel materials is extensive, and more and more kinds of aeronenenеba gel

have been developed. According to its composition, it can be roughly divided into oxide aeronenenеba gel, organic aeronenenеba gel, carbon or carbide aeronenenеba gel and other types (Figure 1).

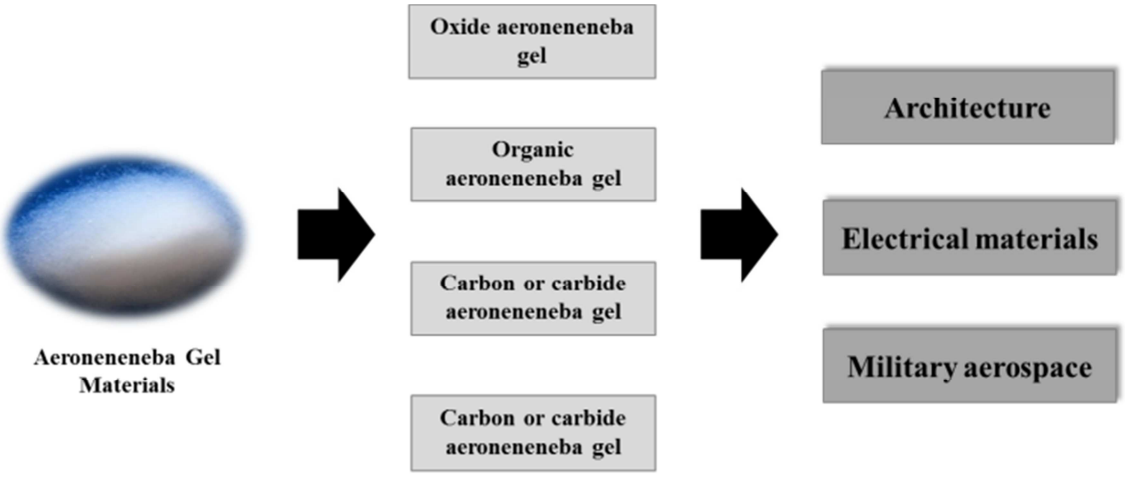

Figure 1. *Aeronenenеba gel materials and applications.*

2.1. Oxide Aeronenenеba Gel

The oxide aeronenenеba gel thermal insulation material has the characteristics of high temperature resistance and low thermal conductivity. The oxide aeronenenеba gel material can also be compounded with the high-temperature resistant oxide ceramic fiber to prepare a composite material with better performance. The prepared composite material has high strength and good processability. The composite material can be processed into large-size samples. Therefore, it is the most important type of aeronenenеba gel in aerospace thermal insulation applications at present, Among them, there are mainly SiO_2 aeronenenеba gel and two-component oxide aeronenenеba gel.

Silica (SiO_2) aeronenenеba gel has been gradually developed by scholars in the last century. Its structure is also nano porous, which is a super thermal insulation material with excellent thermal insulation effect. Because this aeronenenеba gel has the structural characteristics of large specific surface area, large porosity and low density, these structural characteristics make the material have many excellent properties, such as extremely low thermal conductivity and high adsorption and load capacity. Among many oxide aeronenenеba gels, SiO_2 aeronenenеba gel is the most widely studied and most mature aeronenenеba gel used in thermal insulation applications. In recent years, the research directions of SiO_2 aeronenenеba gel thermal insulation materials at home and abroad mainly focus on mechanical enhancement, suppression of high temperature radiation heat transfer and atmospheric drying.

Some studies [2] have successfully prepared glass fiber reinforced SiO_2 aeronenenеba gel by sol-gel method. The prepared aeronenenеba gel has low thermal conductivity, and its thermal conductivity is measured to be 26MW/(m·K). At the same time, it also increases the bending modulus of this aeronenenеba gel, reaching 1194MPa Yang et al. [3] prepared SiO_2 aeronenenеba gel with water glass as silicon source with lower cost. This study summarized and proved the influence of different preparation conditions on the length of reaction gel time. The average pore diameter and specific surface area of the samples prepared in this study are better. Industrial water glass is the conventional silicon source of SiO_2 aeronenenеba gel, which has been deeply studied. In addition to this silicon source, some industrial residues and production wastes can also be processed into water glass, such as wheat straw and fly ash. The application of these materials also increases the way of silicon source of aeronenenеba gel. Xia et al. [4] prepared SiO_2 aeronenenеba gel with porosity of about 90% and good pore volume and specific surface area by sol-gel method and vacuum freeze-drying method with straw ash as raw materials. Yi et al. [5] successfully prepared a nano fiber reinforced SiO_2 aeronenenеba gel through sol-gel method combined with ethanol supercritical drying technology. The addition of such nano fibers effectively increased the compression strength of the aeronenenеba gel, making the compression strength of the modified SiO_2 aeronenenеba gel more than 6Mpa. At the same time, the maximum allowable temperature of the aeronenenеba gel reached 1200°C. Chakraborty et al. [6] prepared tetraethoxysilane fiber reinforced SiO_2 aeronenenеba gel through gel, silylation and atmospheric pressure drying, which effectively improved the hydrophobicity of aeronenenеba gel. With the increase of the concentration of silylating agent, the thermal protection performance of the composite aeronenenеba gel was improved.

2.2. Organic Aeronenenеba Gel

Compared with traditional inorganic aerogels, organic aerogels are based on polymer molecular chains. In terms of characteristics, organic aerogels not only retain the advantages of inorganic aerogels such as low density, high porosity and low thermal conductivity, but also determine the performance of gel. Therefore, organic aerogels have flexible

molecular designability and performance adjustability. Phenolic resin has the characteristics of high residual carbon rate and heat resistance. After carbonization, the structure is compact and stable. It is often used as the precursor of carbon aeronenenеba gel [7]. During the ablation process of phenolic aeronenenеba gel, two substances are generated by thermal decomposition, i.e. pyrolysis gas and pyrolysis carbon. The heat will be dissipated in the boundary layer. The heat dissipation is caused by the thermal blocking effect and mass ejection effect. The thermal conductivity of phenolic aeronenenеba gel and its pyrolysis carbon aeronenenеba gel is low, the thermal insulation effect lasts for a long time, the preparation time of phenolic aeronenenеba gel is short, the process is simple, the raw materials are widely sourced, and the cost is low. Therefore, Phenolic aeronenenеba gel has great application potential in many high-temperature thermal insulation and heat protection fields. In the past decade, the research on phenolic aeronenenеba gel thermal insulation materials has mainly focused on improving its anti-ablation performance, thermal insulation performance and mechanical properties under high temperature and aerobic environment [8]. In terms of improving the thermal insulation performance of phenolic aeronenenеba gel, by adjusting the microstructure of phenolic aeronenenеba gel, its thermal conductivity at normal temperature can be effectively reduced, and phenolic aeronenenеba gel with different thermal insulation properties can be obtained [9], Phenolic aeronenenеba gel can also be compounded with inorganic aeronenenеba gel (such as SiO_2 aeronenenеba gel, Al_2O_3 aeronenenеba gel, etc.), and the thermal insulation performance of the material can be improved by using the nano porous structure and intrinsic low thermal conductivity of inorganic aeronenenеba gel [10].

Polyimide (PI) is a kind of high-performance resin. Its aromatic heterocyclic structure makes it have good thermal stability and mechanical properties, and can resist high temperature and Corrosion [11]. Polyimide aeronenenеba gel has the advantages of low density and low thermal conductivity, and has a broad application prospect in aerospace field. In the past decade, the research on polyimide aeronenenеba gel thermal insulation materials mainly focused on inhibiting shrinkage, improving temperature resistance, and polyimide aeronenenеba gel fibrosis. Although polyimide aeronenenеba gel can be used at higher temperatures, its high temperature resistance still needs to be improved when it is used as an organic aeronenenеba gel in the aerospace field [12]. A sol-gel confined transformation method was proposed by the Suzhou Institute of nano science, Chinese Academy of Sciences to prepare polyimide aeronenenеba gel fibers with high specific surface area (364 m^2/g), excellent mechanical properties and super hydrophobic structure, which solved the fibrotic problem of polyimide aeronenenеba gel [13].

2.3. Carbon or Carbide Aeronenenеba Gel

Carbon and carbides have very stable chemical properties and are substances with high melting point. By making use of their high-temperature resistance characteristics, they can be made into aeronenenеba gel structure, and can be used to prepare ultra-high temperature resistant aeronenenеba gel thermal insulation materials. Therefore, they are applied in military equipment, aerospace and other high-temperature fields. Carbon aeronenenеba gel not only has most of the advantages of traditional aeronenenеba gel, but also has excellent characteristics such as mesoporous structure, high infrared extinction coefficient, acid and alkali resistance and degradability, which can withstand 2800°C ultra-high temperature in inert atmosphere. When applied to the ultra-high temperature thermal protection parts of new high-speed aircraft, carbon aeronenenеba gel shows more excellent performance and greater application value.

In the past decade, the research focus of carbon aerogel thermal insulation materials mainly focuses on the improvement of mechanical properties, process simplification and low-cost preparation, oxidation resistance, ablation resistance and ultra light and ultra elastic.

In terms of simplification of carbon aeronenenеba gel process and low-cost preparation, long-term solvent replacement and complex and high-cost supercritical drying process have always restricted its industrial application. Research shows that proper network strength, increased particle size/macroporous network and low surface tension are of great significance to reduce pore structure collapse and shrinkage during atmospheric drying [14].

Carbide aeronenenеba gel is a new type of aeronenenеba gel developed in recent years, which has attracted the attention of many experts and gradually developed. Carbide aeronenenеba gel has many excellent properties, such as corrosion resistance, high hardness, high melting point, and stable mechanical properties. Carbon aeronenenеba gel and organic aeronenenеba gel insulation materials will be partially oxidized at high temperature. Compared with these two aerogels, the high-temperature oxidation resistance of carbide aeronenenеba gel is more remarkable [15]. The intrinsic thermal conductivity of carbides is high, and the high porosity and three-dimensional network structure can greatly reduce its thermal conductivity. Nano thermal insulation materials are prepared for high-efficiency thermal insulation. SiC aeronenenеba gel has stable chemical properties and is a potential high-temperature thermal insulation material. It not only has small thermal expansion coefficient, high specific extinction coefficient and good thermal shock resistance, but also can withstand high temperature above 1000°C in the air. It also shows excellent performance in the environment with strong corrosion, strong thermal shock and serious electromagnetic interference. Therefore, it is suitable for a variety of harsh environments [16].

3. Application of New Aeronenenеba Gel Materials

3.1. Architecture

Since the thermal conductivity of aeronenenеba gel is very

low, aeroneneneba gel materials are very suitable for making thermal and cold insulation materials. In addition, the density of aeroneneneba gel materials is small and the thickness of the materials is low, which also has a good advantage in space saving.

In the construction stage of the construction industry, many resources are consumed. In such a high-energy consumption industry, the advantages of aeroneneneba gel materials are very obvious. High temperature resistant aeroneneneba gel has excellent performance, which not only has the advantage of low thermal conductivity, but also has low density. It has great potential in the application of insulation materials in the construction industry. For the application of aeroneneneba gel particles in the construction industry, they are usually used to add them, which can better play the thermal insulation effect of aeroneneneba gel materials. Sometimes they are mixed with a variety of different materials. Generally, the diameter of aeroneneneba gel particles is 0.5-5.0 mm, with a small density. When used in construction projects, aeroneneneba gel particles can be mixed with traditional inorganic materials used in buildings. The building materials prepared by mixing aeroneneneba gel have better thermal insulation performance. This method can prepare more effective thermal insulation mortar [17]. At present, most of the insulation materials used in the construction industry is mainly EPS and other kinds of felt materials. The comprehensive performance of these conventional materials is deviated, the thermal insulation performance is uneven, the thermal insulation effect is not good enough, and the service life is short [18]. As an essential material in the construction industry, thermal insulation materials must have better performance. After the use of aeroneneneba gel thermal insulation materials, the disadvantages of traditional thermal insulation materials are compensated. Under the excellent performance of greatly reducing the loss of building heat energy, the thermal insulation layer also has a certain fire-retardant performance.

3.2. Electrical Materials

Super capacitor is a new type of energy storage element [19]. It has the technical characteristics of high energy density, fast charging speed, wide temperature range and long service life [20]. It has great application potential in military equipment. The application research on radar, armored vehicles and other military equipment has great significance. It also has great potential in some pulse laser weapons and military countermeasure systems. At present, there are many kinds of materials used to make supercapacitor electrodes. Usually, some materials with good performance and moderate cost are used, such as metal oxides and some polymers with conductive properties [21]. The appearance of aeroneneneba gel materials provides a material with better performance for the fabrication of electrodes. Among them, carbon aeroneneneba gel has great advantages as an electrode material. Compared with these commonly used materials, carbon aeroneneneba gel has three more excellent characteristics: (1) high electrochemical stability and conductivity; (2) The pore size is adjustable. The pore size of carbon aeroneneneba gel can be controlled by different reaction conditions in the preparation process, such as different catalyst concentration and reactant concentration. The pore size of the prepared aeroneneneba gel materials is also different. The pore size of different sizes has different effects on enhancing or weakening ion transport velocity; (3) The specific surface area is large, and a larger specific surface area increases its reactive active site.

3.3. Military Aerospace

When the aerospace vehicle is running at a high speed, the body shell of the aircraft is subject to the friction of huge air resistance under the condition of high-speed flight. The friction will cause the temperature of the body surface to rise rapidly, and the internal working elements of the aircraft will be damaged if it is in a high temperature state for a long time, thus reducing the service life of the components, and the high temperature will greatly increase the risk of spontaneous combustion of the aircraft. In this case, it is necessary to ensure the safety of the aircraft, High temperature resistant materials with outstanding thermal insulation performance are very important. The thermal insulation materials block the heat transfer from the surface of the body to the inside of the body, thus protecting the components inside the body. In addition to its excellent thermal insulation effect and low density, aeroneneneba gel is also very suitable for aircraft materials, which is of great significance in reducing aircraft load, reducing fuel consumption and extending flight distance [22]. NASA has developed a carbon aeroneneneba gel sandwich material for aerospace thermal protection application. The carbon material in this material is carbon fiber reinforced resin based material, which mainly acts as an ablation component, the oxide aeroneneneba gel material acts as a thermal insulation component, and the good mechanical properties of carbon material can avoid the shedding and deformation of the oxide aeroneneneba gel material during the thermal scouring process. Phenolic aeroneneneba gel thermal insulation material has been widely used in aerospace field due to its advantages of low density, low thermal conductivity, low cost and short preparation cycle. It is applicable to the outer surface of high-speed aircraft with high heat flux density, such as DMC, DMS and ZMS series anti insulation integrated composite materials developed by aerospace materials and Technology Research Institute [23].

4. Conclusion

This paper introduces the current development of new aeroneneneba gel materials, mainly from the aspects of microstructure, preparation methods, classification, and basic properties of different aeroneneneba gel materials. It also summarizes and introduces the development of different kinds of new aeroneneneba gel materials and the applications of various aeroneneneba gels in different fields. The particularity of the structure and excellent physical properties of aeroneneneba gel materials make it widely used in

building materials, aerospace, power components and energy storage, chemical industry, environmental protection and other fields. Among the many aeroneneneba gel materials, oxide aeroneneneba gel has been in existence for a long time, and its research technology is relatively mature. It has wide application value in the fields of heat insulation, adsorption and photocatalysis. In the future, with the in-depth research in all aspects, the preparation technology and drying technology of carbon and carbide aerogel will also make great progress. Meanwhile, the research on new carbon source channels will also increase the carbon source channels and make the carbon source cheaper. This is of great significance to the reduction of the production cost of carbon aerogel, the continuous expansion of the production scale and the acceleration of the production cycle. It will attract more scholars and experts in different fields to study it, Multi domain and multi-channel application development. At the same time, carbon aeroneneneba gel will be more fully applied in the military, more in-depth and extensive research is also gradually increasing, and new aeroneneneba gel materials with better performance and lower cost are also gradually developing, striving to add bricks and tiles to China's national defense cause.

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