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# Study on $SiO_2$ Aerogels/Inorganic Fiber Insulation Packaging Composite Material

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**Abstract:** This article analyze the characteristics of prepared aerogel insulation composites material, then thermal performance of composite aerogels, aerogel insulation the performance of composite materials by SEM and other test, it has a certain significance about thermal insulation composite aerogels in packaging applications.

**Key words:** Aerogels, fiber, insulation, packaging composite material, transportation

## INTRODUCTION

In recent years, the preparation of silica aerogels has made great progress (Schwarz, 2003; Dorcheh and Abbasi, 2008; Fesmire, 2006; Akimov, 2003; Qin and Men, 2005). Review process, performance and application of many articles (Holman, 1986; Kreith, 1973; ASHRAE Handbook Fundamentals, 1985; ASTM, 2003; Vollet *et al*., 2003; Schwertfeger and Schmidt, 1998; Pope and Mackenzie, 1986; Lopez-Manchado and Arroyo, 2000; Satas, 1984; Zhao *et al*., 2003; Shen *et al*., 1994). However, there are still some difficulties that the silica aerogels directly replace traditional insulation materials. The application of thermal insulation packaging is not been reported, one important reason is that low-density silica aerogels, the characteristics of high porosity lead to a sharp decline in mechanical properties,low intensity aerogels, brittleness (Hegde and Rao, 2007). Woignier *et al*. (2004) enhance the grain skeleton can improve the strength of aerogels by increasing the density aerogels, high-temperature heat treatment and other methods, it is still difficult to meet the requirements of practical packaging application Limiting applications of thermal insulation of silica aerogels. Thus, it is an important direction of development by the introduction of the mechanical properties of aerogels reinforcement to solve the problem of poor, developed with insulation composite.

Fiber material is widely used in aeronautical materials and heat insulating material, the heat transfer performance is directly related to the improvement of Aeronautical Materials and heat insulating material and optimum design. Material heat transfer performance for fiber material or warm clothing, special field of protective clothing design, all kinds of insulation material has extremely important influence.

Insulation composite can be applied to refrigerated container plate in the product transportation packaging industry.

## EXPERIMENTAL

**Silica aerogels/basalt fiber insulation composites:** A certain volume fraction of inorganic fibers and silica aerogels mix, get fiber composite mixture of silica aerogels, the alcohol solvent as the drying medium can be vacuum dried silica aerogels/inorganic composite fiber insulation materials.

## TEST METHODS

Using a muffle furnace for silica aerogels/inorganic fibers 500 ? 2 h heat-treatment temperature performance characterization; with S4300 Scanning Electron Microscope (SEM) of silica aerogels/inorganic fiber and composite materials were characterized by morphology; with rapid thermal conductivity Determination of thermal conductivity of composite materials measured.

## RESULTS AND DISCUSSION

**Silica aerogels/inorganic fiber microstructure analysis:** SEM morphology observed $SiO_2$ aerogels know of many small spherical particles, nano-clusters into the porous structure of the network (Fig. 1), elementary particles of particle size of about 50nm. Of $SiO_2$ aerogels/ceramic fiber insulation composite microstructure morphology (Fig. 2): $SiO_2$ aerogels can be good with inorganic fiber composite, the fibers were previously dispersed aerogels filled, between the fiber connection.

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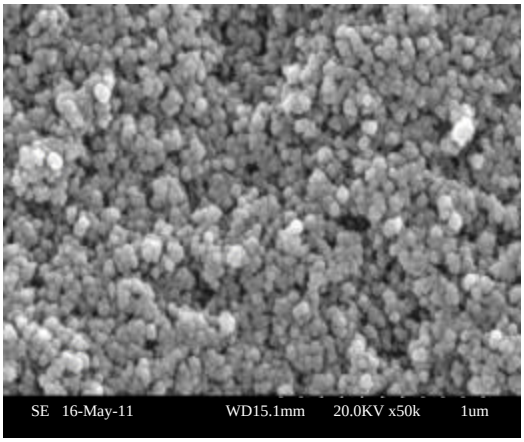


Fig. 1 SEM microstructure of aerogels under (×50K)

Figure 3 for silica aerogels/basalt fiber SEM images can be found, silica aerogels/basalt fibers have a more complete porous network structure, network uniform particle size, and these particles connected to each other, stacked and connected into the network, the formation of a large number of holes, no serious network structure collapse or agglomeration of particles. This is mainly due to vacuum drying of silica aerogels/basalt fiber network for multi-crystalline structure (Fig. 3), and silica aerogels was amorphous (Fricke *et al*., 2006). Studies suggest that (Poco *et al*., 2001), silica aerogels/basalt fiber is its polycrystalline structure at high temperature has a higher specific surface area of the main reasons. Therefore, there is a better position for silica aerogels/basalt fiber in high-temperature insulation.

**Silica aerogels/basalt fiber composite insulation performance analysis:** For visual comparison with conventional ceramic fiber insulation composite silica aerogels performance differences, in the same external environment, the use of rapid thermal conductivity detector test two different materials in the surface temperature of the thermal insulation performance, the results showed that conventional ceramic fiber insulation and composite silica aerogels the thermal conductivity of a lot of difference, the conventional thermal conductivity of aluminum silicate fiber felt as the 0.0301 W/(m•K) and silicon oxide gas gel/Basalt fiber composite insulation thermal conductivity 0.0195 W/(m•K) is low. This indicates that silica aerogels insulation composite basalt barrier effect of gas convection is fairly obvious, insulation performance higher.

In general, most of the thermal conductivity of insulation material there are four main parts (Lee *et al*., 2002):

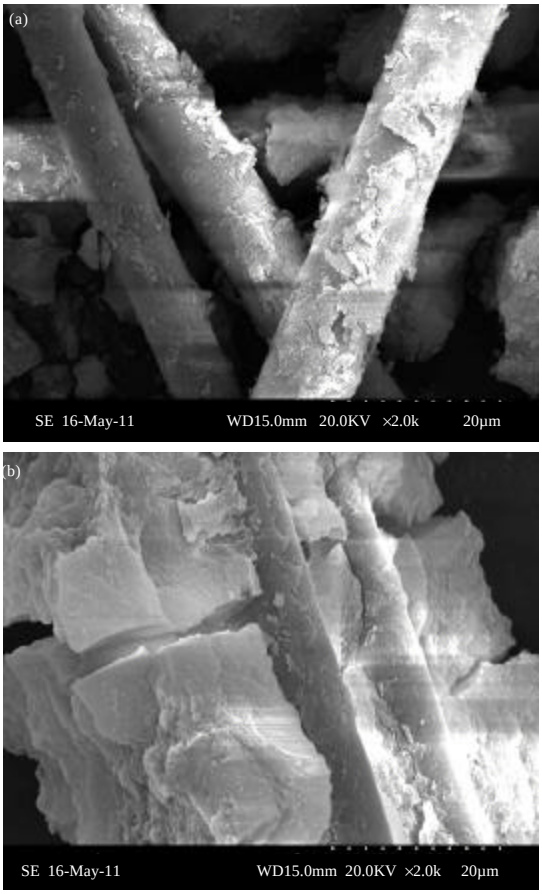


Fig. 2(a-b): SEM under Aerogel/ceramic fiber composite microstructure, (a) ×6K and (b) ×60K

- Thermal conductivity of solid materials
- Thermal conductivity of gas molecules
- Gas convective heat transfer
- Radiation heat transfer

Research shows that when the average pore size of aerogels is less than the mean free path of air molecules (typically as 69 nm), can effectively inhibit the heat conduction and convection, thereby reducing the thermal conductivity of the material (Ryu and Satas, 2000). The average pore size of silica aerogels is about 50nm, less than the mean free path of air molecules, the virtual elimination of the convective heat transfer, heat transfer significantly reduced the gas, so the introduction of silica aerogels for thermal insulation composite significant performance improvement. There are many inorganic fibers in the micrometer holes, loose fibers present between the state, its main mode of heat transfer fiber-fiber contacts and fiber heat-air-fiber heat. One fiber-fiber contacts a fiber to increase the path of solid

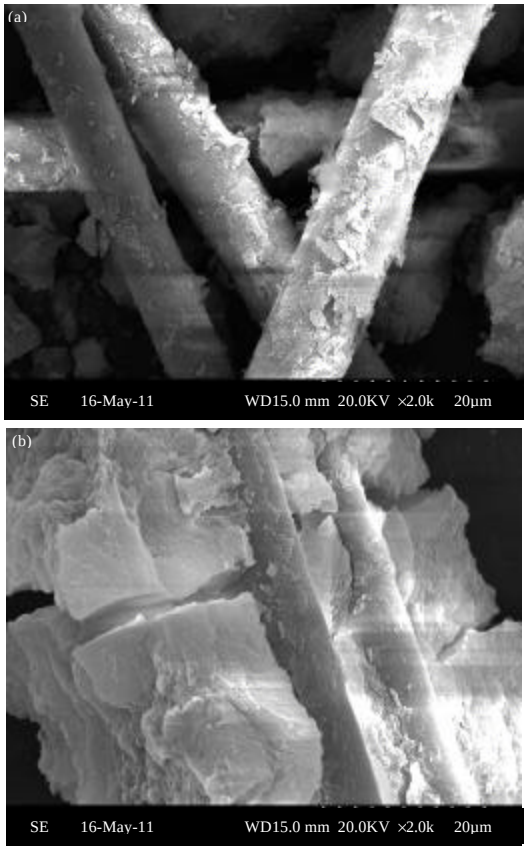


Fig. 3(a-b): SEM under the basalt fiber composite microstructure, (a) ×2K and (b) ×2K

conduction, the heat conduction in a "thermal bridge" effect, is not conducive to heat; fiber - air - air-fiber heat transfer is mainly gas heat transfer, is not conducive to heat (Fig. 4a). When the inorganic fiber and composite silica aerogels, the majority of the gap between the fiber and the fiber was filled by silica aerogels, aerogels fully wrapped reinforcing fibers, between fiber and fiber is effectively dispersed by aerogels obtained after drying the matrix skeleton wrapped in fiber composite structures. Since the introduction of silica aerogels, making the heat transfer from the pure fiber carpet fiber-fiber contacts and fiber heat-air-fiber.

Heat transfer into the gas insulation composite silica aerogels of fiber-aerogel-fiber contact heat transfer (Fig. 4b). The introduction of low thermal conductivity aerogels heat transfer path for the formation of a new, lower solid heat transfer, the use of air aerogels nano-aperture suppress convection, aerogels and composite fibers decreased fiber-fiber contact heat transfer, resulting in most of the low thermal conductivity of solid heat transfer through the transmission of

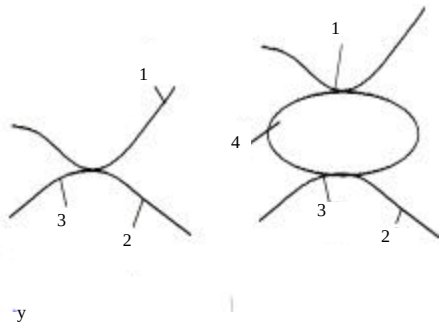


Fig. 4(a-b): Thermal conduction model of fiber-fiber and alumina aerogel-fiber (Lee *et al*., 2002), (a)fiber-fiber contact and (b)fiber - Aerogel - fiber contact 1,2- fiber; 3- contact; 4- Aerogel

aerogels, aerogels while fully filled cavity between the fiber, effectively inhibit the freedom of the heat transfer gas molecules, so the composite aerogels with good thermal insulation.

## CONCLUSION

The use of silica aerogels inorganic fiber composite insulation material with good insulation, which was mainly due to the nano-porous silica aerogels structure can effectively suppress thermal conduction and convection, while the composite with the fiber, changing the fiber heat transfer means, has a relatively high specific surface area, porous network structure does not appear obvious aggregation or collapse, thermal conductivity is still low, has good thermal insulation, thermal insulation in the packaging area it has broad application prospects. The research production of composite insulation material has good heat preservation and heat insulation performance, the coefficient of thermal conductivity in the 0.01-0.03 W/(m•K), its performance is superior to the traditional thermal insulation material, has reached the goal of high insulation, the thickness of the phase at the same time, reduces the reefer container leakage quantity of heat, reduce the energy consumption and energy consumption at the same time, using the composite thermal insulation material reduced the thickness of the insulation layer, so as to increase the internal volume of the refrigerated container and loading capacity, but also improves the efficiency of container transport, at the same time, reduce the quality of the empty containers, reefer container is better for transport.

Through the above study to elucidate the preparation technology of fiber insulation board, mechanics performance, thermal performance

characteristics and the optimization of mechanical properties of hybrid structure is offered for the further is widely used for its good experimental basis and has guiding significance.

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