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Aerogel: Future Material

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Abstract: ***Understanding key characteristics of aerogel will allow industries to better improvements. This paper examines types; synthesis, applications and future about aerogel. The unique physical properties of aerogel have proven to be enabling variety of both scientific as well as industrial sector. In the future, we expect significant further development for aerogel in the area of scientific and industrial sector.***

Keywords: Aerogel, Physical Properties, Development, Future.

1. Introduction

The rapid development of sol-gel techniques during the past decades has led to fast progress in synthesis of porous material. Aerogel is a synthetic porous ultra light material derived from gel, in which liquid component of gel is been replaced with a gas. It is made via sol-gel technology. It was created by Samuel Stephens Kistler. The aerogel is a solid with extremely low density and thermal conductivity. It can withstand up to 2000 times greater load than its own weight. Within the aerogel structure, very little is solid material, with up to 99.8% of the structure consisting of nothing but air; hence it is often referred as 'frozensmoke'. Aerogel is a broad term used to extraordinary group of material that has been used since 1960's in space travel, but are now finding uses across whole range of industries. It widely used as insulation in thermal bottles, chemical absorber for cleaning up spills, a catalyst, as thickening agents in some paints and cosmetics, etc.

2. Types of Aerogel

The three most common types of aerogels are silica, carbon and metal oxides, but it's silica that is most often used experimentally and in practical applications.

Metal oxides are used as catalysts for chemical transformations. They are also used in production of explosives and nanotubes. Each type of metal oxide results in an aerogel of a slightly different color.

Carbon-based are made up for high surface area and electrically conductive capabilities. They are widely used for super capacitors, desalinations systems and fuel cells.

Silica aerogels are blue in color. Owing to their poor reactivity, very large surface areas, optical properties and very low thermal conductivity, they find high added-value applications in physics of high-energy particles, transparent and super insulating double windows, life and space science as well.

3. Synthesis Of Aerogel

The sol-gel processing involves four stages, which are, mixing of chemicals, gelation, drying and final product.

Figure: Synthesis of Aerogel

In the initial stage, alcoxide, alcohol, water and catalyst are mixed together. After the mixing of liquid reaction compounds, formation of a network of colloidal particles, i.e. gel takes place. Later, in the drying process, removing of the liquid from the pores is done and final product is obtained.

4. Properties

One of the best known and most useful physical properties of aerogel is its amazing lightness- it has density between 0.0011 to 0.5 g cm^{-3}. Their further property includes:

a) Low density, High porosity
b) Large sound absorption, Low sound velocity
c) Low thermal conductivity
d) Variable refractive index
e) Flexibility
f) Knuden effect
g) Surface can be functionalized
h) No reaction with metallic melts up to 950^0 C

5. Applications

5.1 In Scientific Field

One of the first use of aerogel in scientific field and in area there are still used, is in Cherenkov radiation detectors. They are so useful in detection because of two main properties, low refractive indices and easy to handle. Aerogels are also used with lasers to help explain the

'supernova' explosions.

5.2 Aerogel as thermal insulator

Aerogels possess a very small thermal conductivity, ~1–10% that of a solid,". Therefore, thermal transport through the solid portion of an aerogel occurs through a very tortuous path and is not particularly effective. The space not occupied by solids in an aerogel is normally filled with air (or another gas) unless the material is sealed under vacuum. These gases can also transport thermal energy through the aerogel.

5.3 In Housing, Refrigerators, Skylights and Windows

Silica aerogels can be synthesized using low cost precursors at ambient pressure which makes aerogels suitable for commercialization. Aerogels transmit heat only one hundredth as well as normal density glass. The first residential use of aerogels is as an insulator in the semitransparent roof. Aerogels are a more efficient, low-density form of insulation than the polyurethane foam currently used to insulate refrigerators, refrigerated vehicles, and containers. Foams are blown into refrigerator walls by chlorofluorocarbon (CFC) propellants, the chemical that is the chief cause of the depletion of the earth's stratospheric ozone layer. Replacing chlorofluorocarbon-propelled refrigerant foams with aerogels could help eliminate this problem.

5.4 In Space

NASA used aerogels to trap space dust particles aboard the Stardust spacecraft. The particles vaporize on impact with solids and pass through gases, but can be trapped in aerogels. NASA also used aerogel for thermal insulation of the Mars Rover and space suits .The US Navy is evaluating aerogel undergarments as passive thermal protection for divers.

6. Future of Aerogel

Today various significant efforts are underway to apply aerogels for use as hydrogen storage media. Hydrogen production using semiconductor aerogels will change the way we think about energy and fuel. In future, scientists hope to use aerogel in solar energy collectors. They are looking to create various other useful things from aerogel in research. Other uses that will occur in industrial sector include using aerogel to improve acoustics in rooms, virus and bacteria detectors, water and air purifiers, computer processors, and in field of electrical engineering especially. They are endless possible applications of aerogel materials in future. .

7. Conclusion

Aerogel has been developed and utilized in various sectors across globe due to its low thermal conductivity, poor reactivity, optical properties, well dampens vibrations and sound, etc. It has its unique place in most of industries and scientific fields in future. Hence, it can be concluded that 'aerogel' is a material of future.

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