NANOMORPHOLOGY AND THERMAL CONDUCTIVITY OF COMMERCIAL SILICA AEROGELS

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Abstract

Based on the research market in the world Alibaba and Weiku, it found and selected samples of 12 main commercial silica aerogels from manufactures. Two independent methods, Izomet and QTM500, was measured the coefficient of thermal conductivity of silica aerogel to verify the material sheets suppliers[1] and assertions in the literature[2], that silica aerogel has a low thermal conductivity and as reference standard of thermal insulation was measured also a sample of foamed polystyrene (SF). Nanomorphology aerogels was shown by scanning electron microscope for analyzing the effect of surface shape - roughness, sphericity, smoothness - to the size of coefficient of thermal conductivity..

Key words: silica aerogel, thermal conductivity, nanomorphology, foamed polystyrene, Izomet

1. INTRODUCTION

To construct the thermal insulation[3], the market offers a silica aerogels having coefficients of thermal conductivity better than the heat conductivity of air, these values aerogels offers manufacturers and literature

It also offers excellent insulating composite materials, airgel powder with building materials, but advertising is not credible, because it denies the laws of physics, the claim that just a thin layer of plaster on on the walls.

To verify the values of thermal conductivity given in data sheets of manufacturers was performed complete research of silica aerogels manufacturers in the world of database Alibaba and Weiko a total from 12 manufacturers were bought samples of micro powdered of silica aerogels.

2. EXPERIMENTAL

2.1. Used methods

2.1.1. Thermal samples

Before measurement the samples were kept in a laboratory at 25 ° C for 72 hours, the measurement was carried out at 25 ° C. During the measurement the samples were compressed at ISOMET pressure p = 2.2 mbar and 500 QTM pressure p = 1.7 mbar.

2.1.2. Microscopic samples

Hydrophobic aerogel sample was stored at room temperature for 24 hours and glued onto a supporting disc, measurements were performed in a high vacuum turbo pump.

2.2. Methods of characterization

2.2.1. Coefficient of thermal conductivity (CTC)

Thermal conductivity was measured directly using the apparatus ISOMET 2104, Applied Precision. To measure the thermal conductivity were used as devices Japanese company KYOTO Electronics QTM-500th

2.2.2. Scanning electron microscopy (SEM)

Scanning microscopy was applied on scanning electron microscope JEOL JSM-7001F during 15kV with resolution 3.0 nm and SEI detector.

Table 1 Data sheet of commercial silica aerogels

No.	Supplier	ρ[kg/m³]	Porosity [%]	Pore Ø [nm]	Pore V [cm³/g]	Surface [m²/g]	Particle size [μm]	λ [mW/m.K]
1	China	200±20	90-98	20-50	3-3.6	600	300-500	
2	Korea	70-150	90	20-50		300-500		18-20
3	Spain	80						12
4	China	40-150	90	20-100		500-650	500-5000	
5	China	40-80			1.8	160-280	4-5	30
6	China	40-150		20	2.63	500-900		
7	China	200	90	20-50		500		20
8	Sweden	40-150	97	2-100		100-750	1-100	18-22
9	USA	120-150		20		600-800	2-40	12
10	China	100	90	20-50		650	20	
12	China	110-160	90-98			500-900	10-150	15-20
13	China	40-150	90	20-100		500-1000	100-5000	

3. RESULTS AND DISCUSION

3.1 Coefficient of thermal conductivity

The results are shown in the Table 2. As reference standard of thermal insulation was measured also a sample of foamed polystyrene (SF) and in the table contains the value of the ratio of the measured values of the thermal conductivity of each sample from the value measured on the SF as the difference in percent. The thermal conductivity coefficient of 12 samples at the level of values of expanded polystyrene, with the fact that for 3 samples is reduced by up to 20%, for 3 samples is higher by 40%, one sample is unusable as a heat insulating material having a coefficient of thermal conductivity 192% higher than the polystyrene foam. Differing coefficients of the two measurement methods correspond to the different method of measurement and geometry,thus nanoporosity samples. which affects the size of the contact area of the heated shapes.

Table 2 Coefficient of thermal conductivity for commercial samples of silica aerogels and styrofoam SF

No. Sample	λ_{QTM500} [mW/m.K]	change from SF [%]	λ_{IZOMET} [mW/m.K]	change from SF [%]
1	27,4	-18	35,5	-6
2	33,3	0	39,4	+4
3	64,1	+192	63,3	+67
4	28,5	-14	36,1	-4
5	47,4	+42	50,3	+33
6	43,9	+32	47,8	+26
7	34,3	+3	40,7	+8
8	44,9	+35	44,3	+17
9	**27,7**	**-17**	**34,1**	**-10**
10	**34,3**	**+3**	**38,1**	**+1**
12	**34,3**	**+3**	**50,7**	**+34**
13	**31,9**	**-5**	**36,9**	**-2**
SF	**33,3**	**-**	**37,8**	**-**

3.2 Scanning electron microscopy

Samples of silica aerogel can be seen in SEM (Figure 1 - 12) with nanoporozity structure. This structure is reflected in low thermal conductivity as Styrofoam, where the sample No. 3 is not nanoporous and therefore has a high thermal conductivity.

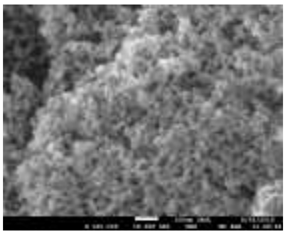

Fig. 1 Sample No.1

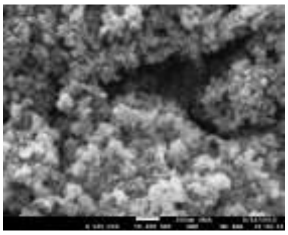

Fig. 2 Sample No.2

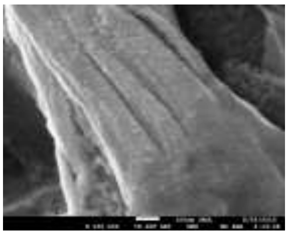

Fig. 3 Sample No.3

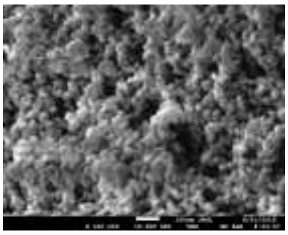

Fig. 4 Sample No.4

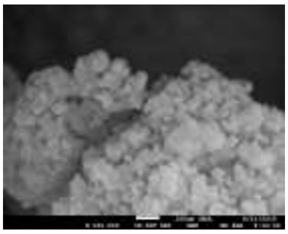

Fig. 5 Sample No.5

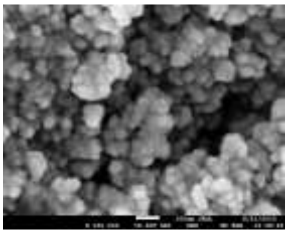

Fig. 6 Sample No.6

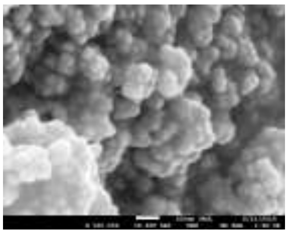

Fig. 7 Sample No.7

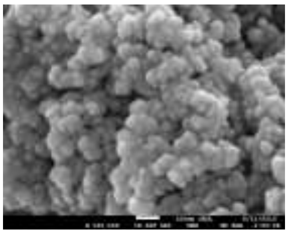

Fig. 8 Sample No.8

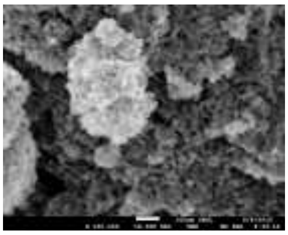

Fig. 9 Sample No.9

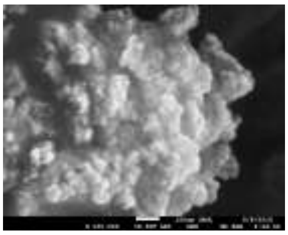

Fig. 10 Sample No.10

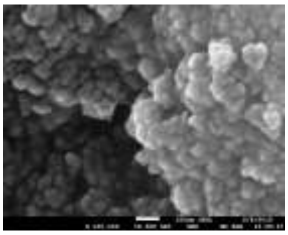

Fig. 11 Sample No.11

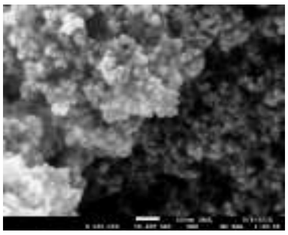

Fig. 12 Sample No.12

3. CONCLUSION

The measured thermal conductivity two independent methods indicate that commercial samples of silica aerogels have no good insulating properties, because isolated as styrofoam and do not reach low values of thermal conductivity lower than air, as reported in the technical data sheets and also in the literature..

ACKNOWLEDGEMENT

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LITERATURE

[1] ASPEN AEROGELS, INC. 30 Forbes Road, Building B, Northborough, MA 01532 USA. *Aspen aerogels.* http://www.aerogel.com/products-and-solutions/all-insulation-products/default.aspx

[2] Thermal conductivity" in Lide, D. R., ed. (2005). CRC Handbook of Chemistry and Physics (86th ed.). Boca Raton (FL): CRC Press. ISBN 0-8493-0486-5.. section 12, p. 227

[3] Schmidt M., Schwertfeger F. Applications for silica aerogel products. Journal of Non-Crystalline Solids, Volume 225, April 1998, Pages 364-368