The highest surface area derived via ambient pressure drying - synthesis and characterization of DMF-modified silica aerogel for thermal insulation

Artur Miros[1], Barbara Szpikowska-Sroka[2], Natalia Pawlik[2], Agnieszka Ślosarczyk[3], Bronisław Psiuk[4]

[1] *Łukasiewicz Research Network - Institute of Mechanized Construction & Rock Mining, Center of Building Materials and Mineral Resources, Branch in Katowice, 193A Al. Korfantego Street, 40-157 Katowice, Poland*
[2] *Institute of Chemistry, Faculty of Mathematics, Physics and Chemistry, University of Silesia, 9 Szkolna Street, 40-007 Katowice, Poland*
[3] *Institute of Structural Engineering, Faculty of Civil and Environmental Engineering, Poznan University of Technology, 5 Piotrowo Street, 60-965 Poznań, Poland*
[4]*Łukasiewicz Research Network - Institute of Ceramics and Building Materials, Refractory Materials Division in Gliwice, 99 Toszecka Street, 44-100 Gliwice, Poland* *

presenting author: Artur Miros
e-mail: a.miros@imbigs.pl

Abstract

Silica aerogels are a unique class of highly porous materials (80 – 99.8%) with large specific surface area (500 – 1200 m^2/g). Due to their properties, silica aerogels are considered as objects of widespread interest through last years, e.g. as excellent insulating materials [1,2]. This super-insulating property is due to the air entrapped inside the pores within silica backbone.

In this work, the hydrophobic silica aerogels were prepared via ambient pressure drying method (APD) by a surface silylation using TMCS/n-hexane mixture [3,4]. The structural and physical properties of synthesized DMF-modified and unmodified aerogels were characterized using BET, TG, SEM, FT-IR and Raman techniques.

The BET specific surface area for pure silica sample (unmodified with DMF) is quite large (estimated at ~828 m^2/g). Particularly, the BET surface area of DMF-modified silica sample is much more higher and reaches up ~1231 m^2/g. Such high surface area is comparable with the values obtained by other researchers for silica aerogels dried in supercritical conditions and significantly higher from the surface areas obtained via APD [1,3]. As far as we know, such high BET surface area for APD aerogels was reported for the first time.

On the basis of the obtained results have been presented the differences in structure between samples before and after a surface silylation, which was not previously documented. The structural measurements confirmed the efficient silylation process (TMCS/n-hexane), as well as the presence of DMF residues of hydrogen-bonded with unreacted Si-OH groups within silica backbone after surface modification. Based on TG analysis, it has been found that DMF addition improves thermal resistance (up to ~320°C) and hydrophobic character (up to ~270°C) due to the presence of Si-$(CH_3)_3$ modified groups of prepared aerogel. The chemical aspects of modification, influence on the structure and physical behavior have been described in details and compared with unmodified aerogel.

* *present institution: The "Edith Stein School with Character" Foundation, Bałtycka 8, 44-100 Gliwice, Poland*

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