Mineral aerogels for energy applications

Arnaud Rigacci, Christian Beauger

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Arnaud Rigacci*, Christian Beauger

Center for Energy and Processes (CEP), Mines ParisTech

BP 207, 06 904 Sophia Antipolis Cedex, France

arnaud.rigacci@mines-paristech.fr

Abstract

Silica aerogels have been studied for long regarding applications for thermal superinsulation. Nowadays, some products are developed at industrial levels. However, some improvements are still to be achieved. Within this frame, first of all, we present in this paper some of the brand new advances in this sector based on literature examples (organic/inorganic hybrids and composites, nanodispersions, coatings, …). To illustrate our contribution to this sphere, we also detail some of our most illustrative realizations on superinsulating monolithic, granular and blanket-types materials, paying a particular attention to the famous “spring-back” effect based on silylation of the silica pore walls (Figure 1) [1].

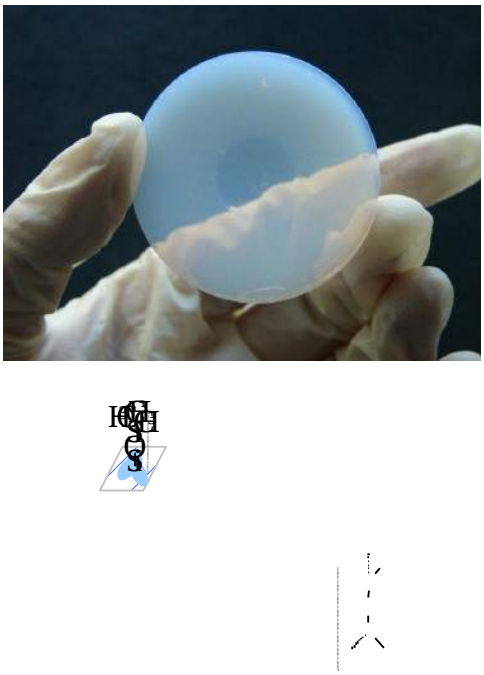

Figure 1. View of a superinsulating silica aerogel sample (top) and the schematic representation of the trimethylsilyl functionalization of silica used for hydrophobization

Regarding the energy sphere, silica aerogels are not the only ones intensively studied. To illustrate this point we present our works in emerging domains like watersplitting (or “how to produce hydrogen from water and sun without electricity inputs”). For this purpose, we have developed some platinised TiO_2 aerogels showing very promising efficiency compared to the standard commercial reference [2] (Figures 2 and 3).

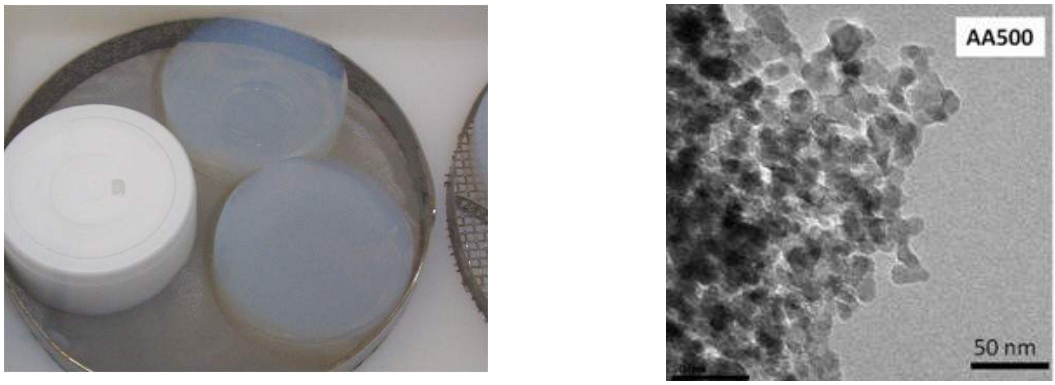

Figure 2 : view of representative wet TiO_2-based gels before drying (left) and their TEM micrograph after supercritical CO_2 drying and calcinations at 500 °C (right)

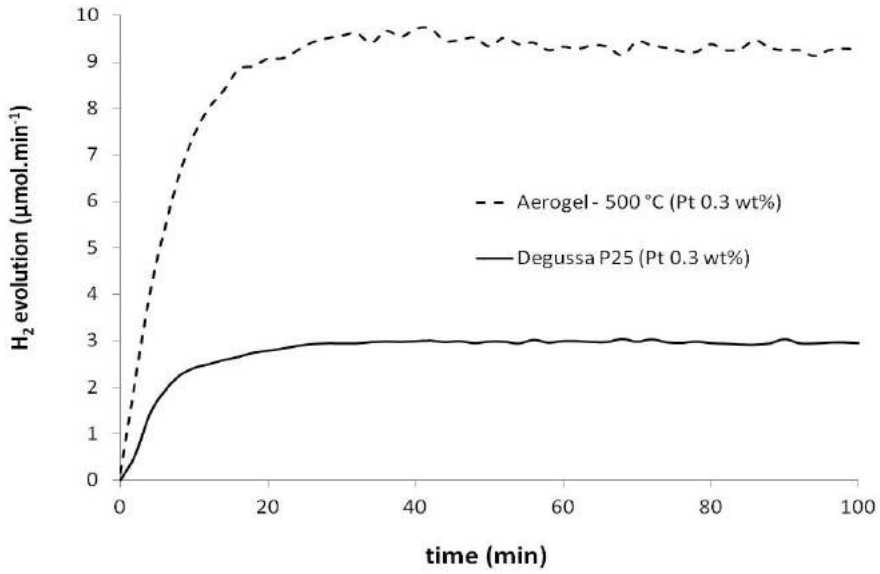

Figure 3 : H_2 evolution on TiO_2 Pt loaded samples: aerogel calcined at 500 °C and P25 – 150 W metal halide lamp, 0.9 l water + 0.1 l MeOH, 0.7 g samples, 0.3 wt% Pt/TiO_2, room temperature - Strasbourg, France.

Finally, we complete the picture with our native studies on tin dioxide (SnO_2) aerogels for Proton Exchange Membrane Fuel Cells (PEM-FC) electrodes. These brand new materials appear very exciting to try to replace more classical but highly corrodible carbonaceous materials classically used in this kind of systems. The first step consisted in preparing nanostrucured SnO_2 aerogels starting from home made tin alkoxide (Figures 4 and 5). Doping has then been performed with vanadium or niobium to make the materials electronic conductive. These first results will thus soon be enriched with conductivity measurements.

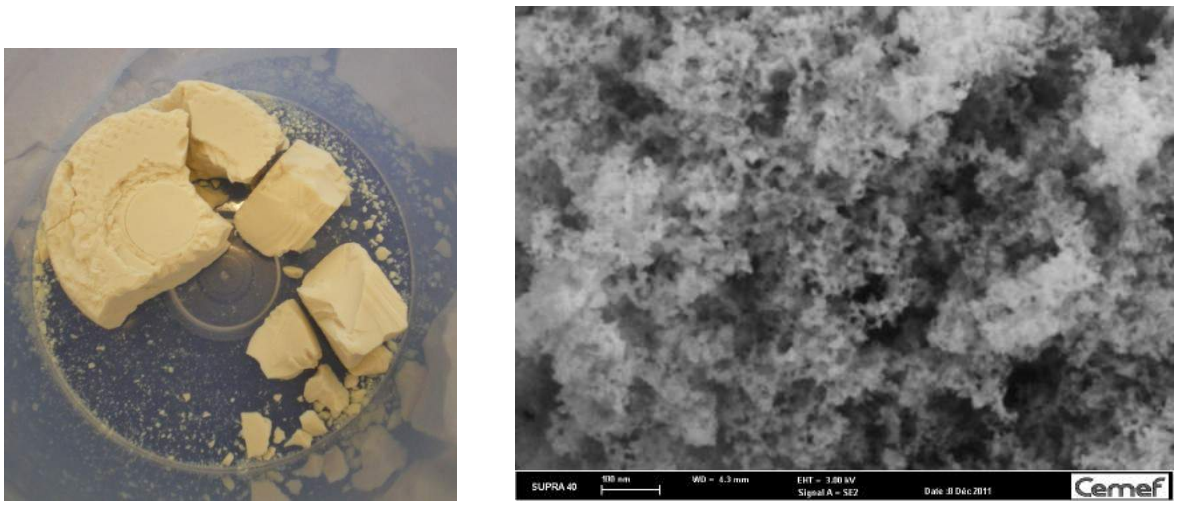

Figure 4 : view of a representative SnO_2 aerogel (left) and its SEM micrograph showing mean particle size of about 10 nm (right).

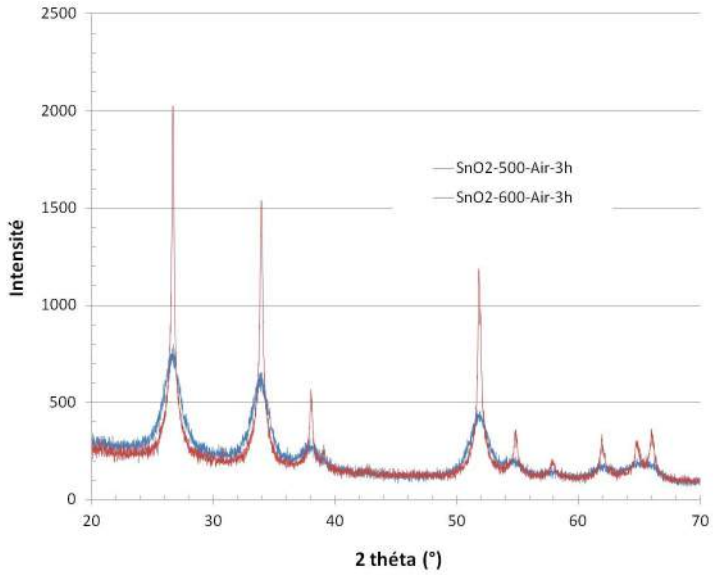

Figure 5 : XRD spectra of SnO_2 aerogels calcined at 500 and 600 °C under flowing air during 3 h.

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REFERENCES

1. A. BISSON, A. RIGACCI, D. LECOMTE, P. ACHARD, "Effective thermal conductivity of divided silica xerogel beds", *Journal of Non-Crystalline Solids*, 350, 379-384 (2004)
2. D. D'ELIA, C. BEAUGER, J.F. HOCHEPIED, A. RIGACCI, M.H. BERGER, N. KELLER, V. KELLER-SPITZER, Y. SUZUKI, J.C. VALMALETTE, M. BENABDESSELAM, P. ACHARD, "Impact of three different TiO_2 morphologies on hydrogen evolution by water-splitting: nanoparticles, nanotubes and aerogels", *International Journal of Hydrogen Energy*, 36 14360-14373 (2011)