Workshop on Aerogels Characterization and Modelling

29-31 March 2023

Debrecen, Hungary

GENERAL INSTRUCTIONS FOR ABSTRACT SUBMISSION

The abstract deadline is March 10, 2023. Please indicate whether you prefer oral presentation or poster. Since usually the abstracts submitted with preference for oral presentation are more than those that can be accommodated in the program, the Members of the Organizing and the Scientific Committees will decide by March 15, 2023 whether the contribution will be scheduled for oral or poster presentation. If a formal acceptance of the abstract is needed at an earlier date, please indicate so in the e-mail with the abstract submission.

Abstracts should be no longer than two pages. Abstracts that do not meet these formatting requirements will be returned. The Organizing Committee reserves the right to edit abstracts for clarity or correctness of English, but will consult the author if any significant changes are needed. Please save your file as **PRESENTING AUTHOR NAME.doc or .docx** and upload it at the end of the registration form. The abstracts will appear in the book of abstracts in .pdf format.

I would prefer (please put a cross in one of the boxes):

☐ **Oral presentation**

☐ **Poster presentation**

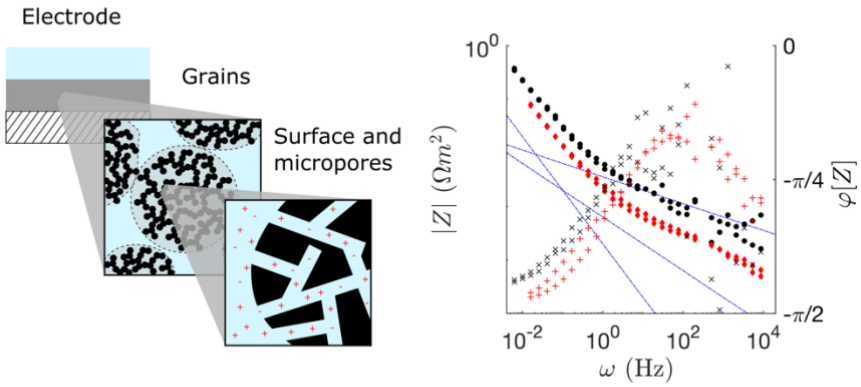
Workshop on Aerogels Characterization and Modelling
29-31 March 2023
Debrecen, Hungary

The electrical impedance of carbon xerogel hierarchical electrodes

Cedric J. Gommes[a,*], François Chaltin[a]

[a] Department of Chemical Engineering, University of Liège, allée du Six Août 3, B-4000 Liège, Belgium

* cedric.gommes@uliege.be



ABSTRACT

Porous materials have many applications in the field of electrochemical energy storage, notably as battery electrode materials or as supercapacitors. In this context, it is central to understand the transport and storage of electrical charges (ions and electrons) in the materials. In many practical situations, the electrode is prepared by grinding the active material into a powder and depositing a layer of it on a current collector, which leads to hierarchical structure. The largest scale is that of the macroscopic layer. The intermediate scale is that of the micrometer-sized porous grains that make up the layer. The smallest scale is that of the nanostructured skeleton of the porous grains. The storage of the electrical charges happens at the smallest scale (in micropores and on the mesoporous surface), but their transport takes places simultaneously at all scales.

We discuss electrical impedance experiments performed on carbon xerogel electrodes soaked in KCl aqueous solutions [1]. The impedance characterizes the relation between the electrical current and at an applied voltage at increasing frequencies. Low-frequency measurements allow the electrical charges to reach their equilibrium configuration, and the central electrode characteristic in that context is it capacitance. When increasing the frequency, the measurements become increasingly limited by the transport of electrons and ions.

Considering impedance over a wide range of frequency ω therefore offers a unique opportunity to study charge storage and transport in porous materials.

Specifically, we present impedance results obtained on a variety of carbon xerogels differing by their mesopore size, and by their microporous volumes. Moreover, nonane adsorption is used for the preparation of some electrodes to selectively plug micropores and make them inaccessible to the ions. We also develop a mathematical model to analyze the data, assuming electrical-double-layer (EDL) mechanism for charge storage and a Nernst-Planck equation for ion transport.

The impedance data exhibit the expected ω^{-1} scaling at low frequency, which is typical of capacitive behavior. The values of the capacitance show that the ions barely enter into the micropores, so that it is mostly the mesoporous surface area that contributes to the storage capacity. At high-frequency, a scaling of the type $\omega^{-1/4}$ is observed, which differs from the classical Warburg behavior in $\omega^{-1/2}$ that is usually expected for porous electrodes [2]. The mathematical modelling shows that this unusual exponent ¼ corresponds to a situation where charge transport is rate-limiting at two scales simultaneously, in the macroscopic layer and in the micrometer-sized grains. It is therefore unique to hierarchical structures.

ACKNOWLEDGEMENTS

This publication is based upon work from COST Action "Advanced Engineering of aeroGels for Environment and Life Sciences" (AERoGELS, ref. CA18125), supported by COST (European Cooperation in Science and Technology). The work was supported by the Funds for Scientific Research (F.R.S.-FNRS, Belgium) through grant J.0075.19-CDR.

REFERENCES

[1] C.J. Gommes, F. Chaltin, Electrochimica Acta, 433, 141203, 2022.

[2] R. de Levie, Electrochimica Acta, 9, 1231-1245, 1964.