Nanometer-scale wetting of porous carbons: a synchrotron small-angle scattering study

François Chaltin[1], Martin Rosenthal[2-3], Alexandre Léonard[4],
Bart Goderis [2] and **Cedric J Gommes**[1]

1. *University of Liège, Department of Chemical Engineering, Liège, Belgium*
2. *KULeuven, Department of Chemistry, Leuven, Belgium*
3. *European Synchrotron Radiation Facility, Dual Belgian beamline (BM26, DUBBLE), Grenoble, France*
4. *University of Liège, CARPORVISU-Department of Chemical Engineering, Liège, Belgium*

Numerous applications of nanoporous materials require their pores to be filled with liquids. In spite of its huge technological importance, the conditions for the wetting of nanometer-sized pores and its phenomenology are still poorly understood. This is due partly to the new physics expected at the nanometer scale - with a potentially important role of disjoining pressures, triple-line tensions, slipping boundary conditions, and thermal fluctuations - and partly to the lack of experimental methods to investigate liquids at nanometer scale.

Here, we use synchrotron small-angle scattering to analyze in-situ the nanometer-scale configuration of water during capillary rise experiments in carbon xerogels (Fig. 1). These materials have a structure that consists in molecular-sized micropores (< 2 nm) coexisting with larger mesopores about 20 nm across (Fig. 1b). They are widely explored for applications in catalysis as well as in energy storage and conversion devices such as batteries, surpercapacitors, and fuel cells [1].

The time- and space-resolved scattering data reveal a two-step wetting process, whereby water first enters molecular-sized micropores, and this is followed by the imbibition of the larger mesopores [2]. A Cassie-Baxter analysis shows that the presence of water in the micropores is central as it turns the mesopores from being hydrophobic to hydrophilic. Based on so-calculated contact angles, the overall nanometer-scale wetting kinetics is found to be quantitatively captured by a macroscopic Washburn law.

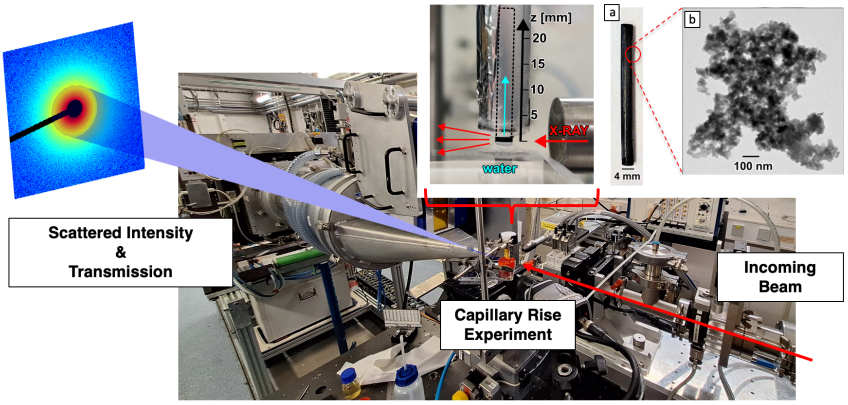

Figure 1: Experimental setup used for the in-situ synchrotron small-angle scattering analysis during capillary rise. The macroscopic appearance of the material and its nanostructure are highlighted in (a) and (b).

[1] S A Al-Muhtaseb & J A Ritter, Adv. Mater. **15** (2003), 101.

[2] F Chaltin, M Rosenthal, A F Léonard, B Goderis, C J Gommes, Langmuir **40** (2024), 20604.