Contribution ID: **654** Type: **Oral Presentation**

Gelation in model porous media investigated with environmentally-sensitive molecular rotors

Wednesday, 24 May 2023 14:15 (15 minutes)

Sol-gel processes have been widely used as an easy way to form stable thin films of inorganic polymeric materials for ceramics, coatings and more recently to enhance the mechanical properties of porous media. The latter is extremely important for the preservation of our stone cultural heritage, where several types of gel treatment have been proposed to consolidate damaged porous stones [1-3]. The consolidation treatment should not only restore the mechanical properties of the stone but also not change its physical appearance and other properties such as porosity or permeability. A homogeneous distribution of the gel in the porous network of the material is also very important, as fragile materials usually break at their weakest points. While the kinematics of transport and drying of Newtonian fluids in porous media have been widely studied by both experimental and theoretical approaches [4], the case of non-Newtonian fluids such as gels remains largely unexplored.

During sol-gel transitions induced by evaporation, the solution (sol) containing the precursor aggregates to form an elastic network that percolates throughout the material (gel) as the solvent evaporates. Here , we presents our study on the gelation dynamics in porous media: in capillaries as models for a single pore, and in quasi 2D 'lab-made'porous media with monomodal and bimodal pore size distribution [5]. By using molecular rotors (*i.e.* molecules whose fluorescence intensity depends on the local viscosity) the gelation dynamics have been investigated at the microscale [6]. This allows to estimate the local viscosity of the solution by doing fluorescence microscopy, and monitor the sol-to-gel transition. Confocal fluorescence microscopy then allows us to determine precisely where the gelation starts in the 2D porous media and how it evolves in time, because the fluorescence intensity can be directly related to the viscosity of the solution during the gelation.

In round and square capillaries, this technique allows us to investigate the impact of corner flows on the gelation kinetics and on the final distribution of gel. In the 2D model porous media, we observe that a heterogeneous gelation front appears near the evaporation boundary due to the advection. Our study reveals that a gradient of gel density develops starting from the evaporative boundary and successively invading the porous media, accompanied by a sharp decrease in the evaporation rate: the gel forms a 'skin'that decelerates the evaporation. The local viscosity of the solution during the drying can be successfully mapped with the molecular rotors and related to the decrease in the evaporation rate in capillaries and in 2D porous media with interconnected pores (see Figure).
Our results give new interesting insights into the sol-gel transition in confinement and the dynamics of gel formation in a porous network . Moreover, we show for the first time that fluorescent local viscosity probes are a promising new method to study the drying and transport of complex fluids in porous media without the need of highly advanced techniques such as as NMR imaging or X-ray microtomography.

Participation

In-Person

References

[1] G. Wheeler, "Research in Conservation: Alkoxysilanes and the Consolidation of Stone". The Getty Conservation Institute (2005)

[2] C. Pötzl, S. Rucker, E. Wendler et al. "Consolidation of volcanic tuffs with TEOS and TMOS: a systematic study ", Environ Earth Sci 81, 13 (2022)

[3] E. K. Kim, S. Y. Park, H. D. Cho, J. Won, J. Do, S. D. Kim,"Development of Alkoxysilane Mixed Solution as Stone Preservation and Consolidation Materials", J. Conserv. Sci., 21, p21-32, (2007).

[4] P. Coussot, "Scaling approach of the convective drying of a porous medium ", Eur. Phys. J. B 15, 557–566 (2000)

[5] R. W. Liefferink, A. Naillon, D. Bonn, M. Prat, and N. Shahidzadeh, "Single layer porous media with entrapped minerals for microscale studies of multiphase flow", Lab Chip 18, 1094–1104 (2018)

[6] M. R. Bittermann, M. Grzelk, S. Woutersen, A. M. Brouwer, D. Bonn, "Disentangling Nano- and Macroscopic Viscosities of Aqueous Polymer Solutions Using a Fluorescent Molecular Rotor", J. Phys. Chem. Lett. 12, 3182–3186 (2021)

MDPI Energies Student Poster Award

No, do not submit my presenation for the student posters award.

Country

The Netherlands

Acceptance of the Terms & Conditions

Click here to agree

Energy Transition Focused Abstracts

Primary author: LE DIZÈS CASTELL, Romane

Co-authors: Ms MIRZAHOSSEIN, Elham (University of Amsterdam); Dr GRZELKA, Marion (Laboratoire Léon Brillouin, CEA Saclay); Prof. BONN, Daniel (University of Amsterdam); Dr JABBARI FAROUJI, Sara (University of Amsterdam); SHAHIDZADEH, Noushine (University of Amsterdam -Institute of Physics)

Presenter: LE DIZÈS CASTELL, Romane

Session Classification: MS11

Track Classification: (MS11) Microfluidics and nanofluidics in porous systems