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

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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 present 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 NMR imaging or X-ray microtomography.

### Participation

In-Person

### References

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