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SALT CRYSTALLIZATION IN PORES: PRECIPITATION KINETICS, ION TRANSPORT, STRESS GENERATION

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Salt crystallization can damage natural rocks, buildings, or artworks by exerting stress on the walls of the porous media constituting the material [1]. This phenomenon is due to a crystallization pressure, shown to be increasing with the excess concentration of dissolved salt with respect to the crystal-solution equilibrium (supersaturation S, S=1 at equilibrium). It has been shown that S can be much higher than 1 when the first nucleus of salt appears [2]. However, the value of S at the instant when the crystal touches the pore walls is not trivial to determine. Indeed, spatio-temporal distribution of salt results from an interplay between reaction kinetics and ion transport (convection and diffusion toward the crystal).

In this context, we use a simple microfluidic configuration mimicking an elementary pore to study precipitation kinetics and stress generation on walls. A sodium chloride salt solution is concentrated by evaporation in a dead-end PDMS-glass channel of typical cross-section and length $5x5 \ \mu\text{m}^2$ and $200 \ \mu\text{m}$ respectively (see Figure, left).

At short time scales (acquisition at 1000 frames per second), we measure the kinetics of crystal growth with unprecedented temporal resolution (see Figure, left), and show that the reaction coefficient is strongly underestimated in the literature, the process being controlled by transport phenomena after only a few ms [3].

Stress generation is characterized both numerically by solving transport equations with the appropriate boundary conditions, and experimentally by measuring channel's walls deformation during growth. We establish a simple stress diagram involving the geometry and the competition between reaction kinetics and ions transport towards the growing crystal (Damkhöler number, Da).

This work should improve the understanding of damages induced to porous media by salt crystallization. It also demonstrates a new method to measure the reaction coefficient of crystal growth easily adaptable to others salts.



<u>Figure</u>: Left: snapshots of a crystal growth in a PDMS-glass channel, enabling to extract precipitation kinetics (first ms) and stress on walls (bottom). Scale Bar 10 µm. Right: stress diagram. Crystallization pressure (Pc) as function of Damkhöler number and geometrical parameters (H: liquid plug length and W pore diameter).

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