Sodium chloride precipitation reaction coefficient from crystallization experiment in a microfluidic device

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Sodium chloride precipitation reaction coefficient from crystallization experiment in a microfluidic device

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Abstract
The crystal growth of sodium chloride from an aqueous solution is studied from evaporation experiments in microfluidic channels in conjunction with analytical and numerical computations. The crystal growth kinetics is recorded using a high speed camera in order to determine the intrinsic precipitation reaction coefficient. The study reveals that the crystal growth rates determined in previous studies are all affected by the ions transport phenomena in the solution and thus not representative of the precipitation reaction. It is suggested that accurate estimate of sodium chloride precipitation reaction coefficient presented here offers new opportunities for a better understanding of important issues involved in the damages of porous materials induced by the salt crystallization.

Keywords:
A1. Evaporation
A1. Growth models
A1. Supersaturated solution
A1. Diffusion
B1. Sodium Chloride

1. Introduction

The crystallization of sodium chloride from an aqueous solution is a key phenomenon in relation with evaporation from porous media, [1], the generation of damages in buildings and monuments [2], or the injection of CO_2 in underground formations [3], to name only a few. The crystallization process is generally decomposed into two main steps: the nucleation step and the growth step. In this respect, it is important to distinguish the crystal growth kinetics [4] from the nucleation kinetics, which involves the induction time between the application of a supersaturation state and the appearance of the first crystals [5]. In the literature, they can both be found under the expression of "crystallization kinetics". In this paper, we focus on the crystal growth kinetics.

The crystal growth is studied within the framework of the diffusion reaction theory [6] (where other crystal growth theories: surface energy theory, adsorption layer theory and kinematic theory, are also presented). Crystal growth starts only once a stable nucleus, large enough to be stable, appears in the metastable solution. It relies on two coupled steps: an ion diffusion process from the solution to the crystal surface, followed by a reaction process where ions fit in the crystal lattice. These processes have been highlighted in refs. [7,8].

As illustrated in Fig. 1, the two steps occur in series and three zones can be defined. The first zone corresponds to a stagnant film (or adsorption layer) at the crystal-liquid interface. Far from the crystal, there is the bulk solution with a constant concentration. The concentration

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