

## Morphological Study of Cyclopentane Hydrates in Brine Solutions for Desalination Application

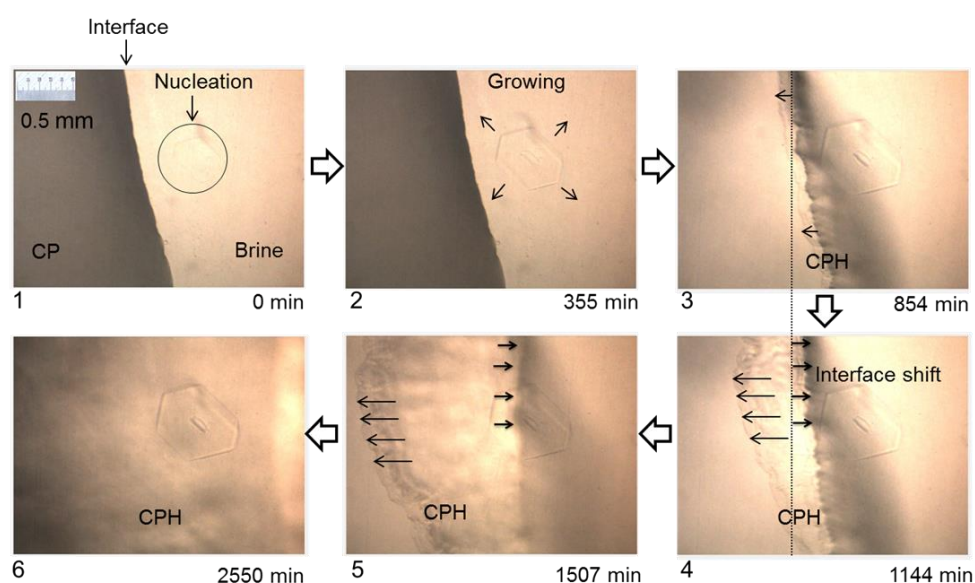
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### Abstract

Cyclopentane hydrates (CPH) is considered as a candidate for desalination due to its low operating required energy. In order to design such desalination plant, it is crucial to understand both the thermodynamics of crystallization of CPH, as well as the kinetics in the presence of diverse salts. While thermodynamics has been studied prior to this study (Ho-Van et al 2018), the present work focuses on kinetics and morphology of CPH in pure as well as saline water. Different brine solutions of Na<sub>2</sub>SO<sub>4</sub>, NaCl, NaCl-MgCl<sub>2</sub>, or NaCl-KCl-MgCl<sub>2</sub> are considered at different concentrations (3.5% and 5% mass fraction) and at different subcoolings (2.5°C, 3.5°C, and 4.3°C). A small horizontal vessel (flat cylinder shaped: inner volume ≈ 1.23 ml, height 4 mm, diameter 19.8 mm) was used under a microscopy without agitation.



*Figure 1. CPH crystallization mechanism in the presence of NaCl-KCl-MgCl<sub>2</sub> 5% at subcooling of 3.5°C*

Results show that the CPH crystals morphology is approximately comparable at the same subcooling, while the dimension of the individual crystals drops significantly with increasing of subcooling, regardless the type of salts and their concentration. The crystallization mechanism was also discussed and explained (see Figure 1). The nucleation of a few crystals and their growth were detected. Moreover, a quick growth toward the CP phase and a slower growth into the water phase were observed as the different in the CP and water diffusion through the hydrate structure. An interface shift into the water

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phase was also witnessed due to the change in water phase volume and in the new phase property. The growth of the crystal interface remained somehow parallel to the liquid-liquid interface, without any obvious preferential direction. Therefore, we suspect that the limiting step in the crystallization process is the crystal growth itself, and that there is no limitation due to the diffusion. Finally, the hydrate-film formation rate is proportional to subcooling in any of the salt systems.

**Keywords :** Cyclopentane hydrates ; Morphology ; Desalination ; Brine ; Crystallization.

## **Références**

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