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NEW INSIGHTS ON GAS HYDRATE FORMATION IN SAND THROUGH MAGNETIC RESONANCE IMAGING

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ABSTRACT

Methane hydrate was formed in an unconsolidated bed of silica sand and the process was monitored with magnetic resonance imaging. The sand particle size and the water content were varied and their effect on hydrate nucleation and growth was observed. It was found that hydrate formation in porous media does not proceed in a uniform manner and nucleation of hydrate crystals occurs at different times and different positions inside the bed, a phenomenon which is referred to as multiple nucleation in space and time. Furthermore, hydrate formation was found to be faster in a bed with lower water content and smaller particle size.

Keywords: hydrate formation, magnetic resonance imaging, kinetic, nucleation, porous media

NOMENCLATURE

I	Intensity of the MRI image [a.u.]
I_0	Intensity at time 0 [a.u.]
n	Number of moles of gas [mol]
n_f	Number of moles of gas consumed at the end of experiment [mol]
t	Time [min]
PSR	Particle Size Range (diameter in μm)
W.C.	Water Content (mL)
χ	Percentage of conversion of water to hydrate(%)

INTRODUCTION

Hydrates or clathrates are crystalline storehouses of natural gas which are composed of cage-like structures of hydrogen-bonded water molecules known as the host lattice. Generally, any molecule with an appropriate size can be accommodated inside the cages under favorable thermodynamic conditions, usually high pressure and near freezing temperature. These molecules are called the guest species and examples of that include CH_4, C_2H_6, C_3H_8, CO_2, N_2, H_2, THF, etc [1-8].

The discovery of this interesting substance goes back to 1811 when Sir Humphry Davy observed a hydrate of chlorine in his lab [9]. In 1934, Hammerschmidt reported the plugging of oil and gas pipelines by hydrate and this formed the basis of the hydrate inhibition industry [10]. Later, in the 1960's, Russian scientists found hydrates in nature [11]. A more complete list of early international contributions on hydrate science can be found in [12].

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