Mechanism for conversion from methane hydrate over to carbon dioxide dominated hydrate during injection of carbon dioxide into methane hydrate filled sediments

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Abstract (300 word limit)

Huge amounts of methane are trapped in ice-like structures (hydrate) around the world. Estimated amounts vary but the most recent estimates indicate that the energy trapped in these hydrates may be as much as twice the energy of conventional fossil fuels. 99% of theses hydrates are almost pure methane hydrate since the dominant sources are biogenic methane form the upper crust. CO2 forms the same structure of hydrate with water as methane but the thermodynamic stability of carbon dioxide hydrate is higher. This implies that injection of CO2 into natural methane hydrates in sediments will lead to a conversion of the *in situ* methane hydrate over to a mixed hydrate dominated by CO2. This is a win-win situation in which the methane is realeased as energy source while leaving CO2 stored as a solid phase in underground sediments. There are two primary mechanisms that can lead to this conversion. The first of these is a solid state mechanism in which the CO2 gradually replace the filling of methane in primarily the 75% largest water cavities in the structure. This is a very slow process and practically not important. Another mechanism involves the formation of a new hydrate from available free water in the sediment pores. This formation process releases heat which will distribute and assist in dissociation the *in situ* methane hydrate. In order to verify the latest mechanism we utilize Phase Field Theory (PFT) modeling. In simplified terms this corresponds to a minimization of free energy under the constraints of mass- and heat-transport.. In this modeling we have placed liquid water of various thickness around and initial methane hydrate and then sampled the dynamics of the reformation process. It is observed that the more available liquid water around the initial methane hydrate core – the longer a fast conversion is retained. When this initial liquid water layer is consumed the slow mechanism takes over.

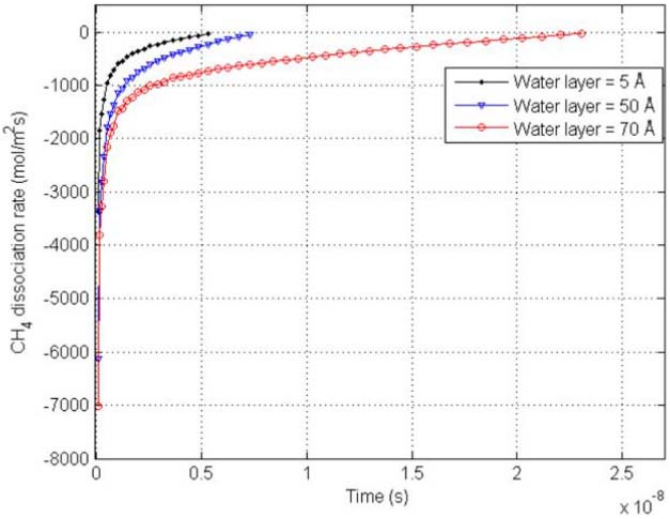


Fig. 1. Kinetic rate of conversion from CH4 hydrate over to CO2 dominated hydrate as function of initial liquid water around the CH4 hydrate.

Recent Publications

1. Kvamme, B., Qasim, M., Baig, M., Kivelä, P-H, Bauman, J.M., Phase field theory modeling of methane fluxes from exposed natural gas hydrate reservoirs, 2014, International Journal of Greenhouse Gas Control, 29, 263–278
2. Baig, K., Kvamme, B., Kuznetsova, T., Bauman, J.M., The impact of water/hydrate film thickness on the kinetic rate of mixed hydrate formation during co2 injection into ch4 hydrate, AIChE journal Volume 61, Issue 11, November 2015 Pages 3944–3957
3. Kvamme, B., Feasibility of simultaneous CO2 storage and CH4 production from natural gas hydrate using mixtures of CO2 and N2, Canadian Journal of Chemistry, 2015, 93(8): 897-905
4. Kvamme, B., Thermodynamic limitations of the CO2/N2 mixture injected into CH4 hydrate in the Ignik Sikumi field trial, 2016, J. Chem. Eng. Data, 2016, 61 (3), pp 1280–1295
5. Kvamme, B., Iden, E., Tveit, J., Veland, V., Zarifi, M., Qorbani, K., Effect of H2S content on thermodynamic stability of hydrate formed from CO2/N2 mixtures, J. Chem. Eng. Data, 2017, 62. 1645-1658



Biography

Bjørn Kvamme obtained his M.Sc. in Chemical Engineering (1981) and Ph.D. in Chemical Engineering (1984) from the Norwegian University of Technology and Natural Sciences. After a short period with SINTEF and two years at Bergen University College he was appointed to full Professor in 1987 and started education of M.Sc. and PhD in Process Technology in Telemark. He entered a position as Professor in Gas Processing at Department of Physics, University of Bergen, March 2000. He is the author/coauthor of 461 publications during latest 25 years, of which 153 are in good international scientific journals. Number of citations per September 1, 2017 is 2394. In addition numerous international presentations. His main research effort is in in thermodynamics, statistical thermodynamics, Quantum mechanics and molecular simulations. Molecular integral equation theories based on atomistic interactions for predictions of structure and thermodynamic properties. Non-equilibrium thermodynamics. Hydrates stability and kinetics. Polar solutions and electrolyte solutions. Kinetics of phase transitions. Emulsion fundamentals.

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