Development of possible leakage pathways for CO2 in between well cement and injection pipeline during injection of CO2 for aquifer storage

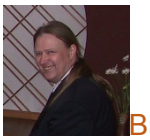
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Abstract (300 word limit)

Aquifer storage of CO2 is one option for reducing CO2 emissions to the atmosphere. Offshore Norway this is being utilized for storing 1 Million ton CO2 per year from the Sleipner hydrocarbon production of hydrocarbons. A slightly smaller amount (0.7 Million tons per year) is being stored in another field (Snøhvit) offshore Norway. On a nano to micro scale there are flow channels in between the well completion cement and the rusty injection pipeline. During year of CO2 injection water with dissolved CO2 as well as some separate CO2 phase will be dragged into these channels. This can lead to dissolution of the cement minerals, as well as corrosion of the pipeline. As a first step in modeling these processes it is important to understand how water, CO2, H+ and HCO3- will distribute on the surfaces of rust (Hematite is used as a model) and cement. These distributions can then provide a basis for setting up realistic Quantum mechanical modeling for studies of reaction kinetics and associated parameters (activation energies etc.) needed for kinetic models in reactive flow modeling of the pathways from injection point of the pipeline to the seafloor. It is found that CO2 adsorbs well on cement but not directly on rust. Bicarbonate and H+ adsorbs on both surfaces but compete with water and natural ions in groundwater.

Recent Publications

1. Olsen, R., Leirvik, Kim; Kvamme, B., Kuznetsova, T., A molecular dynamics study of triethylene glycol on a hydrated calcite surface, Langmuir, **2015**, *31* (31), pp 8606–8617
2. Olsen, R., Kvamme, B., Kuznetsova, T, A molecular dynamics study of hydrogen bond statistics and hydrogen bond lifetimes of triethylene glycol in water, 2016, AIChE, in press (published online)
3. Kuznetsova, T., Jensen, B., Kvamme, B., Sjøblom, S., Water wetting surfaces as hydrate promotes during transport of carbon dioxide with impurities, 2015, PCCP, **17**, 12683-12697
4. Olsen, R., Kvamme, B., Kuznetsova, T., Free energy of solvation and Henry's law solubility constants for mono-, di-andtri-ethylene glycol in water and methane, 2015, Fluid Phase Equilibria, Volume 418, 25 June 2016, Pages 152–159
5. Olsen, R. Kvamme, B., The effects of added water on the free energy of solvation of water into carbon dioxide, 2017, submitted
6. Olsen, R., Nes Leirvik, K., Kvamme, B., The effect of sodium chloride on glycol adsorption in calcium carbonate reservoirs, 2017, submitted
7. Olsen, R., Kvamme, B., Impact of ethylene glycol on corrosion in pores between iron oxide and calcium Carbonate, 2017, Submitted
8. Olsen, R., Nes Leirvik, K., Kvamme, B., Kuznetsova, T., Effects of sodium chloride on acidic nanoscale pores between steel and cement, J. Phys. Chem. C, 2016, 120 (51), pp 29264–29271
9. Kvamme, B., Kuznetsova, T., Kivelæ, P-K_Adsorption of water and carbon dioxide on Hematite and consequences for possible hydrate formation, 2012, PCCP, Apr 7;14(13):4410-24
10. Van Cuong, P., Kvamme, B., Kuznetsova, T., Jensen_ B., The Impact of Short-Range Force Field Parameters and Temperature Effect On Selective Adsorption of Water and CO_2 On Calcite, International Journal of Energy and Environment, Volume 6, 2012, 301-309
11. Van Cuong, P., Kvamme, B. Kuznetsova, T., Jensen, B., Molecular dynamics study of calcite and temperature effect on CO_2 transport and adsorption stability in geological formations, Molecular Physics Volume 110, Issue 11-12, 2012, 1097-1106



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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