



Contribution ID: 549

Type: Oral Presentation

Clathrate Hydrates in Porous Media: Application to Low-carbon Fuels in Clean Energy Transition

Wednesday, 15 May 2024 15:00 (15 minutes)

Carbon capture and sequestration (CCS) plays a crucial role in facilitating low-carbon fuel adoption during the clean energy transition. Clathrate hydrates are solid compounds consisting of gas molecules enclathrated in crystalline lattices formed by water molecules. Specifically, CO₂ hydrate has become an attractive way for CO₂ capture, storage and long-term sequestration. For CO₂ capture, fixed bed reactor (FBR) configuration using porous media was reported to significantly enhance the kinetics of the hydrate-based CO₂ separation process. Porous media are beneficial as they can provide more hydrate nucleation sites, tortuous pathways for fluid diffusion and sufficient gas-water contact area. On the other hand, forming CO₂ hydrates in deep marine sediment offers a secure solution for long-term carbon sequestration due to their higher density than seawater, high stability under moderate oceanic depths, and low susceptibility to oceanic flow perturbation. It is also possible to sequester CO₂ in natural gas hydrate reservoirs via CO₂-CH₄ swapping and bring more economic benefits by recovering natural gas. This work will highlight the research efforts carried out by our group in the aforementioned aspects [1-6] and discuss the key roles of porous media in these hydrate processes. The major challenges and prospects are also identified and highlighted.

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Session Classification: MS17

Track Classification: (MS17) Complex fluid and Fluid-Solid-Thermal coupled process in porous media: Modeling and Experiment