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## Pore-scale morphologies of CO<sub>2</sub> hydrate formation in microfluidics with in-situ Raman spectroscopy for CO<sub>2</sub> sequestration

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CO<sub>2</sub> hydrates are cage-like solid compounds consisting of CO<sub>2</sub> gas molecules and water molecules. The properties of CO<sub>2</sub> hydrates, such as high gas storage capacity and moderate formation conditions of pressure-temperature, are desirable for long-term and safe CO<sub>2</sub> storage in geological setting. The purpose of work is to probe the feasibility of CO<sub>2</sub> storage in hydrate in marine subsurface. Compared to natural gas hydrates, it is difficult to investigate morphological CO<sub>2</sub> hydrate dynamics in microfluidics, as the morphologies of CO<sub>2</sub> in liquid and water phases are similar. In this work, two scenarios were investigated regarding different CO<sub>2</sub> states controlled by different pressures above or below CO<sub>2</sub> liquid liquefaction pressure (PL-CO<sub>2</sub>), by means of pore-scale microscopic observation coupled with in-situ Raman spectroscopy in microfluidic chip. In one scenario, the system pressures were kept lower than PL-CO<sub>2</sub> to form CO<sub>2</sub> hydrate. The system was tested by both microscope and Raman spectroscope to distinguish CO<sub>2</sub> in gas, water and hydrate. A pressure difference was observed in the system indicating hydrate blocked pore channels and prevented unwanted CO<sub>2</sub> flow. In another scenario, the system pressures were increased over PL-CO<sub>2</sub>, which was the typical reservoir pressure, to observe CO<sub>2</sub> hydrate formation in the system containing liquid CO<sub>2</sub>. The differences between both morphological patterns and Raman peak shift were observed, verifying CO<sub>2</sub> could be stored in states of both hydrate and liquid. The quantitate calculation of CO<sub>2</sub> storage capacity showed about 80 volumes of CO<sub>2</sub> was retained in the system having only CO<sub>2</sub> hydrates, compared with about 150 volumes of CO<sub>2</sub> stored in the system having both CO<sub>2</sub> hydrates and liquid CO<sub>2</sub>. The morphological patterns, Raman spectra and calculation of storage capacity indicates that CO<sub>2</sub> hydrate storage could serve as a secondary storage option for geological CO<sub>2</sub> storage in marine subsurface. The results of this work are beneficial to understand marine CO<sub>2</sub> hydrate storage in confined space of porous media, and the enhanced CO<sub>2</sub> hydrate storage capacity can be explored by coupling with hydrate promoters and thus achieve more efficient CO<sub>2</sub> storage in marine subsurface conditions.

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## References

### Conference Proceedings

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