

## **Carbon Dioxide Hydrate in a Microfluidic Device: Phase Boundary and Crystallization Kinetics with Micro-Raman Spectroscopy**

Jonathan Wells<sup>S</sup>

*Chemical and Biological Engineering, Colorado School of Mines, Golden, CO, U.S.A.*

Weiqi Chen and Ryan Hartman

*Chemical and Biomolecular Engineering, New York University, Brooklyn, NY, U.S.A.*

Carolyn Koh<sup>C</sup>

*Chemical and Biological Engineering, Colorado School of Mines, Golden, CO, U.S.A.*

*ckoh@mines.edu*

Carbon dioxide transport is becoming of greater interest applications such as enhanced carbon capture and sequestration become important for stopping or even reversing adverse environmental impacts. To ensure safe flow of carbon dioxide at low temperature and high pressures, hydrate formation must be considered. This work utilizes a high pressure silica microfluidic reactor in order to more rapidly measure carbon dioxide hydrate properties. First the hydrate phase boundary was measured and found to be in good agreement with macroscale experiments and CPA EOS predictions. Next, hydrate crystallization kinetics were measured at low subcoolings (<2K) when mass transfer still impacts overall reaction rates. Beyond this, further increasing subcoolings have no effect on crystallization kinetics as they become reaction limited. Throughout the experiments Raman spectroscopy was used to confirm the identity of the water phase. Hydrate conversion values are estimated from Raman spectra and are in-line with available macroscale data. and complete hydrate conversion in the microchannels only requires a couple of hours compared to days for macroscale apparatuses. Microfluidics coupled with Raman spectroscopy provide a quick and effective way to predict bulk properties of carbon dioxide hydrate.