

Stacie Meruelo

Class of 2019

Chemical Engineering

**Study of Thermodynamics and Kinetics of Carbon Dioxide Hydrate Formation and
Dissociation**

Mentor: Kristine Horvat Ph.D.

The study's goal was to gain an understanding of carbon dioxide (CO₂) as it enters and leaves the gas hydrate form. Gas hydrates occur when water forms a crystalline structure around a guest gas molecule. One option for carbon emission management would be to store CO₂ in hydrate form while simultaneously extracting methane as a fuel since estimates claim 20 million trillion cubic meters of natural methane hydrates exist in deep-sea locations worldwide.¹ The questions for this study involved determining optimal conditions for hydrate formation. One idea investigated was if a surfactant, sodium dodecyl sulfate (SDS), would speed up the time that it took for the first hydrate to form (induction time) when compared to hydrates formed in deionized (DI) water or Instant Ocean salt water. Another idea focused on mimicking seafloor conditions and how the presence or absence of sand affected induction time and the overall conversion of gas into gas hydrates. A small volume (~79 mL) reactor was built to monitor the conditions of CO₂ hydrates as they formed in 12-15 mL of DI water, salt water, or SDS solution with or without sand. For each trial, the reactor was filled with solution at room temperature (23-29°C) and then pressurized to 450-475 psig before being placed in a 2°C cooling bath. The original proposal included six different run conditions, each performed two different times. The hope was to fit two runs in every week, but during the first run, it was decided to let all the runs last at least four days to allow for more CO₂ hydrate formation. The second set of runs got pushed to a future time to follow up on some unpredictable findings during these first runs. When releasing the pressure at the end of each run, reactor conditions were still recorded and compared to predicted equilibrium data generated from a program from the Colorado School of Mines called CSMHYD.

Cutting the number of runs in half means the results are not verified for repeatability. Results show that sand does inhibit the conversion of CO₂ gas into gas hydrates, as all the runs with sand had lower overall pressure drops than the runs without sand. This is not ideal, as most interest is in forming CO₂ hydrates within the ocean floor. Of the six runs completed, the runs with salt water averaged the longest induction times. However, the results for SDS impacting the induction time are inconclusive. This leads future research to focus on completing a second set of runs for better trend analysis. The analysis of conversion was also more complicated than anticipated, so more research into the solubility of CO₂ in water with changing temperature and pressure conditions needs to be completed, but spending over a week coming up with different methods for models put coursework in perspective, as concepts from all courses came up in attempting to determine a solution. Once all 12 runs are completed, we plan to publish our findings and present them at a regional conference.

1. Goel, Naval. "In Situ Methane Hydrate Dissociation with Carbon Dioxide Sequestration: Current Knowledge and Issues." *Journal of Petroleum Science and Engineering*, vol. 51, no. 3-4, 17 Jan. 2006, pp. 169-184., doi:10.1016/j.petrol.2006.01.005.