

Article

Hydrate Composite Particles for Ocean Carbon Sequestration: Field Verification

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Abstract

This paper reports on the formation and dissolution of CO₂/seawater/ CO₂ hydrate composite particles produced during field experiments in Monterey Bay, CA using a CO₂ injector system previously developed in the laboratory. The injector consisted of a coflow reactor wherein water was introduced as a jet into liquid CO₂, causing vigorous mixing of the two immiscible fluids to promote the formation of CO₂ hydrate that is stable at ambient pressures and temperatures typical of ocean depths greater than ~500 m. Using flow rate ratios of water and CO₂ of 1:1 and 5:1, particulate composites of CO₂ hydrate/liquid CO₂/seawater phases were produced in seawater at depths between 1100 and 1300 m. The resultant composite particles were tracked by a remotely operated vehicle system as they freely traveled in an imaging box that had no bottom or top walls. Results from the field experiments were consistent with laboratory experiments, which were conducted in a 70 L high-pressure vessel to simulate the conditions in the ocean at intermediate depths. The particle velocity and volume histories were monitored and used to calculate the conversion of CO₂ into hydrate and its subsequent dissolution rate after release into the ocean. The dissolution rate of the composite particles was found to be higher than that reported for pure CO₂ droplets. However, when the rate was corrected to correspond to pure CO₂, the difference was very small. Results indicate that a higher conversion of liquid CO₂ to CO₂ hydrate is needed to form negatively buoyant particles in seawater when compared to freshwater, due primarily to the increased density of the liquid phase but also due to processes involving brine rejection during hydrate formation.

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