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Growth-controlling processes of CO_2 gas hydrates

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ABSTRACT

During dissolution of liquid or gaseous CO_2 into the ocean, a potential process for CO_2 ocean sequestration to offset global warming, a hydrate film forms at the CO_2-water interface and limits the CO_2 dissolution rate. By experimentally studying the conditions under which such a CO_2 gas hydrate film maintains a constant thickness, we determined the processes that control CO_2 hydrate growth rates. A constant film thickness cannot be maintained when the decomposition rate exceeds a certain critical value. The decomposition rate was varied by adjusting the flow velocity of a water stream directed perpendicular to the hydrate film. An increase of the flow speed increased the decomposition rate, which decreased the steady-state film thickness. However, at a critical value, net decomposition occurs and the hydrate film completely dissolves. The critical decomposition rates are roughly proportional to pressure and relatively independent of temperature from 274.6 to 278.7 K. The transport of H_2O through the hydrate layer to the growth sites near the CO_2-hydrate interface controls the growth rate when it is relatively small, but the supply of CO_2 molecules limits it at relatively high growth rates.