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Nano Porous Particle: A Novel Additive for Gas Storage Technology Based on the Hydrate Method

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This study investigates the thermodynamic and kinetic characteristics of nano porous particle as an additive in the formation of CH4 hydrate, essential for hydrate technology applications and energy estimation in gas storage process. Thermodynamic analyses were conducted with varying nano porous particle concentrations. Differential Scanning Calorimetry (DSC) was employed to determine phase equilibrium temperatures and pressures within the range of 3-10 MPa. As pressure increases, the endothermic peak shifts to the right, indicating higher decomposition temperatures, and the peak of hydrate decomposition intensifies, signifying enhanced hydrate formation with increased pressure. Phase equilibrium points measured by DSC align with existing literature values, indicating that nano porous particle does not alter CH4 hydrate phase equilibrium under varying pressure conditions.

The kinetics of CH4 hydrate formation were examined under different nano porous particle concentration. Observations show a reduction in the induction time with increased nano porous particle concentration, attributed to enhanced gas solubility and increased nucleation sites in the porous medium. The porosity, specific surface area, and mobility of nano porous particle accelerate hydrate formation and enable it to adsorb more CH4 than pure hydrate, emphasizing its role in gas storage.

Raman spectroscopy was employed to analyze CH4 solubility in water with nano porous particle. Results demonstrate an increase in solubility with rising nano porous particle concentration, suggesting nano porous particle's significant role in promoting CH4 hydrate formation. This indicates potential efficiency improvement in CH4 hydrate production by substituting pure water with nano porous particle.

The stability of this nano porous particle immersed in water for various durations was analyzed by XRD and SEM, and the results were consistent without obvious structural changes. BET analysis confirms the stability of pore diameter and specific surface area. The good stability of nano porous particle can ensure the effectiveness of nano porous particle as an additive in the hydrate system.

In summary, this study reveals the thermodynamic, kinetic properties of CH4 hydrate formation in water with nano particles, providing insights into its potential applications and efficiency improvements in gas storage processes.

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