

Micromechanical Cohesion Force between Gas Hydrate Particles Measured under High Pressure/Low Temperature Conditions

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To prevent hydrate plugging conditions in the transportation of oil/gas in multiphase flow flowlines, one of the key processes to control is the agglomeration/deposition of hydrate particles, which are determined by the cohesive/adhesive forces. Previous studies reporting measurements of the cohesive/adhesive force between hydrate particles used cyclopentane hydrates particles in a low pressure micromechanical force apparatus. In this study, we introduce a new high-pressure micromechanical force (MMF) apparatus to directly measure gas hydrate cohesive forces to measure the cohesive force of ice particles, mixed (methane/ethane, 74.7:25.3) hydrate particles (Structure II), and carbon dioxide hydrate particles (Structure I). This high pressure system has two cantilever fibers, one stationary and another controlled via a nano-manipulator. Size-controlled water droplets, approximately 500 μm in diameter, are placed at the end of the each cantilever fiber so that it can be converted into gas hydrates after the system is cooled and charged with the gas of interest. The cohesive forces are measured as a function of the contact time, contact force, temperature, and pressure, and determined from pull-off measurements based on the Hooke's law ($F = K_{\text{spring}} \times \Delta D$, where K_{spring} is the spring constant of the cantilever, and ΔD is the displacement of the cantilever). For the measurements performed of the gas hydrates particles in the gas phase, the determined cohesive force is about one order of magnitude higher than that of cyclopentane particles in liquid cyclopentane.