Promoting Gas Hydrate Formation for Improved Gas Storage Over HKUST-1

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As the energy demand increases globally, the use of natural gas as a source of fuel also increases. Natural gas requires purification and storage once acquired from a reservoir. Technology that can advance the efficiency of storage techniques is highly desired for both economic and environmental reasons. Two methods undergoing research currently as a means for methane storage are gas hydrates (e.g. ice-like structure that entraps gas molecules) and metal organic frameworks (e.g. porous material with both inorganic and organic components). In this study, the potential benefits of combining these two storage techniques was investigated using a high pressure differential scanning calorimeter. The metal organic framework used is HKUST-1, a material composed of copper nodes connected by 1,3,5-benzenetricarboxylic acid, as it has a large surface area (increases the gas-to-water contact area) and a thermally conductive framework (removes local heat of hydrate formation). When HKUST-1 was added to a water-methane system at high pressure and low temperature, HKUST-1 caused an increase in water-to-hydrate conversion from 5.9% to 87.2%, which increased the amount of methane storage relative to the amount of water in the system from 0.55 mmol/g to 8.1 mmol/g. The HKUST-1 also decreased the hydrate nucleation time by 4.4 hours. The nitrogen isotherm and powder X-ray diffraction of HKUST-1 before and after hydrate formation and dissociation indicate that the gas hydrates formed on the surface of the material, not inside of the pores. HKUST-1 exhibited high structural integrity after the formation and dissociation of gas hydrates, suggesting that the material would have a long lifecycle. This study concluded that HKUST-1 promoted gas hydrate growth significantly, and therefore increased the methane storage capacity.