Thermodynamic Study of New Hydrogen Storage Materials and Phase Change Materials

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Studies of economic, highly efficient and safe hydrogen sources play an important role in the development of fuel cells in vehicles. However, the state-of-the–art of hydrogen storage materials (HSMs) hardly meets the requirements designed by the U.S. Department of Energy (9 wt % for gravimetric hydrogen and 81 $kg \cdot m^{-3}$ for volumetric hydrogen) for on-board storage applications for 2015. Organic phase change materials (PCMs) have the advantages of large phase change enthalpy, high stability and relatively low super-cooling temperature, but their heat conductivities are very low. In recent years, studies on HSMs were performed in our lab.. The promising materials for HSMs studied in our laboratory include MHx: M= Mg, La, Ni, etc., alanate , borohydride and MOF were performed. The molar heat capacity of the MOF-177 was measured by a modulated differential scanning calorimetry (MDSC) over the temperature range from 260 to 360 K for the first time. The hydrogen storage performances of materials were improved by using catalysts with hydrogen spill-over effect or other additives. Furthermore the effects of multi-walled carbon nanotubes (MWNTs) on the phase change enthalpy (ΔH) and the thermal conductivity (κ) of a solid-liquid phase change materials (PCM), palmitic acid (PA), have been investigated in our laboratory. The results showed that both the ΔH and the κ of the composite were lower than that of PA when the loading of MWNTs was small. As the concentration of MWNTs in the composites increased, the ΔH of the composites was slightly improved and then decreased linearly. However, the κ of the composites was monotonously increased from the minimum value. When the loading of MWNTs increased to 5 % and no surfactant was added, the κ of the composite was enhanced to be 26 % higher than that of PA. The κ of the composite could be enhanced by cetyltrimethyl ammonium bromide (CTAB) instead of sodium dodecylbenzene sulfonate (SDBS) when the loading of MWNTs was small, as SDBS showed no obvious effect on the κ of the composites. The effects of surface modification of MWNTs on the ΔH and the κ of the composites have also been investigated.

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