

Thermodynamics of Dehydration in Zeolites for Thermal Energy Storage and Heat Pump Applications

Jie Wang and Philip S. Neuhoff
University of Florida

Zeolites have significant application in compressor-free heat pumps because of their high capacities to store heat energy and absorb water vapor. This kind of heat pump operates from low temperature energy such as solar and industrial waste heat and converts underutilized resources into useful energy. Zeolite-water is one of the most commonly used working pairs for heat pumps because it is non-toxic, non-flammable and of limited corrosiveness. Sorption capacities and heats of reactions are critical parameters for evaluating the efficiency and applicability of the solid-gas sorption cycle.

The present study investigates the thermodynamics of dehydration and rehydration of zeolites by a new gas absorption calorimetric technique, which employs simultaneous measurement of calorimetric response by differential scanning calorimetry and sample mass by thermogravimetric analysis. Example measurements and strategies for interpretation are presented for three natural zeolites : natrolite, analcime, and chabazite, whose heats of hydration are determined to be 516 kJ/kg, 389 kJ/kg, and 855 kJ/kg, respectively. The various characteristics of dehydration and rehydration of natural zeolites can lead to different applications in the heat pumps. Some abundant zeolites like chabazite with high hydration heat and stable sorption capacity are good replacements of the expensive synthetic zeolites for heat pumps. Some zeolites with high absorption rate such as natrolite can release heat quickly although it loses sorption capacity gradually after repeated uses. In the case of analcime, due to the slow hydration rate, there is no need to limit the initial amount of water vapor to control the exothermic reaction.