Mixed-metal Metal-organic frameworks as promising adsorbents for adsorption cooling system

Israt Jahan
Doctoral Student, International Institute for Carbon-Neutral Energy Research (I2CNER), and Department of Mechanical Engineering, Kyushu University, Fukuoka, Japan

Adsorption cooling system is a promising alternative to the conventional vapor compression refrigeration system with the features of low electricity consumption and environmentally friendly refrigerants. The adsorption-desorption process of the refrigerant within the adsorbent is utilized for the phase change of the refrigerant as well as to provide cooling. Hence, the thermophysical properties of an adsorbent, such as thermal conductivity, specific heat capacity, and the interaction between the adsorbate and the adsorbent, are crucial for performance improvement of the adsorption cooling system. Water, carbon dioxide, ethanol, and methanol are most commonly studied as refrigerant and silica gel, zeolite, activated carbon, and metal-organic frameworks (MOFs) as adsorbents. Water, a natural refrigerant, is regarded as a promising working fluid for adsorption cooling systems because it has the highest heat of evaporation. The adsorption of water onto MOFs gives an S-shaped adsorption isotherm, i.e., one single steep uptake step within the working pressure region, which outshines MOFs other conventional adsorbents from an energetic perspective. MOFs are a class of porous organometallic coordination compounds with large surface area, well-defined porosity, and high tunability. It is constructed by coordination of inorganic metal clusters and organic linkers. Their properties can be functionalized by design with a large variety of metal clusters and functional groups with promising properties. In this work, we studied the effect of the presence of mixed metals in the MOF clusters of two promising MOFs, Cu-BTC (BTC = 1,3,5-benzenetricarboxylate) and MOF-801. A large series of bi, tri, and tetra valent metals were incorporated in the structure of Cu-BTC by the one-pot synthesis method. In the case of MOF-801, two transitional metals, nickel and cobalt was doped in the pristine MOF. Their structural characterization and affinity towards water vapor were studied experimentally. It has been found that the mixed-metal MOFs that are isostructural with the pristine MOF show superior performance compared to the homometallic MOFs. The synergism derived from the presence of different metals in the structure and the additional degree of structural complexity makes mixed metal MOFs advantageous over single-metal MOFs to be applied as adsorbents for adsorption cooling systems.

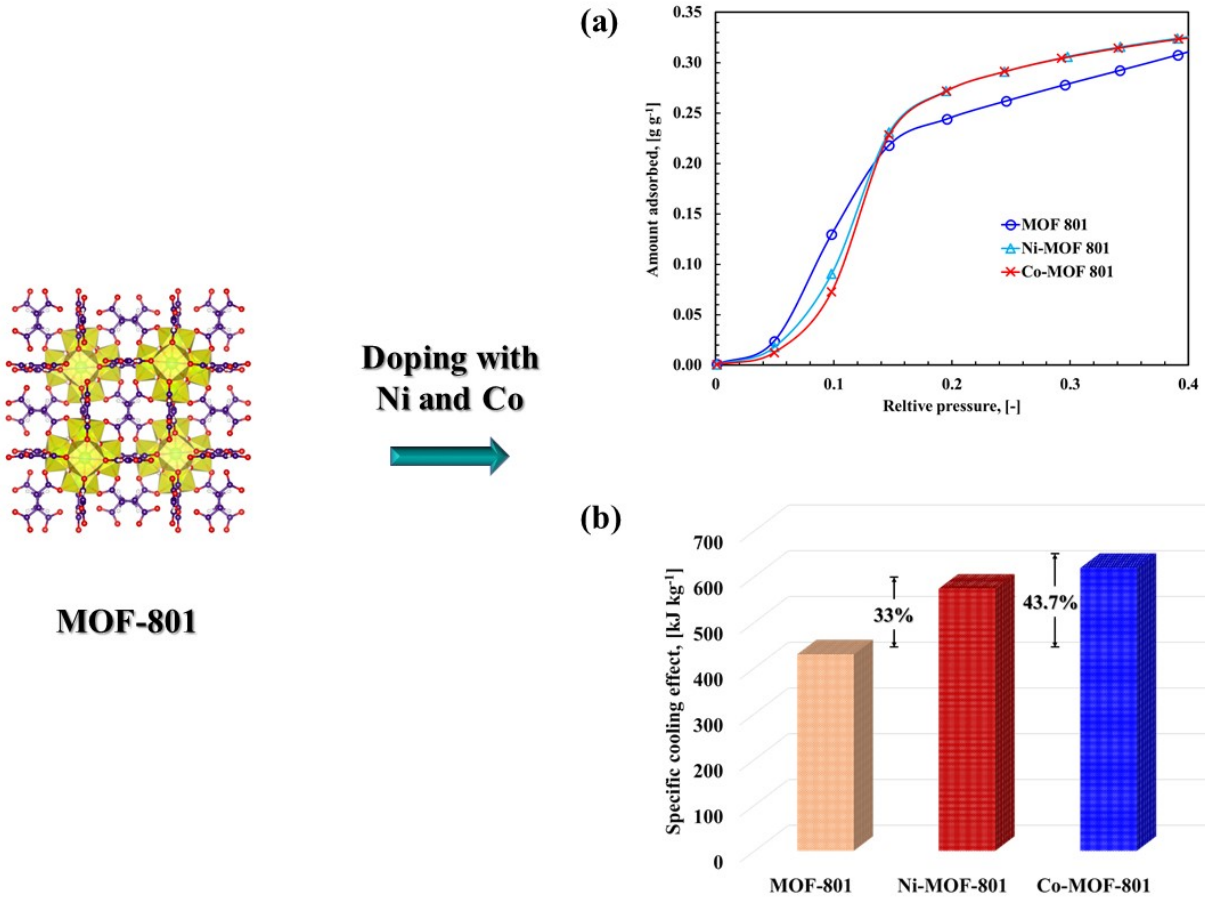

Fig. 1. Effect of metal doping on the properties of MOF-801, (a) water adsorption isotherm of MOF-801, Ni-MOF-801, and Co-MOF-801, (b) Specific cooling effect of the samples.