

STUDY ON THE SYNTHESIS AND CHARACTERIZATION OF COMPOSITE ADSORBENTS

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論文題名: STUDY ON THE SYNTHESIS AND CHARACTERIZATION OF COMPOSITE ADSORBENTS (複合吸着剤の合成と特性評価)

Thesis Summary

Low-temperature waste heat or solar energy-powered adsorption cooling system (ACS) is an energy-efficient and green technology, which is considered a promising alternative option to the conventional vapor compression (CVC) system. However, the adsorption cooling system needs more improvements for its extensive implementation. The performance of an ACS mostly depends on the properties of adsorbents and adsorbates/refrigerants. The poor heat transfer and low packing density of adsorbent materials are among the major limiting factors of an ACS. Consolidated composite adsorbents consisting of adsorbent, thermal conductivity enhancer (TCE), and binder are found very promising to overcome these shortcomings. This thesis consists of six chapters mainly focusing on the synthesis and characterization of novel consolidated composite adsorbents.

Chapter 1 describes the background of the adsorption cooling and heating system. It also includes a brief introduction of the adsorption cooling system along with its advantages and drawbacks. This chapter also presents the aims and objectives and the outline of the thesis.

Chapter 2 presents a comprehensive literature review on the thermophysical and adsorption properties of composite adsorbents developed so far for adsorption heat transformation applications. This chapter also includes the scopes of this thesis and the future research directions towards attaining adsorption-based efficient heating, cooling, and refrigeration systems.

Chapter 3 includes the significance of specific heat capacity, the experimental procedure, and experimentally obtained specific heat capacity data of parent materials and composites at the operating temperature range of the adsorption cooling system. This chapter also presents a generalized equation to determine the specific heat capacity of composite adsorbents. The beauty of this equation is that one can determine the specific heat capacity of any composite for any composition ratio by only knowing the specific heat capacity of parent materials. This equation greatly helped to determine the specific heat capacity of our newly developed composites.

Chapter 4 focuses on the synthesis, thermophysical, and water adsorption characterization of zeolite-based consolidated composite adsorbents. This chapter also shows the correlation between experimental adsorption uptake data and several widely used isotherm models. Besides, this chapter presents the net water uptake of each composite for adsorption cooling application. In this

study, it is observed that zeolite-graphene composites exhibit reduced specific heat capacity, enhanced packing density, thermal diffusivity and conductivity, and improved volumetric water adsorption uptake, which are very favorable for developing an efficient and compact adsorption cooling system.

Chapter 5 describes the synthesis and chemical characterization of several amino acid-based polymerized ionic liquids (AAPILs), which have been used as binders to develop activated carbon-based consolidated composite adsorbents. This chapter mainly stresses the synthesis, thermophysical, and adsorption characterization of activated carbon – AAPIL based composites to find a suitable binder. This chapter also presents the correlation of experimental ethanol and CO₂ adsorption uptake data with several widely used adsorption isotherm models. In this study, it is found that a smaller amount (minimum 3.5 wt%) of AAPIL is needed to get mechanically stable activated carbon-based consolidated composite adsorbent. In contrast, at least 10 wt% widely used binder PVA is required to develop a consolidated composite. Besides, AAPIL contained composites contribute to the thermal conductivity enhancement and adsorption capacity. All the findings of this study indicate that AAPILs are promising binders to synthesize efficient consolidated composite adsorbents.

Chapter 6 is the final chapter that deals with the significant findings of this thesis and recommendations for future researchers.