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A SOLAR-POWERED ICE-MAKER WITH THE SOLID ADSORPTION PAIR OF ACTIVATED CARBON AND METHANOL

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SUMMARY

This paper presents the description and operation of a solar-powered ice-maker with the solid adsorption pair of activated carbon and methanol. A domestic type of charcoal was chosen as the adsorbent, and a simple flat-plate collector with an exposed area of 0.92 m^2 was employed to produce ice of about 4–5 kg d^{-1} at an evaporator temperature of about -6°C. The above system could achieve solar refrigeration COP of about 0·1–0·12. With the description of the idealized refrigerating system, the influences of evaporating temperature, adsorbing temperature and condensing temperature on the COP were also analysed. Copyright © 1999 John Wiley & Sons, Ltd.

KEY WORDS: solar energy; solid adsorption; activated carbon and methanol; ice-maker

INTRODUCTION

Solar energy technologies attract world-wide attention owing to their non-polluting nature. Indeed, the technology is matured in some countries and for more than 30 years, exploitation has proceeded. Among various applications, refrigeration is one of the attractive applications of solar energy, because, the amount of sunshine and the need for refrigeration reach maximum levels in the same season. One of the very effective forms of solar refrigeration is the production of ice, because, ice accumulates much latent heat, thus the volume of the ice maker can be small. In 1981, Pons and Grenier (1986, 1987) worked on a solid adsorption pair of zeolite and water, to produce a refrigerating effect and the coefficient of performance was about 0.1. In 1986, they successfully experimented with the adsorption pair of activated carbon and methanol. Similar work was carried out by Exell *et al*. (1987) employing a flat-plate collector which consists of an array of 15 copper tubes. Sakoda and Suzuki (1986), utilizing solar heat, presented the advantages and limitations of the simultaneous transport of heat and adsorbate in a closed-type adsorption cooling system. In order to increase the desorption temperature and have a good cooling effect during the adsorption period at night, Headley *et al*. (1994) constructed a charcoal–methanol adsorption refrigerator powered by CPC concentrating solar collectors, but the solar COP was very low (about 0.02).

In China, Li *et al*. (1980) constructed a solar ice-maker with the absorption pair of ammonia and water. With the exposed collector area of 1·5 m^2, daily ice production reached 6·8–8 kg, and the solar COP of the system was 0·105, Lin *et al*. (1994) designed a solid absorption ice maker using calcium chloride + ammonia, which could produce ice of about 3·5 kg d^{-1}, with exposed collector area of 1·6 m^2. Information gathered from the literature reveals that the performance of various solar refrigeration systems varies over a wide range and the reported COP is only about 0·1.

An attempt has been made in the present study to improve the COP of such systems. This paper focuses on a solar-powered ice-maker with solid adsorption pair of activated carbon + methanol. A simple ice-maker

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