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Fundamental Study on the Probability of Oyster Shell Desiccant Cooling System Driven by Renewable Energy of Photo-Voltaic Effect

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Abstract : This paper has dealt with the probability of oyster shell desiccant cooling system driven by renewable energy of photo-volatic effect with fundamental experiment. The test materials for desiccant are activated charcoal, silica-gel, hi-dry, and oyster shell. The experiments were mainly performed with focusing on the observation of surface features, adsorption amounts of the adsorbent species, and the effect of temperature. Oyster shell has sufficient probability for using as desiccant in a air-conditioning system. Moreover, the heat releasing device would be attached in the system, the system based with oyster shell can be operated with high efficiency.

Key words : Oyster shell, Desiccant cooling system, Renewable energy, Photo-voltaic effect, Peltier element, Adsorption, Desorption

Nomenclature

A_{sur} : Specific surface area, [m^2/g]
d_{ave} : Average diameter of oyster particle, [mm]
M_{ads} : Non-dimensional adsorption amount (mass of adsorbate per mass of adsorbent), [-]
P_v : Partial pressure of vapor, [Pa]
P_s : Saturation pressure of vapor, [Pa]

1. Introduction

Recent years, the crisis of energy is growing seriously and also the contamination of ecology have been reverberated as international problems[1].

The social concern with energy crisis has been growing for the last several years. To realize effective air conditioning system and to solve the energy problem, the desiccant cooling system or the adoption idea is in the spotlight of new concept air conditioning system.

In warm climates, cooling is important for space conditioning of most buildings and the cooling load in refrigerator or air conditioning system increases during the daytime. So the efforts of reducing the cooling load have been performed at many places and it is regarded as necessary key point to whom design the system of cooling system.

Some studies[2]-[8] on desiccant are

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concentrated in finding and developing the raw materials of adsorbent.

The goal of this study is to clarify the possibility of oyster shell as a desiccant in a air conditioning system. Especially, peltier element and photo voltaic cells were used for remove adsorption heat generation of oyster shell in the process of adsorption.

In order words, this study is to introduce the new concept of air conditioning system driven by photo voltaic energy as operating power and oyster shell used for desiccant from fishery wastes. So this system would be achieved with solar energy as a renewable energy from photo voltaic cells and reuse the fishery wastes as desiccant without costs.

2. Characteristic of oyster shell and adsorption mechanism

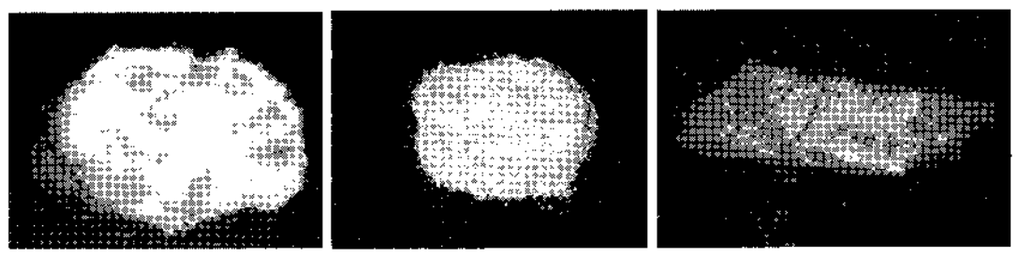
Fig. 1 show the apparent(Fig. 1(a), (b)) and microscopic photo(Fig. 1(c)) of oyster shell. Generally as it known, oyster shell has many cavities on its surface and these are widening the surface area. The table 1 shows the typical specific surface areas of adsorbents for usually used in industrial fields.

Table 1 Typical specific surface areas of adsorbents

Adsorbent	A_{sur} [m^2/g]
Activated carbon	300~1500
Activated alumina	200~400
Silica	300~900
Shell-based carbon	800~1500
Oyster shell※(particle) d_{ave}= 1.0[mm]	1.35~1.95

※ mainly used in this study with consideration of probability on the usage of desiccant

The specific surface area of activated carbon indicates the most high value than others in table 1. Although the value of oyster shell is very low, It can be derived from nature without any other efforts and costs.



(a) Real shell (b) Particle state (c) Micro size

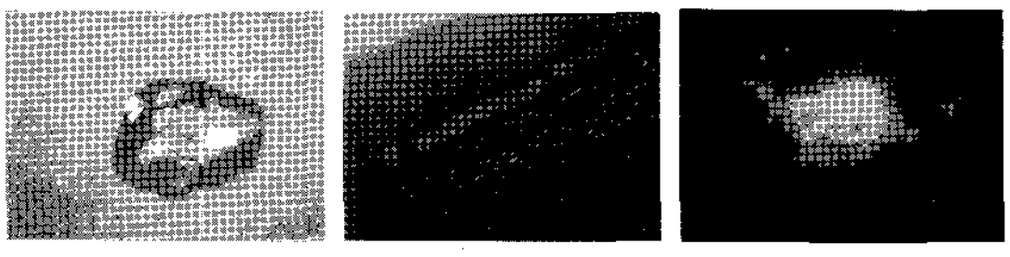
Fig. 1 Apparent and microscopic photo of oyster shell

Fig. 2 are the microscopic photos of silica-gel(Fig. 2(a)), activated charcoal (Fig. 2(b)), and hi-dry(Fig. 2(c)) for comparison with oyster shell. From the microscopic photos, they have similar surface shapes, especially Fig. 1(c) and Fig. 2(b), that have many corrugations on their surface so oyster shell can be used as desiccant for dehumidifying material in air-conditioning system.

Under the constant temperature condition, the process of adsorption on porous material can be illustrated as Fig. 3. It is mainly divided into three steps as follows.

- Step 1 : Molecule diffusion process into the thin layer of fluid(called as fluid film) which is attached on the adsorbent.
- Step 2 : According to developing of diffusion, the surface diffusion process which attach the vapor or gas along the pores. It is called as mixed diffusion because there exit two diffusions of pore diffusion and surface diffusion.

● Step 3 : Adsorption process in the pore adsorption sites.



(a) Silica-gel (b) Activated charcoal (c) Hi-dry

Fig. 2 Microscopic photos of adsorbent species

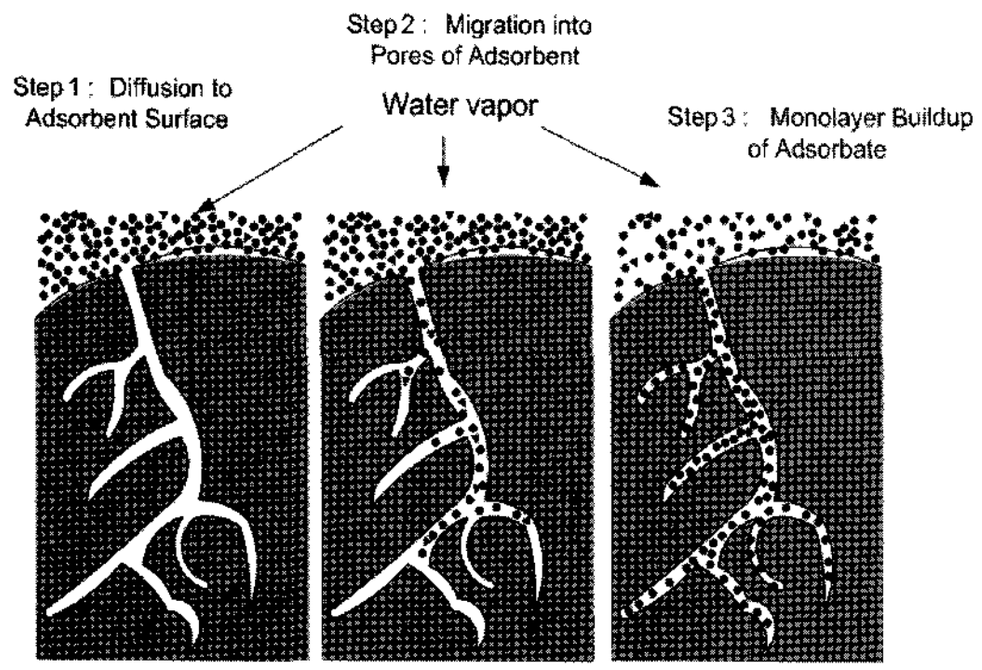


Fig. 3 Mechanism of adsorption

3. Experimental Apparatus and Method

To find the variation of surface with adsorption of vapor, the microscope (Olympus, BX60M) was used.

Fig. 4 indicates the experimental schematic to observe the variation of surface shape of oyster shell. The experiment was performed with constant temperature and humidity conditions. Excessive humid condition range was kept out.

As mentioned at introduction, to investigate the probability of oyster shell as a desiccant, some desiccants were used for examining the adsorption amount of vapor on their surfaces. Fig. 5 is the schematic of experiment.

The apparatus is mainly consisted of constant temperature and humidity chamber(Samheung instrument, SH-FDO 150), electronic balance(OHAUS, adventurer, ±2mg) and test section used for setting the desiccants.

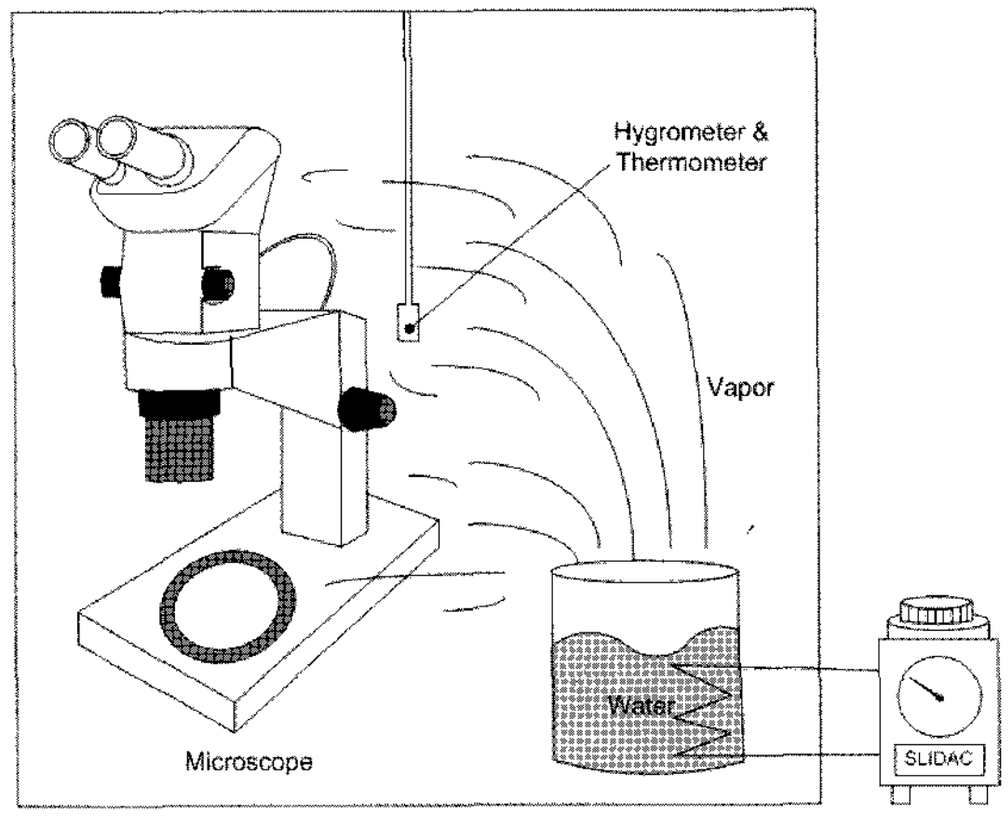


Fig. 4 Experimental schematic of microscopic observation

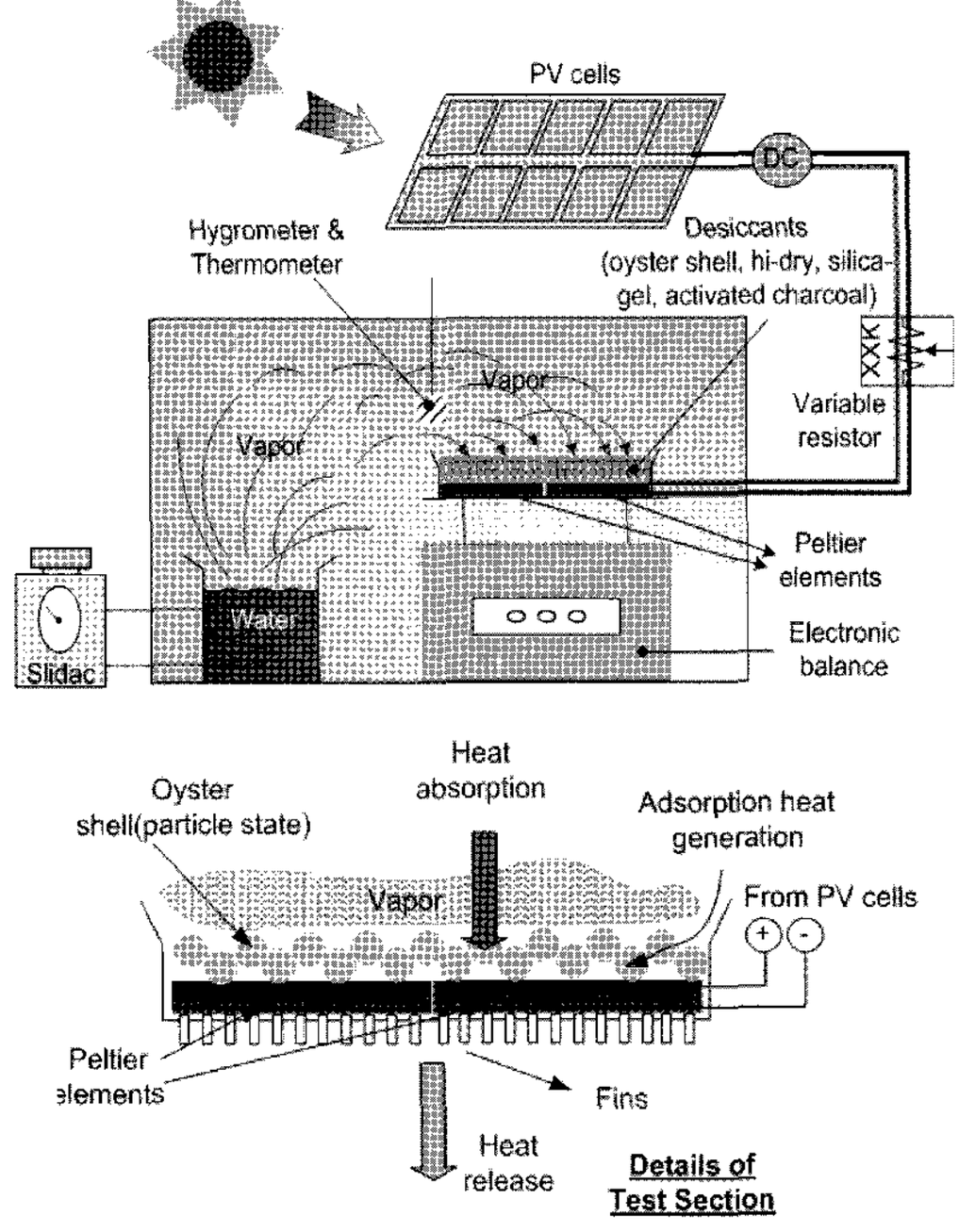
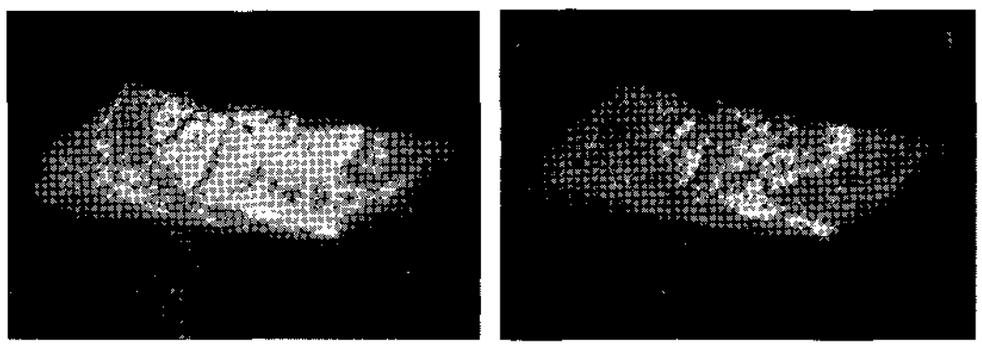


Fig. 5 Experimental schematic for measuring adsorption amount



(a) Perfect dry condition (b) Fully wet condition

Fig. 6 Microscopic variation of surface feature (in the case of oyster shell)

4. Acquired Results and Discussions

4.1 Microscopic surface variation of oyster shell

Fig. 6 are the microscopic photos of variation of surface features with adsorption of vapor. From Fig. 6(b), it is shown more softened compare to Fig. 6(a) also the corrugations were disappeared somehow. From these results, it could be existed the phenomena of swelling[9] on the oyster shell surface according to adsorption of vapor. The swelling is usually occurred on the surface of polymer with adsorption and the mechanism could be explained as Fig. 7.

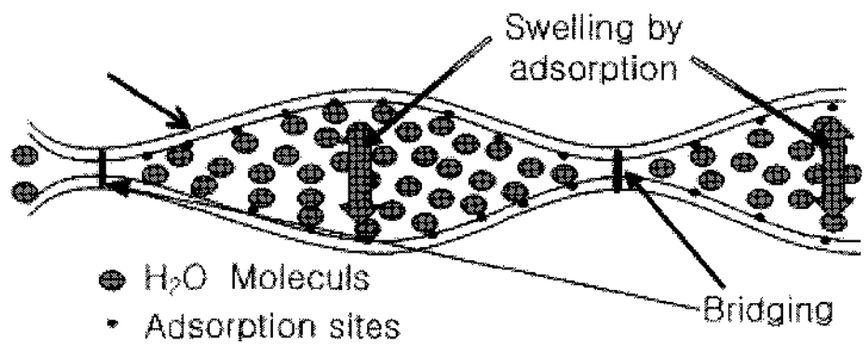


Fig. 7 Swelling mechanism by adsorption

4.2 Examinations of adsorption amount (Comparison of adsorbent species)

Fig. 8 indicates the results of adsorption experiments of silica-gel, activated charcoal, hi-dry(japan made; commercially used), and oyster shell. From Fig. 8, it is clearly known that the highest value of non-dimensional adsorption amount exists at activated charcoal among any other materials.

This result would be explained that the specific surface area indicated in table 1 of activated charcoal is the most high value so the non-dimensional adsorption amount would increase with this proportion.

As general characteristic behavior of adsorbent, all species of adsorbent used in this experiment showed that the non-dimensional adsorption amount have tendencies of increasing at higher saturation pressure of vapor.

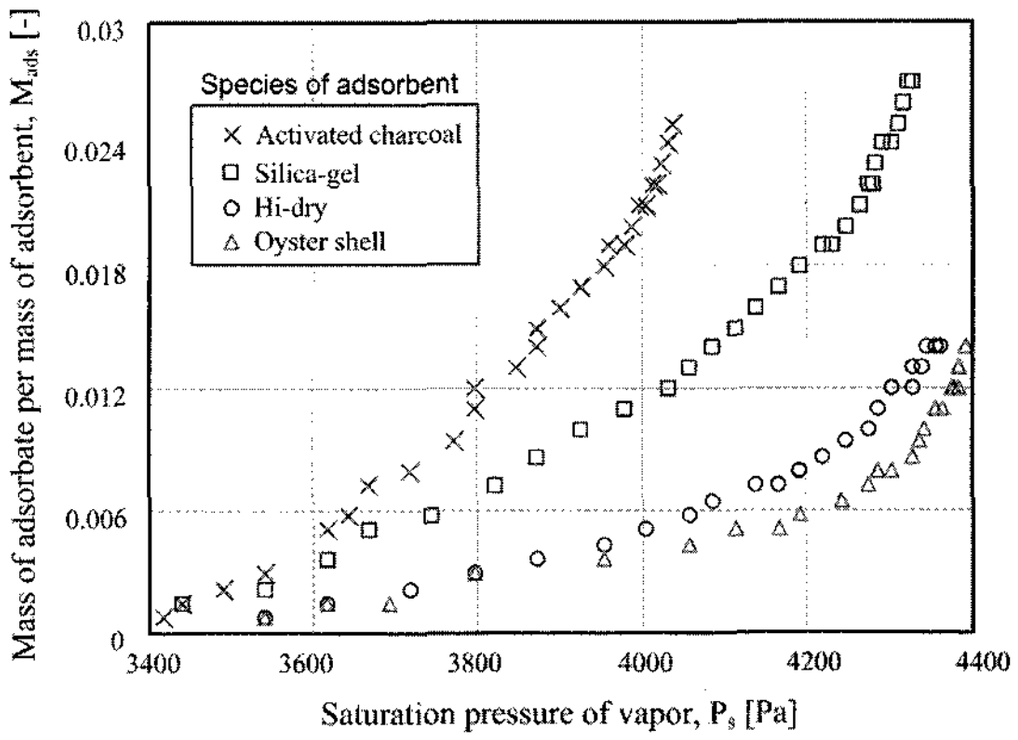


Fig. 8 Non-dimensional adsorption amount (Comparison of adsorbent species)

4.3 Examinations of adsorption effectiveness(Effect of induced current)

In order to investigate the effect of cooling of oyster shell, peltier elements and photo voltaic cells were used to remove adsorption heat generation in the oyster shell. The driving energy of peltier elements is derived from solar(Details of test section in Fig. 5).

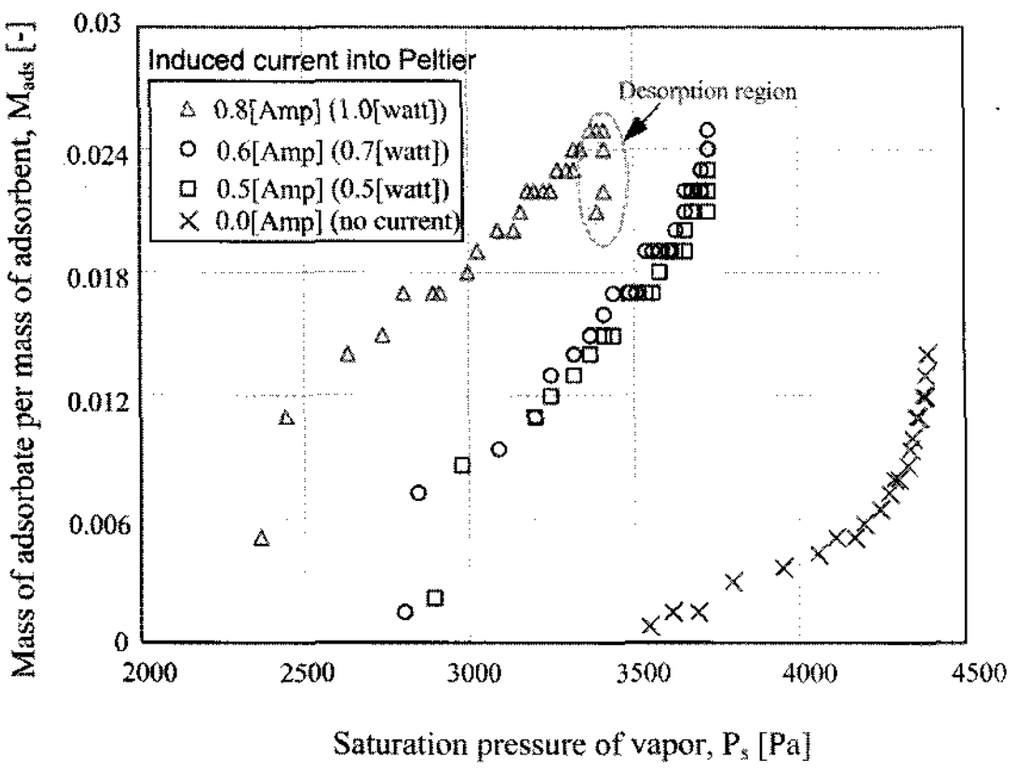


Fig. 9 Non-dimensional adsorption amount (Effect of induced current)

Fig. 9 is the results of induce current for cooling effect. From Fig. 9, it is clear that the cooling effect exists in this experiment and this effect is generally known phenomena among some references[10], [11]. The increase in electric current induced into peltier elements is effectively release the heat generation of adsorption. Consequently, the non-dimensional adsorption amount would increase with increase in electric current.

However, in the case of 0.8[Amp] of induced current, desorption process has been existed at the end region of experiment.

The reason of this phenomena can be explained from the characteristic of peltier effect. Heating part of this experimental apparatus is composed with rectangular fins to release the heat generation. According to the increase of induced current into peltier elements, the heat release fins can not release the adsorption heat sufficiently. Consequently, the heat of hot side of peltier is transferred into the cold side so the desorption is occurred.

4.4 Comparison with typical types of adsorption isotherm lines

The typical types of adsorption isotherm lines are well known as Fig. 10[11].

To compare with Fig. 10, the acquired results were re-plotted as Fig. 11 and 12. From Fig. 11, oyster shell and other

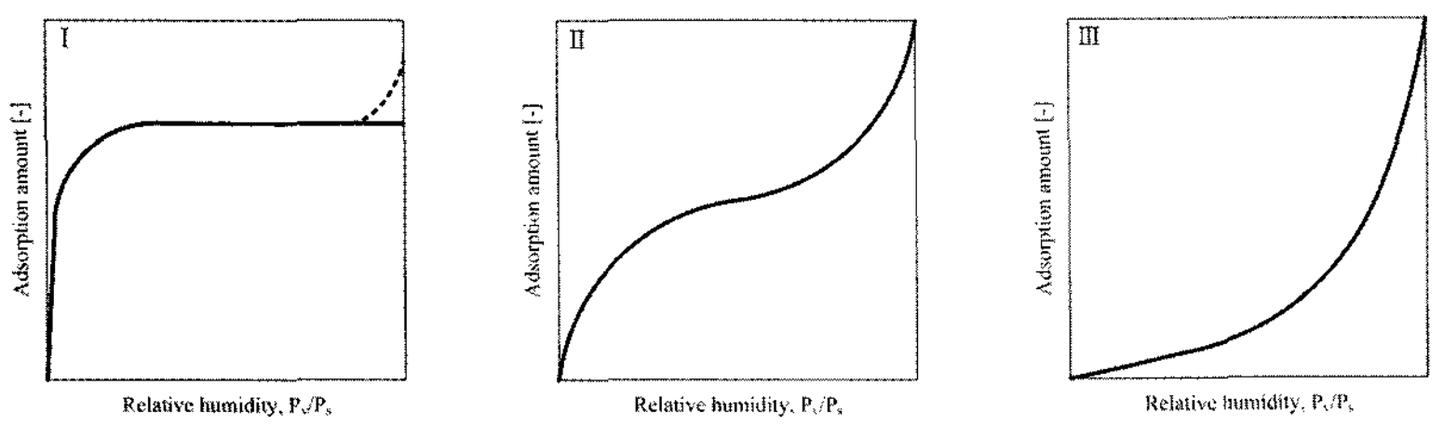


Fig. 10 Typical types of adsorption isotherm lines[11]

materials indicate the similar tendency with type III of Fig. 10. The type III is physical adsorption characteristic which is suitable for multi-layered molecular adsorption. And it is generally considered unfavorable for adsorption. On the other hand, the data of adsorption amounts in Fig. 12 are increased with the increasing of induced current into peltier elements. This means that the effect of adsorption heat release enhances the efficiency of adsorption. Consequently, the non-dimensional adsorption amount gradually approaches to the type II of Fig. 10 with increasing electric current. The type II is considered favorable for adsorption.

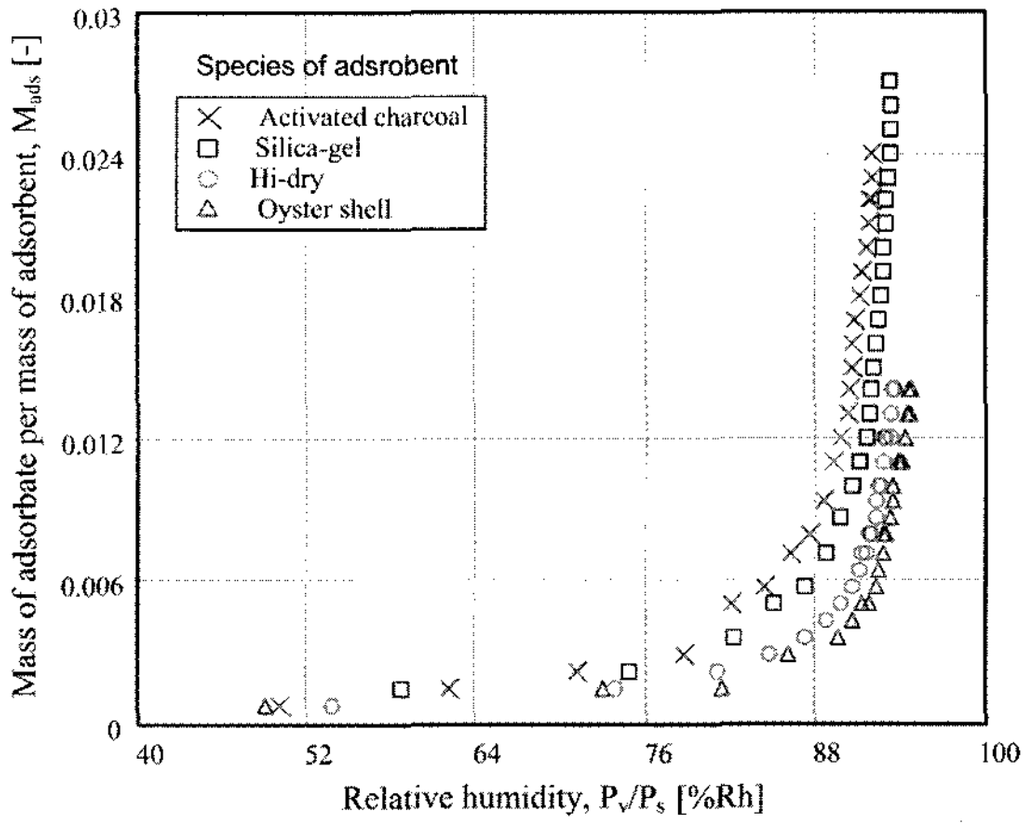


Fig. 11 Non-dimensional adsorption amount of adsorbent materials according to relative humidity

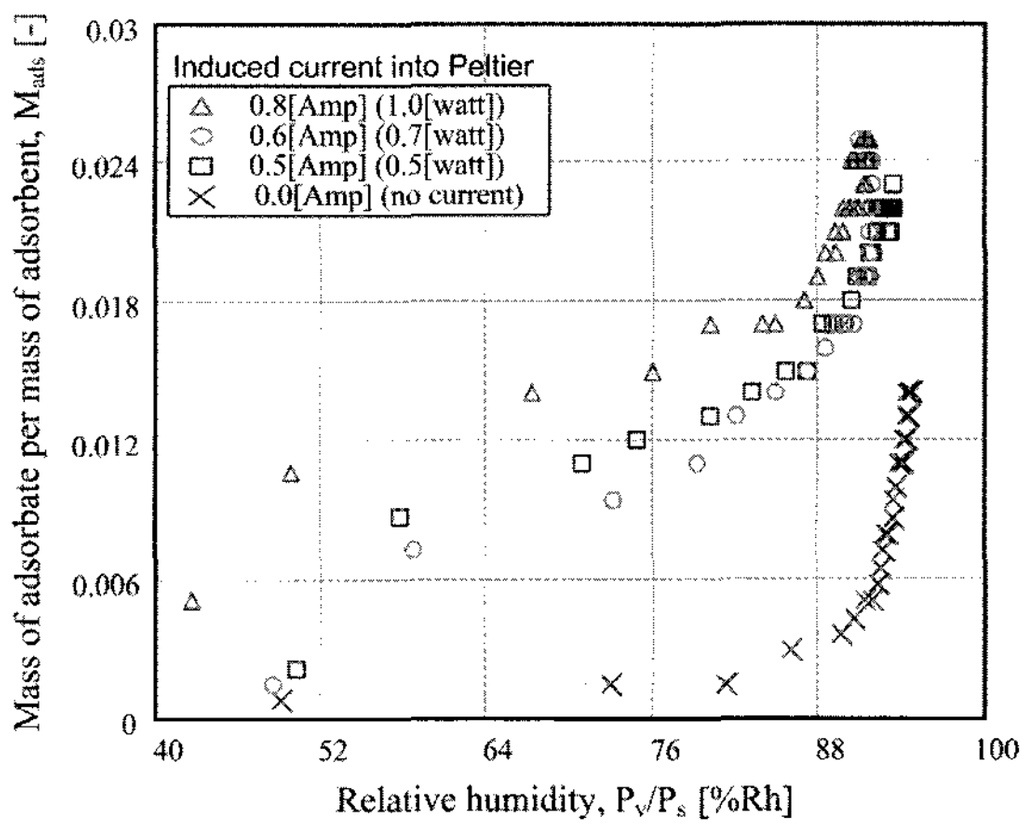


Fig. 12 Effect of induced current into peltier elements

5. Conclusions

The probability of oyster shell desiccant cooling system driven by renewable energy of photo-volatic effect was experimentally examined. It is clarified that the oyster shell has sufficient probability for using as desiccant in a air-conditioning system. Moreover, the heat releasing device would be attached in the system, the system based with oyster shell can be operated with high efficiency. The acquired main conclusions are summarized as follows.

1) Oyster shell has similar surface feature with other adsorption materials. This means that it can be used as desiccant material in a air-conditioning system.
2) As general characteristic behavior of adsorbent, all species of adsorbent used in this experiment showed that the non-dimensional adsorption amount have tendencies of increasing at higher saturation pressure of vapor.
3) Increase in electric current induced into peltier elements is effectively release the heat generation of adsorption. Consequently, the non-dimensional adsorption amount would increase with increase in electric current.
4) The non-dimensional adsorption amount of oyster shell gradually approaches to the type II(typical adsorption isotherm line; favorable for adsorption) with increasing electric current.

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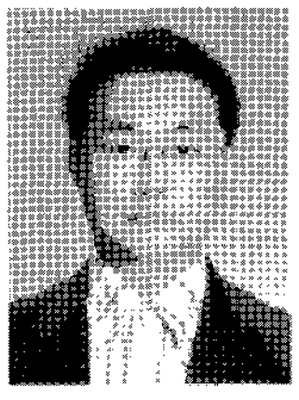
Author Profile



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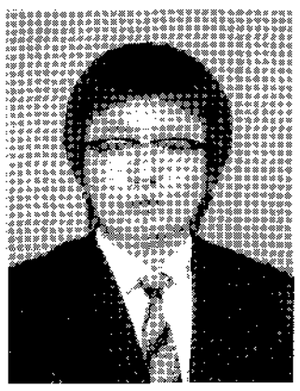

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