Experimental study on the cool storage performance of super absorbent polymers for cool storage clothes

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Abstract. In this paper, a kind of cool storage clothes which can cool the human body in high temperature condition is put forward. Super absorbent polymers was selected as a cold storage material, through at the normal and extreme environment simulation, the cold storage materials were prepared with different composition, and their performance was tested. Test results show that: under normal temperature conditions, the 1:50 concentration of super absorbent polymers continued to release the longest cooling time, compared with pure water, cooling time extended 43 minutes by about 30%; under the condition of 37°C, the 1:100 concentration of super absorbent polymers continued to release the longest cooling time, compared with pure water, cooling time extended 105 minutes by about 50%.

1. Introduction

As known to all, the traditional cooling method is not enough to improve the comfort of the human body under high temperature environment, and the superabsorbent polymers is a new type of functional polymer material, which has excellent performance[1-3] and wide range of uses[4-5], relative to water, eutectic salt storage and ethylene glycol solution storage, super absorbent polymers storage has many advantages.

As it was shown above, in view of the universality of the thermal comfort problem in the extreme environment, so a special cold and hot storage clothes need to be developed, the clothes can be cooling in high temperature environment, low temperature heat production, to meet the thermal comfort requirements at the same time, must also have low cost, simple structure and portability and other requirements.

2. Experimental system and process

As shown in Fig.1., the cool storage clothes can be divided into three parts: the cool storage device, the circulation heat exchange system and the power supply device. Cold storage capacity of the device is brought to the whole clothes, by cyclic heat transfer between the circulation heat exchange system and the cool storage device. Copper tube with good thermal conductivity, was used as the heat exchange tube between the cool storage device and the circulation heat exchange system. The circulating water pump in
the circulation heat exchange system drives the water to flow in the circulating pipe, and the water which is cooled or heated is guided to each part of the body. In addition, in general, cool storage clothes in the outdoor sunny places, electrical energy is supplied to the DC circulating pump through the thin film solar cell, in order to reduce the use of personnel with large capacity battery weight, saving energy and reducing the weight of the system.

Cool storage in the storage material selection of clothes is the most critical part, and super absorbent polymers as a new type of polymer composite phase change storage material, has strong water absorption properties and gel strength, which can effectively extend the freezing and the length of the, because of its water absorption after the formation of the gel strength, to avoid melting water leakage.

![Fig.1. The structure of cool storage clothes](image)

Super absorbent resin has the advantages of low cost, non-toxic, odorless, no stimulation to the skin, so the use of super absorbent resin as a cold storage material in the cool storage device. In this paper, five kinds of super absorbent resin with different proportions were prepared, and then the cool storage and heat release experiments were carried out, to study the effect of slow cooling performance and duration on the weight and volume of the whole system. The experimental process is as follows:

1. Preparation of low temperature treatment equipment (refrigerator), packaging bags, electronic scales, temperature measurement equipment.

2. Super absorbent polymers were prepared by the electronic weighing scale, and the 1:20, 1:50, 1:100, 1:150, 1:200 super absorbent resin hydrogels (100g) were prepared respectively.

3. Each super absorbent polymersis encapsulated by using a packaging bag and sealed with a pure water sample (100g).

4. The samples were placed in the low temperature treatment equipment for a long time (this experiment is 72 hours), the freezing temperature is -18°C, each sample can reach the limit when the cold storage capacity can be taken out for the next test.

5. Computer is connected with a temperature measuring device, connected to the 7 channel temperature probe test: test samples will be placed in insulation materials, avoid heat transfer error, the temperature probe is attached to the sample surface, you can see the sample temperature change.

6. As Fig. 2 shows, the cold storage reached the limit of the sample is placed under the environment of room temperature (26°C), temperature data line and quickly connected temperature measuring equipment, due to its actual application condition on the body surface for cooling the sample surface, so the temperature data line is placed on the surface of the sample, observe the change of the temperature measuring equipment in the experimental data was recorded.

7. As Fig. 3 shows, the constant temperature heating surface will be placed in the cold storage sample reached the limit of 37 °C (simulated body surface temperature), temperature data line and quickly connected temperature measuring equipment, due to its actual application condition on the body
surface for cooling the sample surface, so the temperature data line is placed on the surface of the sample, observe the change of temperature in the temperature measurement device, and record the experimental data.

8. Closing equipment, saving data and analysis.

3. Results and discussion

The contrast experiment was carried out with the comparison of water storage, the environmental temperature was 26℃.

1. Under the condition of normal temperature and cold discharge, the comparison experiment of different concentration of super absorbent resin and pure water cold storage

The samples were placed in the environment of -18 ℃ for 72 hours, so that the cold storage capacity reached the limit, placed at room temperature using the temperature measurement equipment testing, temperature change curve shown in Fig.4.

| Concentration          | Time(min) |
|------------------------|-----------|
| 1:20 super absorbent   | 196       |
| 1:50 super absorbent   | 221       |
| 1:100 super absorbent  | 203       |
| 1:150 super absorbent  | 204       |
| 1:200 super absorbent  | 208       |
| Pure water             | 178       |

From the data in Table 1 show that the concentration of 1:50 super absorbent polymers discharging the longest, and compared with the pure water cool storage capacity, the cooling time of the super absorbent gel under the 1:50 concentration was extended by 43 minutes, and the cooling time
increased by about 30%.

Comparison of different concentrations of super absorbent resin and water storage under the condition of 37 ℃.

Experiments using constant temperature heating film constant (37 ℃) to simulate the human body temperature, the experimental samples, and the experiment process is the same as the above room temperature test, the temperature change curve shown in Fig.5.

Fig.5. Temperature variation curves of high water absorbent resin and pure water under simulated body surface temperature

Take the cold storage material 0 ℃ as the initial temperature, the temperature rises to the temperature of 22 ℃, the temperature of each sample is long as shown in table 2:

| Material Sample       | Time(min) |
|-----------------------|-----------|
| 1:20 super absorbent  | 171       |
| 1:50 super absorbent  | 188       |
| 1:100 super absorbent | 212       |
| 1:150 super absorbent | 181       |
| 1:200 super absorbent | 176       |
| Pure water            | 107       |

From the data in Table 2 show that the concentration of 1:100 super absorbent polymers discharging the longest, and compared with the pure water cool storage capacity, the cooling time of the super absorbent gel under the 1:100 concentration was extended by 105 minutes, and the cooling time increased by about 50%. This has a great advantage in the application of cool clothes.

4. Summary
In this paper, the results obtained, the phase change latent heat of super absorbent resin is large, and it can be extended to about 50% at high temperature. It has a great advantage in the aspects of cold storage capacity, cost and material chemistry. In the same amount of cold storage needs, super absorbent resin is smaller, lighter weight, which is a great improvement in the comfort of clothing wear.

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