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Encapsulation of Phase Change Material into Cellulose as a Fever Compress

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The instant fever compresses on the market have a weakness, namely that they are only used once. Therefore, it is necessary to develop an instant compress that can be used repeatedly. Phase change materials (PCM) have unique properties because they can absorb and release heat at certain temperatures. However, PCM has the disadvantage of being in the form of a candle. Therefore, PCM needs to be encapsulated with other materials to strengthen its properties. In this research, a PCM-cellulose-based fever compress will be developed. The method used goes through 4 stages, namely: (1) cellulose synthesis (2) PCM encapsulation on cellulose (3) Printing of fever compresses (4) analysis and testing of the ability of the compress to absorb heat. The results of the research show that fever compresses are able to reduce heat. from 40 oC to 36 oC in 10 minutes. Adhesion test results show that the fever compress can be sticky for up to 24 hours. The best combination of fever compresses in the 20% eicosane cellulose encapsulation formulation. Fever compresses can be done repeatedly with the same results after being done 3 times.
Keywords: cellulose, compress, fever, phase change material, thermal

1. Introduction

In reaction to microbial invasion brought on by an infection or inflammation, endogenic pyrogens induce the hypothalamus' set point to alter to a higher than normal value, resulting in a process known as fever. Due to this, the current core body temperature was calculated below the new set value. In order to raise body temperature to the new set point, the anterior hypothalamus then activates heat generation systems (Plaza et al., 2016; Walter et al., 2016).

Each year, more people around the world experience fever from an infection. Seizures and mortality are frequently brought on by temperatures above 38 C (Rahmawati & Purwanto, 2020).

One of the non-pharmacological methods for reducing fever is to compress. Bulibuli and washcloths are compressive tools that can produce a warm or cold sensation that is relaxing where it is needed (Barabara et al., 2010). There are two types of compresses: warm compresses and cold compresses. Warm compresses can be applied to the area around big blood arteries with the goal of stimulating the hypothalamus to reduce body temperature. To eliminate the effector system, the hypothalamus sends a warm signal that stimulates the preoptic area of the hypothalamus. The body's heat output causes the peripheral blood vessels to enlarge in response to an effector system signal, which causes someone to perspire (Potter & Anne, 2011). The body reacts to the brain in order to control the temperature and prevent it from rising.

Children's body temperatures can be lowered with cold compresses. Vasoconstriction and shivering are induced by cold compresses, which cause the blood vessels to enlarge and the body temperature to return to normal. Additionally, the hypothalamus's collection of signals through the bone marrow causes the body to return to normal temperature as a result of applying cold compresses (Susanti, 2012). Research by Kurniawan (2018), It was discovered that using cold compresses had a substantial impact on the body temperatures of sepsis patients who were hyperthermic in the hospital's ICU room.

According to Walter et al. (2016), hydrogel has long been used as a plaster to lower fever. The administration of a fever-reducing hydrogel plaster is meant as supportive therapy or first aid to ease fever symptoms and give fever victims, particularly infants and young children, a sense of peace and serenity. Since antipyretic medications (drugs that lower fever) must still be administered or performed, compress therapy is not the primary therapy or medication. According to research by Darwis et al. (2010), the hydrogel has rather good qualities for use as a fever reliever, having a 70% gel fraction at a 35 kGy irradiation dose. When opposed to traditional compresses (using cold water), some benefits of hydrogel plaster include giving patients a soothing sensation, is easy to use, practical, and soft on the skin. It can also drop the temperature of the water in a container for tap water in a reasonably short amount of time (73–76%). within 21–24 minutes, go from 40 °C to 36 °C. As a result of the findings, it is possible to draw the conclusion that PVP-Starch hydrogel has the potential to be utilized to lower fevers.

Since hydrogel has a very high water content, it can help lower the temperature but more research is needed because it has a number of flaws, including a poor ability to stick to the skin. Additionally, the hydrogel can only be used once. In order to create materials with heat-absorbing properties that can be used repeatedly and have high stability, such as hydrogel, is necessary. Because PCM has various properties depending on temperature, it might be developed to replace hydrogel as a fever compress. By lowering the moisture barrier, PCM demonstrates temperature buffering abilities. According to its melting point, PCM releases the heat it has stored throughout the transition of energy (Yuannyuan, et al., 2017; Yoo, et al., 2017). In the transition phase, paraffin-encapsulated organic PCM can absorb 200 kJ/kg of heat of transformation, which is released into the environment following solidification. PCM is being used in several industries, including textiles and energy. The phase of PCM, which can alter its temperature range and heat storage capability, is what distinguishes it. Low toxicity, durability for repeated melting and compacting, excellent thermal conductivity, simplicity, and affordability are just a few benefits of PCM. PCM will turn from solid to liquid as it absorbs heat and back to solid when it releases heat. The PCM encapsulated with organic chemicals, such as paraffin and poly (urea-urethane), was created to suit the environment's fluid-free requirements for things like textile textiles, energy, equipment, and mobile phones. By expanding the heat transfer area, microencapsulation lessens the PCM's sensitivity to its surroundings, avoids PCM leakage when it is in the liquid state, and has the advantages of being stable, reusable, and long-lasting.

The PCM microencapsulated compress has the ability to absorb, store, distribute, and automatically release heat. It also has the ability to act as an intelligent thermostat, preventing abrupt fluctuations in human body temperature and establishing a cozy environment. It is anticipated that the PCM microencapsulated compress will be able to regulate temperature in both directions. The PCM will absorb heat while the body has a fever, but the PCM will release heat when the body temperature drops. to maintain a constant body temperature. Studies that used PCM as a cold compress have not yet been published.

Because of this, PCM will be created in this work by encasing cellulose in organic solvents [9–11] until a melting point of 40 ˚C is reached, which is the temperature at which the body experiences an infection.

2. Experimental Section

Materials

eicosane wax (Merck 99%) per year Aluminum foil, technical NaOCl, distilled water, technical NaOCl2, NaBr, NaOH, fever compress, zinc acetate dihydrate 95%, dibutyltin diaurate 95%, ethanol, and acetone are some of the ingredients.

Instrumentation

A hotplate stirrer, glass chemical, beaker, vacuum pump, 41 Whatman filter paper, print, ultrasonic Elmasonic S 300 H batch, and Buchi B are the instruments required for conducting the research 290 spray dryers as well as analytical tools.

Procedure

1. Micro-encapsulation of cellulose with eicosane

Cellulose is divariated at concentrations of 0.5, 1.2, and 1.0% by purifying water. Furthermore, eicosane with a weight variation of 5.10,20 times the weight of cellulose was added to the solution. After complaining for 24 hours, the excess eicosane on the top is taken.

2. Synthesis Phase change material

The PCM gel is made with gelated calcium-aided ions from the emulsion in a polytetrafluoroethylene mold. Then, 200 g of paraffin is emulsified with a cellulose concentration of about 0.2, 0.5, and 1% weight and poured into a 90 mm-diameter polytetrafluoroethylene mold. The emulsion is left uninterrupted for 2 hours at 4 °C for pre-gelation. After that, 20 mL of 1% t CaCl2 solution is added to the emulsion. After mixing for 10 minutes, a strong piece of gel is obtained. PCM compresses are obtained by drying the gel at room temperature. Then the PCM is cut and printed to the instant compression size (10 cm x 3 cm x 0.4 cm)

3. Adhesive testing and heat adsorption

The fever compresses are swallowed on a bottle at a temperature of 40 ˚C for 24 hours then the 24-hour heat decrease is measured using a thermometer.

3. Results and Discussion

Cellulose encapsulation with Eicosane

Cellulose encapsulation with eicosane aims to maintain the physical, chemical, and biological properties of eicosan with cellulose as a transducer [12].

In this study, cellulose was divariated at concentrations of 5, 10, and 20 percent by weight using purified water. The result was water-soluble cellulosis. Subsequently, eicosane was added to cellulase with a weight variation of 5.10,20 times the weight of cellulosa. In this addition, two layers are formed because cellulose is polar, while eicosane is non-polar. To be mixed, then a 24-hour mixture at a temperature of 40℃ as shown in Figure 1.

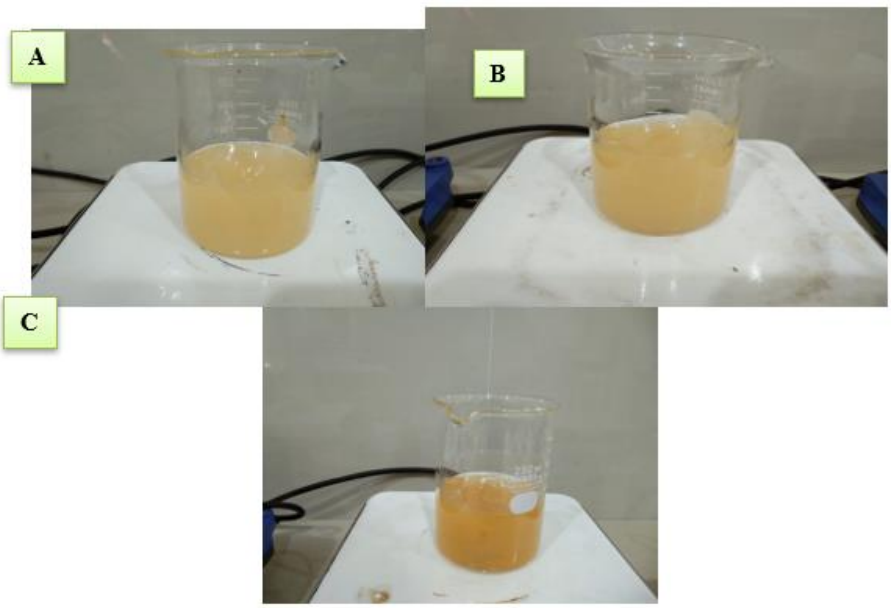

Figure 1. Cellulose with added eicosane. (A). 5 x w cellulose (B). 10 x w celulosa (C). 20 x w Cellulosa

Figure 1 shows that after 24 hours of coagulation, eicosane and cellulose can merge.

2. The manufacture of the phase-modifying material (PCM) of the PCM gel is made with a gelation assisted by calcium ions from the emulsion in a polytetrafluoroethylene mold. Then, 200 g of eicosane is emulsified with a cellulose concentration of about 2.5, and 20% weight is poured into a 90 mm-diameter polytetrafluoroethylene mold. The emulsion is left uninterrupted for 2 hours at 4 °C for pre-gelation. After that, 20 mL of 1% t CaCl2 solution is added to the emulsion. After mixing for 10 minutes, a strong piece of gel is obtained. PCM compresses are obtained by drying the gel at room temperature. The result of gel formation is shown in Figure 2.

Figure 2. PCM gel

Once the PCM gel is formed, then printing and cutting is done according to the size of the byebye fever as shown in Figure 3.

Figure 3. PCM gel 3.

Testing equipment

Equipment tests were conducted to see if the synthetic material could stick to the body. In the experiment, a bottle containing 40℃ hot water as shown in Figure 4. The temperature of 40 °C was used because this is the temperature when the body has a fever [13].

Figure 4. Testing equipment

Figure 4 shows that a synthetic fever compress can stick to the test bottle for 24 hours. After 24 hours, the compresses slowly start to release. This is because the phase-changing material used has absorbed heat and re-emitted heat at cold temperatures. It is consistent with the report that PCMs can store the transformation energy heat and release the stored heat according to its melting point [3,4].

4. Hot Adsorption Trials The heat adsorption trials were performed on PCM by looking at the temperature changes on the thermometer. As a control, a bottle without PCM was used. Tests were carried out on a closed bottle container (Figure 5.A) and an open container.

Figure 5 shows the heat adsorption capabilities of PCMs in open and closed containers resulting in the same trend change.

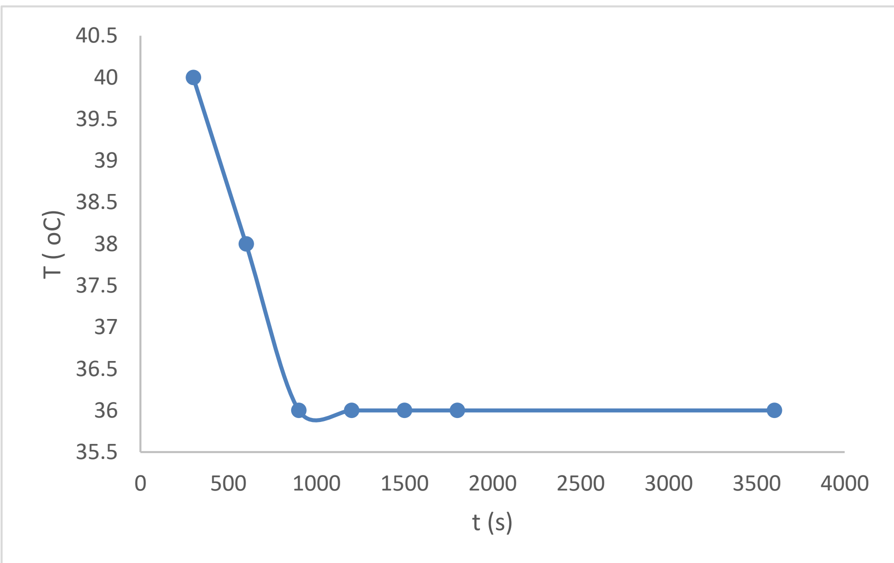

Figure 6. Chart of temperature drop on PCM

Figure 6 shows that the PCM is able to lower the temperature from 40 oC to 38 oC in 5 minutes. Then the next 5 minutes the PCM is able To reduce the temperature of 38 o C to 36 oC. After the next five minutes up to 1 hour the PCHM is unable to decrease the temperature. The water temperature remains constant at 36 oC. This can happen because of the melting point of 40 oC PCM. When the PCM temperature is 40 °C, PCM changes shape to liquid, now PCM absorbs heat. After absorbing heat and the water temperature to 36 o C, PCM returns to a solid re-form by releasing the heat it absorbs. An illustration of adsorption and heat release on PCM is shown in Figure 7.

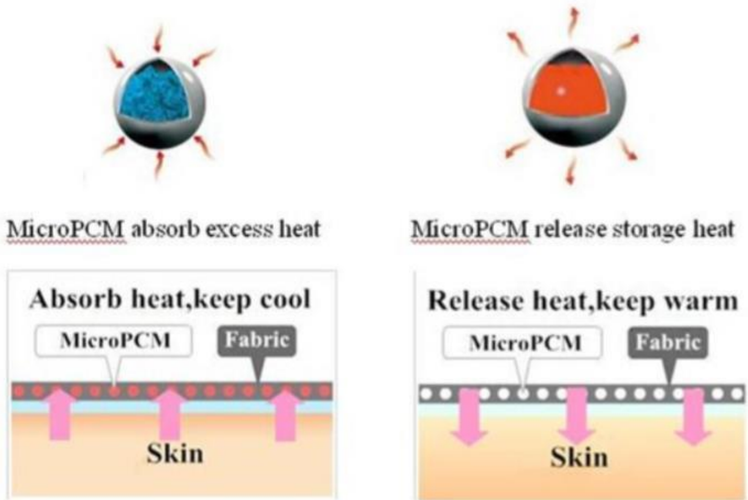

Figure 7. An illustration of PCM absorbing and removing heat [9]

4. Conclusion

The phase change material has been successfully made with the best formulation of encapsulating eicosane into a 20% paraffin. PCM is capable of decreasing heat within 10 minutes from a temperature of 40 oC to 36 oC. After 10 minutes the water temperature decreases constantly at 36 o C. The PCM can be used as a repeated instant compression with a 24-hour set.

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