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Chemical Experimentation for Solar Pain Reliever

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Abstract:
The Solar Pain Reliever is a cutting-edge device that combines renewable energy and therapeutic relaxation. By harnessing the power of the sun, the Solar Pain Reliever utilizes small solar panels to convert sunlight into heat energy to provide gentle and comforting heat therapy. This innovative device offers an eco-friendly alternative to traditional massagers by reducing reliance on electricity grids. The project is a result of thorough research on menstrual and general abdominal pain, its remedy, need for a solution, market survey and technical aspects like use of renewable energy, chemical experimentation, electrical design and ergonomics of product design.
It is designed to provide users with a soothing massage experience, relieving muscle tension and promoting relaxation. Its versatile nature allows for indoor and outdoor use, catering to individual preferences and providing flexibility in various settings. With an emphasis on sustainability, it encourages eco-conscious living while enhancing personal well-being.
In summary, the Solar Pain Reliever offers a subtle and sustainable solution for relaxation. The product provides users with a therapeutic heat and massage experience while attempting to minimize environmental impact.

Keywords: *Solar Energy, Electric Energy, Power generation, therapeutic experience*

Literature Review
A thorough investigation of existing research and prior developments is indispensable when designing a product. Understanding the landscape of solar-powered massagers and related technologies is vital for creating an innovative and effective product. By exploring published works, patents, and academic papers, we were able to gain valuable insights into the state-of-the-art advancements in solar energy applications and their integration into wellness devices. A study from 2012 aimed to determine the frequency of dysmenorrhea, as identified by different definitions, in a population of young women. The study concludes that menstrual pain is a very common problem, but the need for medication and the inability to function normally occurs less frequently.[1] Nevertheless, at least one in four women experiences distressing menstrual pain characterized by a need for medication and absenteeism from study or social activities.

Massage Therapy

The objective of researching on therapeutic massages is to learn about the different effects of these massages and to pinpoint the locations where the massages must be applied to. Therapeutic massage, a manual manipulation of soft tissues, has been practiced for centuries across various cultures for its potential health benefits. Today, it remains a popular complementary and alternative medicine (CAM) intervention used to address various physical and mental ailments. This literature survey explores the current state of research on therapeutic massages, examining their efficacy, diverse techniques, and potential applications. Several studies have investigated the diverse benefits of therapeutic massage. A systematic review of randomised clinical trials were carried out on people with musculoskeletal disorders. After carrying out therapy and testing the results on 95 eligible participants it was found that massage therapy as a standalone treatment reduced pain and improved function compared to no treatment [2]. Another test in 2021, carried out pre and post tests on 31 participants and were given 15 minute massages that lead to the result that it must be added to routines of the people for reducing anxiety levels and increasing job satisfaction[3]. Now with a focus on deep tissue chronic pain, massage therapy was carried out with significant difference in the two control groups, ones that were given regular hand massages and those that were given deep tissue massages. Deep tissue Massages was found to be statistically a better therapy in terms of satisfaction and relaxation[4].

Exothermic Reactions

Carbon's isotopes with other elements produce heat reactions that can be used but only work once and would thus need a continuous supply of these elements[5]. A chemical structure that heats up when electric current passes through and reforms itself into it's original form when the circuit is left open was needed. Reactions and Rearrangements by crystal structures was researched into with a motive to find one that would fulfill it's purpose[6]. Trihydrate structures were found to have reversible reactions. Depending on the voltage provided it either rearranges into liquid state or remains in a heated solid state. The liquid state provides the required conductive heat inside a tight enclosed package like structure that is resistant to melting while also does not corrode on coming in contact with liquidised trihydrate[7].

Heating pads typically use exothermic reactions to generate heat and provide warmth. Exothermic reactions are chemical reactions that release energy in the form of heat. The heat produced during these reactions is harnessed to warm up the heating pad and provide relief for sore muscles, cramps, or to keep warm in cold environments. There are various types of exothermic reactions used in heating pads, and the specific reaction can vary depending on the brand and type of heating pad. Some common exothermic reactions used in heating pads include:

Iron-Oxidation Reaction

$Fe_2O_3(s) + 2\ Al(s)\ Al_2O_3 + 2\ Fe(s) + \Delta H$

Some heating pads contain iron powder and sodium chloride (salt) sealed in a pouch. When the pouch is exposed to air, iron reacts with oxygen (oxidation) to produce iron oxide and release heat in the process. To understand the underlying chemical process that powers these heating pads, we delve into the fascinating world of the thermite reaction between aluminum and iron(III) oxide. This experiment sheds light on the exothermic nature of this reaction, which is harnessed to generate heat in modern heating pads.

Salt Crystallization

$CH_3COONa + H_2O\ Na + CH_3COO + \Delta H$

Certain heating pads use a mixture of water and sodium acetate, which is a supersaturated solution. When the metal disk inside the pad is clicked or flexed, it acts as a nucleation site, causing the sodium acetate to crystallize rapidly, releasing latent heat in the process.

Calcium Oxide and Water Reaction

$CaO + H_2O\ Ca(OH)_2 + \Delta H$

Some heating pads utilize a combination of calcium oxide (quicklime) and water. When the two substances come into contact, they react exothermically to produce calcium hydroxide and release
heat

Testing Stages

Before coming down to the final design for the Solar Pain Reliever, shortlisted concepts from initial ideas were worked upon after theoretical study to verify which of them would work best for our product.

Chemical experiments for effective heating

In the initial phase of experimentation, three different exothermic chemical reactions involving Iron oxide and Aluminium, Sodium Acetate and Water, and Calcium Oxide and Water were examined. The evaluation focused on calculating heat generation and temperature release for each reaction. Among them, the reaction between Sodium Acetate and Water yielded the desired temperature of approximately 55 degrees Celsius, meeting the criteria for the open container experiment. Consequently, this reaction was deemed successful as it fulfilled all necessary parameters for the intended product.

Performing Exothermic reaction of Sodium Acetate Trihydrate
Materials and Methods

For the experiment, the equipment available in the chemistry lab were used. Equipment used:
1. Beaker
2. Bunsen Burner
3. Stirrer

Safety precautions

- Have the fume hood on.
- Have the doors and windows open.
- Have safety goggles and a jacket on, and gloves on.
- Prevent exposure of sodium acetate to air or water.
- Do not touch or eat sodium acetate - even if it is edible.
- Make sure the pan is clean of water.

Procedure

Before beginning the experiment, one must have a clear understanding of the VA principle and scale narrow-down approach. Let Y be the quantity of water and X be the quantity of sodium acetate trihydrate

Solution preparation

1. Begin trial with an initial value of z and scaling factor s.
2. Take a fixed volume of Y= 30ml. Mix X= 50g in Y ml thoroughly and allow them to dissolve partially in the beaker.
3. Now place the beaker containing X and Y to the Bunsen burner / hot plate or any other heat-adjustable modality and start heating the beaker containing the sample.
4. Stir until the complete salt gets dissolved in the Y ml of solvent. A clear solution is obtained at the end of dissolution.
5. The clear solution is labeled as sample A and the heating process is stopped. Allow the solution to cool to room temperature by sufficiently placing it in the external environment.
6. Now repeat the procedure for X=100g, 125g, 150g, 155g, 162g, 165g ; and let Y be the same throughout. As we increase the quantity of X, we shall label each solution in alphabetical order. So in the case of X= 100g, the sample will be labeled Sample B, and so on.

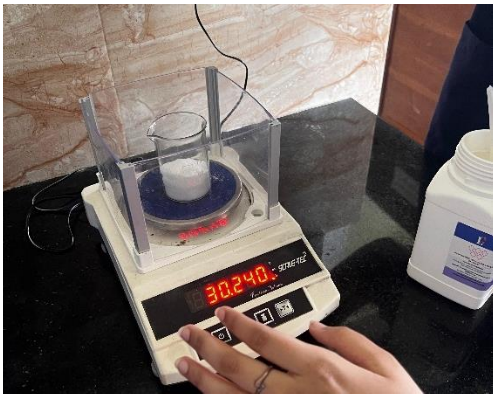

Figure 1 Measurement of Solute

Crystallization process

1. Once solution A is brought back to room temperature, place the temperature measuring device, say thermometer onto sample A.
2. Initiate the crystallization process by adding the same pinch of sodium acetate crystal to sample A.
3. The solution begins to change its phase from liquid to solid phase.
4. Start your stopwatch and note down the temperature changes in the tabulation for about 10 minutes at an interval of 30s.
5. The solution will begin to liberate heat, due to the exothermic principle
6. Repeat the crystallization process for other samples in the same way.

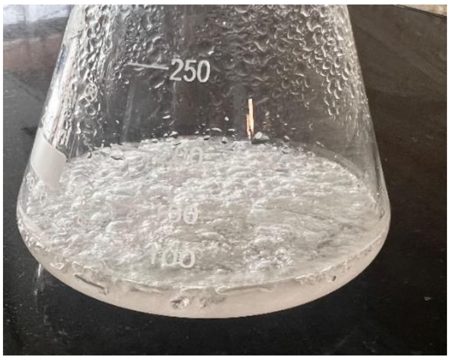

Figure 2 Formation of Trihydrate Crystal

Observations

Table 1 Experimental Observations

Sr.No	Solute(X)	Solvent(Y)	Heat	Temperature(°C)

1	10gms	30ml	47.59 kJ	25.09
2	20gms	30ml	95.18 kJ	50.11
3	30gms	30ml	142.77 kJ	75
4	40gms	30ml	190.36 kJ	100.25
5	50gms	30ml	237.96 kJ	125

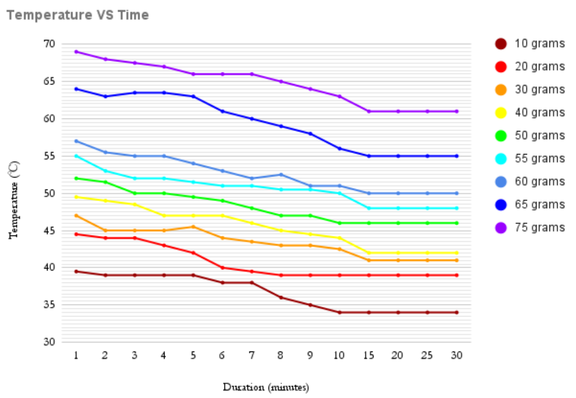

Figure 3 Temperature and Time Graph

Concluding the experiments performed before, this cooling curve shows how the solutions having different concentrations cool down over time. The solution having 75gms of sodium acetate and 50ml of water rose to a temperature of 69°C in the first minute, which after 10 minutes, fell down to 61°C. The solution having 55gms of sodium was observed to have the least slope (the sky blue line), starting at 55°C and after a while, ending at 48°C. As the product aims to maintain a constant temperature of 50-55°C, the solution having this concentration proved to be a successful experiment

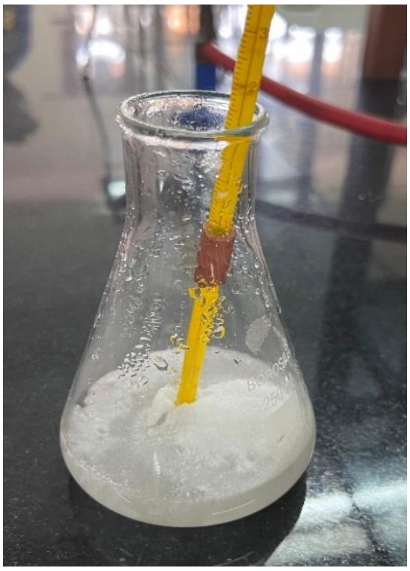

Figure 4 Temperature measurement of crystallization process

Theoretical Calculations vs Actual Experimentation

Table 2 Temperature with respect to solute (1)

	10 gms	20 gms	30 gms	40 gms	45 gms
1	39.5	44.5	47	49.5	50
2	39	44	45	49	49
3	39	44	45	48.5	49.5
4	39	43	45	47	48
5	39	42	45.5	47	48
6	38	40	44	47	47
7	38	39.5	43.5	46	46.5
8	36	39	43	45	46
9	35	39	43	44.5	45
10	34	39	42.5	44	45
15	34	39	41	42	44
20	34	39	41	42	44
25	34	39	41	42	44
30	34	39	41	42	44

Table 3 Temperature with respect to solute (2)

	50 gms	55 gms	60 gms	65 gms	75 gms
1	52	55	57	64	69
2	51.5	53	55.5	63	68
3	50	52	55	63.5	67.5
4	50	52	55	63.5	67
5	49.5	51.5	54	63	66
6	49	51	53	61	66
7	48	51	52	60	66
8	47	50.5	52.5	59	65
9	47	50.5	51	58	64
10	46	50	51	56	63
15	46	48	50	55	61
20	46	48	50	55	61
25	46	48	50	55	61
30	46	48	50	55	61

After carrying out the theoretical calculations, we observed the values while performing the Practical experimentation. It was concluded that the differences between the theoretical and practical's values is high. By manually calculating the heat generated and the temperature released, we observed that the temperatures obtained were greater than the practical values. The difference in the values could be due the environmental factors affecting the the practical experimentation.

Conclusion

The Solar Pain Reliever is a device designed to provide heat therapy using solar energy for pain relief. Chemical experimentation focused on exothermic reactions to generate heat. Sodium acetate trihydrate was chosen due to its ability to reach desired temperatures around 55°C. Experiments with different concentrations identified a 50g sodium acetate trihydrate to 30ml water solution achieved the target temperature range. While theoretical calculations predicted higher temperatures than those achieved in practice, the chosen solution demonstrated promise for further development.

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