THERMAL INVESTIGATION OF HYBRID NANO BASED PHASE CHANGE MATERIALS TO CATER COOLING NEEDS FOR ENERGY SYSTEMS

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Abstract - Day by day energy needs are increasing and there is a disparity between energy supply and energy request. Buildings are major consumers of energy of approximately 27% in the world wide. And also increasing anxieties about climate transformation and environmental emissions have directed to conserving energy through the development of numerous energy-effectual systems.

Latent thermal energy storage system is one important method amongst different thermal energy storing methods due to excellent features like high energy storage density, storing thermal energy at constant temperature. In spite of these it has very poor thermal conductivity of phase change materials which would reduce energy storage capacity and reduces time for melting and solidification thereby heat transfer from heat transfer fluid to PCMs (Phase Change Materials) decreases.

The main objective of current investigation is to enhance the thermal properties of PCMs with dispersion of hybrid nanoparticles which suit for development of Latent Thermal Energy Storage (LTES). The work proceeds with selection of PCM which suits for passive cooling applications having freezing and melting temperatures around human comfort conditions. Later, hybrid nanoparticles which can enhance thermal properties are synthesized using sol gel process and the as-prepared particles are characterized for studying the crystalline lattice structure of elements and surface morphology using X-Ray Diffraction, Field Emission Scanning Electron Microscope (EDAX Analysis also). The nanoparticles are dispersed in PCM with different weight percentages (0.2%, 0.4%, 0.6% and 1%) using ultra sonic vibrator. The as prepared hybrid nano based PCM samples were thermal investigated like melting, freezing, heat energy storage density, specific heat etc. using differential scanning calorimeter (DSC), Fourier Transform Infrared Spectrometry (FTIR) Results are validated comparing pure PCMs with NPCMs and predicting the optimized one among different proportions of Nano based PCMs for efficient passive cooling applications.

Key Words – X-Ray Diffraction(XRD), Field Emission Scanning Electron Microscope(FESEM), Differential Scanning Calorimetry(DSC), ultra sonic vibrator.

1. Introduction

The climatic change in the earth outcomes to relentless increment popular latest heat load in structures and in energy. Henceforth the solace cooling in building is increasing and the interest for consolation cooling is also expanding rapidly around the globe. The elevated cooling request brings about high top electric power request amid in the sultriest overdue

spring. This request makes any other trouble or takes a look at to electric utilities and their customers. Consequently, current-building administrations is probably deliberate to configuration provide adequate deliver to load and power use control with a selected give up purpose to get the most prudent operations.

heat energy stockpiling approach, it can be say as "putting away low temperature power for later use so that you can join the time hole between energy accessibility and vitality utilize" is taken into consideration as a helpful apparatus to address the request modern day heap of electrical customers.

Within the beyond, researchers were inquisitive about reducing the fee cutting-edge power and shop the diminishing fossil fuels. However, lately, the incentive has transformed from those areas latest reducing CO2 emission, from the environmental viewpoint. Electricity performance and the use of smooth and inexhaustible power, has received the fundamental care state-of-the-art the advanced and growing nations. Inside the current electricity and environment situation there may be simply no want to justify the need for electricity conservation. Growing efficient and cheaper power storage gadgets is as significant as growing new resources present day energy. Thermal storage minimize the time or price mismatch among thermal deliver and energy call for, and it plays a crucial position in energy conservation thermal storage enhance overall performance modern-day electricity systems with the aid of smoothing deliver and increasing reliability. The better performance might cause thermal conservation and enhance fee effectiveness. Modern day the renewable power sources can only offer electricity intermittently.

2. PROCEDURE:

SYNTHESIS OF NANOPARTICLES

Sol-gel process

The sol-gel process contains the development of inanimate networks through the development of a colloid period (sol) and gelation of the sol to form a network in a non-stop liquefied phase (gel). The precursors for synthesis of this colloid have commonly of a metallic component a rounded with the aid of number responsive ligands. The preliminary materialis process to shape a dissoluble oxide and varieties a sol in interaction with water or diluted acid. Deduction of the liquefied from the sol produces the gel, and the sol/gel change controls the element size and shape. Calcinations of the gel produce the oxide.

Sol-gel process discusses to the hydrolyzes and condensation of alkoxide-based precursors such as Si(OEt) 4 (tetraethyl orthosilicate, or TEOS). The reactions worried in the sol-gel chemistry primarily grounded on the hydrolyzes and condensation of metallic alkoxides M(OR)z can be define as monitors:

$$MOR + H2O \rightarrow MOH + ROH \text{ (hydrolysis)}$$

$$MOH + ROM \rightarrow M\text{-}O\text{-}M + ROH \text{ (condensation)}$$

The sol-gel procedure can be categorized by a sequence of different steps.

1. Forming of dissimilar steady solutions of the alkoxide or solvated metal precursor.
2. Gelation resulting from the creation of an oxide- or alcohol- bridged network (the gel) by a polycondensation reaction that results in a significantly rise in the viscosity of the solution.
3. Aging of the gel (Syneresis), meanwhile which the polycondensation reactions go on as far as the gel transfers

into a solidified mass, coexist by abbreviation of the gel network and exclusion of solvent from gel pores. Ostwald mellow (also make reference to as coarsen, is the phenomena by which small molecules are consumed by bigger molecules in the growing procedure) and phase changes may happen simultaneously with syneresis. The aging procedure of gels can exceed seven days and is dangerous to the stoppage of cracks in gels that have been cast.

4. Drying of the gel, when H2O and other unstable liquids are detached from the gel network. This procedure is complex due to essential changes in the shape of the gel.

The drying procedure has itself been fragmented into 4 different steps:

I. The constant rate period,
II. The critical point,
III. The falling rate period,
IV. The second falling rate period.

If isolated by thermal vaporization, the resulting monolith is termed a xerogel. If the solvent (such as water) is removed below supercritical or nearby super critical circumstances, the product is an aerogel.

5. Dehydration, during which surface-bound M-OH groups are detached, there by stabilizing the gel against rehydration. This is generally achieved by calcining the monolith at temperature up to 8000 C.

6. Densification and decomposition of the gels at high temperatures (T>8000 C).

materials procured

Phase change material (PCM)

- Paraffin C16 PCM

Chemicals for copper nano

- Precursor - copper acetate
- Stabilizing agent - polyvinyl pyrrolidone
- Reducing agent – sodium borohydride
- Distilled water was used for reaction
- Speed 450 rpm
- Temperature – 45 degree centigrade

Chemicals for silver nano synthesis

- Precursor – silver nitrate
- Stabilizing agent - polyvinyl pyrrolidone
- Reducing agent – ascorbic acid
- Distilled water was used for reaction
- Speed - 400 rpm
- Temperature – 45 degree centigrade

Stepwise procedure

1. 5g of cupric nitrate +30ml of distilled water (precursor solution 2) are mixed and dissolve it fully using magnetic stirrer at 50 degree Celsius, 350RPM.

2. Simultaneously, prepare a solution of 0.5g Polyvinylpolypyrrolidone (PVP) + 30mL distilled water at ambient temperature.
3. Slowly add the solution obtained from step 2 to the solution from step 1 while continuing the stirring process.
4. 1g of Sodium Borohydride + 30 mL Distilled water (strong reducing agent)
5. Transfer solution obtained from step 4 into a burette.
6. Add this solution drop-wise into the solution prepared in step 4 while continuing the stirring process.
7. Color changes from light bluish to cream color with pale white.
8. Keep titrating till the color change is observed.
9. Decant, if necessary. Wash with acetone and filter out the hybrid nano-particles using double filter paper. Keep the contents for drying.
10. Keep the contents for drying.

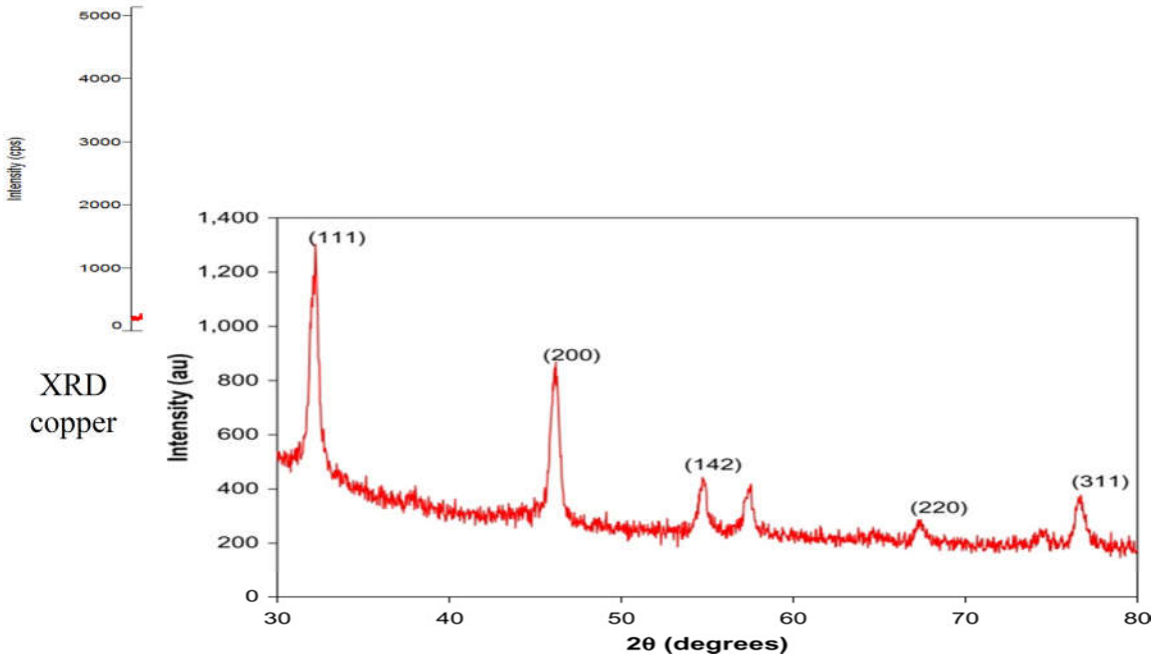
Preparation of Nano based paraffin C16 PCM samples

The synthesized solid nanoparticles copper and silver 50-50% were dispersed in the paraffin C16 PCM by using Ultrasonicator. The weight percentages are 0.2, 0.4, 0.6, 0.8 and 1. The samples were then sent for further testing.

3. RESULTS:

The dried solid nanoparticles were given for XRD testing to determine the size and FESEM testing to determine the surface morphology. The nanoparticles were further dispersed in paraffin C16 PCM in different weight ratios and given for DSC testing to determine the melting, freezing point and latent heat of the Nano based paraffin C16 PCM. The weight ratios of nanoparticles dispersed in paraffin C16 PCM are 0.02%, 0.04%, 0.06%, 0.08% and 0.1% by weight. The pure paraffin C16 PCM was also tested to compare the properties.

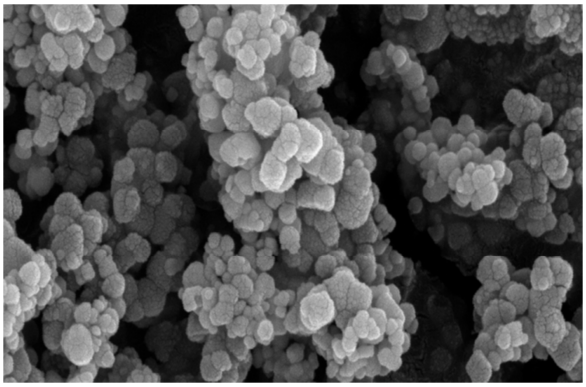
X-ray diffractometer (XRD) RESULTS



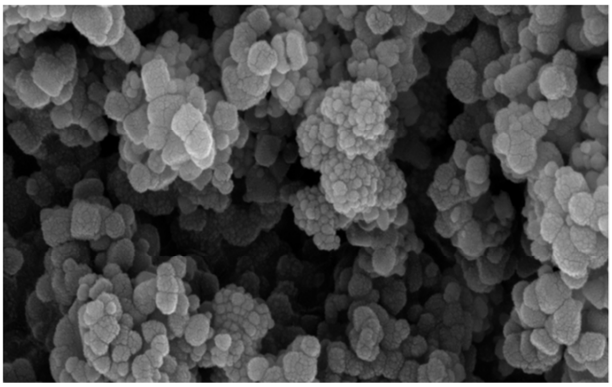
XRD result of copper

XRD results of silver nano

Field Emission Scanning Electron Microscope (FESEM) results



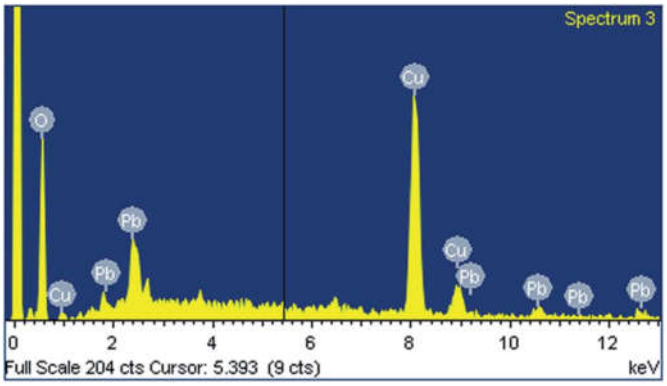
FESEM of Cu nanoparticles



FESEM of Ag nanoparticles

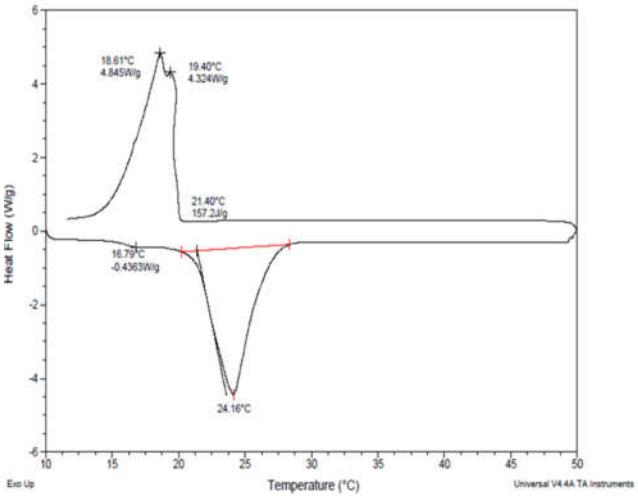
The studies of FESEM reveal that the particles produced were spherical in shape and is of Nano size. The size varies from 30mm to 140 mm with variations for both copper and silver nanoparticles.

EDAX analysis

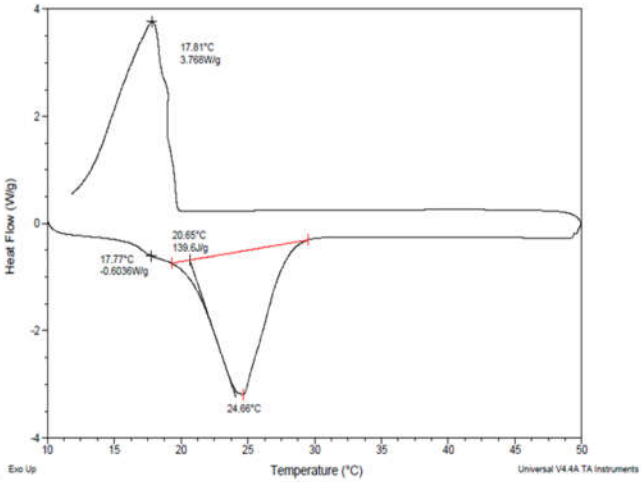


The EDAX analysis gives us the amount of crystallization and the weight percent of composition of the hybrid nanoparticles. From the figure above we can observe the crystallization percent of copper. On the top right corner we have the weight percentage of the elements.

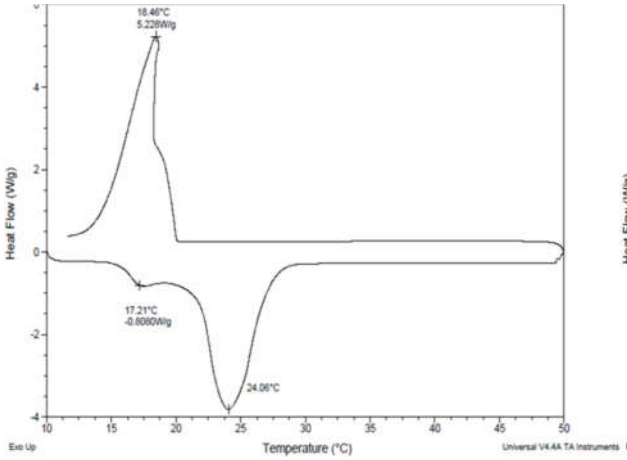
Differential Scanning Calorimetry (DSC) results



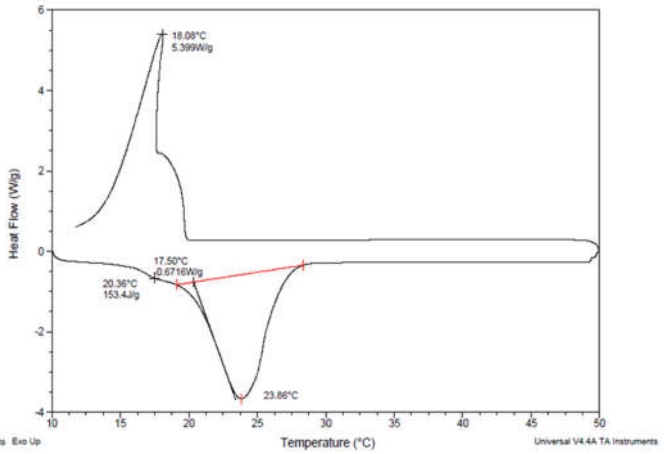
DSC for pure paraffin C16 PCM



DSC for 0.2% by wt. N-PCM



DSC for 0.4% by wt. N-PCM

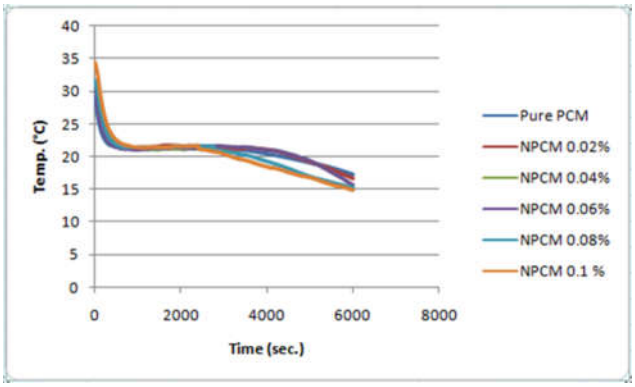


DSC for 0.6% by wt. N-PCM

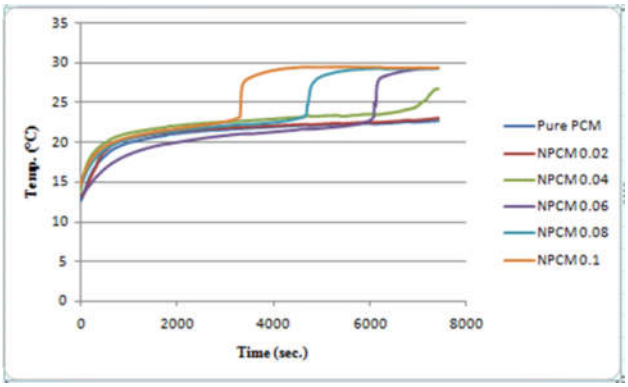
	Freezing (^{O}C)	Melting (^{O}C)	Latent heat (kJ/kg)	
			Freezing	Melting
Pure PCM	21.22	22.42	181.28	194.99
NPCM (0.2%)	22.06	22.78	182.15	187.03
NPCM (0.4 %)	22.50	22.68	191.87	200.14
NPCM (0.6 %)	22.44	22.45	202.36	207.77
NPCM (0.8 %)	22.36	22.99	187.44	195.82

NPCM (1 %)	22.47	22.99	185.25	189.01

Summary of DSC results.



Freezing curves of Pure and NPCM using Experimental setup



Melting curves of Pure and NPCM using Experimental setup

Process	Parameters		Hybrid nano based PCM				
		Pure	0.02%	0.04%	0.06%	0.08%	1%
Freezing	Commencement (min)	9.5	8.33	7.5	6.67	6.5	6.3
	Completion (min)	25	23.33	20.83	16.67	16.67	15.83
	Enhancement %	-	7.15	20.5	49.9	49.9	57.9
	Reduction %	-	12.3	21.05	29.7	31.5	33.6

Freezing characteristics of Pure and Hybrid nano based PCM

Process	Parameters		Hybrid nano based PCM				
		Pure	0.02%	0.04%	0.06%	0.08%	1%
Melting	Commencement (min)	28	27	26.1	25.8	24.9	24
	Completion (min)	39.1	38.2	37.6	35.4	35.2	34.4
	Reduction %	-	3.57	6.78	7.85	11.07	14.28

Melting characteristics of Pure and Hybrid nano based PCM

5. Conclusion:

1. The nanoparticles synthesized for both copper and silver were found to in Nano size with a range from 30nm to 140nm.
2. The SEM results reveal that the copper and silver nanoparticles spherical in shape with high surface to volume ratio, which can enhance heat transfer characteristics.
3. From the DSC results, there is little variation in the melting and freezing points due to addition of nanoparticles but, there is significant increase in the latent heat of the N-PCM until the wt. % of 0.6 beyond which the latent heat decreases. This shows that the optimum value of that amount of nanoparticles that should be dispersed in the paraffin C16 PCM is **0.6%**
4. Based on the above test results, the as-prepared paraffin C16 PCM with nanoparticles can be expected to provide better cooling effect through regulating the temperature within the comfortable range of 23 °C to 25 °C in indoor spaces.

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