IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

# Maltitol Based Nano $Al_2O_3$-PCM for Solar Thermal Energy Storage System

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***Abstract:*** Phase Change Material (PCM) plays an crucial position as a thermal strength garage tool by way of using its excessive storage density and latent warmness property. The thermo- physical guidelines of Maltitol, (a sugar alcohol), became investigated as a potential fabric for developing increasingly meaty solar thermal power storage structures than those presently available. This latent warmth storage medium could be applied for business and industrial applications using solar thermal electricity garage inside the temperature variety of 100–145°C. The goal of this investigation was to decide through experimentation, if Al2O3 sparse in pure Maltitol for combos of 1, and 3% (by weight) progressed the thermal overall performance of Maltitol for sun thermal strength structures. Nanoparticles best bodily interacted with Maltitol and not chemically, plane without 25 thermal cycles. Without cycling, Nano-Maltitol studied right here suffered a decrease subtract in warmth of fusion than pure Maltitol, which makes Nano-Maltitol increasingly appropriate for solar thermal garage packages at 100–145°C.

***Index Terms* – Maltitol(PCM), $Al_2O_3$ Nano particle, Thermal Cycling, Ball Milling, DSC, FTIR, SEM.**

## I. INTRODUCTION

Recently, a lot of material are unchangingly decided on as PCM for thermal storage gadget which includes water and Barium hydroxide, but these thermal garage systems are confined in warmthstorage density, protection and phase transpiration temperature. Organic PCMs together with sugar alcohols can potentially underpass the gap among peak warmness demand and deliverthrough storing electricity in the form of latent warmth because of their availability and suitable melting and freezing temperature ranges. $Al_2O_3$ nanoparticles used paraffin to disperse sodium stearoyl lactylate as a surfactant and found composite enjoyable temperature of 2.5, 5.0, 7.5, and 10.0 wt percent nano Al2O3 is 1.20, 1.50, 1.35, 1.60 C better then unadulterated paraffin and four.13 kJ/kg, 5.41 kJ/kg ,14.86 kJ/kg and 22 kJ/kg. (M.Nourani.[1]). Reported a make properly inside the heat limit of nano titania price erythritol by means of 40% in sturdy stage and 14% in liquid (or gas) degree while an fee semester of 0.2 vol% of nano-titania became positioned to use.(L.Zhichao[2]). The objective of this investigation became to determine through experimentation, if Al2O and CuO nanoparticles sparse in natural MI for mixtures of 1, 2 and 3% (via weight) stepped forward the thermal performance of MI for solar thermal strength systems. Without thermal biking MI-A is increasingly appropriate for thermal strength storage than MI-C. (D.K. Singh [3]). The thermal conductivity of the PCMs turned into discovered to increase via 407.8 percentage with a mass of 10 percentage unalleviated one of the short stat threads.

The loss of enthalpies, however, is 11.3% for variegated parts or materials fabricated from 10% brief stat threads. With their low space among parts and suitable thermal conductivity of CNT offer ramified unused first-class as combined substances. (Zhang Q [4]). A evaluation of the mixing of PCM into solar creditors and water garage tanks turned into presented. They mentioned the techniques used to modernize the characteristics of PCM warmth transfer, such as using exceedingly conductive additives and fins. (Abokersh MH [5]).Studied eicosane / graphene Nano platelets (GNPs) and observed that the midpoint latent warmth of be part of by means of heating 1, 2, 5 and 10 wt. percent of variegated elements or substances is lower than that of well- spoken eicosane by using 0.five, 1.7, 5.4 and 16.zero percent one at a time and points of variegated elements or substances are slowly removed scrutinizingly independently of subtracting weight, quantity of GNPs. (X. Fang [6]). It gave quiet idea to the palmitic corrosive TiO2 1 as a Nano-upgraded natural degree transpiration material and found that the traction in liquid temperature 2 become variegated from the observation range of zero.26 and a pair of C 3 and the relaxation of the mixing warmness somewhere in the range of 2 percent and 15.5 percent and no warmth from the aggregate of palmitic corrosive was reduced by using 17.88 percentage without 1500 liquefied. (R.K. Sharma [7]). Sparse Al2O3 nanoparticles with paraffin, a mass element of 5 and 10 wt. percent and a ripen of 7 and 13% in fusion warmth. Whereas the thermal conductivity has been improved for five and 10 wt. % Al2O3 nanoparticles was 2 and 6 percent one at a time. (C.J. Ho [8]). Revealed a thermal conductivity upgrade of 48% and 60% for paraffin containing 10 wt % and 20 wt % of iron nanoparticles one after the other. In writing some reviews show that there may be no uncontrived relationship between the mass semester of nanoparticles and the resurgence of heat conductivity. (N. Sahan [9]). Studied the restrained melting of wax Studied the constrained melting of wax interior a spherical sheathing was found that the waviness and immoderate melting of the marrow of the PCM turned into shown to be underestimated by way of the experimental observation because of the assist structure to maintain the sphere. (N.A.M. Amin [10]) Recently, plenty of sustentation has been paid to the minutiae of recent PCMs for TES applications at intermediate temperature (100-200 °C). Hence, using sugar alcohols

Till level no examine has been reported on the label of nanoparticle impregnated maltitol. Hence, the purpose of this observe is to assess and typify the latent heat storage potential of maltitol with and without Nano-additives for meaty sun latent warmth storage applications inside the temperature variety of 100–145°C. Thermal cycling assessments have been done on pure maltitol with Al2O3 nanoparticles (particle size 10–60 nm) with mass fractions of natural, 1, 2 and 3 wt %. The measurements were performed over 25 charging-discharging cycles the use of differential scanning calorimetric (DSC), Fourier transform infra-red (FT-IR) spectroscopy and Scanning Electron Microscopy (SEM) to observe thermos-physical properties, mass change, latent warmth of energy, molecular immigration and functional organizations and the distribution of nanoparticles in maltitol.

## II. METHODOLOGY

Commercially misogynist pure Maltitol, chemical components $C_{12}H_{24}O_{11}$, became acquired from (Spectrochem Pvt. Ltd., Mumbai, India) with a mass density of 3.95 g/cm3, molecular weight of 344.31g/mol, melting range between 145°C turned into employed. Aluminium oxide $Al_2O_3$ and Carbon Nano tubes nanoparticles (particle size 10–60 nm) were procured from Alfa Aesar, USA.

Fig 1 Experimental Setup

For thermal biking process, an experimental installation consisting of regular temperature warm plate heater (Fig. 1) was used. During charging 50 g of the PCM (Maltitol blended with nanoparticles) became heated the usage of a hot plate from 30°C to 150°C in a silver beaker. The molten PCM became cooled normally from 150°C to room condition (30°C) through passive cooling. Calibrated J-type thermocouples used to measure and record the temperature of PCM. The physical kingdom of PCM all through melting and solidification became confirmed visually. The temperatures have been recorded at 30 s intervals at some stage in melting and solidification.

## III. NANO- MALTITOL

$Al_2O_3$ nanoparticles had been uniformly mixed at pure, 1, 2 and three wt% to Maltitol by the usage of a low power ball mill which becomes circled for 1 h at 300 rpm for uniform mixing using 3 chrome steel balls offering centrifugal force. Melting temperature, time taken for melting and the version of melting factor over 25 charging and discharging cycles have been recorded, and no predominant change located for melting points for the duration of thermal cycling. The time taken for melting and freezing become about 14 min, for every Nano-Maltitol suspension studied. Fig. 2, 3 and 4 indicates Nano-Maltitol before and after 25 thermal cycles.

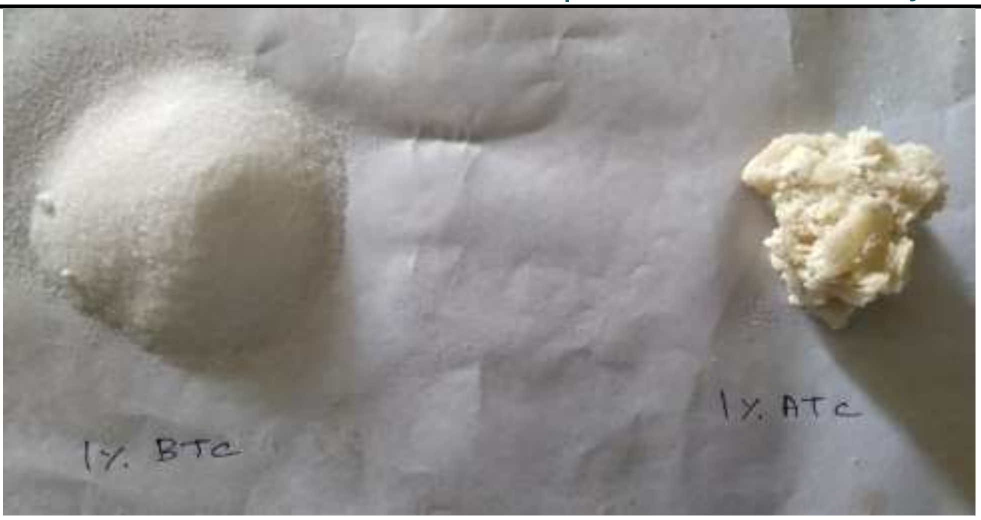


Fig. 2 Before and After thermal cycling of 1%


Fig. 3 Before and After thermal cycling of 2%

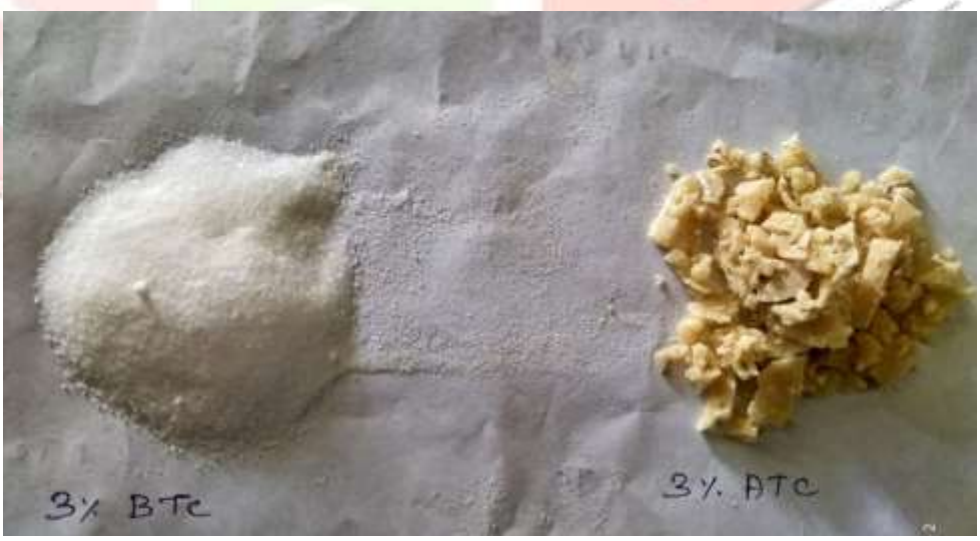


Fig. 4 Before and After thermal cycling of 3%

Sample of natural Maltitol, Maltitol – Al2O3 and Maltitol-Aluminum Oxide weighing 50 mg had been taken before beginning of the thermal biking and at the stop of 25th cycle for DSC and FT-IR tests. PerkinElmer DSC equipment (DSC 6000) was used for these tests. The test were performed in N2 atmosphere in the temperature range of 30°C–250°C with a heating rate of 5°C/min. Material decomposition changed into characterized by way of the mass loss measured with a high-precision balance. A PerkinElmer FT-IR spectrometer (FT-IR spectrum two) with wavelength variety from 8300 to 350 cm-1 became hired for reading the chemical compatibility between natural Maltitol and nanoparticles over wavenumber range of 4000–500 cm-1 in steps of 4 cm-1.

## IV. RESULT AND DISCUSSION

DSC equipment turned into used to degree the strength of nano-pcm samples at 1% and 3% of before and after thermal cycling. Table 1 shows the heat of fusion for pure maltitol, before thermal cycling, become measured to be 296.5 kJ/kg and for Pcm-Nano it turned into measured to be 321.7 kJ/kg, 345.3 kJ/kg respectively for 1 and 3 wt. %. This amounts to be increase of 25.2 kJ/kg and 23.6 KJ/kg respectively for 1 and 3 wt. %. When compared pure maltitol with Nano-maltitol significant upward thrust of 7.97% in the warmness of fusion within the case of 3 wt. %. Heat of fusion of natural maltitol after 25 cycles changed into measured to be 274.5 kJ/kg which become 22 kJ/kg much less in comparison to pure maltitol. After 25 charging and discharging cycles, warmness of fusion for 1 and 3 wt.% became measured to be 314.4 kJ/kg, 326.2 kJ/kg respectively which have 2.18% and 5.45 % lesser heat of fusion when compared to before thermal cycling.

Table 1. Phase Changing Property Before and After Thermal cycling

| PCM - Nano Wt % | Phase Change Peak Temperature ($^0$C) | | Latent Heat (kJ/kg) | |
|---|---|---|---|---|
| | Melting | Melting (25 cycles) | Melting | Melting (25 cycles) |
| 0 % | 145.3 | 144.3 | 296.5 | 274.5 |
| 1% | 146.8 | 144.7 | 321.7 | 314.4 |
| 3% | 146.1 | 145.3 | 345.7 | 326.2 |

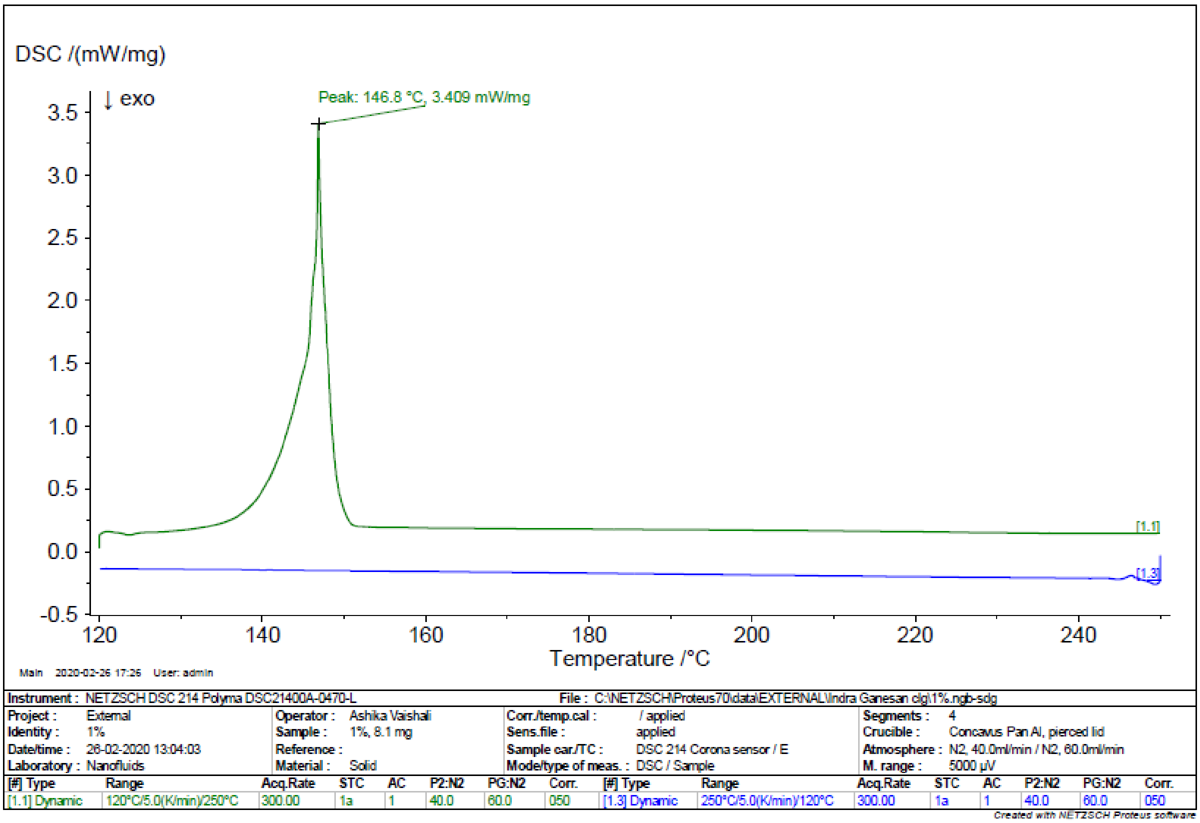


Chart 1 After thermal cycling 1%

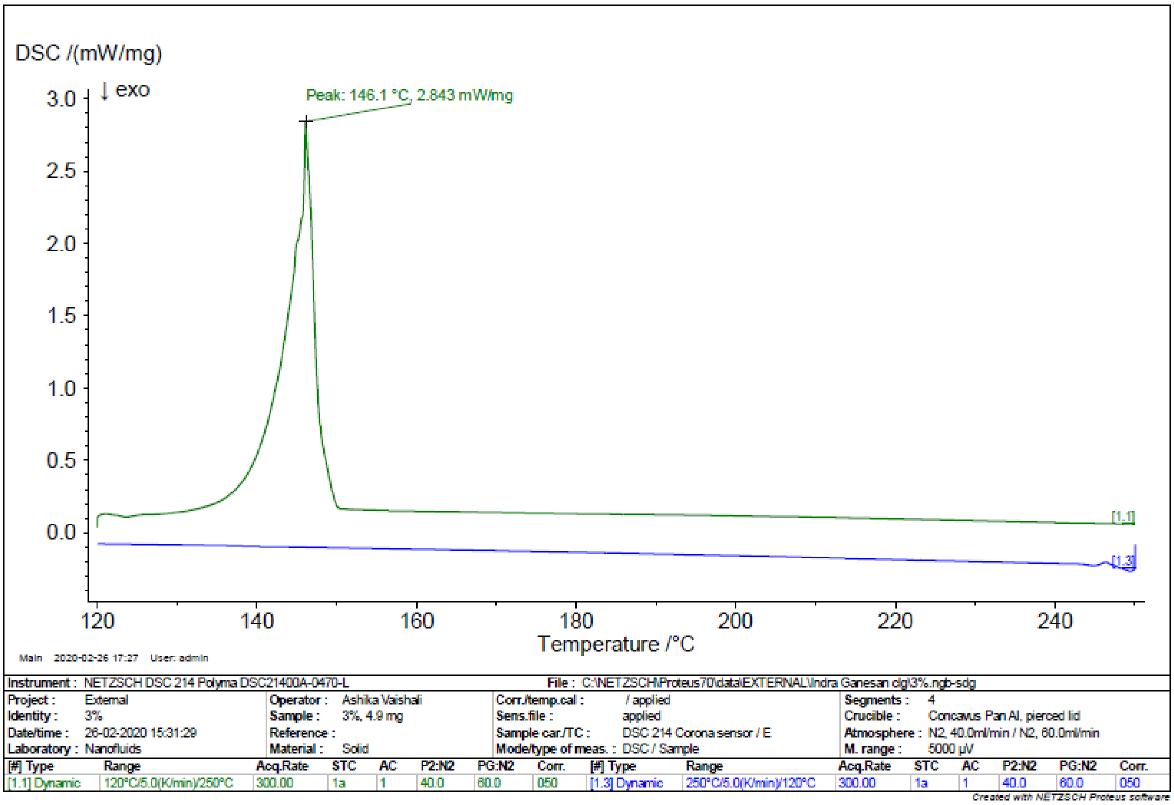


Chart 2 After thermal cycling 3%

FTIR equipment became used to degree the transmission spectra of maltitol-$Al_2O_3$ see chart 3,4and 5. Functional groups present inside the samples are designated in Table 2. There turned into an illustration of reaction with nitrogen, and a few halogens all through thermal cycling. Same functional businesses are discovered on addition of Nano particles ($Al_2O_3$). Major functional companies are robust OH (typically stretching vibration) and CH3, CH2 and CH (2 or 3 bands) with wavenumbers are 3252 cm-1 and 2974 cm-1 in nano-pcm (ATC1%) which has infra-red Transmission of 79.48% and 84.20% respectively.

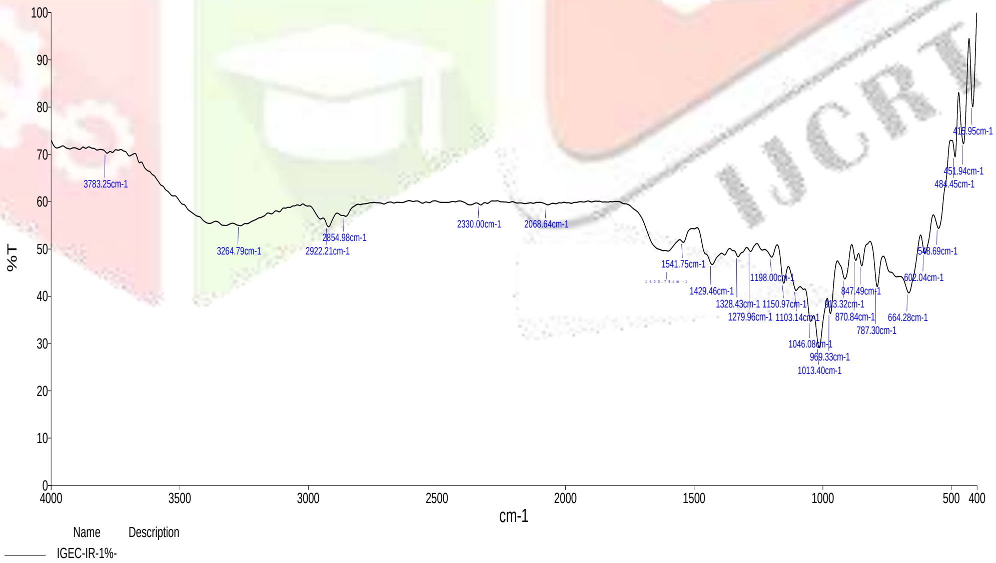


Chart 3 FTIR measured ATC 1%

BTC 2%, BTC three% confirmed transmission 85.57%, 81.76% for 3219 cm-1, 3176 cm-1 and 3245 cm-1 respectively. After the 25th cycle a slight lower in transmission inside the functional group region (4000–1500 cm-1) for all samples may be seen in chart 3&4 , even though this fluctuation become much less as compared to the ones with out cycling, as shown in chart 5 and in Table 1. It shows that natural maltitol with $Al_2O_3$ nanoparticles have been chemically stable even after 25 cycles of melting and solidification. It may be inferred that maltitol and nanoparticles simplest interacted thermo-physically and no chemical interaction took place.

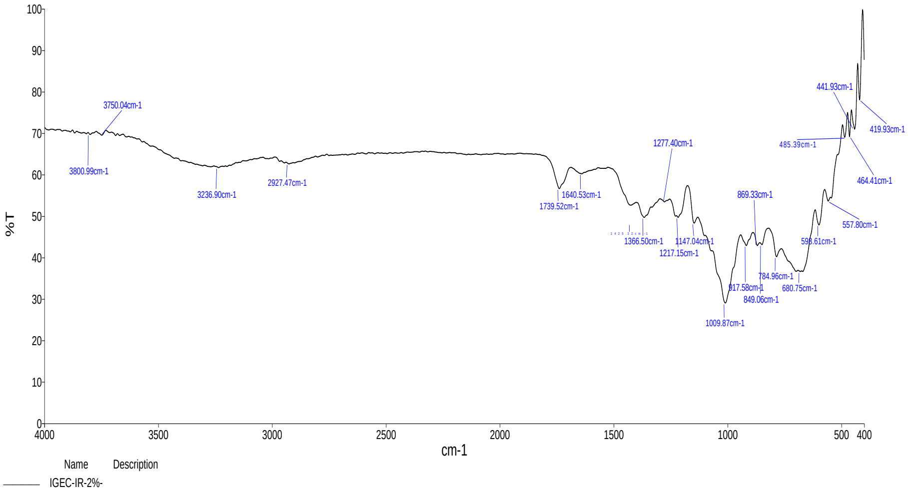


Chart 4 FTIR measured ATC 2%

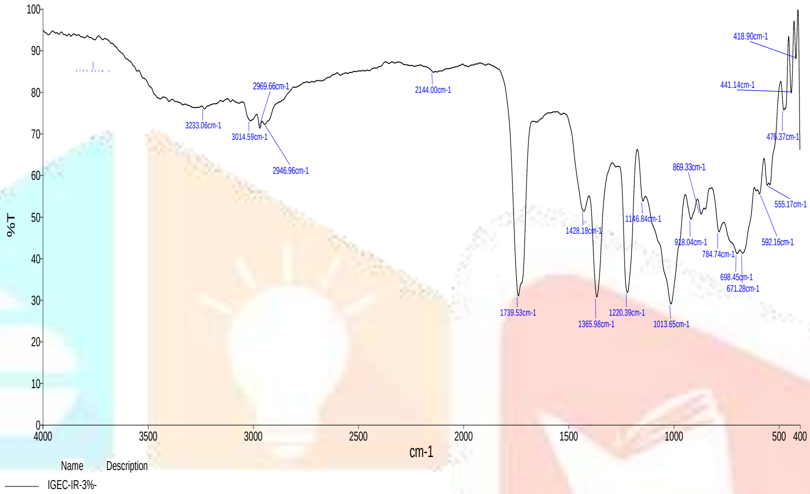


Chart 5 FTIR measured ATC 3%

The floor morphology of pure Maltitol the usage of field emission scanning electron microscope (SEM) proven in Fig.5. Suggests that maltitol particles are notably irregular in shapes and sizes. There were huge difference in shapes and size amongst Maltitol (exceptionally abnormal), aluminum oxide NPs (almost spherical), Fig. 6 indicates aluminum oxide nanoparticles distribution during Maltitol with certain aggregation.

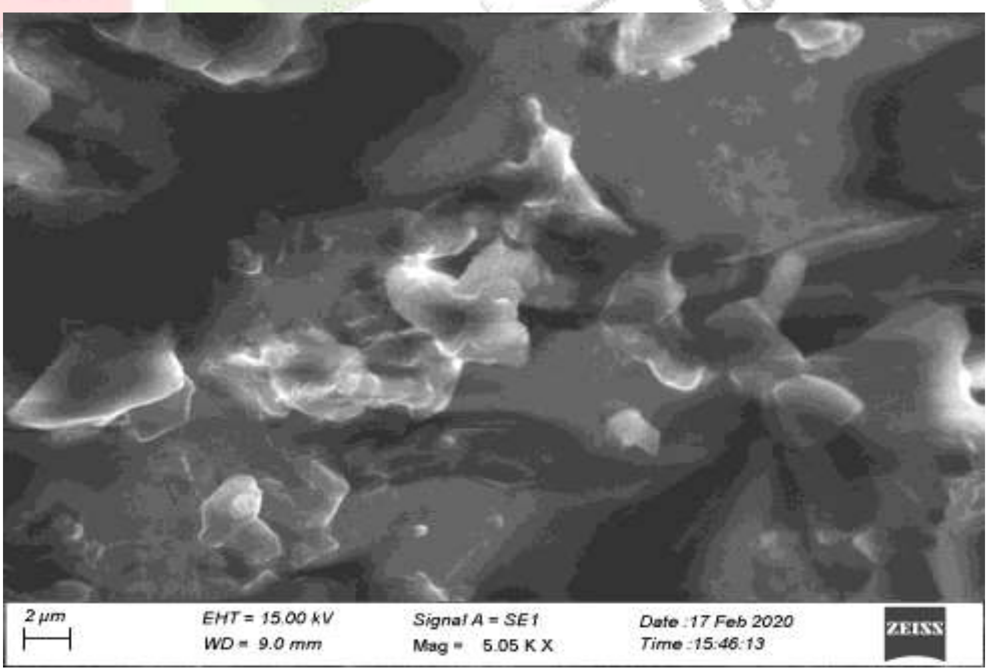


Fig 5 SEM image for ATC 1%

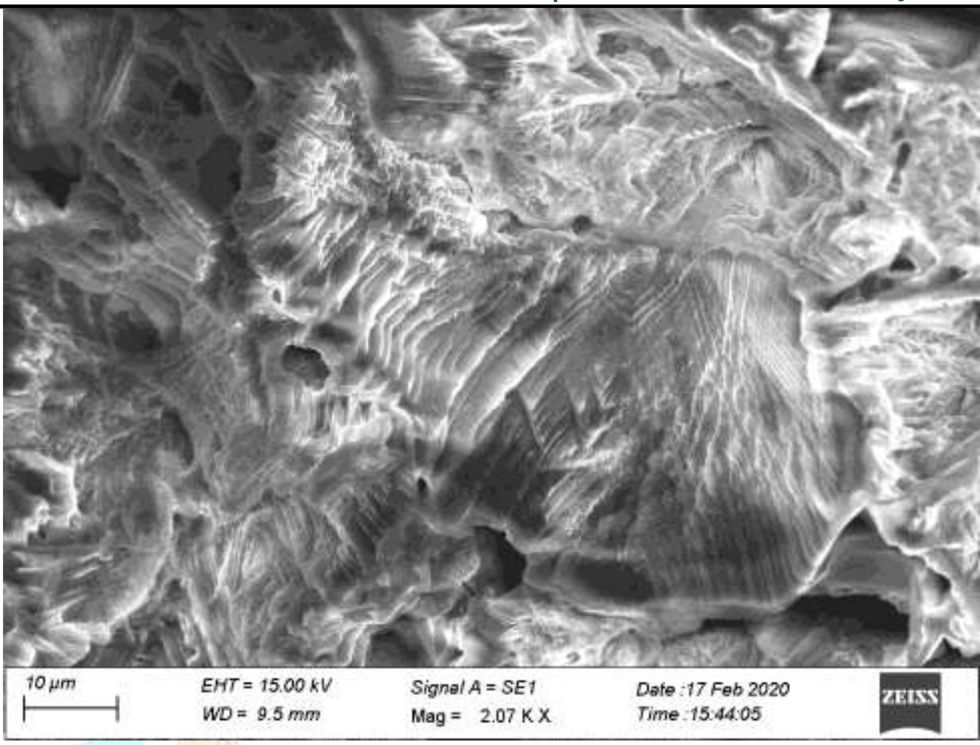


Fig 6 SEM image for ATC 3%

## V. RESULT AND DISCUSSION

Thermal and chemical homes of maltitol with nano debris are $Al_2O_3$ with natural maltitol, 1,2 and three wt. had been experimentally studied the usage of DSC,SEM and FTIR. DSC consequences describe if adding big quantity of nano particles, to boom the latent warmness of fusion and melting points. Maltitol-nano 1wt. 2wt. And 3wt. Of after thermal cycling had been excellently chemical stability over temperature range from $30^0$C-$250^0$C using FTIR. Also 1wt. And 3wt. Of earlier than thermal cycling have been correct thermal stability. In view of outcomes, Maltitol based nano-pcm might be prescribed as a potential fabric for solar thermal utility at $30^0$C-$150^0$C.

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