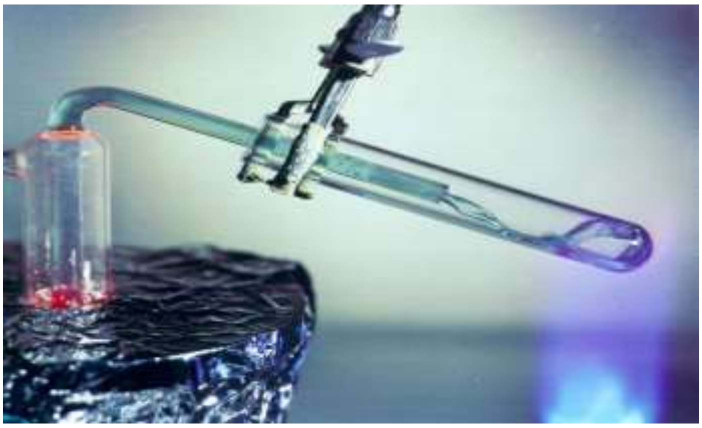
Thermal Energy

It is generally agreed that the most crucial inflection point in the evolution of humanity occurred with the discovery of flame. Simple actions like boiling food were among the first applications of energy from heat that people discovered. Thermal energy was widely available in the natural environment even before people. Our bodies require a specific minimum ambient temperature to remain alive. There is an urgent need for thermal energy as a result of these realities. Energy is the ability to do work. If this ability due to the temperature of the system, then it will be categorized as thermal energy. The stationary temperature is not responsible for the thermal energy. Thermal energy is something when temperature flows from one place to another. The study of temperature transfer is known as thermodynamics. It is mostly involved in conservation of energy, as the conversion is not 100% and losses are mostly considered in thermal energy term. It also relatable to the 3^{rd} law of thermodynamics. As thermal energy is disorderness of the system, thermal energy is the mobility of atom of the system, for solid vibration and for liquid and gas translational. It is stated as low-level thermal energy, as it is existed at such temperature which is very close to the environment temperature and it is very hard to extract this energy in term useful energy. This type of thermal energy exists during friction, drag, explosive and momentum conversion processes. It is the main reason behind the inelastic collision. The myriad new applications for thermal energy which our modern way of life has created have also raised the demand for thermal energy. Heat, electrical power, and mechanical effort are the three main types of energy that we use nowadays at the user-end. The International Energy Organisation publishes the user-end consumption of energy data as "Final consumption." power, heat, and mechanical energy are produced from a variety of energy sources that include both natural and artificial fuel sources. The International Energy Organisation refers to the energy source data as "primary energy supply." According to the 2014 report on global energy statistics, the world's annual "total primary energy supply" will be 573 exajoules (13700 million tons of oil equivalent), and its annual "total final consumption" will be 394 exajoules (9,425 million tons of oil equivalent). Because so much energy is needed, a sizable fraction of it (around 31%) is lost during the transition from Primary energy supply to Final consumption. Sustainable development is such type of development by which existing requirements completely fulfill without creating any type of risk for coming generation regarding their requirements. So, it’s a concept which merge different concept of economy prosperity and safety, environmental risks and social enhancement. To achieve sustainability goals, world started to look for such energy resources by which current energy starvation fulfill and parallelly create no risk for environment, play o role in degradation of ecosystem and have no impact on the resources for upcoming generations. This concept helps to think that, why no we use such elements for energy production which are reason of environment degradation and pollution. Pollution is the contamination of ecosystem. It has different types including air pollution, land pollution, water pollution and noise pollution. When the system's temperature surpasses the thermal oil temp limit, molten salts become the preferred fluid for transferring heat and heat-storing material. Thermal oil's temperature limit will be exceeded by CSP facilities using solar power tower and parabolic dish collector types. Molten salts have become the most popular thermal energy storage technology in CSP installations.

Specific heat of molten salt and nanoparticles

Molten salt is clear from its name, a salt in its molten state. It is a form of ionic liquid, the liquid which in ionic form even at room temperature and pressure. Molten salts have been used in a variety of applications, but their primary use has been in thermal energy storage systems for concentrated solar power plants. Thermal energy storage systems are employed to balance out the disparity between energy supply and demand. A heat transfer fluid transmits heat to a turbine or engine, after which it is used in a thermodynamic cycle, such as the Rankine or Brayton cycle, and others, to create electricity. In the solar thermal method, the heat transfer fluid is pumped at a low temperature from a cold-storage tank to the receiver, after which it is heated to an elevated temperature. The hot heat transfer fluid is then poured into the heated storage tank. In order to make electricity, the steam is then moved from the heated tank that holds it to the steam engine, where superheated steam is manufactured to produce power at an elevated temperature. Thermal energy storage devices have the potential to have an important function in energy conservation and environmental mitigation by permitting the daytime retention of excess solar energy that may be used at night or for managing load levels in the electrical grid during times of high demand. The greater the heat transfer fluid working the temperature, the more effective the entire power production system will be since the efficiency of Carnot increases with increasing operating temperature. Conventional heat transfer fluids usually have a low point of boiling (less than 400 °C), which makes them unsuitable for use with CSP devices that function at higher temperatures. This limitation may be overcome by using molten salts to store and convey thermal energy. A variety of materials are used in the preservation of thermal energy. TES materials must have the proper thermophysical properties, including, among others, an optimal point of melting suited to the specified thermal implementation, high latent energy, high heat specificity, and high heat transfer. Additional desirable characteristics of thermal energy materials for storage include low supercooling, low cost, wide availability, thermal dependability, chemical strength, low volume change, environmentally friendly, small vapour pressure, synchronous melting, and low flammability. TES systems can be broadly categorised into three kinds depending on the type of TES medium selected for heat or cold. Water has some drawbacks, including high pressure of vapour and corrosiveness. In comparison to water, thermal oils possess two disadvantages: they are more expensive and have a lower specific heat. As a result of processes including oxidation by air, that can result in the development of acids like acidic carbolic acid including peroxide chemicals, which can speed up the degradation of containers and pipes, thermal oils degrade at elevated temperatures over their operational range. It slowly degrades with age after being exposed to extreme temperatures for a prolonged length of time and experiencing several thermal cycles. Thermal oil vapour presents a fire risk when mixed with surrounding air. Although the system is running, prohibit any thermal oil spills because they are costly and harmful for the environment.

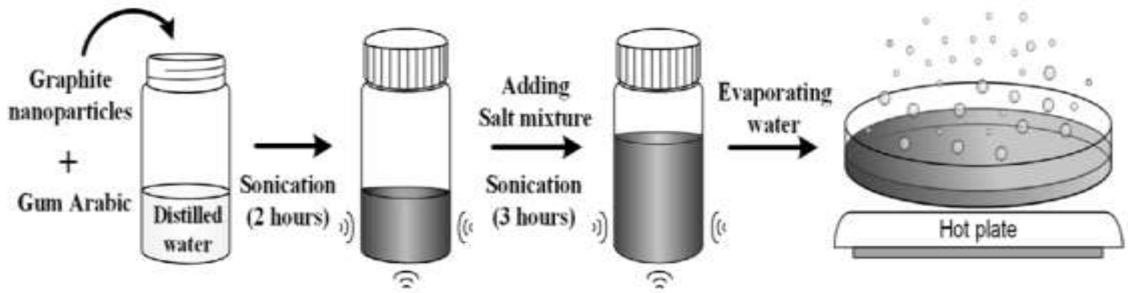


Molten salts continue to be thermally stable at temperatures well beyond 600 °C. This can dramatically raise the thermal energy storage ambient temperature limit and cycle efficiency. Molten salts are also non-toxic to the environment and less expensive than conventional thermal energy storage materials and heat transfer fluid. However, the thermophysical qualities of these molten salts are subpar. Material security, heat transfer effectiveness, and heat storage capability are therefore crucial factors. The specific heat storage capacity has a significant impact on the heat capacity for thermal energy storage substance storage in sense heating systems since this capacity is heavily influenced by temperature changes. Low specific heat capacity values in molten salts, limit successful thermal energy storage, which has up until now required the use of enormous thermal energy storage devices. Therefore, it is essential for effective thermal energy storage systems to increase the molten salt's specific heat capacity. This is the reason that countless investigations using various salts and nanoparticles have focused on molten salt nanofluids. Various efforts have been undertaken to enhance the thermal characteristics, such as reducing the point of melting and bolstering the thermal properties, to increase the thermal energy storage capacity. There has been a great deal of research done on boosting the specific heat of the molten salts by adding nanoparticles into the ensuing salts ever since SiO2 nanoparticles were found to increase the specific heat of eutectic salts by 15% for a quaternary chloride salt and by 24% for binary carbonate salt.

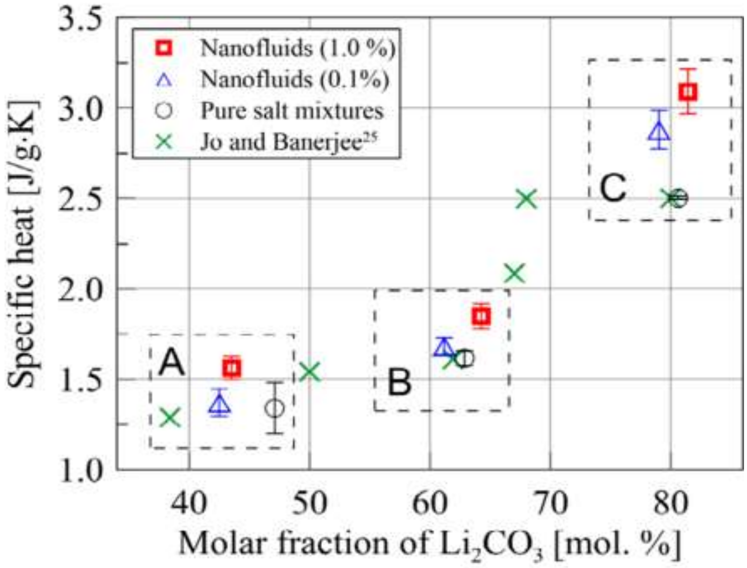
Nanoparticles usage

Nanofluids are colloidal solutions containing solid nanoparticles with a diameter less than 100 nm. Since Choi1 first reported higher efficient thermal conductivity rises for nanotube suspensions, numerous researchers have noticed enhanced effectiveness thermal conductibility of diverse nanofluids. There are many explanations for the increase in efficient thermal conductivity over the past ten years. Some of these include Brownian motion, semi-solid layering of liquid molecules, the mechanism of heat transmission in nanoparticles, and the effects of nanoparticle aggregation. Both academic and industrial investigators are interested in these suspensions because of their extraordinary thermo-physical properties, which defy predictions made by theoretical models. In the last ten years, ISI journals have published approximately 10,000 articles on nanofluids. The majority of research on thermal conductivity of water- or oil-based nanofluids was done among 1995 and 2005, which was which was the first era of nanofluids. Other properties, specifically heat capacity, received little attention because early studies showed a negative effect on heat capacity improvement. In 2009, Nelson discovered a significant increase in heat capacity when he introduced nanoparticles to paraffin-based oil in minute amounts. A few years later, Shin and Banerjee stated that molten salt nanofluids have improved in terms of heat capacity. Molten salt is one of the most widely used for heat transfer agents as well as thermal storage devices for energy in concentrated solar power. Because it can significantly reduce the cost of power to raise the heat capacity of liquid slats, numerous researchers have corroborated the claimed heat capacity augmentation across different salt eutectic systems.

Despite multiple studies using various molten salts and nanoparticles, the mechanism underlying the enhanced produced by salt molten nanofluids remained not well understood. However, a lot of research focused on the unique zone where salt ions would develop around the nanoparticles. This region, also known as the compressed aqueous layer, ordered layer, semi-solid layer, etc., was statistically observed in molecular dynamic simulations. It was discovered that the semi-solid layer had a density higher than the typical value of the base solvent salts. The simulations attribute the semi-solid layer's ability to hold more thermal energy to the nanoparticles' enhanced surface energy. The semi-solid layer was experimentally observed as periodic contrast disturbances at the aluminum solid–liquid interface using transmission electron microscopy, a technique with high resolution. Recently, the diffuse region and stern layer were coupled to create an electric double layer model of the semi-solid layer. A mathematical model centered on the electric double layer has been created to further explain the amplification in the nanofluids. Jeong and Jo hypothesized the existence of the electric double layer as the reason for the enhanced specific heat of the nanofluids based on their quantitative evaluation of the surface area of the electric double layer in the aqueous KNO3-SiO2 culture based on the zeta potential measurement. The total potential energy between two particles in a colloidal system is formed by the interaction of the Van der Waals and electric double layer forces. The concentration of ion has a significant effect on the interaction of potential energy because, as was already shown, the electric double layer is composed of fluid ions that form a colloid. In the electric double layer, the diffuse layer, which is composed of opposition from its outer charge and is slackly associated with the particulates in the colloid, dictated the relationship between the elements' energies. A quantitative analysis of the electric double layer width and electric double layer energy interactions is thus necessary to understand the effects of nanoparticles in the nanofluids. Although various attempts have been made to throw light on the SHC characteristics of molten salts which were infused with nanoparticles, more investigation is still required to ascertain the mechanism underlying the enhanced SHC of molten salt. In the majority of past studies on the SHC of molten salt nanofluids, the solvents were binary or more complex salt combinations. It is required to do research on single-salt-based nanofluids to ascertain the effects of the electric double layer. Following that, it is important to look into how the base solvent salt composition affects binary molten salt nanofluids. Chieruzzi investigated KNO3 nanofluids by spreading Al2O3 and SiO2 nanoparticles. However, these investigations did not describe any mechanisms; they only published the SHC outcomes of the nanofluids. Jeong and Jo recently used salt that was chemically altered by various acids to study KNO3 nanofluids. Zeta potential analyses were also performed to establish the height of the electric double layer and later to identify the mechanism causing the enhanced SHC. The SHC enhancement of single salt (KNO3 and NaNO3) based nanofluids was studied using SiO2 and graphite nanoparticles. The binary molten salt-based nanofluids was also examined as the salt content of the binary mixture altered. The zeta potentials of the nanoparticles in the salt aqueous solution were calculated to compare the effects of various salt solvent upon the SHC of the nanofluids. The electric double layer thickness and the electric double layer impact force were ultimately measured by zeta potential measurements to comprehend the different consequences of the solution salt across the molten salt nanofluids. It was suggested that the solvent composition influences how much the specific heat improvement of binary-salt mixture-based nanofluids. The actual chemical compositions of each salt ingredient for all materials analyzed by the DSC were evaluated experimentally using an inductively coupled plasma optical.



The specific heat values of pure carbonate salt mixtures and group A, B, and C graphite nanofluids are due to the Li2CO3 composition. the starting concentrations of both the Li2CO3 and K2CO3 salt components, however as previously stated, the ICP-OES was employed to measure the compositions themselves. Each group's salt compositions were obviously different from the others. Since the pure carbonate salt mixture's specific heat was not greatly altered in that group C region, the variation in group C was thought to not represent a major problem for research on the augmentation of specific heat in carbonate salt mixes.



The type of nanoparticle that alters the specific heat of nitrate salt combinations is a crucial factor as well. In terms of increasing specific heat, metal oxide nanoparticles such as SiO2 and Al2O3 are superior to graphite nanoparticles. The majority of recent studies have suggested that the electrical double layer, also referred to as the pulled liquid layer and made up of a harsh layer and an expanding layer, improves the property, even though the precise reason for the higher specific heat of the molten salts remains to be determined. The electric dual layer, which is denser than the total solvent value, behaves like a solid. The percentages of the two ingredient salts inside this electric dual layer were also shown to diverge from the typical standard for binary carbonate salt mixtures in a molecular dynamic calculation. This investigation showed that the thermal properties of the molten salt mixtures underwent significant changes in the liquid phase. A recent study also determined the capacity to exchange ions for all of three individual nitrate salts and both different nanoparticles, which is defined as the moles of an ion swapped group per unit mass of a nanoparticle. That study described the IEC as the outcome of a link among the salt with the nanoparticle, which was equivalent to a boost in specific heat.

These findings lend credence to the hypothesis that the composition-dependent thermal characteristics in combination with the compressed fluid layer affect the molten salt nanofluids' specific heat. However, in order to evaluate the specific heat amplification and the alteration in the latent energy for single salt as well as multi-salt mixtures, a quantitative analysis of the dimension of the electric dual layer is needed.

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