Abstract

Solar energy is attracting attention as a renewable energy source due to the rapid depleting conventional energy resources and current environmental problems such as global warming, removal of ozone layer, escalating pollution, and also the increasing cost of fossil fuels. The use of solar energy is two folds: (i) energy conversion and its utilization and (ii) energy conversion, storage and use it later on demand. The later will rely on efficient energy storage materials and systems for probable applications such as electricity generation, solar cookers, solar water heaters, building heating/cooling, heat packs for therapeutic/body comfort applications etc.

Thermal energy can be stored either as a sensible or latent heat or in both forms, depending on the storage media and operating conditions. Phase change materials (PCMs) are used as the thermal energy storage media, where heat is stored as latent heat of the storage material. A wide number of organic and inorganic PCMs are developed for such applications. However, the latent heat of fusion is comparatively low for commonly available PCMs in 15-20 ^{0}C range of melting temperature. Further, very little data are available for thermophysical properties of PCMs. The different solar thermal applications require relatively higher melting temperature and high latent heat. Additionally, the therapeutic applications require small crystallite PCMs in contrast to conventional hard crystallites, causing body discomfort, shape adaptability problem, damage to the heat packs in conjunction with low discharge time. PCMs also suffer with low thermal conductivity, which may hinder effective heat transfer during charging/discharging. This compels to design and develop suitable PCMs for such applications. Furthermore, the conventional differential scanning calorimeter (DSC) does not provide reliable data on thermophysical properties of PCMs because of its small sample size limitation and temperature-history system, suitable for PCM characterization is not available commercially.

The present thesis work aims: (i) design and development of low and high temperature phase change materials, (ii) improvement of SAT PCM thermophysical properties for heat pack applications, (iii) development of temperature – history (T-history) measurement setup, and (iv) optimization of exfoliated graphite process and development of high thermal conductivity PCM-exfoliated graphite composites to enhance thermal conductivity of PCMs. The fatty acids (capric, lauric, myristic and palmitic acids) and 1-deodcanol based binary eutectic compositions are developed with suitable melting temperature 17-20 ^oC and sufficiently high latent heat of fusion 175-190 kJ kg^{-1}. The sodium acetate trihydrate (SAT), water and ethylene glycol based composite PCM is developed showing enhanced heat retention time (~10%), small crystallites, enhanced thermal stability against spontaneous nucleation. Further, $NaNO_3$, KNO_3, $LiNO_3$ and NaCl derived homogeneous high temperature eutectics are synthesized at room temperature using an innovative approach and their thermophysical properties are evaluated. The chemical exfoliation process is optimized and volume of graphite flakes is enhanced ~ 250 times. Further, the work is extended to develop PCM- ExG composites with different wt% of ExG (5, 10, 15 and 20%) to enhance thermal conductivity of PCMs. The maximum thermal conductivity of $LiNO_3$/NaCl-ExG composite is ~ 13.8 W m^{-1} K^{-1} at ~1400 kg m^{-3} density with 20 wt% ExG.

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