**Enhanced Phase-Change Materials for Heat-Storage Applications**

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47% of UK energy consumption is in the form of heat – associated with domestic and commercial heating of buildings, and the heating requirements for a wide range of industrial processes. Since many heating requirements rely ultimately on the combustion of fossil fuels, inevitably this has a major impact on emissions of CO2. Furthermore, with the ever-increasing price of fuel and electricity, there are significant economic impacts for both domestic and industrial customers. Hence there is a very strong driver towards the exploitation of renewable heat, and a key challenge for renewable heat must be effective heat storage.

We have therefore developed a compact store (known as a Sunamp Heat Battery) which can replace domestic boilers, hot water tanks and air conditioning units, and can connect to solar panels and other forms of renewable energy heating and cooling equipment. A key technology component of the store is the use of Phase-Change Materials (PCMs). Such chemical compounds absorb heat and undergo a phase transition, e.g. dissolution or melting. Such chemical compounds can include inorganic salt hydrates, (e.g. sodium acetate trihydrate) or organic materials (e.g. beeswax) that absorb heat and undergo a phase transition, e.g. dissolution or melting. On cooling, the reverse phase transition occurs, e.g. crystallisation or freezing, and heat is released. Although PCMs based on salt hydrates offer several advantages over organic materials (e.g. higher energy densities, non-flammability), they often suffer from disadvantages of incongruent melting and sub-cooling, resulting in non-reproducible performance and poor long-term stability. This is particularly true for sodium acetate trihydrate (mpt 58 °C), which melts incongruently to form anhydrous sodium acetate and which has a marked tendency to sub-cool.1,2 These factors severely limit the use of this material as a PCM.

We have overcome both of these problems and have developed a polymer additive that suppresses the formation of the anhydrous salt, together with nucleating agents that prevent sub-cooling. Using *in situ* X-ray powder diffraction, we have interrogated in real time the structural and chemical evolution of these formulations during repeated temperature cycling, and have identified the mechanisms by which phosphate-based nucleating agents can be thermally deactivated by excessive heating. We have also successfully modified the freezing temperature and thermal-profile behaviour of sodium acetate trihydrate in order to optimise its performance for specific applications. These new PCM formulations retain their high energy densities (~250 kJ dm-3) and have been incorporated in Sunamp Heat Batteries, which are currently being used in domestic applications in order to balance electrical demand from the grid, store solar thermal energy, and reduce heating bills for customers. Large-scale applications for district-heating are also planned.

References

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