International Journal of Frontiers in Sociology
ISSN 2706-6827 Vol. 2, Issue 8: 6-10, DOI: 10.25236/IJFS.2020.020802

Research Process in Phase Change Energy Storage Materials

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ABSTRACT. *This paper reviews the phase change mechanism and application of variable energy storage materials, and introduces the application of phase change energy storage materials in the fields of building, solar energy, refrigeration and so on. The development trend of phase change energy storage materials in the future is prospected.*

KEYWORDS: *Phase Change Energy Storage Materials, Heat Storage Technology, Thermal Conductivity*

1. Introduction

In recent years, with the rapid development of the world economy, the global energy supply has become a hot issue. With the increasing dependence of human on energy, the energy crisis is becoming more and more serious. At present, the fossil energy accounts for up to 89% of the energy consumed in the world [1]. Burning of fossil fuels causes serious pollution to the environment which is harmful for human and environment. Renewable energy has been developed by researchers to replace traditional fossil-based energy resources. The energy storage not only avoids the discrepancy between supply and requirement but also increases reliability over energy storage systems. The different ways of storing energy are sensible heat, latent heat, and thermochemical heat.

Sensible heat storage uses the heat capacity of the material itself to store heat. For example, when ancient people boiled water, they stored the heat released by burning firewood in water and poured it into copper for people to keep warm, which is also a process of heat storage and utilization. Therefore, water is also a sensible heat storage material that has been utilized earlier. Due to its low cost and mature technology, this sensible heat storage method has been widely used in the fields of power peak regulation and chemical engineering, etc. However, due to the limitation of the specific heat capacity of materials, temperature control cannot be realized. Most of them can only be used in medium and low temperature environment, unable to be used in high temperature environment.

Thermochemical heat storage uses reversible reaction to convert heat into chemical energy first, and then uses reverse reaction to release energy, so as to

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achieve controllable heat storage. In this way, the heat stored in unit body is much higher than sensible heat storage and can be stored without heat loss for a long time. However, due to the small number of ideal reaction systems and strict experimental conditions, the technology is complex and difficult, so it is still in the research and development stage and difficult to be applied in practice. Sensible heat storage technology is still the most widely used heat storage technology.

Due to the above limitations of sensible heat storage and thermochemical heat storage,phase change heat storage which can store a large amount of latent heat has gradually gained extensive attention from scholars. The latent heat can be absorbed and utilized by the change of material state. The phase change heat storage material has a constant temperature during the phase change, which can realize temperature control. It has a high heat storage density and a constant phase change temperature, and can be used for both heat storage and temperature control.

2. Phase Change Energy Storage Materials

2.1 Principle of Phase Change Energy Storage

Phase change energy storage materials absorb (release) a large amount of heat energy for energy storage when their state changes. Thermodynamically, The principle of phase change energy storage material heat storage can be divided into two aspects[2] : the molecular arrangement in the material changes. The arrangement of molecules in the material changes, as shown in Figure 1 and bond fracture and recombination occur within the material, as shown in Figure 2.

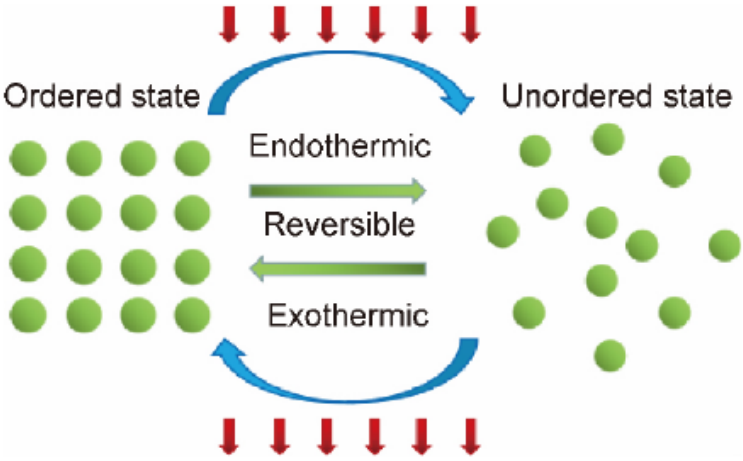

Figure. 1 Schematic diagram of physical phase transition[2]

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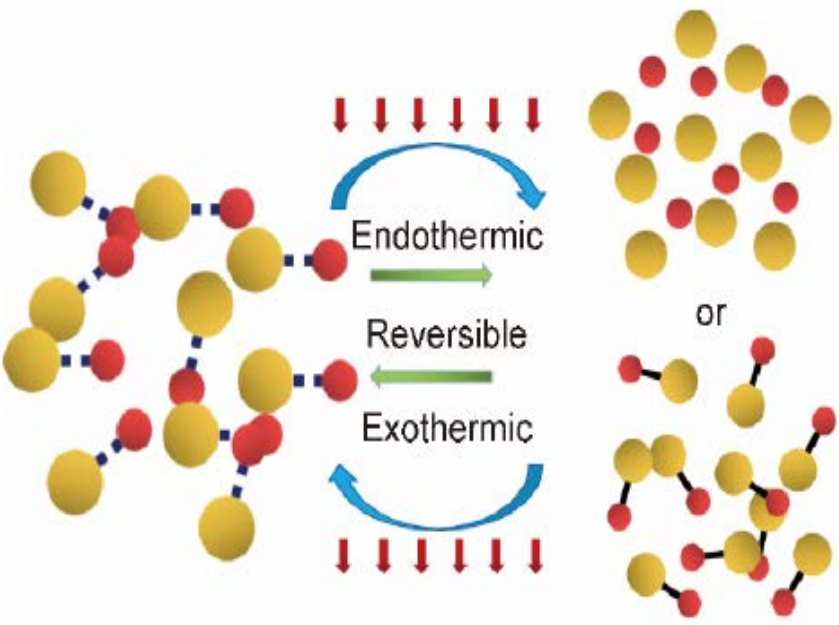

Figure. 2 Schematic diagram of chemical phase transition[2]

2.2 Classification of Phase Change Energy Storage Materials

The phase change heat storage materials can be divided into four types according to the phase change mode：solid - liquid, solid - solid, solid - gas and liquid - gas. Solid-liquid phase variable materials have the advantages of high thermal conductivity and low cost, but at the same time there are also phenomena of supercooling and phase separation, which affect the life of the materials. The fixed phase change heat storage material is composed of phase change material and matrix, which can maintain the same shape when used. According to the different morphologies, the fixed phase change heat storage materials can be divided into microencapsulated phase change heat storage materials, polymer-based phase change heat storage materials and porous phase change heat storage materials.

Microencapsulated phase change heat storage material improves the low energy storage density and high technical requirements of traditional phase change materials in the process of use. But the thermal conductivity has not been improved. A new type of nano-microcapsule phase change material with organic phase change material as core material and inorganic material as wall material combines the advantages of organic phase change material in heat storage and the good thermal conductivity of inorganic material[3].

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2.3 Applications of Phase Change Energy Storage Materials

The phase change heat storage technology can solve the imbalance of energy supply in time and space,and has important application value in many fields. Phase change energy storage materials are used in building envelope, cooling and heating systems. Wang et al. Prepared multifunctional nanocomposites with PEG / SiO_2 as shape stabilized PCMs and Fe_3O_4 functional graphene nanosheets as energy converters, as shown in Figure 3[4]. The heat generated during the energy conversion process is stored in phase-change materials, which greatly improves the efficiency of solar energy utilization. A large number of phase change materials have been developed for use in cold storage air-conditioning systems and cogeneration units. From the practical use effect, it can effectively solve the power grid peak load shortage[5]. The phase change energy storage materials have the characteristics of high efficiency, energy saving and environmental protection, which can replace the traditional liquid cooling and air cooling technologies and become the first choice in the field of temperature control.

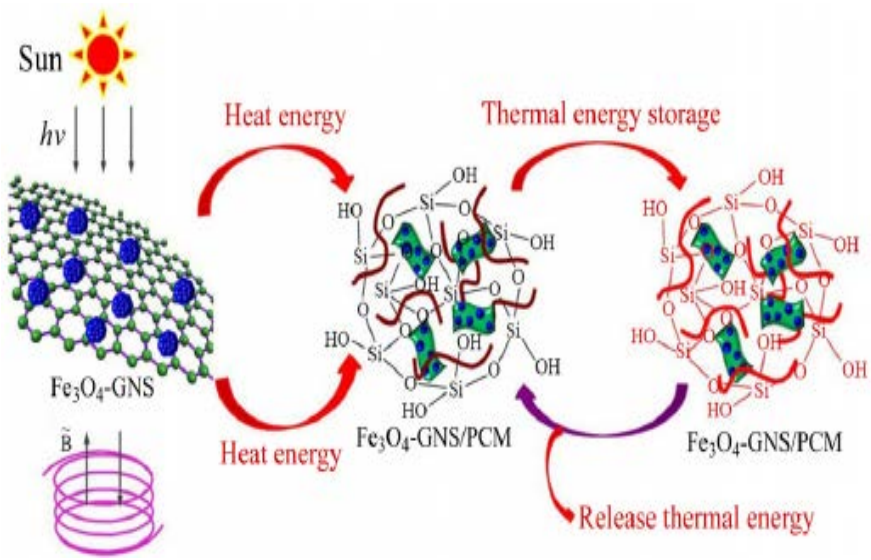

Figure. 3 Schematic diagram of magnetothermal and photothermal energy conversion and storage [4]

3. Conclusion

With the increasing requirements of environmental protection, energy conservation and pollution reduction in human society, there is more demand for phase change energy storage technology. Phase change energy storage materials will play a great role in the green and healthy development of human society.

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Acknowledgements

This paper is within the research of innovation and entrepreneurship training program for college Students of Xijing university.(No. 127152019086)

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