



ELSEVIER

Contents lists available at ScienceDirect

Solar Energy Materials & Solar Cells

journal homepage: www.elsevier.com/locate/solmat

Review

Salt hydrates as latent heat storage materials: Thermophysical properties and costs



Murat Kenisarin*, Khamid Mahkamov

Department of Mechanical and Construction Engineering, Northumbria University, Wynne-Jones Centre, Newcastle upon Tyne NE1 8ST, UK

ARTICLE INFO

Article history:

Received 14 July 2015

Received in revised form

14 October 2015

Accepted 22 October 2015

Available online 17 November 2015

Keywords:

Phase diagrams

Salt hydrates

Phase change materials

Latent heat storage

Thermophysical properties

Wholesale prices

ABSTRACT

Thermal energy storage is considered as one of the most perspective technologies for increasing the efficiency of energy conversion processes and effective utilization of available sources of heat. Advantages and technical attractiveness of the thermal energy storing have resulted in continuously increasing numbers of research activities, especially in the last four decades. Among various applications of thermal energy storage, the heat or cold accumulation in the temperature range from $-50\text{ }^{\circ}\text{C}$ to $120\text{ }^{\circ}\text{C}$ has a greater market potential and this can be carried out using a wide range of phase change latent heat materials. Among these materials the salt hydrates deserve a special attention and currently a large number of phase change compositions based on salt hydrates are produced commercially and available on the market. However, reliable data on thermophysical properties as well as their thermal stability over their lifetime is required to build effective storage systems. Currently this data is insufficient and is scattered across numerous sources that are often difficult to access for potential consumers. This paper summarises practically all available original experimental data on the phase change diagram of salt-water systems, melting temperatures, heat of fusion, specific heat, density, thermal conductivity, and thermal diffusivity in solid and liquid states and viscosity in the liquid state for 18 salt hydrates. The above information is provided for major market products on the basis of the salt hydrates for latent heat storage. The wholesale prices for pure salt, salt hydrates, and salt hydrate heat storage compositions are also additionally discussed.

© 2015 Elsevier B.V. All rights reserved.

Contents

1. Introduction	257
2. Salt hydrates for latent heat storage	258
2.1. Lithium chlorate trihydrate (LCT – $\text{LiClO}_3 \cdot 3\text{H}_2\text{O}$)	258
2.1.1. The melting temperature and other thermophysical properties	258
2.1.2. LCT as phase change latent heat storage material	258
2.2. Potassium fluoride tetrahydrate (PFT – $\text{KF} \cdot 4\text{H}_2\text{O}$)	258
2.2.1. The melting temperature and heat of fusion	258
2.2.2. Other thermophysical properties	259
2.2.3. PFT as phase change latent heat storage material	259
2.3. Manganese nitrate hexahydrate ($\text{MnNH} - \text{Mn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$)	259
2.3.1. The melting temperature and heat of fusion	259
2.3.2. Other thermophysical properties	259
2.3.3. MnNH as phase change latent heat storage material	259
2.4. Calcium chloride hexahydrate (CCH – $\text{CaCl}_2 \cdot 6\text{H}_2\text{O}$)	259
2.4.1. The melting temperature and heat of fusion	260
2.4.2. Density	260
2.4.3. Specific heat	260
2.4.4. Thermal conductivity	260

* Corresponding author. Tel.: +44 191 227 3685.

E-mail address: murat.kenisarin@northumbria.ac.uk (M. Kenisarin).

2.4.5.	CCH as a phase change latent heat storage material	261
2.5.	Lithium nitrate trihydrate (LNT– $\text{LiNO}_3 \cdot 3\text{H}_2\text{O}$)	261
2.5.1.	Melting temperature and heat of fusion	261
2.5.2.	Density	261
2.5.3.	Other thermophysical properties	262
2.5.4.	LNT as phase change latent heat storage material	262
2.6.	Sodium sulphate decahydrate ($\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ Glauber's salt – SSD)	262
2.6.1.	Melting temperature	263
2.6.2.	Density	263
2.6.3.	Specific heat and heat of fusion	263
2.6.4.	Thermal conductivity	263
2.6.5.	SSD as the phase change latent heat storage material	263
2.7.	Sodium carbonate decahydrate (SCD – $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$)	263
2.7.1.	Melting temperature and heat of fusion	263
2.7.2.	Density	264
2.7.3.	Specific heat	264
2.7.4.	Thermal conductivity	264
2.7.5.	SCD as phase change latent heat storage material	264
2.8.	Zinc nitrate hexahydrate (ZNH – $\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$)	265
2.8.1.	Melting temperature and heat of fusion	265
2.8.2.	Density	265
2.8.3.	Specific heat	265
2.8.4.	ZNH as phase change latent heat storage material	265
2.9.	Disodium hydrogenphosphate dodecahydrate (DHPD – $\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$)	265
2.9.1.	Melting temperature and heat of fusion	265
2.9.2.	Density	266
2.9.3.	Specific heat	266
2.9.4.	Thermal conductivity	266
2.9.5.	DHPD as phase change latent heat storage material	267
2.10.	Calcium nitrate tetrahydrate (CNT – $\text{Ca}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$)	267
2.10.1.	Melting temperature and heat of fusion	267
2.10.2.	Density	267
2.10.3.	Specific heat	268
2.10.4.	Thermal conductivity	268
2.10.5.	CNT as the latent heat storage material	268
2.11.	Sodium thiosulfate pentahydrate (STP – hyposulphite – $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$)	268
2.11.1.	Melting temperature and heat of fusion	268
2.11.2.	Density	268
2.11.3.	Specific heat	269
2.11.4.	Thermal conductivity	269
2.11.5.	STP as phase change latent heat storage material	269
2.12.	Sodium acetate trihydrate (SAT – $\text{CH}_3\text{COONa} \cdot 3\text{H}_2\text{O}$)	269
2.12.1.	Melting temperature	269
2.12.2.	Density	270
2.12.3.	Specific heat and heat of fusion	270
2.12.4.	Thermal conductivity	270
2.12.5.	SAT as phase change latent heat storage material	271
2.13.	Cadmium nitrate tetrahydrate (CNT – $\text{Cd}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$)	271
2.13.1.	Melting temperature and heat of fusion	271
2.13.2.	Density and viscosity	272
2.13.3.	Specific heat	272
2.13.4.	CNT as phase change latent heat storage material	272
2.14.	Sodium hydroxide 3.5-hydrate and monohydrate (SHH_3.5 – $\text{NaOH} \cdot 3.5\text{H}_2\text{O}$; SHM – $\text{NaOH} \cdot \text{H}_2\text{O}$)	272
2.14.1.	Melting temperature and heat of fusion	272
2.14.2.	Density	272
2.14.3.	Specific heat	272
2.14.4.	Other thermophysical properties	273
2.14.5.	SHH_3.5 and SHM as phase change latent heat storage material	273
2.15.	Barium hydroxide octahydrate (BHO – $\text{Ba}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$)	273
2.15.1.	Melting temperature	273
2.15.2.	Density	273
2.15.3.	Specific heat and heat of fusion	273
2.15.4.	Thermal conductivity	274
2.15.5.	BHO as latent heat storage material	274
2.16.	Magnesium nitrate hexahydrate (MNH – $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$)	274
2.16.1.	Melting temperature and heat of fusion	275
2.16.2.	Density	275
2.16.3.	Specific heat	275
2.16.4.	Thermal conductivity	276
2.16.5.	MNH as phase change latent heat storage medium	276
2.17.	Ammonium alum dodecahydrate (AAD – $\text{NH}_4\text{Al}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$)	276
2.17.1.	Melting temperature	276

Download English Version:

<https://daneshyari.com/en/article/77681>

Download Persian Version:

<https://daneshyari.com/article/77681>

[Daneshyari.com](https://daneshyari.com)