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New storage materials for thermolchemal storage of low temperature solar thermal energy

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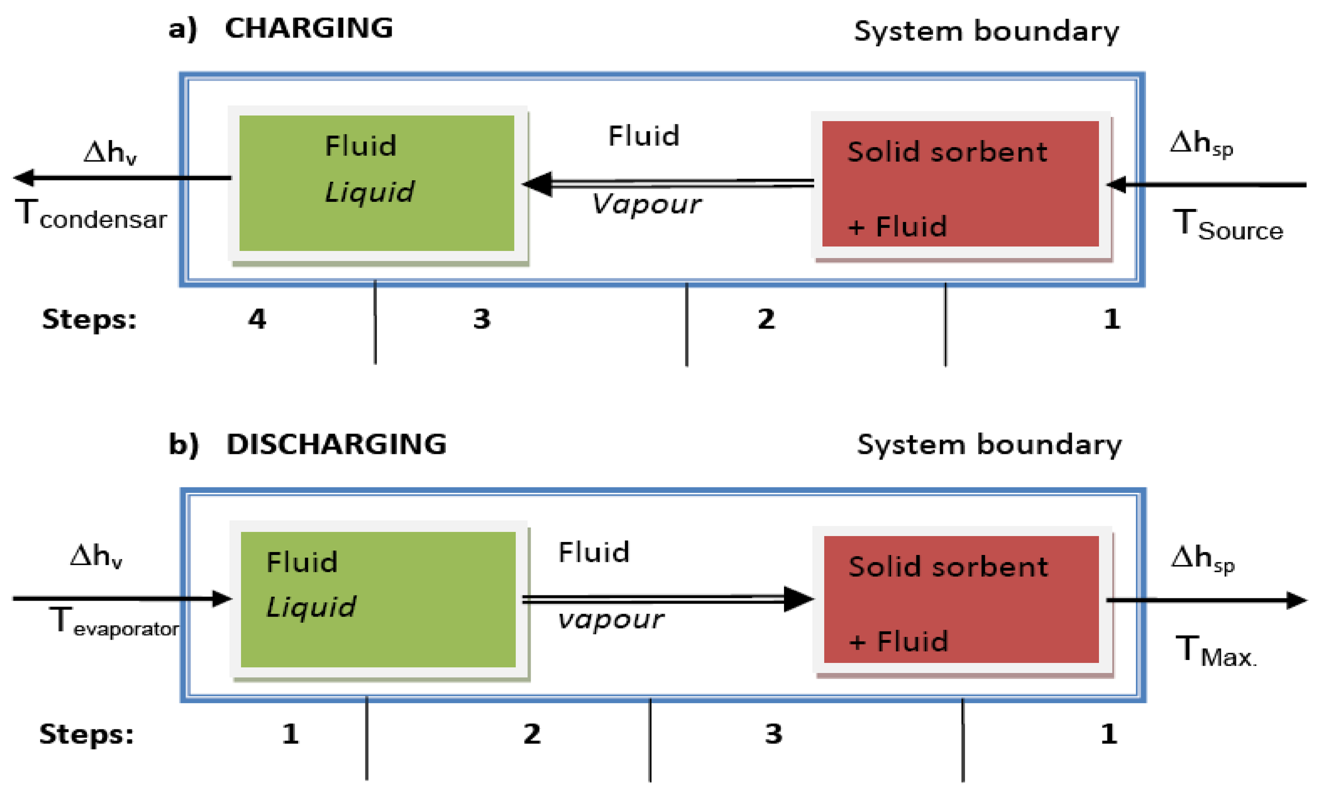
Introduction: The company ZEOSYS has emerged from the former German Academy of Science in Berlin. The present emphasis of the company's activity is focused on experimental and theoretical research works. The research profile spans a wide range from fundamental studies to industrial applications in the areas of environmental protection, medicine and energy technology. The aim of the research and development, whose results are discussed here, corresponded to the above-stated considerations and proceeded in searching and testing of new porous materials for thermochemical storage of solar low-temperature thermal heat. The substantial advantages of the method are very high energy storage densities, the loss-free storage of the thermal heat during the storage time as well as the simultaneous supply of cold and heat.

Thermochemical Energy Storage

Figure 1: Material and energy flow in a closed thermochemical heat storage



Fluid : Water

Advantages (Selection):

- High enthalpy of evaporation
- Dipol character (high interaction)
- Availablity
- Non-toxic
- Low preis

Solid sorbent: Requirements

Application and selection depends on :

- Temperature of the energy source T_{Source}
- Usable temperature of the application T_{Max}
- Heat transport efficiency
- Stabilitäy
- Preis

Experimental Setup

Figure 2: Laboratory scale 1.5 L thermochemical storage unit

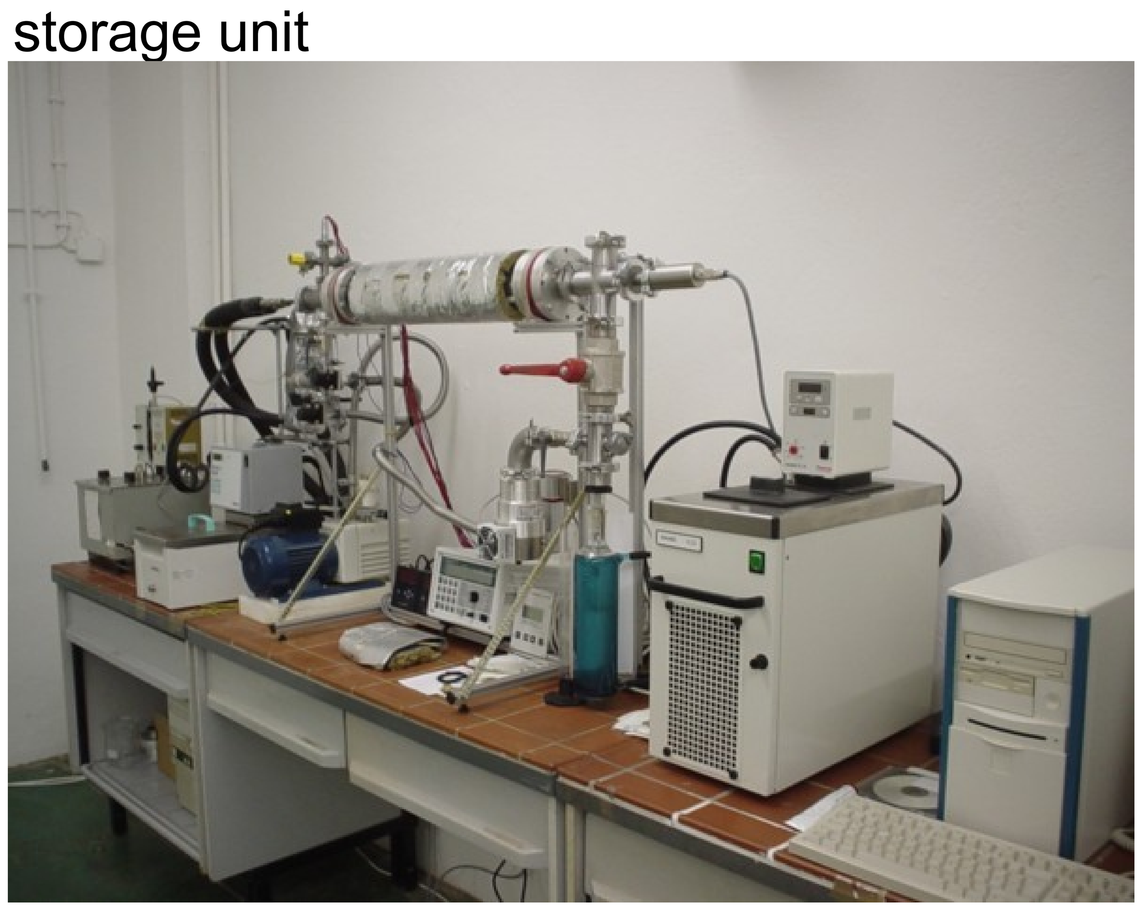
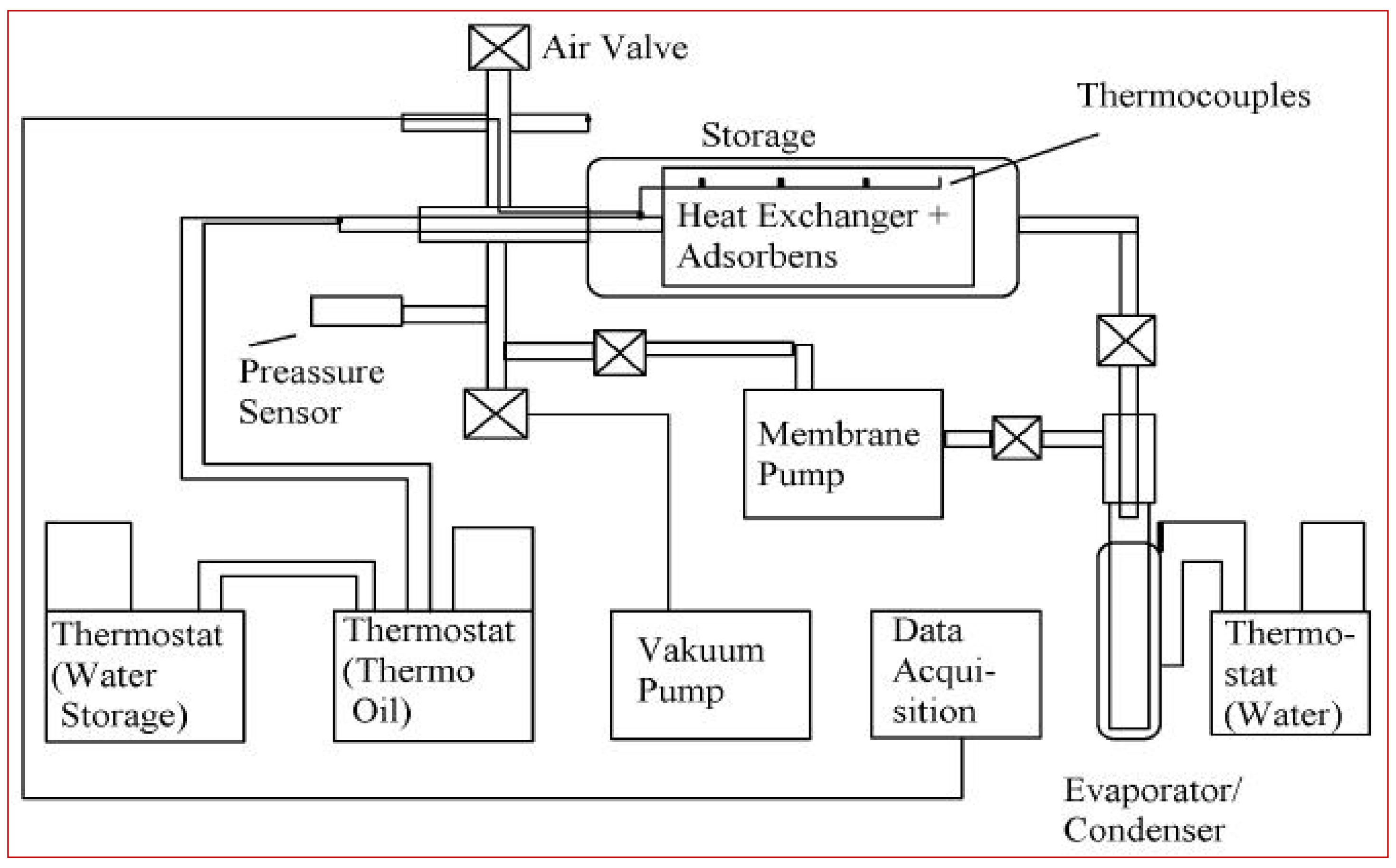


Figure 3: Schematic representation



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The results presented here are the product of a research collaboration between the TFH Wildau and the research and development enterprise ZEOSYS Ltd. The financial support was provided from the German Federal Ministry of Economics and Labour (Grant No. 0329525F).

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Experimental methods: Partial dealumination of NaY-Zeolites (Si/Al = 2,3 - 30), Thermo-gravimetry (DTG, DTA) isotherms measurement, determination of adsorption capacities, desorption temperatures and storage densities, measurement carried out using laboratory scale thermo chemical storage unit (1,5 Liter)

Storage Materials

Table 1: Studied groups of storage materials

Poro-Tekto-Alumosilicate (Zeolite)
MCM-41-material
Composite adsorbents (hydrate-forming salt on a porous carrier or support)
Silicoalumophosphate and aluminophosphates (SAPOs and AlPOs)
metal organic frameworks, MOFs

Table 2: Composition of the investigated faujasite zeolites

Material	Si/Al	Elementary cell
NaLSX	1	$Na_{96}[(AlO_2)_{96}(SiO_2)_{96}]$
NaX	1,3	$Na_{83}[(AlO_2)_{83}(SiO_2)_{109}]$
NaY-1	2,4	$Na_{56}[(AlO_2)_{56}(SiO_2)_{136}]$
NaY-2	7,4	$Na_{23}[(AlO_2)_{23}(SiO_2)_{169}]$
NaY-3	11,4	$Na_{15}[(AlO_2)_{15}(SiO_2)_{177}]$
NaY-4	30	$Na_{6}[(AlO_2)_{6}(SiO_2)_{186}]$
NaY-5	100	$Na_{2}[(AlO_2)_{2}(SiO_2)_{190}]$

Tabelle 3: Water adsorption capacity of modified faujasite zeolites (spherical))

Material	a [g/g]	Q_1 [kJ/kg]	Q_2 [kWh/kg]	Q_3 [kWh/l]
NaLSX	0,280	1049	0,291	0,198
NaX	0,287	1000	0,278	0,176
NaY-1	0,283	935	0,257	0,169
NaY-2	0,217	952	0,165	0,078
NaY-3	0,241	796	0,207	0,099
NaY-4	0,130	445	0,123	0,057
NaY-5	0,054	21	0,053	-

Results

Figure 1: TG-profile of dealuminated NaY- Zeolites

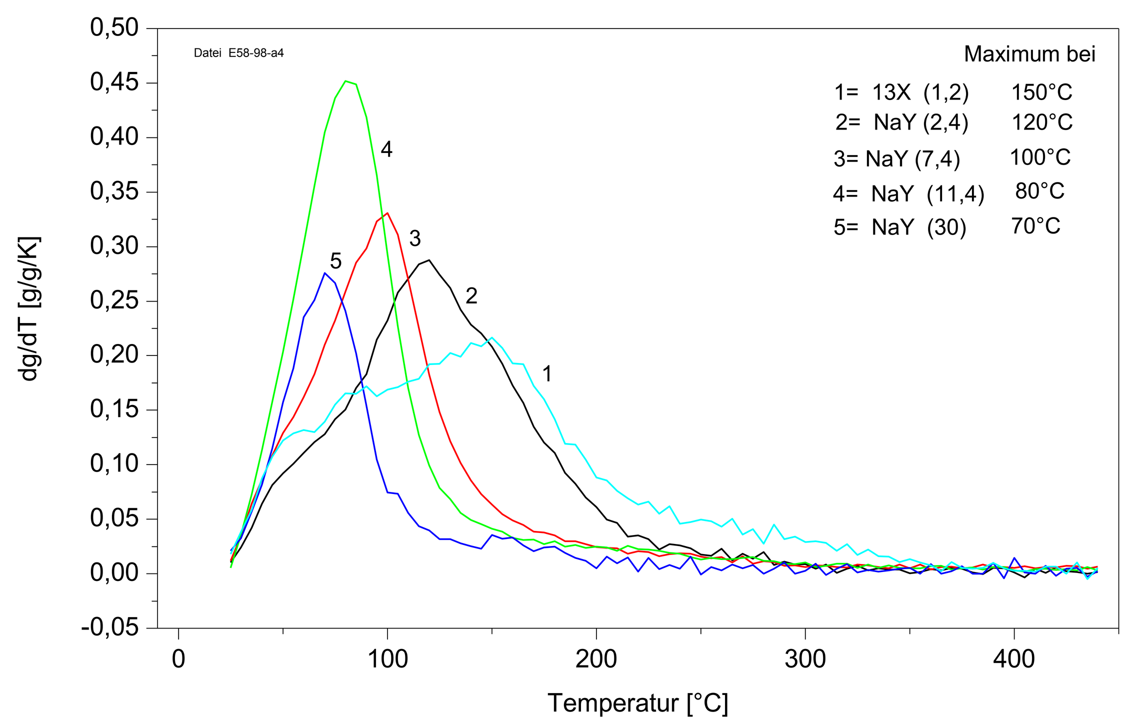


Figure 2: Water isotherms of NaX (1,2), NaY (2,3), NaY (7), NaY (11); from left to right

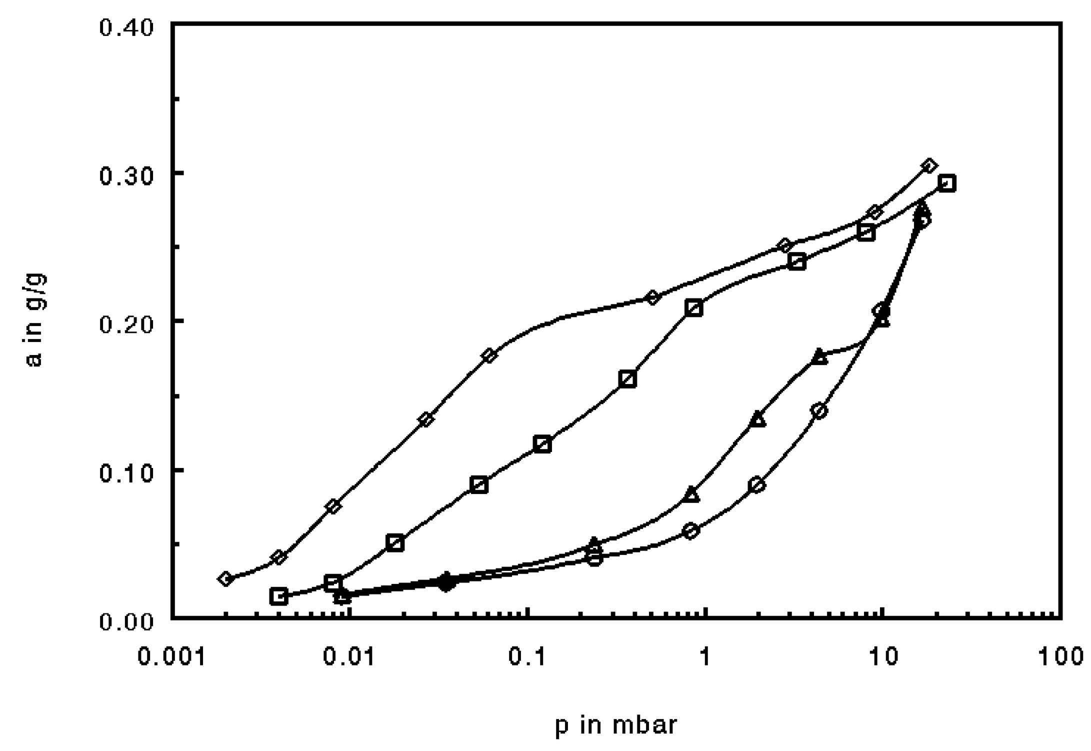
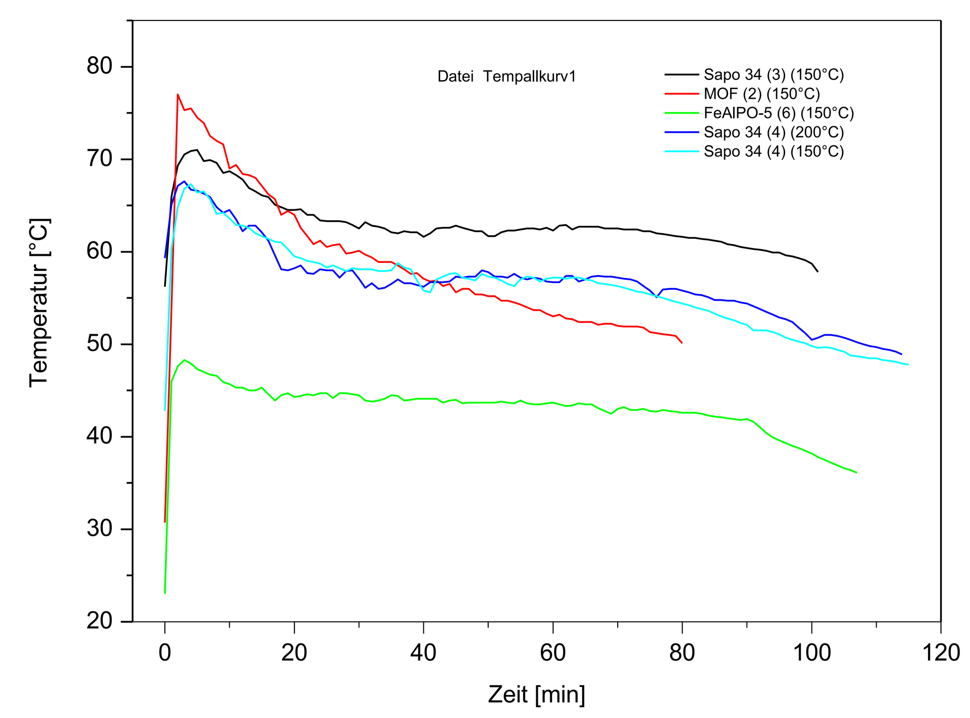


Figure 3: Temperature profiles as a function of time for different storage materials



Results and Conclusions

1. **Storage materials are available for solar driven heat storage with slightly dealuminated NaY zeolites, which fulfills several conditions to thermal requirements. Their frequent application will reduce the recently relatively high zeolite price and thus it will strongly promote the use of thermochemical heat storages.**

2. **Test on adsorbents SAPO4-34 and AlPO4-18 types showed that both micro-porous solid materials are well suitable as storage materials for thermochemical heat storage, when solar heat collectors supply a temperature ranges from 100 to 150°C. At the same desorption temperature (T_{Source}), their storage densities and water adsorption capacity exceed that of the corresponding values of NaLSX, NaX and NaY-1.**

3. **Essential pre-requisite for the application as thermochemical storage materials possess special composite adsorbents, i.e. porous supports (e.g. silica gels, clay/tone minerals among others) impregnated with hydrate-forming salts (e.g. $MgCl_2$ x 6 H_2O, $CaCl_2$ x 6 H_2O among others). However thereby the process conditions are to be kept constant, since otherwise decomposition can occur that leads to a destruction of the system.**

4. **Two adsorbents from a new adsorbent classes called Metal Organic Framework (MOF) exhibit high water adsorption capacity. This is found to be consistent (or higher) to those studied SAPO4-34-samples. A comparison of their specific heat energy (attained from heat storage measurements) with those examined best zeolitic adsorbents displays higher values. Therefore, they seem to be very well suitable for the solar heat storage.**

We would like to thank Ms. DI JANSEN und DR D. ACKERMANN for their participation in the experimental works . Our thanks goes also to Mrs. E. Weiler (Berlin), not only for the measurements she has carried out but also for her great support and team work.