Porous solids for heat storage applications: In-depth material testing by vapor breakthrough measurements

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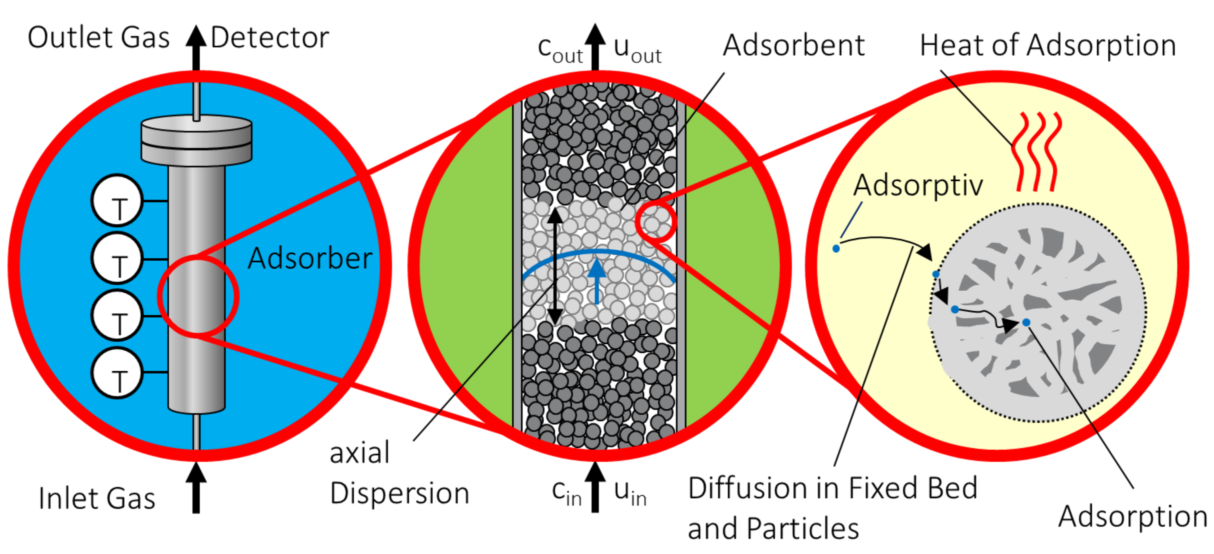
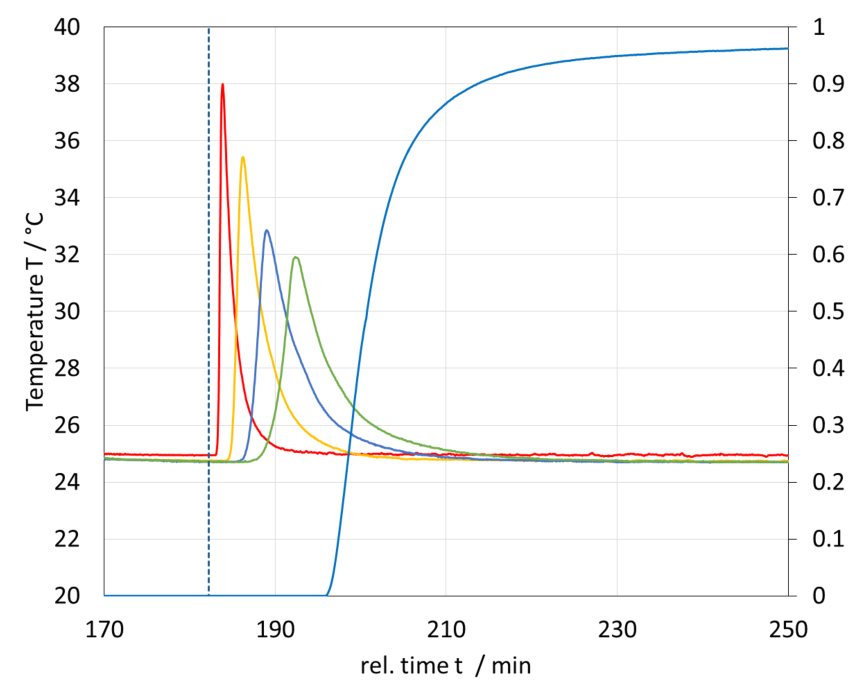
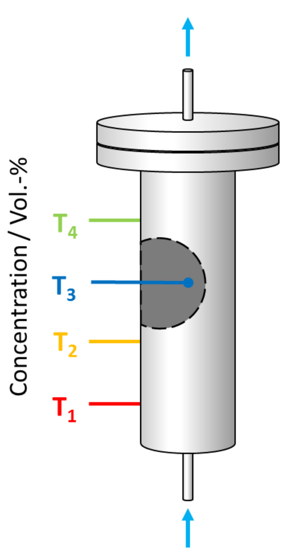
Experimental

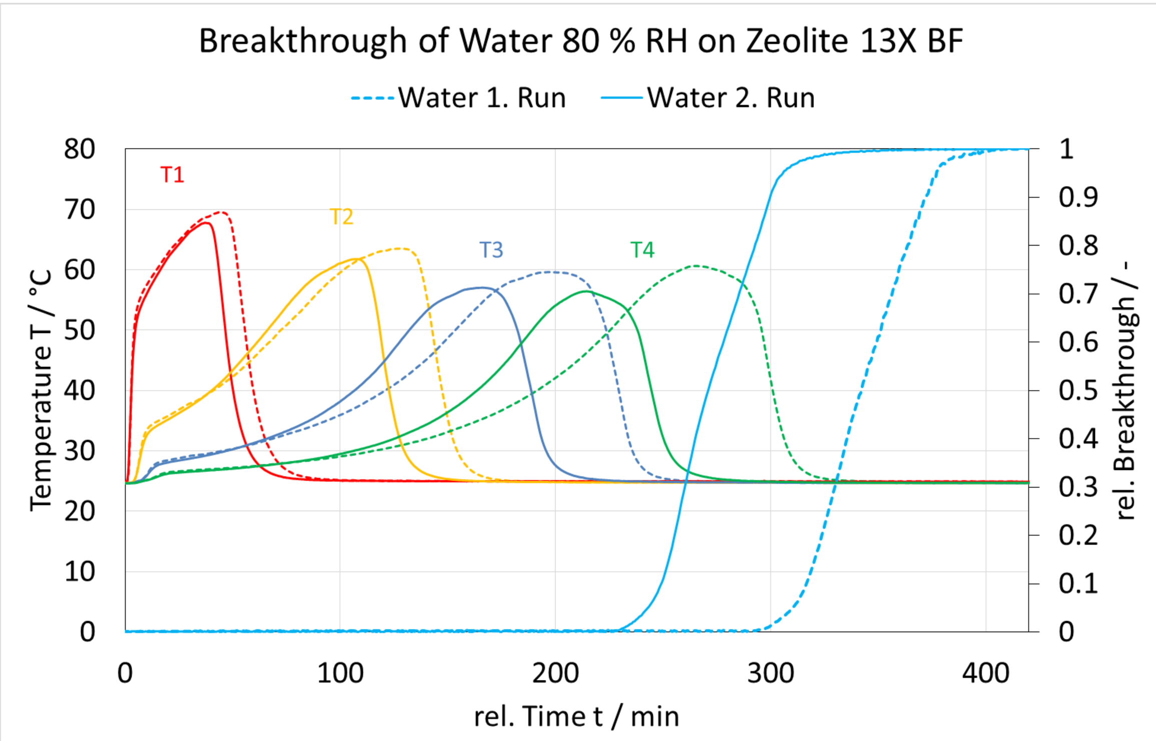


- about 80 g of sample where filled in an adsorber and **activated** at 350 °C for 6 h in 2 L min^{-1} nitrogen flow
- **1. Run: Breakthrough of H_2O** in N_2 carrier gas (80 % RH at 25 °C, total gas flow 4 L min^{-1})
- **Regeneration:** temperature ramp 1 K min^{-1} to 130 °C, dwell time 210 min, 2 L min^{-1} N_2-flow → **2. Run**
- **2. Run:** conditions identical to 1. Run
- **Temperature measurements** along the adsorber axis



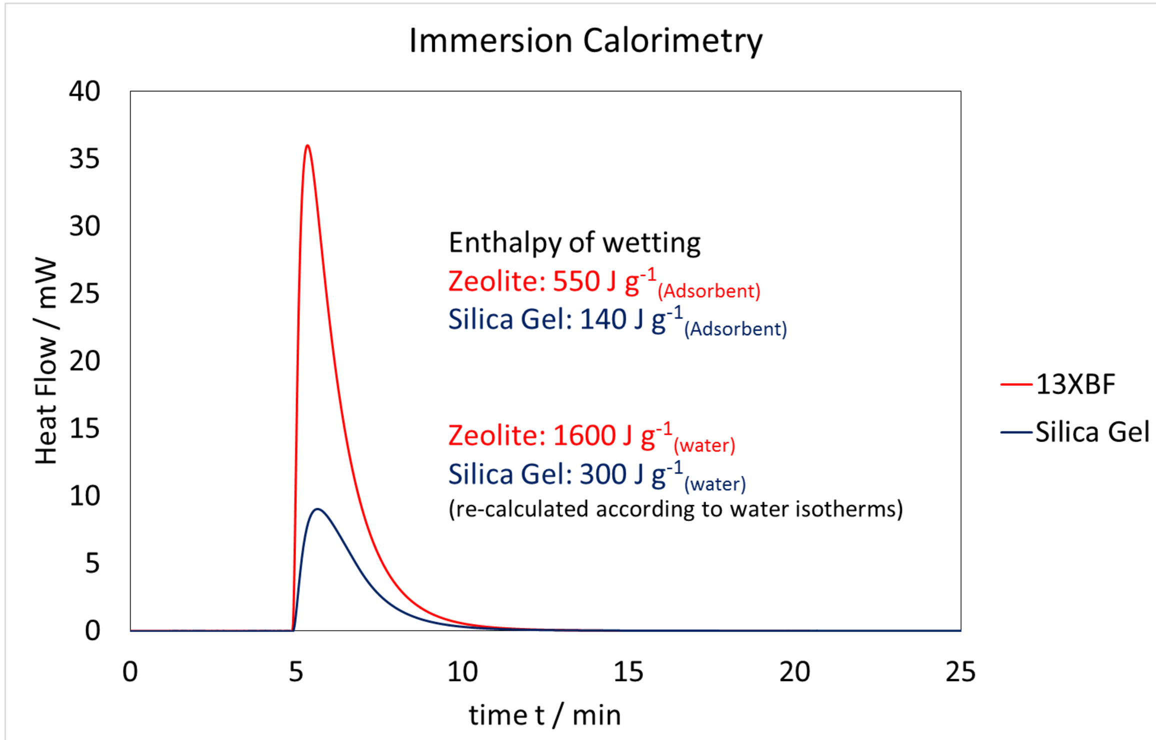


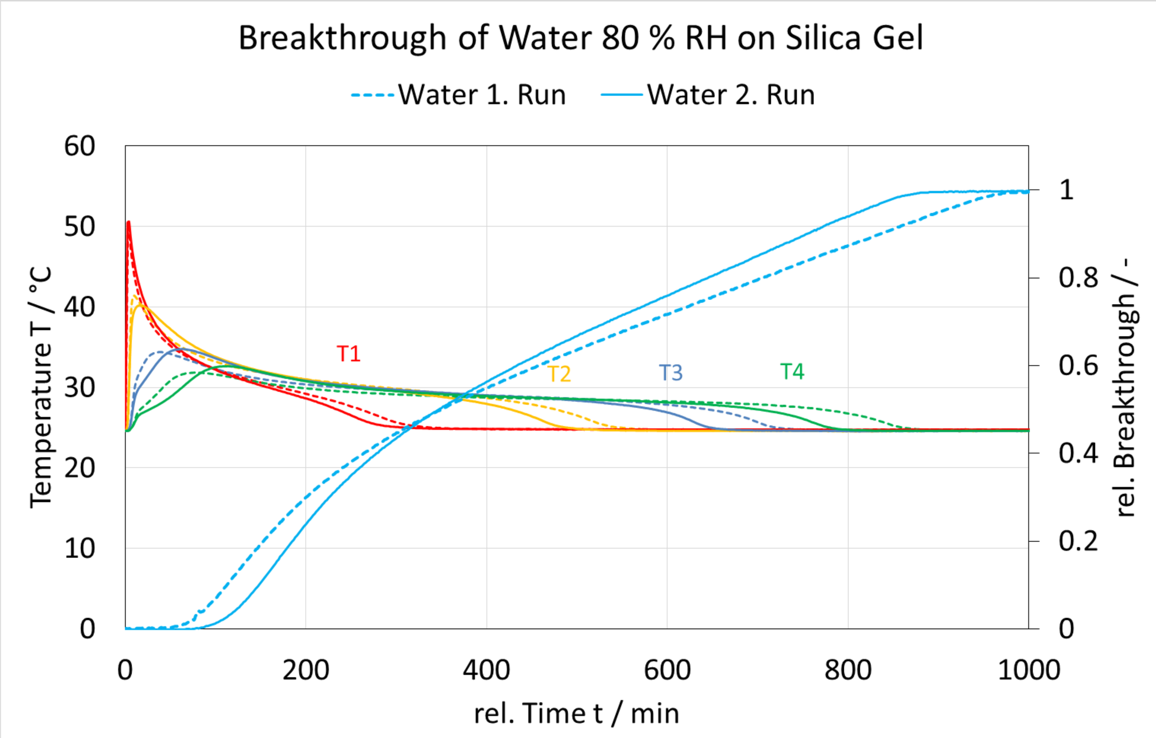
Results

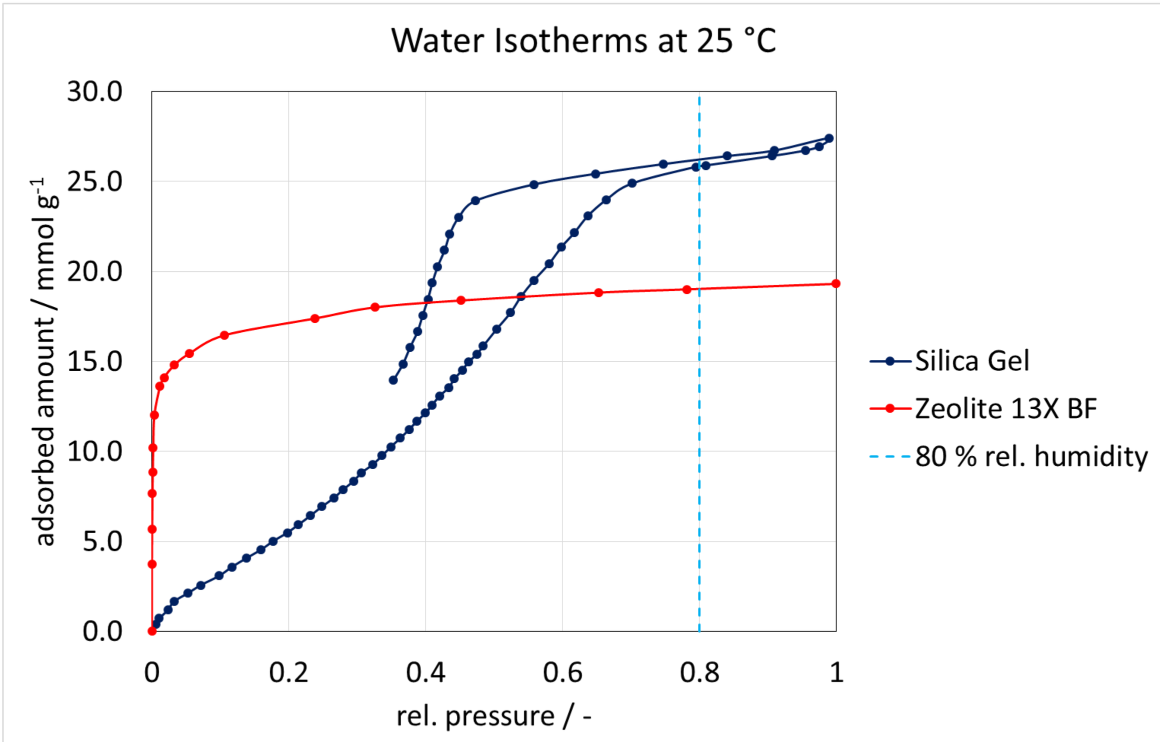


Adsorption capacity / mmol g^{-1}	Zeolite 13X BF	Silica Gel
1. Run	**18.9**	**25.9**
2. Run	15.4	25.1

- **After Activation:** Integration of 1. Run-breakthrough curves yields adsorption capacities in perfect agreement to water isotherm data measured in a volumetric manner.
- **After Regeneration:** Silica Gel reaches similar adsorption capacities whereas zeolite 13XBF loses about 20 %.





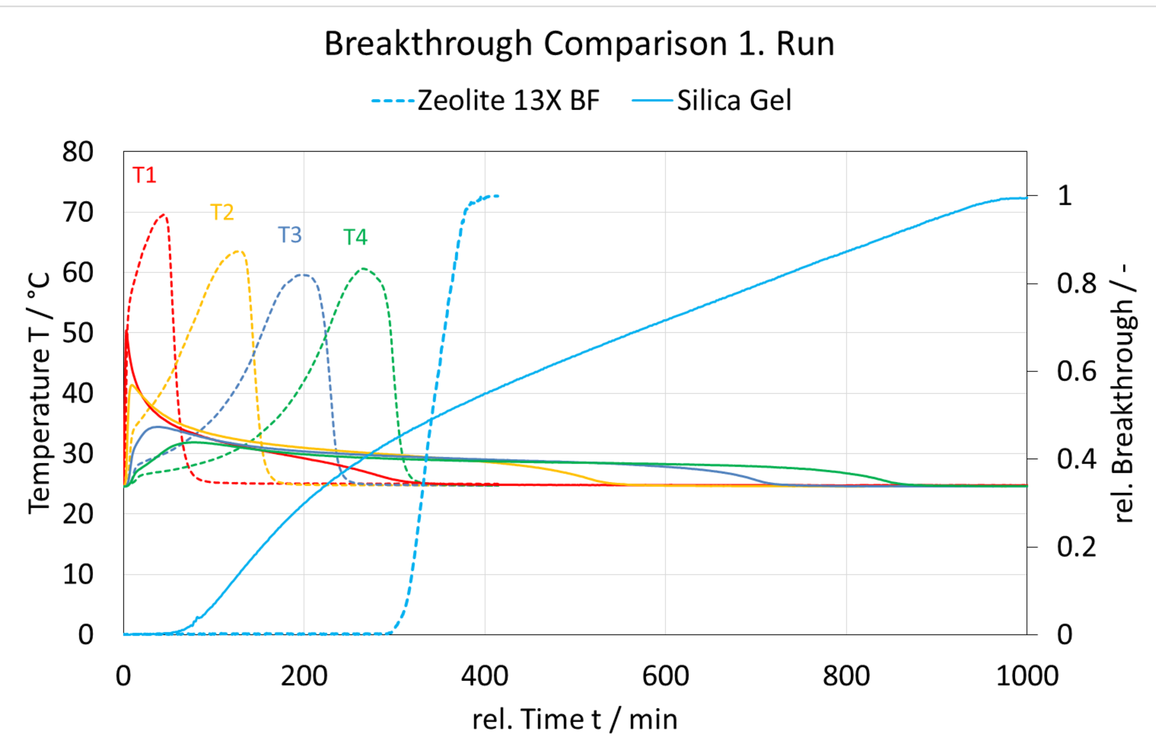


››Enthalpy of Adsorption = Wetting + Evaporation‹‹

$h_A = h_W + h_E$

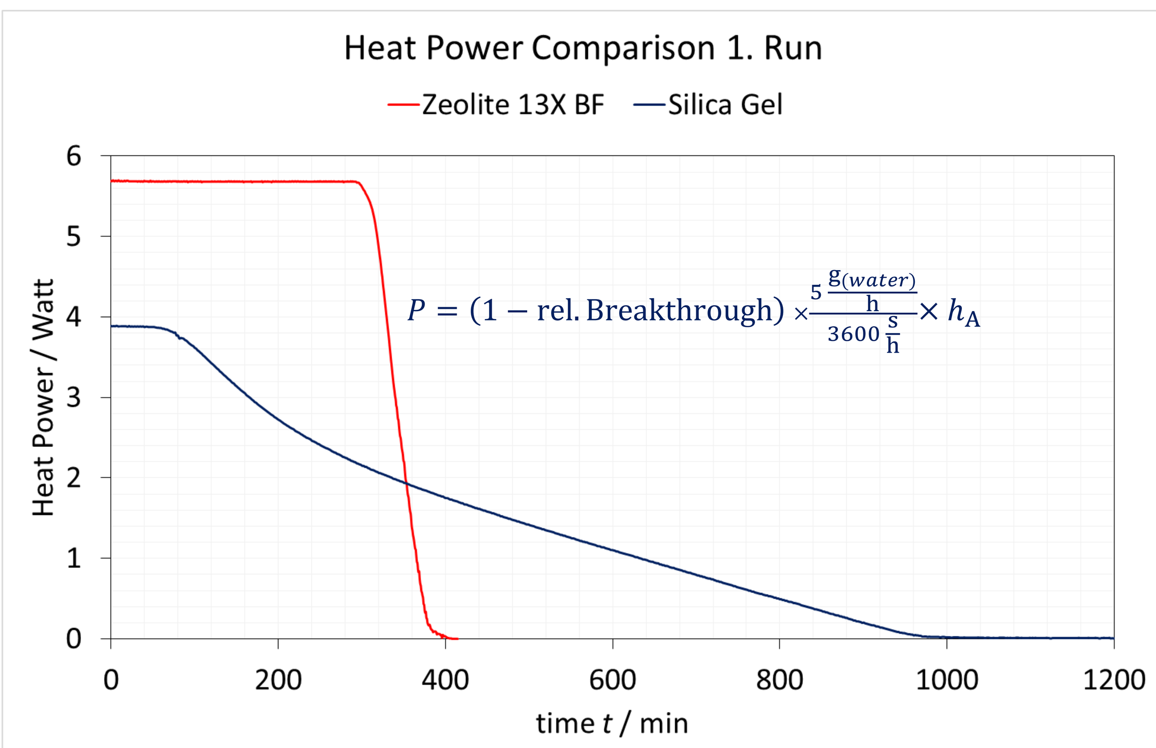
	Zeolite 13X BF	Silica Gel
h_W / J g^{-1} (H_2O)	1600	300
h_E / J g^{-1} (H_2O)	2500	2500
h_A / J g^{-1} (H_2O)	**4100**	**2800**

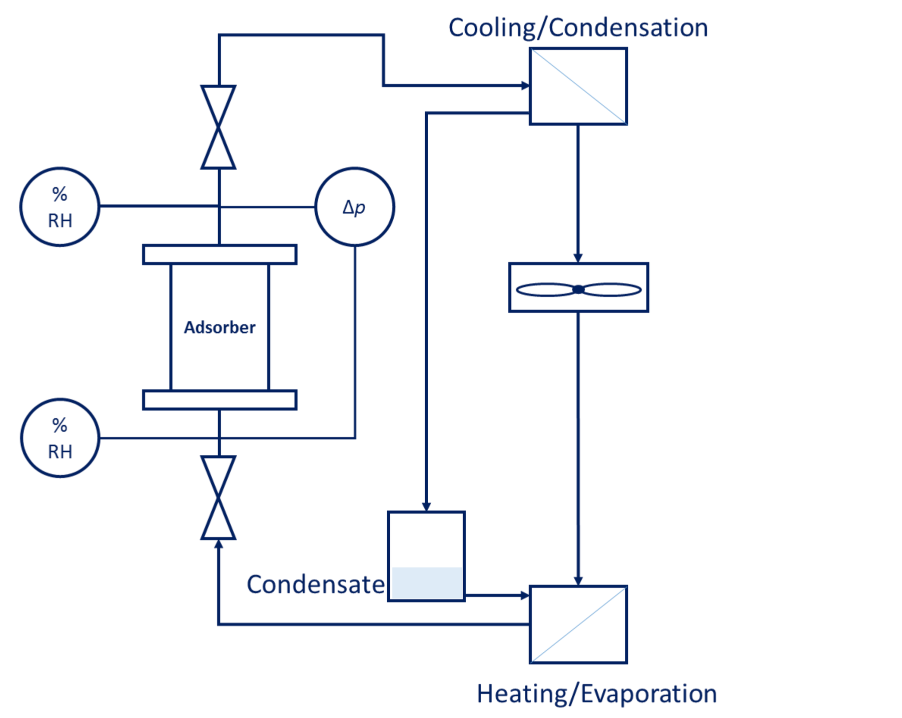
h_A



5 g H_2O / h

80 % rel. humidity @ 25 °C
4 L min^{-1} gas flow





Scheme of an open adsorptive heat storage

Conclusions

- Breakthrough measurements with water vapor provide useful information relevant for adsorptive heat storage applications, e.g. temperature profiles within the adsorber, adsorption capacities, kinetics of adsorption, etc.
- Aging and regeneration studies can be conducted under technically relevant conditions.
- Breakthrough curves can be converted into **››heat power curves‹‹** characteristic for an open adsorptive heat storage at certain process conditions.
- Energetic considerations (calorimetry) alone miss the impact of dynamical aspects in adsorptive heat storage applications

✓ Regeneration studies
✓ Material testing at various conditions
✓ Direct material comparison at similar conditions
✓ Temperature profiles within the fixed bed
✓ Estimation of heat power
✓ Information on adsorption dynamics

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