International Energy and Environment Conference 2025

8. – 10. 9. 2025
Hotel Sepetná, Ostravice

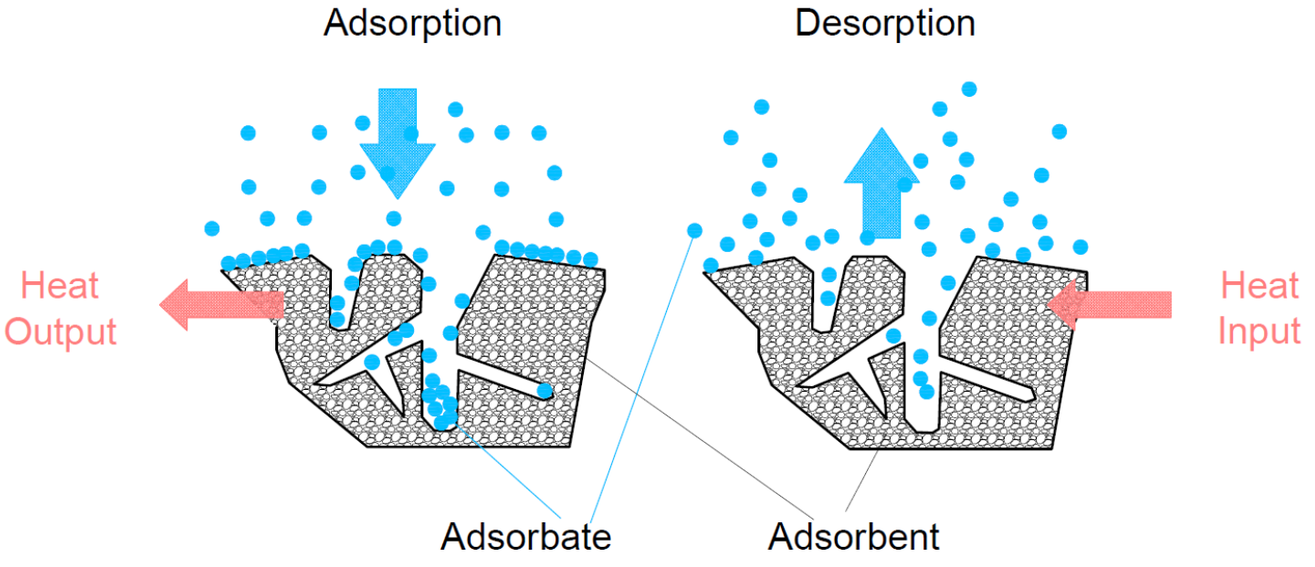
Coated Adsorption Beds for Enhanced Heat Transfer in Adsorption Cooling Systems

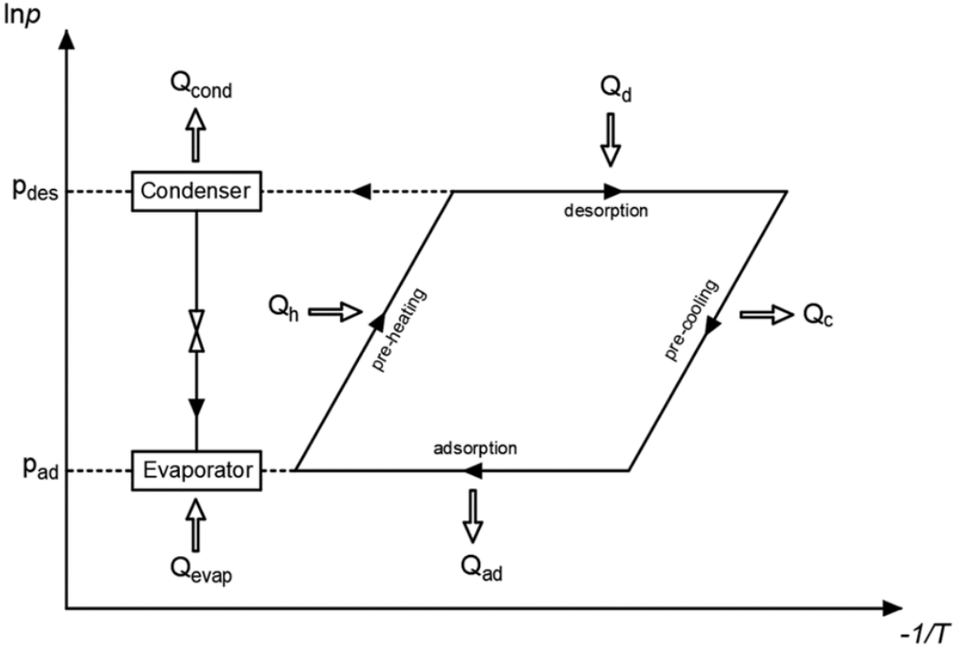
Tomasz Bujok, *Ewelina Radomska, Wojciech Kalawa, Agata Mlonka-Mędrala, Łukasz Mika, Karol Sztekler, Piotr Boruta*

bujok@agh.edu.pl

Ostravice, 08-10.09.2025

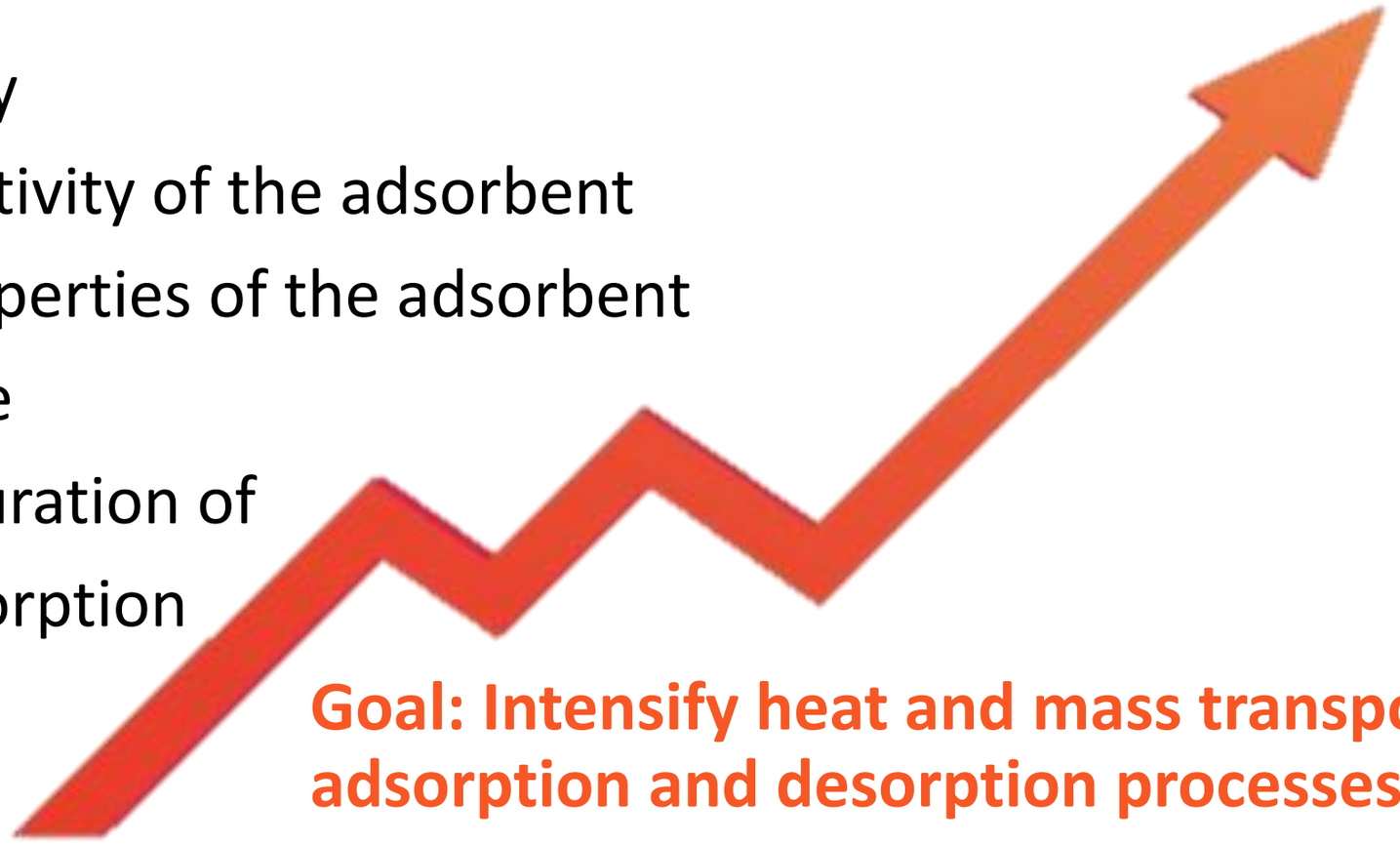
Adsorption chillers





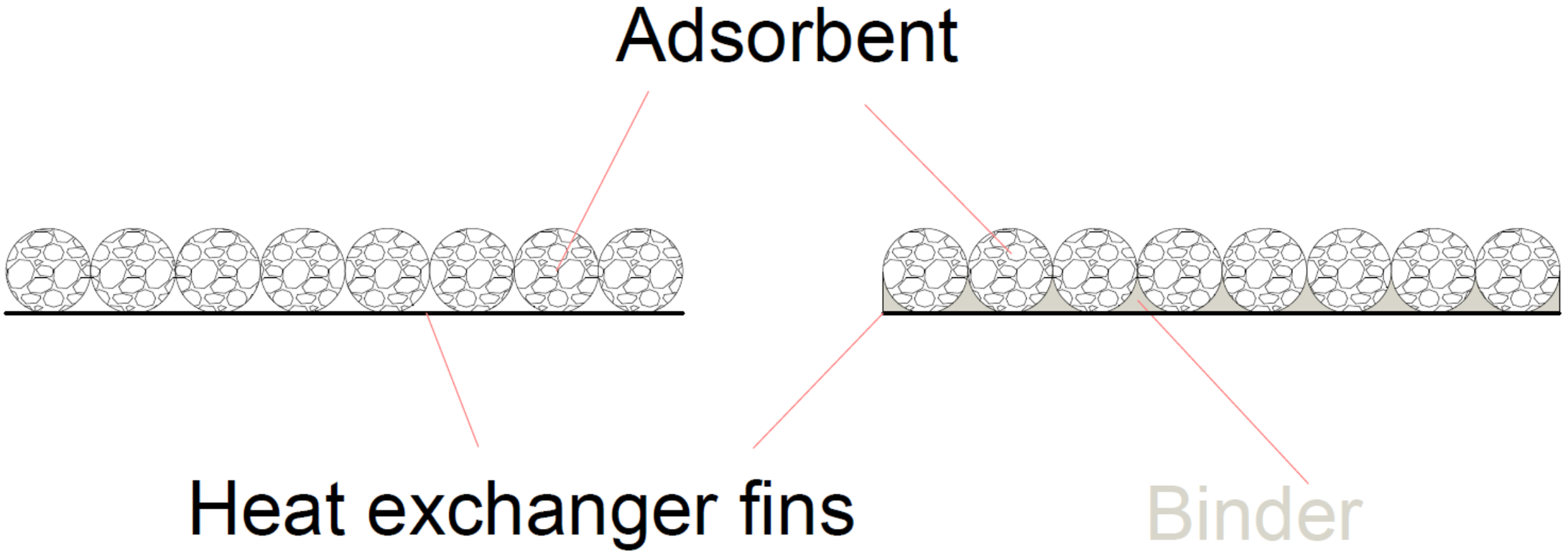
Motivation of the research

- Low chiller efficiency
- low thermal conductivity of the adsorbent
- limited sorption properties of the adsorbent
- large equipment size
- differences in the duration of adsorption and desorption processes



Goal: Intensify heat and mass transport in adsorption and desorption processes

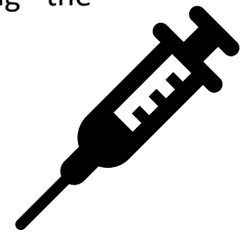
Binder as Solution - Maybe



Preparing bonded samples

Soaking in 10% sulphuric acid solution, washing with distilled water, pickling in NaOH and washing with distilled water

Preparation of the adhesive following the given procedure



Taking the necessary amount of adhesive to achieve a specific coating thickness and applying the adhesive to the aluminium pan

Preparation of specific silica gel fractions: lab mill + sieve. Application of silica gel on glue-coated pan

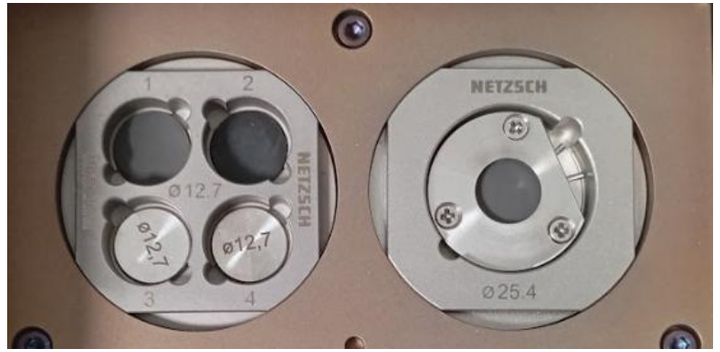
Two- step coating: binder application followed by sorbent application

Drying under room conditions for 12 h and then at 100 ^{o}C for 2-3 h

Methods

DSC

DSC 214 Polyma
Differential scanning calorimetry, Specific heat determination



LFA

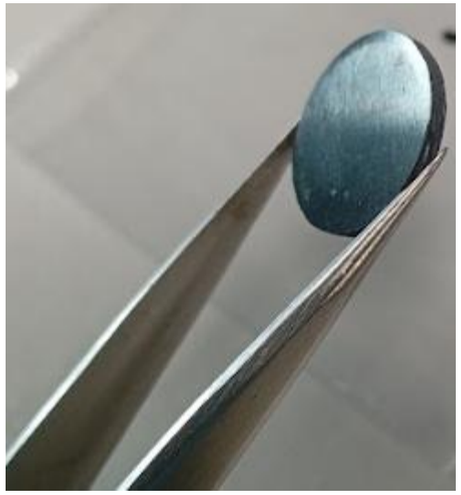
NETZSCH LFA 467 HyperFlash
Thermal diffusivity and conductivity coefficient

TGA

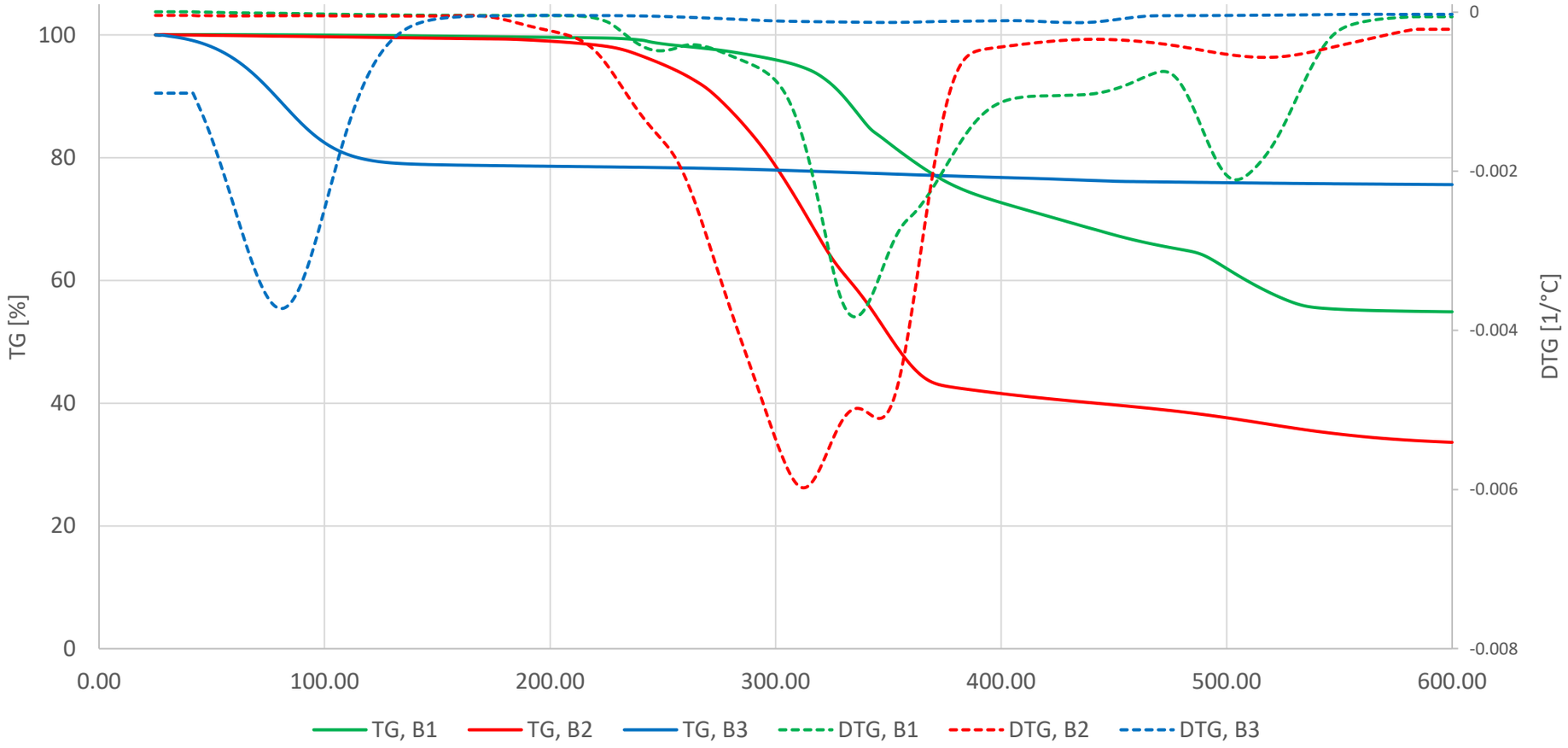
Mettler Toledo TGA-DSC 3+
Heating rate: 10 K/min
Thermal stability

DVS

DVS Vacuum, Gravimetric Vapor Sorption Analyzer
Sorption isotherms and kinetics



Thermal stability



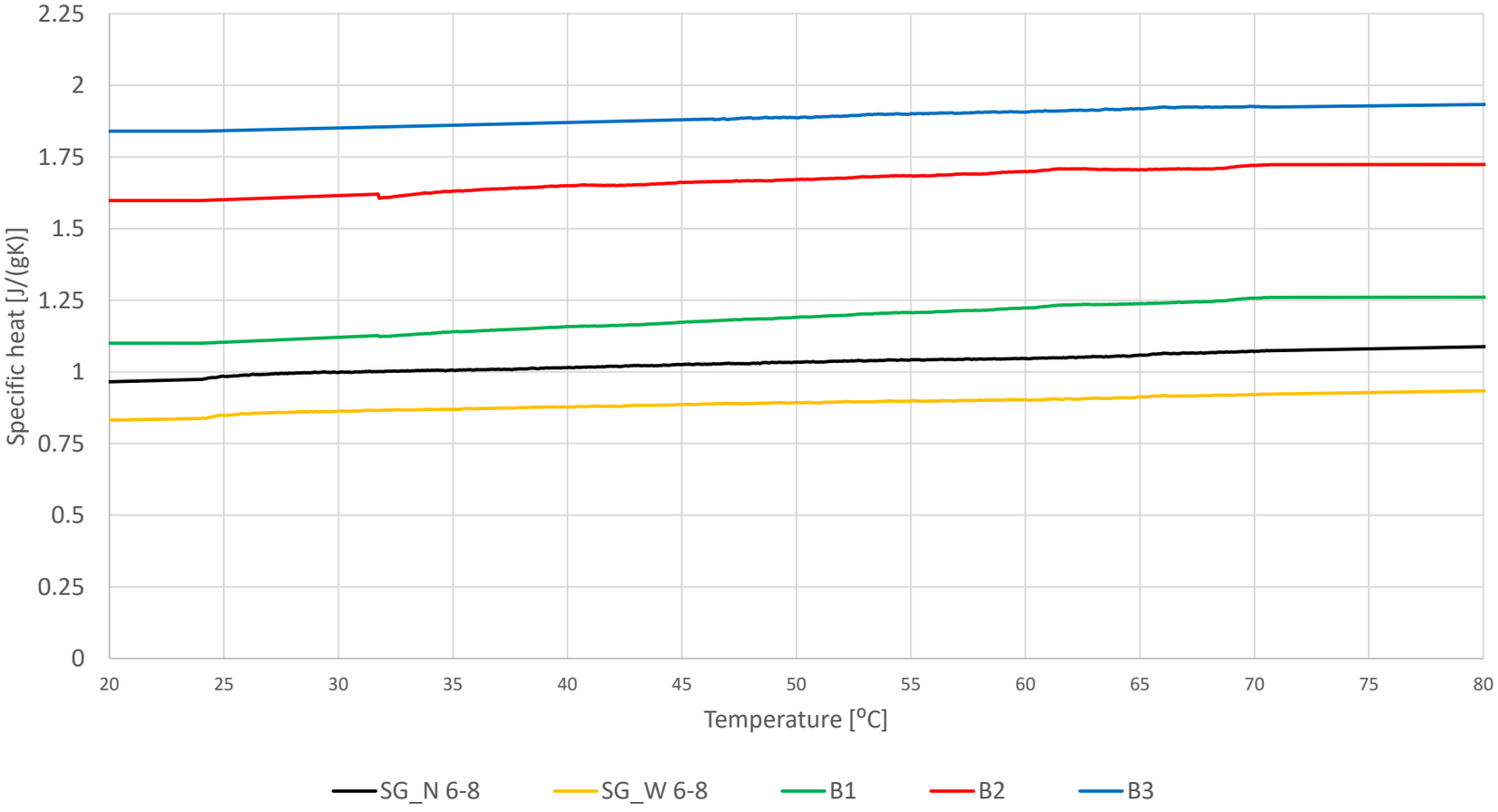
B1 – based on epoxy resin and graphite flakes

B2 – based on polyurethane resin and graphite flakes

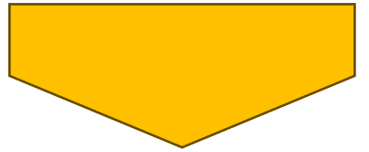
B3 – based on PVA and graphite flakes

Figure 1. Thermal behaviour of selected adhesives up to 600 °C under air conditions.

Specific heat determination



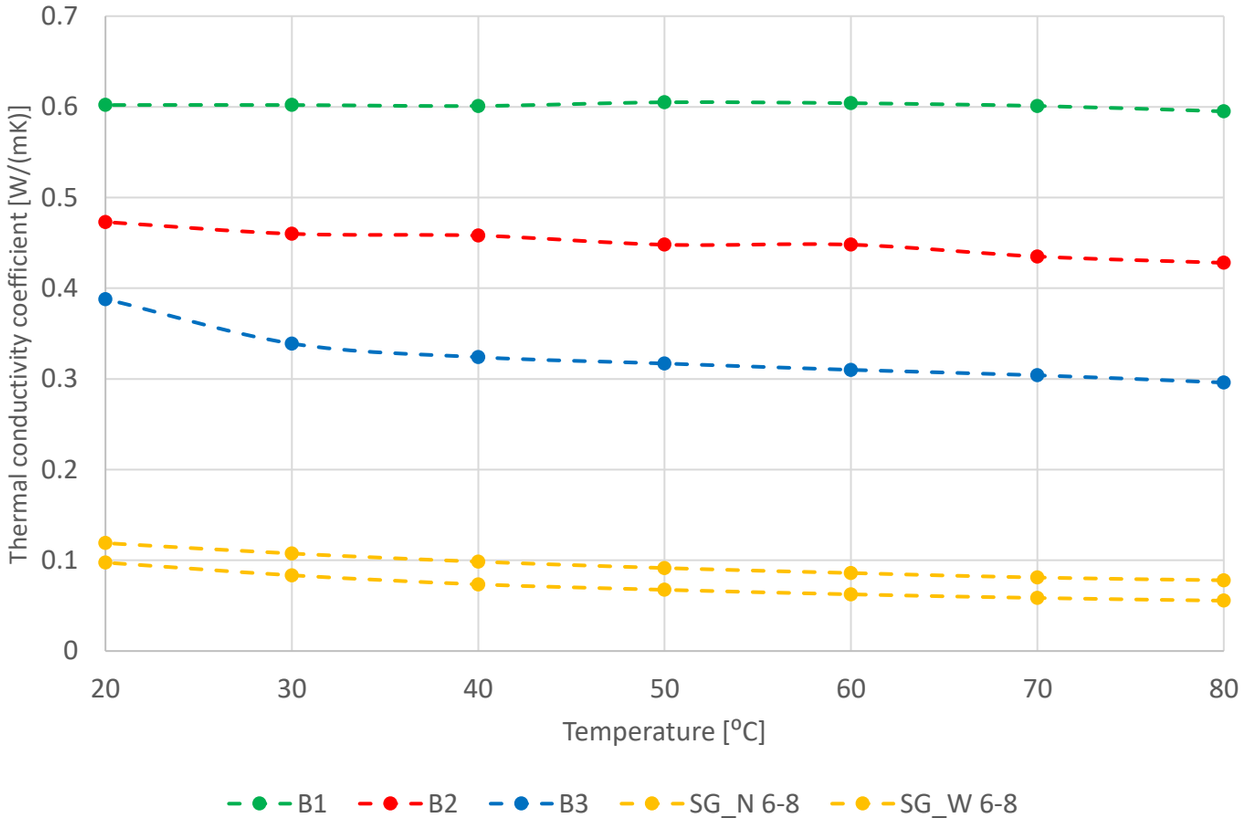
- B1 adhesive (based on epoxy resin and graphite flakes) has a specific heat similar to silica gel.



- uniform heating of the sorption bed

Figure 2. Specific heat of sorbents and selected adhesives.

Thermal conductivity



$$\lambda(T) = \alpha(T) \cdot \rho(T) \cdot c_p\,(T)$$

B1 – based on epoxy resin
B2 – based on polyurethane resin
B3 – based on PVA

LFA samples holders
Samples were graphite-coated
Sample h=1,5mm Ø=14,8 mm

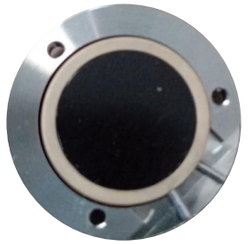


Figure 3. Thermal conductivity coefficient of adhesives and sorbents.

Thermal conductivity

Temperature	[°C]	20	30	40	50	60	70	80
Thermal conductivity of SG_N 6-8	[W/(mK)]	0,078	0,081	0,086	0,092	0,099	0,108	0,119
Thermal conductivity of SG_N 6-8 + B1	[W/(mK)]	0,216	0,224	0,230	0,240	0,252	0,263	0,272
Improvement	[%]	177	176	167	162	155	145	128
Thermal conductivity of SG_N 6-8 + B2	[W/(mK)]	0,175	0,180	0,187	0,192	0,198	0,207	0,214
Improvement	[%]	124	122	117	108	99	91	79
Thermal conductivity of SG_W 6-8	[W/(mK)]	0,056	0,059	0,063	0,068	0,074	0,084	0,098
Thermal conductivity of SG_W 6-8 + B1	[W/(mK)]	0,397	0,399	0,402	0,402	0,399	0,395	0,387
Improvement	[%]	614	581	542	495	443	373	297
Thermal conductivity of SG_W 6-8 + B2	[W/(mK)]	0,165	0,168	0,170	0,173	0,177	0,182	0,188
Improvement	[%]	195	184	169	154	139	117	91

Sorption kinetics results

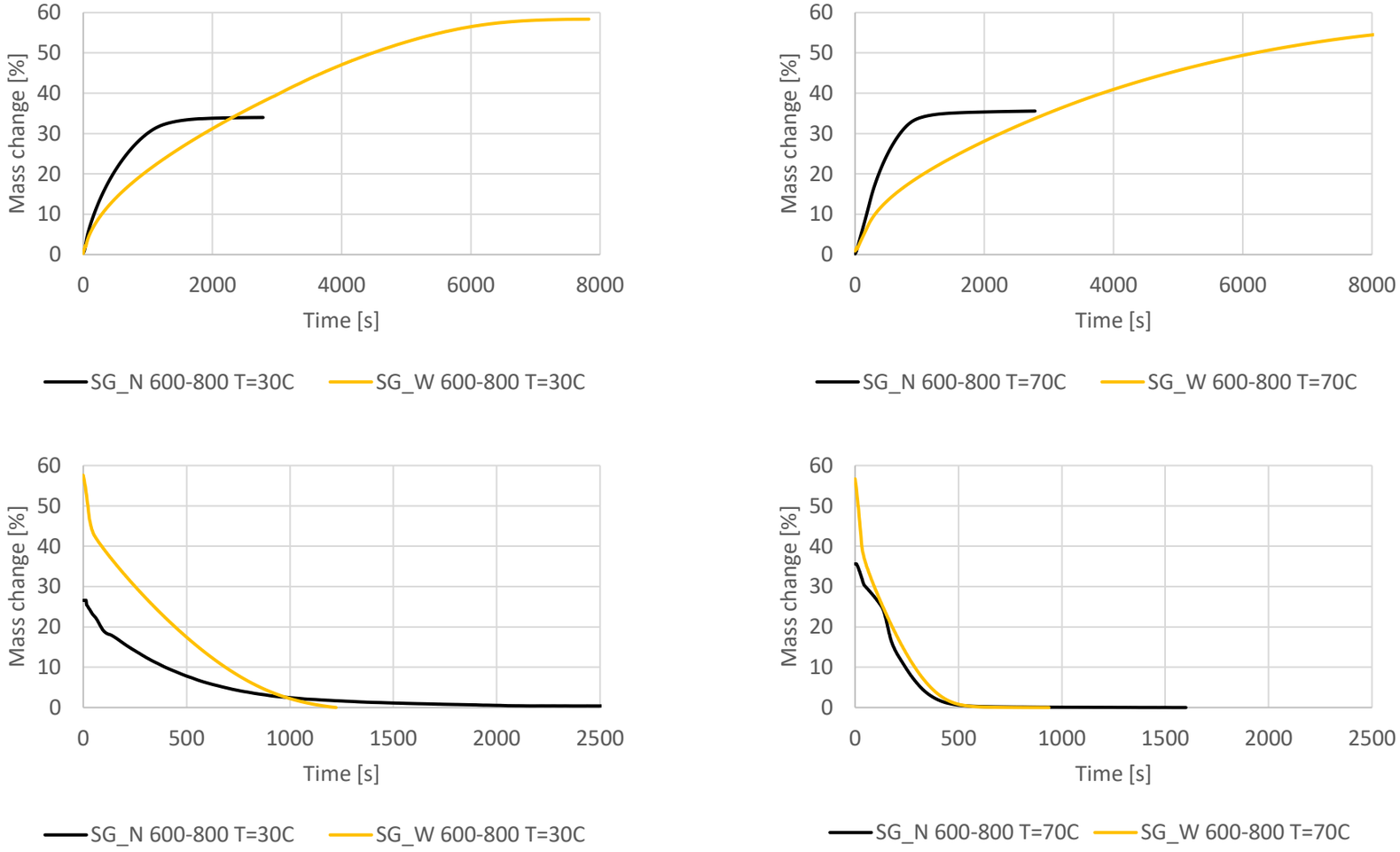
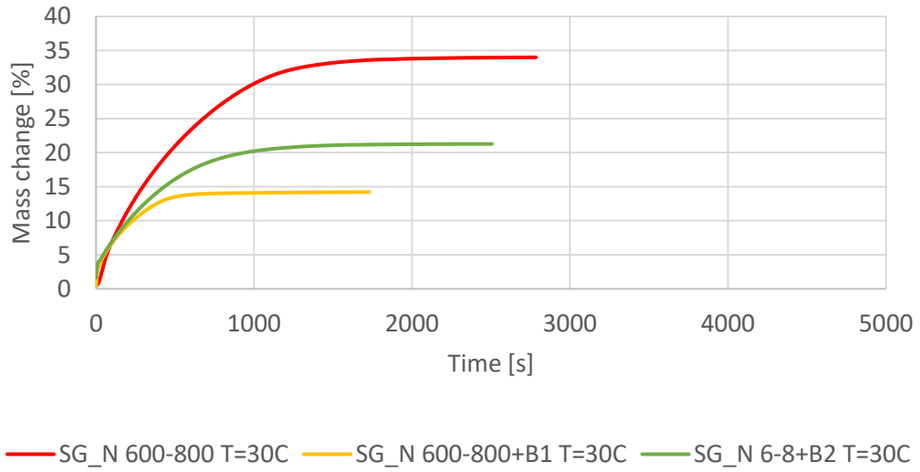
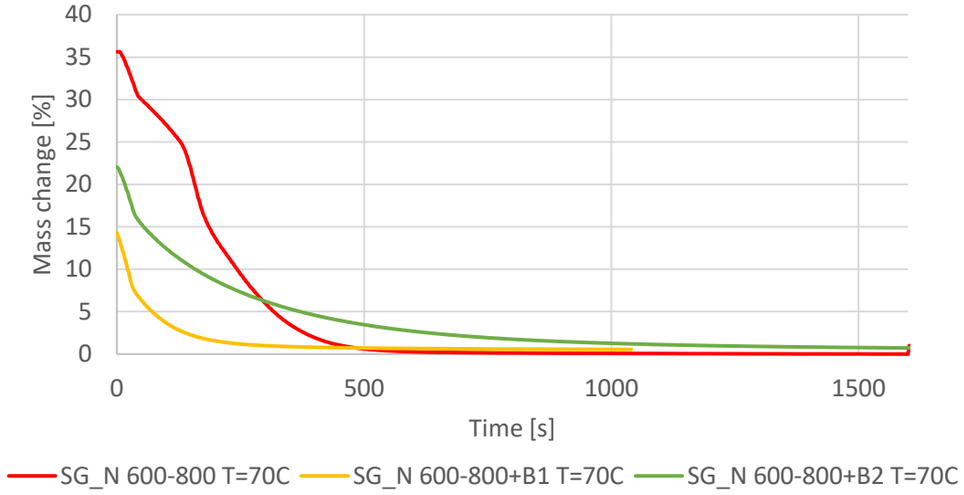
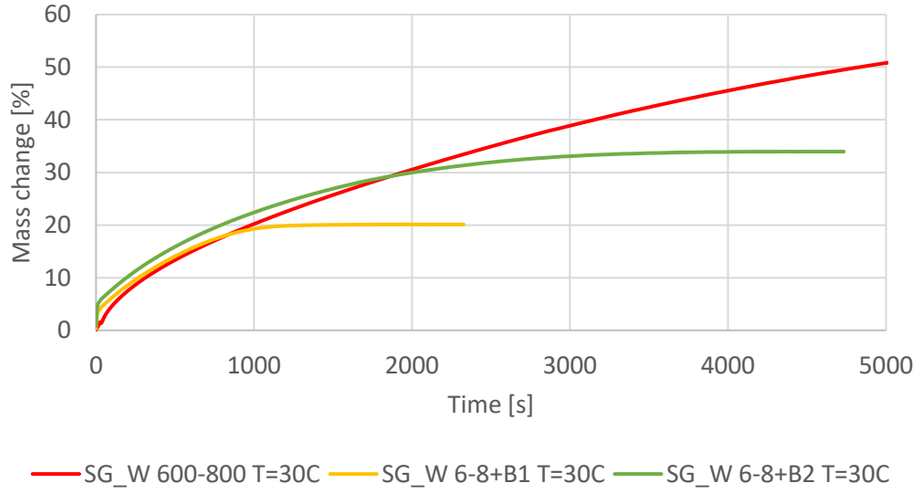


Figure 4. Adsorption and desorption kinetics for narrow-pore and wide-pore silica gels at 30 and 70 °C.

Sorption kinetics results







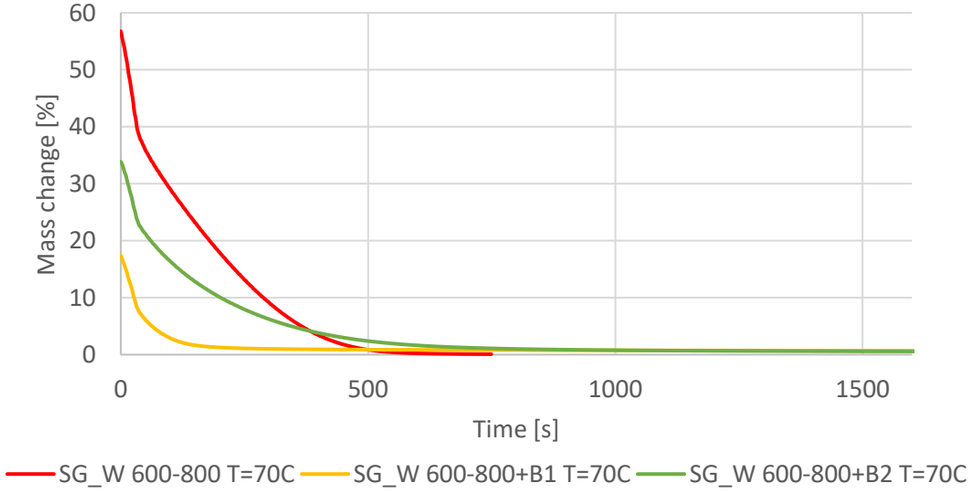


Figure 5. Adsorption at 30 °C and desorption at 70 °C kinetics for bonded samples.

Conlusions

- ✓ Appropriate preparation of aluminum pans and the use of two-step coating almostcompletely eliminate the problem of detachment of the binder from the aluminum.
- ✓ Adhesives B1 and B2 (resin-based) demonstrate thermal stability up to 200 °C, making them suitable for use in adsorption chillers. In contrast, PVA-based adhesive B3 shows a 20% mass loss between 20–100 °C due to water sorption and desorption.
- ✓ Thermal properties measurements indicate graphite flakes as the best thermally conductive binder additive.
- ✓ Epoxy resin-based adhesive doped with graphite flakes allows to improve the thermal conductivity of the sorbent by 177% and 614% with respect to SG_N and SG_W, respectively.
- ✓ Silica gels combined with adhesives B1 and B2 exhibit more intensive sorption kinetics during the initial 100 seconds of the cycle compared to raw silica gels.
- ✓ The use of thermally conductive binders may enable the chiller to operate with shorter cycle times or lower the desorption temperature.

AGH RESEARCH UNIVERSITY EXCELLENCE INITIATIVE

International Energy and Environment Conference 2025

8. – 10. 9. 2025
Hotel Sepetná, Ostravice

Coated Adsorption Beds for Enhanced Heat Transfer in Adsorption Cooling Systems

Tomasz Bujok

bujok@agh.edu.pl

Ostravice, 08-10.09.2025