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8th Post-Combustion Capture Conference

Enabling rapid thermal swing adsorption of carbon dioxide using water-tolerant sorbent coatings

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Poster 10, Dr. Xavier Daguenet

Dr. Xavier Daguenet

Poster Nº 10

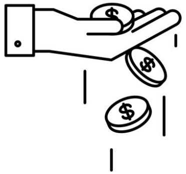
Low-grade heat driven rapid thermal and pressure swing adsorption gas separation

OST Ostschweizer Fachhochschule

SPF INSTITUT FÜR SOLARTECHNIK

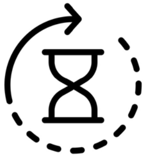
Flue gas separation column (OST)

Problems with solid sorbents



High cost of steam generation

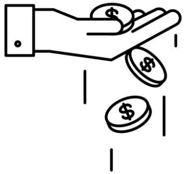
Slow regeneration / Poor thermal management



Low water tolerance

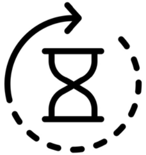
Our solution

Low-grade heat driven rapid thermal swing adsorption



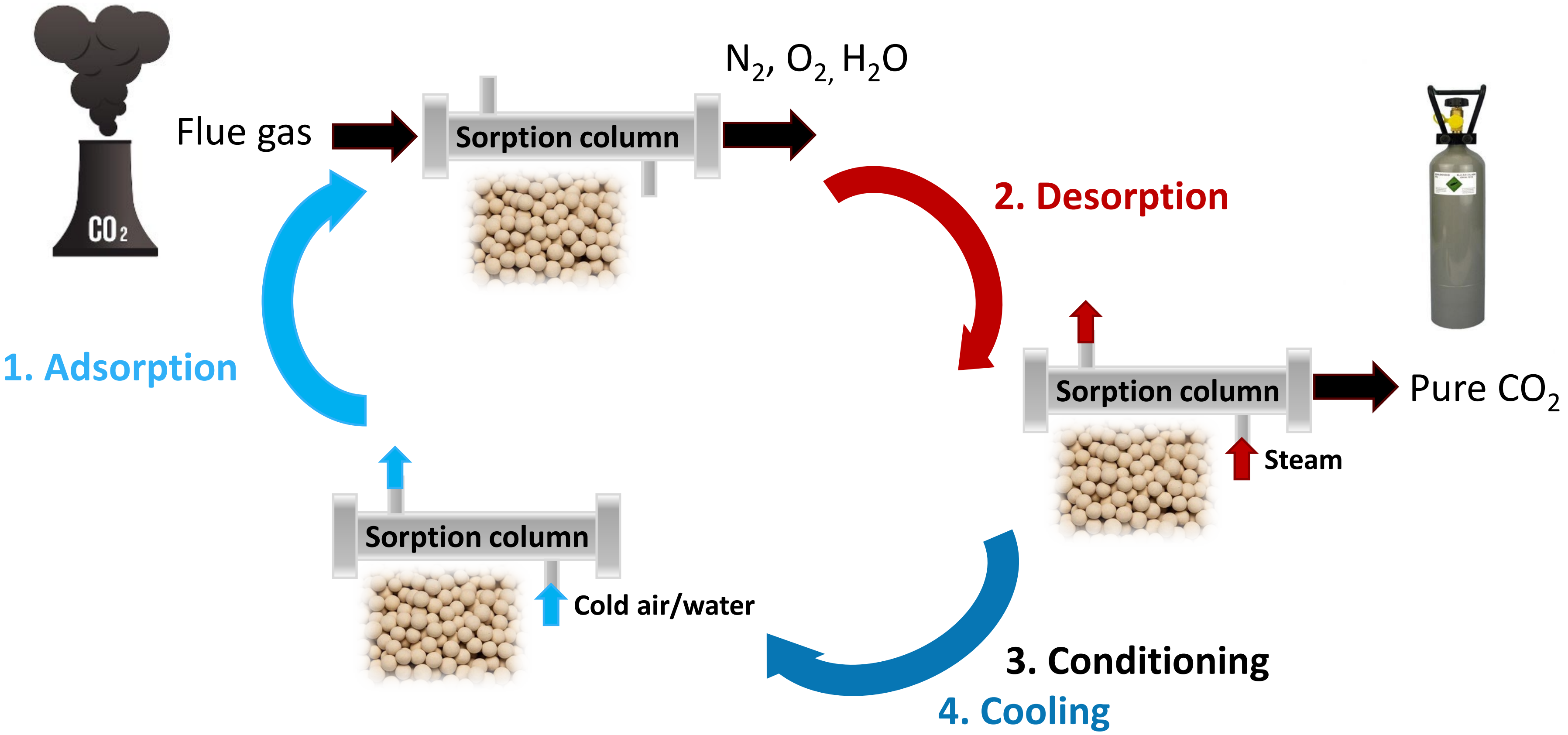
High cost of steam generation → 25-75°C cycles ✓

Slow regeneration & adsorption → Optimized diffusion/conduction ✓

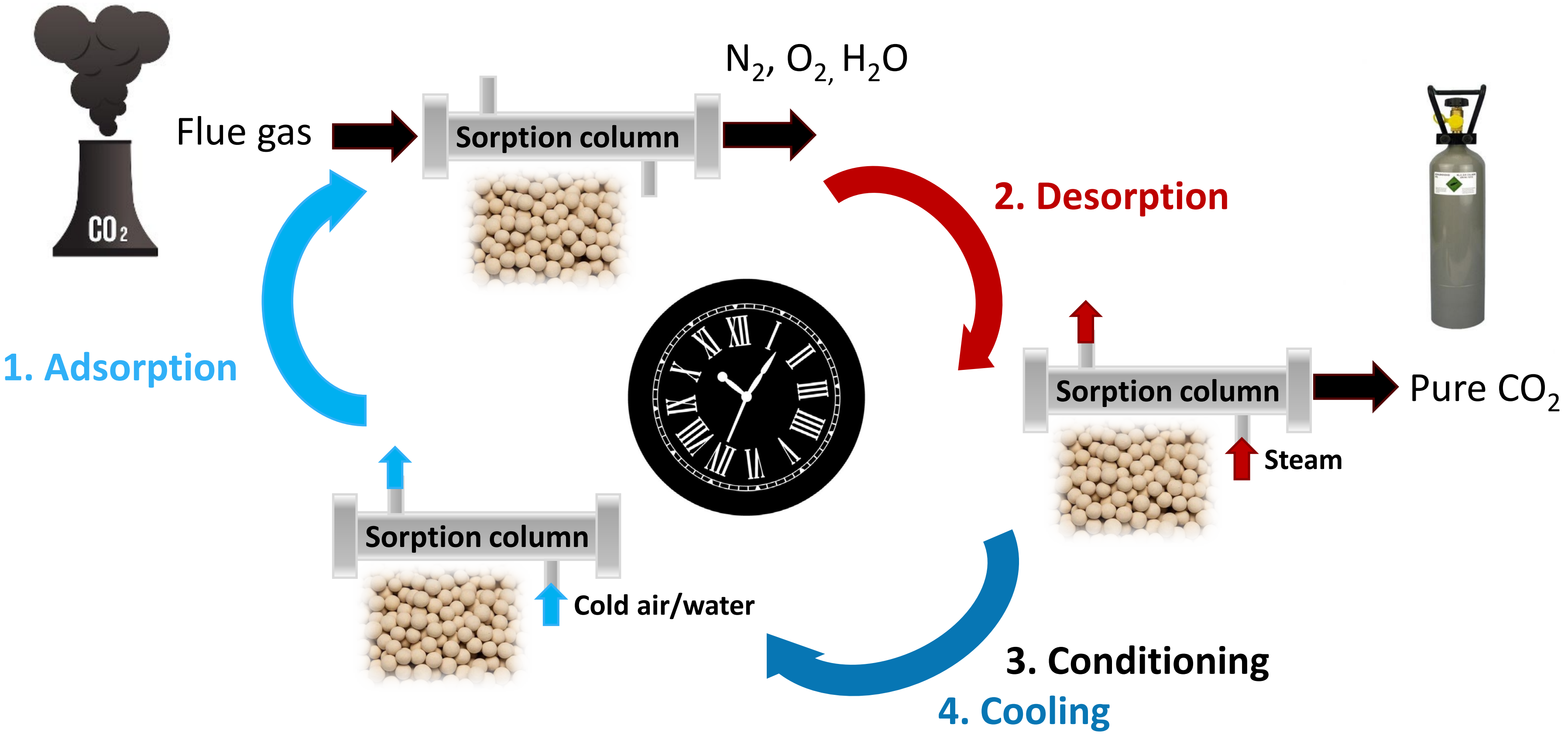


Low water tolerance → Water-tolerant materials ✓

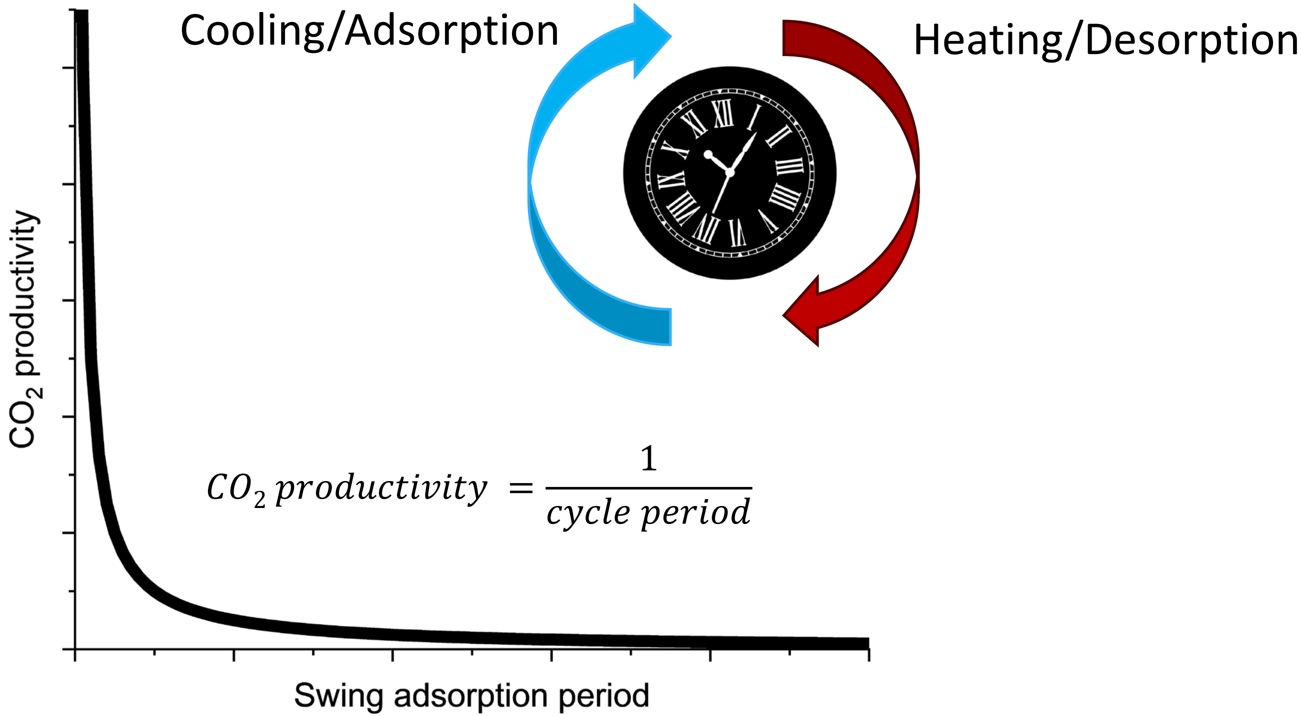
Thermal swing adsorption with solid sorbents



Thermal swing adsorption with solid sorbents

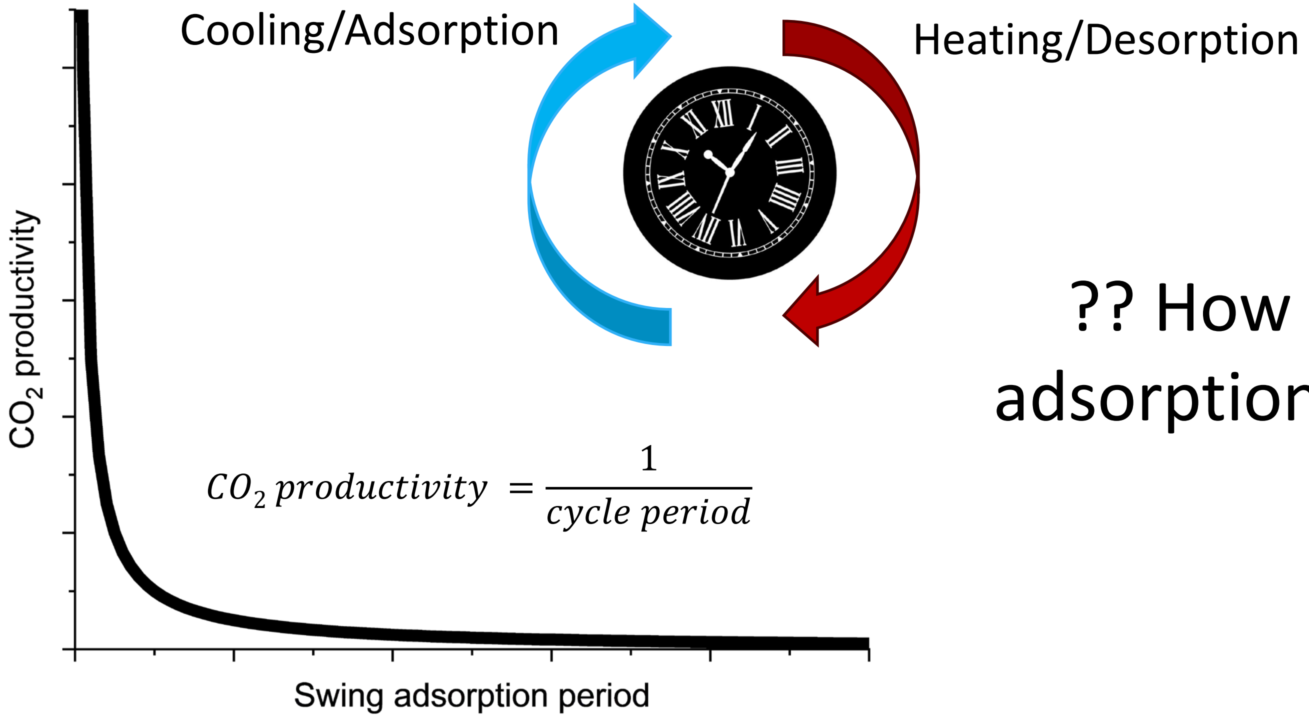


Thermal swing adsorption with solid sorbents



$$CO_2\,productivity = \frac{1}{cycle\ period}$$

Thermal swing adsorption with solid sorbents



$$CO_2\,productivity = \frac{1}{cycle\ period}$$

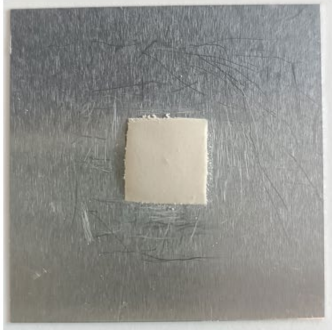
?? How to speed up adsorption/regeneration

Optimize diffusion/conduction within the sorbent?

Heat exchanger coatings

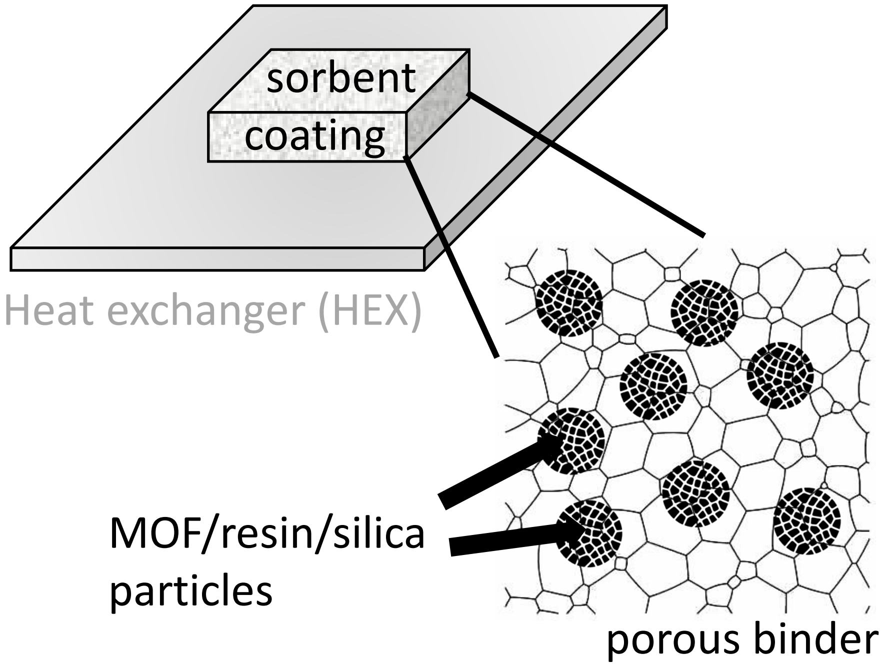
ZIF-8-TEPA

functionalized silica gel

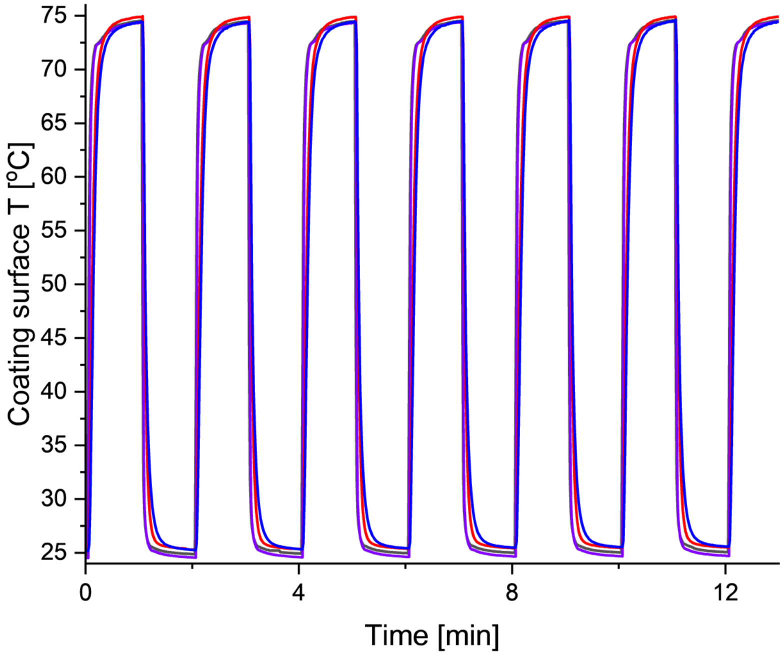


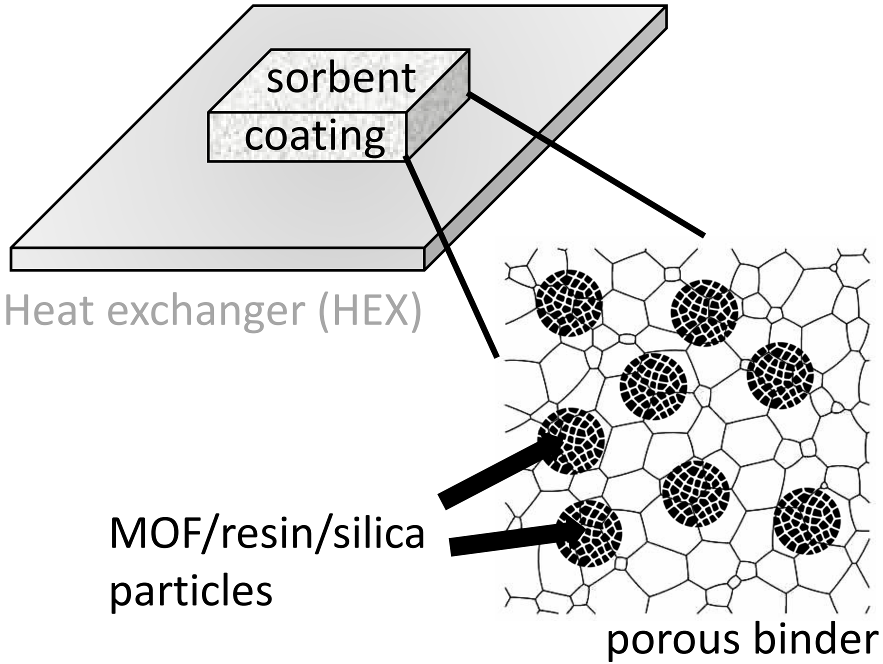
amino-functionalized resin

Zn-triazole MOF

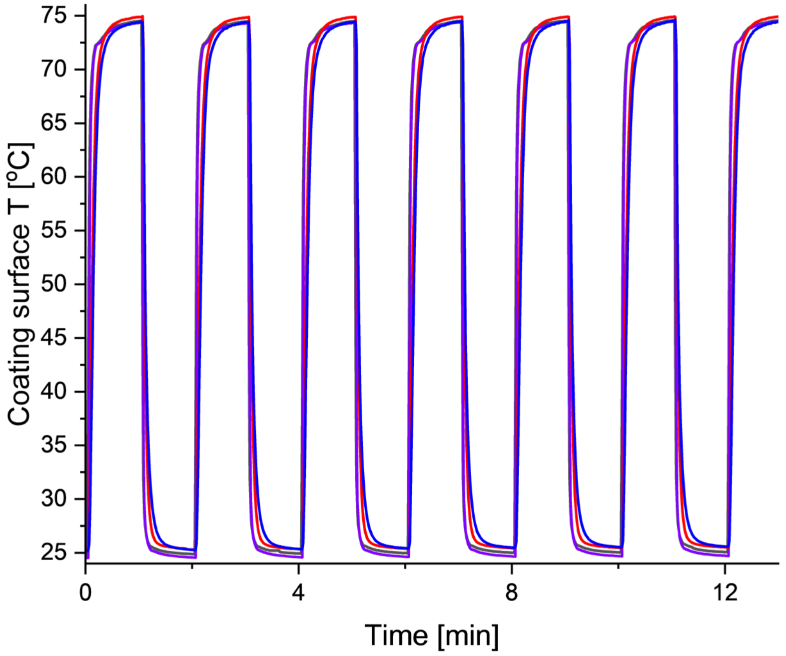


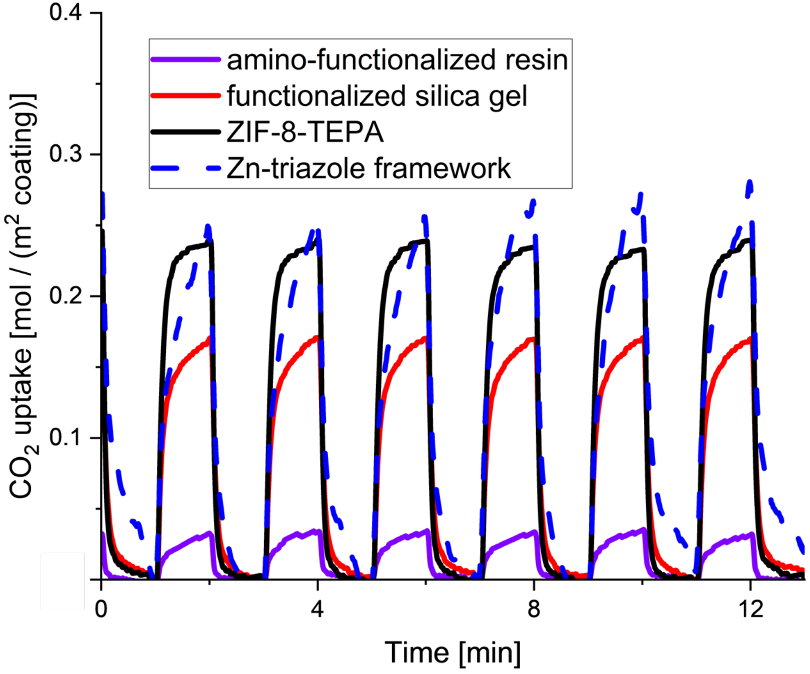
Heat exchanger coatings



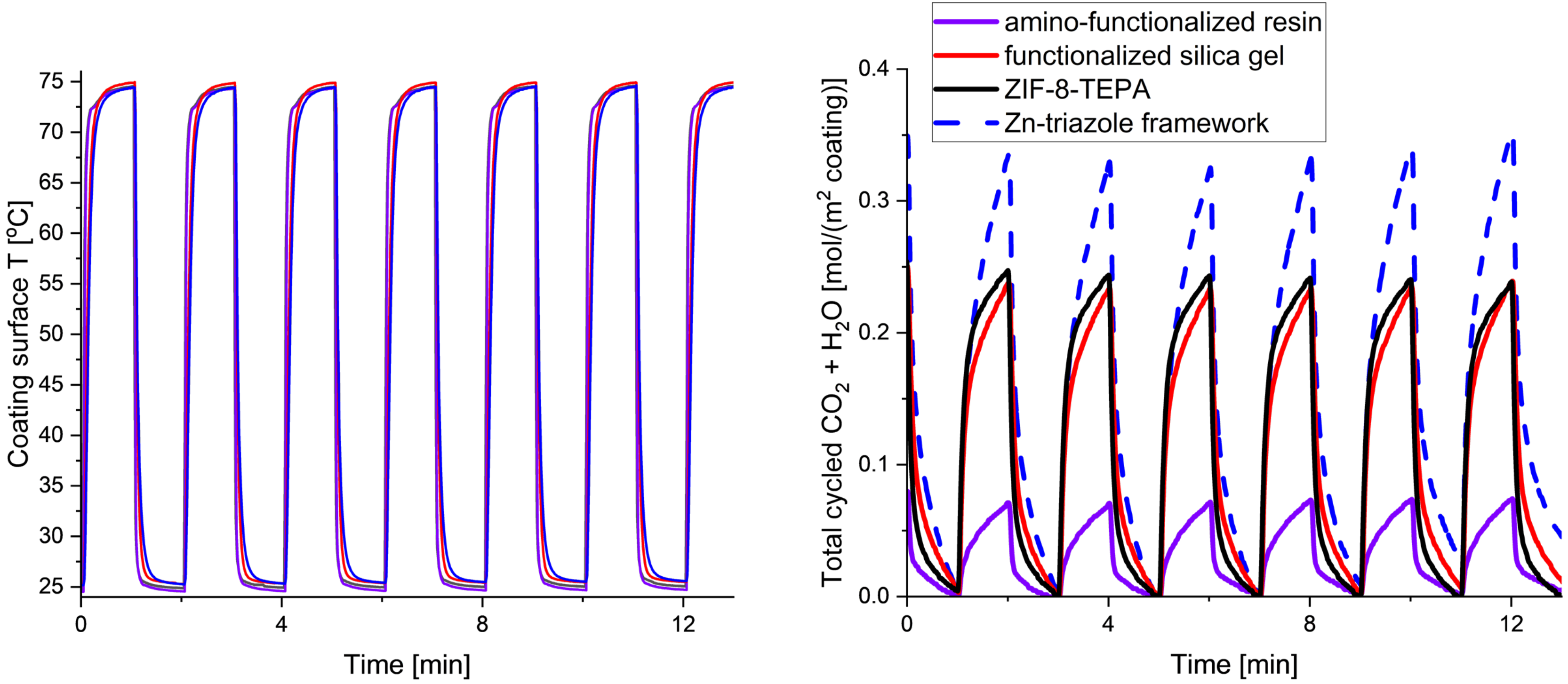


100 mbar CO_2 RTSA





100 mbar CO_2 , 10 mbar H_2O RTSA



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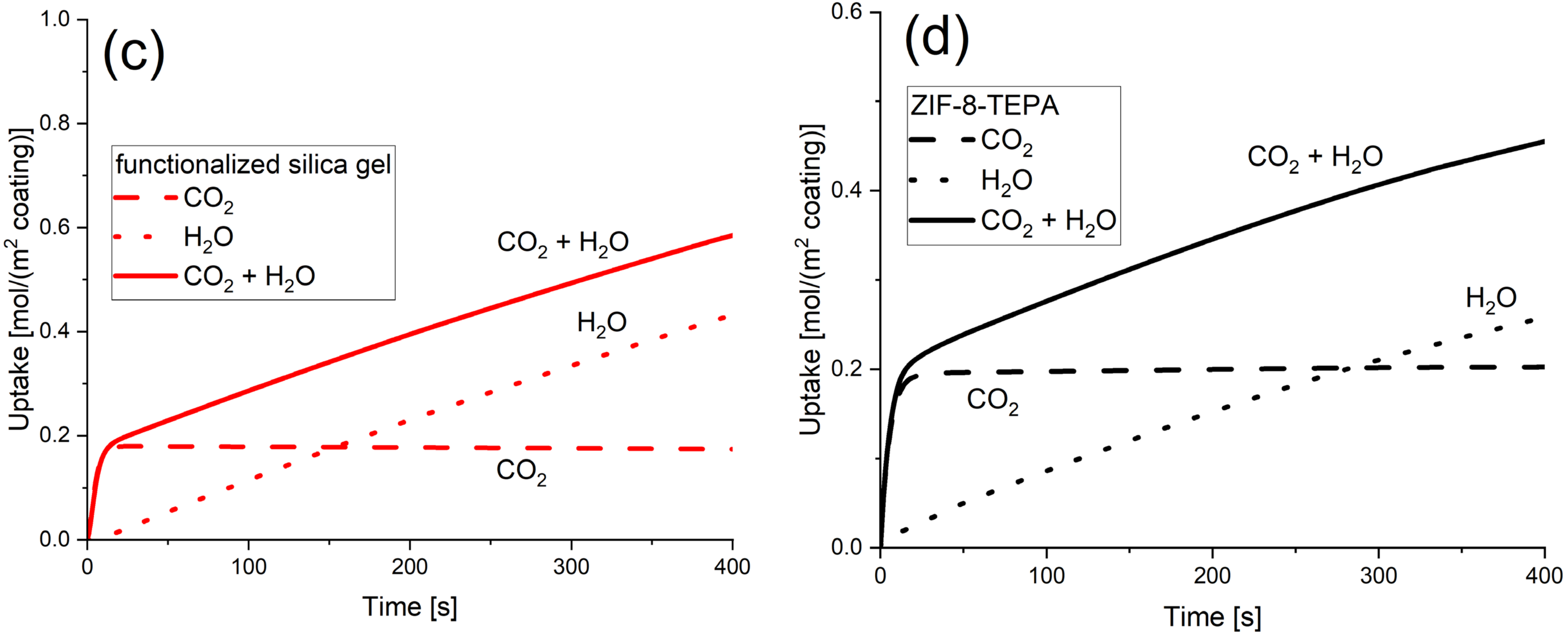
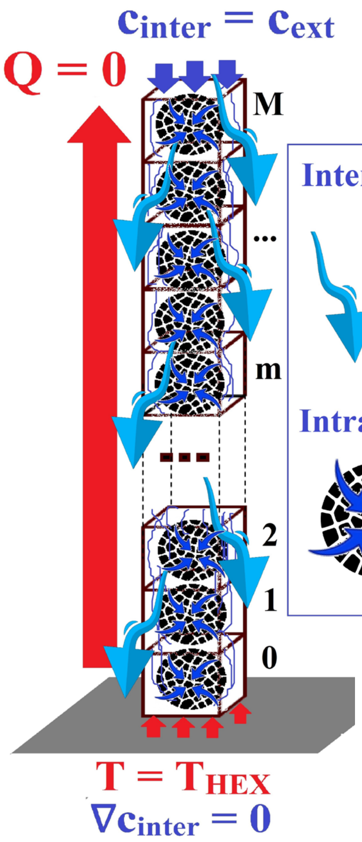


Coupled heat and mass transfer model for coatings



Finite element model

Interparticle mass balance

$$\epsilon_{inter} \nabla\left(D^i_{inter} \nabla c^i_{inter}\right) = \epsilon_{inter} \frac{\partial c^i_{inter}}{\partial t} - \frac{\rho^{env}_{coating}}{\rho^{env}_{sorb}} \cdot x \cdot \epsilon_{sorb} \frac{(c^i_{inter} - c^i_{sorb})}{R^i \cdot V_{sorb\ pores}}$$

Intraparticle (sorbent) mass balance

$$\frac{dc^i_{sorb}}{dt} = \frac{(c^i_{inter} - c^i_{sorb})}{R^i \cdot V_{sorb\ pores}} - \frac{\rho^{env}_{sorb}}{\epsilon_{sorb}} \frac{dw^i}{dt}$$

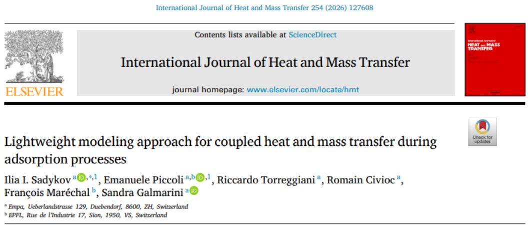
Isotherms

$$w^{CO_2}_{sorb}(T, p^{CO_2}_{sorb}) = w_0 \frac{(b \cdot p^{CO_2}_{sorb})^n}{1 + (b \cdot p^{CO_2}_{sorb})^n}$$

$$p^i_{sorb} = c^i_{sorb} \cdot \Re \cdot T$$

Energy balance

$$\nabla\left(k_{sol} \nabla T\right) = \rho^{env}_{coating} \cdot c^{sol}_p \cdot \frac{\partial T}{\partial t} - \rho^{env}_{coating} \cdot x \cdot \left(\sum_i (Q^i_{ads} \cdot \frac{\partial w^i}{\partial t})\right)$$



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Lightweight modeling approach for coupled heat and mass transfer during adsorption processes

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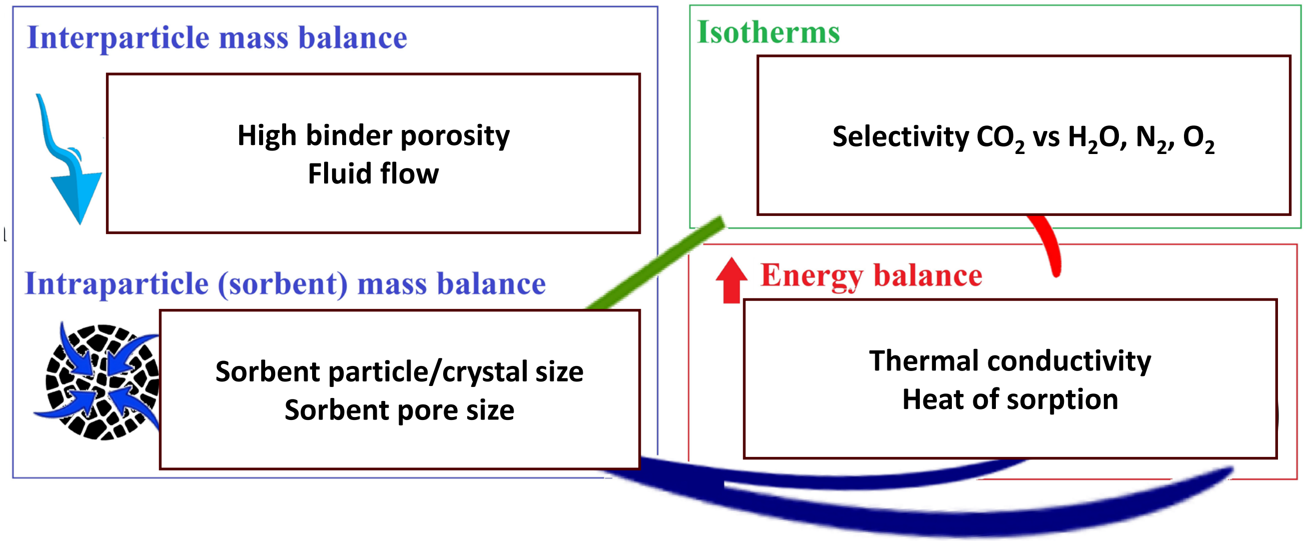
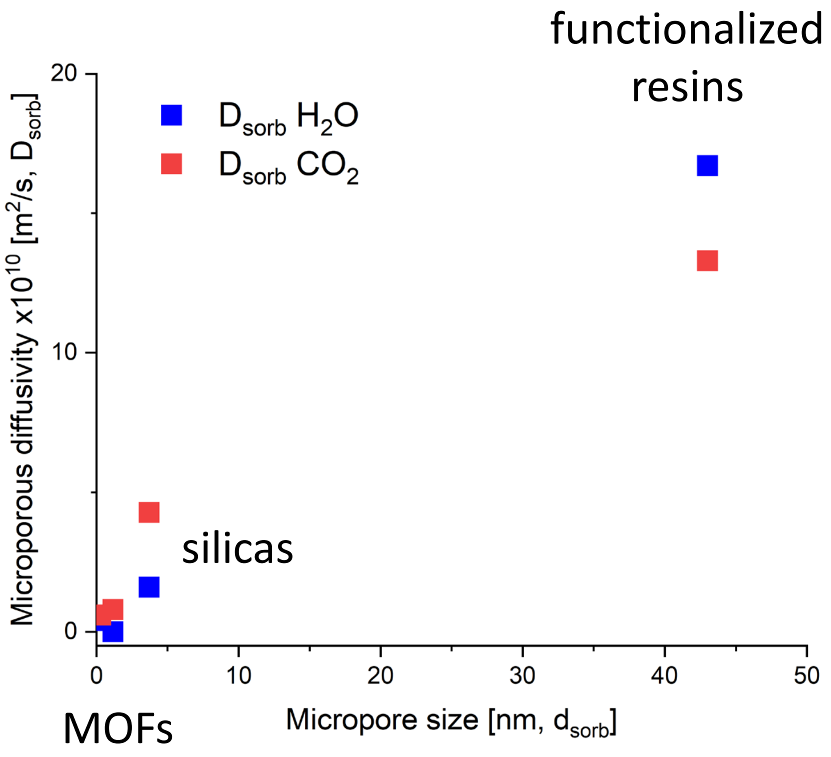
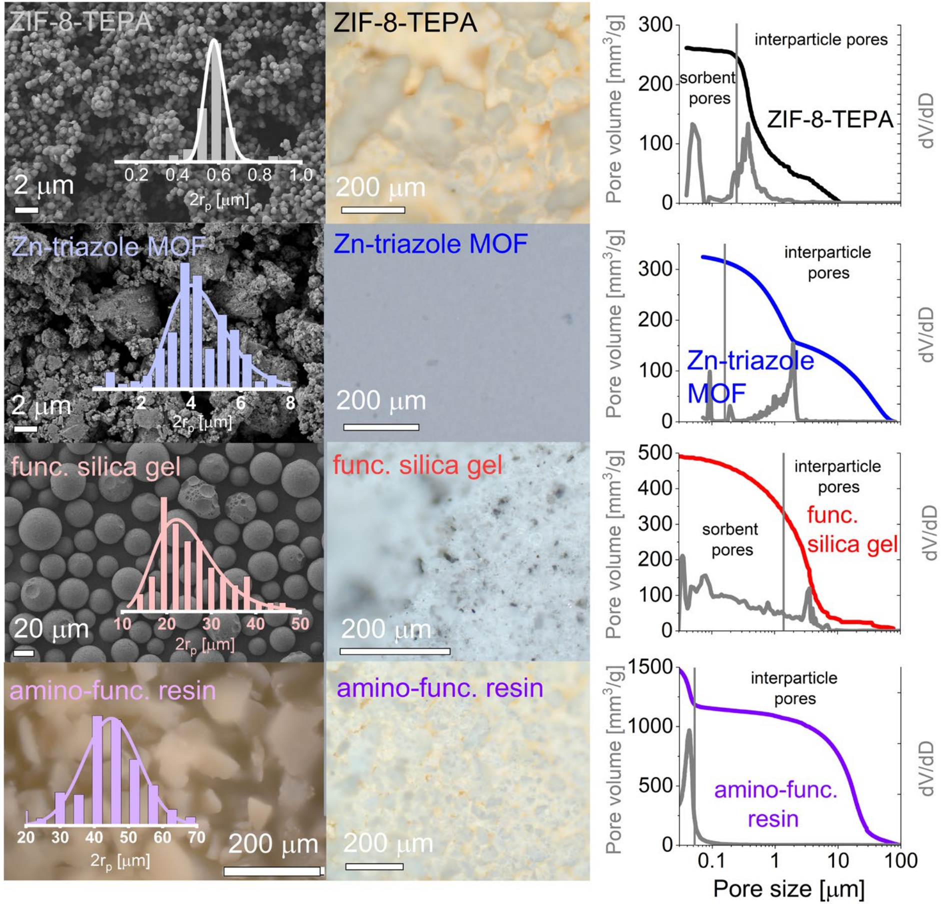
Coating properties

Finite element model

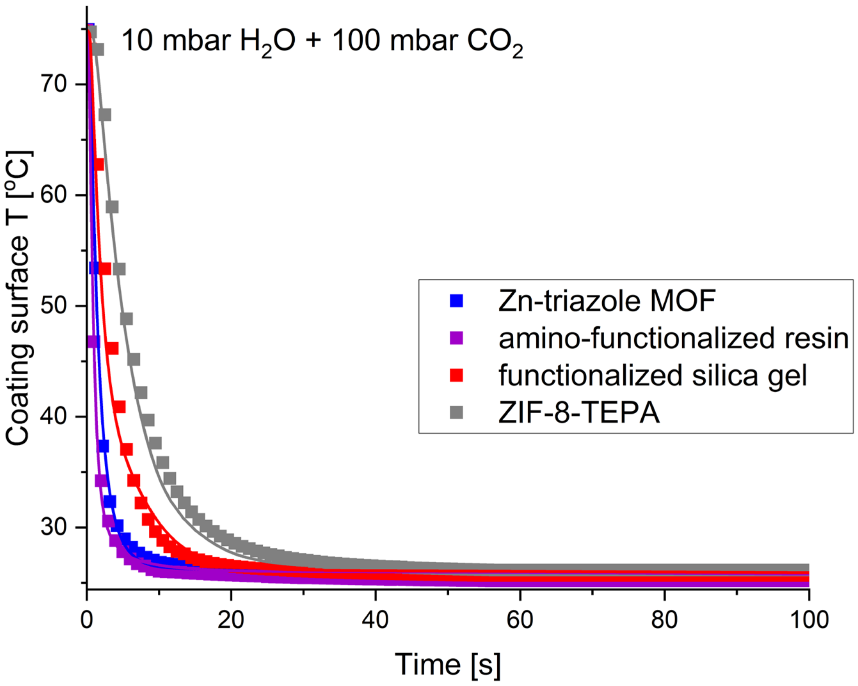


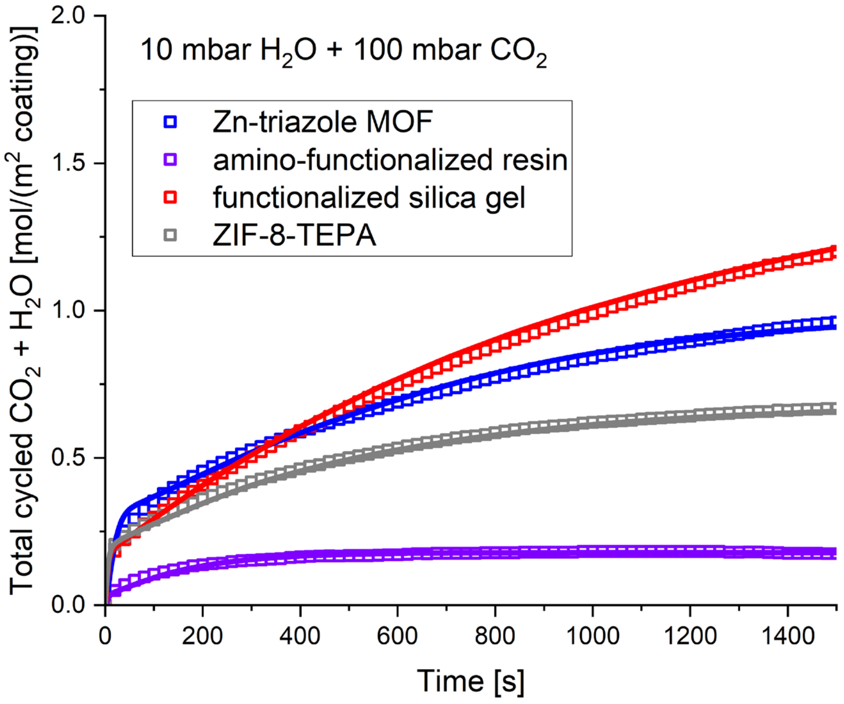
Coating properties



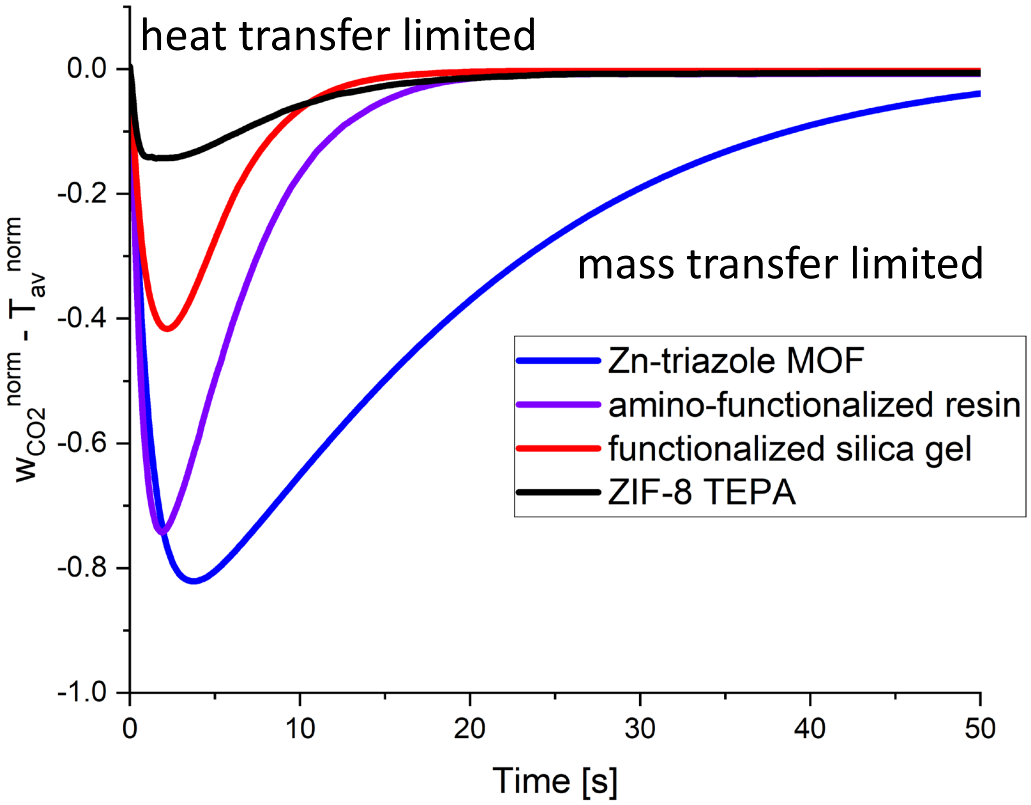


Model validation

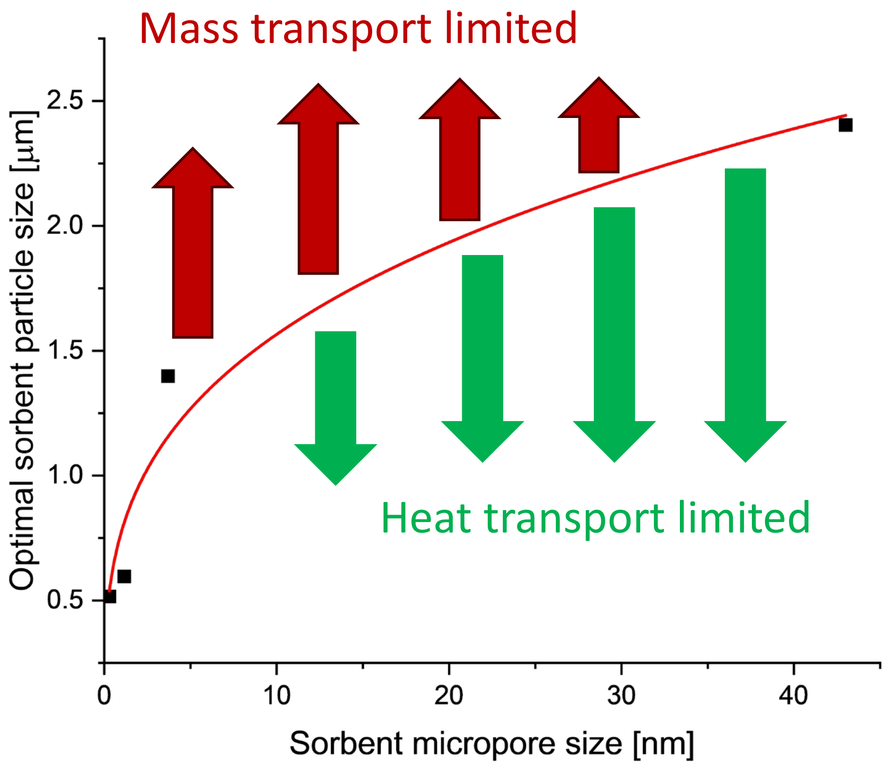




Heat vs mass transport



Conclusions



- ❑ Rapid thermal swing is mass transport limited if sorbent particles are above:
- ❑ ~500 nm for MOFs
- ❑ 2.3 μm for resins

Thank you for your attention

Contacts

Poster Nº 10
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