Institute of Technical Thermodynamics (LTT)

RWTH Aachen University

Matthias Henninger

Institute of Technical Thermodynamics | RWTH AACHEN UNIVERSITY


Leeuwarden
Groningen
Oldenburg
Bremen
Lüneburg
Norwich
Peterborough
Alkmaar
Zwolle
Amsterdam
Hanover
Wolfsburg
Berlin
Gorzów Wielkopolski
Cambridge
Ipswich
Colchester
Osnabrück
Brunswick
Brandenburg
Frankfurt an der Oder
The Hague
Netherlands
Bielefeld
Magdeburg
Luton
Münster
Arnhem
Rotterdam
Zielona G
London
Paderborn
Cottbus
Breda
Dortmund
Göttingen
Halle (Saale)
Eindhoven
Essen
Canterbury
Kassel
Leipzig
Bruges
Antwerp
Düsseldorf
Dunkirk
Ghent
Germany
Bautzen
Zgorzelec
Dresden
Calais
Cologne
Brussels
Erfurt
Jena
Chemnitz
Jelen
Brighton
Bonn
Aachen
Lille
Liège
Zwickau
Ústí nad Labem
Liberec
Mons
Belgium
Fulda
Teplice
Koblenz
Karlovy Vary
Amiens
Trier
Le Havre
Rouen
Beauvais
Luxembourg
Caen
Reims
Saarbrücken
Metz
Paris
Versailles
Nancy
Strasbourg
Parc naturel régional du Perche
Troyes
Laval
Le Mans
Orléans
Colmar
Auxerre
Parc national de forêts
Belfort
Blois
Angers
Tours
Dijon
Basel
Besançon
Parc naturel régional Loire-Anjou-Touraine
Bourges
Parc naturel régional
Leverkusen
Sittard
Maasmechelen
Bergisch Gladbach
Jülich
Bergheim
Cologne
Heerlen
Kerpen
Maastricht
Brühl
Aachen Cathedral
Düren
Bonn
Herstal
Euskirchen
Liège
Eupen
Rheinbach
Verviers
Parc naturel Hautes Fagnes - Eifel
Nationalpark Eifel
Mechernich
Bad Neuenahr-Ahrweiler

The Institute of Technical Thermodynamics (LTT)

Univ.-Prof. Niklas von der Aßen
Head of Institute

Prof. Hans-Jürgen Koß | Prof. Kai Leonhard

Administration	IT	Workshop

42 PhD Students (=PhD Candidates) … Dr. Ing.

90 Students (B.Sc/M.Sc.) working in research and teaching

The LTT – Thermodynamics on all Scales

Process

Energy Systems Engineering

S. Deutz / C. Reinert

Machine

Sorption Systems Engineering

M. Engelpracht

Material

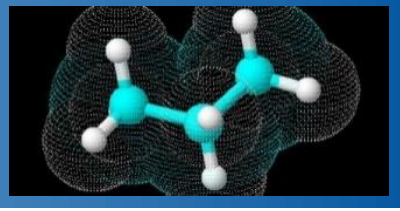
Measurement Systems Engineering

Prof. H.-J. Koß

Molecule

Molecular Systems Engineering

Prof. K. Leonhard



Research groups at LTT

The LTT – Thermodynamics on all Scales

Process

Machine

Material

Molecule

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Molecular Systems Engineering

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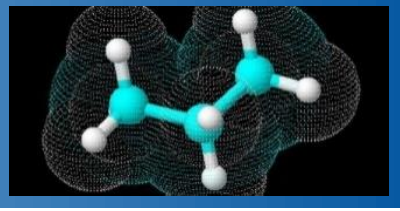


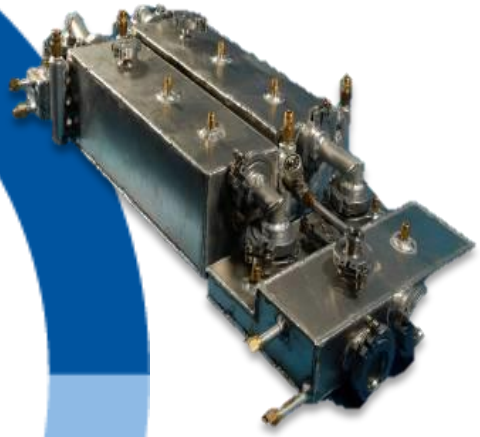
Research groups at LTT

Matthias Henninger | PhD Candidate | 4th year

Working Areas and Competence

Material Characterization

Prototyping and Test Bench Operation



Conceptual Designs

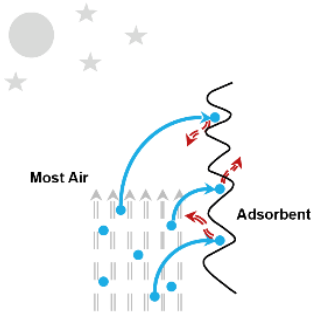


Figure 1: Adsorption phase (night)

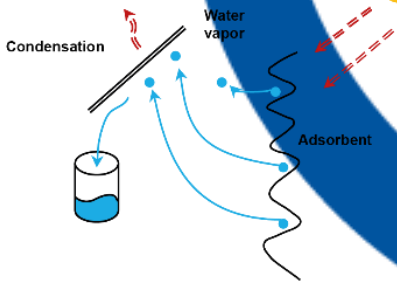
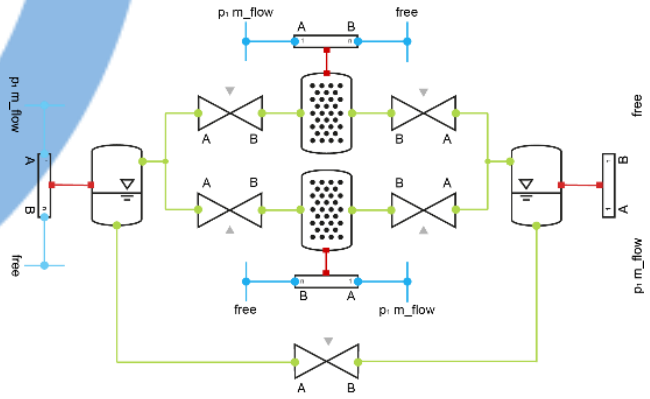


Figure 2: Desorption phase (day)

Modelling and Simulation



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02.05.2023

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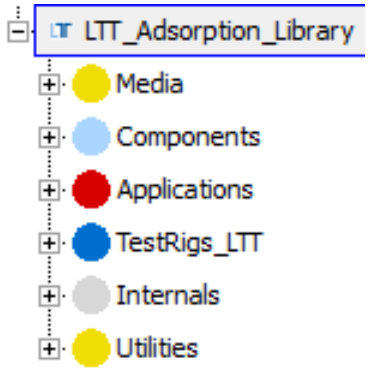
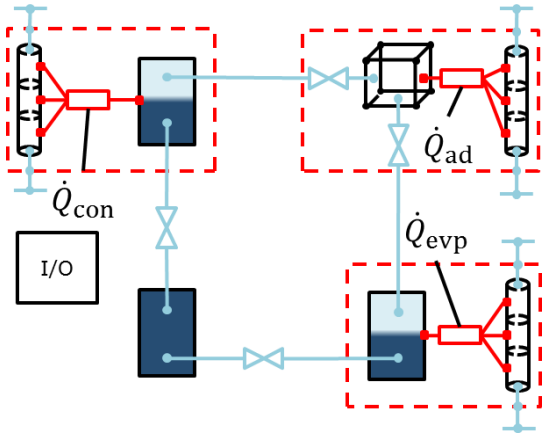
Dynamic simulation and optimization of adsorption energy systems

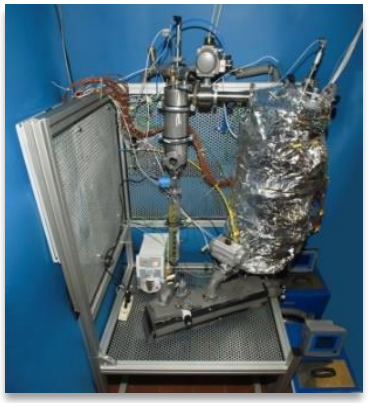
Modelica library



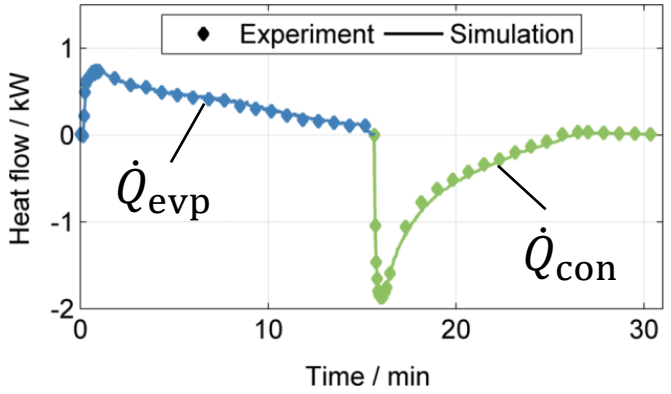
Dynamic model



Test stand



Validation



MODELICA

Simulation workflow

Model export

fmi FUNCTIONAL MOCK-UP INTERFACE

Optimization workflow

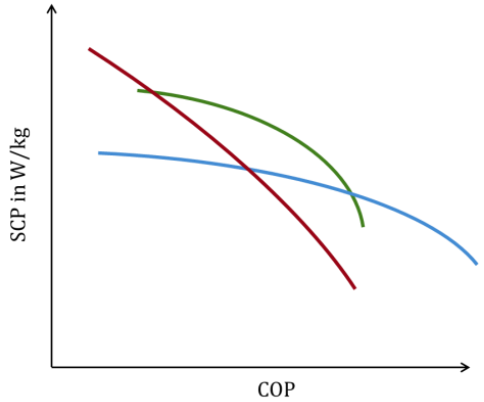
Interface for optimization problem

MUSCOD II / **FMPy** **SciPy**

Efficient Multiple Shooting algorithm

Multi-objective optimization of:

- Design
- Control



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Current Research Topics

More @ HPC23 in Edinburgh

Heat Exchanger Design

Adsorption Chillers <0°C

Adsorption Heat Transformer (AdHT)

AdC/AdHP

Natural Refrigerants/ Mixtures (EtOH/MeOH)

Process Optimization

Small-scale experi-ments (LTJ/TGA)

Direct Air Capture (DAC)

DAC

Novel adsorbents

Influence of ambient conditions

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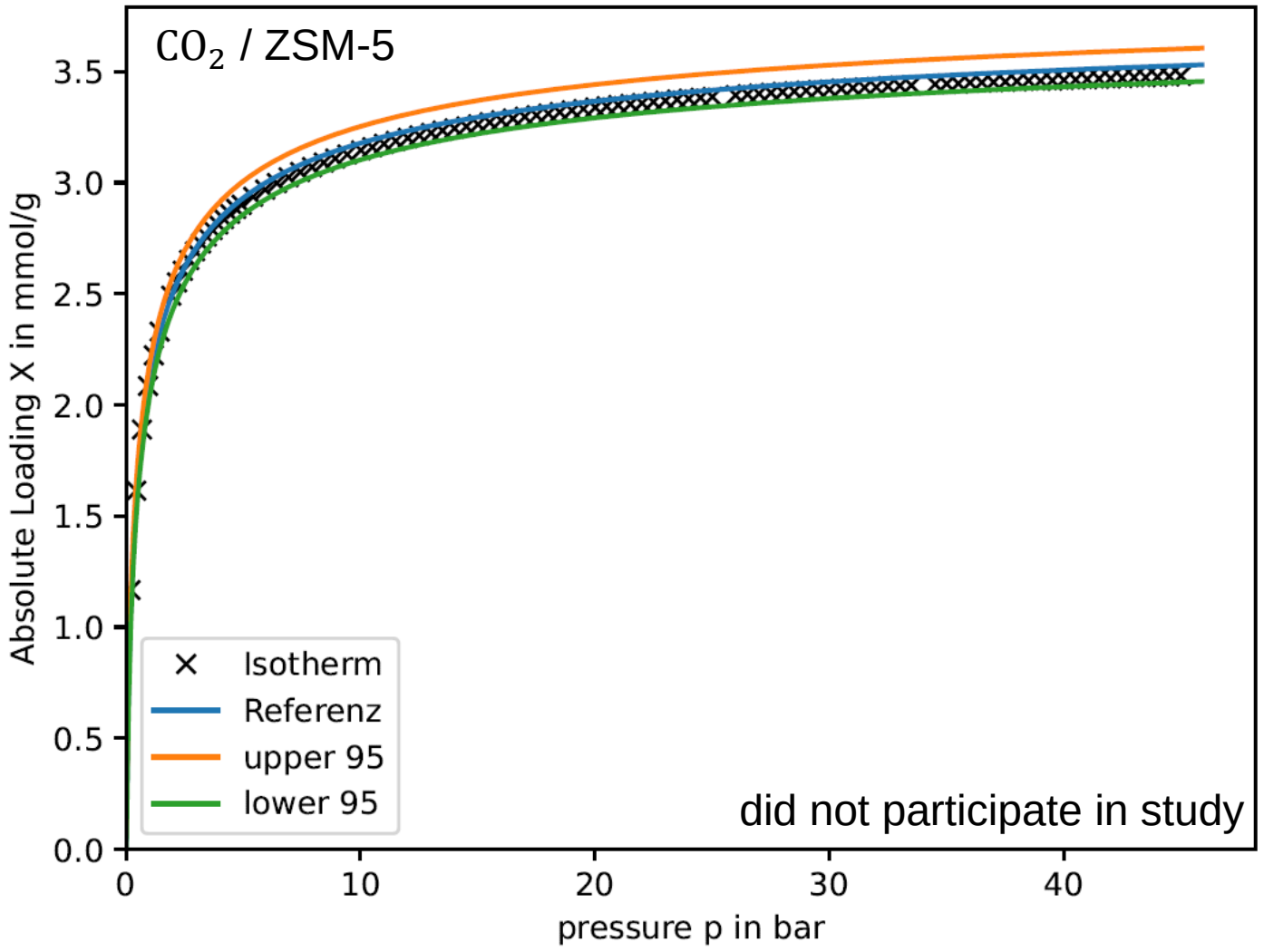
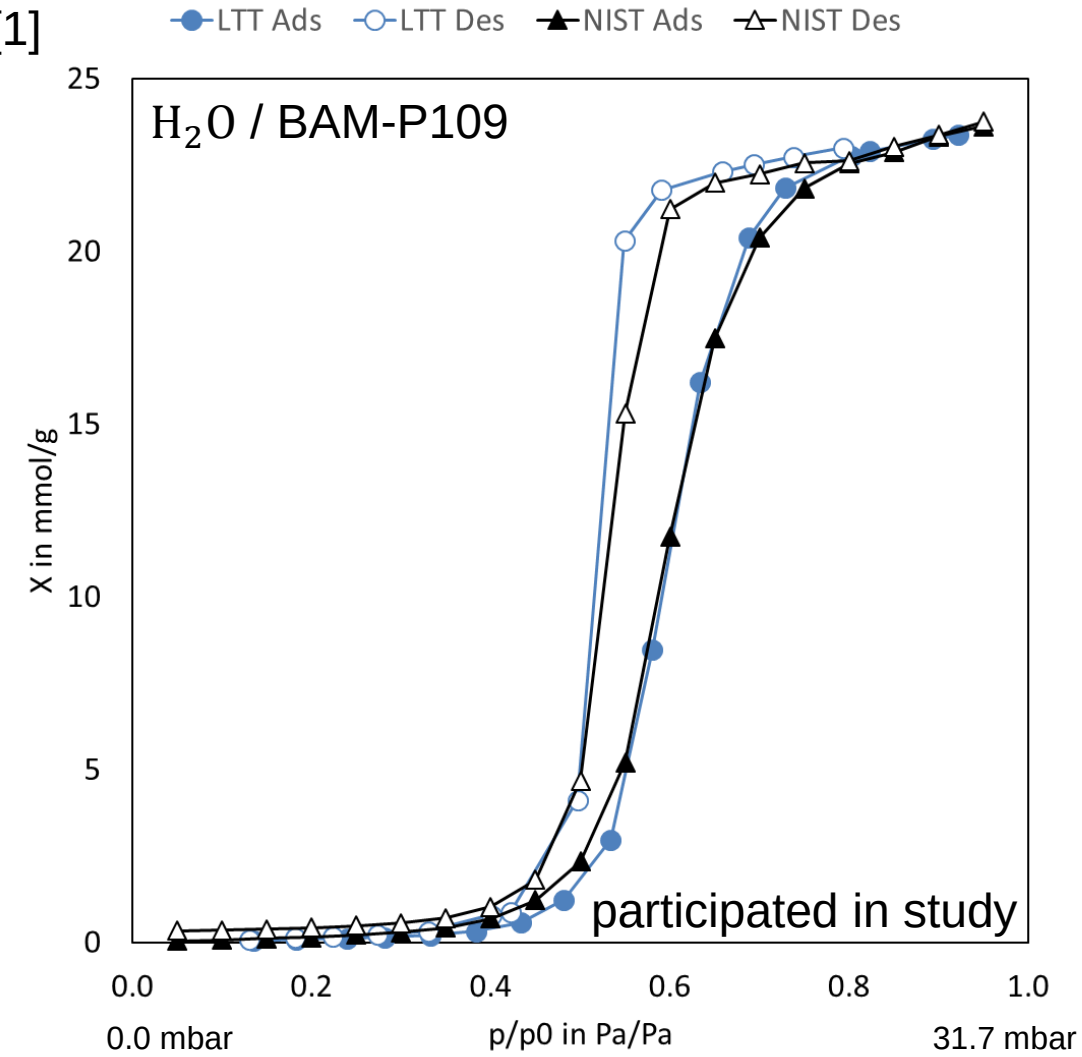
Thermogravimetric Analysis (TGA): Reference Isotherms from NIST @ 25°C



[1]



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[1] Nguyen et al.: A reference high-pressure CO2 adsorption isotherm for ammonium ZSM-5 zeolite: results of an interlaboratory study, *Adsorption* 24 (6), 2018.

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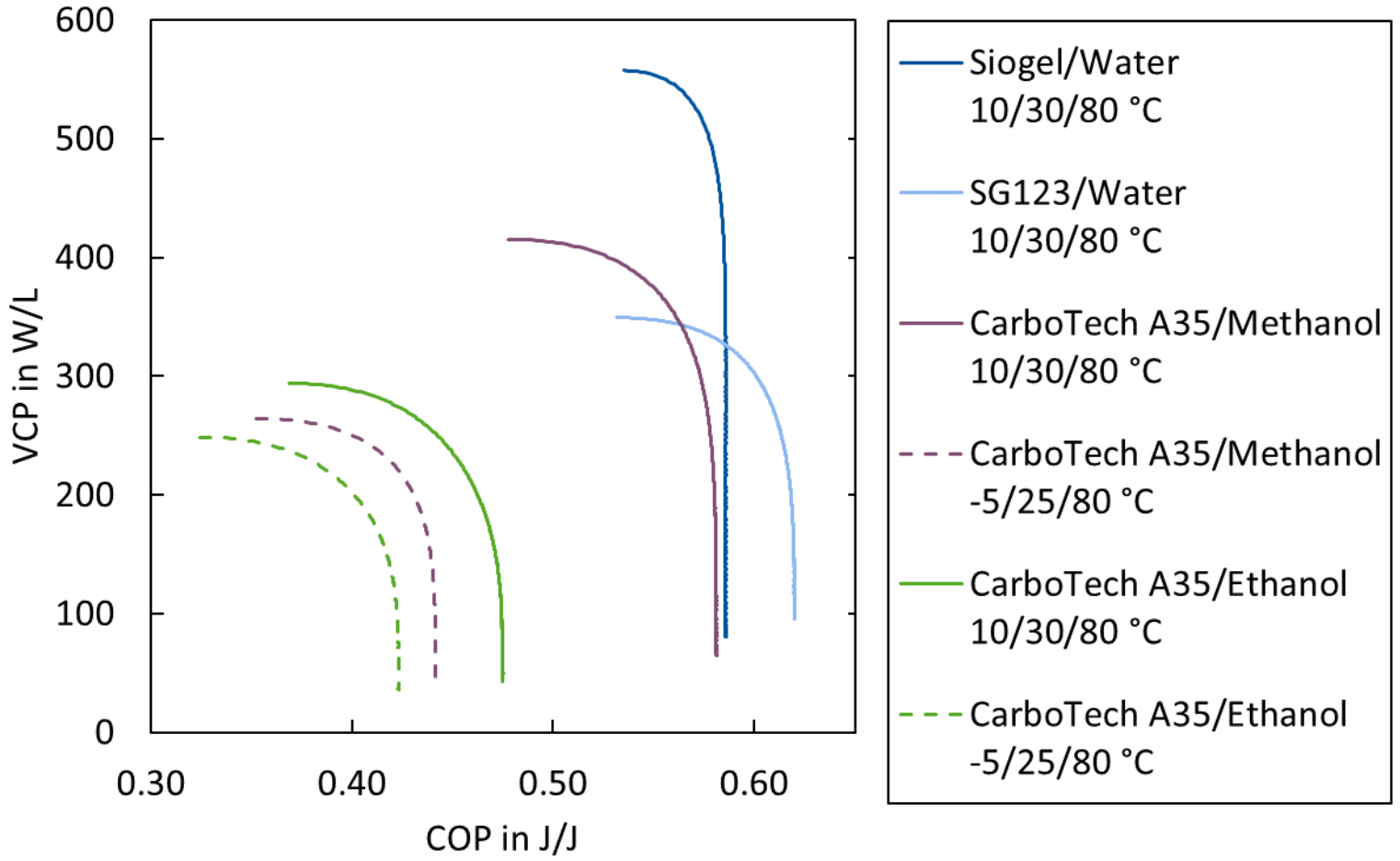
Adsorption Chiller <0°C

1. LTJ Measurements

→ Heat and Mass Transfer

2. Parametrize Adsorber [2]
3. 1D-discretized in flow direction
4. Add all balances and correlations
5. Two-bed system
6. Ideal Evaporator/Condenser
7. No heat losses
8. Materials:
   a. Siogel (Silica gel Oker Chemie)
   b. SG123 (Silica gel InvenSor GmbH)
   c. CarboTech A35 (Activated Carbon) [3]



→ Add MOFs until HPC23 with Al-fum/CAU-10/ZIF-8

[2] Kummer et al.: A Functional Full-Scale Heat Exchanger Coated with Aluminum Fumarate Metal–Organic Framework for Adsorption Heat Transformation, *Ind. Eng. Chem. Res*. 56 (27), 2017.

[3] Henninger et al.: Evaluation of methanol adsorption on activated carbons for thermally driven chillers part I: Thermophysical characterization, *Int. J. Refrig.* 35 (3), 2012.

Thank you for your kind attention!

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