Karlsruhe Institute of Technology

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Hydrodynamics and mass transfer in viscous absorption media

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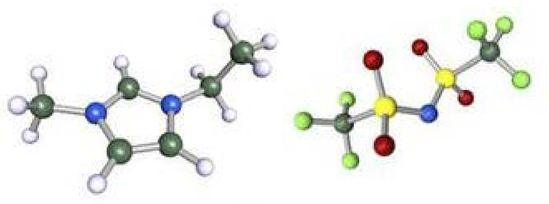
Motivation

Application of Ionic Liquids for gas scrubbing processes

Ionic Liquids (IL)

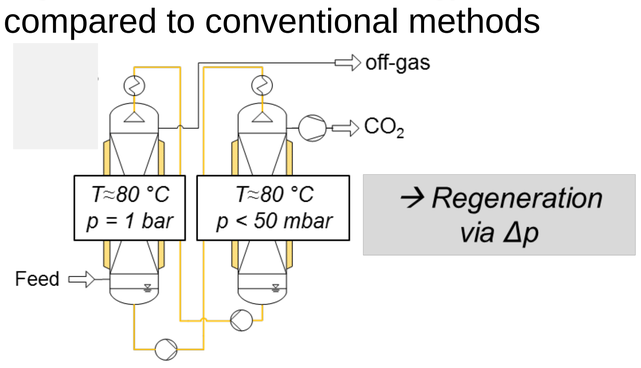
- Molten salts, liquid at T < 100 °C
- Negligible vapor pressure
- High solubility of CO_2
- → selective absorption is possible



Cation and anion of a typical IL ([EMIM][Tf2N])

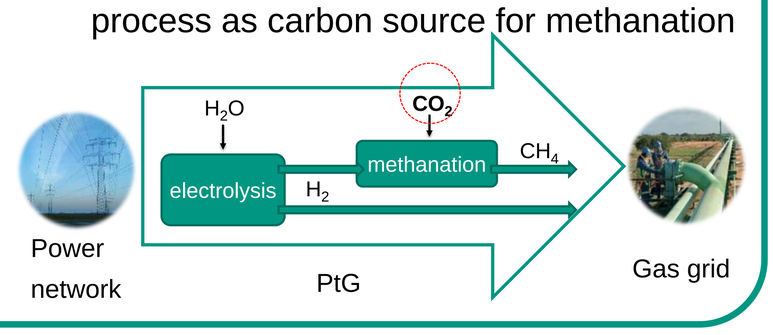
Process Intensification

- Desorption at p < 50 mbar possible
- IL stays liquid → no recondensation needed
- → Significant reduction of energy demand compared to conventional methods



Applications

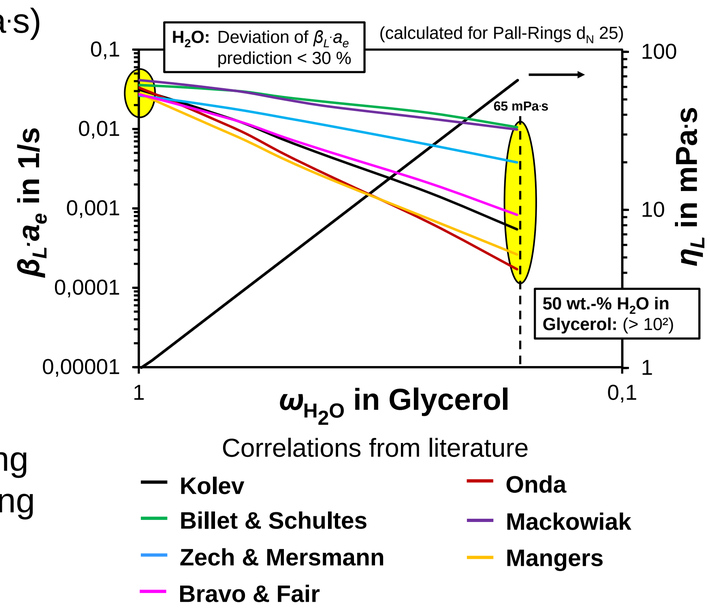
- Biogas upgrading
- Cleaning of CHP plant exhausts
- Harvesting CO_2 from air (Direct air capture)
- → Integration of method in power-to-gas (PtG) process as carbon source for methanation



Challenges

High viscosity of IL (*25* < η < *75* mPa·s)

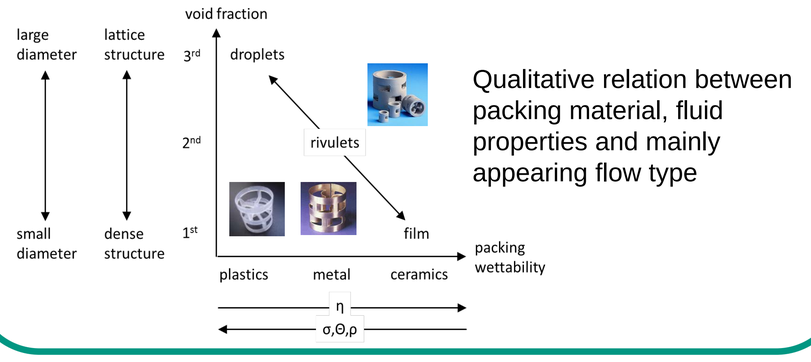
- Mass transfer for viscous media rarely researched in literature
- Validity range of design correlations for mass transfer mostly is violated (see right)
- First experimental results show strong deviations from $\beta_L \cdot a_e$ – predictions
- → Precise Dimensioning and upscaling of packed columns for gas scrubbing not possible



Objective

Development of a valid mass transfer model for viscous fluids in packed columns

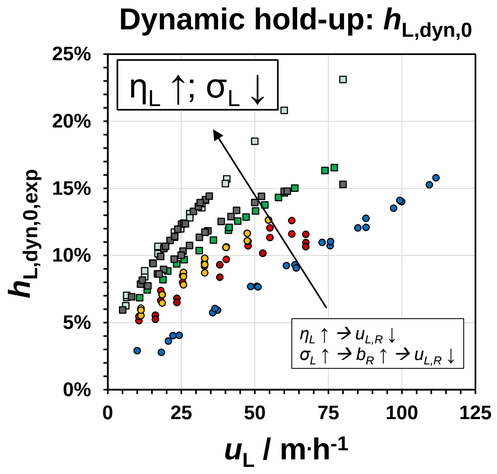
- Studying the influence of different substance properties (η, σ, ρ, θ) on hydrodynamics
- Modelling of hydrodynamics and mass transfer
- Experimental validation in a DN 250 column



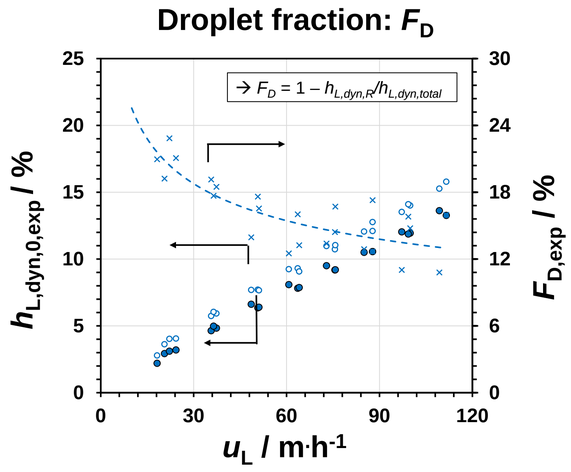
Qualitative relation between packing material, fluid properties and mainly appearing flow type

Selected experimental results

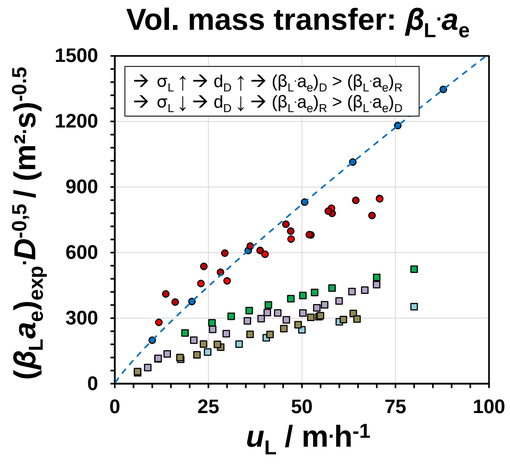
Dynamic hold-up: $h_{L,dyn,0}$



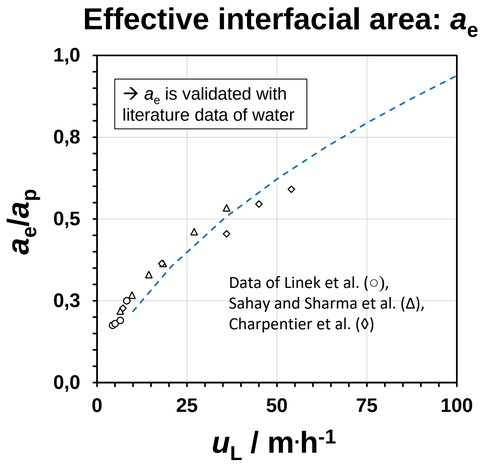
Droplet fraction: F_D



Vol. mass transfer: $\beta_L \cdot a_e$



Effective interfacial area: a_e



Color code for used fluids: water | water+glycerol (η_L=10mPas) | water+glycerol (η_L=20mPas) | Shellsol D100 | water+glycerol (η_L=40mPas) | n-octanol | T 15 | T 22

Results for Pall-Rings: a_{geo} = 220 m^{-1} and ε = 0.91

Conclusion and Outlook

- Experiments with alternative media allow insights into influences of liquid properties
- Intensive studies for different packing materials have been made
- Upgrading of measurement set-up for higher accuracy and additional measurement parameters is ongoing
- Research will be expanded to structured packings

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