Environmental Engineering and Reactor Technology

- Teaching and research
  - principles of separation,
  - reactor technology and
  - process design

- The largest research group in the department
  - about 19 PhD-students
  - And 10 postdoc/researchers
- Close cooperation with SINTEF

Magne Hillestad

May-Britt Hägg

Jens-Petter Andreassen

Hallvard Svendsen

Hugo Jakobsen

Teachers and Supervisors

Liyuan(Lilly) Deng

Jon Samseth

Jana P. Jakobsen

Hanna Knuutila

Specialization modules

- TKP6 Reactor Modeling (H. Jakobsen/Solsvik)

- TKP7 Gas cleaning (Hägg/Knuutila)

- TKP8 Membrane separation (Deng)

- TKP9 Crystallization and particle design (Andreassen)

- TKP11 Advanced process simulation (Preizig/Hillestad)

- TKP1? Absorption (Knuutila/J. Jakobsen)

Reactor Technology

Transport Phenomena provide fundamental modeling principles with universal applicability!

Topics of research/projects:
Reactor and separator modeling and analysis

Hydrogen production in Steam Methane Reforming, Chemical Looping Combustion (CLC) and phase separation in separators (gas-water-solid separation).

Interfacial transport (bubble/droplet coalescence/breakage)
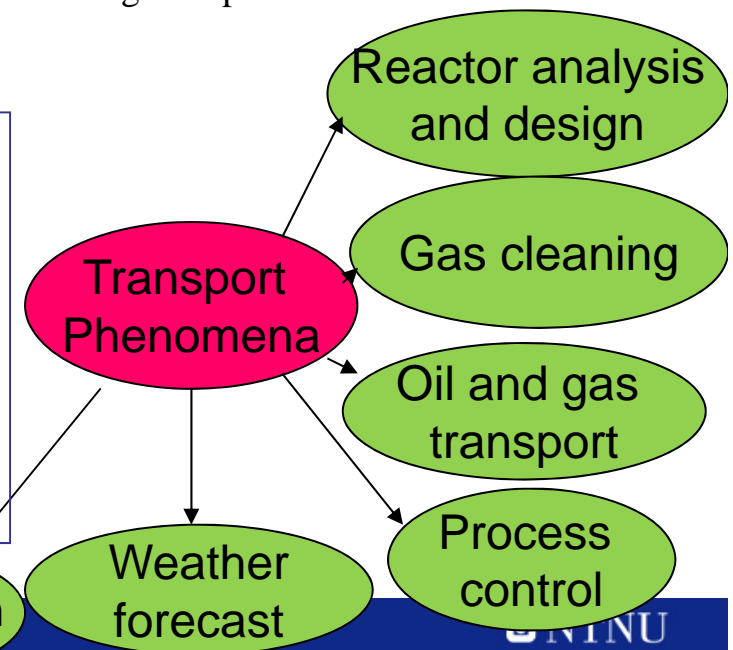Multicomponent mass diffusion processes

Project proposals: (1) hp-adaptive spectral-element solver in MATLAB. (2) Population balance solution using cell method. (3) Population balance breakage and coalescence closure discrimination. (4) Modeling and simulation of ultrasound assisted drug transport in tissue for cancer treatment.

Modeling Methodology:

– Problem analysis (physical understanding of the problem)
– Modeling (mathematical representation of these problem physics)
– Numerical solution methods
– Implementation (programming)
– Parallelization (program to distribute work on many processors)
– Supercomputing (expensive computer, fast with large memory)
– Model validation (everything correct and physical?)
– Simulation/analysis (what can we learn from our simulations …?)

Transport Phenomena

Reactor analysis and design

Gas cleaning

Oil and gas transport

Process control

Weather forecast

Acid rain

climate

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Process Design

- Project / Master topics

    - Systematic Staging in Chemical Reactor Design
    - Dynamic modelling and simulation of a CO_2 capture plant
    - Modelling and optimization of a Gas-to-Liquid plant
    - Energy considerations around an amine CO_2 capture plant
    - Offshore methanol production
    - Offshore Gas-to-Liquid production
    - Modelling and simulation of catalyst deactivation in fixed bed methanol synthesis reactor.

- Process Technologies
    - Syngas production
    - Methanol and ammonia
    - FT technologies
    - CO_2 capture
    - Polyolefin production

Crystallization and particle design

Reseach topics:

- CO_2-capture based on precipitating systems
- Water purification be freeze crystallization and selective precipitation
- Biomineralization
- Scaling and impurity removal
- Fundamentals of crystal growth

Specialization Projects/Master

- CO_2-capture in carbonate solutions with simultaneous precipitation
- Nucleation kinetics of carbonate particles in natural gas production.
- Crystal growth kinetics of carbonate particles in natural gas production.
- Scaling of calcium carbonate on heated surfaces.
- Spherulitic growth of crystals in solution
- Precipitation of calcium phosphate and carbonate in presence of biopolymers.
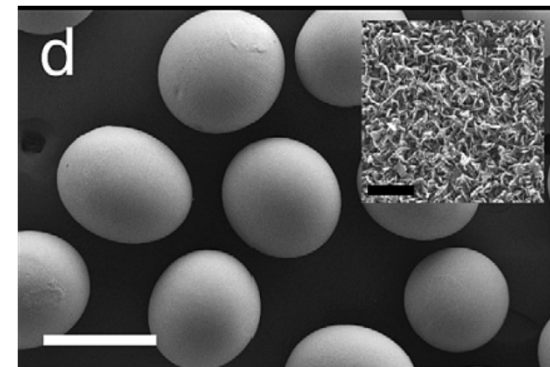
Gel beads of alginate mineralized with calcium phosphate, the scale bar is 500 µm. The inset shows nanocrystals on the bead surface, scale bar 300 nm.

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# Membrane research

- Purification of gases (flue gas, natural gas, CO_2, VOC, SF_6..),
- CO2 capture in precombusion and postcombustion
- Renewable energy (H_2, upgrading of biogas)
- Purification of aggressive gases (Cl_2, HCl, SO_2...)
- Simulation of environmental membrane processes for energy optimization
- Membranes in bioprosesser (biodiesel, bioethanol)
- Membrane hollow fibre spinning
- Studies on ionic liquids

Research Focus :

MATERIAL DEVELOPMENT &
TRANSPORT Phenomena through
MEMBRANES
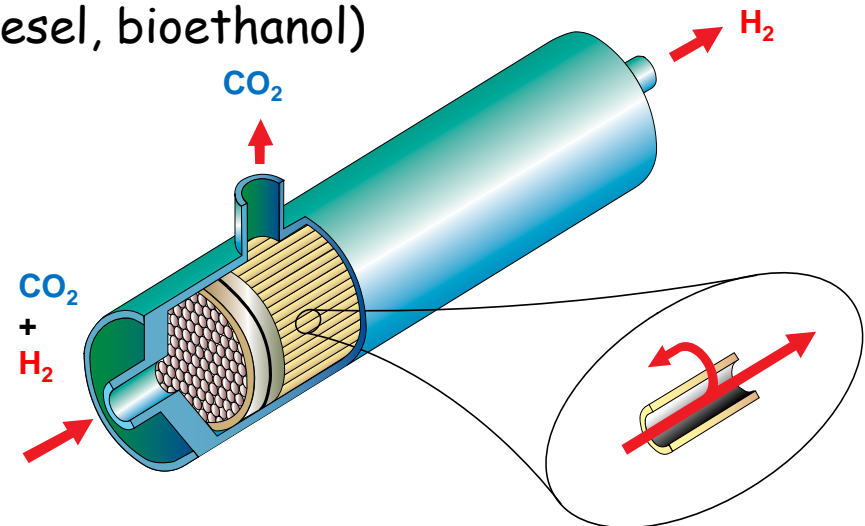
CO_2-selective hollow fibre membrane to separate CO_2 from mixtures of CO_2/H_2

Specialization Projects– Membrane technology

- Pilot scale studies for cement industry – CO_2-capture

- Pilot scale studies for oil/gas industry – CO2-capture

- Production of pilot scale flat sheet membranes

- Production of hollow fibre membranes

- Hydrodynamic studies for a pilot scale membrane module / simulations

- Evaluation of ionic liquids-based solvent for CO_2 absorption

- Investigation of solvent transport properties in a membrane contactor

- Techno-economic study of pre-combustion CO_2 capture process using membrane process

- Supported ionic liquid membrane for CO_2 capture
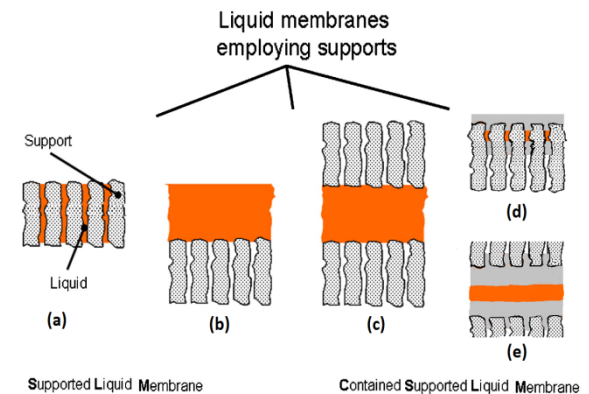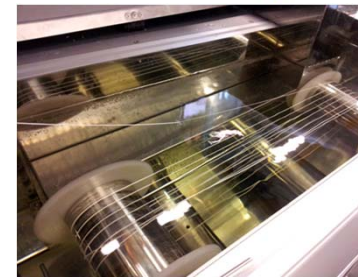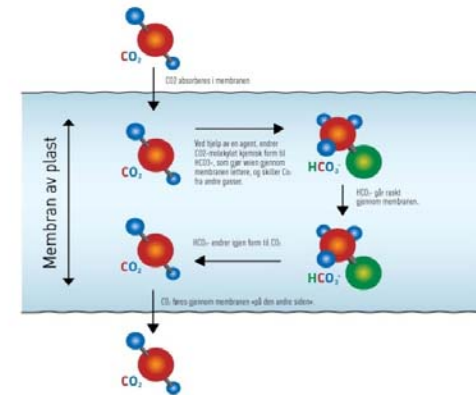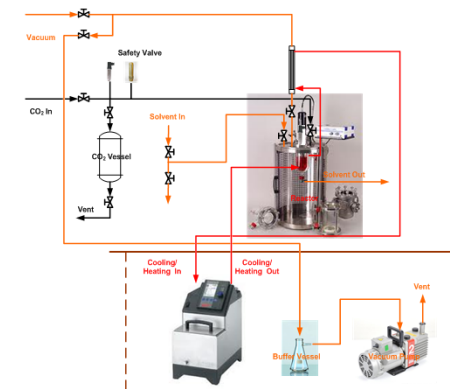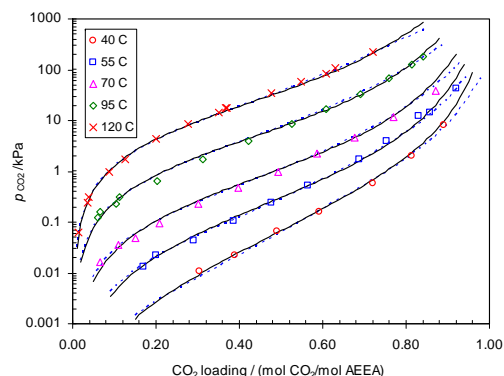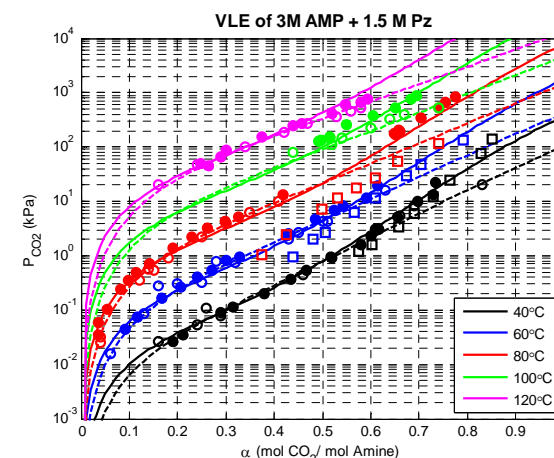
Absorption

Reseach focus:

- Development of novel solvent systems for post combustion applications and natural gas sweetening
  - The search for economically favorable absorbents
  - Experimental characterization of absorbents
  - Establishment of basic models

- Process modeling/simulation and pilot testing
  - Experimental validation of models for absorption and desorption

- Studies of environmental impacts of the technology

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Specialization projects

CO_2 REMOVAL
- Kinetics and physical solubility in CO_2-absorbent systems
- Strong bicarbonate forming solvents for absorption of CO_2 (EU-project HIPERCAP)
- Measurements and modeling of physical properties of solvents at high pressure
- CO_2 absorption: Calorimetric measurements
- Gas (N_2O/CO_2) Solubility into water at moderate pressure

H_2S REMOVAL
- Combined H_2S removal and hydrate control (SUBPRO) (testing of new solvents)

SO_2 REMOVAL
- Measurement of vapor liquid equilibrium in SO_2 absorption

EXPERIMENTAL AND/OR MODELING

Absorption

Reseach focus:

- Process modeling/simulation and pilot testing
  - Experimental validation of models for absorption and desorption

- Studies of environmental impacts of the technology

Specialization projects

CO_2 REMOVAL
- Modeling of amine degradation

H_2S REMOVAL
- Simulation of combined H_2S removal and hydrate control (SUBPRO)