Acid Gas Removal expertise at SINTEF and NTNU

Short overview

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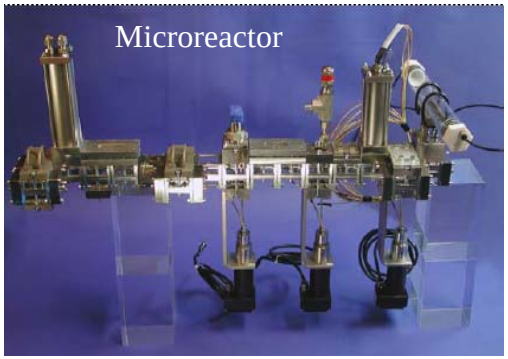
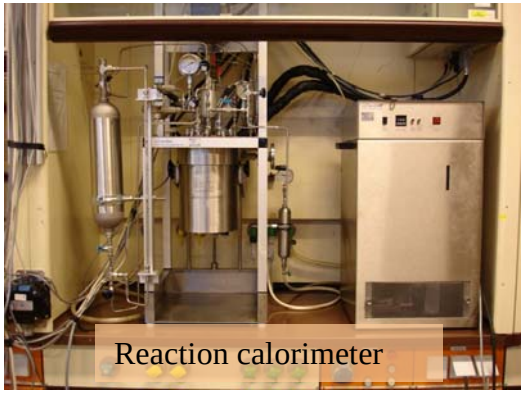
CO_2 absorption activities at SINTEF/NTNU

- New solvents and absorption systems development:
  - Vapor-liquid equilibria
  - Kinetics
  - Solubility
  - Heat of absorption
  - Speciation (NMR)
  - Environmental impact
  - Degradation
  - Foaming
- Thermodynamic modeling:
  - CO2SIM
- Process modifications:
  - Packing
- Dehydration study

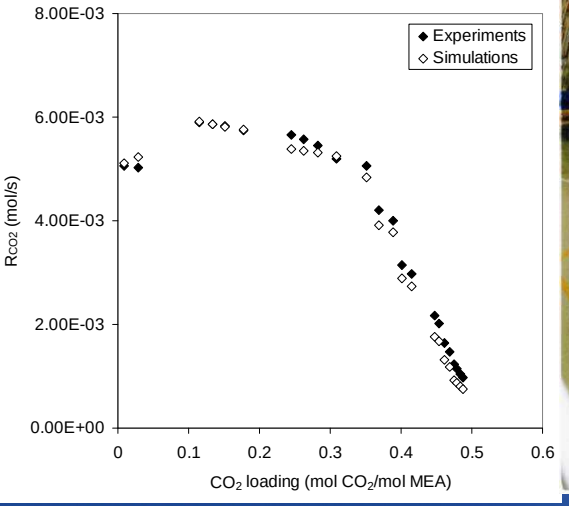
Lab scale high-pressure equipment





Pilot scale testing and model validation

Membrane contactor



Pilot plant construction site at Tiller

Absorber/Desorber rig at Gløshaugen

Membrane and Materials Process Laboratory

- Safety measures allowing for the use of flammable and toxic gases
  - Hydrogen and carbon monoxide detection systems
  - Ventilation up to roof
  - Circulation in-between double walls
- Gas pipeline infrastructure of 40 bars pressure
  - H_2, N_2, Ar, CO, CO_2, CH_4 and O_2
  - Equipped with 15 $m^3(STP) \cdot h^{-1}$ MFC's
- Mass flow & pressure controlled gas feeding system
- Lab-view software allowing for data acquisition during long-term testing

Membrane and Materials Process Laboratory

- Used for testing of membranes under conditions relevant for many processes
  - **Membrane-related**
  - H_2 separation with dense Pd-based membranes
  - H_2 separation with ceramic mixed conductor membranes
  - O_2 separation with ceramic mixed conductor membranes
  - CO_2 separation with hybrid and dual phase membranes

  - **Sorbent-related**
  - Oxygen-carrier materials for Chemical Looping Combustion
  - Oxygen-carrier materials for Chemical Looping Reforming
  - Oxygen sorbents for the CAR process
  - CO_2 sorbents for sorbent-enhanced processes

  - **Running projects**
  - FP7: DeCarbIt, CAESAR
  - FP6: CACHET, ENCAP
  - NFR: NanoPCFC, BIGCO_2, Perovskite oxygen carriers, N-INNER

“Sulphur” - lab established at SINTEF MC

- HSE as high priority:
  - Separate high flow ventilation up to roof
  - All equipment in ventilated fume cupboards
  - Ventilation at the floor (H_2S heavier than air)

Ventilation > 0.7 m^3 / s

- Lab space can easily be extended to include new equipment

- Experiments (TG)
  - High pressure – up to 40 bar
  - High temperature – up to 1100 ^oC
  - Steam / wet conditions
  - Test at sour conditions

“Sulphur” - lab established at SINTEF MC

- Development and testing of adsorbents for
  - H_2S removal
  - SO_2 removal
  - CO_2 removal (in presence of H_2S)
  - Oxygen carrier materials for CLC (in presence of H_2S)
- Development of testing of membranes for removal of
  - H_2S
  - SO_2
  - CO_2
- Running projects H_2S-related
  - CAESAR – FP7 – Sorption-enhanced WGS
  - NFR-Renergi – Pd-alloy membranes for use under harsh conditions: H_2S
- Project proposals
  - CO_2 and H_2S-related projects submitted to FP7, Energy 2009.5.1.1

Material aspects: CO_2 / Amine corrosion

Corrosion of the process equipment in amine based CO_2 capture process plants is a problem influenced by many parameters like e.g.:

- Type and concentration of amine
- Gas concentration and composition (O_2, CO_2)
- Temperature
- Steel grade
- Fluid flow
- Products from corrosion and degradation
- Corrosion and degradation inhibitors

} Complex system

Degradation products can be chelating agents for iron or chromium ions and it is documented that e.g. iron ions produced during corrosion of the equipment can catalyze the degradation process of amines.

Ongoing internal project to understand this type of corrosion.

H2S can cause Stress corrosion (SCC)

Definition

" Stress corrosion cracking is the unexpected material failure caused by a synergistic interaction of tensile stress and a corrosive environment "

- Susceptible material (CRA, CS, Cu, Ti a.o.)
- Tensile stress, external or internal (residual)
- Corrosive environment (aggressive elements, chemicals)

➢ Stress corrosion cracking or hydrogen embitterment can be a dangerous problem in MEA plants. In 1984 an amine absorber pressure vessel containing MEA ruptured because of hydrogen induced cracking, **17 lives were lost**.

Stress corrosion cracking

- CONCLUSION

Critical need for more research and testing on relevant system combinations for better understanding of the fundamental mechanisms taking place

and

how to deal with this potential fatal rapid failure mode problem (SCC) in future plants!

Materials science
- cryogenic applications

- Materials evaluation in general (e.g. Al versus steel…)
- Production methods
- Microstructure control
- Ductile / brittle transformation
- Fracture mechanics
- Welding technology and qualification
- Sealing technology (risk of icing, plugging, explosion…)
- A.o..

Ongoing project at SINTEF - "Arctic Materials"