Application of an aqueous ammonia-based process for CO₂ capture to different industrial sources

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**1. Chilled Ammonia Process**

- Features:
  - Low temperature: stable solvent
  - Competitive energy penalty
- Demonstrated in various bench-scale pilot plant tests
- No power plants and in cement (Cement Plant) and steel (Steel Plant) plants

**2. The CO₂-NH₃-H₂O system**

- Features:
  - Thermodynamic model developed by Thomsen et al. (1999) and Dande et al. (2010)
  - Solid properties based on Jänecke (1929)

**3. Phase diagrams**

- Diagrams showing the phase behavior of the CO₂-NH₃-H₂O system at different temperatures.

**4. Thermodynamic model**

- Thomsen model and Chen model eNRTL
- Excess Gibbs energy and Helmholtz energy

**5. Rate-based model**

- A rate-based model using the Thomsen thermodynamic model has been validated with pilot tests from literature.
- Repeatability of experiments

**6. Model validation (CSIRO tests)**

- Methodology adapted from Martínez-Maradiaga et al. (2013)
- Systematic treatment of raw pilot data

**7. Heuristic process optimization**

- Methodology for selecting the optimal process parameters
- Objective function: Total Specific Energy Needs

**8. Pilot tests for CO₂ absorber**

- Test rig for pilot plant data acquisition
- Steady-state (SS) detection
- Mass and energy balances before data reconciliation

**9. Summary and conclusions**

- The Chilled Ammonia Process can be applied to CO₂ capture to different industrial sources.
- The heuristic optimization approach has led to the optimum set of operating conditions of the process, based on:
  - The energy requirements as the objective function.
  - Equilibrium model using the Thomsen thermodynamic model with ad-hoc Murphree efficiencies for cement plant gas compositions.
  - CO₂ absorber tests mimicking power plant and cement plant-like flue gas compositions have been performed.
- A systematic procedure for the post-treatment of the raw pilot plant data has been developed.
- Reconciled data constrained to meet the requirements of the mass and energy balances will be used for the analysis of the experimental results in terms of CO₂ capture rate and NH₃ removal efficiency and for further rate-based model development.

**References**

- Standard deviations
- Representative SS period to compute
- Outliers detection if – SS detection if
- Average values and standard deviations
- From SS detection: 89 experimental points
- In)DR, m³/h
- N₂, CO₂ absorption rate
- CO₂-rich solution
- NH₃ slip < 200 ppm
- No solid formation
- CO₂ depleted flue gas

- Mout
- CO₂ content of the CO₂-lean stream
- Lower specific exergy needs
- More CO₂ absorption rate
- CO₂ purity > 99.9%vol
- NH₃ slip < 200 ppm
- No solid formation