Mixed-Salt Based Transformational Solvent Technology for CO₂ Capture

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Presentation Outline

• Technology Background
  – Needs to reduce CO$_2$ capture costs
  – Advanced Mixed-Salt Process
  – Process Benefits
• Project Structure
  – Objectives and Budget
  – Project Team and Organization
  – Development Path
  – Project Tasks
  – Available Resources
• Project Status and Test Results Update
• Acknowledgements
Reducing Capture Costs Beyond the Current Values

*New transformational technologies*

- *A step reduction of the regeneration energy is required*

- Low regeneration energy by solvent pairing
- Energy recovery by heat integration

*Pathway to reach DOE 2030 CO₂ capture goals*
**Advanced Mixed-Salt Process Details**

**How it works:**

Selected composition of potassium carbonate, ammonium salts and an additive

- Overall heat of reaction 35 to 60 kJ/mol (tunable)

Absorber operation at 20° - 40° C at 1 atm

Regenerator operation at 90° - 120° C at ~10 atm

- Produce high-pressure CO₂ stream

K₂CO₃–NH₃–Additive-CO₂–H₂O system

**High CO₂ cycling capacity**  
**Reduced Ammonia Emission**  
**Reduced Reboiler duty**  
**Reduced CO₂ Compression Energy**

A significant step change for reaching DOE’s reduced CO₂ capture cost targets.
Enhanced Kinetics at High Temperature

- Observed rate enhancement of CO₂ absorption efficiency by comparison of mixed-salt with NH₃.

Low Energy Requirement for CO₂ Stripping

- Estimated regenerator heat requirement for mixed-salt system with 0.2 to 0.6 cyclic CO₂ loading.
- Comparison with neat K₂CO₃ and MEA is shown.

(Source for the Shell K₂CO₃ process, Schoon and van Straelen, 2011).

Absorber side: Reduced packing height
Regenerator side: Reduced water evaporation
Project Objectives, Budget and Period of Performance

- **Project Objectives**
  - High CO₂ loading capacity
  - Solvent rich system
  - Potential to reach DOE cost target $30/ton CO₂ by 2030

- **Period of Performance:** 6/1/2018 to 11/30/2021

- **Project budget (Contract No: DE-FE0031597)**
  - DOE Funding: $3,105,797
  - Partner Share: $951,897
Project Team

*Mixed-Salt Based Transformational Solvent Technology for CO₂ Capture*

Project Manager: Andrew Jones, NETL
Prime Contractor: SRI International
Project Team: US and International Partners

Opportunities for US-Norway Collaborations leading to new IP and new markets
Work Organization

VLE Measurements
- Mixed-Salt based solvents

Kinetic Measurements
- Absorption and desorption kinetics at lab scale
- Absorption/desorption (integrated) rates at bench scale

Modeling
- Equilibrium and rate based modeling
- Flow-sheet modeling of the CC plant
- PC plant and CC plant Integration modeling

Process Risk Evaluation
- Chemical stability measurements
- Emission measurements
- Degradation measurements

- SRI International, USA
  - Advanced mixed-salt composition development and testing
- DTU, Denmark (Cost-share partner)
  - VLE Measurements & Thermodynamic modeling
- OLI Systems, USA
  - Flowsheet Model Design (energy and mass balance)
- Trimeric, Corp., USA
  - Process Techno Economic Analysis
- SINTEF, Norway (Cost-share partner)
  - Emission and degradation studies
  - Alternative Mixed-salt composition development and testing
Mixed-Salt Based Transformational Solvent Technology for CO₂ Capture

Team: SRI (USA), SINTEF (Norway), OLI (USA), DTU (Denmark), Trimeric (USA)
Funding: US DOE (SRI Project) & CLIMIT (SINTEF Project)

Opportunities for reducing CO₂ from small and large-scale applications
Small bench scale absorber system for AMSP testing
Existing Infrastructure for Testing

*Photographs of large bench scale setup*

Large bench scale system

Lab scale system

A: Rich solution inlet locations
B: Discharge locations for high NH₃/K solution
C: Discharge locations for low NH₃/K solution
D: Heat exchangers (Cold rich↔ Hot lean)
Project Tasks

BP1: 24 months  BP2: 12 months

- Task 1: Project Management and Planning (SRI)
- Task 2: Vapor-Liquid-Equilibria Measurements (DTU)
- Task 3: Process Kinetic Assessment (SRI)
- Task 4: Emission and Degradation Measurements (SINTEF)
  - Subtasks 4.1 and 4.2: Emission and thermal degradation measurements
  - Subtask 4.3: Integrated testing with amines and mixed-salt blends
- Task 5: Rate-Based Model Development (OLI)
- Task 6: Preliminary Techno-economic Analysis (Trimeric)
- Task 7: Integrated System Testing (SRI)
- Task 8: Process Flowsheet Model Development (OLI)
- Task 9: Techno-economic Analysis (Trimeric)

* Tasks in Red will be performed in BP2
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<td>Preliminary TEA</td>
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VLE Modeling at SRI
Testing at SRI

Comparison of test data with and modeling

Effect of CO₂ loading on efficiency

Correlation between pH with CO₂ loading
Measured and calculated system pressure of 0.2 to 0.5 CO$_2$ loaded AMSP solutions with temperature
Process Modeling at OLI

Comparison of Solvent Densities in Abs 1

Comparison of Dissolved CO₂ Concentrations

Comparison of Dissolved NH₃ Concentrations

Comparison of H₂O Emissions

- Case 1 vs. Case 2
- Density (g/ml) vs. Temperature (°C)
- Concentration (m) vs. Temperature (°C)
- Water Vapor Flow Rate (mole/hr) vs. Temperature (°C)

No Solids

10 bar

High CO₂ carrying capacity

Reduced steam stripping
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Thank You

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