Speciation of iron in MEA solutions: Solubility and Corrosion

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Outline

• Introduction
• Motivation
• Methodology
• Results
• Conclusions
Introduction: Ideal Solvent

- Low degradation
- Low volatility
- Cheap
- High absorption rate
- High capacity
- Low corrosion rate
Introduction: Corrosion

- Corrosion is one of the main challenges in amine based PCCC
- The ideal solvent should have a minimum effect on corrosion
- Some iron compounds have a catalytic role in the degradation of solvents while others can increase the corrosion rate
- The target of this work is to examine an alternative, fast methodology for corrosion evaluation of solvents
Corrosion Evaluation: Overview

Weight loss technique with metal coupons is one of the most used for the calculation of the corrosion rate.

A number of electrochemical methods for corrosion measuring exist. Potentiodynamic polarization techniques are among the most popular.

SEM-EDS: Scanning Electron Microscopy-Energy Dispersive X-ray Spectroscopy
Surface morphology- Elemental Mapping (homogeneous corrosion or not)

ICP-MS: Inductively Coupled Plasma Mass

Total Metal Concentration in the liquid gives information about the relative corrosivity
Background: Thermal degradation

- Stainless steel cylinders (316 SS) equipped with Swagelok® end caps

- 9 g of loaded solution of amine was injected into the cylinder
- Cell put in forced convection oven at 135 °C
- Experiments run for 5 weeks
- After thermal degradation experiments, we identify FeCO$_3$ on the steel surface with XRD
Background: ICP-MS

Comparison of Fe content after 5 weeks thermal degradation experiments at T=135°C
Motivation

• Tsuda et al. studied the effect of iron carbonate on the corrosivity of amine solutions in CO₂ removal units. They reported that corrosion was inhibited by the formation of FeCO₃ scale.

• They correlated high corrosion with high solubility of FeCO₃.

→ We will try to correlate the ferrous solubility with the solvent corrosivity.
Solubility of Fe(II) in amine solutions

• Could this be a fast methodology to determine corrosivity?

• Is there a correlation between Fe(II) and amine corrosivity?

• Based on literature DETA is more corrosive than MEA and that MEA is more corrosive than MDEA
Methodology

We measured the solubility of ferrous in 30wt% amine solution with 0.4 CO₂ loading

- FeSO₄ is added gradually
- Three temperatures were tested:
  - 25 °C, 40 °C and 60 °C
- Amines tested: MEA, MDEA, DETA
Spectrophotometric Determination of Fe$^{2+}$

Fe$^{2+}$ + 3phen $\rightarrow$ (phen)$_3$Fe(II)

For quantitative analysis, the wavelength $\lambda_{\text{max}} = 508$nm is chosen.
Results

Fe(II) in 30wt% MEA

mg/L

hours

25C
40C
60C
Comparison of Fe\(^{2+}\) values (mg/L)

### 60 °C

<table>
<thead>
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<th>TIME</th>
<th>MDEA</th>
<th>MEA</th>
<th>DETA</th>
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<tr>
<td>3 h</td>
<td>59</td>
<td>64</td>
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<td>16</td>
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### 45 °C

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<td>90</td>
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<tr>
<td>24 h</td>
<td>47</td>
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<tr>
<td>48 h</td>
<td>29</td>
<td>87</td>
<td>200</td>
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</table>
Conclusions

• The measured Fe(II) solubility in an amine solution was correlated with the corrosivity of the solvent

• Corrosivity: DETA>MEA>MDEA

• Our results are in good agreement with literature data from pilot and industrial plants

• Based on the current results, it seems the Fe(II) solubility could be used to predict corrosivity. However further tests will take place to confirm this correlation.
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Thank you for your attention