Linking Solvent degradation with corrosion in Post combustion Carbon Capture Systems

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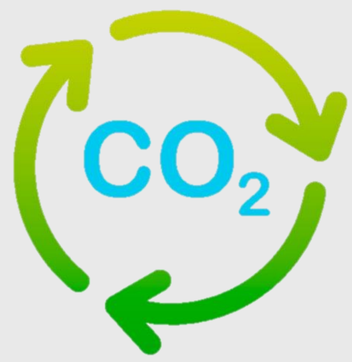
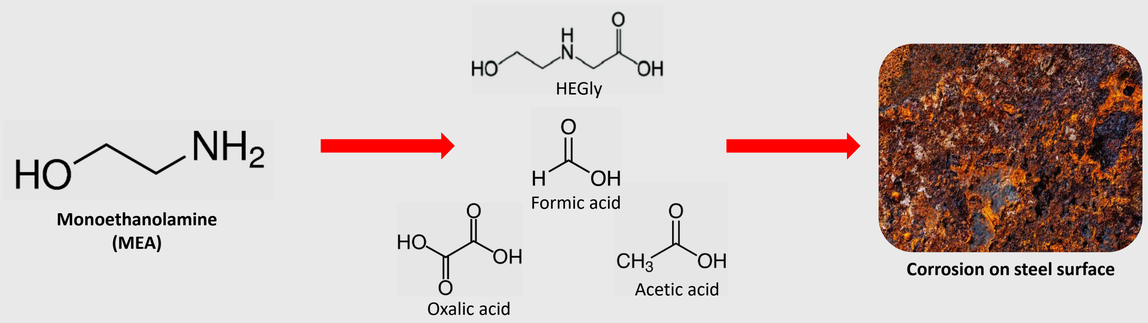
Introduction

Post-combustion carbon capture (PCC) with amine solvents is a key technology for reducing CO_2 emissions. However, solvent degradation during operation forms corrosive by-products, posing serious corrosion challenges to the system. Addressing this issue is crucial for the reliability and efficiency of PCC processes.



Objectives

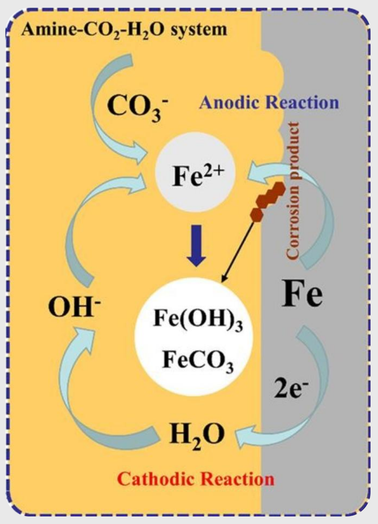
This study aims to assess how amine based solvent degradation products affect steel corrosion in PCC systems and to link specific degradation products to corrosion behaviour, providing a basis for better mitigation strategies.



Degradation products [1]

Significance of the study

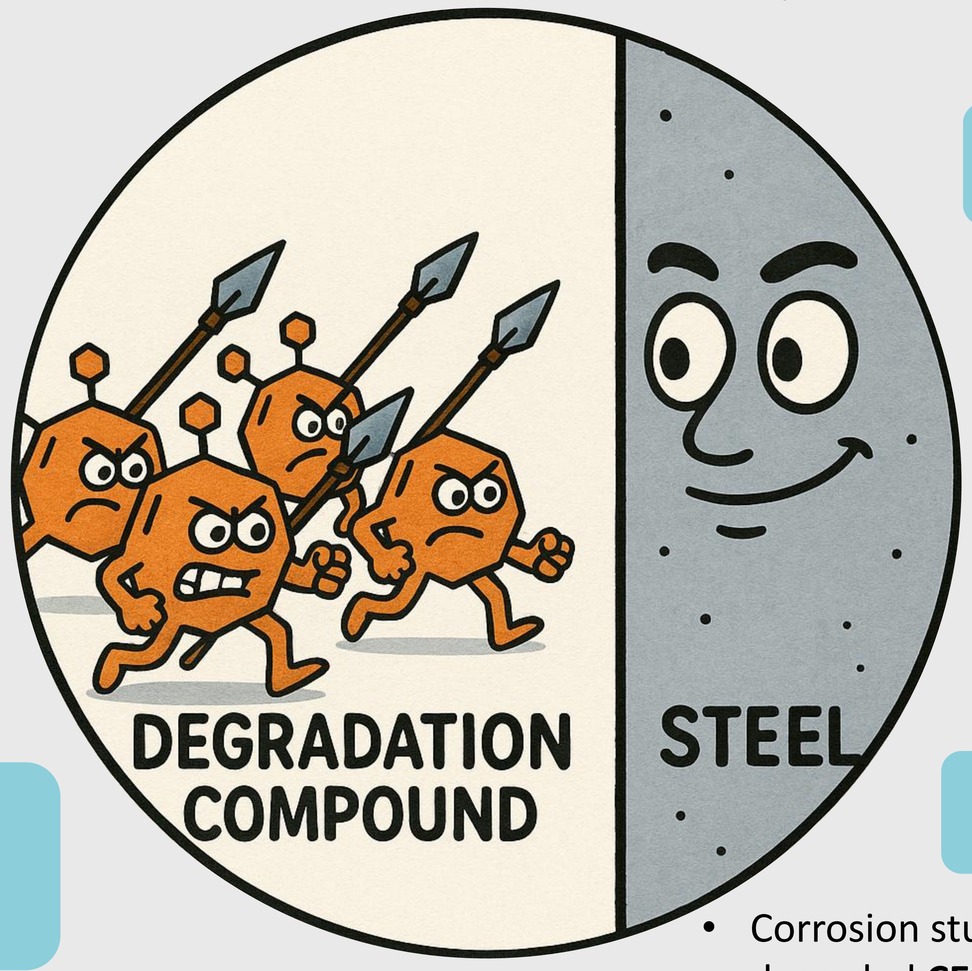
- Develops a deeper understanding of the corrosivity of solvent degradation products in CO_2 capture solvents.
- Provides data essential for designing **corrosion-resistant infrastructure** for CO_2 capture systems.
- Contributes to long-term plant reliability and lower operational costs.



Corrosion mechanism in Amine-CO_2-H_2O system [2]

Research questions

- Impact of solvent degradation products on corrosion?
- Which compounds contribute most towards corrosion?
- What are the best corrosion mitigation strategies?

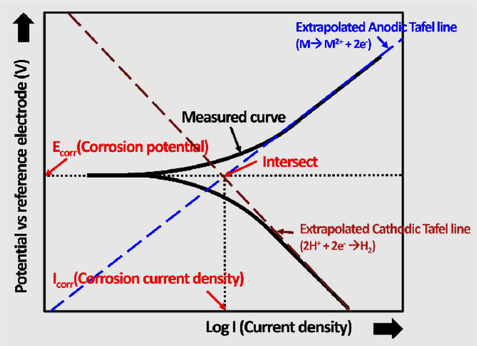


Research gaps

- Limited corrosion data for **DETA degradation**.
- Unclear impact of **HSS formation** on corrosion in CESAR-1.
- Corrosion kinetics of CESAR-1 degradation products not fully explored.

Selection from literature review

- **MEA degradation** products (e.g., HEIA, HEEDA) - **uniform and pitting corrosion** on SS316. [5]
- **DETA and CESAR-1** form **heat-stable salts (HSS)** and organic acids, increasing corrosion risks. (Impact of corrosivity has to be tested) [6] [7]
- **DMOZD** and **DM-PZEA** – main deg. products of **CESAR-1** (corrosion study required).[4]



Tafel plot (Electrochemical analysis) [3]

Future steps

- Corrosion study of **SS316** in degraded **CESAR-1** and **DETA** solvents. (**Potentio-dynamic polarization** & **Impedance spectroscopy**)
- Identify main corrosive degradation products.
- Corrosion mitigation strategy development (Corrosion inhibitors)

Three electrode set up

Degradation products of CESAR-1 [4]

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References

[1] Vevelstad, S. J., Buvik, V., Knuutila, H. K., Grimstvedt, A., & Da Silva, E. F. (2022). Important aspects regarding the chemical stability of aqueous amine solvents for CO2 capture. *Industrial & Engineering Chemistry Research*, *61*(43), 15737-15753.
[2] Zhao, F., Cui, C., Dong, S., Xu, X., & Liu, H. (2023). An overview on the corrosion mechanisms and inhibition techniques for amine-based post-combustion carbon capture processes. *Separation and Purification Technology* , *304* , 122091.
[3] Lee, D., Lee, H., & Jeong, H. (2016). Slurry components in metal chemical mechanical planarization (CMP) process: A review. International Journal of Precision Engineering and Manufacturing , 17 , 1751-1762.
[4] Buvik, V., Grimstvedt, A., Vernstad, K., Wiig, M., Knuutila, HK, Muhammad, Z., ... & Campbell, M. (2024). CESAR1 solvent degradation in pilot and laboratory scale. *CESAR1 Solvent Degradation in Pilot and Laboratory Scale (December 11, 2024)* .
[5] Fytianos, G., Ucar, S., Grimstvedt, A., Hyldbakk, A., Svendsen, HF, & Knuutila, HK (2016). Corrosion and degradation in MEA based post-combustion CO2 capture. International Journal of Greenhouse Gas Control , 46 , 48-56.
[6] Hayfron-Benjamin, E. (2013). Characterization of Corrosion patterns of Stainless Steel in Diethylenetriamine (DETA)-CO2 and amine degradation products systems: and an Introductory Modeling Approach (Master's thesis, Institutt for kjemisk prosessteknologi).
[7] Neerup, R., Øbro, KL, Løge, IA, Kottaki, N., Frøstrup, CF, Gyorbiro, I., ... & Fosbøl, PL (2025). CO2 capture pilot campaign: Understanding solvent degradation of CESAR1 in cement plant operations. Chemical Engineering Journal , 510 , 161542.