Further evaluation of potassium iodide's effect on oxidative and thermal degradation of MEA

Georgios Oikonomou[a], Hanna K. Knuutila[a], Vanja Buvik[b]
[a] Norwegian University of Science and Technology
[b] SINTEF Industry

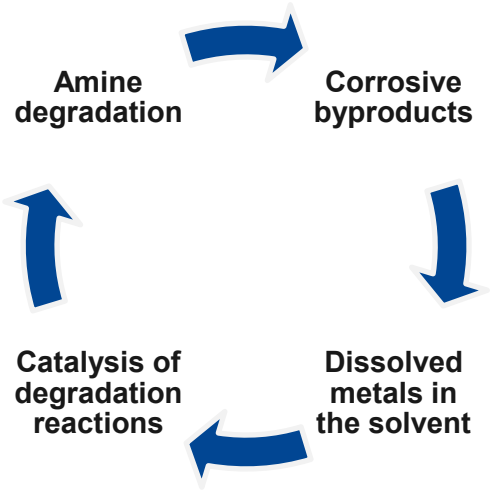
PCCC-8

Introduction

Current challenges in amine-based absorption

Degradation

- Amine oxidation due to O_2, SO_x and NO_x
- Thermal degradation due to high temperatures and CO_2



Corrosion

- Some degradation products induce corrosion
- Metals catalyze amine oxidation

Degradation management

- Solvent reclaiming
- Flue gas pre-treatment
- O_2 removal
- **Inhibitor utilization**

Degradation inhibitor types

Chelating agents: Bond with dissolved metals preventing their catalytic effect

O_2/radical scavengers: React competitively with dissolved oxygen or free radicals, mitigating amine oxidation

Inhibitor	Mechanism	Degradation mitigation	Corrosion mitigation	Thermal stability	Toxicity
Potassium Iodide (KI)	Scavenger/stable salt				
1,3-diaminopropane-N,N,N,N -tetraacetic acid (PDTA)	Chelating agent				
ethylenediaminetetraacetic acid (EDTA)	Chelating agent				
etidronic acid (HEDP)	Chelating agent				
diethylenetriamine pentaacetic acid (DTPA)	Chelating agent				
2,5-dimercapto-1,3,4-thiadiazole (DMTD)	Scavenger/ chelating agent				
Carbohydrazide	O_2 scavenger				
Sodium metavanadate ($NaVO_3$)	Oxidation passivator				
Sodium sulfite (Na_2SO_3)	O_2 scavenger				
Bicine	Radical scavenger				
Formaldehyde	O_2 scavenger				

Why KI?

- Effective oxidation inhibition at isolated absorber conditions
- Not consumed during inhibition
- Can reduce mild steel corrosion in acidic environments
- Non-toxic

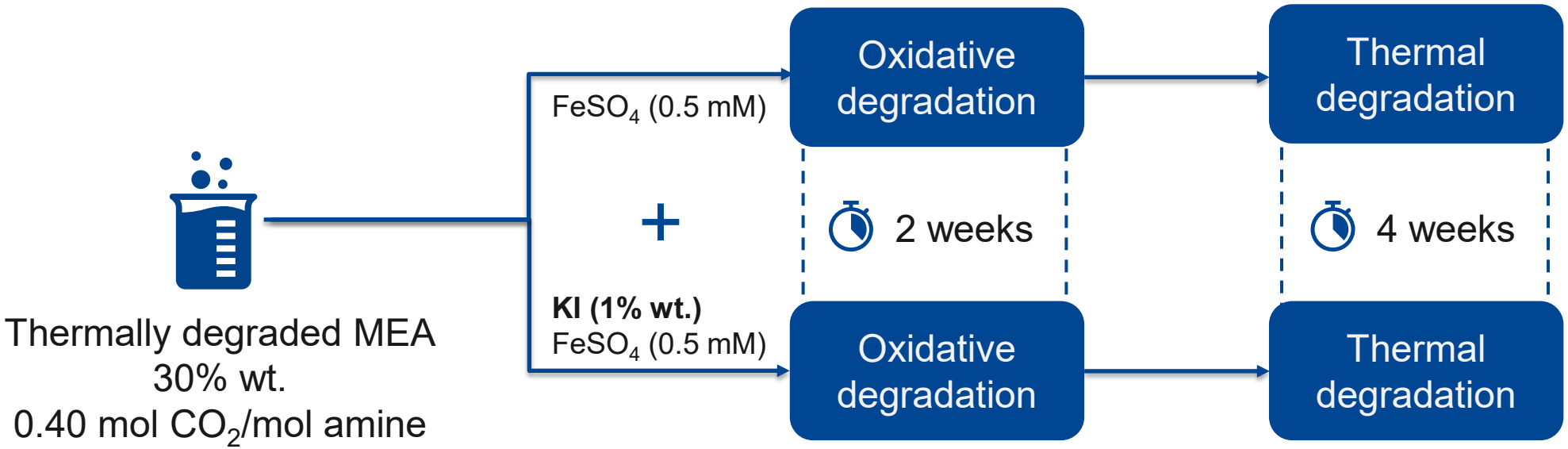
- Ineffective at preventing degradation during solvent cycling between absorber and stripper conditions
- KI was found to mildly increase the formation of specific thermal degradation compounds at stripper conditions

Could KI increase thermal degradation?

Do thermal degradation compounds accumulate more because they oxidize less in the presence of KI?

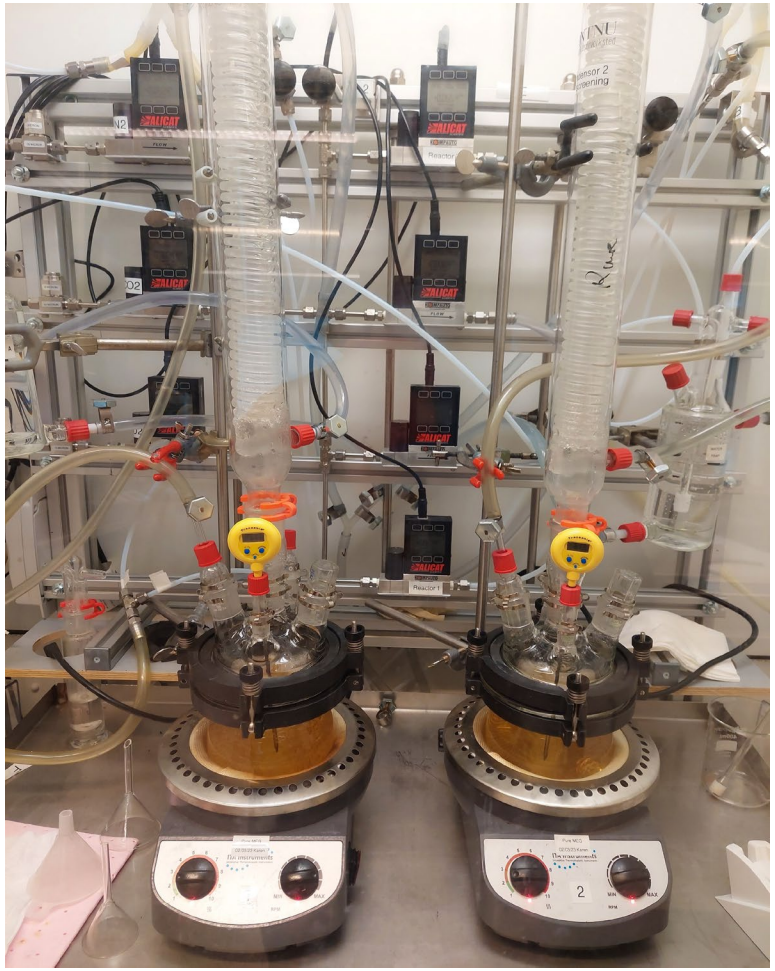
How does the presence of thermal degradation products affect oxidation inhibition of KI?

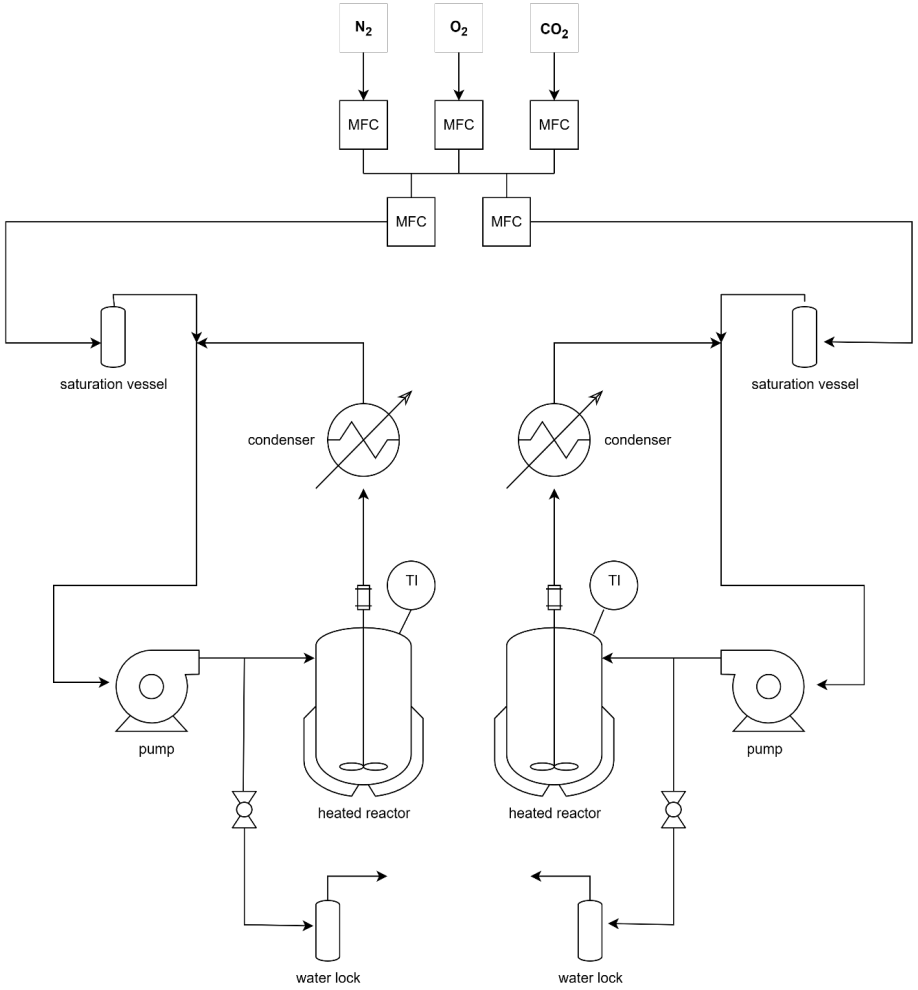
Methodology



Sample analyses:
Acid-base titration: alkalinity
Total Inorganic Carbon (TIC): CO_2 content
LC-MS: degradation compound and MEA concentration

Oxidative degradation setup





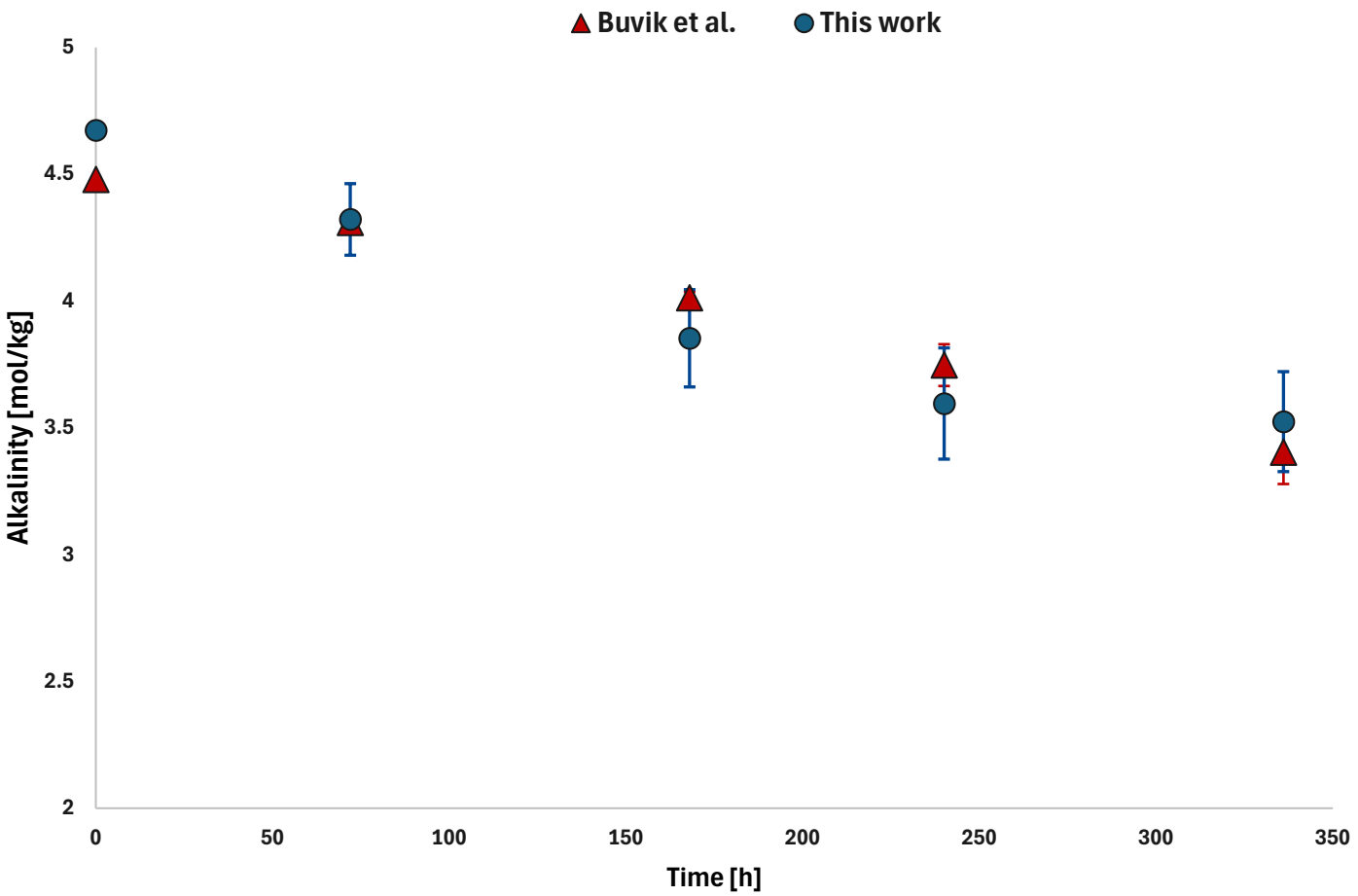
Two glass reactors, each filled with ~1 L of CO_2 loaded solvent and kept at 60 °C inside heating mantles

Each reactor is connected to a water-cooled condenser (5 °C)

A gas mix of 77% N_2, 21% O_2 and 2% CO_2 is sparged into each reactor and circulated by a peristaltic pump

Solvent samples were collected every 3-4 days

Oxidative degradation setup validation



The methodology was found to be repeatable and the results closely align with previous work.

Buvik et al: https://doi.org/10.1016/j.cesx.2021.100096

Thermal degradation

316 SS cylinder equipped with Swagelok valve

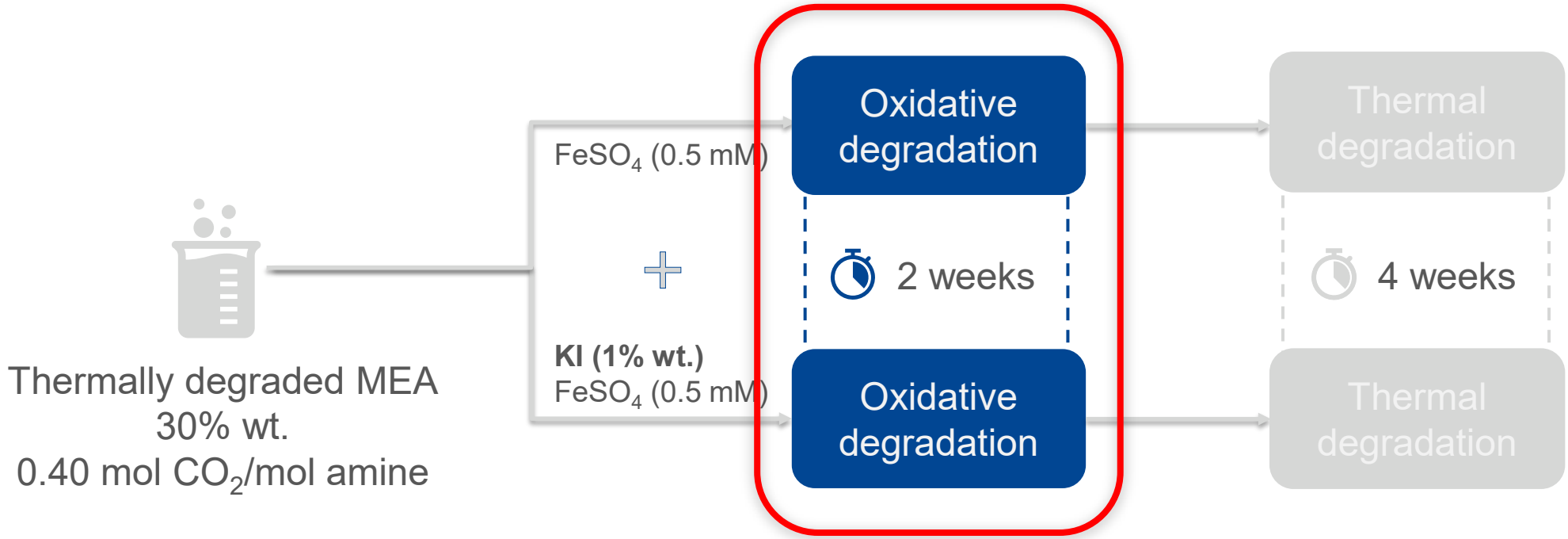
Four cylinders used for each round of thermal degradation testing

Each cylinder was flushed with pure N_2 and loaded with 15 mL of solvent

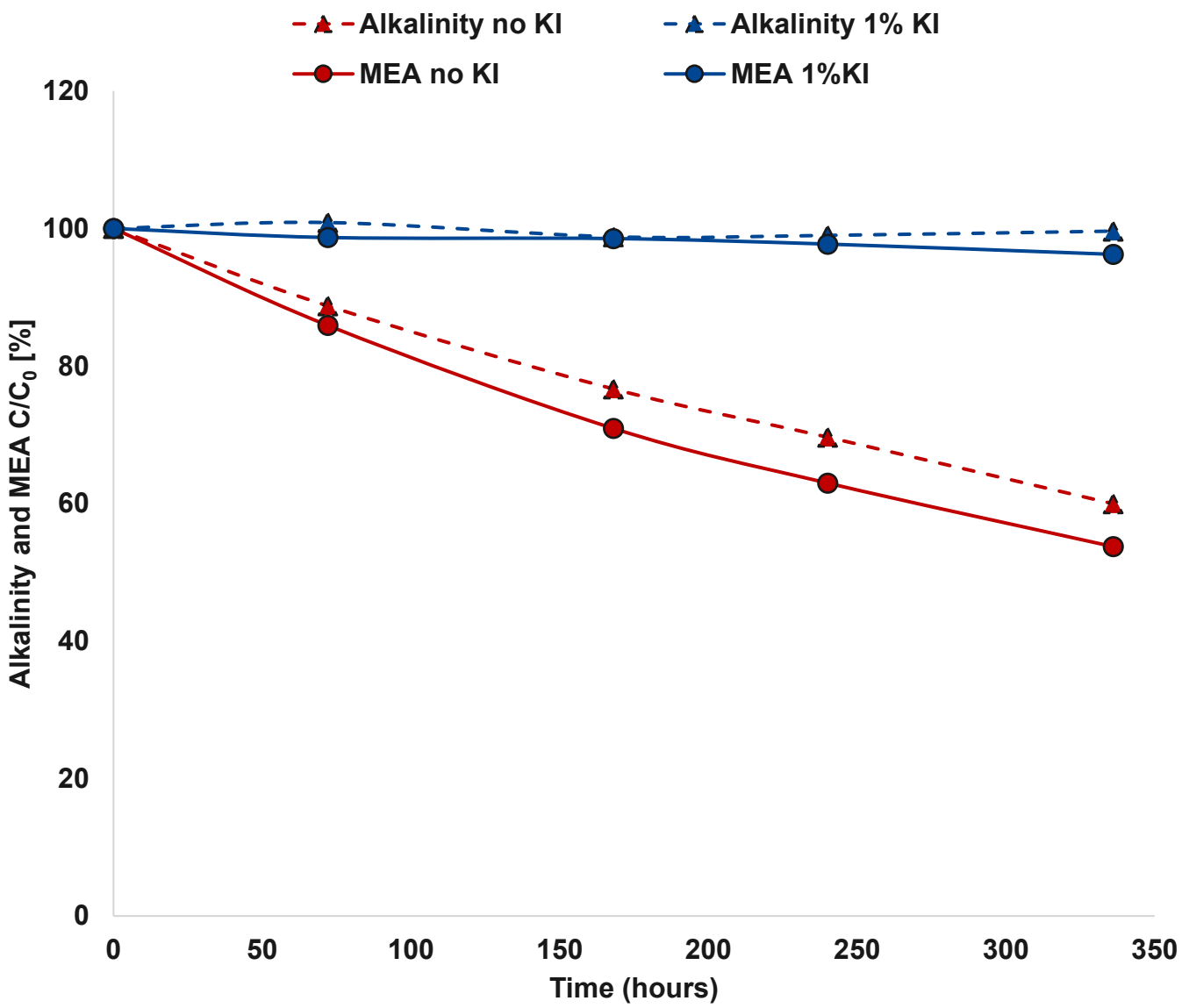
Cylinders were maintained at 135 ^{o}C inside a forced convection oven

Samples were retrieved every 7 days

Oxidative degradation results



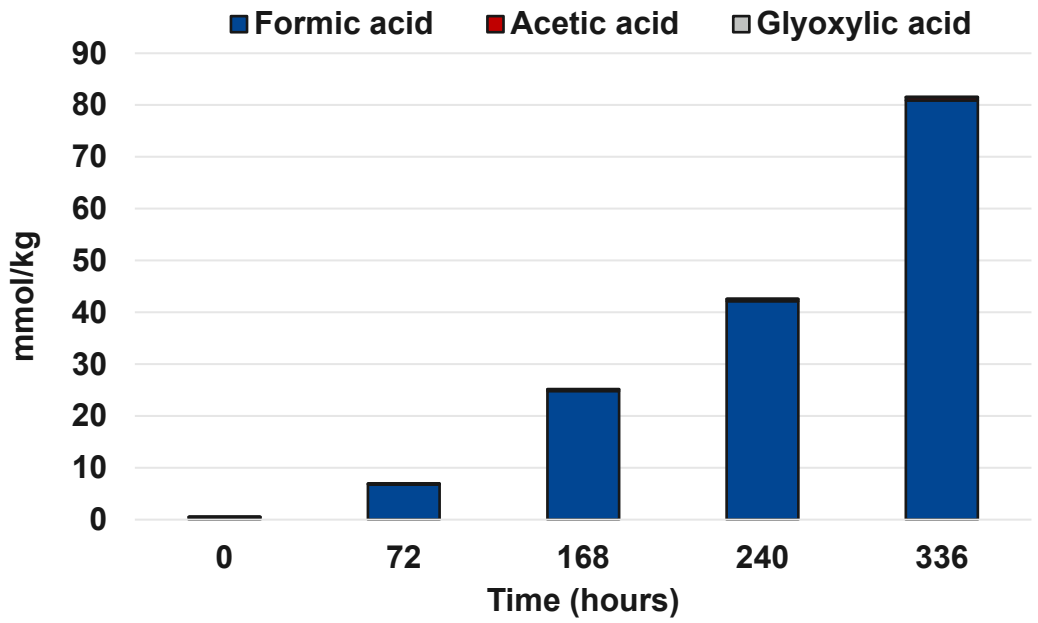
Oxidative degradation - Alkalinity and MEA concentration



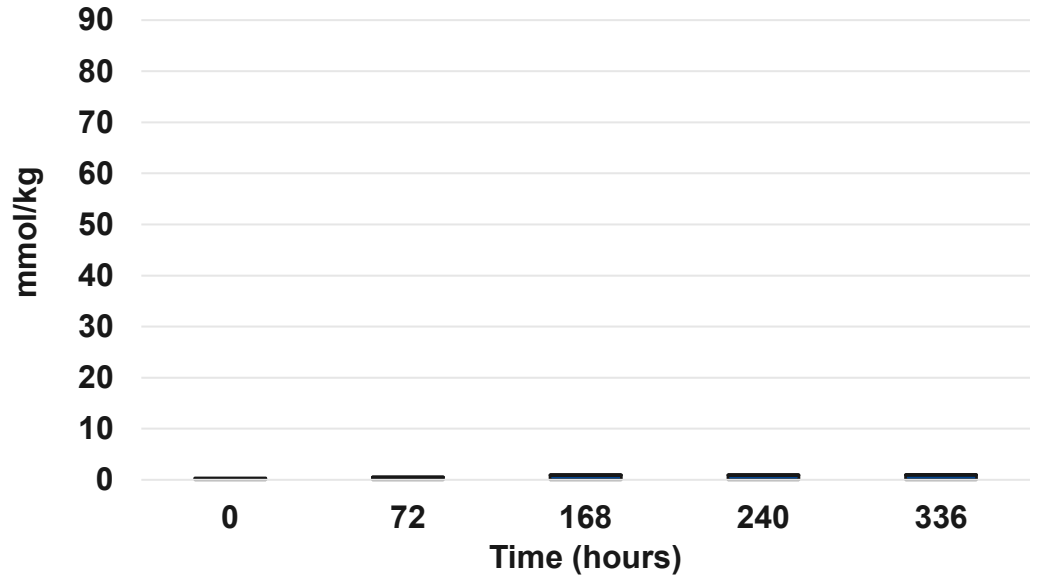
KI maintains oxidation inhibition capability when thermal degradation compounds are present in the matrix.

Oxidative degradation - acid formation

No KI



1% KI

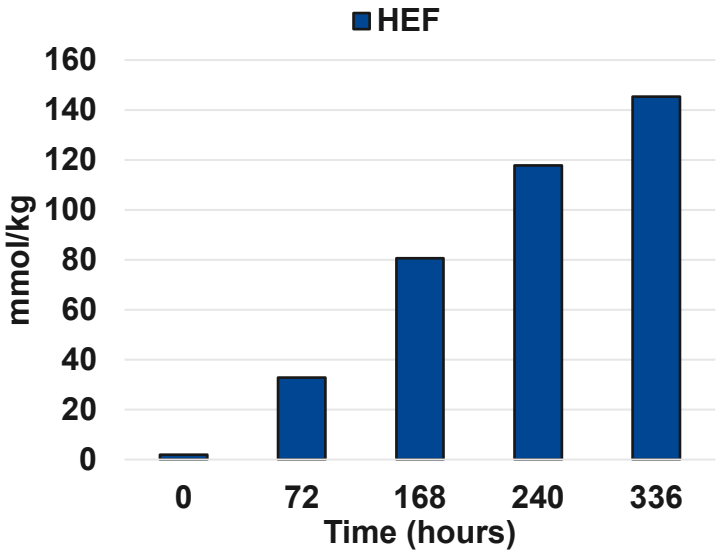


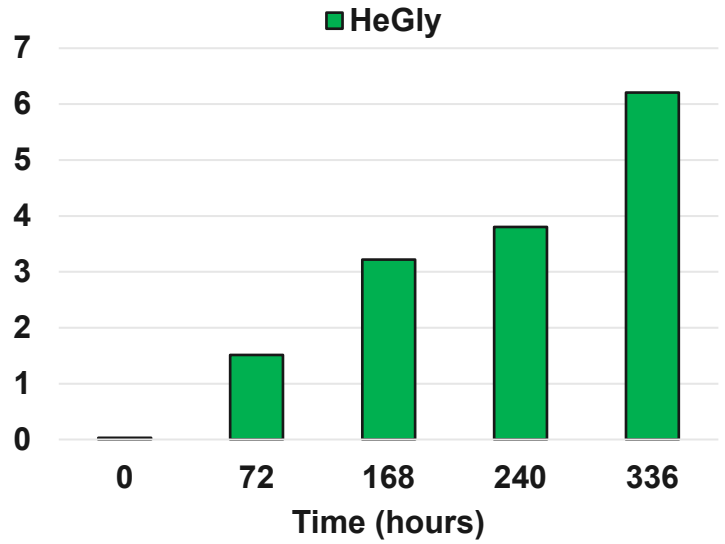
Formic, acetic and glyoxylic were the only acids detected above the LOQ

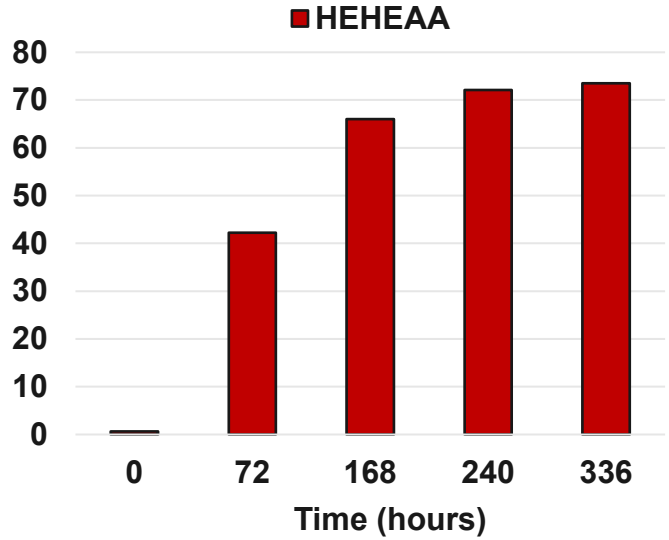
All acid formation was drastically decreased by KI

Oxidative degradation - secondary oxidation products

No KI







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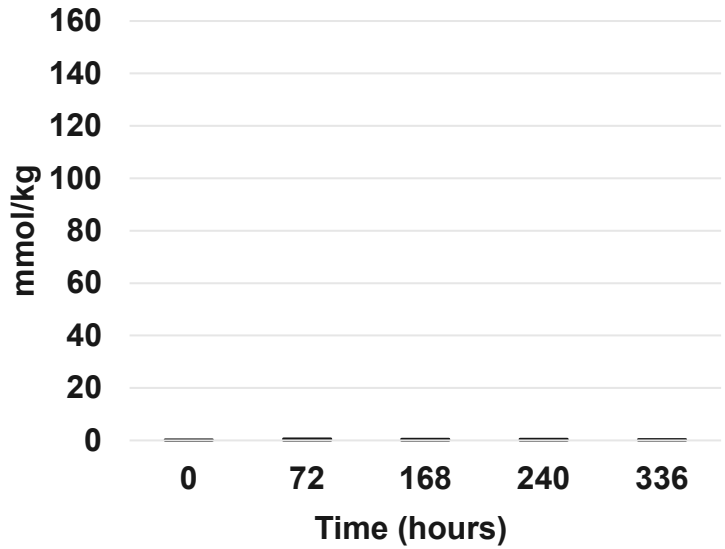
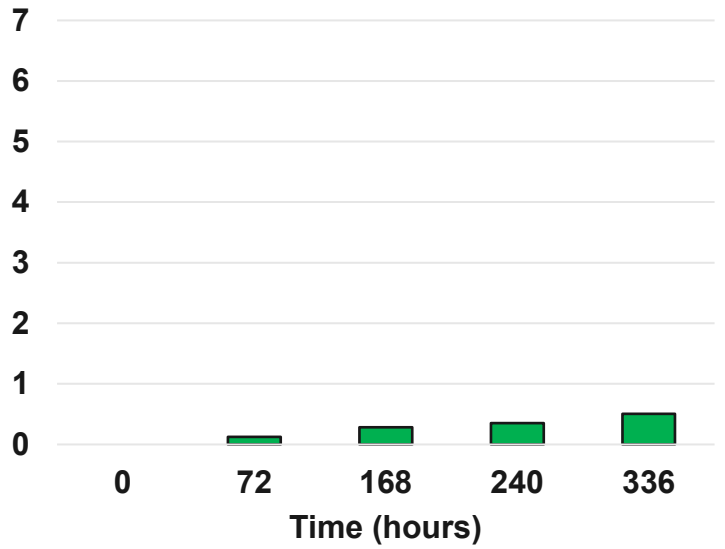
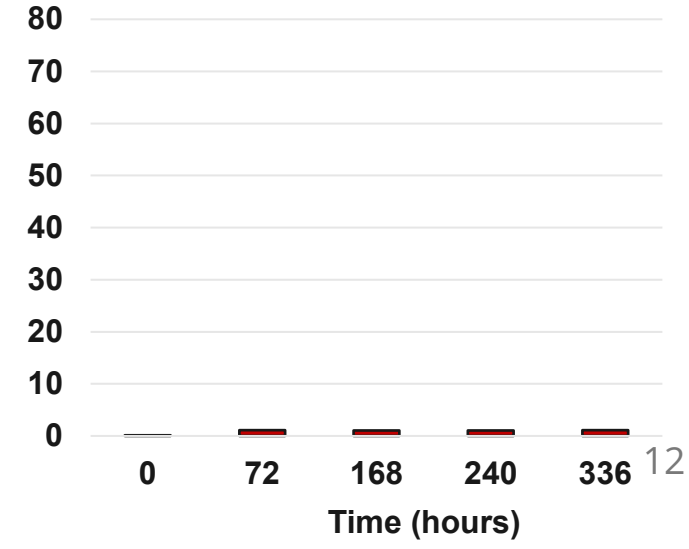
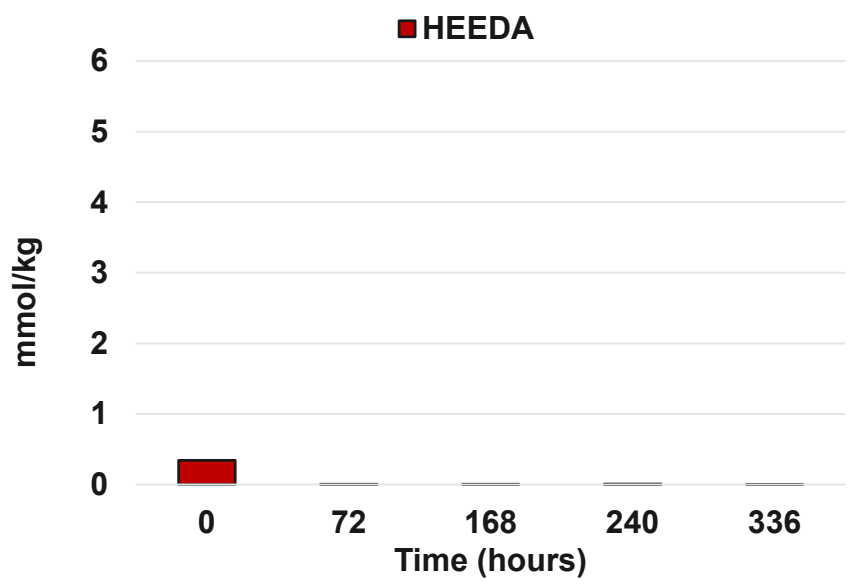


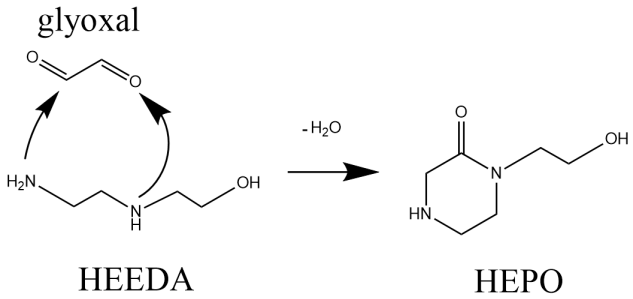




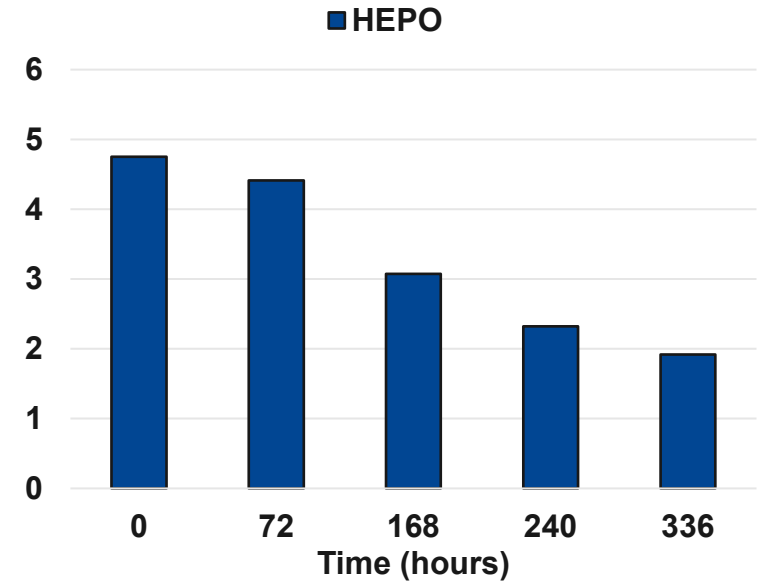
Consumption of thermal degradation products

No KI

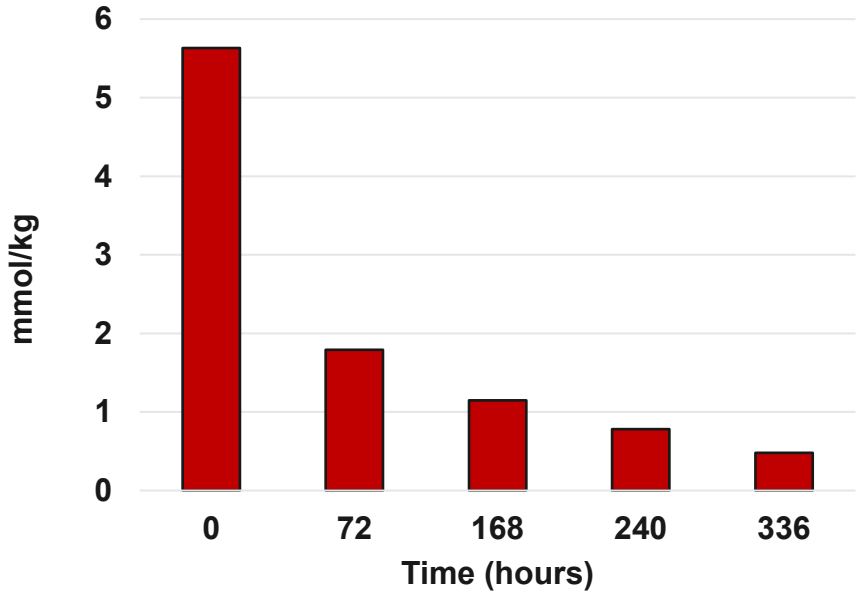


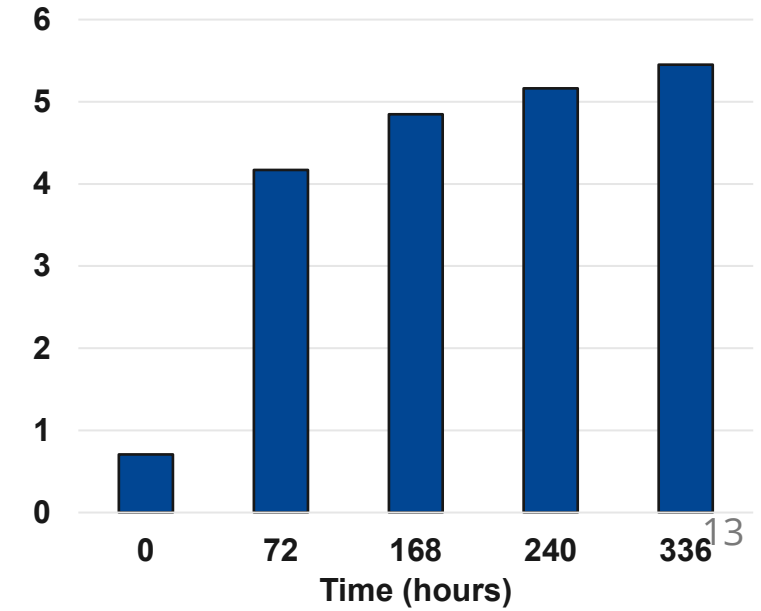


Gouedard (2014)

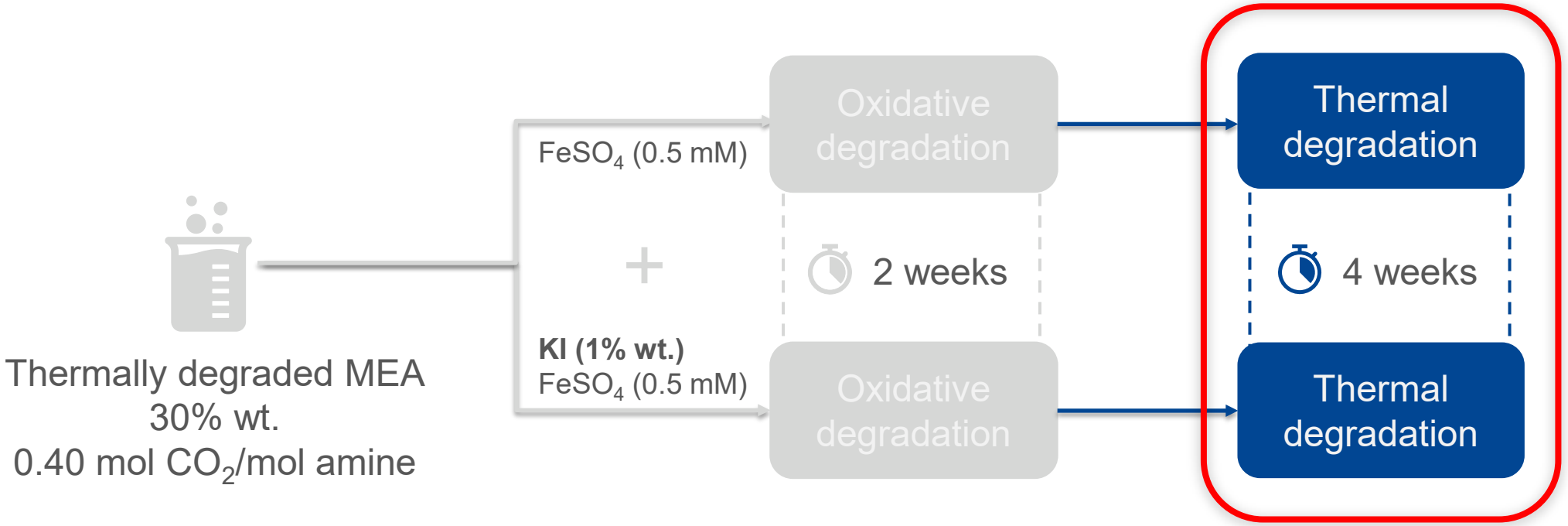


1% KI

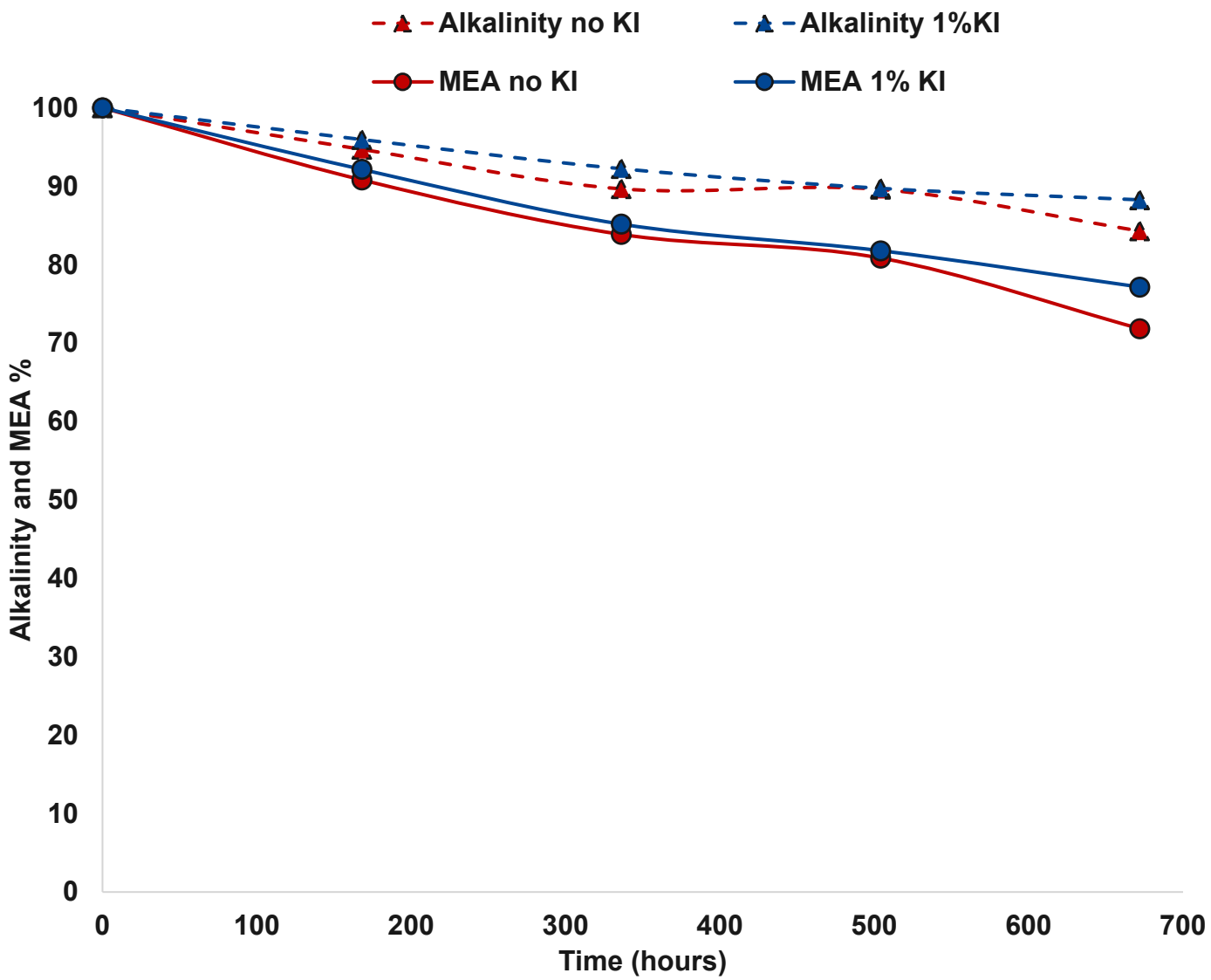




Thermal degradation results



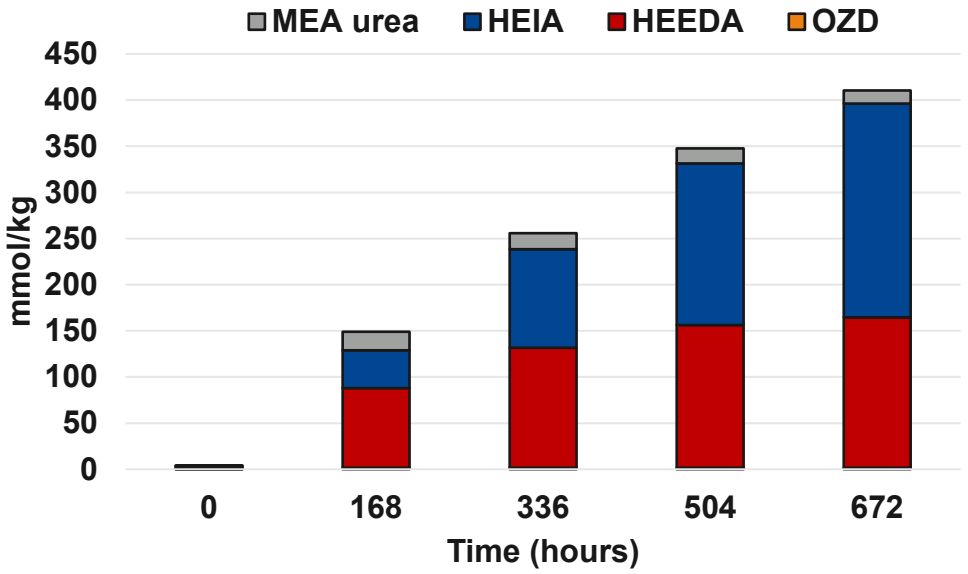
Thermal degradation - Alkalinity and MEA concentration



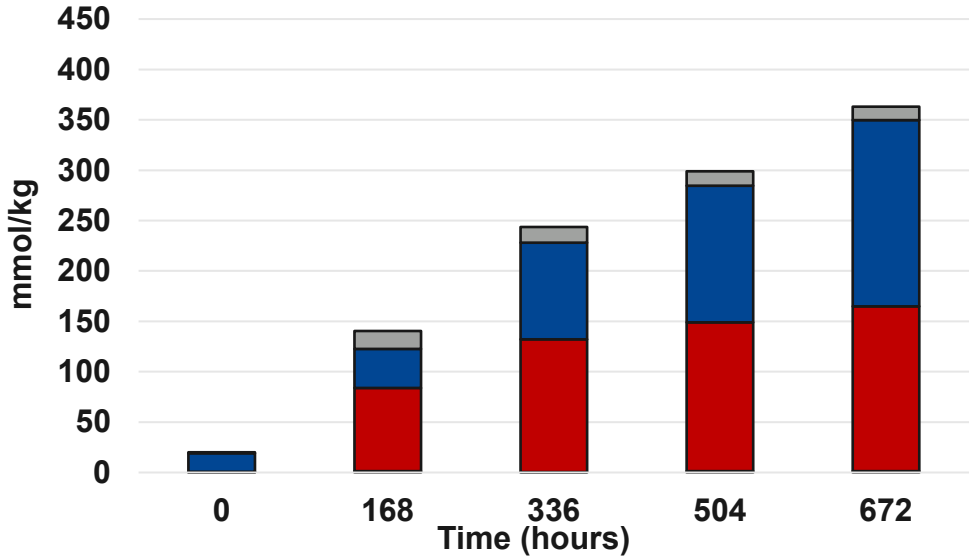
KI does not significantly impact MEA loss to thermal degradation

Does KI affect thermal degradation of MEA?

No KI



1% KI



KI does not significantly alter thermal degradation compound formation.

Conclusions and future work

- Thermal degradation compounds do not impact the performance of KI at absorber conditions.
- KI does not have any noticeable impact on thermal degradation of MEA.
- HEEDA seems to rapidly react to form HEPO in the presence of oxidation products. This reaction is significantly slowed down by KI.
- Future experiments will focus on evaluating KI's performance in AMP-PZ solutions.

Acknowledgements

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Thank you for your attention!

georgios.oikonomou@ntnu.no