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A Study of Oxidative Degradation of AMP for Post-combustion CO_2 Capture

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June 15, 2011- Trondheim

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Outline

- Introduction
- Experimental Conditions
- Results
- Conclusion

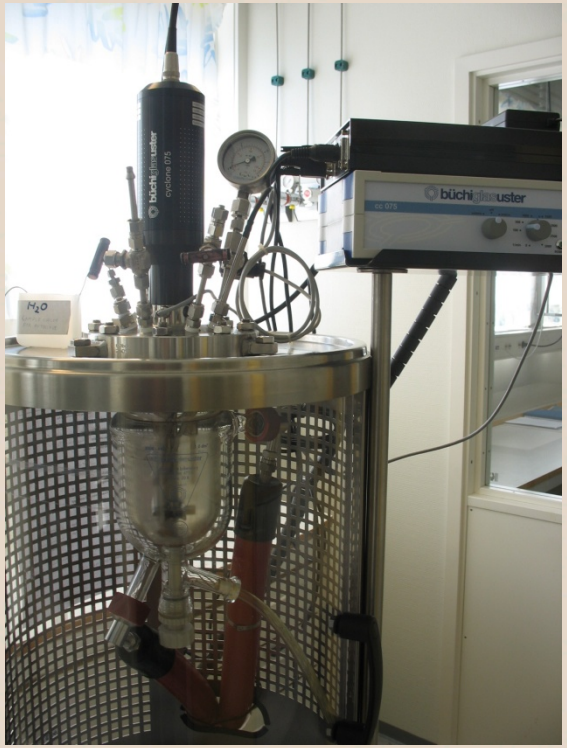
Introduction

- Background
  - The oxidative degradation mechanism of amines is unclear, even for the benchmark molecule MEA
  - 2-amino-2-methyl-1-propanol (AMP) is claimed to offer advantages over the traditional amines
- Scope of the study
  - Identification and quantification of the main degradation products
  - Evaluation of the effects of the main operating parameters
  - Proposition of the possible degradation pathways

Experimental Conditions

- Remaining AMP quantification
  - Cation chromatography
- Degradation products identification/quantification
  - Anion chromatography
  - Gas chromatography-Mass spectrometry (GC-MS)
  - Fourier transform infrared spectroscopy (FT-IR)

Experimental Conditions



Our Experimental Conditions
3-5mol/kg
100-140℃ (50-70℃)
2.5-3.5 bar O_2 (atmospheric pressure air)
glass batch reactor

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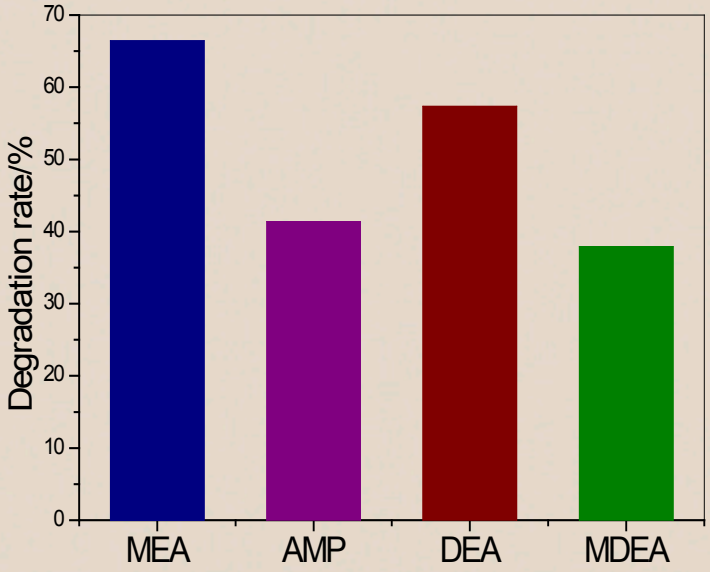
Comparison of degradation rates



5mol/kg amines degraded 16days at 120°C with 350kPa O_2

Degra. Rate = (C_0-C)/C_0

The oxidative degradation rate of AMP was less than that of MEA, but was close to that of MDEA under our experimental conditions.

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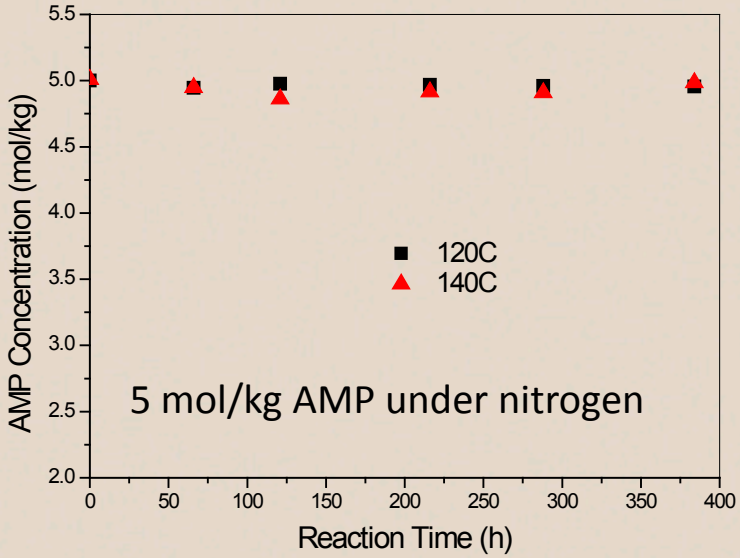
Thermal degradation



The effect of thermal degradation of AMP is negligible (at least, <140℃).

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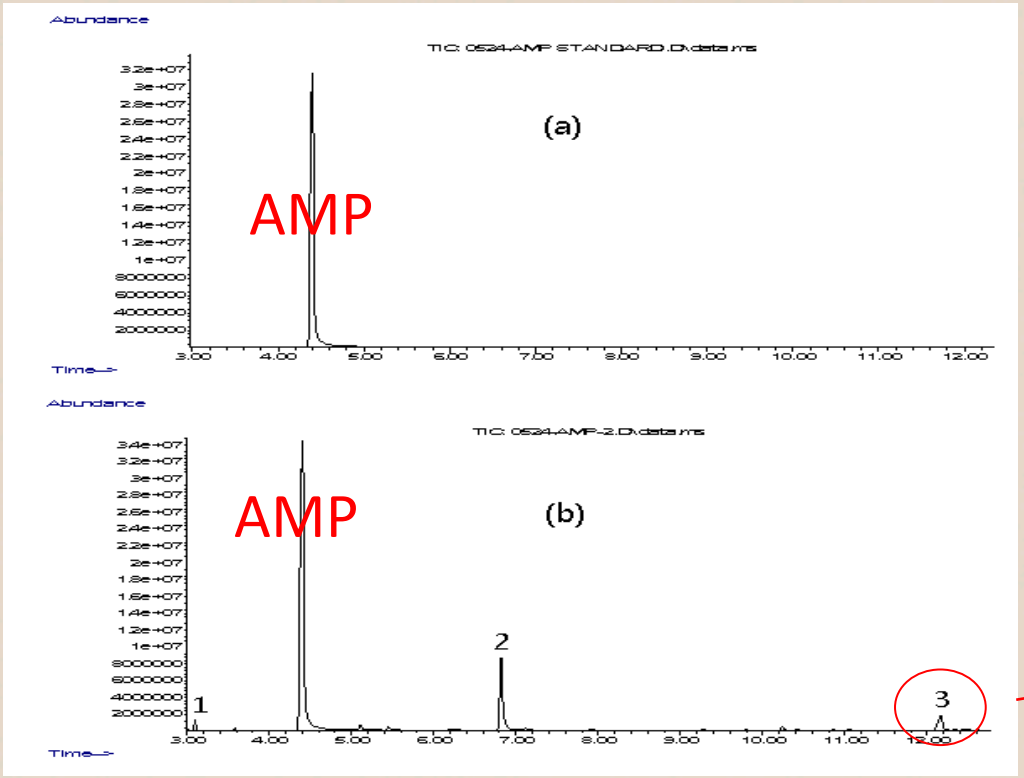
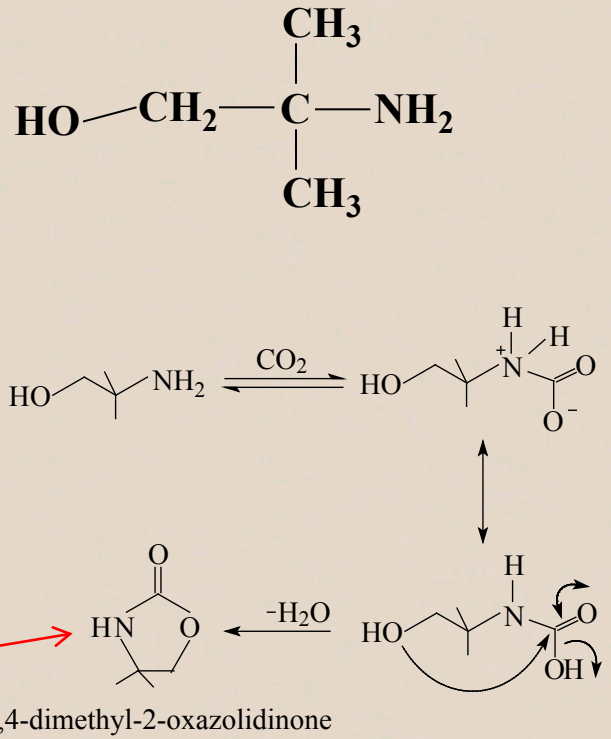
Formation of oxazolidinone





4,4-dimethyl-2-oxazolidinone

(a) Gas Chromatogram of AMP aqueous solution at the beginning of the experiment (0h) using 5mol/kg AMP at 120°C with 250kPa O_2. (b) Chromatogram of a partially degraded AMP aqueous solution at the end of the experiment (384h).

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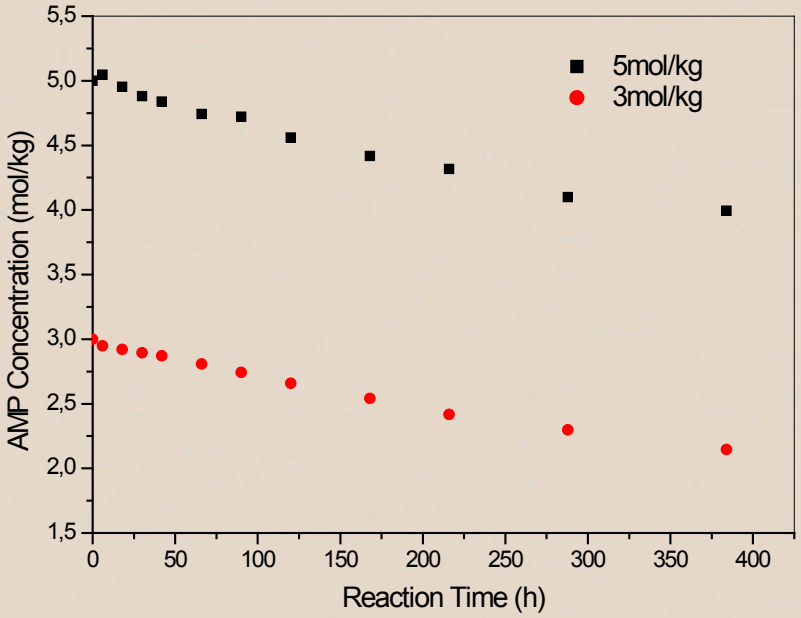
The Effect of Initial Concentration



AMP degraded under 250kPa O_2 and 120°C

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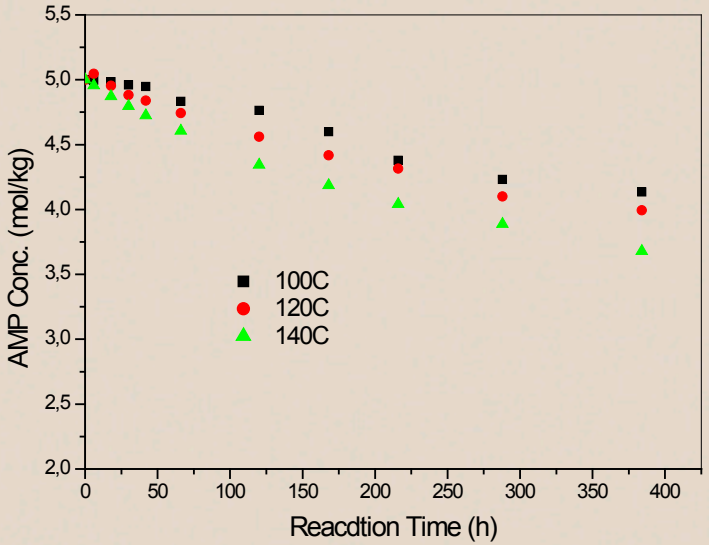
70°C

The Effect of Temperature



5mol/kg AMP degraded with 250kPa O_2

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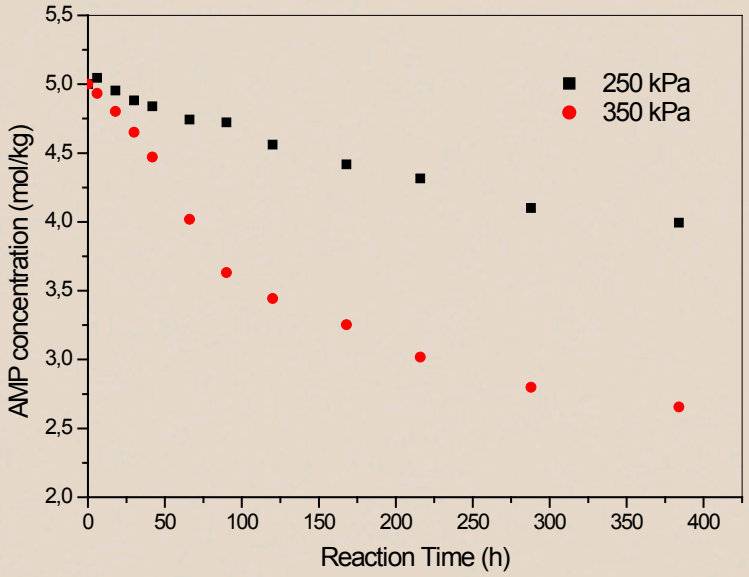
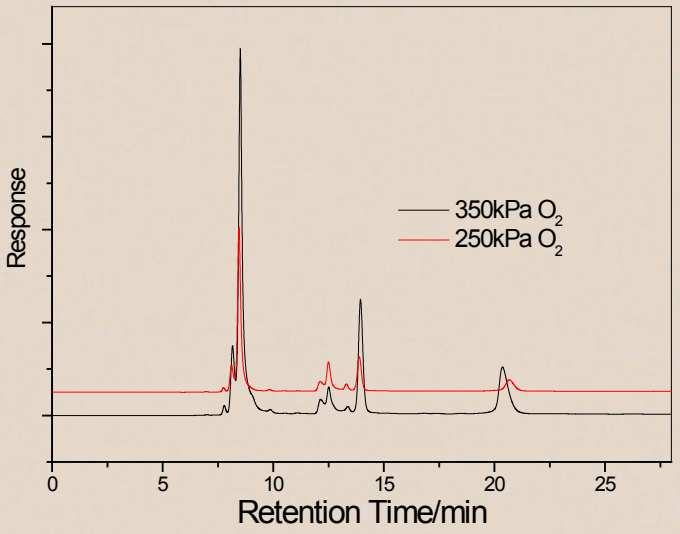
The Effect of O_2 Pressure



5mol/kg AMP degraded under O_2 at 120°C



Corresponding anion chromatograms

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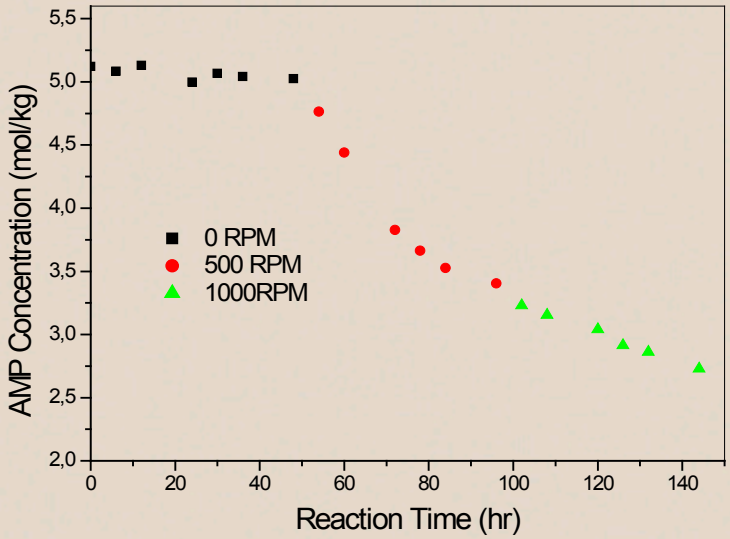
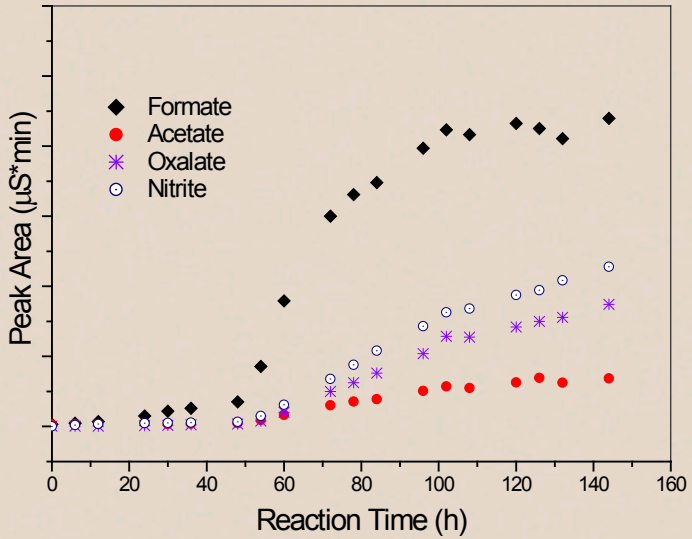
The Effect of Agitation Rate

O_2(gas) ⟶ O_2(Liquid) ⟶ (React with AMP…)

O_2 mass transfer limited?



5mol/kg AMP degraded at 120°C and 250kPa O_2



Corresponding results of anions determination

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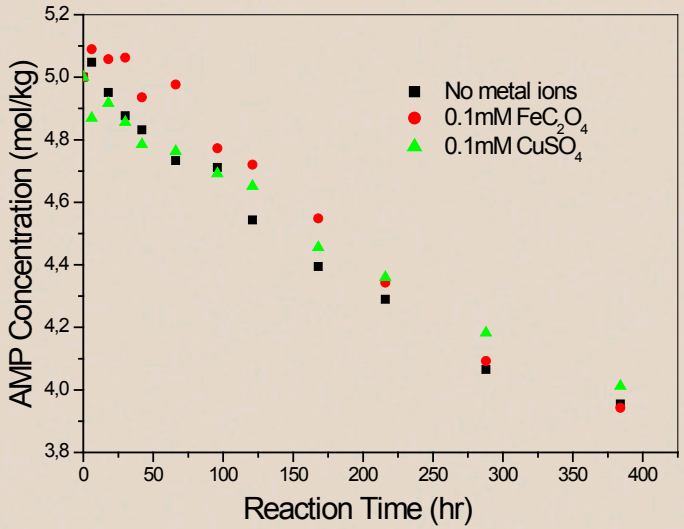
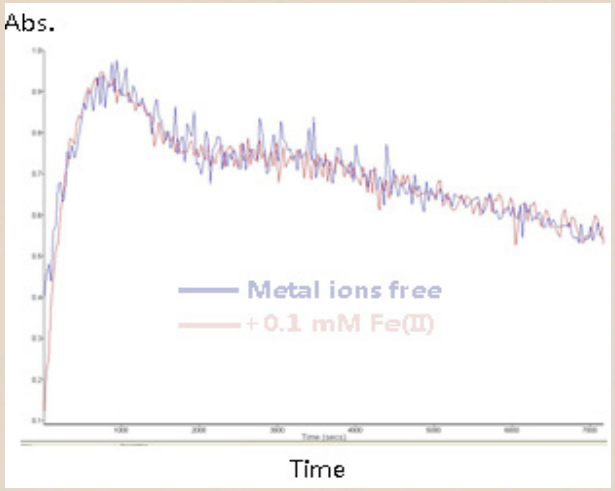
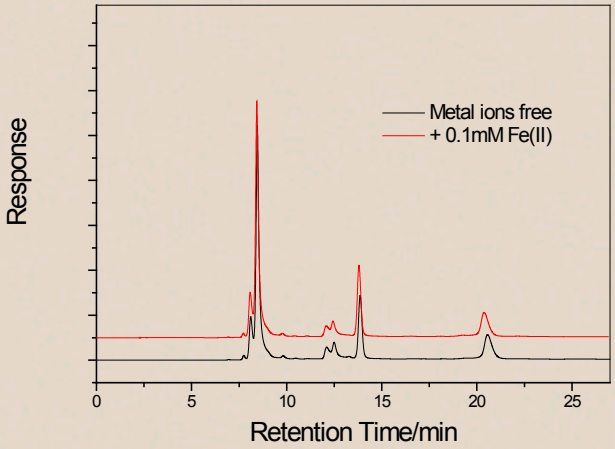
The Effects of Metal Ions



5mol/kg AMP degraded at 120°C and 250kPa O_2



5mol/kg AMP degraded by bubbling air at 50°C (0.5Ln/min)



Anion chromatograms

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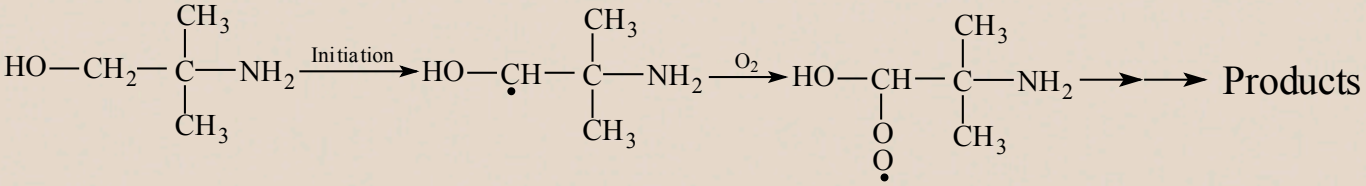
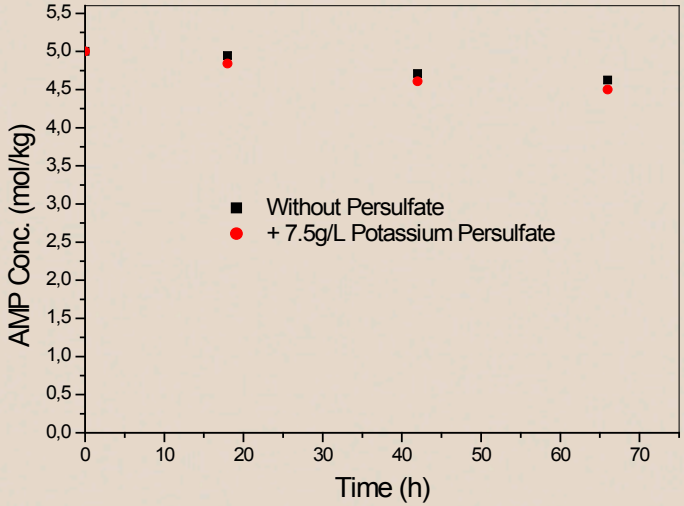
The Effect of Radical Initiator





5mol/kg AMP degraded at 120°C and 250kPa O_2

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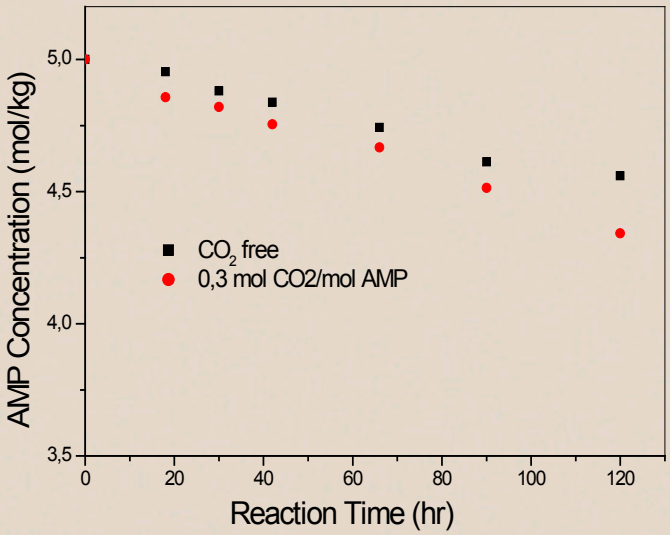
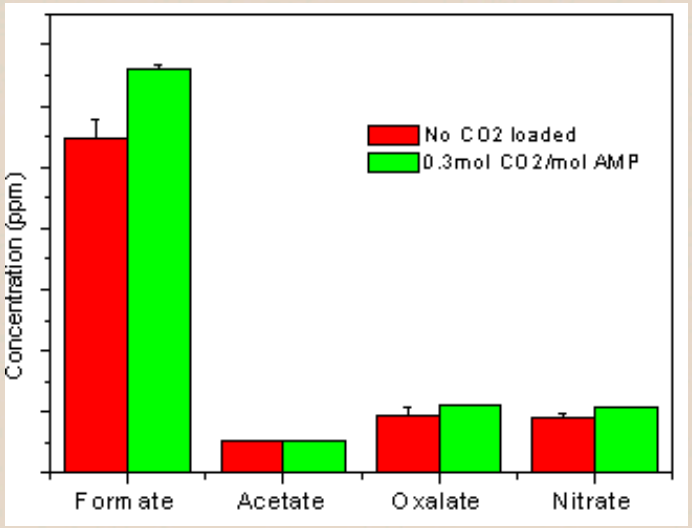
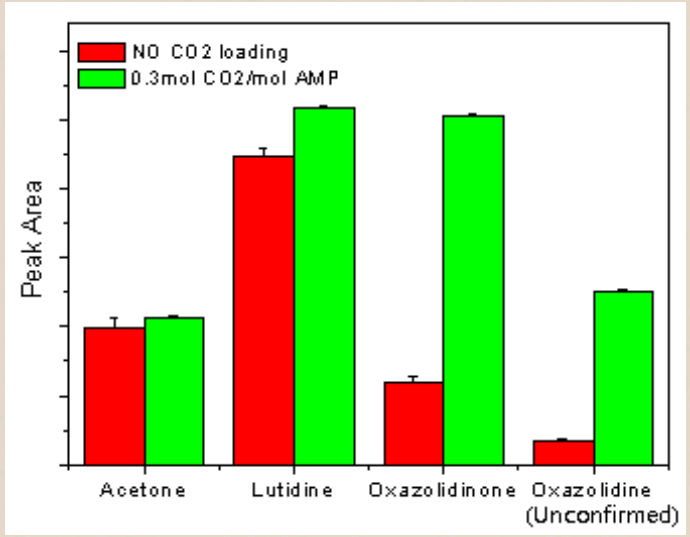
The Effect of CO_2 Loading



5mol/kg AMP degraded at 120°C and 250kPa O_2





Conclusion

- AMP is not stable and the steric hindrance does not prevent oxazolidinone formation.
- The degradation of AMP is O_2 mass transfer limited under the experimental conditions.
  - Degradation rates strongly depended on O_2 pressure.
  - Degradation rates increased dramatically with increasing agitation rate.
  - Transition metal ions and free radical initiator have no obvious effects on the oxidative degradation rate.
- Degradation rates apparently increase with CO_2 loading.

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Thank you!