Corrosion of pipeline materials due to impurities in separated CO_2 from fossil fuelled power plants

Institute of Energy Systems

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- **Purity of separated CO_2 varies depending on the separation technology**
  - Oxyfuel and Post-Combustion Capture → oxidizing CO_2-compositions
  - Pre-Combustion Capture → reducing CO_2-compositions
- **Some impurities in the separated CO_2 can cause severe corrosion → purification may be required**
- **Higher purification correlates with higher expenditure of energy and/or capital**
- **Investigations are performed within the COORAL research project:**
  - Overall objective: Define the required CO_2 purity for capture and storage (covering the whole chain from power plant to storage site)
  - Sub-objective: Determine the maximum permissible concentrations of impurities in the separated CO_2 stream for pipeline and compressor materials

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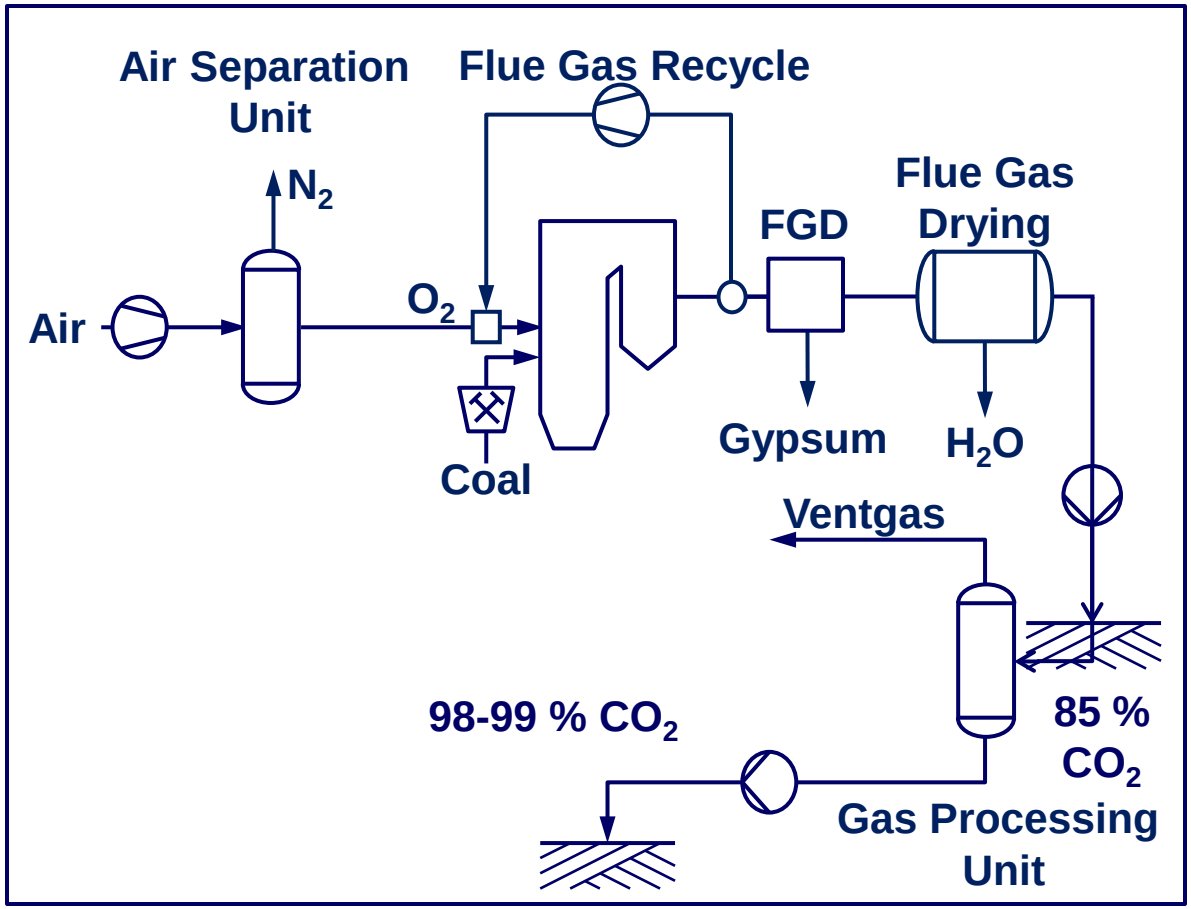
- **Definition of different cases with varying gas compositions for experiments depending on the separation technology**
- **Three cases for Oxyfuel**
  - „Zero Emission“ (ZE)
  - „Purification“ (Partial condensation)
  - “Rectification” (Partial condensation + Destillation)



Gas Compositions for the Corrosion Experiments

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Component	Zero Emission	Purification	Rectification
CO_2	Rest	Rest	Rest
N_2	5,8 Vol.-%	0,71 Vol.-%	100 ppmv
O_2	4,7 Vol.-%	0,67 Vol.-%	100 ppmv
Ar	4,5 Vol.-%	0,59 Vol.-%	100 ppmv
H_2O	0-1000 ppmv	100 ppmv*	100 ppmv*
$NO+NO_2$	100 ppmv	100 ppmv	100 ppmv
SO_2+SO_3	70 ppmv	70 ppmv	70 ppmv
CO	50 ppmv	50 ppmv	50 ppmv

* Water content is limited to a maximum of 50–100 ppmv due to the low temperature of the purification process.

Experimental Setup

- **Test rig**
  - 2 Hastelloy autoclaves (1l)
  - 1 Autoclave (290 ml) with window
  - 1 Syringe pump
  - 1 Thermostat
- **Experimental conditions**
  - Pressure: 110 bar
  - Temperature: 60 °C
  - Duration: 1 Week
- **Materials**
  - L360NB (1.0582)
  - L485MB (1.8977)

Results I

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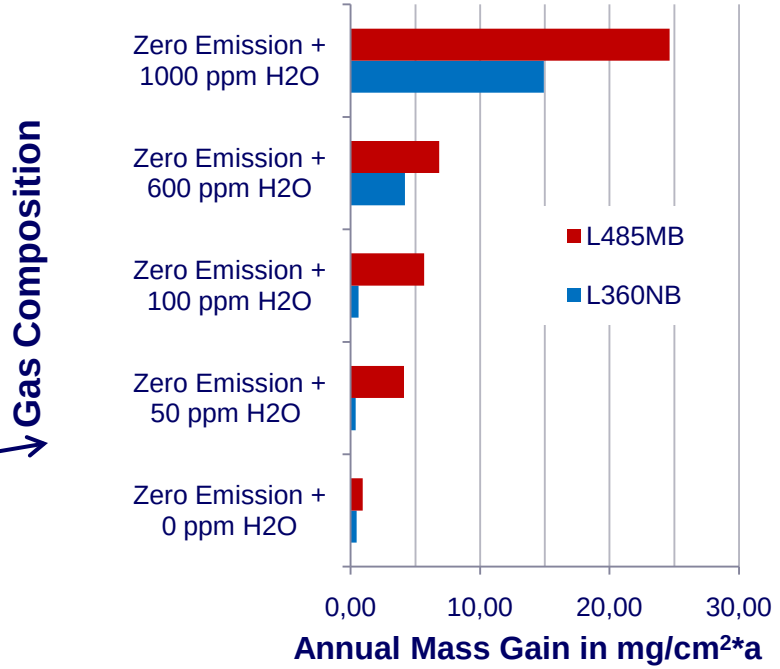
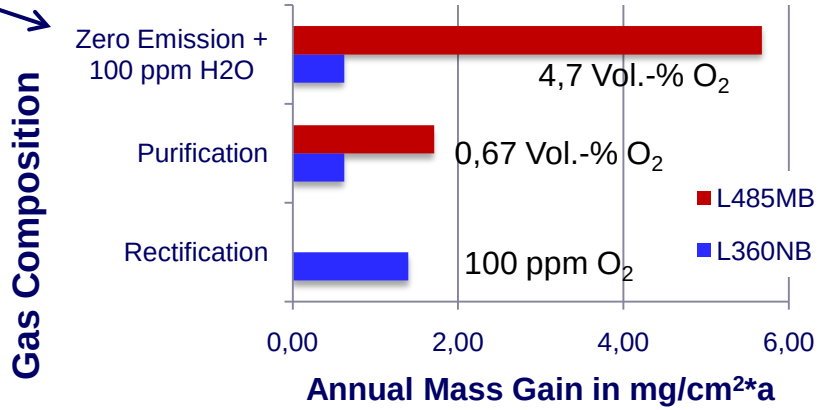
- **Overall mass gain is low**
  - Low corrosion rates
  - Significantly lower when reducing H_2O from 1000 to 600 ppm
- **Most influencing parameters**
  - Water content
  - Oxygen content
- **The same trend for L360NB and L485MB**
  - L360NB outperforms L485MB
  - Both materials seem suitable for the use in CCS pipelines





Results II

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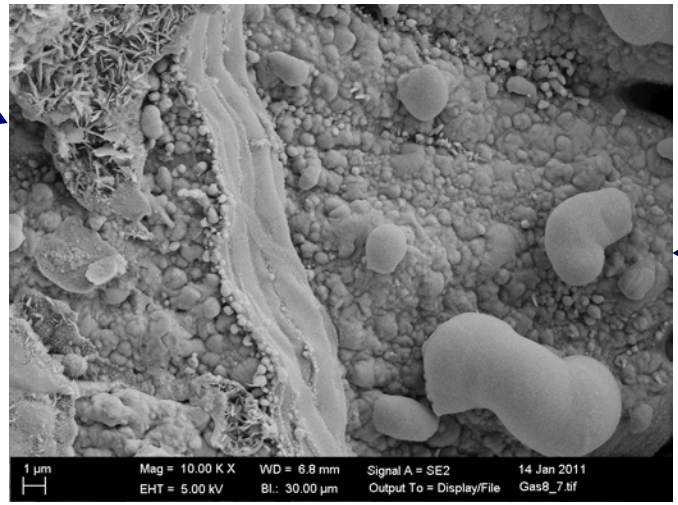
- **Oxide analysis with XRD**
  - Mixture of amorphous and crystalline species
  - Only oxide being identified: α-FeOOH (Goethite)
- **Oxide analysis with SEM-EDX**
  - Primarily: Fe, O and little S
  - Traces of: C, N
- **Only uniform corrosion detected**
  - No signs of pitting

0 ppm H_2O 100 ppm H_2O 1000 ppm H_2O

L485MB specimens in „Zero Emission“-composition with varying water content after 1 week



SEM Image of the surface of a corroded L485MB specimen

Influence of different Impurities

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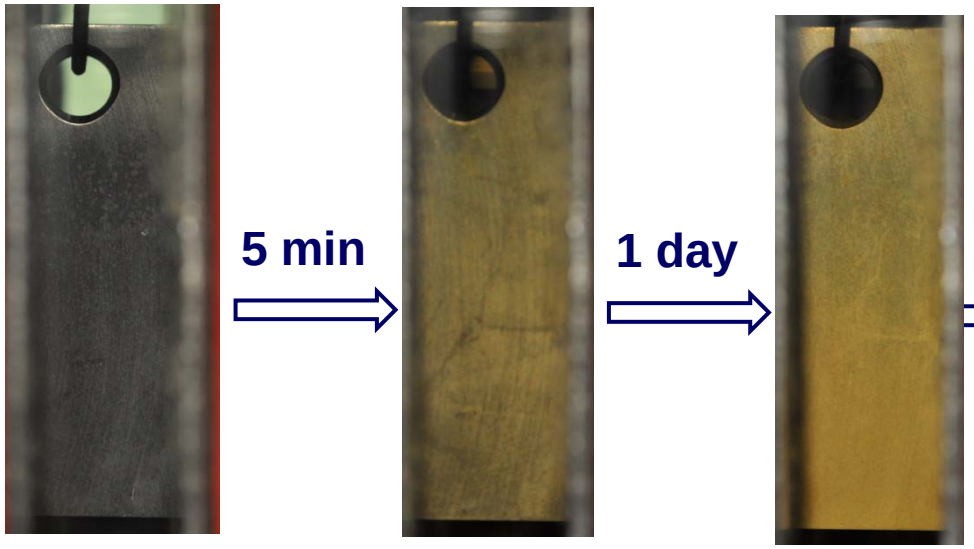
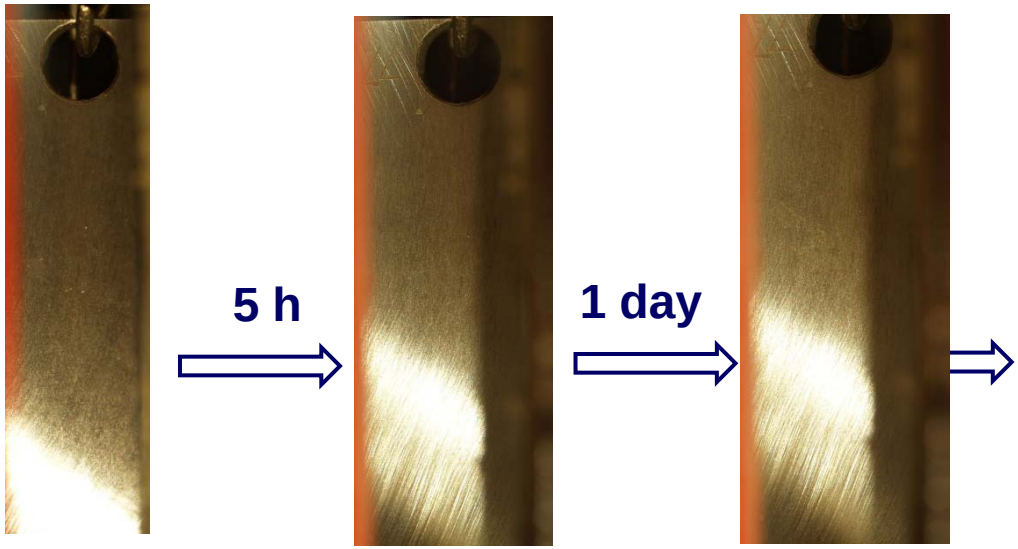
- **Zero Emission + 600 ppm H_2O**



CO_2 + 1000 ppm H_2O + 4,7 Vol.-% O_2



Conclusions

- Either NO or SO_2 was required to initiate corrosion
- Traces of CO have only little or no effect on corrosion
- At least one of the following components should be minimized to reduce corrosion: H_2O, O_2 or acid gas components (SO_x and NO_x)
- Water content should not exceed 600 ppm, 100 ppm or lower is beneficial
- L360NB and L485MB seem to be suitable for transporting impure CO_2 from Oxyfuel processes, whereas L360NB is advantageous

Outlook

- **Investigation of further materials (including compressor materials)**
- **Addition of post and pre combustion capture cases**
  - Corrosion is expected to be lower because impurities are less for both technologies
- **Determination of the influence of fluid flow**
- **Analysis of oxides and corrosion mechanism**

Thank you for your attention!

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