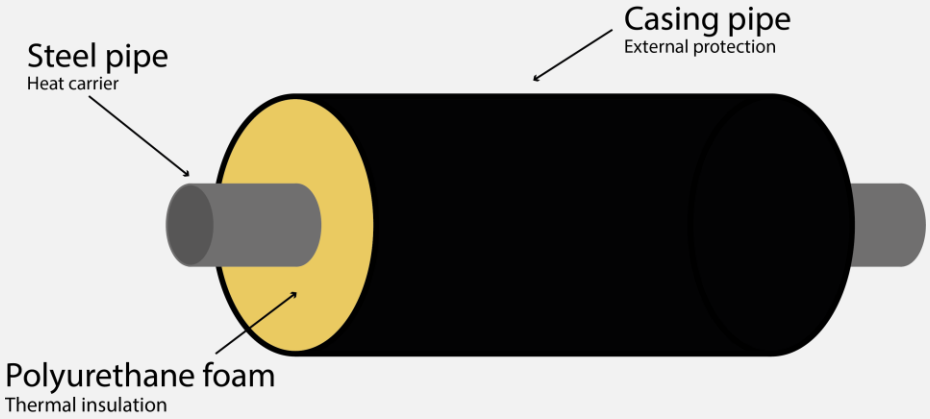
Accelerated ageing of DH pipes – Thermal & mechanical loads

Alberto Vega

RISE Research Institutes of Sweden

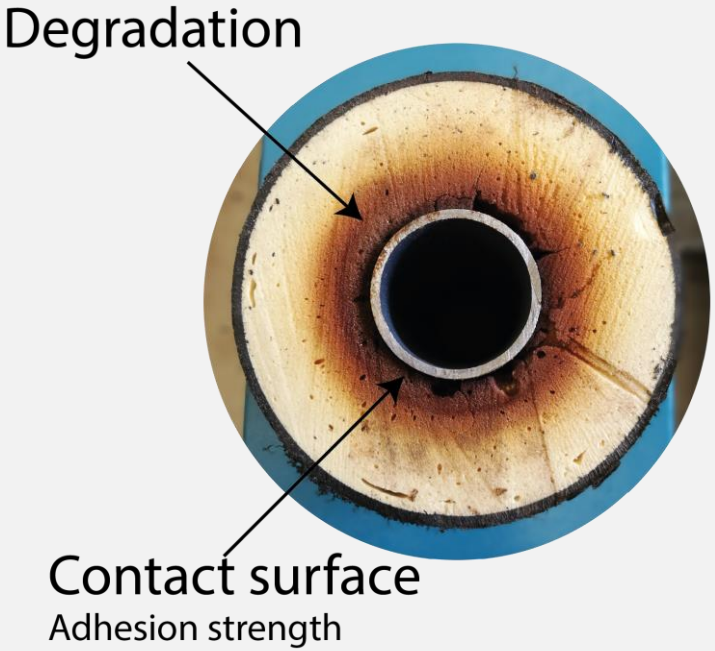
DH pipes

- **Good insulating performance**
- **Withstand mechanical loads**
- **Long-term properties**



DH pipes issues

- **Service life (30 years?)**
- **Decrease in insulating performance**
- **Decrease in mechanical performance**
- **Structural failure**
- **Failures in bending, T-coupling**



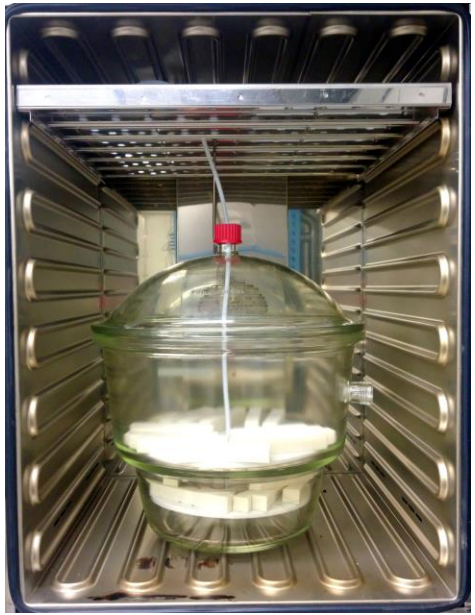
Topics

- Degradation of PUR foam
- Accelerated ageing of DH pipes at elevated temperatures
- Accelerated ageing (Thermal + mechanical loads)
- Natural vs. accelerated ageing

Ageing of PUR

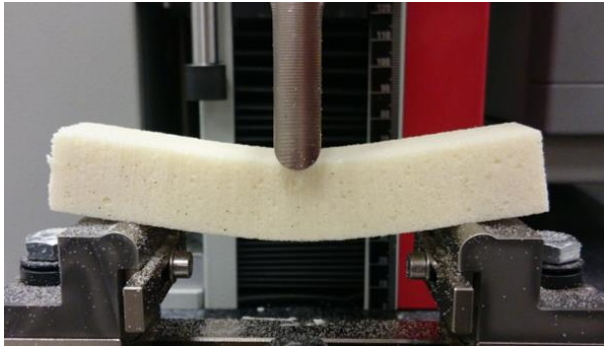
Thermal ageing

150 °C in nitrogen and air

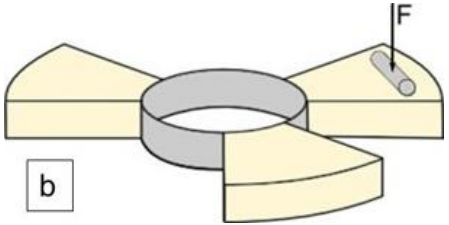


Mechanical properties

Cohesion strength

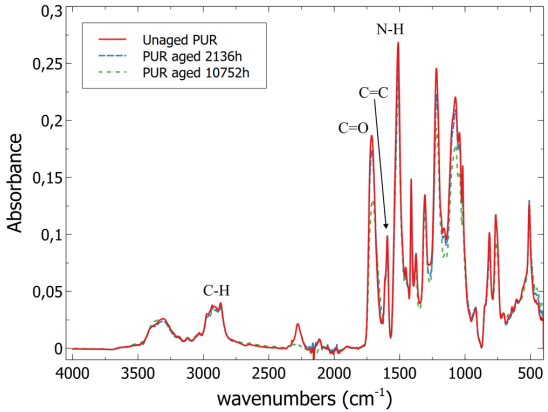


Adhesion strength



Chemical structure

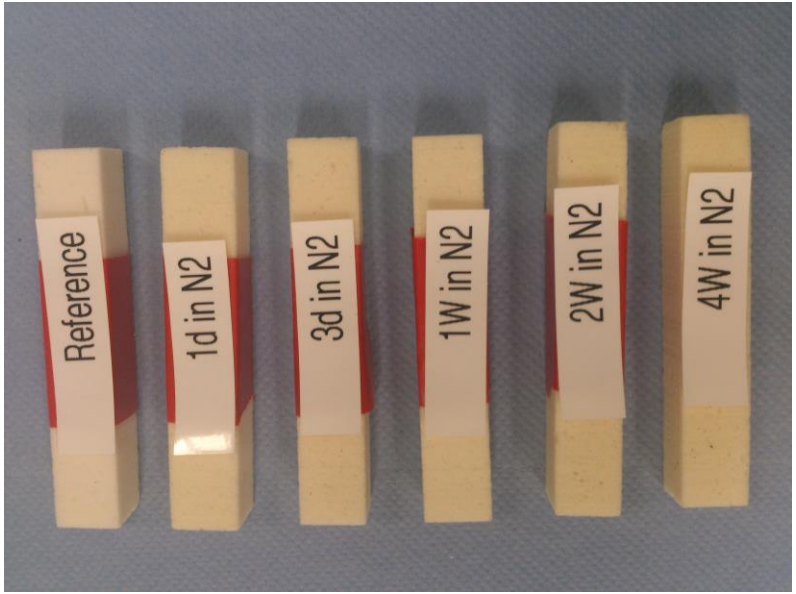
FTIR



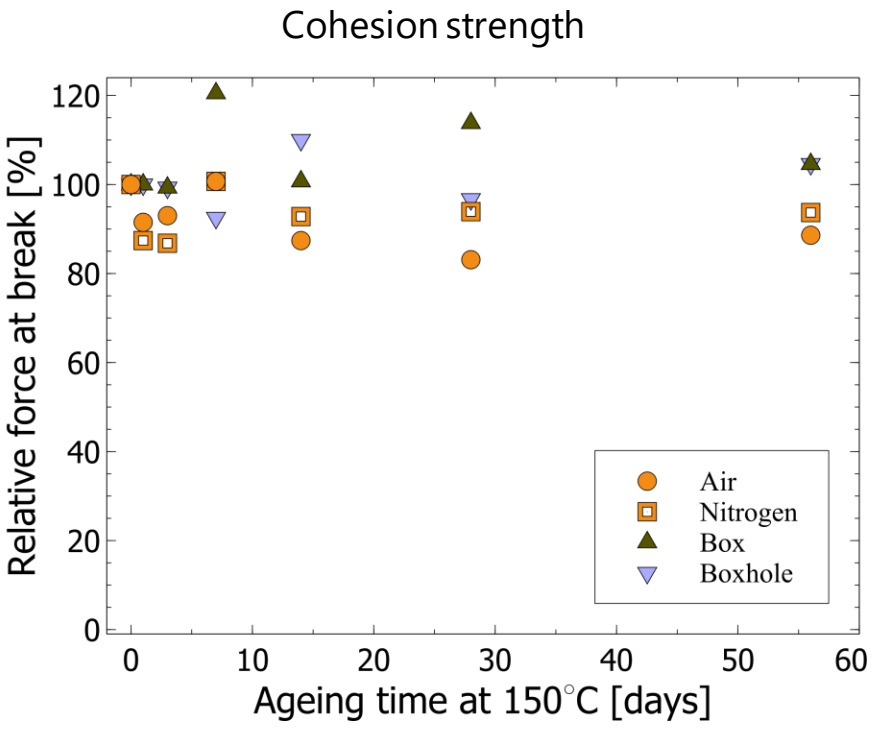
Discoloration

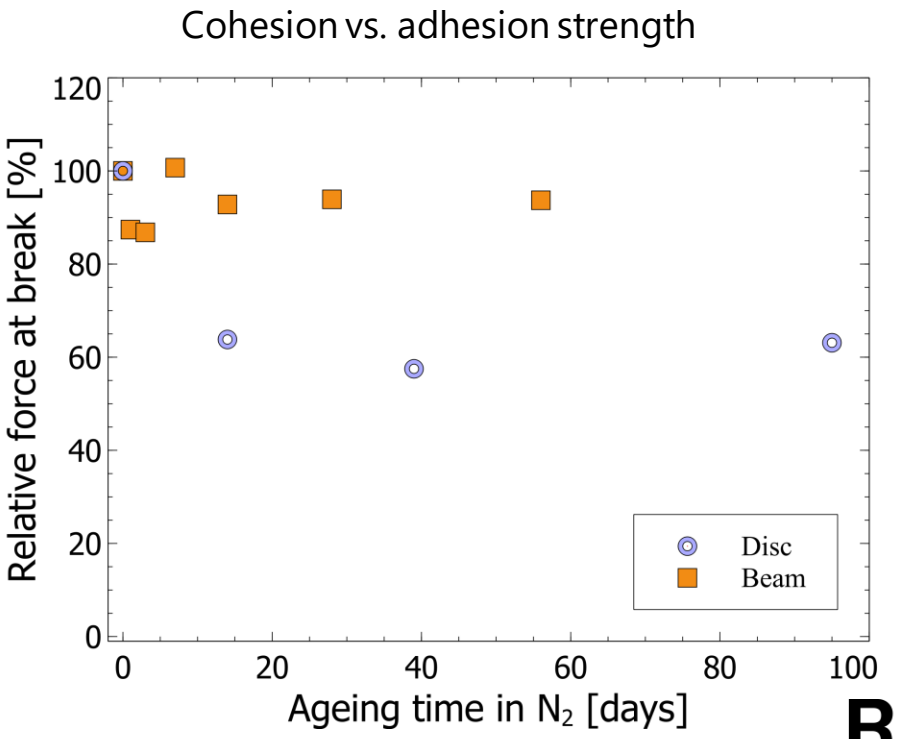
150 °C in air

150 °C in nitrogen

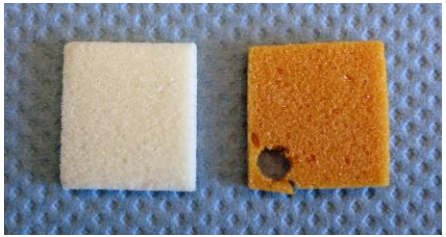


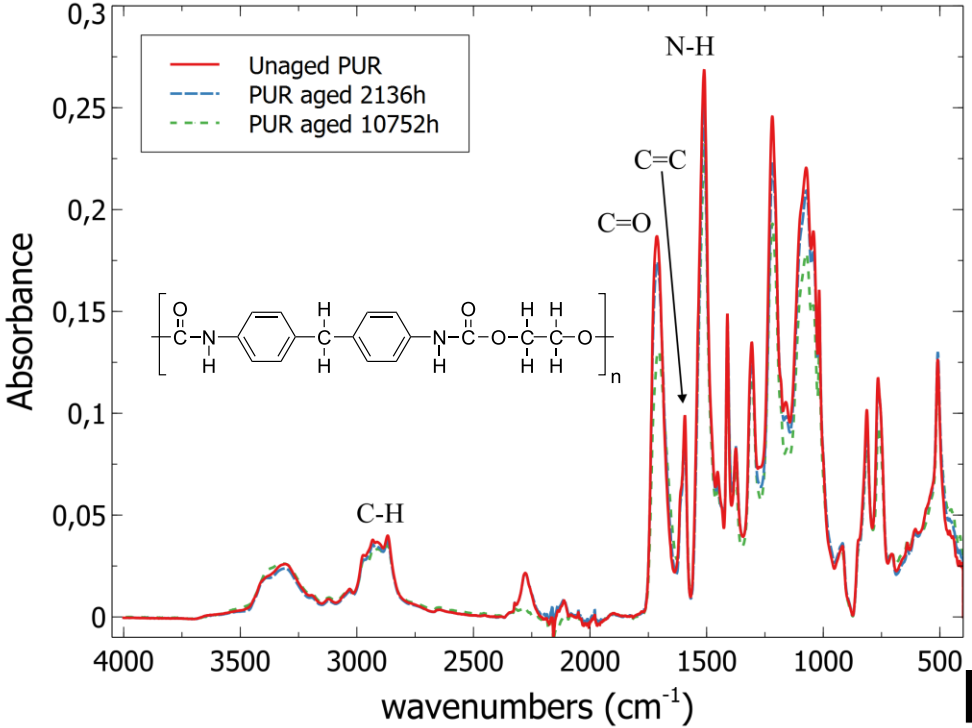
Cohesion vs. adhesion strength



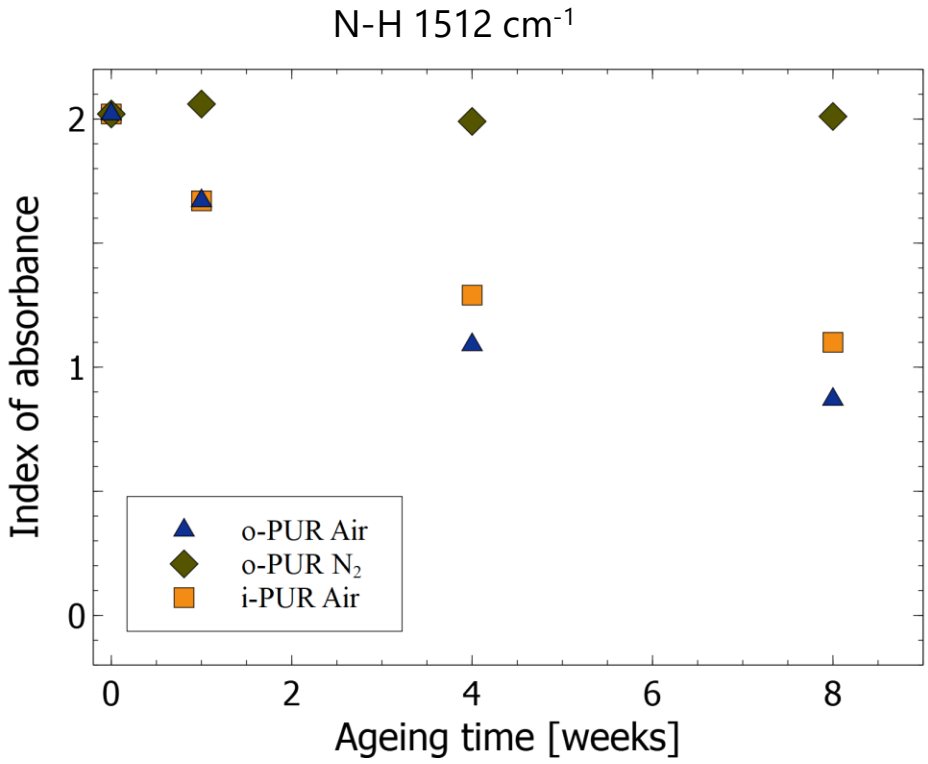


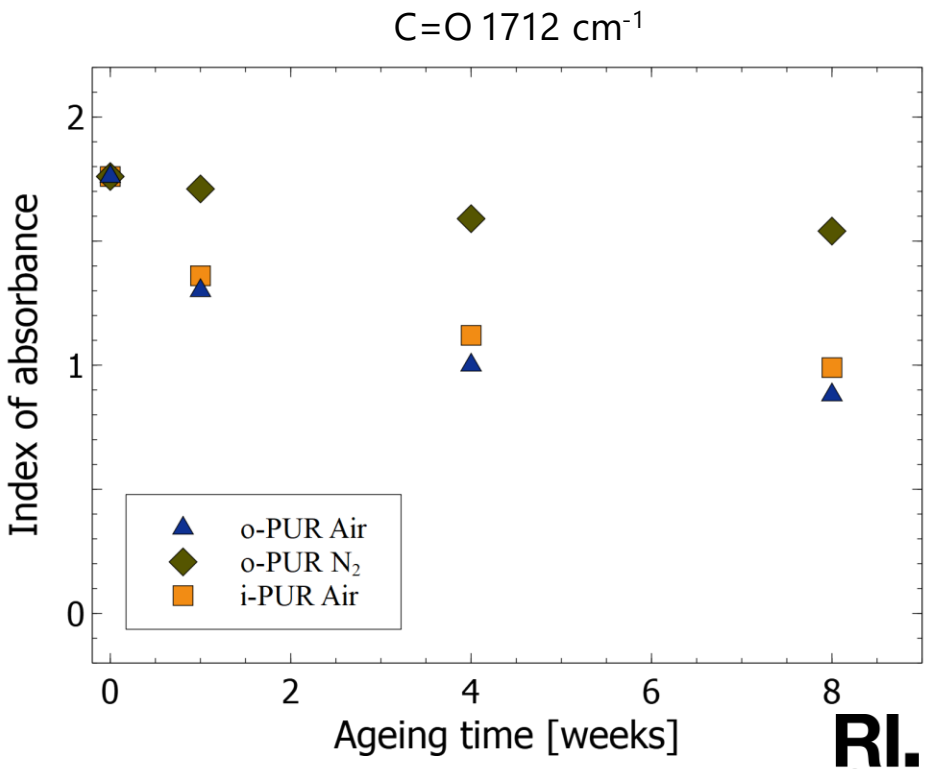
FTIR – Attenuated total reflection mode





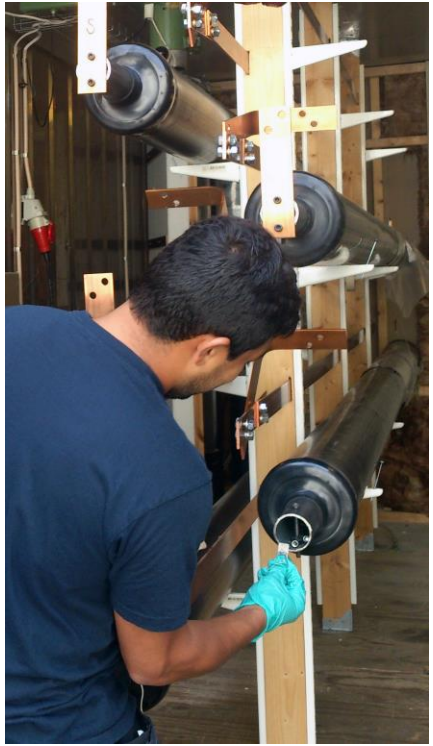
FTIR – Attenuated total reflection mode

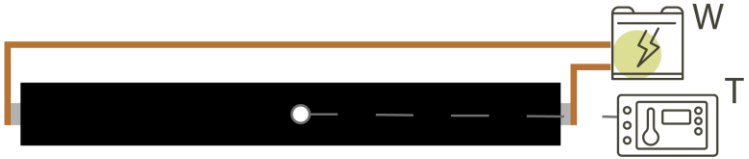




Ageing of PUR in DH pipes

Ageing of DH pipes at elevated temperatures

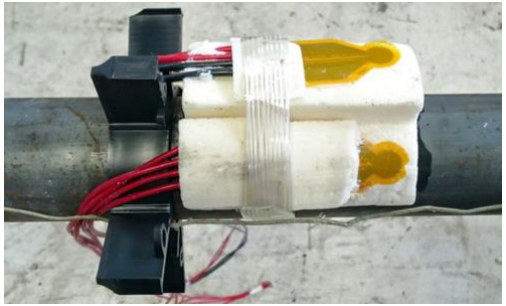


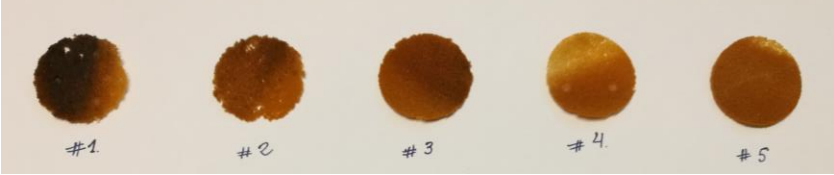


Temp: 130, 150 & 170 °C

Adhesion strength

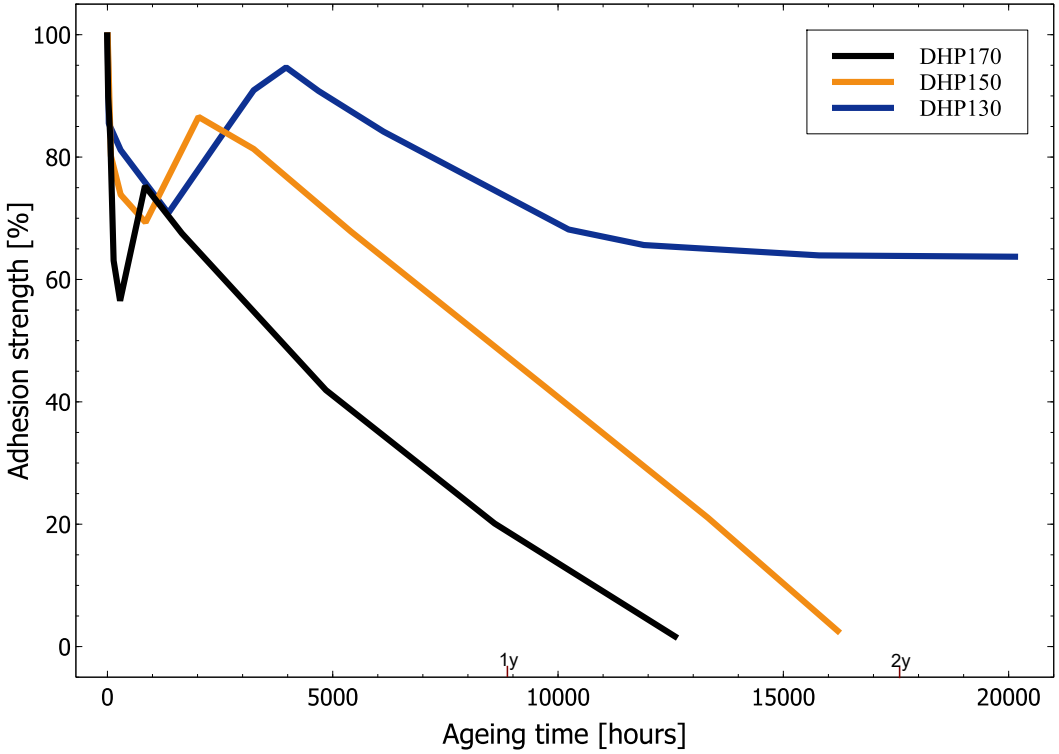
Thermal conductivity



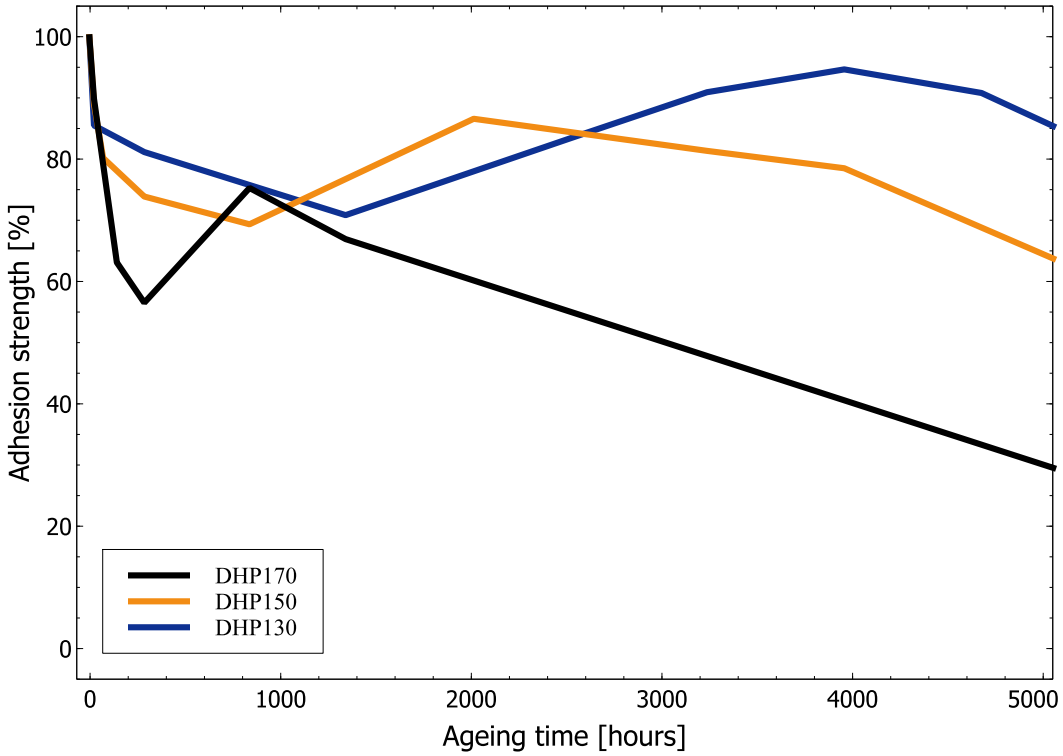


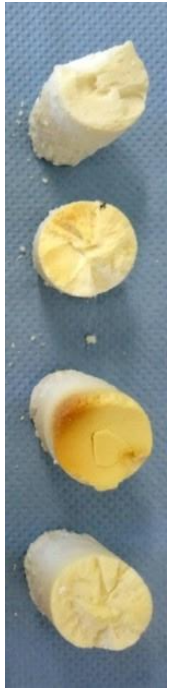
FTIR – chemical structure

Ageing of DH pipes – Adhesion strength

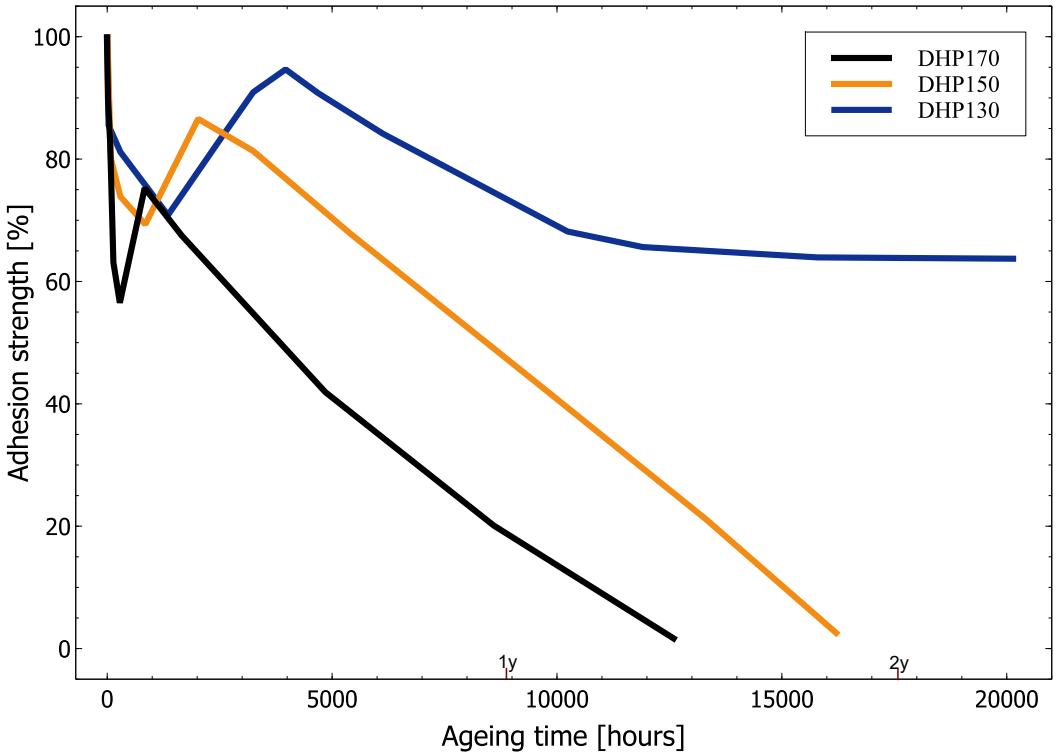


Ageing of DH pipes – Adhesion strength

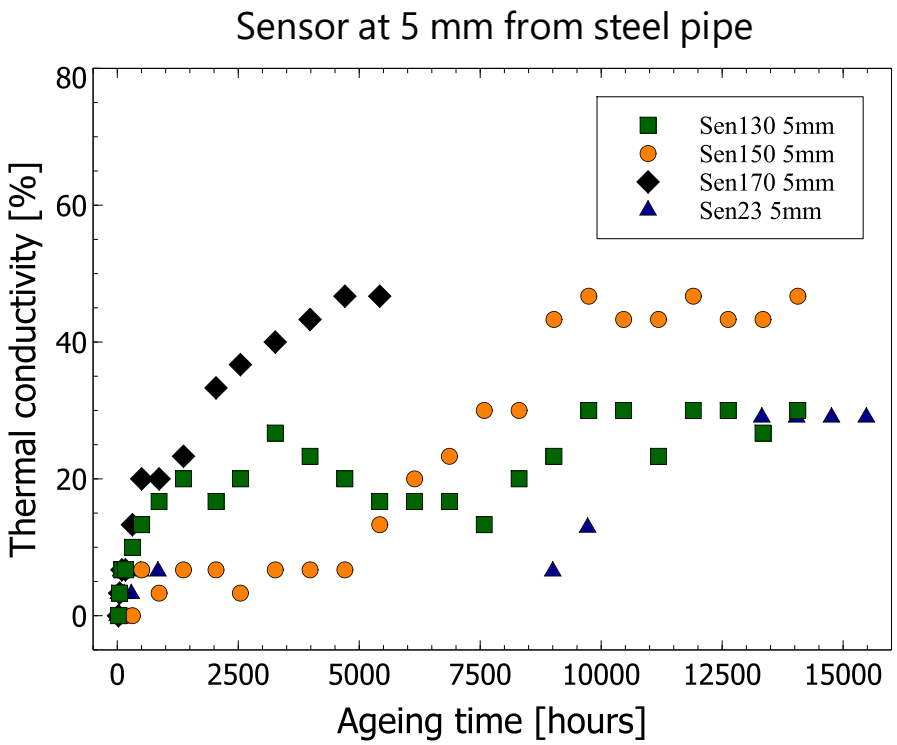


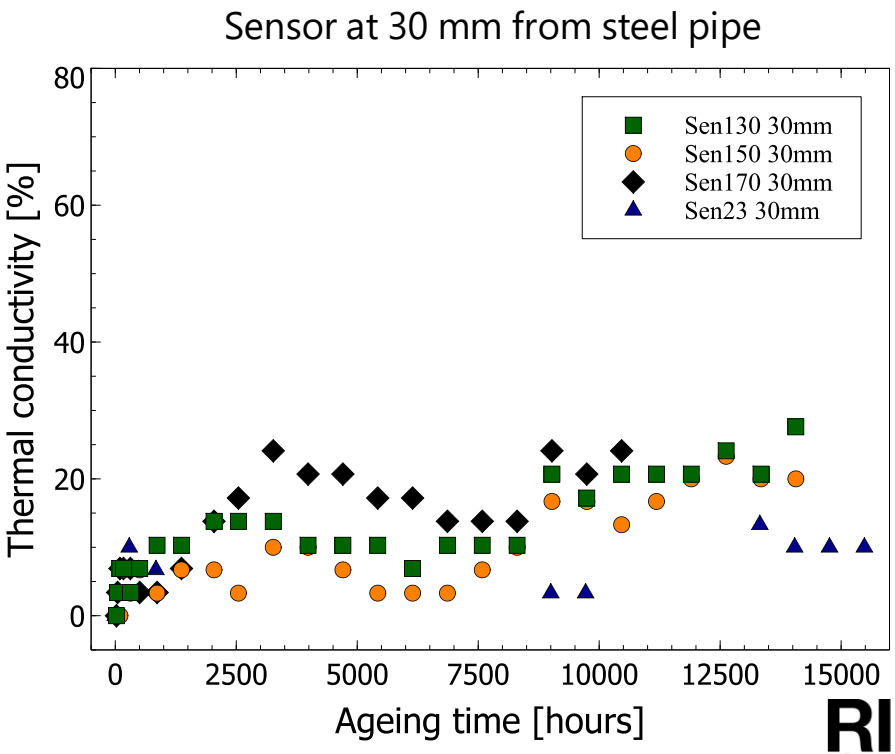


Ageing of DH pipes – Adhesion strength



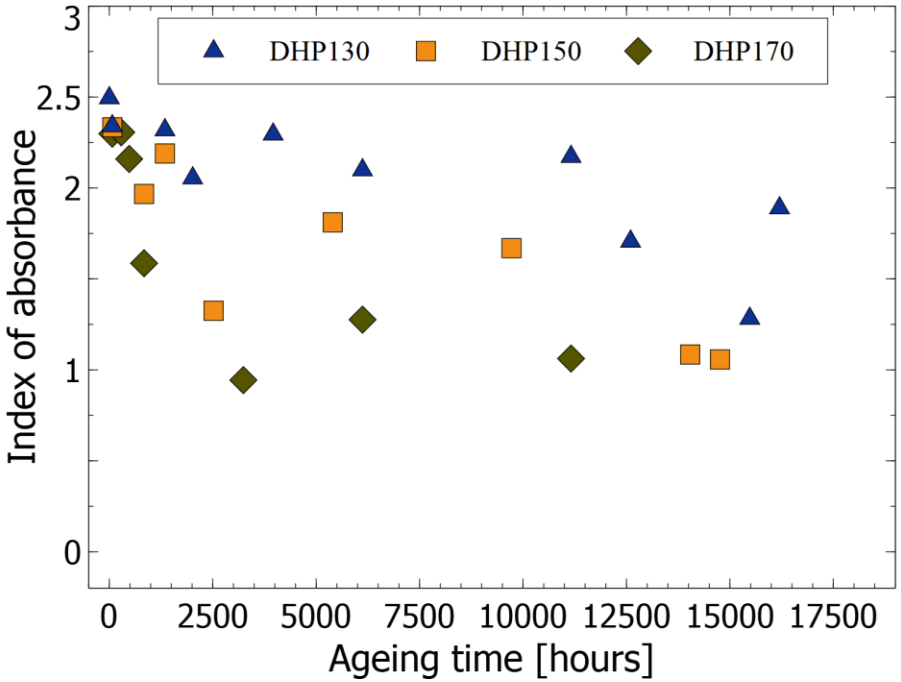
Ageing of DH pipes – Thermal conductivity



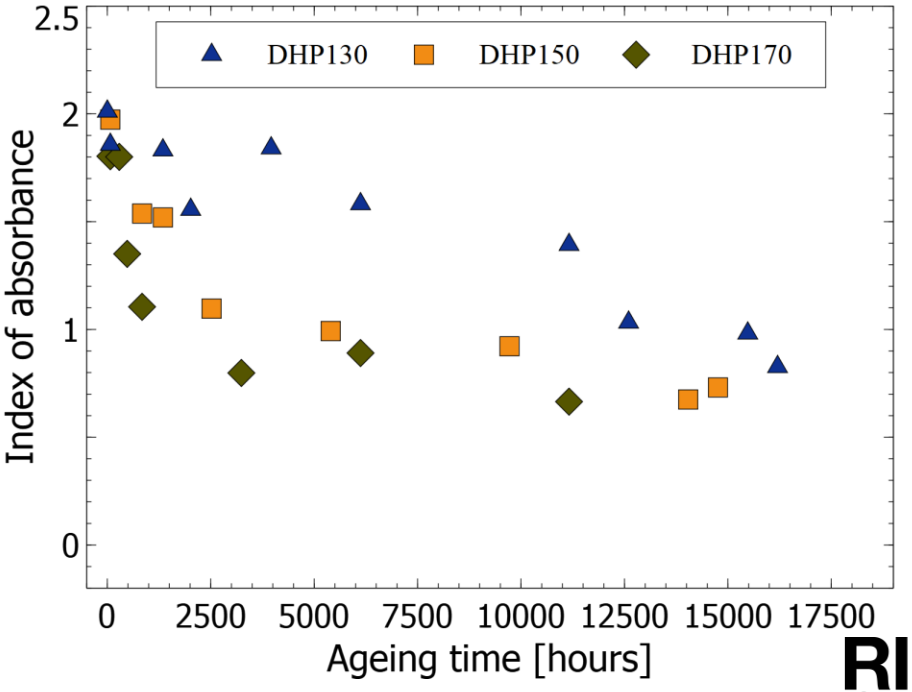


Ageing of DH pipes – FTIR

N-H 1512 cm^{-1}

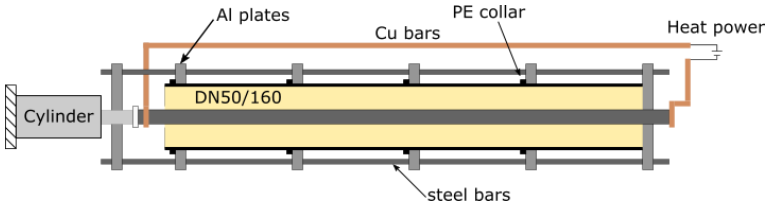


C=O 1712 cm^{-1}

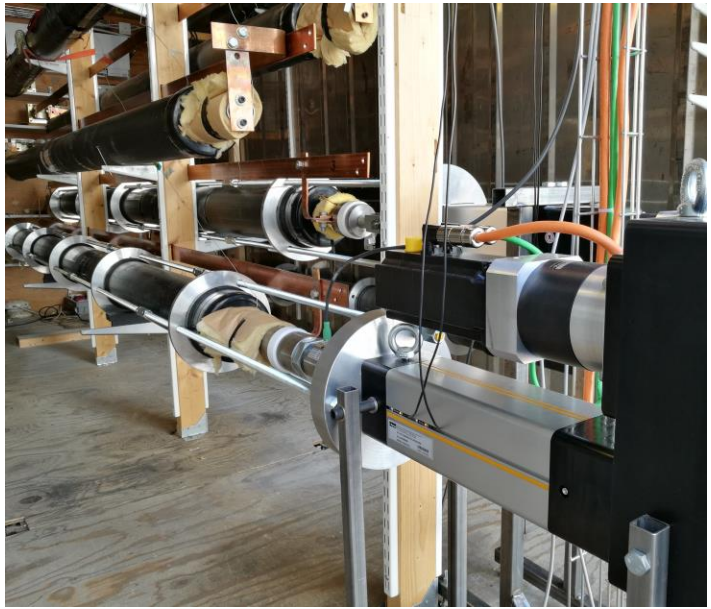


Thermal and mechanical loads

Combination of thermal and mechanical loads

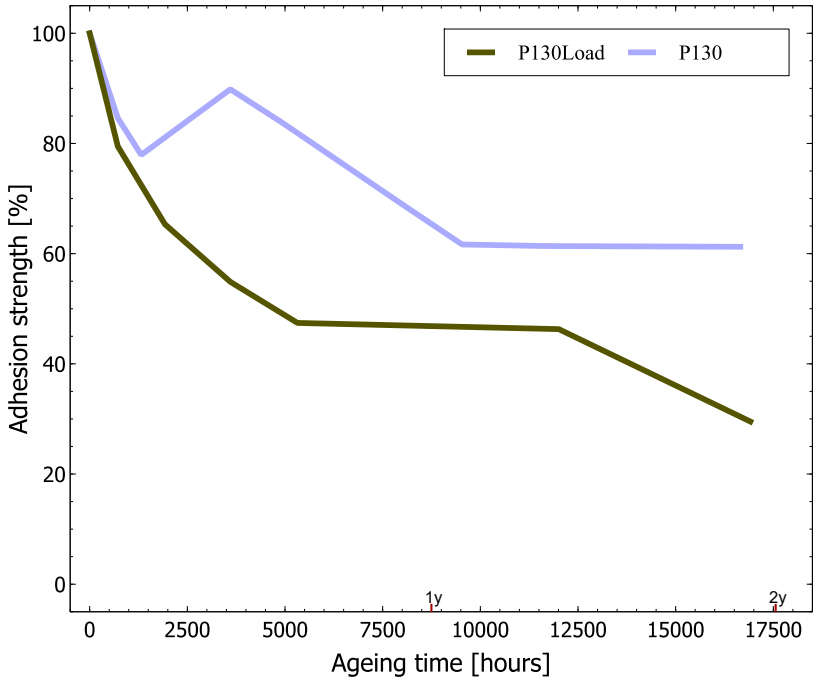


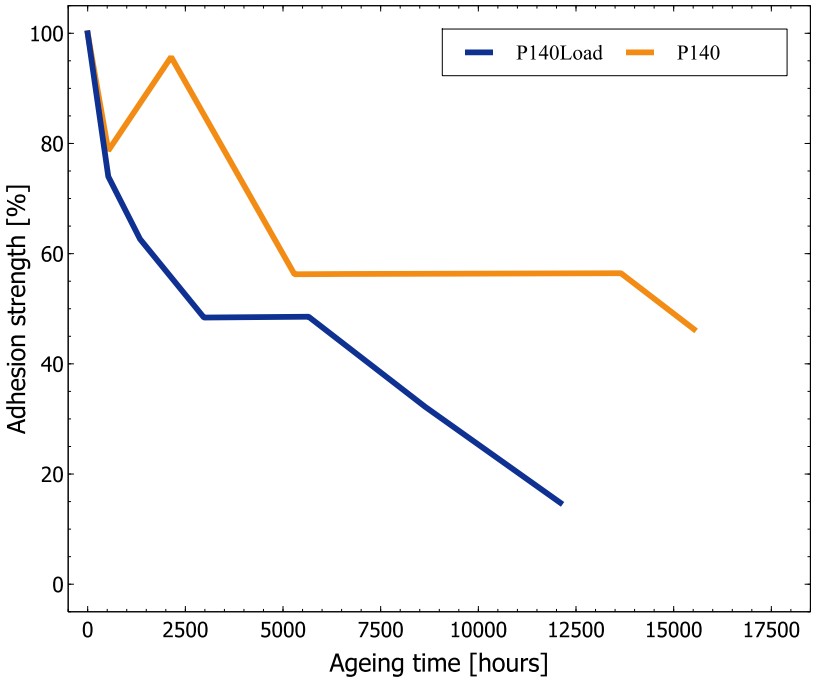
- Temp.: 130 & 140 C
- Cyclic load: 20 kN, 28 min ON and 28 min OFF
- Adhesion strength
- Chemical structure



Combination of thermal and mechanical loads

Adhesion strength

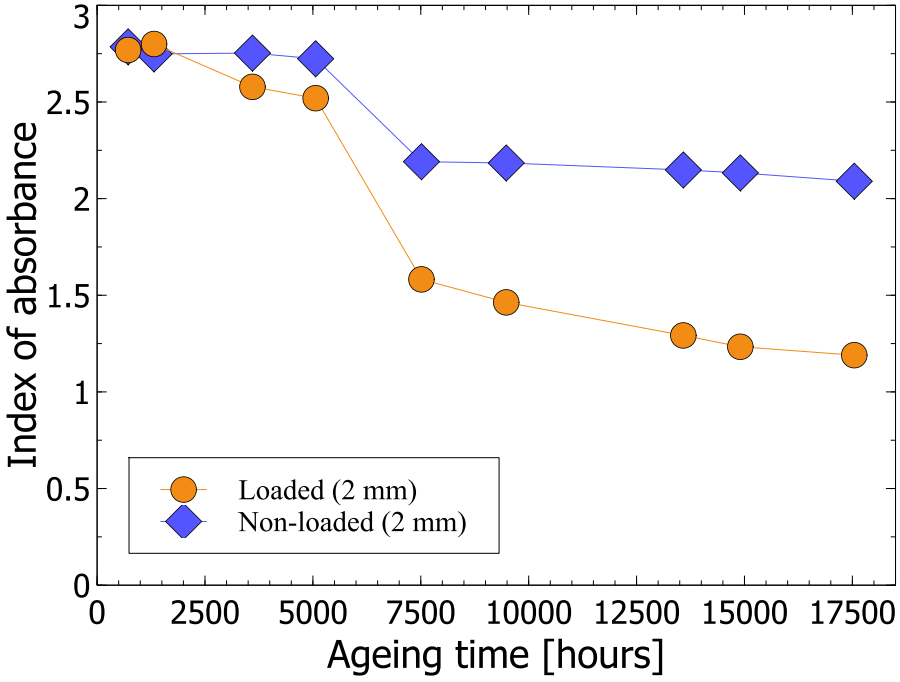




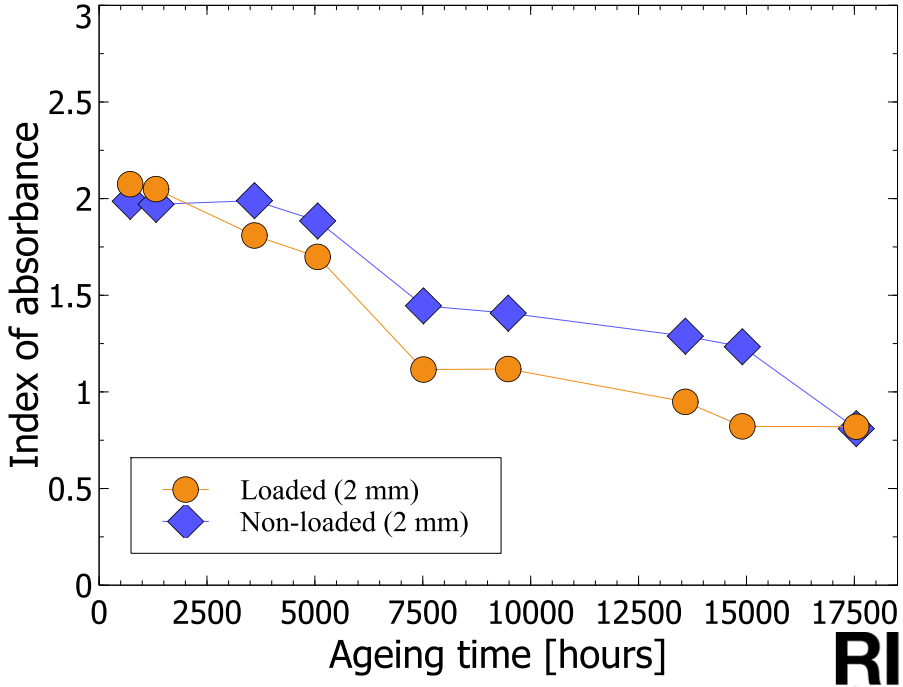
Combination of thermal and mechanical loads

FTIR – P130 & P130Load

N-H 1512 cm^{-1}

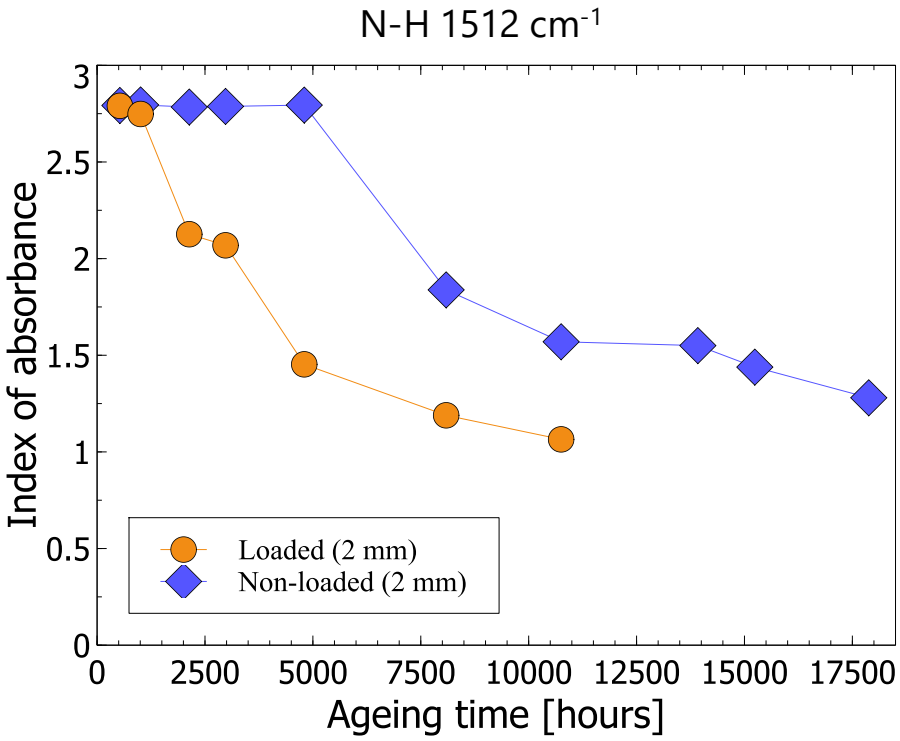


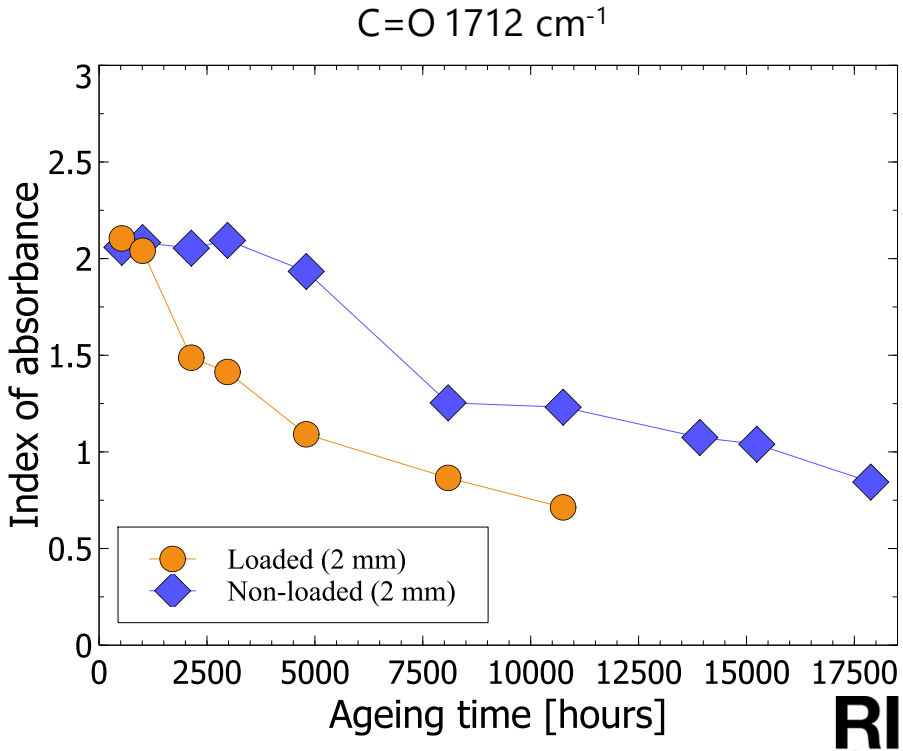
C=O 1712 cm^{-1}



Combination of thermal and mechanical loads

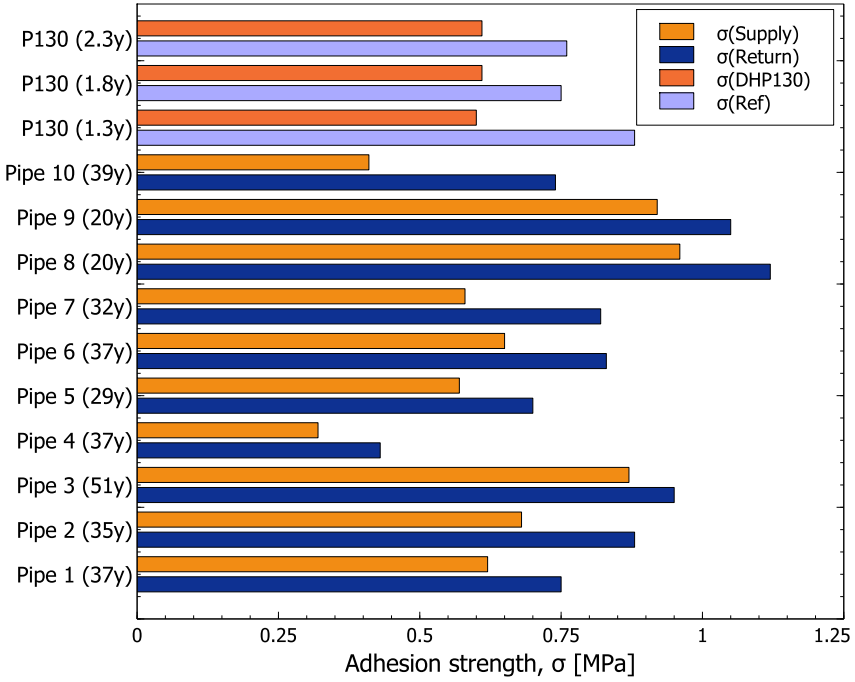
FTIR – P140 & P140Load

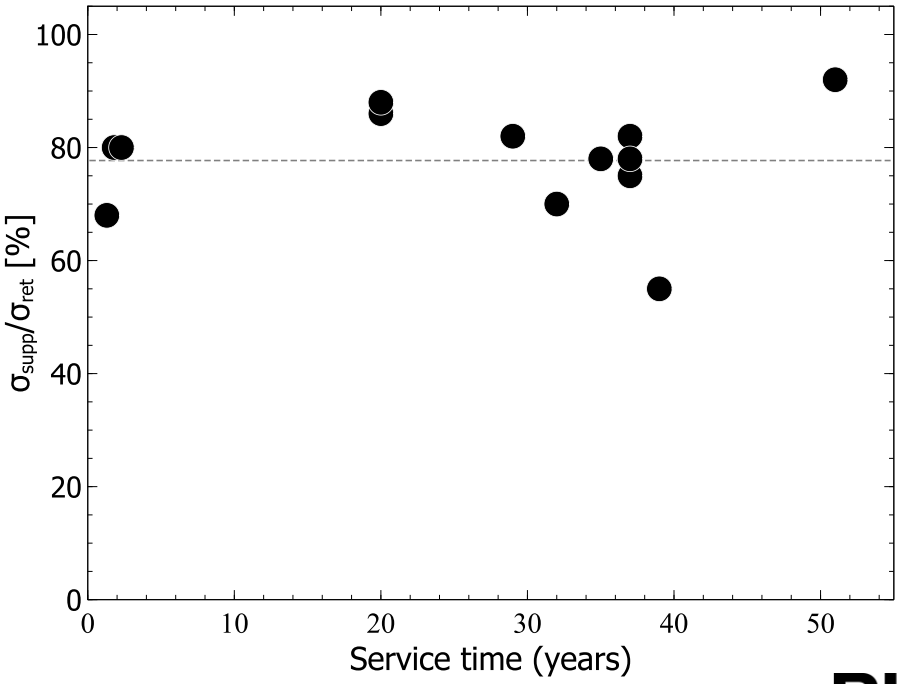




Natural vs. Accelerated ageing

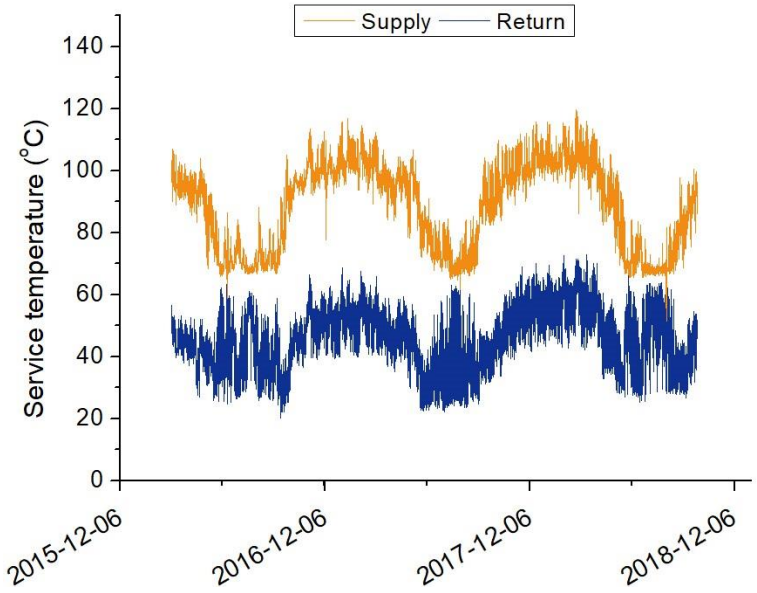
Natural vs. accelerated ageing



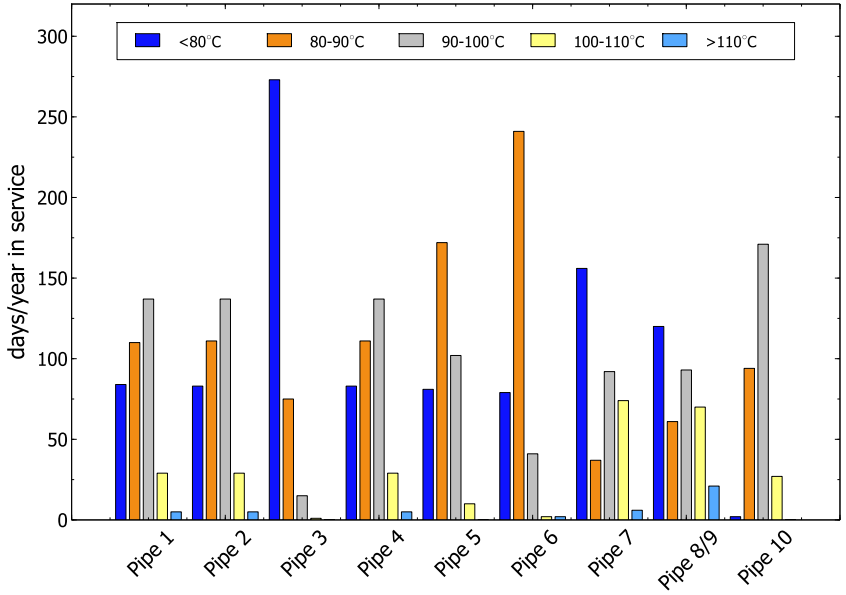


Natural vs. accelerated ageing

Temperature log

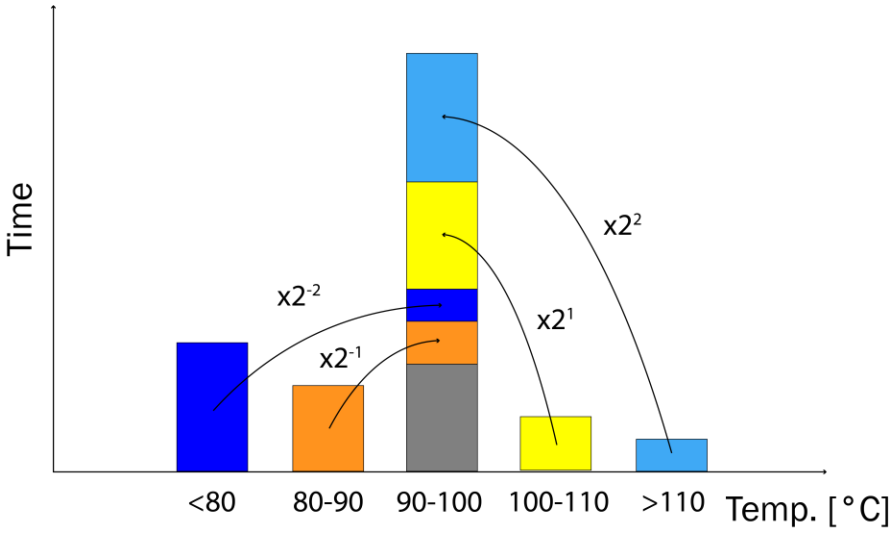


Temperature intervals

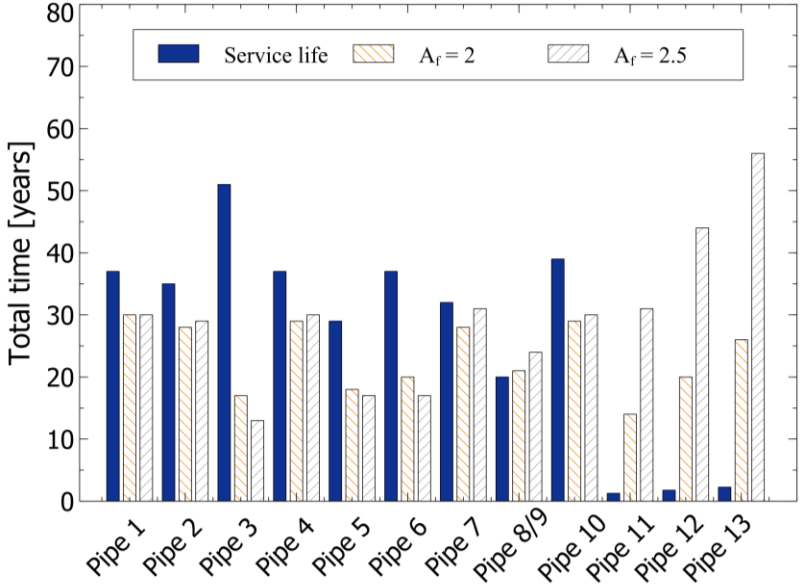


Natural vs. accelerated ageing

Arrhenius relationship

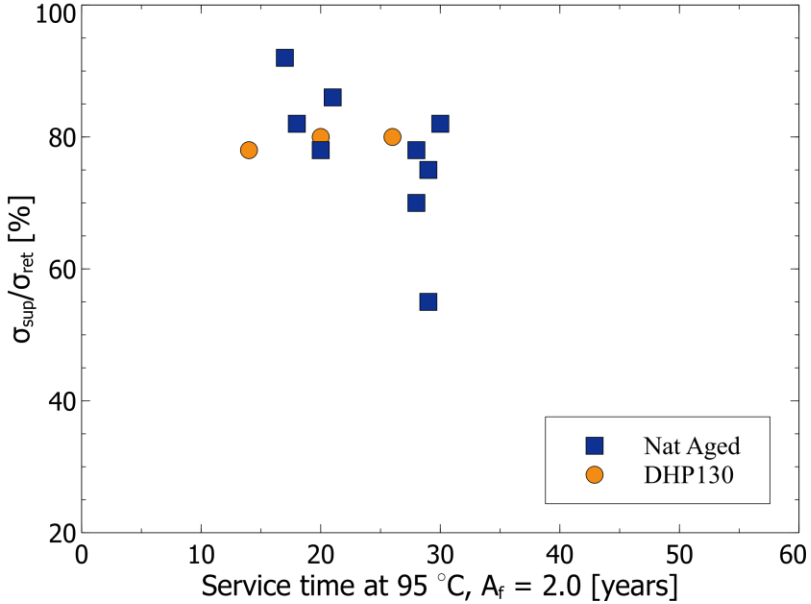


Recalculation

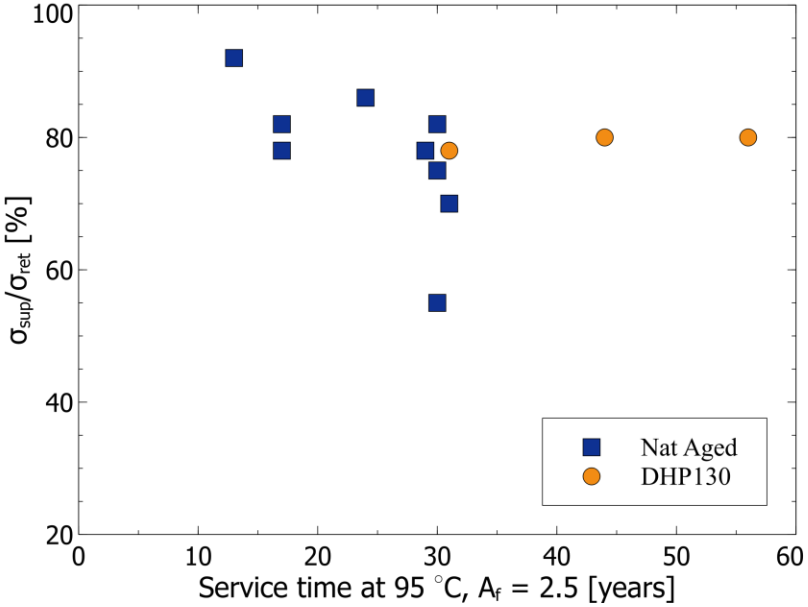


Natural vs. accelerated ageing

A_f=2.0 => E_a=78 kJ/mol (90-100 °C)

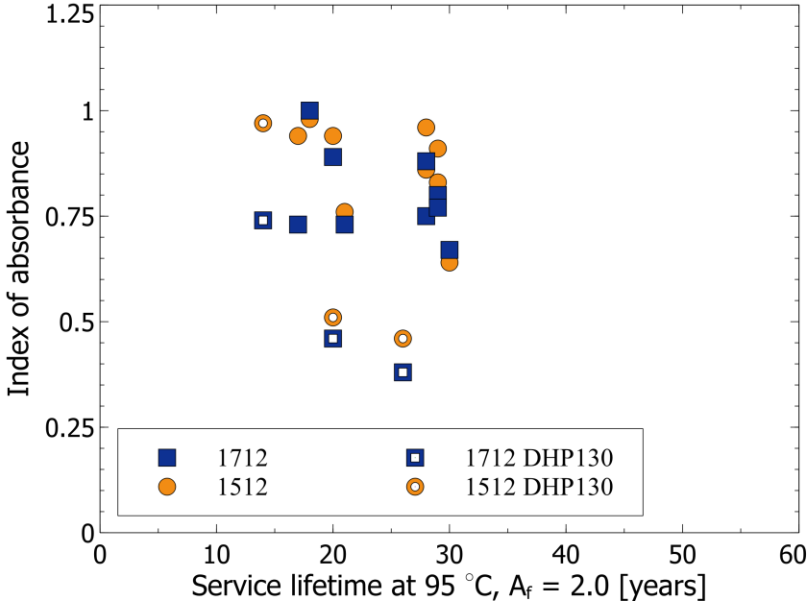


A_f=2.5 => E_a=103 kJ/mol (90-100 °C)

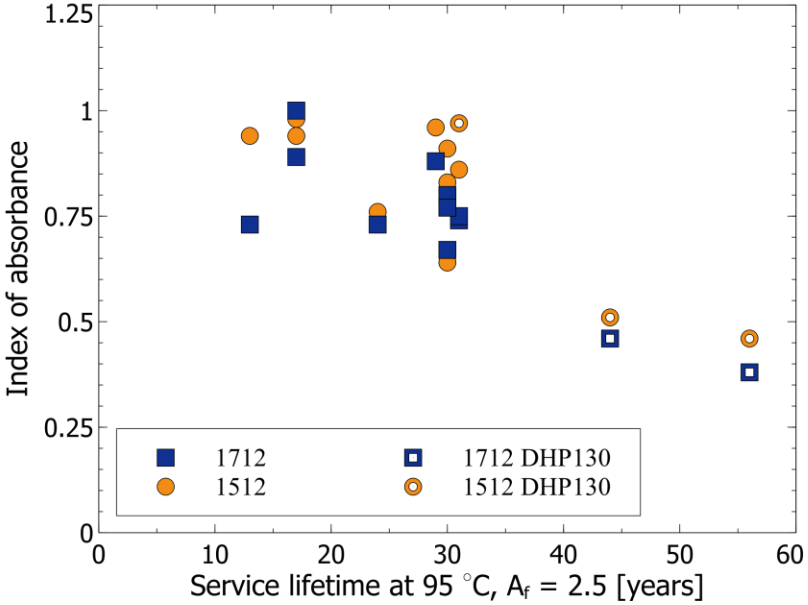


Natural vs. accelerated ageing

A_f=2.0 → E_a=78 kJ/mol (90-100 °C)



A_f=2.5 → E_a=103 kJ/mol (90-100 °C)



Conclusions & Future work

Conclusions

- Choose temperature for ageing carefully
- T≥150 °C seem to alter degradation process
- Thermal and mechanical loads
- FTIR analysis
- Lifetime longer than expected

Future challenges

- Rate of oxygen diffusion
- Cell morphology – X-ray tomography (Synchrotone)
- Parameters for combination of thermal and mechanical loads
- Tools to predict failures in DH (Machine learning)

Thank you for listening!

Contact:
Albeto Vega
alberto.vega[at]ri.se