Fire retarded wood – aging related questions and the quest for answers

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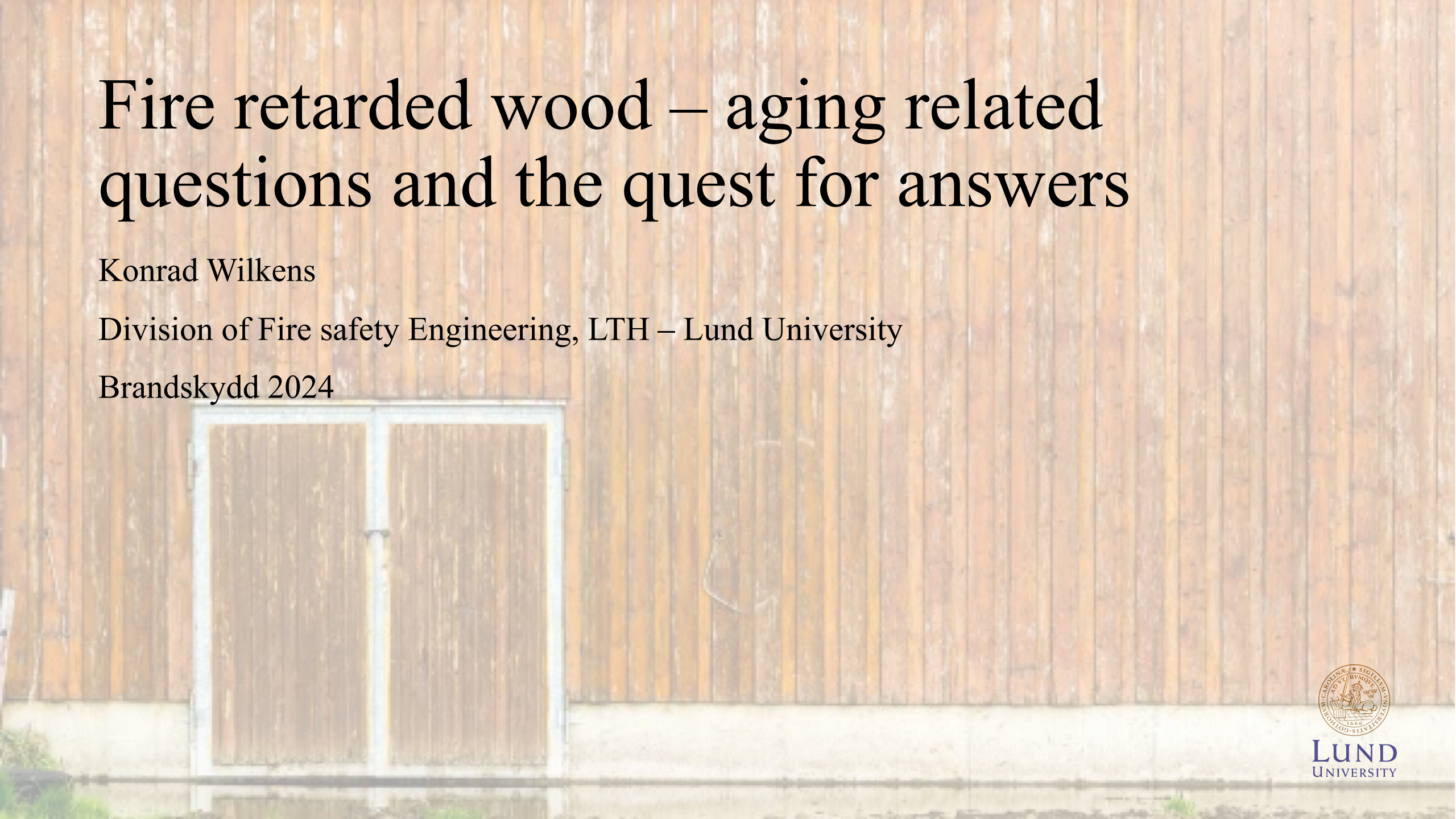
Brandskydd 2024



Wood and Buildings in Sweden

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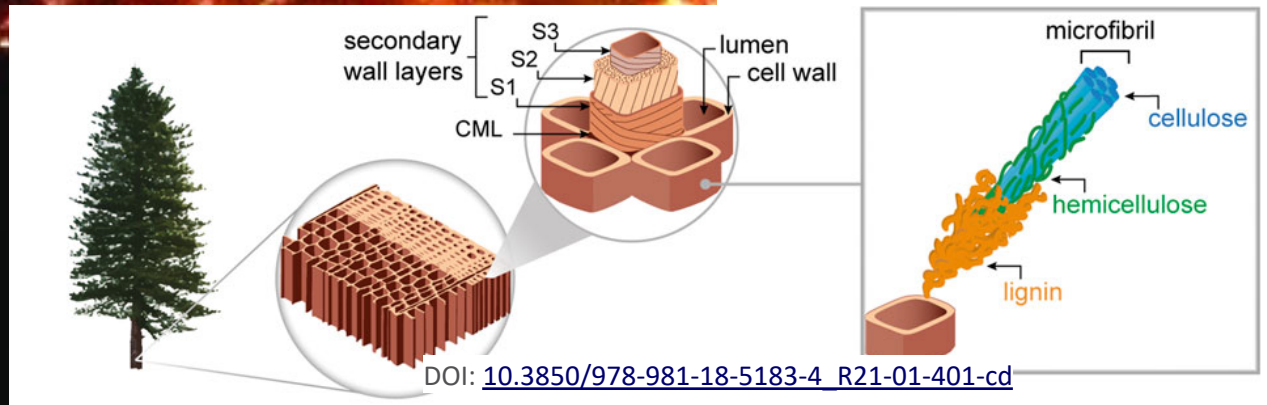
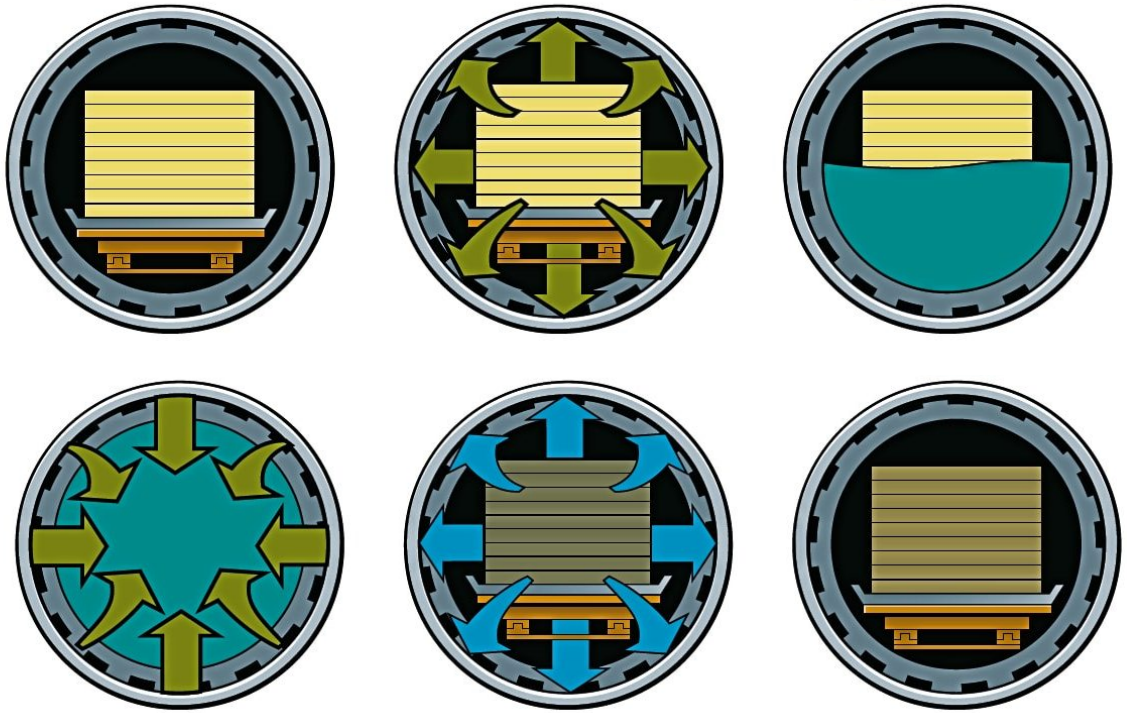
Combustion of wood

Hemicellulose ~ 200-260C
Cellulose ~ 240-350C
Lignin ~ 280-500C



DOI: 10.3850/978-981-18-5183-4_R21-01-401-cd

Wood treatments



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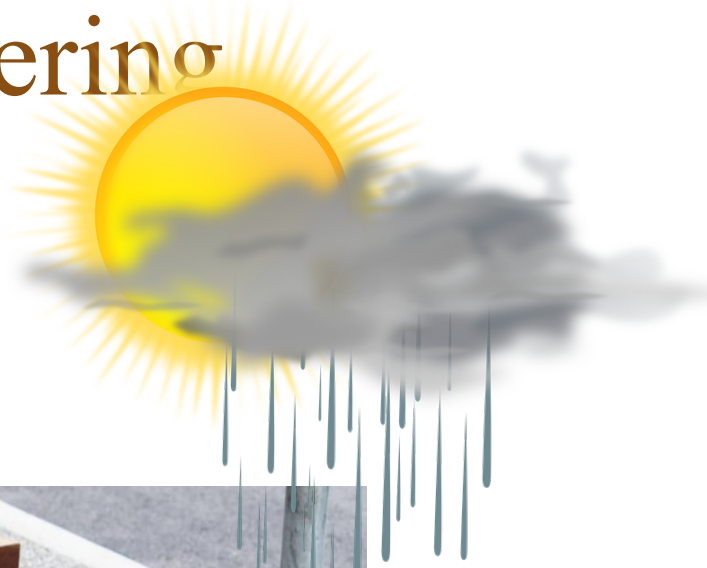
FR chemicals - Aging and weathering

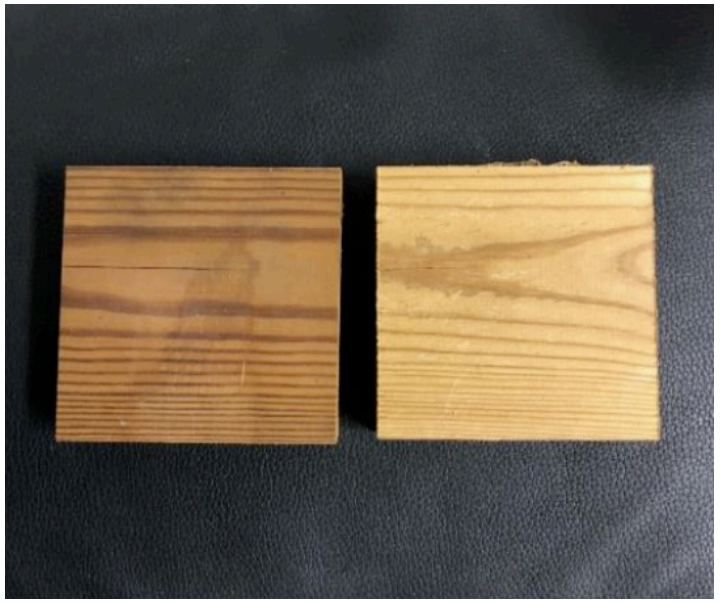


Two main types:

- Water and sun

Two main FR formulations:

- Boronic compounds are being phased out
- Ammonium/x/phosphate compounds are now most common



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Lack of knowledge

- Aging happens
- Leaching happens

- When?
- How much?
- Service life?
- Effects on fire performance?

- ITS A FIRE SAFETY SYSTEM!

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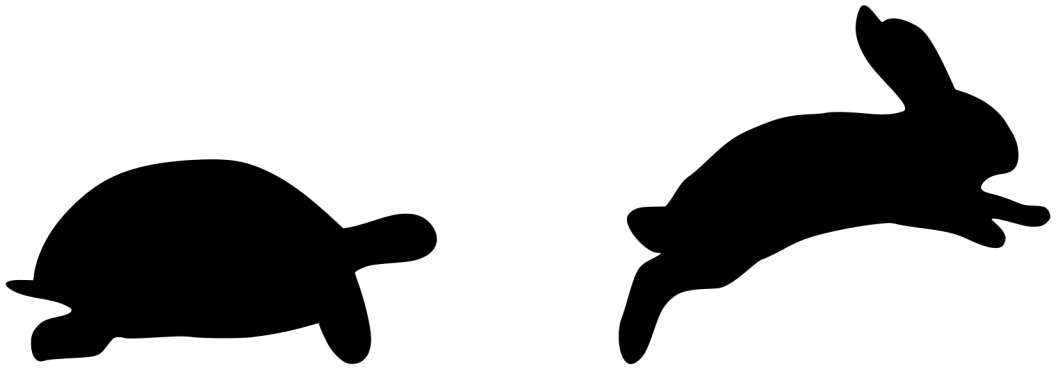
Current control methods

- EN16755 – currently under review



- Natural aging vs Accelerated aging
- According to the current standard **the supplier** is **responsible** for giving a maintenance plan for the systems.

EUROPEAN STANDARD **EN 16755**

NORME EUROPÉENNE

EUROPÄISCHE NORM October 2017

ICS 13.220.40; 13.220.50; 71.100.50

English Version

Durability of reaction to fire performance - Classes of fire-retardant treated wood products in interior and exterior end use applications

Durabilité des performances de réaction au feu - Classement des produits à base de bois ignifugés pour utilisation finale en intérieur et en extérieur

Dauerhaftigkeit des Verhaltens bei Brandeinwirkung - Klassen der mit Feuerschutzmitteln behandelten Holzprodukte für Anwendungen im Innen- und Außenbereich

This European Standard was approved by CEN on 2 July 2017.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 16755:2017 E

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Current research at LTH

- Measurement of FR in wood

- Aging studies

- New (hopefully better) FRs
- Emissions

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Current research - measurement

- Current method:

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Current research - measurement

- New techniques
  - 3D X-ray tomography
  - Fourier Transform Infrared Spectroscopy (FTIR)
  - Chemical indicators (reagents)
  - Raman Spectroscopy
  - Scanning electron microscope with energy dispersive X-ray spectroscopy (SEM-EDS)
  - Micro combustion calorimetry (MCC)

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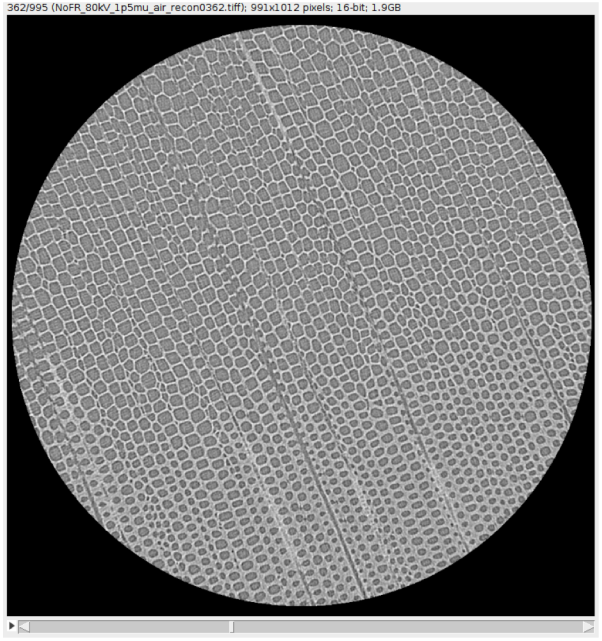
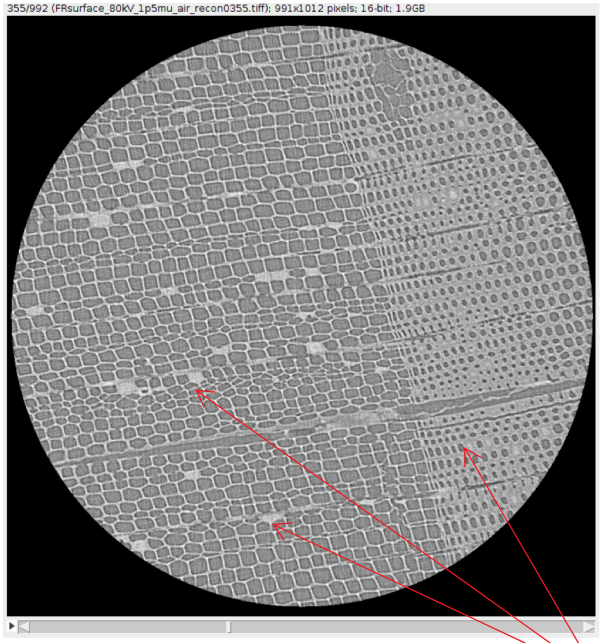
3D X-ray tomography

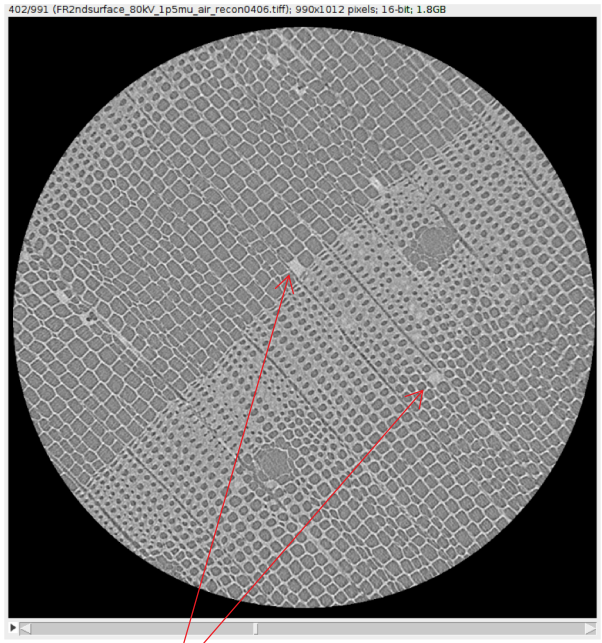
No treatment



Surface



2nd from surface



Treatment chemical?

High resolution scan (1.5 micron voxel size)

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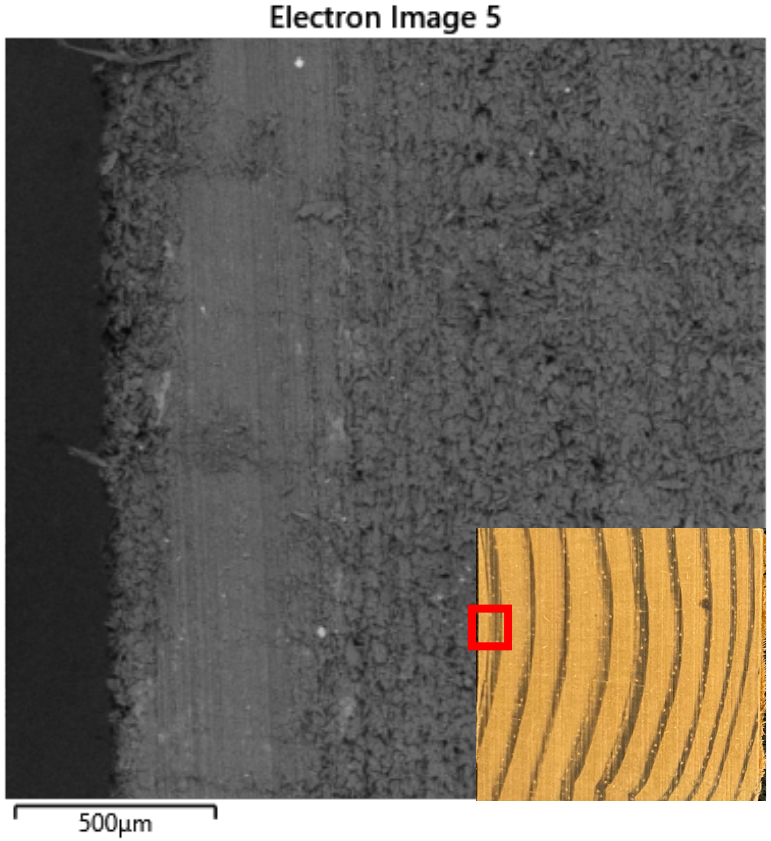
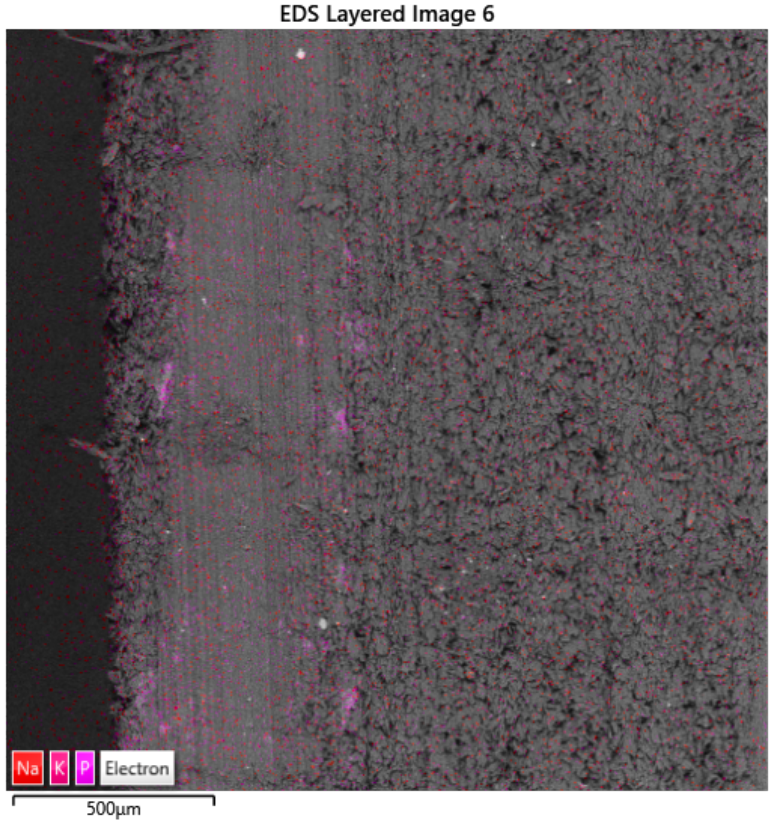
SEM-EDS

- Scanning electron microscope with energy dispersive X-ray spectroscopy





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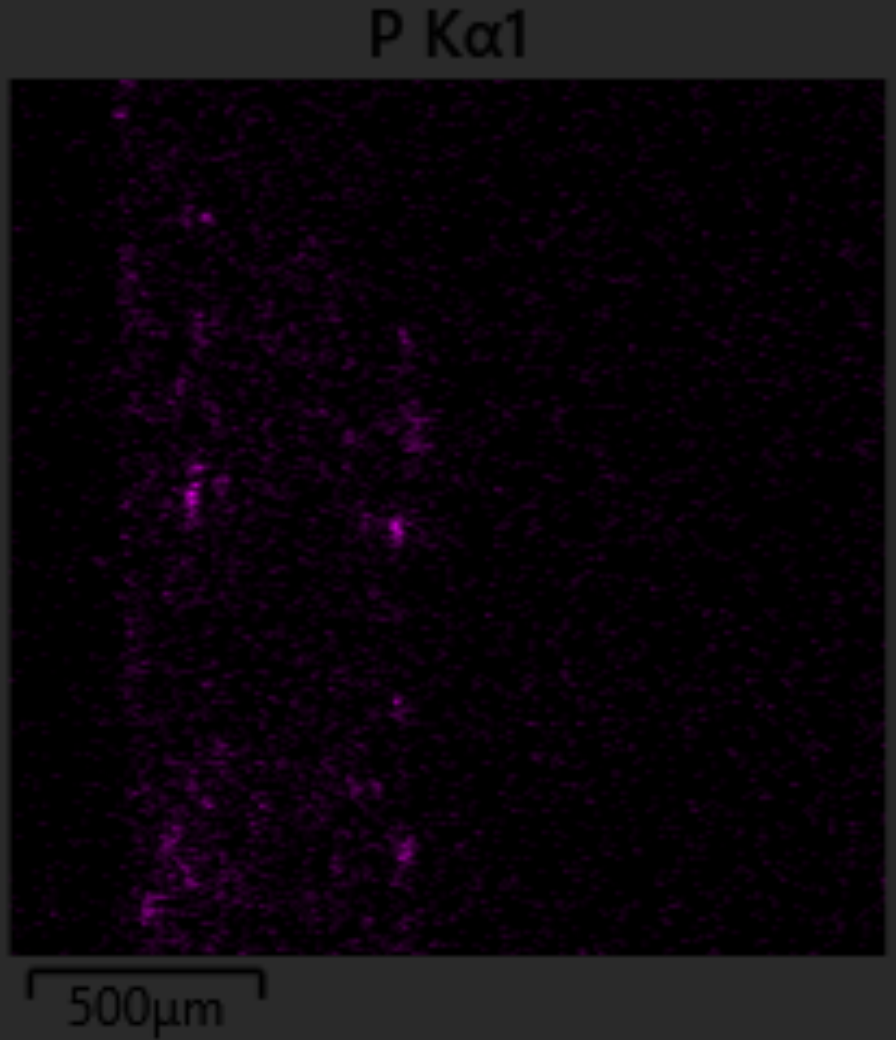
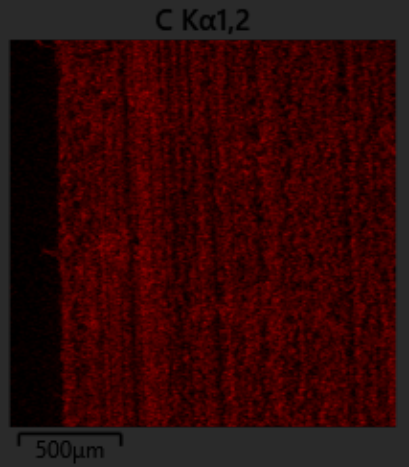
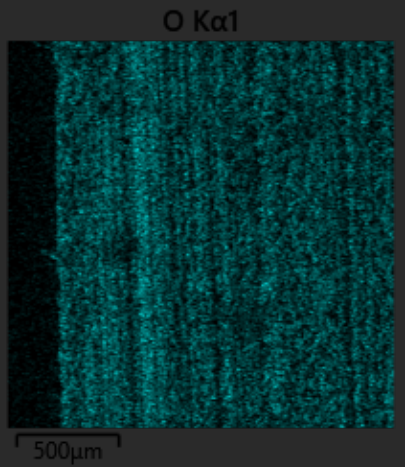
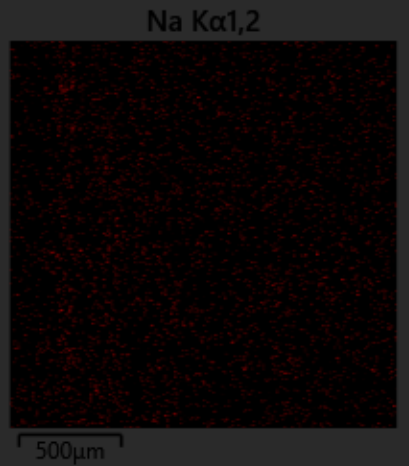
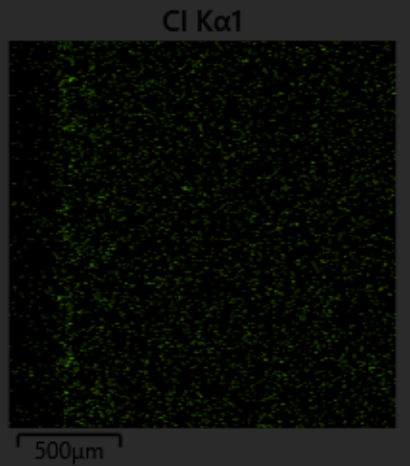
SEM-EDS











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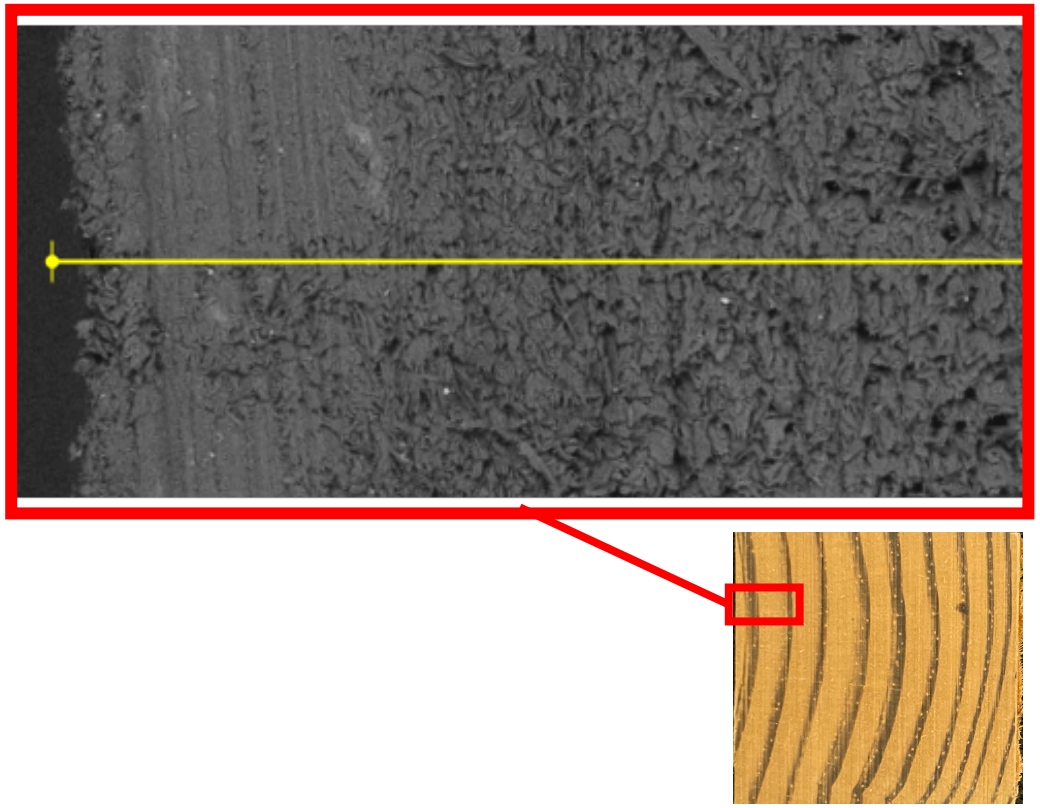

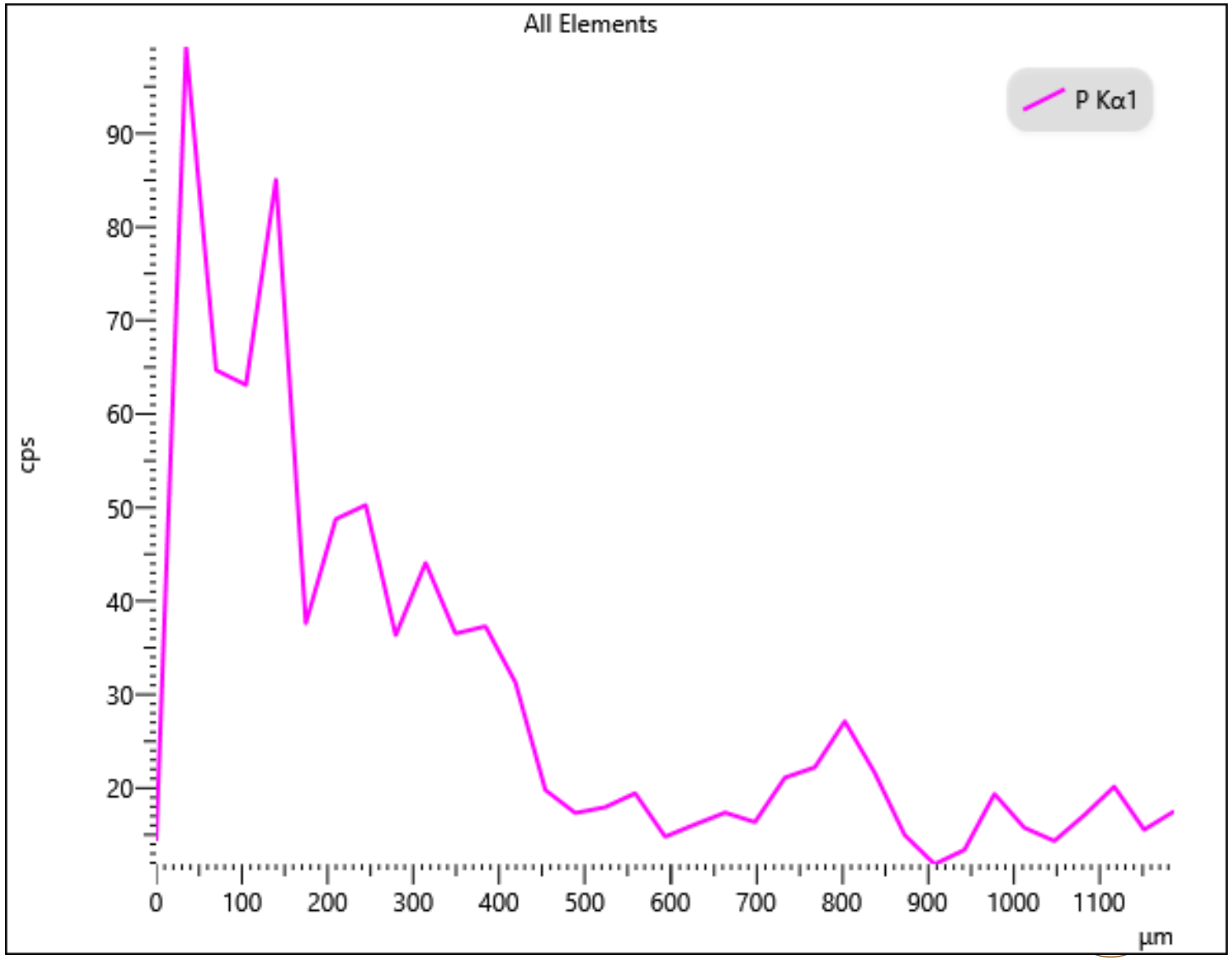

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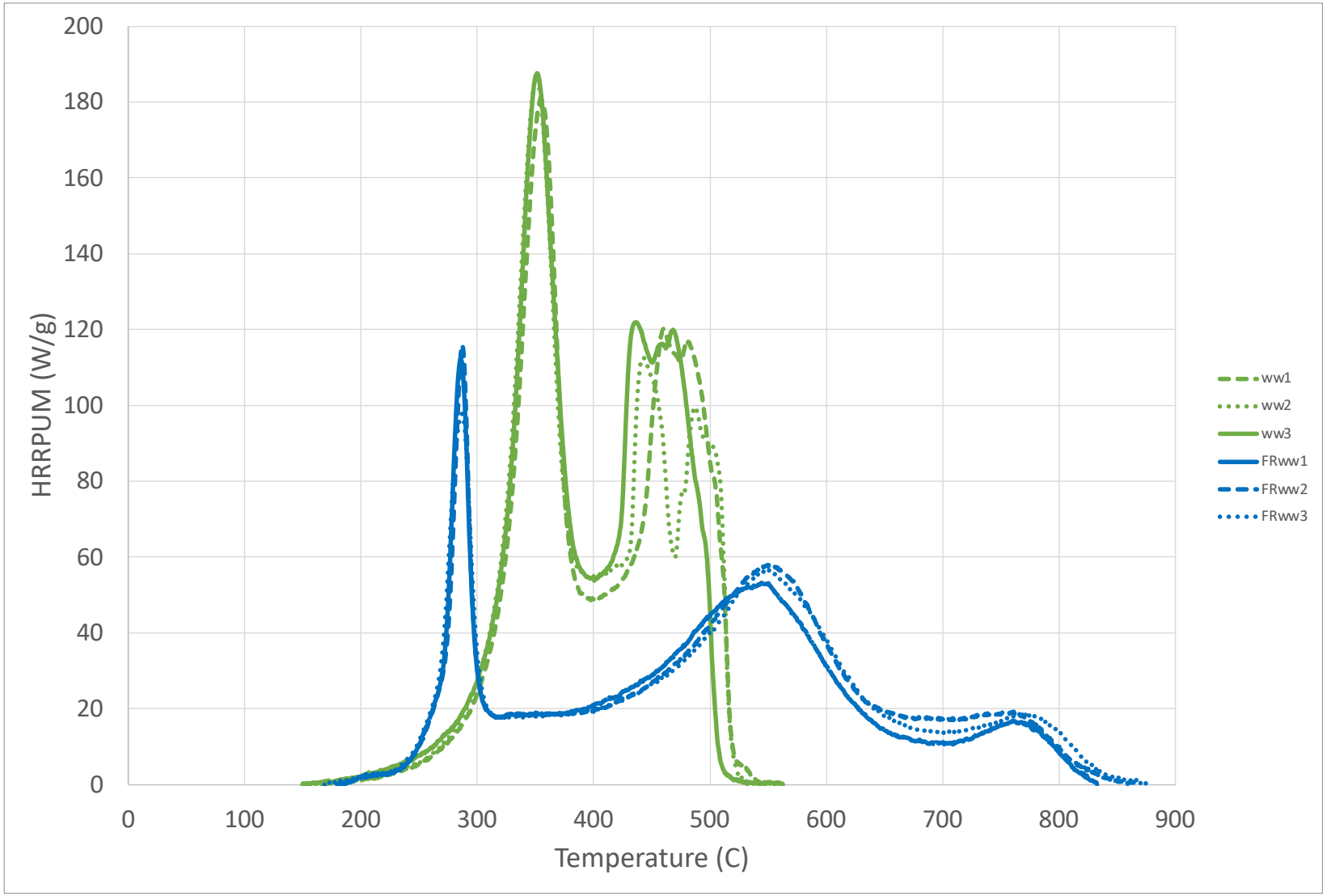
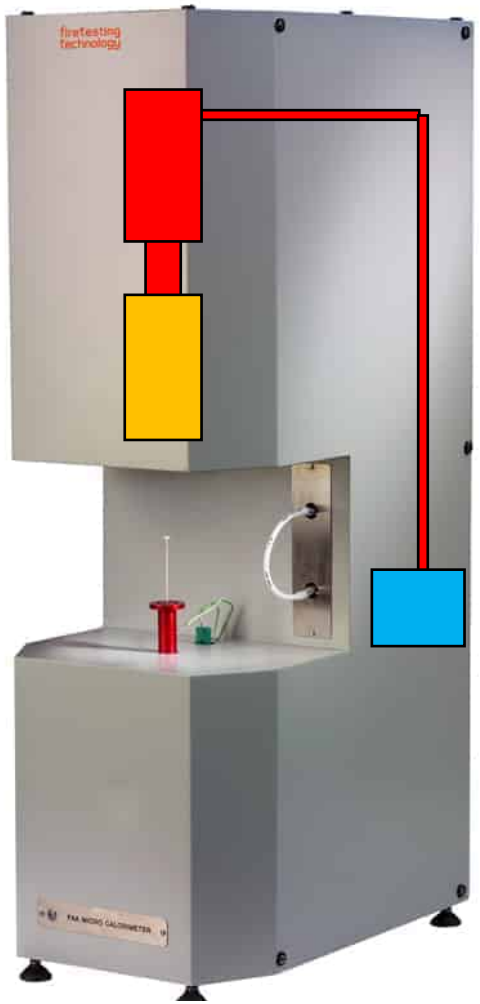
MCC – more familiar





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Current research – aging studies

- Recently completed thesis project
- Internal projects
- Current thesis topic
- Collaboration projects
  - Swedish wood association (Svenskträ)
  - DBI

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Aging studies

- Natural aging and Cone calorimeter testing.
- Minimum 3 heat fluxes, repeat tests
- Analysis
  - Raw cone data
  - Conetools
  - TRP, FPI

F. Engström and H. Psajd, ‘Beständigheten hos brandimpregnerat trä’, Thesis, Lund University , Lund, 2024

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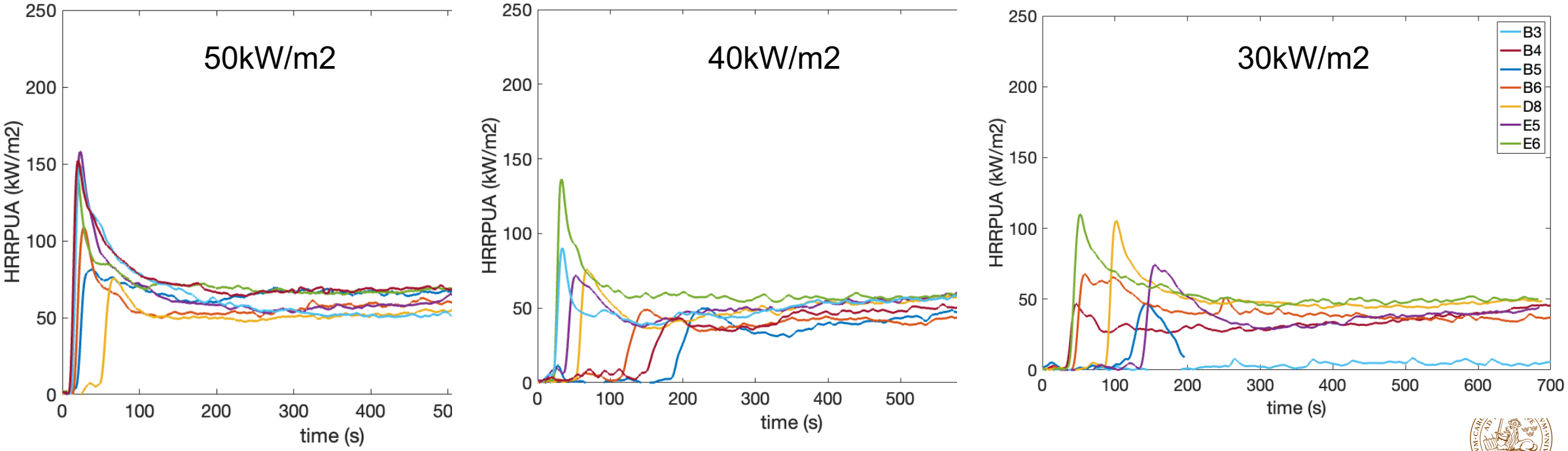
Aging studies – Results so far..

- Very large variance in un-aged FR samples.



F. Engström and H. Psajd, 'Beständigheten hos brandimpregnerat trä', Thesis, Lund University , Lund, 2024

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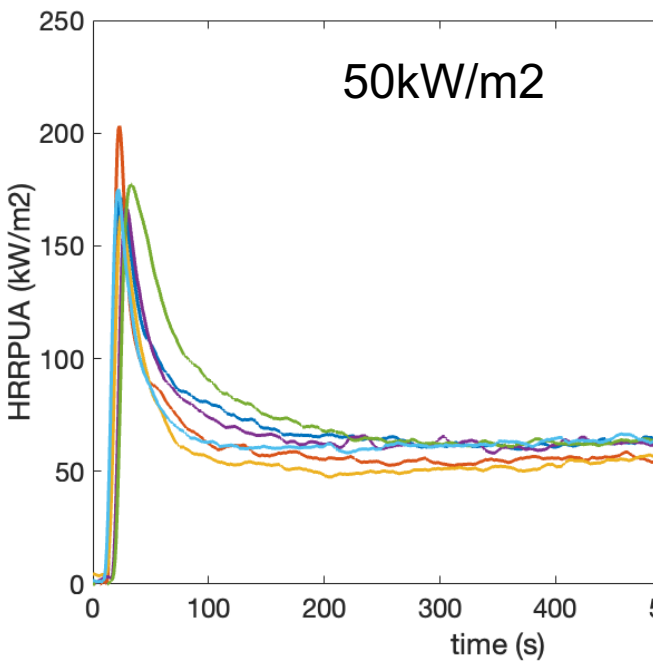
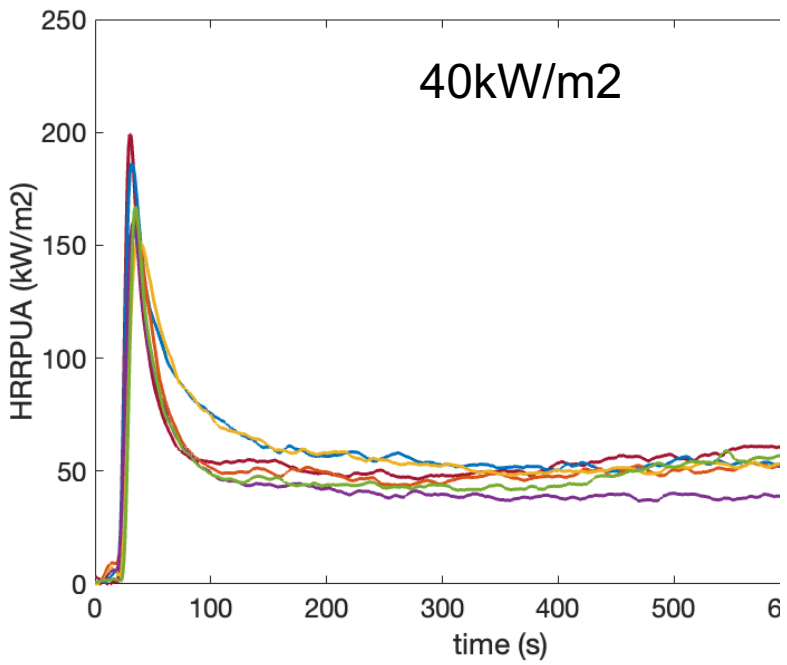
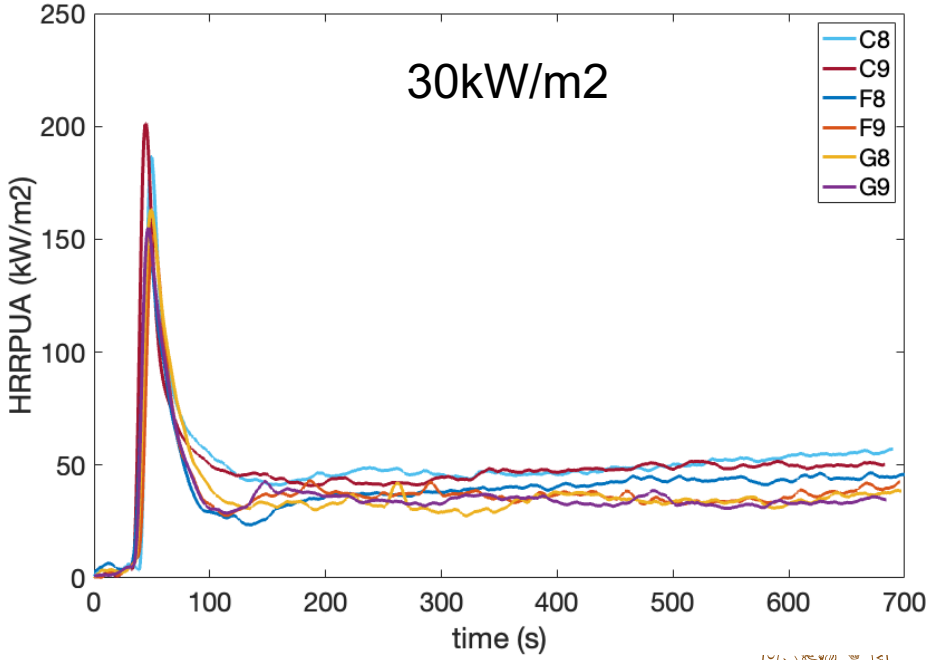
Aging studies – Results so far..

- Not the case in the aged FR samples.







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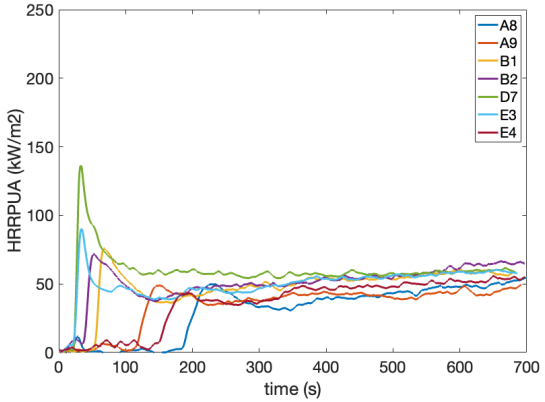
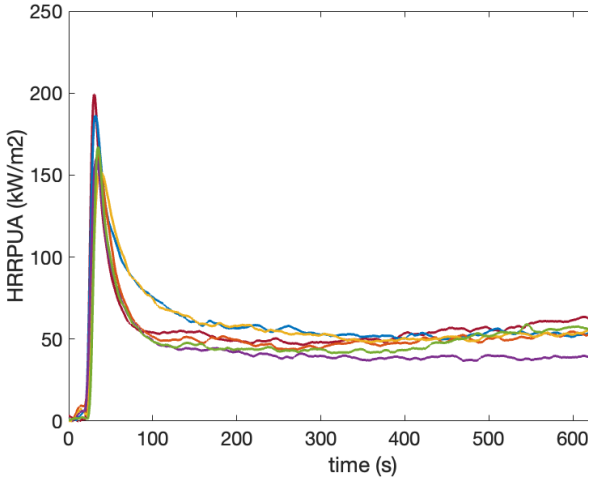
Aging studies – Results so far..

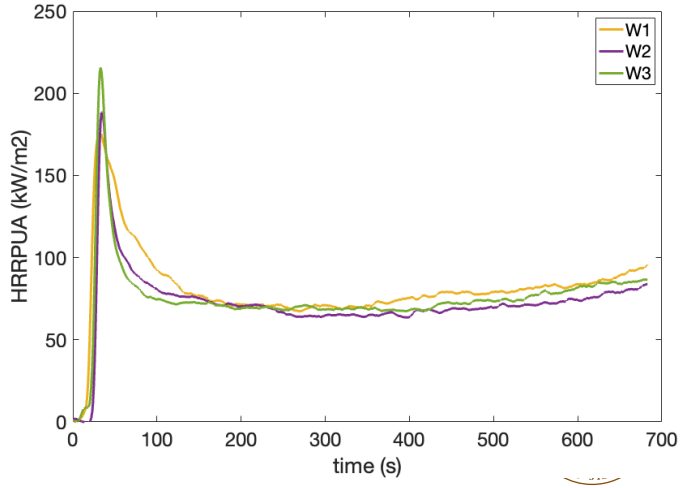
- Increase in all main metrics for aged FR samples.

Material ID	Parameter	Heat flux level (kW/m²)		
		50	40	30
		Average values (standard deviation SD)		
TW	Ignition time (s)	14.7 (3.1)	23.3 (4)	-
FRTW		22.3 (15.2)	63 (62)	66 (42)[2]
FRTW (aged)[1]		18 (2.5)	25.1 (1.8)	40.2 (2.3)
TW	Peak HRR (kW/m2)	222.7 (24.7)	193.3 (20.5)	-
FRTW		124.1 (35)	102.2 (35.2)	84 (23.8)
FRTW (aged)[1]		175 (12)	173.4 (18.1)	166.1 (24)



40kW/m2





F. Engström and H. Psajd, 'Beständigheten hos brandimpregnerat trä', Thesis, Lund University , Lund, 2024

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Aging studies – Results so far..

- Same trends for other analysis methods.

Material	Total number of cone tests	Number of samples with predicted Euroclass classification			
		B	C	D	E
TW	6			2	4
FRTW	28	7	10	11	
FRTW aged	27		1	26	

Flame spread velocity $\propto \frac{incoming\ energy}{material\ properties\ (TRP)}$

$$V_f = \frac{\dot{q}_f''^2 \cdot L_p}{k_f \rho_f c_f \left(T_{ig} - T_0\right)^2}$$

$$TRP = \sqrt{k\rho c}(T_{ig} - T_0)$$

Material	TRP (kW-s$^{1/2}$/m^2)	FPI
TW	-	-
FRTW	326.5	13.7
FRTW aged	259.8	19.3

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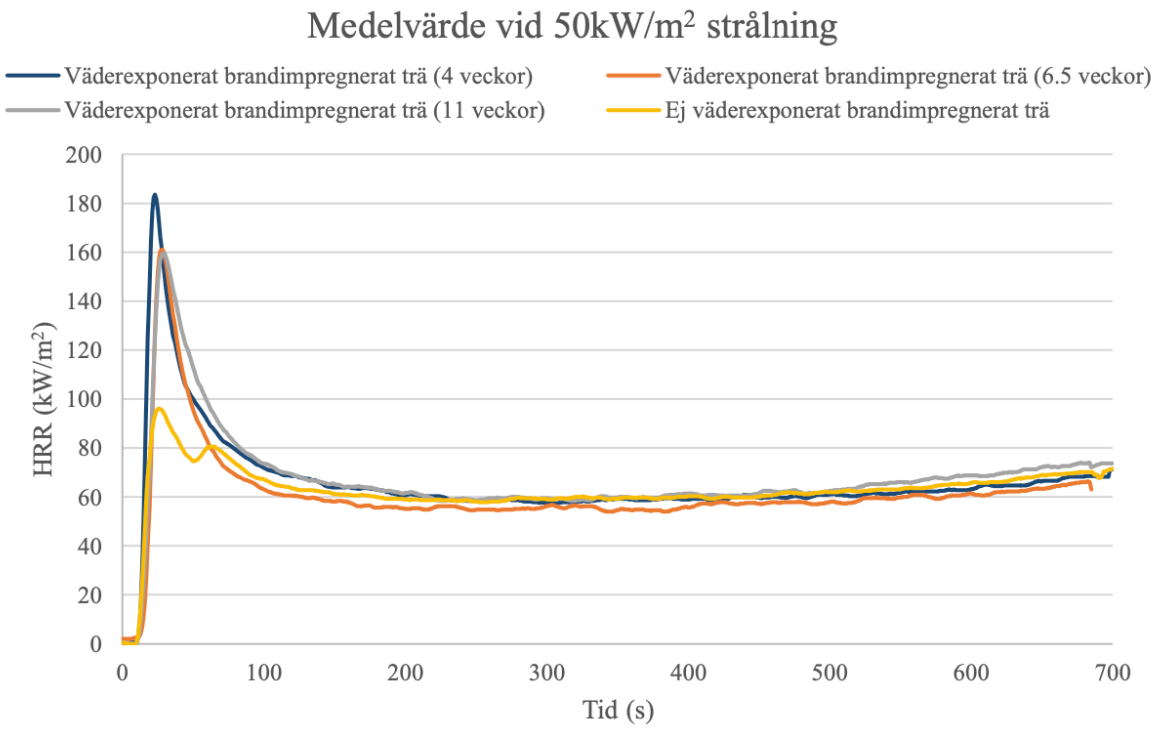
Aging studies – Results so far..

- The majority of the observed changes in fire performance have occurred very early in the exposure period.
  - before the first batch of samples were tested (@4weeks). .



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Aging studies – Results more too come..

Current ex-jobb thesis: Carolina Arvidsson

- Real world facade samples
  - Approximately 2 years old.

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Naturally weathered fire-retardant timber façade in Malmö

An ongoing experimental thesis from a field study

CAROLINA ARVIDSSON, DIVISION OF FIRE SAFETY ENGINEERING, LTH

Hypothesis

- The fire performance has decreased since it was installed.
- There is less fire protection in the **lighter** parts of the timber slats compared to the **darker** parts.
- The fire properties in the **lighter** parts of the timber slats are **similar** to the fire properties of **non-treated** pine timber.

Front side, Back side of the same timber slat.

A rib from the east side showing color scheme between back vs front side.

Issues to be addressed

Main question:

Does the fire-retardant timber on the façade achieve the fire performance it is intended to withstand, after the time is has been installed on the building?

Concluding question:

What issues can be identified in relation to researching naturally weathered fire-retardant timber?

Methodology

Literature review for previous research →

→ Timber façade to sample sizes

→ Climate chamber

→ Cone Calorimeter calibration and settings

→ Sample preparation

→ Procedure of the Cone Calorimeter test

→ Management of the results

Material properties

From the Declaration of Performance, DoP:

✓ Type of wood: ThermoWood

✓ Surface class: B-s2,d0

From "Assessment" from RISE:

✓ Fire impregnation: Exterior Fire-X fulfills the DRF Class EXT (Before accelerated or natural weathering)

This box is based on documents, e.g "byggvarudeklaration" and "DoP", given by the distributors of the façade. The reviewed documentation from the manufacturer is difficult to connect with the specific product, hence this information might be inaccurate.

Suggestions

Here you can write suggestions to the author, on what to bring into the thesis work:

Suggestion	Suggestion

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New FRs

- 2 current projects looking at new forms of FR for wood.
- 1:
  - Phytic acid
  - Chitin
  - Lignin
- 2:
  - Mineralisation of wood

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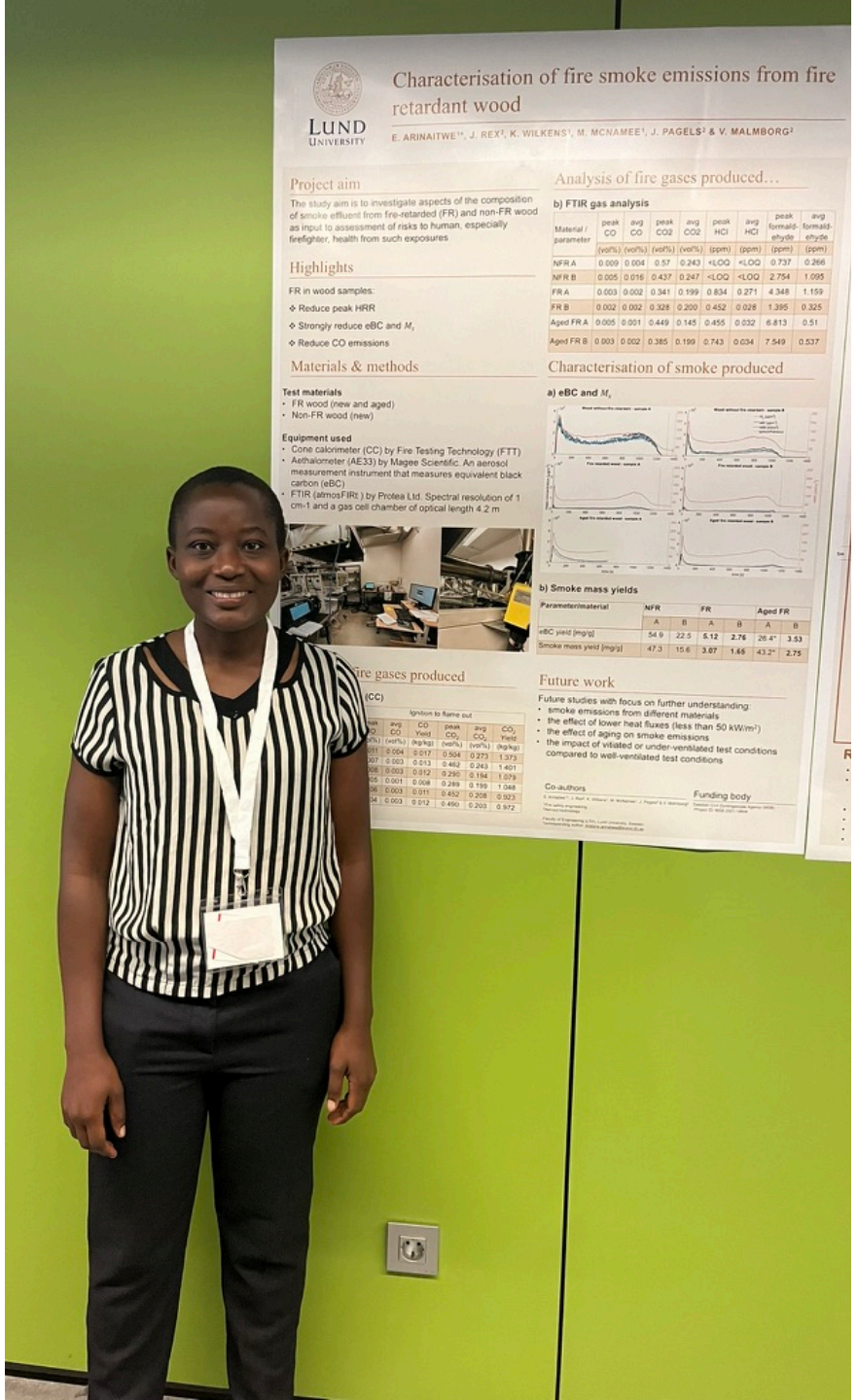
Emissions

- Current Ph.D project with MSB.
  - Evalyne Arinaitwe
- Quantifying emissions (e.g. toxic gases, particles) from materials in the built environment.
- In collaboration with the Aerosol technology division at LTH
- Fire retarded wood is one of the chosen materials.



Future Work

New project and collaborations

- New student thesis project running now
  - Aiming to test real samples
- Svenskträ
  - Natural aging/fire testing
- DBI
  - Bit of everything
- Norway

- Always looking for more partners!

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Thanks for listening!

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