



# Study on the thermal destruction of wood modified with fire-retardant chemicals using cone calorimeter

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# Introduction

- As it is known, wood can ignite and burn very easily. This is one of its main "disadvantages" when we use it as a construction material.
- It is a well-known fact that by modification of wood it is possible to reduce its combustibility.
- The present research is about the thermo-chemical modification of wood, which is aimed at decreasing the flammability of wood.



# MATERIAL, METHOD, EQUIPMENT

- For the study of termo-destruction we used wood samples from **sapwood of Scots pine** (*Pinus sylvestris* L) with dimensions 15x100x100 mm (for Cone Calorimeter) and 4x10x100 mm ( for LOI determination)

Wood has been impregnated with **amino olygomers modified with** different quantity of **Phosphoric acid**:

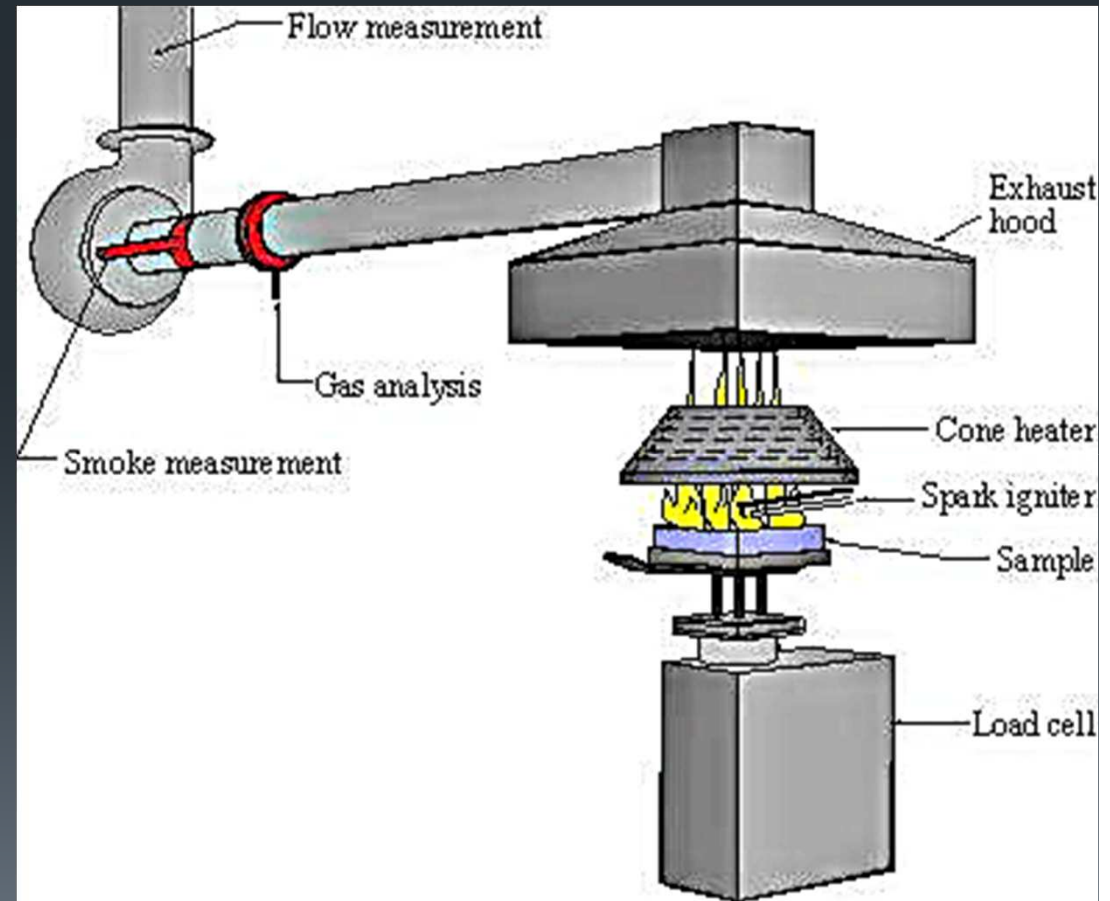
- *chemical compositions Fosfamin 1* contained elements of **phosphorus (10.8 %)** and **nitrogen (4.9 %)**;
- *chemical compositions Fosfamin 2* contained elements of **phosphorus (9.4 %)** and **nitrogen (4.4 %)**;
- *chemical compositions Karbofenor* contained elements of **nitrogen (1.7 %)** and **phosphorus (0.9 %)**

## MATERIAL, METHOD, EQUIPMENT

- The impregnation was made in laboratory autoclave based on the method of vacuum-pressure (respective values -0.075 MPa-1 h and 0.50 MPa - 4 h). Afterwards the pieces were dried (6 h at 103°C and 2 h at 150°C).
- Limited oxygen index (LOI) of modified wood was determined according to standard test (ASTM D 2863). For this test we used samples with different dimension - 4x10x100 mm.

# Cone Calorimeter

- Standard test for fundamental understanding of materials fire behavior
- We used it for measure heat release rate (RHR) by oxygen consumption calorimetry, mass loss rate and smoke production rates



# MATERIAL, METHOD, EQUIPMENT

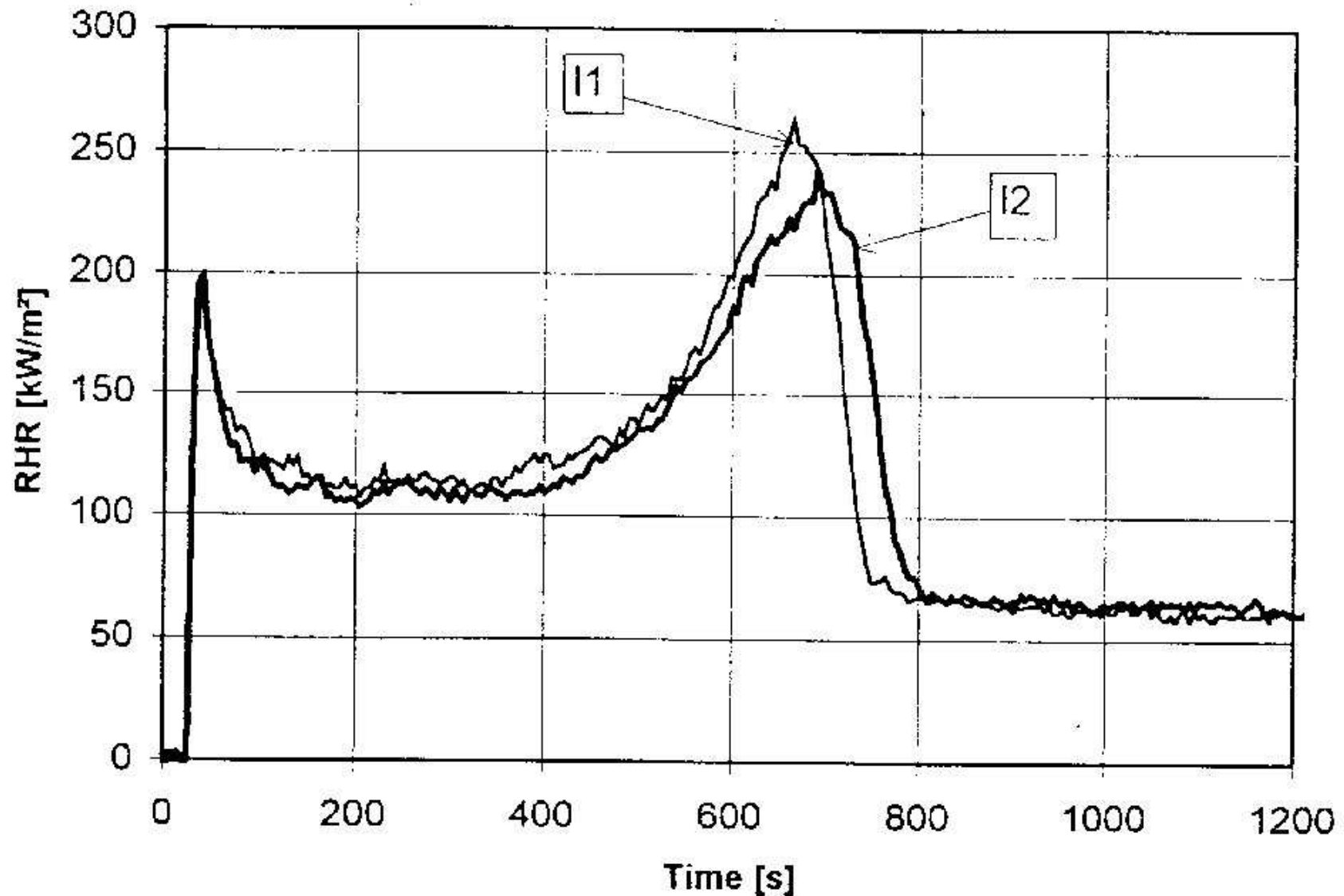
The following **parameters** were determined for modified wood:

- **Density of wood** in dry air state ( $D_w$ );
- **Content of dry modifying substance** ( $M_c$ );
- **Limited oxygen index** (LOI);
- **Effective heat of combustion** (EHC);
- **Specific eclipse area** (SEA), a **parameter characterizing the release of smoke** during wood combustion;
- **Time for ignition** ( $t_i$ );
- **Released heat** in the course of 300 s after ignition ( $RHR_{300}$ );
- **Content of chemical elements** inhibit ignition and combustion.

# Results and analysis

Name of compositions	Sample №	D <sub>w</sub> kg/m <sup>3</sup>	M <sub>c</sub> g/m <sup>2</sup>	LOI %	Cone Colorimeter ISO5660 at 50 kW/m <sup>2</sup>			
					t <sub>i</sub> s	RHR <sub>300</sub> kW/m <sup>2</sup>	EHC MJ/kg	SEA m <sup>2</sup> /kg
Fosfamin 1	11	621	40	47.3	23	95	9.8	43
	12	615	34	45.2	16	79	9.2	50
Fosfamin 2	1	528	46	26.8	16	93	11.2	82
	2	520	45	25.9	19	90	10.9	80
Karbofenor 93	16	514	165	33.6	80	34	6.2	32
	17	574	225	43.7	90	19	5.3	29
Natural pine sapwood	I 1	566	-	18.3	26	118	13.4	57
	I 2	580	-	19.1	29	124	14.2	57

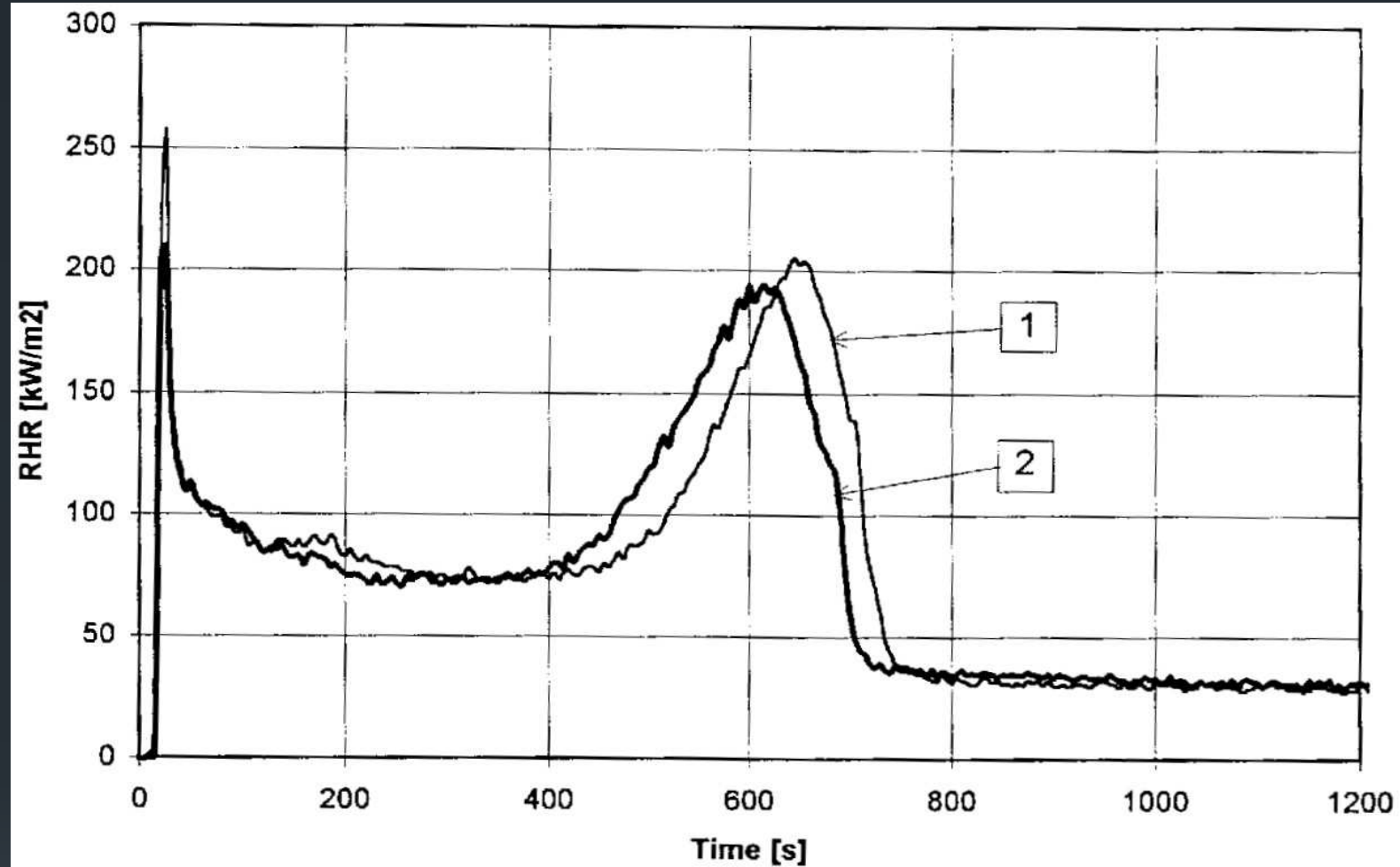
D<sub>w</sub>– density of wood in dry air state; M<sub>c</sub> – content of dry modifying substance; LOI – limited oxygen index; t<sub>i</sub>– time for ignition; RHR<sub>300</sub> – released heat in the course of 300 s after ignition with respect to the exposed area; EHC – effective heat of combustion with respect to mass loss; SEA –specific eclipse area with respect to mass loss, i.e. a parameter characterizing the release of smoke during wood combustion.



### Thermogram of natural Scots pine sapwood

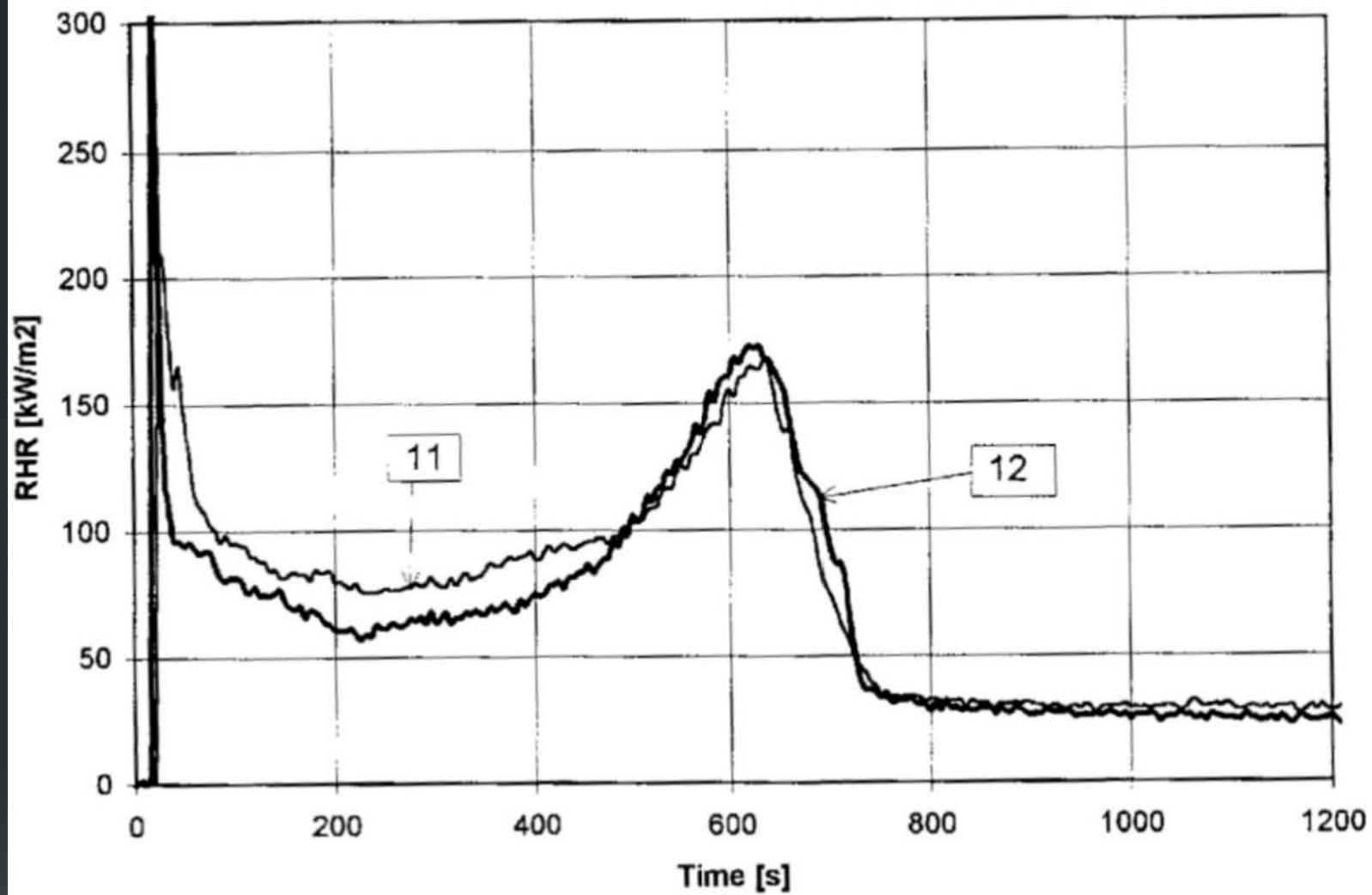
The exothermal peak of combustion for the untreated wood appears at 670 s, the released heat being 120 kW/m<sup>2</sup>.





## Thermograms of pine sapwood treated with Fosfamin 1

- The maximum of the exothermal peak occurs at 600 s, the released heat being respectively 200 kW/m<sup>2</sup>.



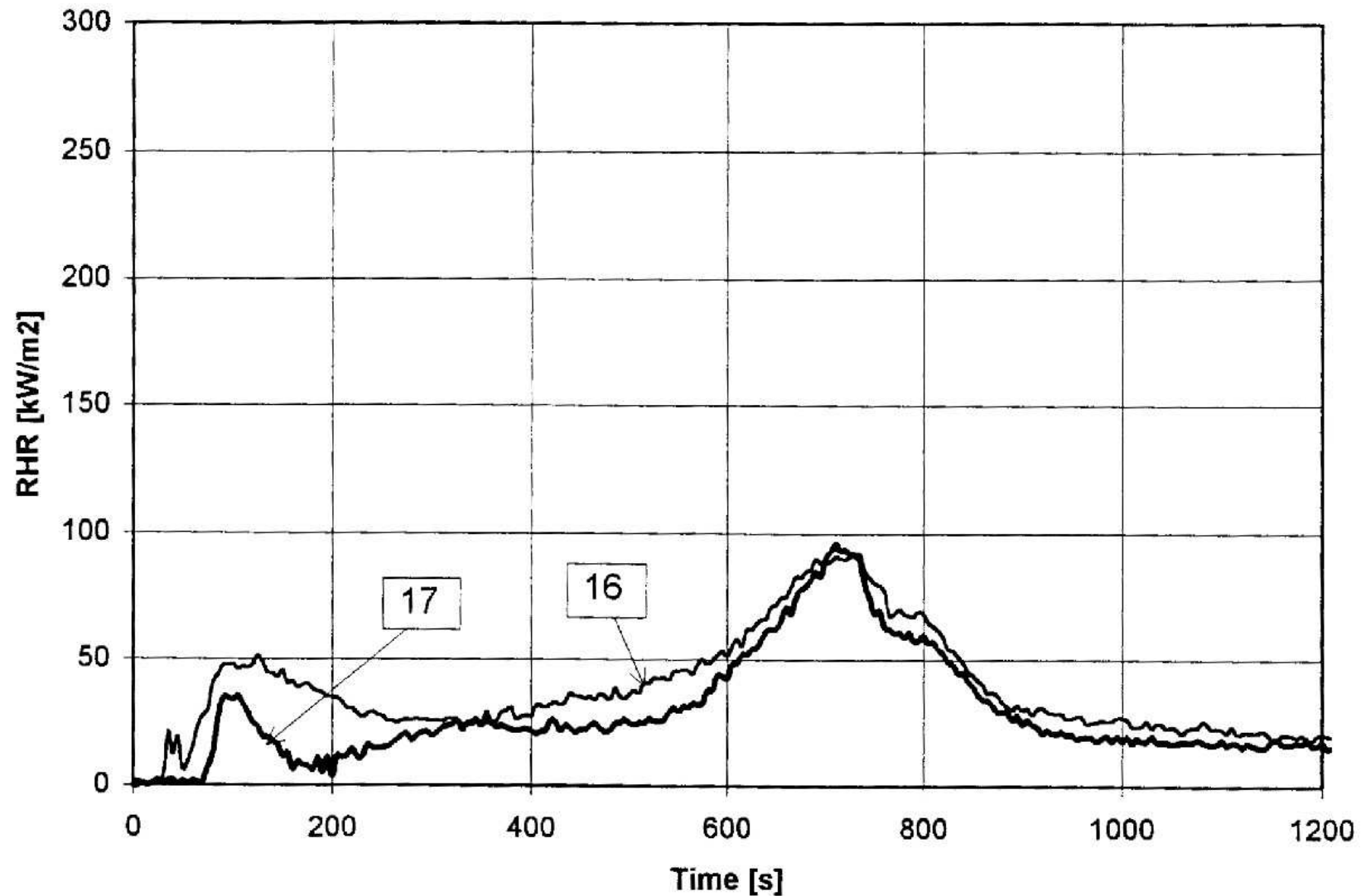
### Thermogram of pine sapwood treated with the Fosfamin 2

- It is seen that the maximum of the exothermal peak occurs at 610 s, the released heat being with values of 170 kW/m<sup>2</sup>.

# Results and analysis



- Pine sapwood treated with Fosfamin 1 contained elements of nitrogen (0.4 %) and phosphorus (0.2 %). The totally amounts of nitrogen and phosphorus is 0.6 %. This corresponds also to increased oxygen index with values of 26 %.
- Pine sapwood treated with Fosfamin 2 contained nitrogen (0.35 %) and phosphorus (0.67 %), i.e. the total amount of nitrogen and phosphorus is 1.02 %. The oxygen index is 46 %.
- The time for ignition of this material is a bit lower than that for natural wood.



### Thermogram of Scots pine sapwood treated with the Karbofenor

The maximum of the exothermal peak occurs after 710 s, the released heat being with values of 90 and 95 kW/m<sup>2</sup>.

The oxygen index is 33.6%.

- The ignition of pine wood modified with Karbofenor occur after 90 seconds.
- Pine sapwood treated with Karbofenor contained elements of nitrogen (1.65 %) and phosphorus (0.85 %). The total amount of nitrogen and phosphorus is 2.5 %.
- The pine wood modified with Karbofenor has also the lowest effective heat of combustion with respect to mass loss – 5.3 MJ/kg. This material releases the lowest amount of heat during the first 300 s after ignition with respect to the exposed area (19 kW/m<sup>2</sup>).
- The pine wood modified with Karbofenor releases also the lowest amount of smoke. The specific eclipse area with respect to mass loss is 29 m<sup>2</sup>/kg.

# Conclusions:



- Based on the results we can conclude that **wood modified with chemical compositions** (Fosfamin 1, Fosfamin 2, and Karbofenor ) has reduced combustibility, i.e. **emits less heat compared to natural wood**.
- **The reduced combustibility is due to the synergism** between the elements nitrogen and phosphorus.
- The wood modified with **Karbofenor** yields **most stable** results about **reducing combustibility**.
- Thermal destruction of **pine wood modified with Karbofenor is attended by absorption of heat** and the inhibition of the combustion process results from the cooling.



Thank you for your attention!!!

