Fire retardant coatings based on aluminium hydroxide, casein, and mica for wood, engineered wood and wood-based products

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Introduction

To extend the use of wood as a building materials requires meeting fire safety rules and regulations. Fire retardants, which produce no toxic and carcinogenic effect while burning, would full fill the necessary fire safety regulations including euro code. Bio-based fire retardants would be one of the potential candidate for mitigating fire sensitivity of wood. The current study focuses on developing bio-based fire-retardant coatings using biopolymer and selected inorganic minerals for wood.

Materials

As nontoxic and cheap chemicals we chose the following to prepare suspensions and composites:

Casein (C)

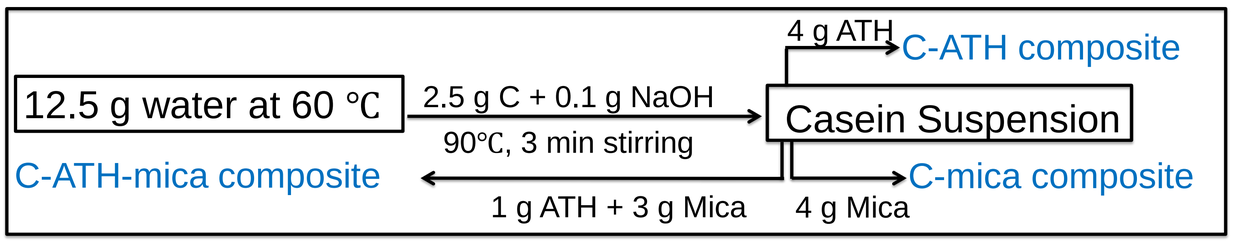
Sodium hydroxide (NaOH)

Aluminium trihydroxide $Al(OH)_3$ (ATH)

Mica nanomaterial $(Na^+[AlSi_3O_{10}].(OH)_2$

Coatings for wood

Suspension of casein and three chemical composites were prepared using the following method and pine wood coated as shown below. Coating composition and weight of the coating on the surface of each sample are listed as follows:



Sample code	Coating composition	Wt of wood (g)	Coated wood wt (g)	Coating wt (g)	Coating wt (g/m²)
Reference	Uncoated wood	80.5	-	-	-
Sample 1	2.5 g C suspension	99.5	100.95	1.45	145.0
Sample 2	2.5 g C + 4 g mica	110.39	116.86	6.47	647.05
Sample 3	2.5 g C + 4 g ATH	100.95	105.98	5.03	502.6
Sample 4	2.5 g C + 3 g mica + 1 g ATH	121.18	126.57	5.39	538.66

(a) Casein suspension

(b) Casein-Mica

(c) Casein-ATH

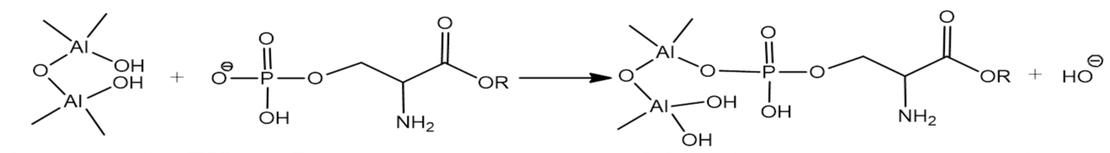
(d) Casein-ATH-Mica

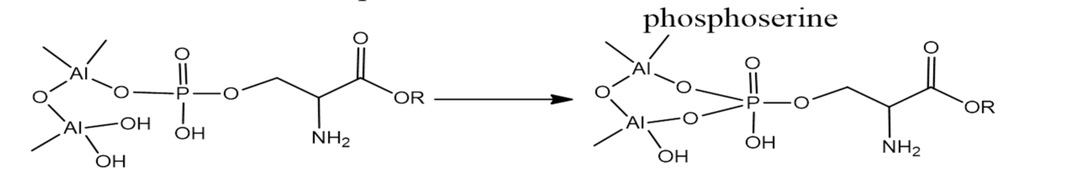
Fire retardancy assessment

The fire extinguishing property of the prepared composites was assessed by cone calorimeter. The combustion parameters e.g. time to ignition (TTI), peak heat release rate (PHRR), total heat released (THR) and total mass loss (TML) were investigated.

Interaction between casein and inorganic minerals

Casein is a phosphoprotein of different amino acids which can interact with selected mineral surface in the following pattern:





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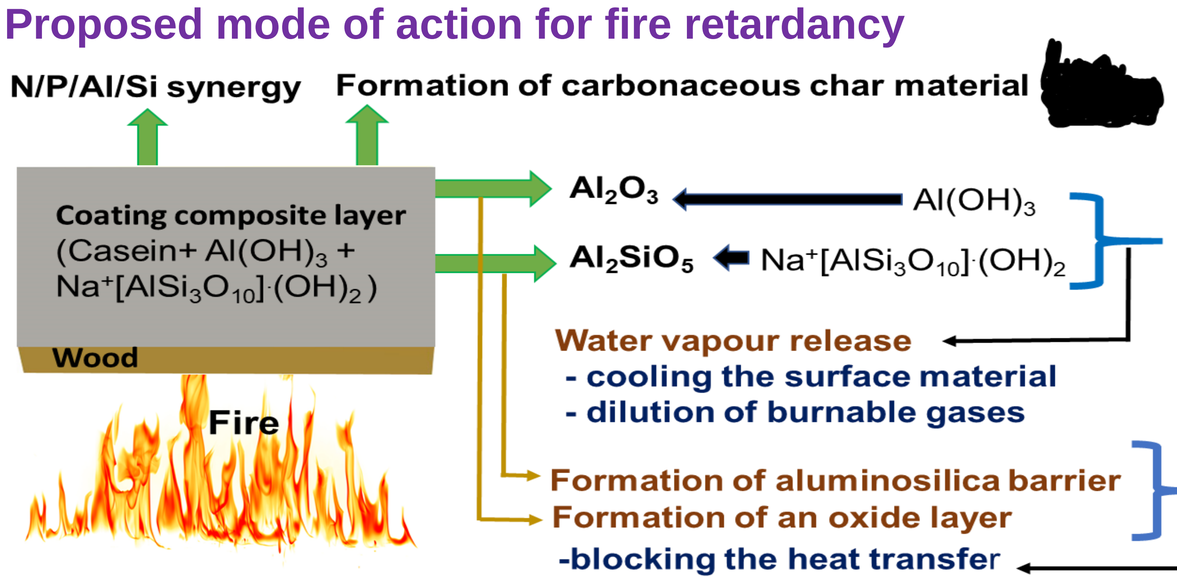
Proposed mode of action for fire retardancy

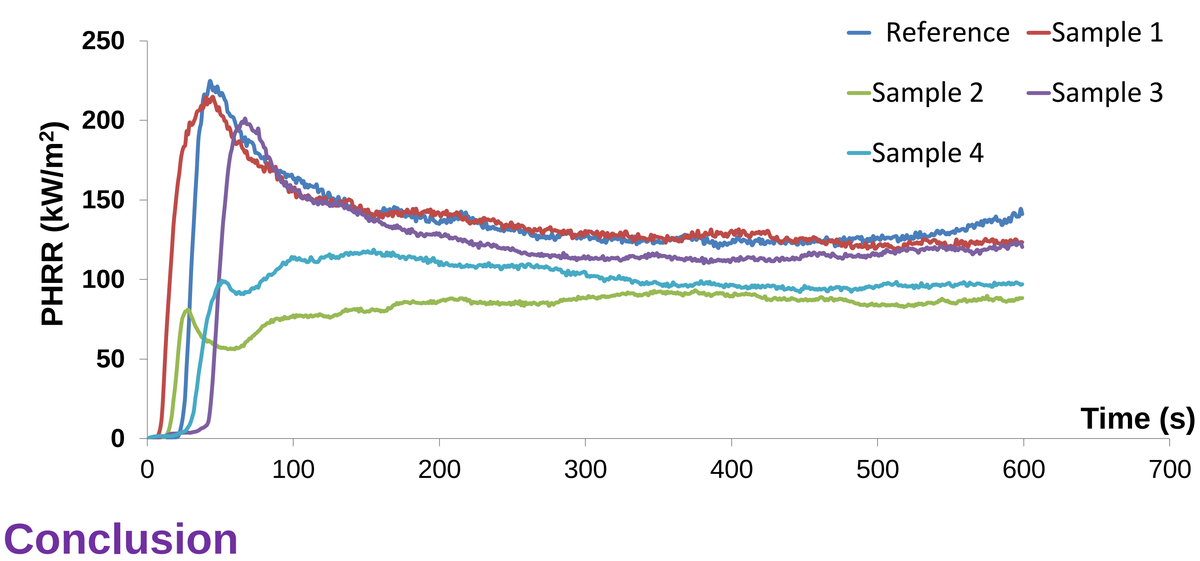


Results and discussion

The cone calorimetric results of all the samples showed improvement of fire retardancy except sample 1. The TTI of sample 2 is lower than sample 3 due to the lower specific heat capacity of mica in comparison to ATH.

However, the PHHR, THR and TML of sample 2 was reduced greatly than sample 3 because mica acts as a char promoter through slowing the degradation of polymer compounds of wood and providing intumescent char in combination with the aluminosilica barrier [1] which block the heat transfer resulting in producing the lowest PHHR from the sample 2 shown below. The TTI of sample 4 was also increased with respect to sample 2 due to the incorporation of 1 g of ATH as a substitute of mica.

Sample code	TTI (s)	PHRR (kW/m²)	THR (MJ/m²)	TML (g)
Reference	12.1	216	79.5	46.6
Sample 1	6.5	214.8	85.7	51.8
Sample 2	16.6	97.3	49.8	37.0
Sample 3	41.7	202.6	70.4	46.0
Sample 4	31.0	149.9	57.6	41.0



Conclusion

Prepared composites can retard fire spread through creating multiple modes of physical and chemical actions. The compact composite surface can, without the unwanted crack formation, release water vapour and generate thermally stable metallic oxide and aluminosilica barrier layer. Sample 2 reduced the PHHR by 55% and sample 4 with added ATH increased the TTI by 156% with respect to the reference.

Acknowledgement

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Reference

1. S. Bourbigot, J. W. Gilman and C. A. Wilkie, *Polym. Degrad. Stab.*, 2004, 84, 483.