Thermal behavior of zinc borate-treated wood

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Contents

I. Introduction

- Zinc borate is a white, oderless powder.
- Zinc borate has ben used industrially since the 1940s.
- The most widely used ZnB formulation:

($ZnO.\ 3B_2O_3.\ 3H_2O$)

- Zinc Borate is used as a flame retardant and smoke suppressant for wide range of plastics, rubbers, papers, textiles and wood products




- Fire Retardant Properties of Zinc Borate

- Emits non flamable gases like water, carbon dioxide, sulfur dioxide, hydrogen chloride *etc*. via endothermic reactions.

- Endothermic reactions cool the surface of substrates and reduce the formation of pyrolysis products.

- Zinc borate dehydrates endotermically, and the hydrate water vaporizes and absorbs heat.

- Zinc borate can also melt to form a glassy layer covering the thermal decomposable surface at sufficently high temprature.
- This layer produces a thermal barrier.

II. Material and Methods

- **Preparation** and **Treatment of Wood Specimens**

- Wood specimens measuring 19(*T*)×19(*R*)×19(*L*) mm were cut from sapwood portions of Scots pine (*Pinus sylvestris* spp.) tree

- ZnB solutions were prepared by using 1% HCI (37%, Merck, Germany) because of its low solubility in water. ZnB was supplied by Eti Boron Inc., Bandırma, Turkey.

- Specimens were vacuum treated with aqueous solutions of ZnB at 0.10, 0.50 and 2% concentrations.

- In the treatments, the pressure cycle consisted of a 30-min vacuum (88 kPa absolute pressure) in a treatment desiccator.

ZnB concentration [%]	Retention [kg/m^3]
2	14.75
0.5	3.65
0.1	0.75

- Thermal Analyses

- Treated and untreated wood specimens from each group were dried at 60°C to constant weight, ground and sieved.

- Treated and untreated wood dust, approximately 230-270 mesh, was used for thermal analyses.

- Perkin Elmer Diamond TG\DTA.

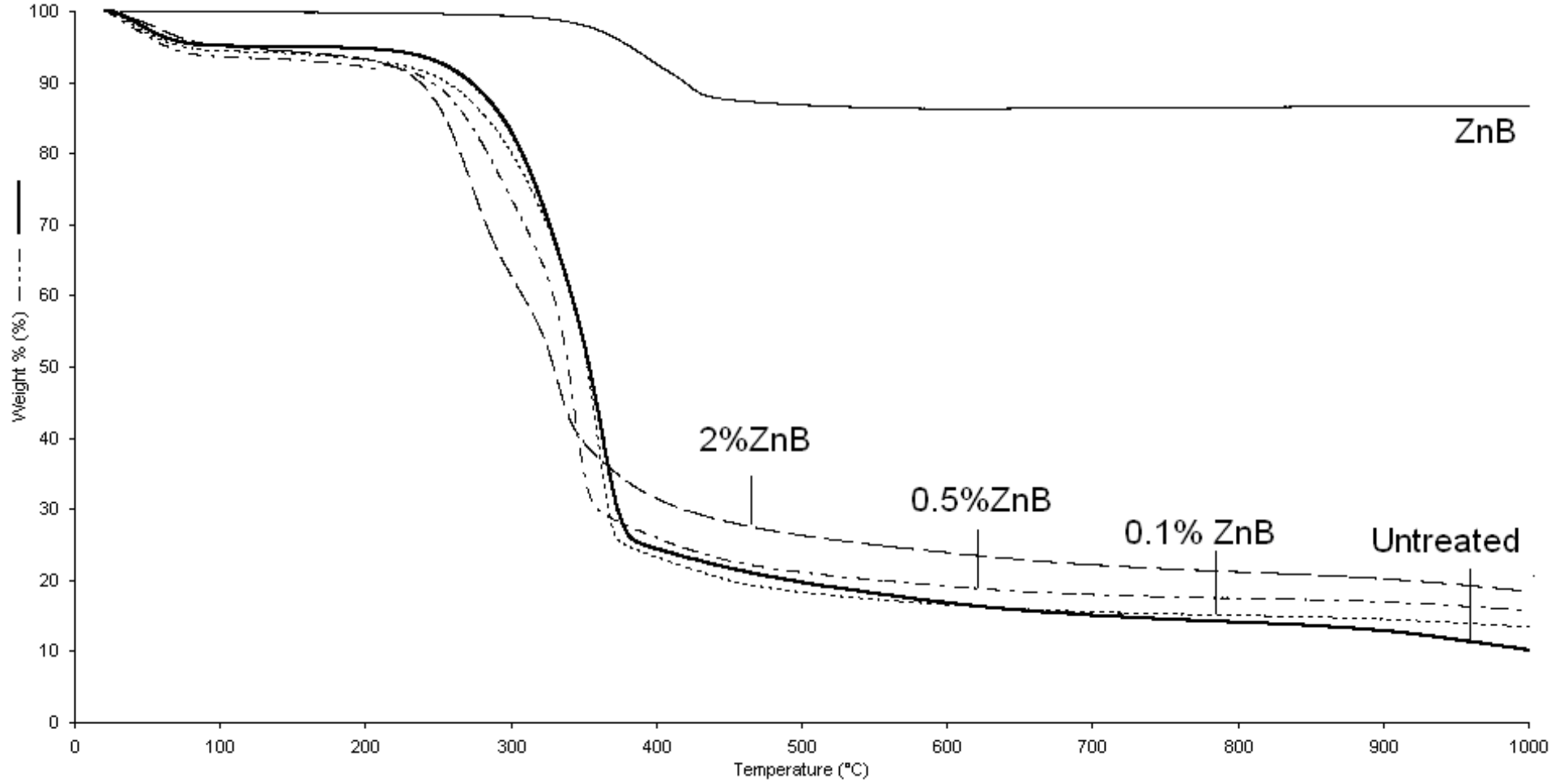
Nearly 4 mg of wood dust samples

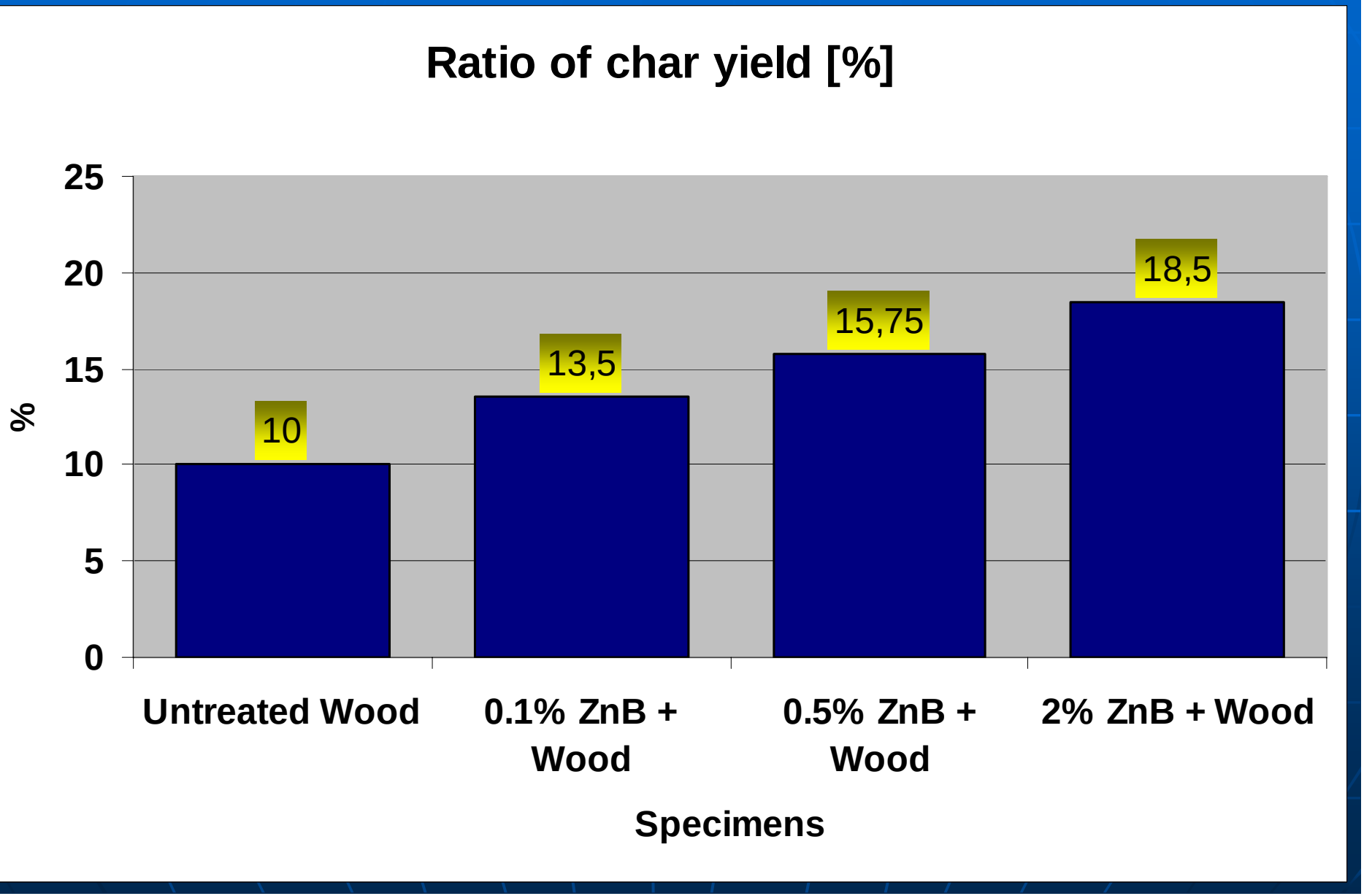
- Flow rate is 100 ml/min nitrogen
- Heating rate is 10 °C/min
- From room temperature to 1000°C.

RESULTS AND DISCUSSION

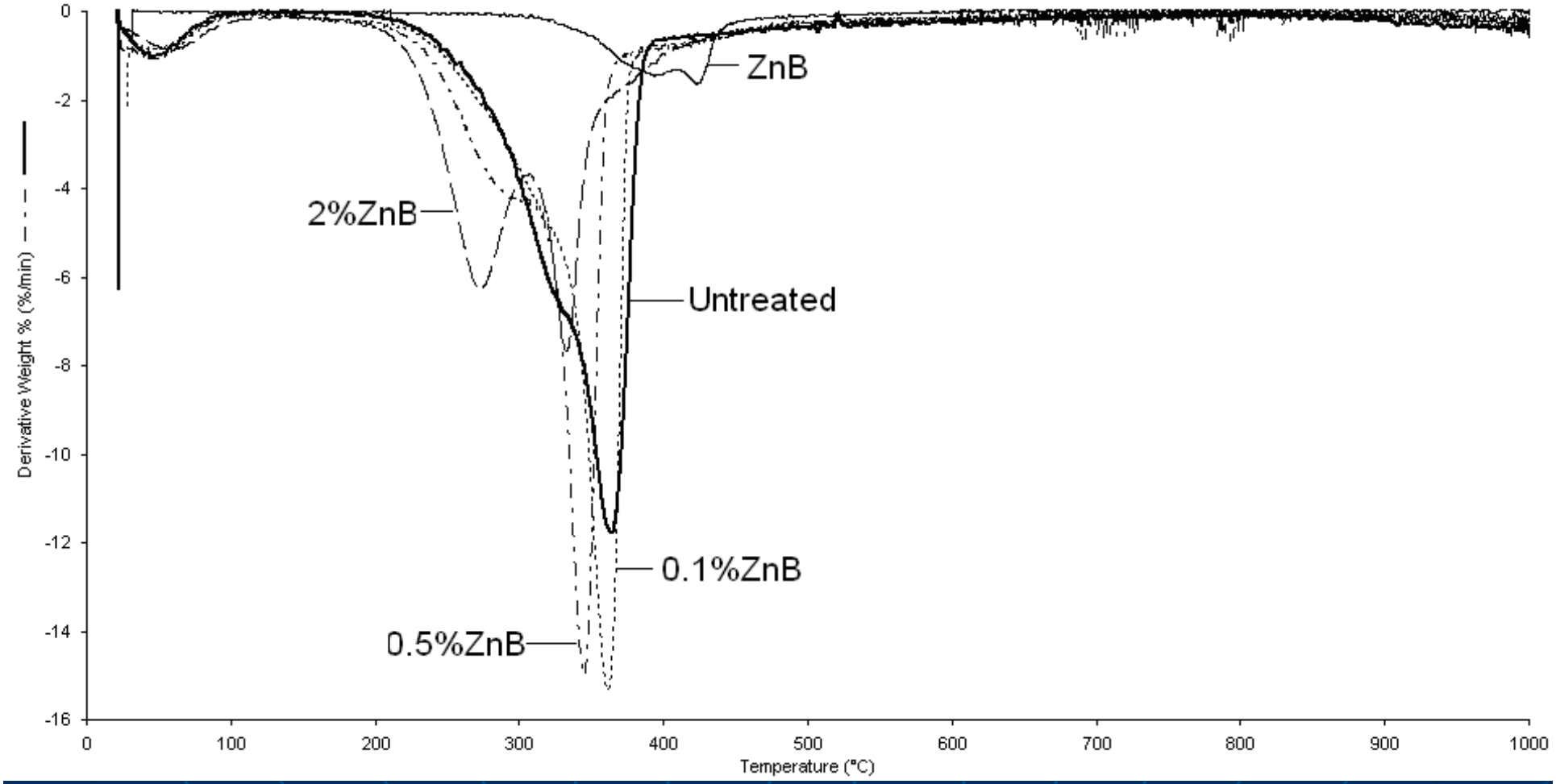
The effectiveness of such a compound as flame retardant can be measured as a function of the temperature at which maximum pyrolysis occurs and the amount of char formed

Comparison of TG curves of untreated and ZnB treated wood samples

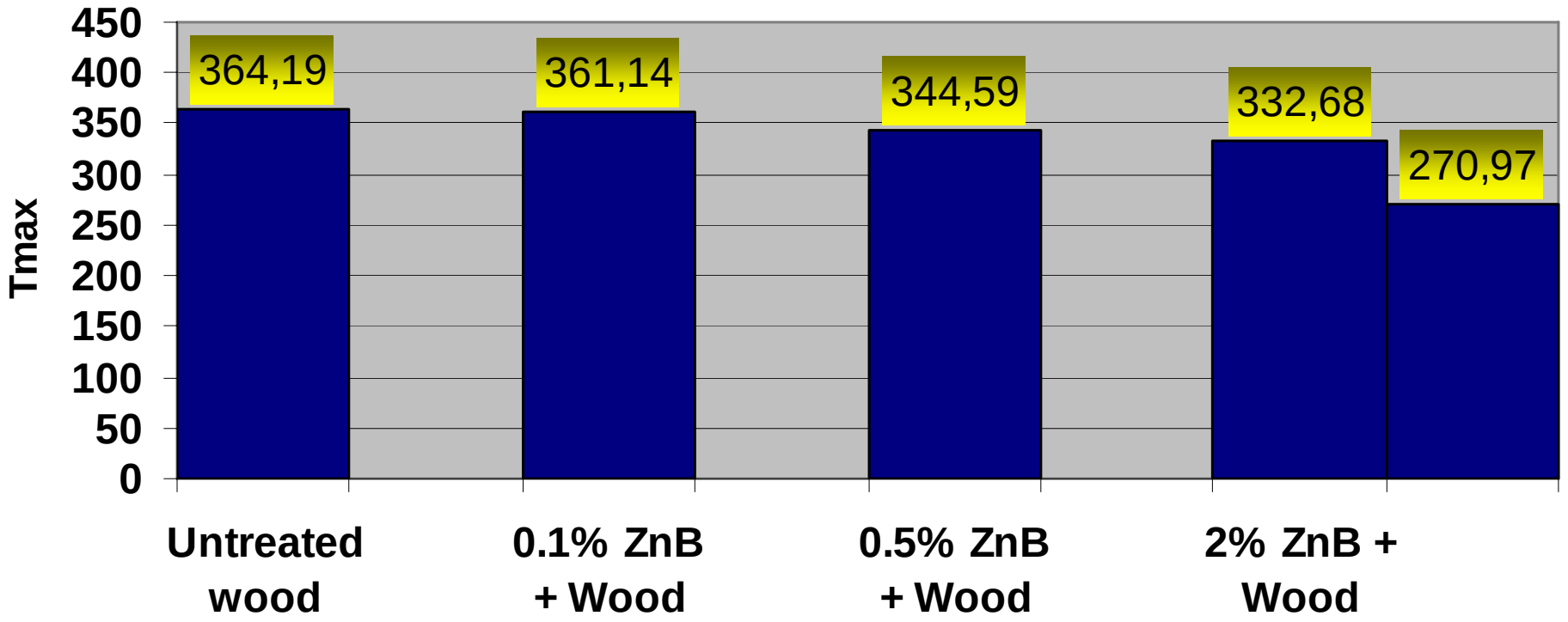



Ratio of char yield [%]
25
20
15
10
5
0
%
10
13,5
15,75
18,5
Untreated Wood
0.1% ZnB + Wood
0.5% ZnB + Wood
2% ZnB + Wood
Specimens

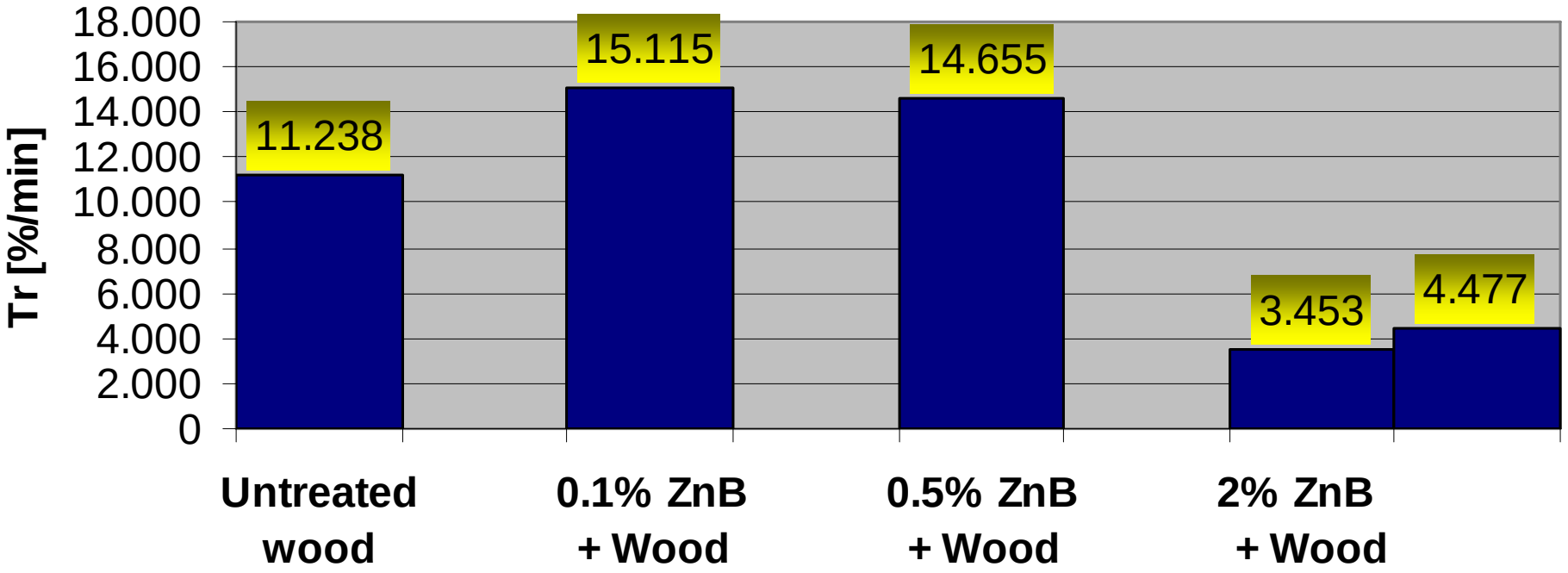
Comparison of DTG curves of untreated and ZnB treated wood samples

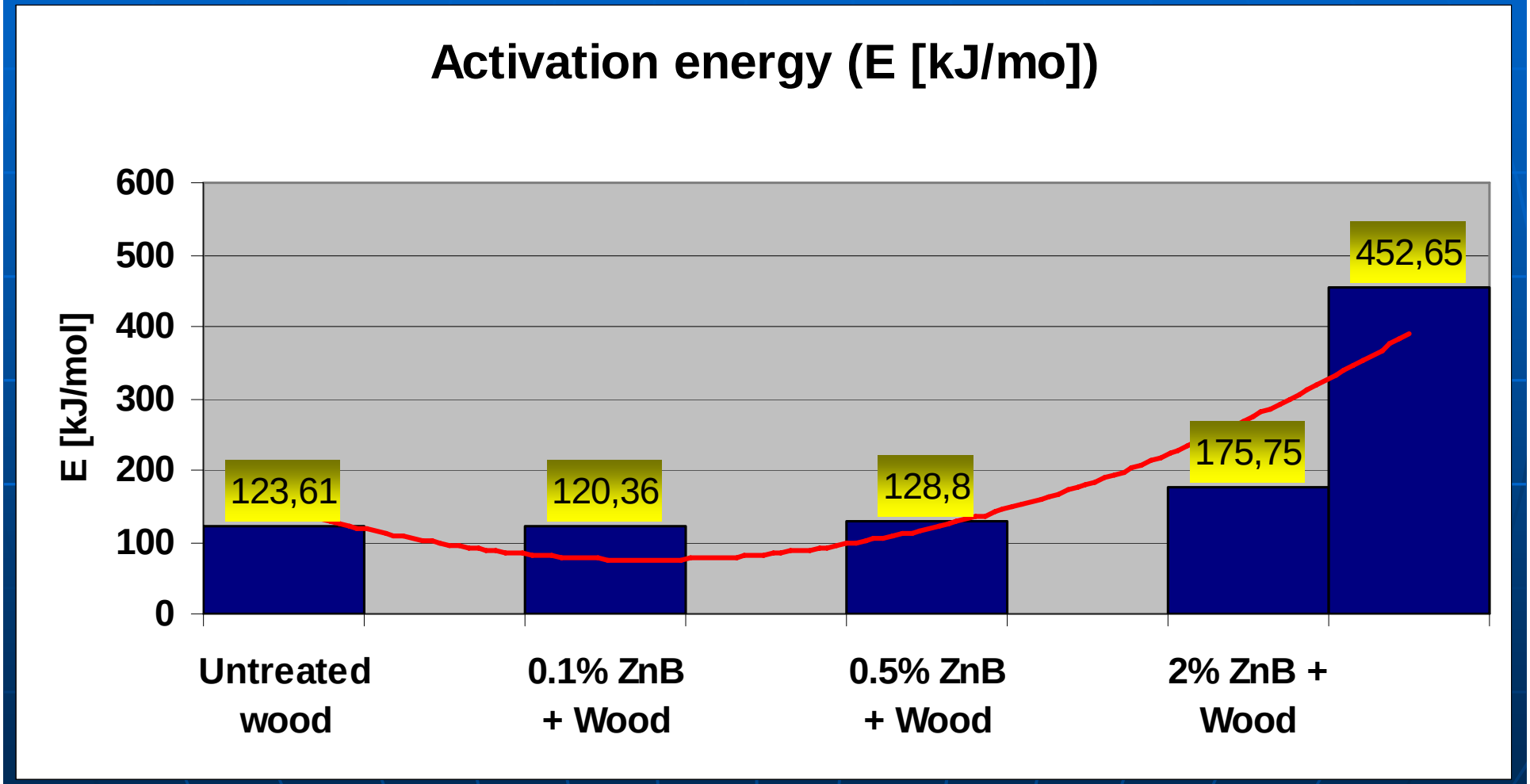


Maximum thermal decomposition temperature (Tmax [°C])



Maximum thermal decomposition rate (Tr [%/min])




Activation energy (E [kJ/mo])
E [kJ/mol]
600
500
400
300
200
100
0
123,61
120,36
128,8
175,75
452,65
Untreated wood
0.1% ZnB + Wood
0.5% ZnB + Wood
2% ZnB + Wood

Conclusion

- Reduction in the maximum thermal decomposition temperature means that decomposition reactions get easier and finish at lower temperature.
- As a result of these impacts, flammable volatile compounds which compose at high temperature can’t emit from wood surface.

- In this study, we found char forming increased while maximum thermal decomposition temperature decreased and eventually ZnB-treated wood was more resistant to thermal decomposition than untreated wood, especially at 2% ZnB concentration level.

- The char yield of ZnB-treated wood was higher than that of untreated wood and this difference increased with increased ZnB concentration

- When maximum thermal decomposition rate was evaluated, this value increased in wood specimens treated with 0.1% and 0.5% ZnB solutions.
- But if ZnB concentration increased to 2.0%, thermal decomposition rate was four times slower when compared to control specimens

- Overall, wood specimens treated with 2% ZnB solution showed better resistance against thermal decomposition.

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Questions?