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Combustion properties of alder (*Alnus glutinosa* L.) *Gaertn.* subsp. *barbata* (C.A. Mey) Yalt.) and southern pine (*Pinus sylvestris* L.) wood treated with boron compounds

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Abstract

Samples from alder (*Alnus glutinosa* L.) *Gaertn.* subsp. *barbata* (C.A. Mey) Yalt.) and southern pine (*Pinus sylvestris* L.) wood were impregnated with boric acid, borax and their mixed solutions according to ASTM D 1413-88 in order to determine their combustion properties.

In this study, the fire resistance properties of wood treated with boron compounds were investigated. In addition, the models for each wood species and fire retardant solution were also determined. The results demonstrated that the lowest mass losses for both alder and southern pine specimens treated with a mixture of 5% boric acid and borax aqueous solutions were found to be 68.72% and 72.37%, respectively. It was found that 5% of borax was the most effective treatment in terms of lengthening the time of glowing.

Keywords: Boron; Fire resistance; Alder wood; Southern pine

1. Introduction

The borate chemicals offer substantial advantages for wood protection, providing fire resistance as well as efficacy against both fungi and insects, low cost, ease of handling and treatment. Boron wood preservatives have been used for many years and there is growing interest in their low mammalian toxicity and environmental acceptability [1]. Boric acid and borax are most common boron compounds which have found many application areas in the wood preservation industry in order to get the benefit of their biological effectiveness and fire retardancy [2,3].

Boric acid and borax mixtures have some efficacy in retarding the spread of fire on wood surface. In addition to the usual char-forming catalytic effect, they have a rather low melting point and form glassy films when exposed to high temperatures in fires. Borax tends to reduce fire spread but can promote smoldering or glowing. On the other hand, boric acid suppresses smoldering but has little effect on fire spread. Therefore, these compounds are normally used together [2,3].

Wood has many good properties from the point of view of processing, physical and mechanical properties, aesthetic, environmental and health aspects. In many countries, wood is widely used as a building material and in some areas as the main construction material [4]. Wood (unlike steel and concrete) is a combustible material, and certain types of constructions (defined by the Code) do not permit the use of combustible materials. There are arguments for and against this type of restriction, but these limitations do exist. The fire-resistive requirements are very important to the building designer [5]. For this reason, predicting the models for thermal degradation of untreated and boron-treated wood is very important.

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In this study, the fire resistance properties of alder and pine wood treated with boron compounds and their models were investigated.

2. Material and method

2.1. Material

Sapwood of alder wood (*Alnus glutinosa* (L.) *Gaertn.* subsp. *barbata* (C.A. Mey) Yalt.) and southern pine (*Pinus sylvestris* L.) samples were used. The wood samples were obtained from northeastern part of Turkey, along the Black Sea coast. The densities of alder wood and southern pine samples were 0.503 and 0.52 g/cm^3, respectively. The samples were cut into 13 × 13 × 76 mm (radial by tangential by longitudinal). The wood samples were prepared according to ASTM E 160 [6].

The solutions of boron compounds, (boric acid, borax) alone or in mixed forms, were used. The concentrations of chemicals used in this study are given in Table 1.

Table 1
Retentions of treatment chemicals

Boron compounds	Retention (kg/m^3)[a]	Retention (kg/m^3)[b]
	Mean	Mean
Control	–	–
Boric acid (1%)	6.53 (0.55)[c]	5.29 (1.32)
Boric acid (3%)	19.09 (2.04)	17.67 (2.38)
Boric acid (5%)	32.11 (3.11)	32.85 (3.27)
Borax (1%)	6.30 (0.38)	6.24 (0.98)
Borax (3%)	19.42 (1.96)	19.61 (2.41)
Borax (5%)	32.24 (3.13)	31.99 (3.34)
Boric acid + borax (1%)	6.12 (0.77)	5.93 (0.98)
Boric acid + borax (3%)	18.13 (1.91)	17.43 (2.19)
Boric acid + borax (5%)	29.88 (2.94)	31.02 (3.21)

[a] Retention for alder wood.
[b] Retention for southern pine wood.
[c] The values in the parenthesis indicates standard deviation.

2.2. Method

2.2.1. Impregnation procedure

Test samples were impregnated with boric acid (1%, 3%, 5%), borax (1%, 3%, 5%) and boric acid + borax (1%, 3%, 5%) with vacuum for 30 min and at ambient pressure for 30 min according to ASTM D 1413 [7]. The wood samples were then removed from the treatment solution, wiped lightly to remove solution from the wood surface, and weighed (nearest 0.01 g) to determine gross retentions for each treating solution and sample. The gross retentions for each treatment solution were calculated according to the following formula:

$$R = \frac{G \times C}{V} \times 10 \quad \text{kg/m}^3, \tag{1}$$

where G: (T_2–T_1) is grams of treating solution absorbed by samples (initial weight of block subtracted from the initial weight plus the treating solution absorbed); C is the grams of preservative or preservative solution in 100 g of the treating solution; and V is the volume of samples in cubic centimeters.

2.2.2. Fire test method

Fire test for the wood specimens was performed according to ASTM E 160. Specimens were conditioned at 27 ± 2 °C and 30–35% relative humidity to the targeted equilibrium moisture content of 7% prior to fire testing. The 24 specimens were arranged into 12 layers shaped like a square prism (Fig. 1).

The heating flame was connected to an LPG tank controlled by a sensitive bar-gauged valve. The flame was balanced the standard height before the fire test samples' frame was put in position. Then, fire testing was performed with a flame source, without a flame source and at the glowing stage according to ASTM E 160. Temperature was recorded as a celsius degree (°C) at the combustion column by a thermocouple at 15, 30 s and thereafter at 30 s

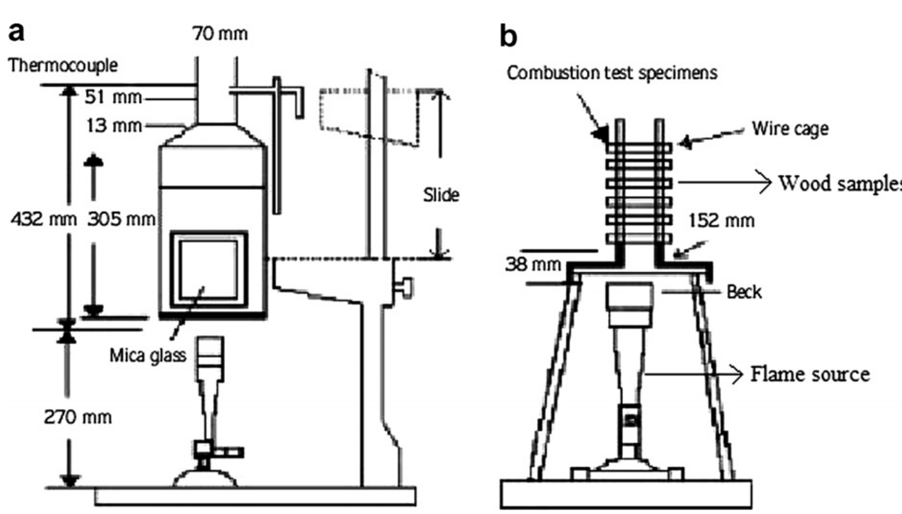

Fig. 1. Fire test apparatus.