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Increasing the fire resistance of particleboard used in architecture with colophony doped boron compounds

Mimaride kullanılan yonga levhaların kolofan katkılı borlu bileşikler ile yangın dayanımının artırılması

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Increasing the Fire Resistance of Particleboard Used in Architecture with Colophony Doped Boron Compounds

Highlights

- *Colophony added boron compounds can be mixed with Urea Formaldehyde adhesive as impregnation material during particle board production.*
- *Colophony added boron compounds (Bx) decrease Flame sourced Combustion (FsC), Self-Combustion (SC) and Glowing period (Gp) temparatures of particle boards*
- *Colophony and Borax based impregnation material decrease weight loss raito of particle board samples after combustion process*
- *Colophony added boron compounds extends combustion period of particle board test samples*
- *Mechanical and Physical features of particle boards after impregnation with Colophony added boron compounds have to be performed separately*

Graphical Abstract

Colophony-added boron compounds (Bx) reduce Self- Combustion temperature (SC) (av. 5%) when compared to the test samples and they can be used as fire retardants in architecture to increase fire safety in particleboard production.

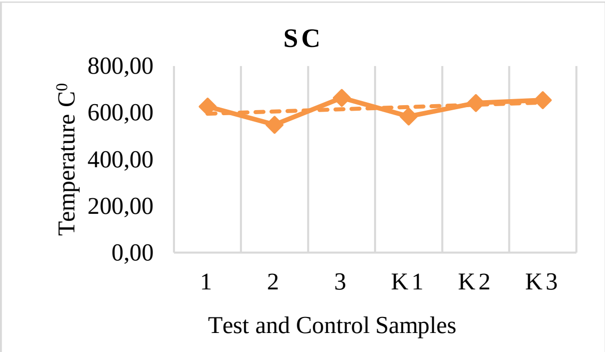

Figure. Self- Combustion (SC) values of test samples

Aim

This study aims to determine impact of colophony and boron mixture on combustion performance of particle boards.

Design &Methodology

Colophony added Boron compounds have been applied through experimental way according to the standarts. Test samples that are made of particle boards, were manufactured with addition of Colophony added Boron compounds and combusted in accordance with related standarts.

Originality

Colophony which provides stability of boron compounds after impregnation in wood material, has not been used as fire reterdant with boron compounds in particle board industry. From this point of view this study is original.

Findings

Colophony added Boron compounds reduces combustion temparatures, weight loss ratio and extends combustion period of particle boards made of pine chips. Colophony added Boron compounds

Conclusion

Colophony added Boron compounds can be preffered as fire retardant agent for particle boards in architecture. However mechanical and physical properties of manufactured particle board have to be studied.

Declaration of Ethical Standards

The authors of this article declare that the materials and methods used in this study do not require ethical committee permission and/or legal-special permission.

Increasing the Fire Resistance of Particleboard Used in Architecture with Colophony Doped Boron Compounds

Araştırma Makalesi / ResearchArticle

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ABSTRACT

One of the important factors that should be considered in architecture is the fire resistance of the materials used. This study, it is aimed to increase the fire resistance of particleboards, which are widely used in architecture. For this purpose, it is aimed to improve the fire resistance by using a new type of impregnation material obtained by modifying boron compounds with rosin additive. Within this context, particleboard samples prepared in accordance with TS 642 ISO 554 were sized according to ASTM-E 160-50. Combustion tests of prepared samples were done in accordance with ASTM-E 160-50 E, and the values obtained through the tests on the basis of burning time, weight loss ratios, FsC, SC, Gp temperatures were compared with the control samples. As a result, it was observed that average temperature values of FsC, SC decreased by 5%, Gp decreased by 1,8%, weight loss was reduced by 0,5% and the combustion period was increased by 2%. This case can be taken into account in the field where particleboard is used with high fire risk in architecture.

Keywords: Architectural materials, particleboard, boron compounds, colophony, combustion resistance.

Mimaride Kullanılan Yonga Levhaların Kolofan Katkılı Borlu Bileşikler ile Yangın Dayanımının Artırılması

ÖZ

Mimaride göz önüne alınması gereken önemli faktörlerden birisi de kullanılan malzemelerin yangın dayanımıdır. Bu çalışmada, mimaride yaygın olarak kullanılan yonga levhaların yangın dayanımlarının artırılması amaçlanmıştır. Bu maksatla borlu bileşiklerin kolofan katkısı ile modifiye edilmesinden elde edilen yeni tip emprenye maddesi kullanılarak yanma direncinin artırılması hedeflenmiştir. Bu kapsamda TS 642 ISO 554'e uygun oalrak hazırlanan yonga levha örnekleri ASTM-E 160-50'ye uygun olarak boyutlandırılmıştır. Hazırlanan numunelerin yanma deneyleri ASTM-E 160-50 E'ye göre yapılmıştır. Deneylerde yanma süresi, ağırlık kaybı oranları, AKY, KKY, KHY sıcaklıları belirlenerek kontrol numuneleri ile karşılaştırılmıştır. Sonuç olarak yeni tip emprenye maddesininAKY, KKY sıcaklık değerlerinde ortalama %5, KHY sıcaklık değerlerinde % 1,8, ağırlık kaybında %0,5 düşüş ve yanma süresinde %2 oranında artış sağladığı ölçülmüştür. Mimaride yangın riski yüksek olan yonga levha kullanım alanlarında bu durum dikkate alınabilir.

Anahtar Kelimeler: Mimari malzemeler, yonga levha, borlu bileşikler,kolofan,yanma direnci.

1.INTRODUCTION

Wood is a renewable natural polymeric material, which is found in large amounts in nature, mainly consisting of cellulose, hemicelluloses, and lignin. Compared to other materials used in thearchitecture, wood material is highly preferred due to its ease of processing and shaping, its high resistance and its unique aesthetic structure [1]. Particleboards are boards formed by shaping wood (wood chips, sawdust, etc.) and/or other lignocellulosic fibrous material (flax, hemp fibers, sugar cane, etc.) under temperature and pressure with the addition of glue [2].

Particleboards are a wood material with properties of both high, medium, and low operating (absorbing and giving water), depending on the adhesive and hydrophobic substances inside in terms of chip geometry. Factors affecting the properties of particleboards are; wood type, specific gravity, compression ratio, pH, extractive substances, permeability, wood moisture, pressing conditions, glue type and amount [3], [4]. Particleboard production stages are shown in Fig 1. The first ideas about wood-based composite boards were mentioned in 1887 by Ernst Hubbard in his publication

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"Evaluation of Wood Waste". Utilizing sawdust and blood albumin glue, Ernst Hubbard produced composite panels with the application of heat and pressure. The first factory producing composite particle board for commercial purposes was established in 1941 by Torfit-WerkeAg company in Bremen city. Wood-based composite boards produced in this factory are produced from spruce chips using phenol resin [5].

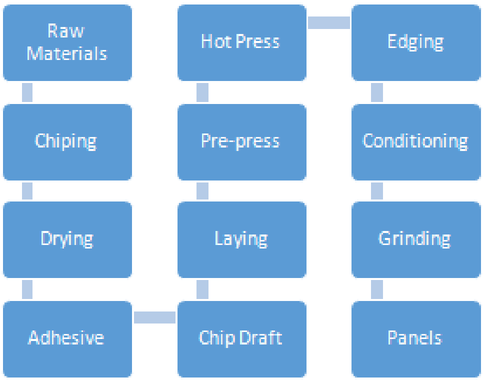

Figure 1. Workflow Chart in Particle Board Production [6].

In a study conducted by Baysal et al., Borate treatment developed a higher rate of burning resistance on calabrian pine test specimens compared to the test specimens impregnated with plant extracts [7].

Thermal and fire retardant effects of boric acid and borax on wood-plastic composites were investigated by Altuntaş et al. According to the obtained TGA results, in case of amount of boron compound increases in the composite material, the decomposition temperatures of both the lignocellulosic material and the plastic material increase[8].

In a study conducted by Özdemir and Tutuş, it was determined that Borax, used as a fire retardant in high density fiberboard (HDF), reduced weight loss rates by 9% compared to control samples. In addition, increasing the concentration amount decreased the burning amount [9]

Çavdar et al., researched polyethylene added Spruce wood flour treated with boron compounds and they tested combustion and mechanically. According to the study Boron-based fire retardants (BpFRs) increased the Limit Oxygen Index (LOI) and carbonization, while reducing the rate of combustion by 50% [10].

In a study conducted by Özdemir and Ayaz, it was aimed to determine the effect of ammonium polyphosphate (APP) and boric acid (BA) added to the surface coating of MDF boards on the burning resistance. Considering the rates of fire retardant chemicals, it has been determined that the most effective fire retardant in reducing the combustion temperature is 5% Boric Acid (278 ^{0}C). The amount of oxygen during flame sourced combustion has been increased by using fire retardants. [11].

In the study conducted by Var, the effects of impregnation materials such as rosin, Tanalith-C, Alkyd resin, Immersol WR were insignificant, considering the fire-induced combustion, boric acid / Borax mixture significantly affected the burning resistance of the particle board in terms of the inclusion rate of the impregnation agent [12].

Ustaömer and Usta produced medium density fibreboards (MDF) with the addition of various fire retardant boron compounds and using ureaformaldehyde glue. In their study, they determined that the highest heat resistance was obtained from the MDF samples produced with borax. [13].

Özdemir, manufactured HDF board by using Scotch Pine and Beech fibers in equal proportions. During production, different amounts of dolomite additives were added into the fibers as a fire retardant. It has been determined that dolomite mineral affects the fire resistance of HDF boards positively and improves depending on the rate of addition. In the LOI test, the most favorable fire resistance feature was achieved with 25% dolomite additive [14].

The wood material is a substance that can burn and catch fire. Burn-retardant impregnants decompose below the decomposition temperature of the wood material and rapidly transform cellulose into charcoal and water. Thus, since volatile and flammable substances that will form at higher temperatures do not occur, the flammability of wood decreases and the flame is prevented from spreading to the environment [15].

Particleboards, which are an industrial material and frequently used in the field of furniture design, also have the potential to burn, as the residues of wood materials and plant fibers are used predominantly. In a study conducted in this context, dolomite additive was used to increase the fire resistance of high-density fiberboard, and it was found that dolomite mineral positively affected the fire resistance of HDF boards and improved depending on the rate of addition [16].

In a study, colophony hasa positive impact on the leaching performance of impregnation materials toabsorb boron compounds in wood material against biotic and abiotic factors [17].

The impregnation process is an industrial application to protect the wood material against biotic and abiotic factors and fire. However, fire-retardant chemicals used as impregnating agents cannot give completely non-flammable features to wood materials. However, they can make it difficult to flame up and delay the spread of the flame after the combustion begins [18].

In a study, the burning properties of the wood material reached a value range close to the fireproof material values when impregnated with the impregnation material obtained with the combination of phosphoric acid and urea-formaldehyde, which are fire retardant, according to their LOI values [19].

LOI (Limit Oxygen Index) values of the samples impregnated with boron compounds were found higher (50.7%) when compared to the non-impregnated samples (24.1%). This is probably due to the interactive effect of the mixture of Boric acid and Borax on the wood surface in delaying the propagation of combustion and carbonization. Carbonization can turn into a coating or a protective layer on the wood surface at high temperatures[20].The coating process can be also chosen as fire retardancy on particleboard surface but the coating of particleboard surfaces with surface-coating materials decreased the fire retardancy of particleboard [21]. On the other hand,Boric Acid and Borax (BA/ BX) treatment has increased the fire resistance of Laminated Veneer Lumber (LVLs).The findings support the beneficial effects of incorporation of BA/BX on fire retardance of LVL[22].

Boron compounds are environmentally friendly when used as flame retardants. They do not cause toxic gas release. They have low volatility. Boron flame retardants cause the formation of a glassy protective layer that acts as a barrier for polymer chain oxidation. They suppress the burning by covering the burning material in a way that it prevents its contact with oxygen [23].

In plywood made of tetra coatings, borax impregnated groups obtained higher tensile-shear strength values than monoammonium phosphate groups.The reason for this is that borax is an alkaline character and monoammonium phosphate is in an acidic character. This situation supports the preference of the artificial board, which is frequently used in the field of industrial design, by strengthening its mechanical properties[24].

In this study, it has been ensured that boron compounds, which are preferred as impregnation material and rosin additive with water repellency, are used together in the production of particleboards, which are industrial products and are frequently used in architecture. It was aimed to determine the effect of rosin-added boron compounds on the fire resistance of the particleboard by testing the fire resistance of the obtained rosin and boron compound-added particleboard.

2. MATERIAL ANDMETHOD

2.1. Material

2.1.1. Pineparticles

The pine chips, which are preferred in the production of the boards planned to be used in the study, were obtained from the composite board factory of ORMA Orman Mahsulleri Entegre Sanayi ve Ticaret A. Chips; It consists of 60% black pine (Pinusnigra Var), 40% Red pine (Pinusbrutia Ten.).In the middle layer, pine chips with a thickness of 0.25-0.40 mm, a width of 2-6 mm and a length of 10-25 mm, a diameter of 0.5-1.5 mm and a length of 3 mm were used in the surface layer. Pine chips used in composite board production are shown in Fig 2.

Figure 2. (a) Pine chips used in the middle layer
(b) Pine chips used in the surface layer

2.1.2. Adhesive

Urea-formaldehyde resins, which are widely used in the furniture industry with wood-based panel productions (MDF, chipboard, plywood, coated board, OSB), are the most preferred resins with high reactivity and low-cost advantages. It is preferred especially in interior applications due to its less water resistance compared to melamine and phenol resins [25]

Urea-formaldehyde glue is sold in the market as 55% or 65% liquid or powder. Although the powdered form can be stored in warehouses for 1 year without deterioration, the liquid can only be stored for a few months. The amount of solid matter in liquid form is generally 65%. Its viscosity is 200-300 cP, depending on the purpose of use of the glue. Press pressure varies between 1.0-3.0 N / mm² depending on the density of the plate. The pressing time varies according to the pressing temperature, the reaction of the catalyst used, and the plate thickness [26].

Some technical features of the urea-formaldehyde glue used in the experiments are given in Table 1.

Table 1.Technical characteristics of Urea formaldehyde glue used in the study [25].

Features	Ambient temperature	Unit	Value
Appearance	0° - 40° C	-	Clear-White
Density (ρ)	20° C	g/cm^3	1.235-1.240
Ph	20° C	-	7.5-8.7
Viscosity	20° C	cP	140-200
Gel time	100° C	sec.	15 - 25
Free Formaldehyde	-	%	Highest - 0,8
Mol Rate	-	-	1.45-1.55
Solid Matter	-	%	55 ± 1
Storage Period	20° C	day	30
10% Ammonium Chloride (NH_4Cl) was added to the glue as hardener.			

2.1.3. Composition of impregnation material

The composition of the experimental impregnation material produced in the laboratory are given in Table 2. Especially with boron compound additives, 3% by weight of impregnation material was used in order to examine the behavior of the chipboard against burning. According to Wang et. al. Boric acid suppresses glowing but has little effect on flame spread. On the other hand, borax tends to reduce flame spread, but it can promote smoldering or glowing [27]. Composition of additive to the particle board production proces using colophony doped boron compounds is shown in Table 2.

Table 2. Chemical composition of the impregnating agent

The composition of the impregnating agent (%)			
Borax ($Na_2B_4O_7.10H_2O$) (%) (%)	Colophony ($C_{19}H_{29}COOH$) (%)	Distilled water H_2O (%)	Ethil Alcohol (C_2H_6O) (%)
3	10	17	70

Borax (BX), which is preferred due to its features, was obtained from private enterprises.

Technical data of Borax;

(Na2B4O7 5H2O) content is 21.28% Na_2O,47.80% B_2O_3,ve 30.92% H2O.

Molecular weight is 291.35,

Density is 1.815 g/cm^3 and Melting point is 741 C^o [28].

Used as a water repellent in the impregnating material and added to the mixture to strengthen the absorption ability of the preservative, Colophony is a transparent, yellow-colored resin formed by distilling pine mastic. Soluble in ether, alcohol, chlorinated hydrocarbons and hydrocarbons. The resin naturally obtained from pine trees contains 80% rosin and 20% turpentine oil. The composition of rosin contains 90% resin acids and 10% neutral substances. It softens at 70-800 and dissolves in water at 100-1300. It is not harmful to health. Its commercial name is passed as "rosin" in USA. Rosin is characterized as waterproofing and fire-resistant [29].

2.2. Method

2.2.1. Preparation of particleboard

Pine chips were dried in a laboratory-type drying oven to 3% humidity. The gluing process for pine chips, which were previously treated with rosin-added boron compounds, was carried out with an air gun that can spray glue in a circular moving mixer. The gluing and pressing processes are shown in Fig 2.

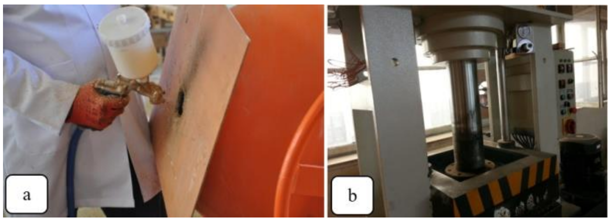

Figure 3. (a) The process of gluing the mixture (b) The process of pressing of obtained dough

Press temperature is 160 ° C, press time is 8 minutes and press pressure is 25 kg / cm^2. The values of the chipboard prepared as an experiment example are shown in Table 3.

Table 3. Values of chipboard made of pine chips

Type of adhesive	Amount of adhesive (%)		Thickness (mm)	Dimensions (mm)
	Surface layer	Middle layer		
UF	12	10,5	18	550 × 550

After the pressing process, the chipboard test samples, whose edge corrections were made, were stacked and left to cool in order to prepare for the burning test. After the boards taken from the press were cooled, they were kept in an air conditioning cabinet at 20 ° C ± 2 ° C and 65 ± 5% relative humidity for three weeks in accordance with the TS 642 ISO 554[30]. It is also shown in Fig. 4.

Figure 4. Test samples left to cool after pressing

2.2.2. Determination of density

According to the principles specified in the TS EN 323 [31], a total of 100 test specimens, including 10 for each plate group, with dimensions of 50 x 50 x 18 mm, were prepared. The plates were acclimatized at 20 ± 2 ° C and 65 ± 5% relative humidity according to the principles specified in the TS-EN 326-1 [32], and weighed with a 0.01 gr precision scale. Its dimensions were measured with a 0,01 precision caliper. These values are put in place in the following equation, density;

$$\delta_0 = \frac{M_{12}}{V_{12}} g / cm^3$$

Here; M_{12} = Air-dry weight (g), V_{12} = Air-dry volume (cm^3)[33]. Fig 5 shows examples of experiments belonging to the boards produced from pine chip mixture in the air conditioning cabinet.

Figure 5. Test samples prepared for density determination

2.2.3. Preparation of test samples

Theparticleboard samples prepared by pressing in the form of a table were brought to dimensions in accordance with ASTM-E 160-50 [34] by using circular and band saws at Ankara Gazi University Faculty of Technology, Woodworking Industrial Engineering Department Woodwork Laboratories, and the samples that were not deformed were separated as test samples. The shape and dimensions of the test samples to be used in the combustion tests were given in Fig 6.

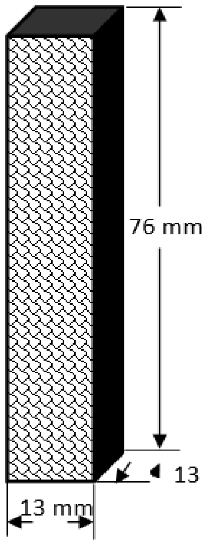

Figure 6. Dimensioning of combustion samples

2.2.4. Combustion test

The principles specified in ASTM-E 160-50 were followed in the combustion tests. Test and control samples were kept in the conditioning chamber at 27 ± 2 ° C and 30 ± 5% relative humidity until they reach 7% humidity before burning. The humidity of some of the control samples was kept as 30%. In the experiment, each burning process was carried out by arranging 24 samples in a square prism form on 12 floors. The incinerator used for burning the experimental samples is given in Figure 5 (a). During the process, the gas pressure was kept constant at 0.5 kg / cm^2. Measurements were carried out in three stages as flame-sourced(FsC),Self Combustion (SC) and Glowing Period (Gp)

The combustion process was carried out using test equipment prepared in accordance with ASTM 160-50 E. After the combustion process, the cooled ash was separated to be examined in order to determine the combustion state of the test samples. An example of ash formed after combustion is shown in Figure 5 (b). Ash weight was used as one of the basic parameters in evaluating combustion performance.

Figure 7. Incinerator and ash remaining after incineration

2.2.5. Data analysis

In the analysis of the data obtained from the experimental samples, the parameters of Flame-sourced Combustion (FsC), Self-Combustion (SC), Glowing period (Gp), Weight Loss and Combustion durations were examined, considering the quantity of the study groups, the values obtained were evaluated based on the arithmetic average.

3. RESULTS AND DISCUSSION

The lowest air-dry density detected in the chipboard prepared in the study was determined as 0.66 g/cm³, the highest air-dry density 0.75 g/cm³ and the average dry air density as 0.70 g/cm³.Statistical values of the density amount of composite boards are given in Table 4.

Table 4. Statistical values for the amount of density

Type of chips	Rate of Adhesive (%)	Rate of colophony doped Boron compounds (%)	Density (g/cm³)			
			N	X_{min}	X_{mak}	X_{ave}
Pine	11	10	10	0,66	0,75	0,70

In order to determine the combustion resistance of the test samples following the impregnation process with rosin-added boron compounds, Flame-sourced Combustion (FsC), Self-Combustion (SC), Glowing period (Gp) values and weight-loss rates after combustion were measured.

Table 5 shows the values that are obtained through the combustion test.The sets of experimental samples prepared according to Table 2 are represented by "1", "2" and "3". In addition, control samples are expressed as "K1", "K2" and "K3" in order to compare the results obtained. The "K" samples representing the control samples were not treated with additives. 24 test samples were used in each set according to ASTM-E 160-50.

Table 5. Values obtained from particleboard samples during and after the combustion process

Test samples for combustion experiment	FsC (C^0)	SC (C^0)	Gp (C^0)	Combustion Period (min)	Weight loss ratio (%)
1	529,50	626,13	259,82	50	89,46
2	482,83	548,67	280,67	48	85,90
3	533,75	663,71	329,20	51	82,57
K1	517,25	583,64	236,88	32	87,31
K2	537,17	641,13	271,89	41	89,06
K3	545,50	654,00	390,40	50	90,53

In this framework, the FsC values formed in the experimental samples after combustion are shown in Fig 8.

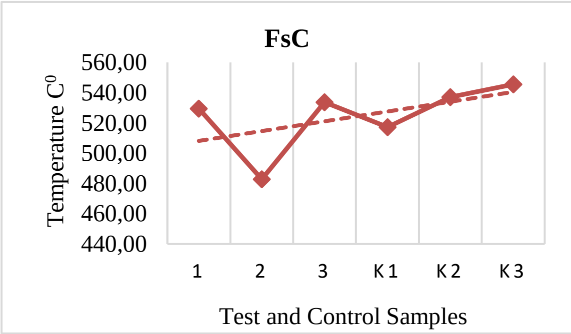

Figure 8. FsC values of test samples

When compared with the control samples according to Fig. 8, it is seen that the average value of FsC decreased to approximately 510 C^0 in experimental samples, and this value reached 540 C^0 in control samples. In the light of the data obtained, it was determined that the FsC value in the chipboard produced with rosin-added boron compounds decreased the value of FsC by approximately 5.5%. İstek and Özlüsoylu determined the lowest FsC and SC values in experimental samples produced with BA by burning the particleboards produced with Siriono 110 S1 and BA[35].

SC values are one of the important indicators in the combustion process. SC values generated during the burning of test samples are shown in Fig 9.

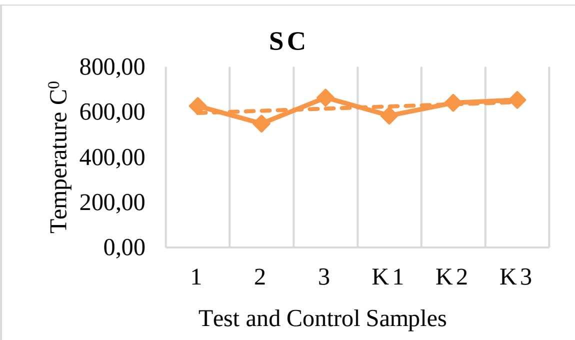

Figure 9. SC values of test samples

When SC values were examined, it was seen that while an average temperature of 601 C^0 was determined in the test samples, this value reached 641 C^0 in the control samples. In this context, it can be said that approximately 5% temperature reduction is achieved in the test samples. This result is in line with the study carried out by Terzi [36]. It shows that the combustion temperature obtained from test specimens produced with the addition of Boric Acid (BA) and Borax (BX) mixture is lower than control samples made of particle board without fire retardant additive.On the other hand, İstek et al. reported that the use of boron compounds as fire retardants generally inversely impacts the physical and mechanical properties of particleboard in itsmanufacturing [37]. Gp values,

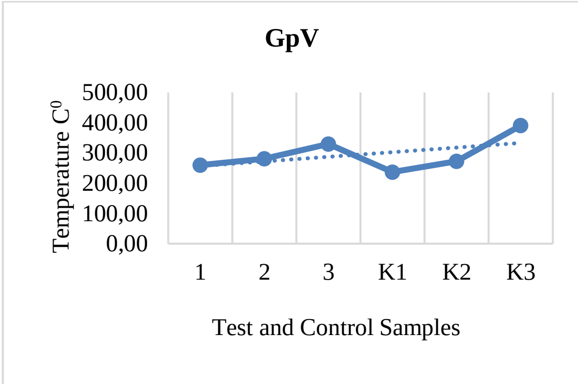

Figure 10. Glowing period values (GpV) of test samples

which are the 3rd stage in the combustion process, are given in Fig 10.

When the Gp values were examined, it was determined that the highest Gp value was detected in the control samples, while the average Gp temperature was determined as approximately 307 C^0 in the test samples, while this temperature value reached 311 C^0 in the control samples. In this context, it is seen that the Gp value is reduced by about 1.8% in the particle boards produced with rosin-added boron compounds. According to Yalınkılıç at al. Boric Acid (BA) addition into the particle board production process causes shorten the glowing time, while Borax (BX) extends it. Additionally mixture of these boron compounds improved fire-retardant effectiveness of particle board as well [38].

Another important factor determining the fire resistance of wood-based building products is the weight loss percentage after the burning process. Percentage values were calculated by measuring the remaining ash amount from the burned test samples. Percentages of weight loss occurring in the testl samples are shown in Fig 11.

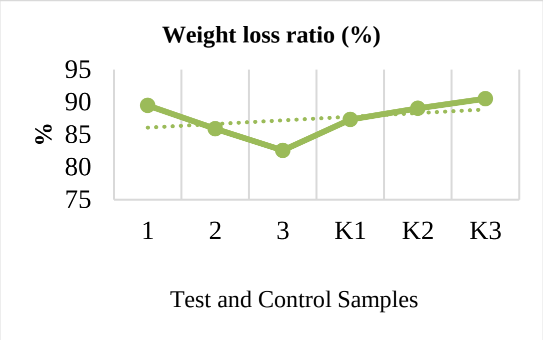

Figure 11. Weight loss values of test samples

When the data were examined, it was determined that the lowest weight loss rate was seen in the test samples with 82%, the average weight loss in the test samples was approximately 85%, whereas in the control samples this rate reached an average of 89%. This situation can be explained as about 0.5% burning resistance developed in the particleboard produced with rosin-added boron compounds. The efficacy of boron compounds in fire retardancy and decreasing weight loss are also supported by Izran et. al. that boron compounds-based fire retardant is effective in reducing the weight loss as well as a flame spread on the surface of the boards [39].

The values of the burning time, which is another important parameterin determining the fire resistance of the particleboards made of rosin-added boron compounds prepared in the study, are shown in Fig. 12.

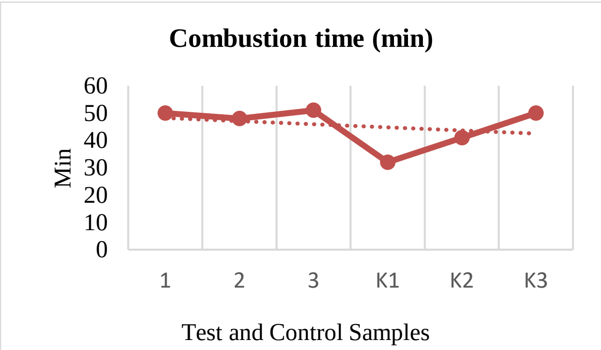

Figure 12. Combustion time values of test samples

The combustion time was also used to determine the combustion resistance of the test samples used in the study. Combustion time represents the time from the FsC process until the ashes are completely extinguished. In the light of the data obtained, the longest burning time was seen in experimental samples, however, it was determined that the average combustion time was approximately 49 minutes. In the control samples, the average combustion time was determined as 41 minutes. With these data, it can be said that the production of particleboard made with rosin-added boron compounds prolongs the combustion time by approximately 2%. According to İstek et al. among different boron fire retardants, the lowest temperature value was determined in the use of BA and it was understood that boron compounds decreased the temperature by delaying the combustion. According to the results, it was seen that boric acid (BA) prevented the temperature increase better than borax (BX) and zinc borate (ZB) [37].

The wood material is an industrial product that can easily burn with high carbon and hydrogen content[40]. Wood material used also as a heat source in the industry and high FsC, SC and Gp temperatures during the burning process are expected and show high weight loss within this framework, while the burning time is expected to vary depending on the wood type and material density. Besides, industrial wood materials and boards used in architecture are expected to reach lower FsC, SC and Gp temperatures and lose weight, and also have a longer burning time. The comparison of the burning properties of the wood material and the burning processes of the experimental samples is given in Table 6.

Table 6. Combustion processes of wood material and experimental samples

Indicator	**Wood material***	**Control samples****	**Colophony doped boron compounds added test samples*****
FsC Temp. (C^0)	*High*	High	Low
SC Temp. (C^0)	*High*	High	Low
Gp Temp. (C^0)	*High*	High	Low
Weight loss (%)	*High*	High	Low
Combustion period (min)	*Short*	Short	Long

*Expected from wood material used as a heat source

**Compared to impregnated samples

***Compared to control samples

4. CONCLUSION

As a result of the study, it can be said that the addition of rosin-added boron compounds in the manufacture of particleboard produced using pine chips on an industrial scale protectsagainst liquids while also responding to the expectations of the architecture in terms of fire safety to a certain extent.During the production of the chipboard test specimens produced using Larch (Pinusnigra Var), Red Pine (Pinusbrutia Ten) chips, the FsC temperature was 5.5%, SC temperature 5%, Gp temperature 1.8% and weight loss 0.5% compared to the control samples by adding rosin-added boron compounds in the study and the burning time was increased by 2% compared to the control samples. It is considered that rosin-added boron compounds can be used as fire retardants in architecture to increase fire safety in particleboard production.

It should be considered that the mechanical properties of the chipboard produced by this method such as surface, bending, screw holding and tensile strength should be investigated separately.

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DECLARATION OF ETHICAL STANDARDS

The authors of this article declare that the materials and methods used in this study do not require ethical committee permission and/or legal-special permission

AUTHORS' CONTRIBUTIONS

Taner AŞÇI: Performed the experiments defined in the study, analyse the results and wrote the manuscript.

Mustafa KÜÇÜKTÜVEK: Produced and sized test specimens according to the existing standarts, helped writing manuscript.

Hakan KESKİN: Provided consultancy, check all data and helped writing manuscript.

CONFLICT OF INTEREST

There is no conflict of interest in this study.

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