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Some Technological Properties of Scotch Pine (*Pinus Sylvestris* Lipsky) and Eastern Beech (*Fagus Orientalis* Lipsky) Woods Impregnated with Alpha-X Chemical

Araştırma Makalesi / Research Article

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ABSTRACT

This study was performed for the purpose of determining the technological properties of Scotch pine (*Pinus sylvestris* Lipsky) and Eastern beech (*Fagus orientalis* Lipsky) woods impregnated with Alpha-X chemicals. The impregnation solution was prepared at 10 % and 20 % concentrations. Alfa-X, a flame-retardant chemical formerly applied to textiles and laminate parquet, was used for the first time in wood work. As a result of the combustion tests, Alfa-X reduced the initial weight loss temperature of the wood material in both samples. However, it has completely raised the combustion temperature gradients in both samples. It is observed that ending temperature increased in eastern beech wood and in scotch pine wood by 117 °C and 50 °C, respectively, with increasing the rate of Alfa-X added into impregnation solution from 0 % to 20 % at deterioration. In addition, the bending and compression strength values of the Scotch pine and Eastern beech wood samples were also examined.

Keywords: Alfa-X, combustion properties, bending strength, compression strength, woods.

Alfa-X Kimyasalı ile Emprenye Edilmiş Sarıçam (*Pinus Sylvestris* Lipsky) ve Doğu Kayını (*Fagus Orientalis* Lipsky) Odunlarının Bazı Teknolojik Özellikleri

ÖZ

Bu çalışma, Alfa-X kimyasalı ile emprenye edilmiş Sarıçam (*Pinus sylvestris* Lipsky) and Doğu kayını (*Fagus orientalis* Lipsky) odununun bazı teknolojik özelliklerinin belirlenmesi amacıyla yapılmıştır. Emprenye çözeltisi %10 ve %20 konsantrasyonda hazırlanmıştır. Daha önce tekstil ve laminat parke uygulamalarında kullanılan Alfa-X yanmayı geciktirici kimyasalı, solid odunda ilk kez bu çalışmada kullanılmıştır. Yanma testleri sonucunda, Alfa-X ilk ağırlık kaybı sıcaklığını her iki ağaç türünde de düşürmüştür. Ancak, Yanmanın sonlandığı sıcaklık derecesini her iki ağaç türünde de artırmıştır. Alfa-X oranının %0'dan % 20' ye çıkmasıyla Sarıçamda 117°C, Kayında 50°C'lik bir artış gözlenmiştir. Ayrıca, Sarıçam and Doğu kayını odununun eğilme direnci ve basınç direnci değerleri de incelenmiştir.

Anahtar Kelimeler: Alfa-X, yanma özellikleri, eğilme direnci, basınç direnci, odun.

1. INTRODUCTION

Wood is among of the most important raw materials that human has been using since the early ages. Along with the world's technological improvements, the usage areas of wood materials have been diversified and the amount used has increased. Wood material is flammable and tends to burn at high temperatures. The negative properties of wood materials related to burning can be reduced by some protective measures and impregnation techniques [1, 2]. Other negativities of wood materials other than burning cause only material loss, while vital hazards also occur in the case of wood material burning

Flames and gases that form in the burning of wood materials can threaten human life and cause deaths [3]. Wood is a burning substance. Therefore, in order to increase the resistance to burning of wood, it is imperative for many uses that it is impregnated with chemical substances [4, 5]. The higher the treatment temperature the better the wood's biological durability. However, at over 150°C the strength decreases by 10%-30%. Therefore, use of heat-treated wood in load-bearing constructions is restricted [6, 7]. Characterized by organic polymer, a wide range of materials from wood to fabric is typically available to ASTM E 162, and flame spread, and smoke density tests were applied. As a result of the experiments, the surface-free hard fiber board (HDF), Meranti plywood and PVC coating provide the

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best possible ignition-proof materials [8]. Plywood, chipboard, and fiberboard (MDF) materials are 1, 2, and 3 times fire retardant via brushing technique with chlorinated rubber paint and were subjected to a burning test. Then, we assessed their rates. As a result, with three layers of paint, the applied flake burning resistance is most visible; with one coat of paint, the applied MDF showed the least resistance against burning [9]. The improving fire retardants of textile materials also was examined. Boric acid borax and zinc borate from boron compounds with three different ratios (5%, 7.5%, and 10%) were added to chemical Alfa-x in a ratio (50%). Besides another two compounds were prepared from Alfa-x in ratios (50% and 100%). In total, we prepared 11 different solvents. Application of solvents to the fabrics were made by a lab pad machine. Fire retardants of fabrics of manufactured specimens were tested using a flammability test. The results showed that boron compounds improve the fire-retardant properties of textile fabrics. The most effective result was undertaken from 7.5% borax and 50% Alfa-x solvent [10]. High-density fiber boards contain a mixture of 50% beech and 50% Scotch pine, which are typically used for laminated floor boards. High-density fiber boards, with a thickness of 6.5 mm, were produced using flame-retardant chemicals. Fire retardants such as borax, boric acid, ammonium polyphosphate, and Alfa-x-chemicals were added in powder form with concentrations of 3%, 6%, and 9% of dry fiber weight. Afterward, surfaces of HDF boards were coated with overlay, decor, and balance sheets, and then laminated floorings boards were produced. The physical, mechanical, surface properties, amounts of free formaldehyde, resistance of fungal decay, and fire resistance of all produced laminated flooring samples were investigated in accordance to relevant standards. The addition of fire-retardant chemicals such as borax, boric acid, ammonium-polyphosphate, and Alfa-x, at 3%, 6%, and 9% proportions improved fire resistance, fungal decay, and mold resistance but had a negative effect on the physical and mechanical properties. It also was detected that the internal addition of fire-retardant chemicals had no negative effects on the surface quality of HDF boards, whereas the application of such chemicals on the melamine-impregnated papers had destructive effects on the surface properties of tested samples [11]. Thermal stability at low temperatures in wood components follows hemicelluloses, lignin, cellulose; at high temperatures, it follows this sequence: Hemicelluloses, cellulose, lignin. Hemicelluloses decompose thermally at 180°C -250°C, cellulose begins to decompose at 280°C and completely decomposes at 300°C-350°C, lignin begins to decompose at 300°C -350°C and completes decomposition at 400°C -450°C reported. In fast pyrolysis, flammable gases include methane with CO, methane, formaldehyde, and acetic acid. Phenolics, xylenols, guaiacols, cresols and catchall's which are aromatic moieties that are released as degradation products of laevoglucose (1,6-anhydro-beta-D-

glucopyranose) and lignin by cellulosic degradation, are also products of rapid pyrolysis. After completion of carbonization at 400°C -500°C and the removal of flammable gases, the charcoal remains [12].

This study was performed for the purpose of determining the combustion properties, bending and compression strength of Scotch pine and Eastern beech woods impregnated with alpha-x impregnation solution.

2. MATERIAL AND METHOD

2.1. Wood materials

Scotch pine (*Pinus sylvestris* Lipsky) and Eastern beech (*Fagus orientalis* Lipsky) woods were selected as test the materials because of wide usage of industry. Special emphasis was given for the selection of wood materials which are nondeficient, proper, knotless, normally grown (without reaction wood, decay and mushroom damages) according to TS 2476 [13].

2.2. Alpha-X impregnation solution

In this study, Alfa-X was used as a combustion-retardant chemical. Test specimens prepared in dimensions of 13x13x76 mm were made according to the immersion method with 10%, and 20% Alfa-X impregnation solution for 48 hours.

The technical properties of the Alfa-x used in this study are given in Table 1.

Table 1. The technical properties of the Alpha-X chemicals

Appearance	Dry powder
Color	White
Granuler size	<50 µm
pH	3.74
Relative density	0.847 (g.cm ⁻³)
Odour	None
Storage	It should be stored in a cool and dry place and should be protected from moisture.

The Alpha-X fire-retardant chemical is used as a complement to the polymer, and is added to the production processes of various products. It is used in thermoplastic, paint, cable, synthetic, membrane and wood-based boards. It is effective up to 1500 °C against flammability.

2.3. Methods

2.3.1. Bending strength

Bending strength tests were carried out according to TS 2474 standards (TS 2474) [14]. The samples having 2x2x30cm dimensions were used for bending strength. Thickness of layers is 6.5 mm. 10 samples have been used for each experiment. The samples prepared are climatized up to reach 12% moisture at 20°C and 65% relative humidity conditions. Test specimens are determined through measurement from the middle parts by ± 1% mm sensitivity micrometer. Span to thickness

ratio for bending is 24 cm. Bending strength test mechanism is given in Fig.1.

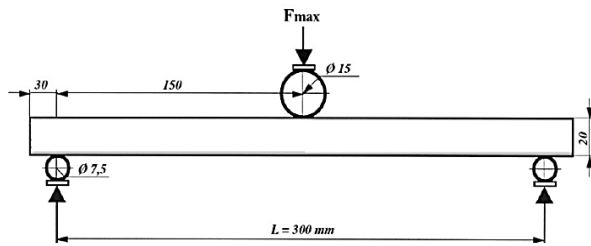


Figure 1. The dimensions of bending strength test specimens

Following eq.1 were used in the calculation of bending strength (σ_e);

$$\sigma_e = \frac{3.P.L_s}{2.b.h^2} \quad (1)$$

where, σ_e is bending strength ($N.mm^{-2}$); P is max. force at the moment of breaking (N); L_s is distance between points of support (mm); b is width of sample piece (mm); h is thickness of sample piece (mm).

2.3.2. Compression strength

Compression strength tests were carried out according to TS 2595 standards (TS 2595) [15]. The samples having 2x2x3 cm dimensions were used for bending strength. 10 samples have been used for each experiment. The samples prepared are climatized up to reach 12% moisture at 20°C and 65% relative humidity conditions. Test specimens are determined through measurement from the middle parts by $\pm 1\%$ mm sensitivity micrometer. Compression strength test mechanism is given in Fig. 2.

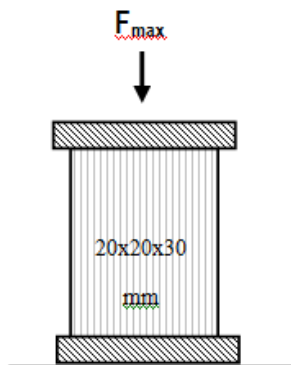


Figure 2. Compression strength test

Following Eq.2 were used in the calculation of compression strength (σ_b);

$$\sigma_b = \frac{F_{max}}{a.b} \quad (2)$$

where, σ_b is compression strength ($N.mm^{-2}$); F_{max} is maximum force at the moment of breaking (N); a is width of sample breadth cross-section (mm); b is length of sample breadth cross-section (mm).

2.3.3. Retention amount of lpha-X

The rough drafts for the preparation of test and control samples were cut from the sapwood parts of massive woods with a dimension of 20x20x500 mm and conditioned at a temperature of $20 \pm 2^\circ C$ and $65 \pm 3\%$ relative humidity till they reach 12% humidity distribution. The air-dry samples with a dimension of 13x13x76 mm were cut from the drafts for impregnation. The test specimens were impregnated according to ASTM D 1413-99 [16, 17]. Retention of impregnation chemical (R) was calculated by the following Eq.6 :

$$R = \frac{G.C}{V} 10^3 \text{ kg. m}^{-3} \quad (G = T_2 - T_1) \quad (3)$$

where, G is the amount of impregnation solution absorbed by the sample, T_2 is the sample weight after the impregnation, T_1 is sample weight before the impregnation, C is concentration (%) of the impregnation solution and V is the volume of the samples. Impregnated test samples were kept under a temperature of $20 \pm 2^\circ C$ and $65 \pm 3\%$ moisture content until they reach to a stable weight.

2.3.4. Combustion test

TGA analyses were carried out in ILTEM laboratory, Kutahya Dumlupinar University. TGA test device was shown in Figure 3.

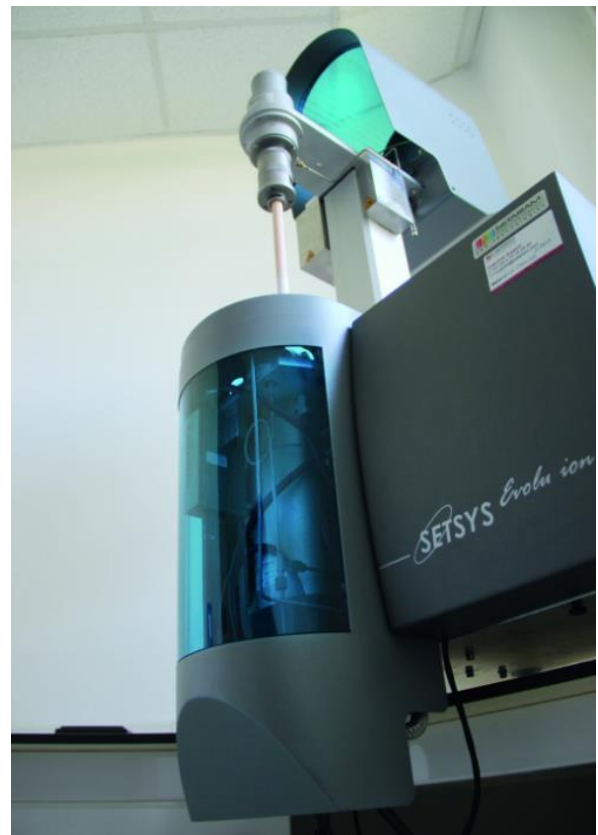


Figure 3. TGA test device

2.4. Data Analyses

In this study, to determine significance of main effects and interactions multiple variance analysis (MANOVA) was carried out. When the differences between groups were found to be significant, Duncan’s Multiple Range test was used to determine the differences between means

at prescribed level of $\alpha = 0.05$ statistical values were then calculated by the SPSS 22.

3. RESULTS AND DISCUSSION

3.1. Bending Strength Results

The values of average bending strength for Scotch pine and eastern beech wood are given in Table 2.

Table 2. The values of average bending strength results (N.mm⁻²)

Samples	Wood Type	
	Eastern beech wood	Scotch pine wood
1	75.32	79.59
2	66.80	74.38
3	74.45	86.80
4	79.76	75.82
5	74.94	72.61
6	69.46	76.54
7	70.81	77.07
8	77.88	82.01
9	68.57	79.76
10	81.07	82.91
Average	73.91	78.74
σ_x	4.86	4.31
n	10	10

The bending strength results of two wood species were compared with analysis of variance.

The results of the analysis of variance obtained are given in Table 3.

Table 3. Bending strength variance analysis results

Variance sources	Df	Sum of squares	Mean squares	F test	P
Wood Type	1	117.273	117.273	5.546	0.030
Error	18	380.619	117.273		
Total	20	117015.637	21.145		

According to the results of variance analysis conducted, the effects of wood type on the bending strength has been found significant with 5% of the error.

3.2. Compression Strength Results

The values of average compression strength for scotch pine and eastern beech wood are given in Table 4.

Table 4. The values of average compression strength results (N.mm⁻²)

Samples	Wood Type	
	Eastern beech wood	Scotch pine
1	34.22	35.82
2	35.85	36.07
3	36.28	35.79
4	35.45	35.61
5	36.09	37.24
6	35.89	35.82
7	36.13	36.39
8	34.97	37.88
9	37.34	37.21
10	35.64	38.63
Average	35.879	36.65
σ_x	0.82	1.03
n	10	10

The compression strength results of two wood species were compared with analysis of variance.

The results of the analysis of variance obtained are given in Table 5.

Table 5. Compression strength variance analysis results

Variance sources	Df	Sum of squares	Mean squares	F test	P
Wood type	1	3.698	3.698	4.204	0.055
Error	18	15.835	0.880		
Total	20	26251.506			

According to the results of variance analysis conducted, the effects of wood type on the compression strength has not been found significant with 5% of the error.

3.3. Results of Weight Loss-Based Combustion Experiment

The results of TGA and DTGA measurements on samples taken from wood materials with the aim of determining the activity ratings of Alfa-X chemical substances and concentration ratios (0%, 10%, and 20%) used for combustion retardation purposes are shown in Figure 4,5, 6, 7, 8 and 9, respectively.

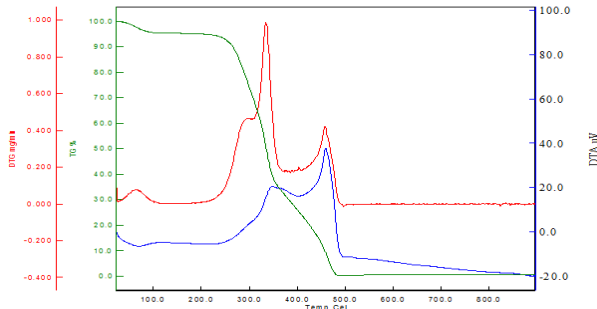


Fig. 4. Change values of weight loss on TGA result of 0% Alpha-x-doped eastern beech wood

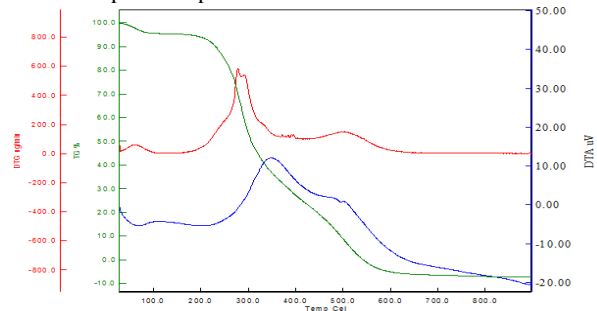


Fig. 5. Change values of weight loss on TGA result of 10% Alpha-x-doped eastern beech wood

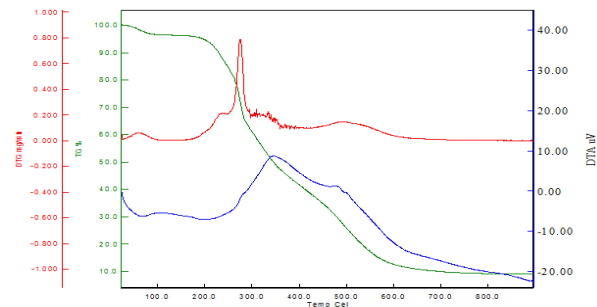


Fig. 6. Change values of weight loss on TGA result of 20% Alpha-x-doped eastern beech wood

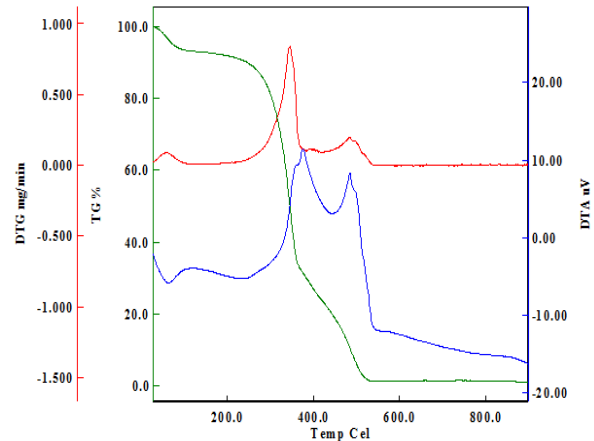


Fig. 7. Change values of weight loss on TGA result of 0% Alpha-x-doped scotch pine

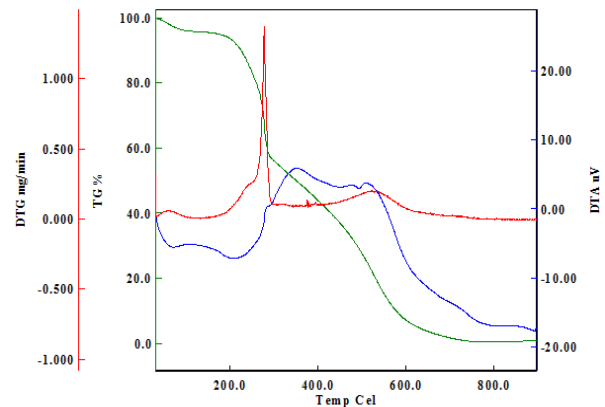


Fig. 8. Change values of weight loss on TGA result of 10% Alpha-x-doped scotch pine

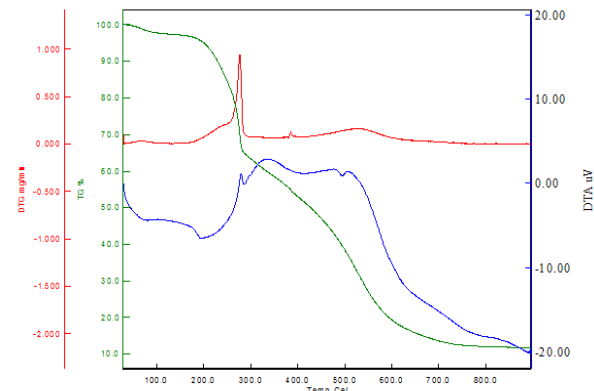


Fig. 9. Change values of weight loss on TGA result of 20% Alpha-x-doped scotch pine

At 10% and 20% Alfa-X added wood samples, the temperature at which the deterioration was finished was determined as 600°C and the same result was obtained in both species. The results obtained with 10% and 20%

Alfa-X-added wood samples showed better results than the 0% added samples. A summary of the data in Fig. 4, 5, 6, 7, 8 and 9 is given in Tab. 6.

Table 6. Summary evaluation of weight loss-based combustion test results

Wood Types	Alpha-x addition ratio %	First deterioration temperature (°C)	First deterioration weight loss ratio (%)	Deterioration ending temperature (°C)
Eastern beech	Control	230	94	483
	10	206	93.7	600
	20	208	93	600
Scotch pine	Control	246	88.8	550
	10	214	91	600
	20	198	94.3	600

3.4. Retention Values

Average values of total retention and retention % is given in Table 7.

Table 7. Average values of total retention and retention

Wood Type	Alfa-X ratio (wt%)	Total retention (kg.m ⁻³)	Retention (%)
Scotch pine	10	52.35	0.68
	20	87.56	0.74
Eastern beech	10	132.5	1.21
	20	189.8	1.90
N	5	5	5

4. CONCLUSION

Table 6 shows that the first deterioration temperature is 20% Alpha-x chemically applied Scotch Pine wood (198 °C), and the highest is 0% Alpha-X chemically applied Scotch Pine (246°C). It is seen that the first amount of disintegration weight is 0% Alpha-X chemically applied Scotch Pine (88.8%), and the highest is Scotch Pine (94.3%) applied with 20% Alpha-x chemistry. Deterioration temperature was determined at the lowest 0% Alpha-x chemically applied Beech wood (483°C) and the highest at 10% and 20% Alpha-x chemically applied Scotch Pine and Eastern Beech Wood samples (600°C). It has been observed that 10% and 20% of the used fire-retardant chemicals protect wood against fire. The use of Alpha-X material for the protection of wood materials against combusting can be suggested according to these results. While the difference between the bending strength values of two tree species was statistically significant, the difference between the pressure strength values was not significant.

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REFERENCES

- [1] Kartal, S.N., Imamura, Y., "Use of wooden materials and composites as impregnation material of boron compounds", *II. International Boron Symposium*, 333-338, (2004).
- [2] Ors, Y., Keskin, H., "Ağaç Malzeme Teknolojisi", Gazi Üniversitesi Yayın No: 352, *Gazi Kitabevi*, Beşevler, Ankara, (2008).
- [3] Terzi, E., "Burning properties of wood material impregnated with ammonium compounds", Master's Thesis, Istanbul University Institute of Science, 106-107, (2008).
- [4] Levan, S.L., Winandy, J.E., "Effects of fire retardant treatments on wood strength", *Wood and Fire Science*, 22: 113-131, (1990).
- [5] Keskin, H., "Effects of impregnation materials on combustion properties of laminated veneer lumber obtained from European oak (*Quercus petraea* Liebl.) and Lombardy poplar (*Populus nigra* Lipsky)", *Journal of applied polymer science*, 105(4): 1766-1773 (2007).
- [6] Atar, M., Keskin, H., "Impacts of coating with various varnishes after impregnation with boron compounds on the combustion properties of Uludag fir", *Journal of applied polymer science*, 106 (6): 4018-4023, (2009).

- [7] Keskin, H., "Impacts of impregnation chemicals on the flame source combustion light intensity of the laminated veneer lumber (LVL)", *Wood Research*, 54(4): 67-78, (2009).
- [8] Hilado, C.J., Murphy, R.M., "Fire response of organic polymeric materials (Organic materials in fire: combustibility)", Design of buildings for fire safety: *A symposium ASTM Special Technical Publication*, Philadelphia, 76-105, (1979).
- [9] Lee, P., "Study On combustion properties of some wood-based materials treated with fire retarding coating by oxygen index method", *Seoul National University Journal of Agricultural Sciences*, Seoul, 205-210, (1989).
- [10] Kalın, M.B., "Improving fire retardancy specify of textile surfaces", *Master's thesis*, Kahramanmaraş S.I. University (2008).
- [11] Özdemir, F., "Investigation on the effects of various fire-retardant chemicals addition on some properties of laminated flooring", *Ph.D. Thesis*, Kahramanmaraş S.I. University, (2012).
- [12] Goldstein, I.S., "Degradation and protection of wood from thermal attack in wood deterioration and its prevention by preservative treatments", *Syracuse University*, 307-339, (1973).
- [13] TS 2476, Methods of sampling for physical and mechanical experiments in wood and general properties, *TSE*, (1976).
- [14] TS 2474, "Wood-determination of ultimate strength in static bending", Ankara, *TSE*, (1976).
- [15] TS 2595, "Wood-determination of ultimate stress in compression parallel to grain", *TSE*, Ankara, (1976).
- [16] ASTM D 1413-76, "Standard test method of testing wood preservatives by laboratory soilblock cultures", *ASTM Standards*, (1976).
- [17] Keskin, H., "Impact of impregnation chemical on the bending strength of solid and laminated wood materials", *Materials and Design*, 30(3): 796-803, 2009