Bartın Orman Fakültesi Dergisi | Journal of Bartin Faculty of Forestry
2023, 25(3): 388–397 | DOI: 10.24011/barofd.1240477

Properties of Experimental Panels Made From a Mixture of Dolomite and Olivine With Calabrian Pine Wood Chips. Part 2.Technological Properties

Halil Turgut SAHIN[1*], Ömer Ümit YALCIN[2], Ali İhsan KAYA[3], Ugur OZKAN[4]

[1,2,4] Isparta University of Applied Sciences, Faculty of Forestry, Department of Forest Industry Engineering, Isparta, Türkiye
[3] Burdur Mehmet Akif Ersoy University, Technical Sciences Vocational School, Design Department, Burdur, Türkiye

Article History
Received: 22.01.2023
Accepted: 05.09.2023
Published: 15.12.2023

Research Article

Abstract − The selected physicochemical properties of urea-formaldehyde bonded experimental panels which produced with two mineral adducts (dolomite and olivine) as proportion in Calabrian pine wood chips were evaluated. It appears each mineral adducts improve the surface discoloration changes rather than control samples. The highest lightness change (darker surface) was found with control (ΔL:-13.13). However, only a sample of PY1 shows greener color surface (Δa: -0,39) while others show less red color properties (Δa: 1.06 to 3.40 for dolomite-based panels and Δa: 0.80 to 1.49 for olivine-based panels) than control (PX0/PY0: 3.55). It has been found that the lowest discoloration (improvement) was found to be PX1 sample which is approximately 63% lower than the control (ΔE PX0: 13.62, ΔE PX1: 5.03) for dolomite-formulated boards. For olivine-formulated boards that the lowest discoloration was found with sample PY2 which shows approximately 87% lower than the control (ΔE PY0: 13.62, ΔE PY2: 1.73). Olivine appears to be more effective for preservation against discoloration from outdoor exposure at similar experimental conditions than dolomite. Although experimental panels show some level lower heat conduction which improves insulation properties, all dolomite- and olivine-based panel's conduction values were found to be higher than the standard value of λ: 0.065 W/mK. The adducts formulated panels have shown lowering mass loss (%) in burning tests which was found to be in the range of 11.98% (PX1) to 17.39% (PX0) for dolomite-based panels and in the range of 10.85% (PY5) to 17.35% (PY0) for olivine-based panels. It is noticeable that olivine-based panels show lower mass loss against heat than dolomite-based panels at similar experimental conditions. It is also found that dolomite and olivine improve the combustion properties of experimental panels to a certain extent.

Anahtar Kelimeler – Olivin, dolomit, weathering, yanma özelliği, TGA, renk bozunması

Dolomit ve Olivin ile Kızılçam Odun Yonga Karışımından Üretilen Deneme Levhalarının Özellikleri. Bölüm 2.Teknolojik Özellikler

[1,2,4] Isparta Uygulamalı Bilimler Üniversitesi, Orman Fakültesi, Orman Endüstri Mühendisliği Bölümü, Isparta, Türkiye
[3] Burdur Mehmet Akif Ersoy Üniversitesi, Teknik Bilimler Meslek Yüksekokulu, Tasarım Bölümü, Burdur, Türkiye

Makale Tarihçesi
Gönderim: 22.01.2023
Kabul: 05.09.2023
Yayım: 15.12.2023

Araştırma Makalesi

Öz – Üre-formaldehit tutkalı ile kızılçam odun yongaları kullanılarak hazırlanmış formülasyona, iki mineral madde (dolomit ve olivin) eklenerek deneme levhaları üretilmiş ve önceden belirlenmiş fizikokimyasal özellikleri ile ilave edilen mineral maddelerin levha özellklerine olan etkileri incelenmiştir. İki mineral maddenin de dış atmosferik şartlara karşı (weathering), levhaların yüzey renk bozulmasına karşı olumlu etki sağladığı anlaşılmıştır. En yüksel parlaklık azalması (ΔL: -13.13) (daha koyu yüzey) kontrol örneğinde elde edilmiştir. Örnek PY_1 daha yeşil yüzey renk özelliği gösterirken (Δa: -0,39) diğer levhalar ise kontrol örneklerine göre (PX_0/PY_0: 3.55) daha düşük kırmızı renk özellikleri (Δa: 1.06 ile 3.40 arası dolomit ilave edilmiş levhalarda, Δa: 0.80 ile 1.49 arasında olivin ilave edilmiş levhalarda) gözlemlenmiştir. Dolomit ilave edilmiş levhalarda, toplam renk değişimine (ΔE) karşı en yüksek pozitif etki PX_1 deneme levhasında gözlemlenmiş ve bu levhada, kontrol örneğinden yaklaşık %63 daha düşük bulunmuştur (ΔE PX_0: 13.62, ΔE PX_1: 5.03). Olivin ile formüle edilmiş deneme levhalarında ise en yüksek etki PY_2 örneğinde, kontrolden yaklaşık 87% daha düşük ölçülmüştür (ΔE PY_0: 13.62, ΔE PY_2: 1.73). Olivin, deneme levhaların dış atmosferik şartlarda renk bozunmasına karşı benzer deneysel ortamda, dolomite göre daha etkili olduğu gözlemlenmiştir. Herne kadar deneme levhaları daha düşük ısı iletim özelliği dolayısıyla yalıtım özelliğine pozitif etki ettiği gözlemlenmiş olmakla birlikte, tüm olivin ve dolomit ilave edilmiş deneme levhaların ısı iletim katsayıları, standart değer olan λ: 0.065 W/mK den daha yüksek bulunmuştur. Mineral ilave edilmiş levhalar yanma testinde, kütle kaybını (%) azaltıcı etki sağladığı; dolomit ilave edilmiş dneme levhaları için 11.98% (PX_1) ile 17.39% (PX_0) arasında, olivin ilave edilmiş deneme levhalarında ise 10.85% (PY_5) ile 17.35% (PY_0) arasında hesaplanmıştır. Her iki mineral maddenin (dolomit ve olivin) ilave edilmesiyle üretilen deneme levhalarının yanma denemelerinde özelliklerinin iyileştiği, fakat benzer deneme şartlarında, olivin-esaslı deneme levhalarının kütle kaybının, dolomit esaslı levhalardan daha düşük olduğu farkına varılmıştır.

Keywords *− Olivin, dolomite, boards, weathering, burning properties, TGA, discoloration*

[1] halilsahin@isparta.edu.tr
[2] omeryalcin@isparta.edu.tr
[3] aikaya@maku.edu.tr
[3] ugurozkan@isparta.edu.tr
*Sorumlu Yazar / Corresponding Author

1. Introduction

Typically, wood-based composites are made from wood sources with using formaldehyde-formulated adhesives as a bonding agent (Maloney, 1996; McKeever, 1997; Bergland *et al.,* 2005). However, most of the research in the field of bio-composites deals with particleboards, fiberboards, OSB, and plywoods that compatibility of wood with synthetic binding agent (Maloney, 1996; McKeever, 1997; Bergland *et al.,* 2005; FPS, 2010; McKeever, 1997). These materials, generally used for construction and decorative purposes, depend on their matrix elements and adhesive types (McKeever, 1997; Sahin and Simsek, 2021; Papadopoulos, 2020; Suchland and Woodson 1987). In this regard, t, the lowest discoloration was found with sample PY2, these engineeringly design products have become popular, particularly worldwide, to meet increasingly stringent design regulations in case of strength and failure in service. In order to improve certain properties, some adducts should be included in board formulations which make the material more resistant to desired properties. Optimization of adducts plays a significant role in enhancing engineering properties (FPS, 2010; McKeever, 1997; Sahin and Simsek 2021; Papadopoulos, 2020). Hence, special care should be taken during manufacturing particularly improving special properties (i.e. insulation).

As a result of the growth of the population, the need for wood and wood-based composites is continuously increasing throughout the world. But these have generated pressure on forestlands. One alternative solution is to utilize non-conventional sources (wastes, residues) by using them as supplementary, which avails in the conservation of nature’s deposits and reduces environmental problems (Ndazi *et al.,* 2006; Rials and Wolcott 1997; Sahin and Arslan 2011). Many of minerals as a reinforced- and/or matrix element in composite systems have already been investigated (Aamr-Daya *et al.,* 2008; Aggarwal *et al.,* 2008 and 2021). The physical properties of mineral particles are usually angular and irregular in shape and have crystalline surface textures. A number of studies have already been established with some valuable results regarding mineral adducts are capable of forming stable products with acceptable properties (Aamr-Daya *et al.,* 2008; Aggarwal *et al.,* 2008; Kozlowski *et al.,* 1995; Yalcin 2018). Most of these studies deals with cement- and gypsum bonded panels, compatibility of wood and/or non-wood species. Among mineral-lignocellulosic formulations, olivine and dolomite may prove to be promising candidates with some improving properties (Yalcin, 2018; Yalçın *et al.,* 2019 and 2020; Özdemir, 2016; Özdemir *et al.,* 2016). However, the application of dolomite and olivine wastes have already reported to be useful in construction, and metallurgical applications depending on their particle size, where it may be used as a substitute material (Özdemir 2016; Özdemir *et al.,* 2016; Yalçın *et al.,* 2020; Agrawal *et al.,* 2021). Calabrian pine (*Pinus brutia)* is a species of pine native to the eastern Mediterranean region while the bulk of its range is in Turkey. However, it is one of the important tree specy in these regions. It generally occurs at low altitudes, mostly from sea level to 600 m, up to 1,200 m in the south of its range. Because of its resistance to drought and warm climate conditions, It is also widely planted for timber and recreational sites both in its native area and elsewhere in the Mediterranean region (Nicolacii *et al.,* 2014; Sahin et al., 2020).

A vast literature reports, regarding physical and chemical properties on lignocellulosic-based composites, have been presented by a number of researchers. However, majority of these research have been mainly deals with wood-based materials including organic and inorganic (mineral) adducts. But there is limited information have been found on both olivine and dolomite formulated wood-based materials. Even some of the important findings with these minerals as adduct to lignocellulosics have already been reported by our research group (Yalcin, 2018; Yalçın et al., 2019 and 2020). In this study, a systematic investigation has been carried out with various formulated Calabrian pine chips-selected mineral adducts to determine the effects of physicochemical properties. The first parts of this study, “Properties of Experiemntal Panels Made from Mixture of Dolomite and Olivine with Calabrian pine Wood Particles. Part 1. Physical properties” was accepted for publication in the Journal Journal of Bartin Faculty of Forestry in 2023. In the second part of this study, we seek to demonstrate clear technological properties of panels made from mixture of dolomite and olivine with Calabrian pine wood particles.

2. Material and Methods

Calabrian pine (*Pinus brutia*) wood chips (3x2x1 cm) and urea-formaldyhde adhesive were supplied from a commercially operating particleboard plant, in Isparta province, Turkiye. The minerals of olivine and dolomite materials were collected from Isparta-Aksu mining sites in Turkey. Detailed information on experimental panel preperation and process variables could be found in first parts of this study.

The color characteristics were measured by X-Rite SP-68 spectrophotometer on weathered samples. The experimental small samples were kept in external atmospheric conditions for 60 days and according to CIE L * a * b * (1976) standard, differences (Δ values) from controls were calculated as surface color values. The standard test method for Thermal Conductivity of Refractories by Hot Wire (Platinum Resistance Thermometer Technique) was used to determine the thermal insulation behavior of composites according to ASTM C 1113-90 Hot Wire Method (Agrawal *et al.*, 2021). To determine the mass burning rate, the test samples were cut as standard dimensions of 100x100x10 mm pieces and placed on the test apparatus at a vertical position (ASTM, 2019). The boards were flamed at approx. 800 ^{o}C with a distance of 30-50 mm from the heater surface in a duration of 5.0 min. At the end of the test, the boards were weighted and mass loss was calculated based on weight differences. TGA/DTA analysis of the sample was performed with a thermogravimetric analyzer (Seiko SII TG/DTA 7200, TA Instruments). Analyzes were performed under a nitrogen flow of 60.0 ml/min and the samples were heated from room temperature to 80 °C. The weight of each sample at baseline (original condition) was measured at approximately 5 mg in TGA analysis. Fourier transform infrared (FT-IR) spectra were recorded on a Perkin Elmer Frontier spectrometer. The flammability of the sample was examined with the flammability test according to the TS EN ISO 11925-2 standard and mass loss is calculated. In the combustion behavior experiment, the temperature differences on the surface were determined by placing the sample between the flame source and the infrared measuring device.

Many combinations were tested, and some code numbers and abbreviations were established throughout the study given in Figures and Tables. These are; X: Dolomite in composite formulations, Y: Olivine in composite formulations, P: Red pine wood chip in composite formulations, X-/Y-, $_{0, 1, 2, 3, 4, 5}$: Dolomite (X) and olivine (Y) proportions (w/w, %) of 0-, 10-,20-,30-,40- and 50%, respectively.

3. Results and Discussion

The surface color changes (Δ) of experimental panels are given in Table 1. All panels show lower lightness changes than control samples. The highest lightness change (darker surface) was found with control (ΔL: -13.13). It seems to both olivine and dolomite positive impact on surface lightness reductions in all conditions. However, only a sample of PY_1 shows more green color surface (Δa: -0,39) while others show less red color properties (Δa: 1.06 to 3.40 for dolomite-based panels and Δa: 0.80 to 1.49 for olivine-based panels) than control (PX_0/PY_0: 3.55). However, more yellow surfaces (Δb: 0.83 to 5.65) were found (PX_0: 0.67) for dolomite-based panels, while there is no clear trend was observed for surface yellowness (+) /blueness (-) properties for olivine-based panels.

Yellowness is one of the important color parameters for determining surface color changes after weathering process (Sahin et al., 2011; Sahin and Arslan 2011). In this regard, the yellowness properties of weathered samples were measured and given in Table 1. It could be seen only the sample of PX_4 showed more white surface than the control (PX_0/PY_0: 9.42 vs PX_4: 12.48) while all other experimental boards show lower white surfaces. It is very complicated to explain or correlate color changes in a simple way. But it is clearly seen that adducts formulated boards show some level of lowering whiteness at two months of weathering. These could not be expected, considering the selected adducts could have some chemical groups that may be influenced by outdoor conditions.

Table 1.
The surface color properties of experimental panels

Boards	ΔL	Δa	Δb	E313 Whiteness
		Dolomite-based boards		
PX_0	-13.13	3.55	0.67	9.42
PX_1	1.19	1.95	4.49	7.37
PX_2	-5.50	2.32	1.45	6.23
PX_3	-10.0	1.06	0.83	7.47
PX_4	-3.88	3.40	5.65	12.48
		Olvine-based boards		
PY_0	-13.13	3.55	0.67	9.42
PY_1	2.20	0.95	-0.62	6.76
PY_2	1.67	-0.39	-0.24	**1.57**
PY_3	-3.55	1.02	2.83	8.47
PY_4	2.62	1.49	3.94	5.90

In order to evaluate total color changes in terms of the effects of mineral adduct on weathered samples, the measured values were plotted (Figure 1). It could be clearly visible that both plot shapes look similar to each other. However, it appears there is a clear trend was found with dolomite and olivine in panel formulations. The highest color reduction change of 13.62 was found with the control sample (PX_0/PY_0). Moreover, the dolomite-based panels show color changes in a range of ΔE: 5.03 (PX_1) to 10.09 (PX_5). The olivine-based panels show total color changes in the range of ΔE: 1.73 (PY_2) to 4.96 (PY_4). The highest discoloration resistance (improvement) was found to be PX_1 sample which is approximately 63% lower than the control (X_0: 13.62 vs. X_1: 5.03) for dolomite-formulated boards. An almost similar trend was also found for olivine-formulated boards the lowest discoloration was found with sample PY_2 which shows approximately 87% lower than the control (PY_0: 13.62 vs PY_2: 1.73). It is also noticeable olivine appears to be more effective for preservation against discoloration from outdoor exposure at similar experimental conditions than dolomite.

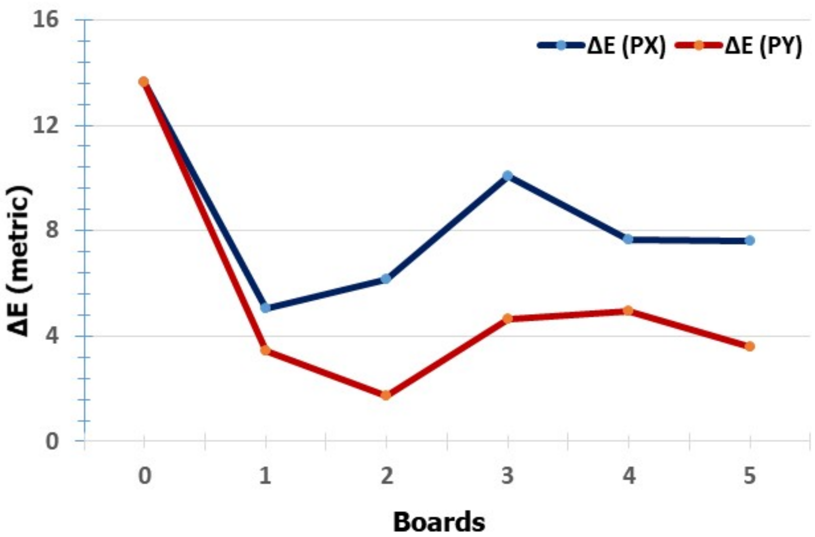

Figure 1. The total color change properties (ΔE) of weathered experimental panels

As it is known, heat is an energy and it tends to flow from the higher side than lower side when two surfaces contact to each other. During this transfer (flow), depends on the thermal conductivity coefficients of the materials, it encounters a resistance (Meng, et al.,2018). In general, this resistance is expressed as thermal insulation and reported as materials heat transmission coefficient (λ). The thermal insulation (heat conduction coefficient) properties of experimental panels obtained with the addition of dolomite and olivine into pine wood chips are given in Table 2. Except for sample of PY_4 which shows a 7.6% higher heat conduction coefficient value than the control (PY_4: 0.407 vs PX0/PY0: 0.378 W/mK), all others show some level lower heat conduction properties which improve insulation properties of experimental boards. For the dolomite-wood-based panels (PX types), the lowest heat transfer coefficients were measured as λ: 0.265 W/mK in PX_1, followed by λ:288 W/mK in PX_3, λ: 0.290 W/mK in PX_5, λ: 0.312 W/mK in PX_2 and λ: 0.329 W/mK in PX_4 in that order. For the olivine-wood-based panels (PY types), the lowest heat transfer coefficients were measured as λ: 0.270 W/mK in PY1, followed by λ:292 W/mK in PX_2, λ: 0.324 W/mK in PY_4, and λ: 0.77

W/mK in PX_3, respectively. But it is important to note that all dolomite- and olivine-based panel's conduction values were found to be higher than the standard value of λ: 0.065 W/mK which is an important threshold level for classification of materials either inside insulation groups or not. This is important because it clearly shows the experimental boards, produced with olivine and dolomite as adducts in pine wood, are not in the heat insulation material class.

Table 2.
Heat conduction coefficient properties of experimental panels

Boards	**Heat conduction coefficient (λ: W/mK)**
Dolomite-based boards	
PX_0	0.378
PX_1	0.265
PX_2	0.312
PX_3	0.288
PX_4	0.329
PX_5	0.290
Olivine-based boards	
PY_0	0.378
PY_1	0.270
PY_2	0.292
PY_3	0.377
PY_4	0.324
PY_5	0.407

The combustion test of experimental panels were performed with a single flame source (DIN 4102,) the heat passes one surface to other (heat flow) with 60-second intervals for total of 5.0 min durations are shown comparatively in Table 3. It is observed the insulation levels of boards have closely related with mineral content. Except sample of PY_5 which show lower heat insulation properties than control after 5.0 min conditions (205 ^{o}C vs. 240.5 ^{o}C), but other measured results clearly imply that olivine is more effective for improving insulation properties than dolomite at similar board preparation conditions. The lowest measured surface temperature of 124.4 ^{0}C was found with a sample of PY_1, followed by 129.9 ^{0}C with a sample of PY_2, and 134.8 ^{0}C with a sample of PY_3.

Table 3.
The insulation properties of experimental panels

Boards	0	60s	120s	180s	240s	300s
Dolomite-based boards						
PX_0	21.2	78.0	99.7	131.3	153.4	205.0
PX_1	22.0	40.6	61.6	84.1	134.0	150.1
PX_2	21.9	55.8	86.6	98.0	125.8	174.9
PX_3	16.5	69.2	94.9	115.0	134.6	219.1
PX_4	18.0	58.9	96.7	129.4	182.0	257.4
PX_5	21.6	90.5	124.4	162.2	198.1	263.0
Olivine-based boards						
PY_0	21.2	78.0	99.7	131.3	153.4	205.0
PY_1	19.1	25.8	54.5	78.7	92.6	124.4
PY_2	20.1	36.3	70.6	80.1	102.8	129.9
PY_3	17.6	45.4	67.2	77.9	108.5	134.8
PY_4	17.0	44.1	77.8	87.8	139.5	189.5
PY_5	17.6	49.5	72.2	90.6	146.8	240.5

The mass loss (w, %) of experimental panels after 5.0 min presented in Figure 2. Although some samples show some level higher heat levels than controls, all boards show lower mass loss values (%) than controls. The mass loss was found to be in range of 11.98% (PX_1) to 17.39% (PX_0) for dolomite-based panels and in range of 10.85% (PY_5) to 17.35% (PY_0) for olivine-based panels. It appears olivine based-panels show higher resistance against heat than dolomite based panels at similar experimental conditions.

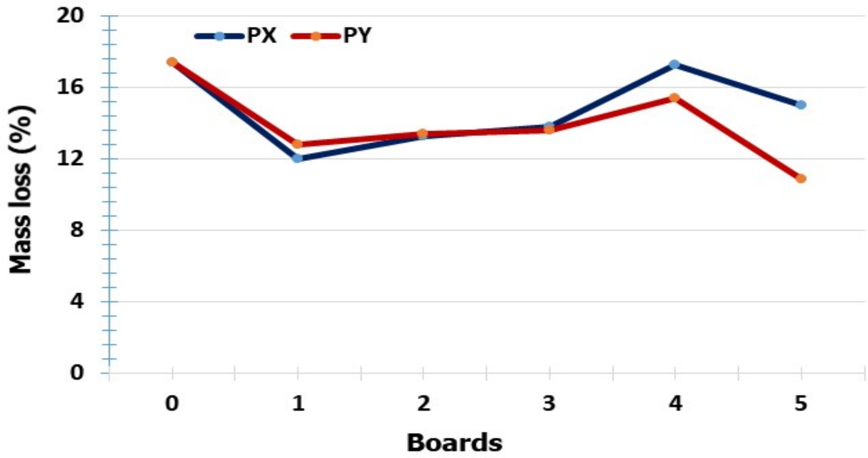

Figure 2. The mass loss (w, %) of experimental panels

Pyrolysis of experimental panels were investigated in the temperature range of 25-900 ^{0}C by thermogravimetry method (TGA) (Figure 3). At initially (warm-up stage), up to 100 ^{0}C, it is assumed that 7-10% mass loss occurs as a result of drying of substances. However, the decomposition of polysaccharides takes place in the temperature range of 200–380 ^{0}C which mass loss occurs in the range of 65-80% on average, while lignin and other substance decomposition seems to be ranging from 180 °C up to 900°C.

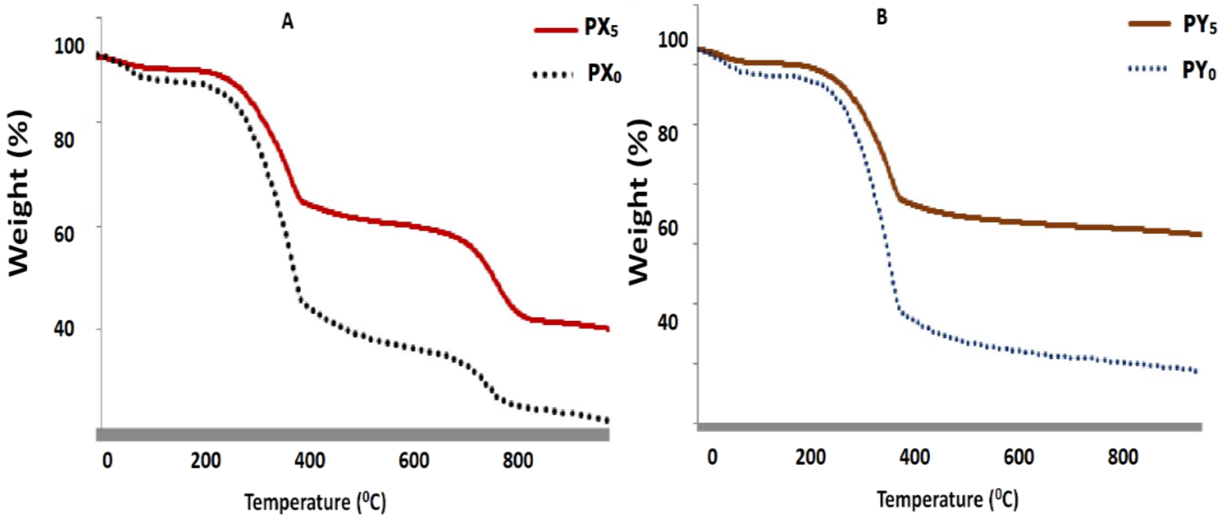

Figure 3. TGA analysis of experimental boards.

TGA analysis at three different temperature degradation, starting temperature (Tb), first maximum temperature (m) and final temperature (Ts), with mass loss properties are given in Table 4. The control samples (AX_0/AY_0) show only 1 ^{0}C and 3 ^{0}C higher degradation temperature levels than PX_5 and PY_5 panels initially (at tb) while 6 ^{0}C higher than PY_5 at Ts. When Table 4 is carefully overviewed, both PX_5 and PY_5 panels show lower mass loss (%) at all three temperature levels than control. One may conclude that each mineral adducts have clear effects on the heat resistance of boards at elevated temperatures (> 400 ^{o}C).

Table 4.
The mass loss properties of experimental panels after TGA analysis

Boards	Tb (ºC)	Mass loss (%)	Tm (ºC)	Mass loss (%)	Ts (ºC)	Mass loss (%)
AX_0/AY_0	200	6.59	357	45.30	416	56.92
AX_5	197	3.63	357	30.13	426	37.57
AY_5	199	4.46	357	32.41	410	40.17

Figure 4 show the surface flame spreading and burning pattern of test samples after a single flame test, compratively. It was observed the burning pattern on all test samples produced with various proportions of olivine with red pine wood chips did not reach the 150 mm threshold limit while the closest feature to this threshold limit is in the board produced from 100% wood chips (PX_0/PY_0). It can be suggested that adding dolomite and olivine to the mixture improves the combustion condition on the surface of the material to a certain extent. Similar results were also found with samples that were subjected to burning. The control sample shows higher fire propagation and spreading features than other adducts formulated samples. This is clear evidence both mineral adducts have some level of improving effects on the burning properties of boards.

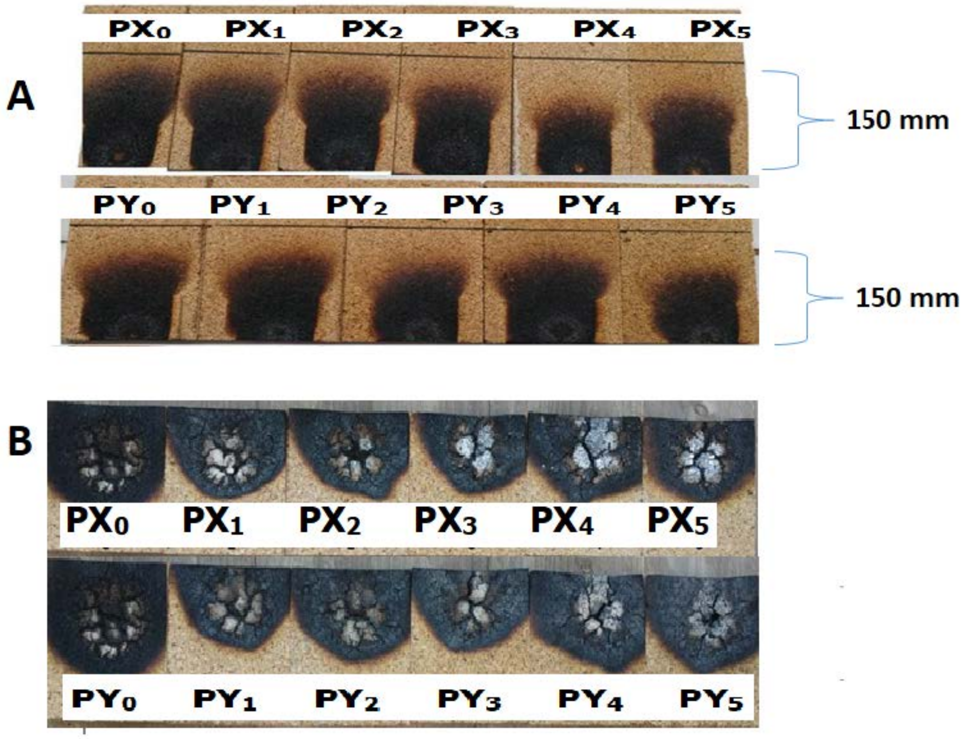

Figure 4. Burning and flame spreading properties of samples

During experimental board manufacturing process (wood and mineral proportions), which consists of disintegration, drying, pre-formation and pressing may influence wood-mineral binding to each other. But data presented in above (Tables 2 and 3 and Figures 2-4) clearly show well compatibility between wood chips to mineral adducts in boards matrix structure. This could be expecting considering very high thermal resistance properties have been reported for both dolomite and olivine minerals (Yalcin, 2018; Yalçın, et al., 2019 and 2020).

Figure 5 show FT-IR spectra of some test boards which produced with proportion mixture of pine wood chips-olivine and dolomite. The spectra of the samples appear to be generally similar to each other. However, some spectra shifted to be lower or higher wavenumbers. Some typical peaks for lignocellulosic substrates were clearly detected. The FT-IR spectra clearly reveal all experimental boards had similar functional groups and that some differences in the intensities of the peaks occurred. The peaks in the range of 2850-3500 cm^{-1} are explained as a characteristic peaks for lignin components due to the O-H- (phenolic and aliphatic -OH), C-H- (CH_3, CH_2, OCH_3) stretching (Can and Sivrikaya 2017; Ceylan & Pekgözlü 2019; Yalcin, 2018).

The peaks between 1100-1510 cm^{-1} show some variations (increase or decrease). However, the peak, in the range of 1350-1376 cm^{-1}, is important in terms of indicating the C-H degradation in hemicellulose and cellulose. It should be noted that the decrease in these peak (PX_0) is probably hydrophobic nature of the substrate (Can and Sivrikaya 2017). It is also reasonable to suggest that the high temperature (> 100 °C) was used during the hot pressing of experimental boards which could be destroyed some chemical components (especially lignin and hemicellulose). It could be concluded the differences between spectra could be a result of a new matrix formation with board formulations while chemical bonding of these groups under heat.

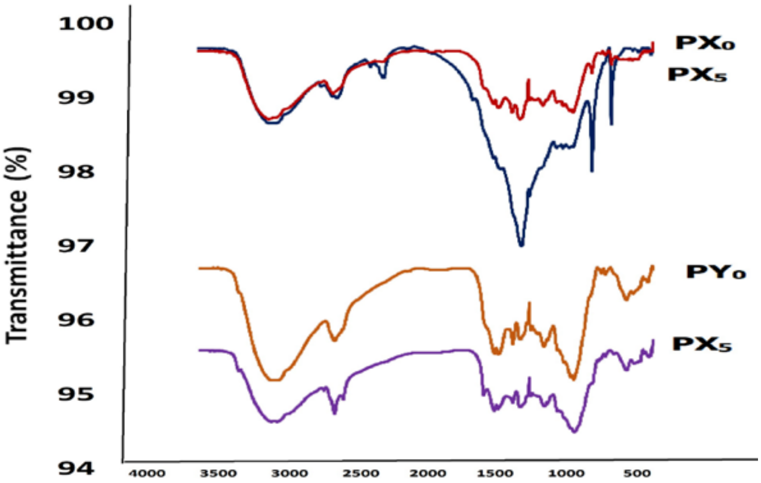

Figure 5. FTIR spectra of samples

4. Conclusion

Extensive research has examined the utilization of various wood and non-wood matetrs for composite manufacturing. There is limited research on the properties of boards which made from mixture of wood with olivine and dolomite as mineral adducts under synthetic adhesive bonding process. However, new bio-composite manufacturing with using alternative sources have become impostant issue in recent years. This is due to environmental and economical issues. The cement- and gypsum-based boards have well known materials and utulized worldwide. Although to find the efectiveness of dolomite and olivine at various research studies are available in the literature, limited studies were reported in place of natural lignocellulosic substitute in composite strutures.

This study presents a study of dolomite and olivine as an adducts material in composite matrix and its effect on various properties. The experimental methods evaluted in this study reveals both olivine and dolomite as mineral adducts in pine wood chips could be feasible and possible to improve some selected properties of experimental panels at certain conditions. There are numerous literature reports on wood-adducts interaction effects on composite properties.

Author Contributions

This work was carried out in collaboration among all authors.

Halil Turgut Sahin: managed and designed the study, analyzed the data, drafted the article and revisions.

Omer Umit Yalcin: carried out experiments, data collection, and reporting.

Al Ihsan Kaya and Ugur Ozkan: designed and planned the analysis.

Conflict of interest

The authors declare that they have received no funds and there is no conflict of interest.

References

Aamr-Daya E, Langlet T, Benazzouk A, Quéneudec M (2008). Feasibility study of lightweight cement composite containing flax by-product particles: Physico-mechanical properties. Cement Concrete Comp. 30: 957–963.

Aggarwal LK, Agrawal SP, Thapliyal PC, Karade SR (2008). Cement-bonded composite boards with arhar stalks. Cement Concrete Comp. 30: 44–51.

Agrawal, Y., Gupta, T., Siddique, S., & Sharma, R. K. (2021). Potential of dolomite industrial waste as construction material: a review. *Innovative Infrastructure Solutions*, *6*(4), 1-15.

ASTM C1113/C1113M-09 (2019). Standard Test Method for Thermal Conductivity of Refractories by Hot Wire (Platinum Resistance Thermometer Technique). *ASTM International West Conshohocken*, PA.

Bergland, L. and Rowell, R.M. (2005). Wood composites, Ch.10, In: *Handbook of wood chemistry and wood composites*, Roger M. Rowell (Ed), *CRC Press*, New York, pp.279-302.

Can, A., & Sivrikaya, H. (2017). *Combined effects of copper and oil treatment on the properties of Scots pine wood*. Drewno*:* 60 (199), 89-103.

Ceylan, E., & Pekgözlü, A. K. (2019). *Utilization of Trapa natans*. Journal of Anatolian Environmental and Animal Sciences, *4*(4), 688-694.

Forest Products Laboratory (2010). Wood Handbook-Wood as an engineering material*, General Technical Report FPL-GTR-190*, Madison, WI, 508p.

Kozlowski R, Helwig M, Przepiera A. (1995). Light-weight, environmentally friendly, fire retardant composite boards for panelling and construction. *Inorganic-bonded wood and fiber composite materials*, USA, 1995. p. 6±11.

Maloney, T.M. (1996). The family of wood composite materials, *Forest Products Journal*, 46 (2), 19-26.

McKeever, D. B. (1997). Engineered wood products: a response to the changing timber resource. *Pacific Rim Wood Market Report*, *123*(5), 15.

Ndazi, B., Tesha, J. V. and Bisanda E.T.N. (2006). Some opportunities and challenges of producing bio-composites from non-wood residues, *J. Mater Sci*., 41,6984–6990.

Meng, X., Huang, Y., Cao, Y., Gao, Y., Hou, C., Zhang, L., & Shen, Q. (2018). Optimization of the wall thermal insulation characteristics based on the intermittent heating operation. *Case studies in construction materials*, *9*, e00188.

Nicolaci, A., Travaglini, D., Menguzzato, G., Nocentini, S., Veltri, A., & Iovino, F. (2014). Ecological and anthropogenic drivers of Calabrian pine (Pinus nigra JF Arn. Ssp. Laricio (Poiret) Maire) distribution in the Sila mountain range. *iForest-Biogeosciences and Forestry*, *8*(4), 497.

Özdemir, F. (2016). Yüksek Yoğunluklu Lif Levhanın Bazı Özellikleri Üzerine Dolomit Mineralinin Etkisinin Araştırılması. *Kahramanmaraş Sütçü İmam Üniversitesi Mühendislik Bilimleri Dergisi* 19, 93-98.

Özdemir, F., Tutuş, A., Çiçekler, M. (2016). Effect of Dolomite Mineral on Surface Roughness of High Density Fiberboard (HDF). *In 2nd International Furniture Congress* (pp. 498-501).

Papadopoulos, A. N. (2019). Advances in wood composites. *Polymers*, *12*(1), 48.

Rials, G. T. and Wolcott, M.P. (1997). Physical and mechanical properties of agro-based fibers, In: Paper and composites from agro based resources, Rowell, R.M., Young, R.A., Rowell, J.K. (Eds), *CRC Press Inc,* Boca Raton, Florida, 63-81 pp.

Sahin, H.T., Arslan, M.B., Korkut, S., & Sahin, C. (2011). Colour changes of heat-treated woods of red-bud maple, European hophornbeam and oak. *Color Research & Application*, *36*(6), 462-466.

Sahin, C. K., Topay, M., & Var, A. A. (2020). A study on suitability of some wood species for landscape applications: surface color, hardness and roughness changes at outdoor conditions. *Wood Research*, *65*(3), 395-404.

Sahin, H.T., Arslan, M.B. (2011). Weathering performance of particleboards manufactured from blends of forest residues with Red pine (Pinus brutia) wood, *Maderas: Ciencia y Technologia*, 13 (3), 337-346.

Sahin, H. T., Simsek, Y. (2021). Mineral-Bonded Wood Composites: An Alternative Building Materials. In *Engineered Wood Products for Construction*. IntechOpen.

Suchland, O., Woodson, G. (1987). Fiberboard Manufacturing Practices in the United States, Department of Agriculture Forest Service Agriculture Handboolk No. 640, Washington DC.

TS-EN 11925-2:2002. Reaction to fire tests- Ignitability of building products subjected to direct impingement of flame- Part 2: Single-flame source test, *TSE*, Ankara.

Yalcin, O.U. (2018). Investigation of performance properties of panels produced from some lignocellulosic sources with mineral (dolomite and olivine) additives, (Ph.D thesis; Turkish, abstract is in English*), Isparta University of Applied Sciences, the Institute for Graduate Education, Department of Forest Product Engineering*, Isparta-Turkey (169p.).

Yalçın, Ö. Ü., Şahin, H. T., & Kaya, A. İ. (2019). Investigation of some performance properties of panels produced from Red pine Bark and Cone sources with dolomite. *ICONST LST 2019*, 41

Yalçın, Ö. Ü., Kaya, A. İ., & Şahin, H. T. (2020). Mineral Based Boards made from Lignocellulosic Wastes: 1st Part-Physical And Mechanical Properties. *Mehmet Akif Ersoy Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, *11*(2), 142-149.

Yilgor, N., Dogu, D., Moore, R., Terzi, E., & Kartal, S.N. (2013). Evaluation of fungal deterioration in Liquidambar orientalis Mill. Heartwood by FT-IR and light microscopy. *BioResources*, 8, 2805–2826.